MOTION

PHYSICS

CLASS - IX

BOOKLET - 1

CONTENTS

BASIC PHYSICS

MOTION

FORCE AND LAW OF MOTION

Motion Education, 394 - Rajeev Gandhi Nagar, Kota-5 (Raj.)
✆ : 1800-212-1799, 8003899588 | url : www.motion.ac.in | ✉ : info@motion.ac.in

GRAVITATION

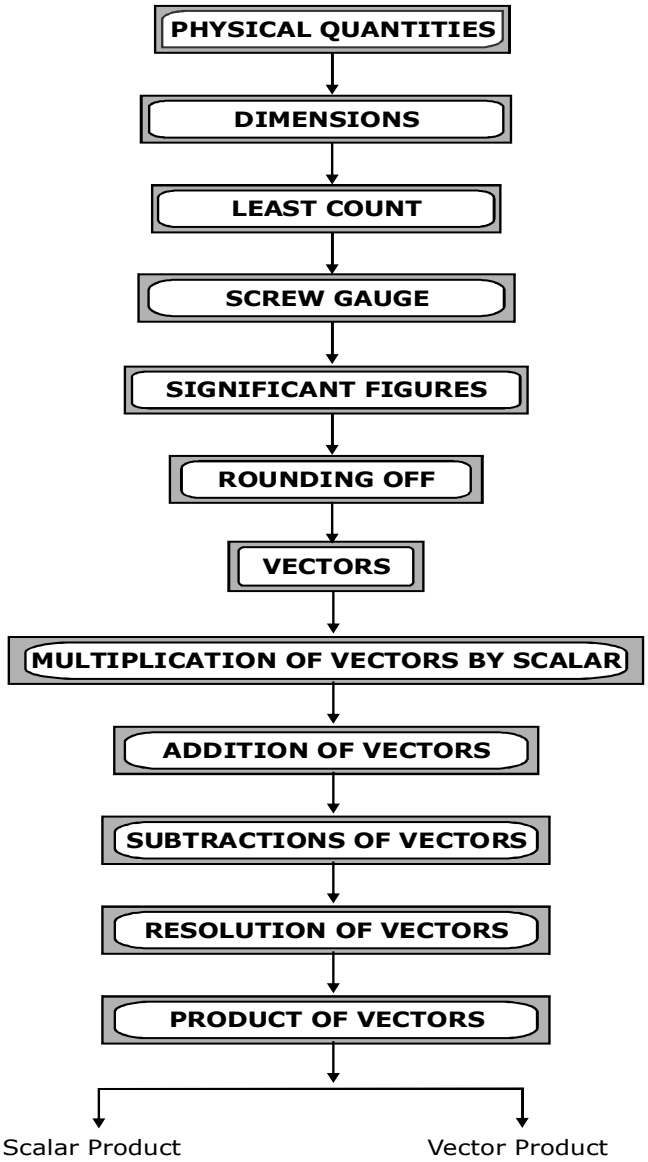
ELECTRICITY

THERMODYNAMICS

ANSWER KEY

CHAPTER 1

BASIC PHYSICS



UNIT AND MEASUREMENTS

PHYSICAL QUANTITIES

All the quantities which are used to describe the laws of physics are known as physical quantities.

Classification: Physical quantities can be classified on the following bases:

I. Based on their directional properties

1. Scalars : The physical quantities which have only magnitude but no direction are called *scalar quantities*.

e.g. mass, density, volume, time, etc.

2. Vectors : The physical quantities which have both magnitude and direction and obey laws of vector algebra are called *vector quantities*.

e.g. displacement, force, velocity, etc.

II Based on their dependency

1. Fundamental or base quantities: The quantities which do not depend upon other quantities for their complete definition are known as *fundamental or base quantities*.

e.g. length, mass, time, etc.

2. Derived quantities : The quantities which can be expressed in terms of the fundamental quantities are known as *derived quantities* .

e.g. Speed (=distance/time), volume, accelaration, force, pressure, etc.

IMPORTANT POINTS

1. Physical quantities can also be classified as dimensional or dimensionless and constant or variable.

2. Some physical quantities can not be completely specified even by specifying their magnitude, unit and direction. These quantities behave neither as a scalar nor as a vector and are called ***tensors***. e.g. Moment of Inertia. It is not a scalar as it has different values in different directions (i.e.about different axes). It is not a vector as changing the sense of rotation (i.e. clockwise or anti clockwise) does not change its value.

Q. Classify the quantities displacement, mass, force, time, speed, velocity, accelaration, moment of intertia, pressure and work under the following categories :

(a) base and scalar

(b) base and vector

(c) derived and scalar

(d) derived and vector

Ans. (a) mass, time

(b) displacement

(c) speed, pressure, work

(d) force, velocity, accelaration

UNITS OF PHYSICAL QUANTITIES

The chosen reference standard of measurement in multiples of which, a physical quantity is expressed is called the *unit* of that quantity.

System of Units :

1. FPS or British Engineering system :

In this system length, mass and time are taken as fundamental quantities and their base units are foot (ft), pound (lb) and second (s) respectively.

2. CGS or Gaussian system :

In this system the fundamental quantities are length, mass and time and their respective units are centimetre (cm), gram (g) and second (s).

3. MKS system :

In this system also the fundamental quantities are length, mass and time but their fundamental units are metre (m), kilogram (kg) and second (s) respectively.

4. International system (SI) of units :

This system is modification over the MKS system and so it is also known as *Rationalised MKS system*. Besides the three base units of MKS system four fundamental and two supplementary units are also included in this system.

SI BASE QUANTITIES AND THEIR UNITS

S. No.	Physical quantity	Unit	Symbol
1	Length	metre	m
2	Mass	kilogram	kg
3	Time	second	s
4	Temperature	kelvin	K
5	Electric current	ampere	A
6	Luminous intensity	candela	cd
7	Amount of substance	mole	mol

1. **Length (meter) :** The meter is the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second (1983). It is denoted by m.
2. **Mass (kilogram) :** The kilogram is equal to the mass of the international prototype of the kilogram (a platinum-iridium alloy cylinder) kept at International Bureau of Weights and Measures, at Sevres, near Paris, France. (1889). It is denoted by kg.
3. **Time (second) :** The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom (1967). It is denoted by s.
4. **Thermodynamic Temperature (kelvin) :** The kelvin, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. (1967). It is denoted by K.
5. **Electric Current (ampere) :** The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} Newton per metre of length. (1948). It is denoted by A.

6. Luminous Intensity (candela) : The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian (1979). It is denoted by Cd.

7. Amount of Substance (mole) : The mole is the amount of substance of a system, which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12. (1971). It is denoted by mol.

While defining a base unit or standard for a physical quantity the following characteristics must be considered :
(i) Well defined
(ii) Invariability (constancy)
(iii) Accessibility (easy availability)
(iv) Reproducibility
(v) Convenience in use

Classification of Units :

The units of physical quantities can be classified as follows :

1. Fundamental or base units :

The units of fundamental quantities are called *base units*. In SI there are seven base units.

2. Derived units :

The units of derived quantities or the units that can be expressed in terms of the base units are called derived units.

e.g. unit of speed

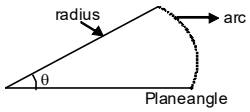
$$= \frac{\text{unit of distance}}{\text{unit of time}} = \frac{\text{metre}}{\text{second}} = \text{ms}^{-1}$$

Some derived units are named in honour of great scientists.
e.g. unit of force - newton (N), unit of frequency - hertz (Hz), etc.

3. Supplementary units, SI prefixes :

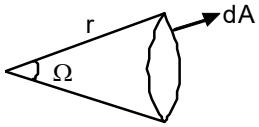
In SI system two *supplementary units* are also defined viz. radian (rad) for plane angle and steradian (sr) for solid angle.

(i) radian : 1 radian is the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle.

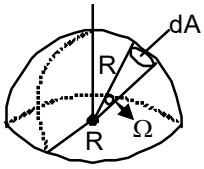


$$\textbf{Plane angle } \theta = \frac{\text{arc length}}{\text{radius}} = \frac{s}{r}$$

(ii) steradian : 1 steradian is the solid angle subtended at the centre of a sphere, by that surface of the sphere which is equal in area to the square of the radius of the sphere.



$$\textbf{Solid angle } \Omega = \frac{dA}{r^2}$$



SI Prefixes

Power of 10	prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da

Power of 10	prefix	Symbol
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

4. Practical units :

Due to the fixed sizes of SI units, some *practical units* are also defined for both fundamental and derived quantities. e.g. light year (ly) is a practical unit of distance (a fundamental quantity) and horse power (hp) is a practical unit of power (a derived quantity).

Practical units may or may not belong to a particular system of units but can be expressed in any system of units.

e.g. 1 mile = 1.6 km = 1.6×10^3 m = 1.6×10^5 cm.

5. Improper units :

These are the units which are not of the same nature as that of the physical quantities for which they are used.

e.g. kg - wt is an improper unit of weight. Here kg is a unit of mass but it is used to measure the weight (force).

UNITS OF SOME PHYSICAL QUANTITIES IN DIFFERENT SYSTEMS

Type of Physical Quantity	Physical Quantity	CGS (Originated in France)	MKS (Originated in France)	FPS (Originated in Britain)
Fundamental	Length	cm	m	ft
	Mass	g	kg	lb
	Time	s	s	s
Derived	Force	dyne	newton (N)	poundal
	Work or	erg	joule (J)	ft - poundal
	Energy			
	Power	erg/s	watt (W)	ft - poundal/s

Some important conversion factors :

Length :

(i) 1 m = 100 cm = 1000 mm
= 3.28 ft. = 39.37 in
= 1.0936 yd (yard)

(ii) 1 km = 0.6215 mi (mile)

(iii) 1 mi = 1609 m

(iv) 1 n mi (nautical mile) = 1852 m

(v) 1 in = 2.54 cm

(vi) 1 ft = 12 in = 30.48 cm.

(vii) 1 yd = 3 ft = 91.44 cm.

(viii) 1 μm (micron) = 10^{-6}m

(ix) 1 Å = 10^{-10} m = 0.1 nm

(x) 1 fermi = 10^{-15} m

(xi) 1 bohr radius = 0.529 Å

(xii) 1 AU (Astronomical unit) = 1.49 × 10^{11} m (Average distance between sun and earth)

(xiii) 1 ly (light year) = 9.461 × 10^{15} m (Distance travelled by light in vacuum in one year)

(xiv) 1 parsec or parallactic second = 3.08 × 10^{16} m= 3.26 ly (Distance at which an arc of length 1AU subtends an angle of one second at a point)

Mass :

(i) 1 kg. = 1000 g = 2.2 lb (pound)

(ii) 1 quintal = 100 kg

(iii) 1 ton = 907.2 kg

(iv) 1 metric tonne = 1000 kg = 10^6 g

(v) 1 lb = 454 g

(vi) 1 slug = 14.59 kg

(vii) 1 ounce = 28.35 g

(viii) 1 amu = 1.6606 × 10^{-27} kg
= 931.5 MeV./$c^{2`}$

(ix) 1 Chandra Shekhar Limit = 1.4 M_{sun}

Time :

(i) 1 h = 60 min = 3600 s
(ii) 1 d = 24 h = 1440 min = 86.4×10^3 s
(iii) 1 y = 365.24 d = 31.56×10^6 s
(iv) 1 shake = 10^{-8} s

Area :

(i) 1 m^2 = 10^4 cm^2
(ii) 1 km^2 = 0.386 mi^2 = 247 acres
(iii) 1 acres = 43,560 ft^2 = 4047m^2 = 0.4047 hectare
(iv) 1 hectare = 10^4 m^2 = 2.47 acres
(v) 1 barn = 10^{-28} m^2 (for measuring cross-sectional areas in sub-atomic particle collisions)

Volume :

(i) 1 m^3 = 10^6 cm^3 = 10^6 cc = 10^3 L = 35.31 ft^3
(ii) 1 gal (gallon) = 3.786 L (in U.S.A.) or 4.54 L (in U.K.)

Density :

(i) 1 kg m^{-3} = 10^{-3} g cm^{-3} = 10^{-3} kg L^{-1}

Speed :

(i) 1 km h^{-1} = 5/18 or 0.2778 m s^{-1} = 0.6215 mi h^{-1} =
(ii) 1 mi h^{-1} 0.4470 m s^{-1} =1.609 km h^{-1} =1.467 ft s^{-1}
(iii) 1 m s^{-1} = 18/5 or 3.6 km h^{-1} = 2.24 mi h^{-1}

Angle and angular speed :

(i) π rad = 180^0
(ii) 1 rad = 180°/π or 57.30^0
(iii) $1^0 = 1.745 \times 10^{-2}$ rad = 60' = 1/360 revolution
(iv) 1 rev = 360° = 2π rad
(v) 1' (min) = 60" (second)
(vi) 1 rev min^{-1} = 0.1047 rad s^{-1} $\approx$ 0.1 rad s^{-1}
(vii) 1 rad s^{-1} = 9.549 rev min^{-1}

Accelaration :

(i) g = 9.8 m s^{-2} (*MKS unit*) = 980 cm s^{-2} (*CGS unit*) = 32 ft s^{-2} (*FPS unit*)

Force :

(i) 1 N = 10^5 dyne = 7.23 poundal
(ii) 1 kg – wt = 1 kg – f = 9.8 N
(iii) 1 g – wt = 1 g – f = 980 dyne
(iv) 1 lb – wt = 1 lb – f = 32 poundal

Pressure :

(i) 1 Pa = 1 N m^{-2} = 10 dyne cm^{-2}
(ii) 1 bar = 10^5 Pa = 10^6 dyne cm^{-2}
(iii) 1 atm = 1.01325 bar = 1.01×10^5 Pa
= 1.01×10^6 dyne cm^{-2} = 760 mm of Mercury
(iv) 1 torr = 1 mm of Hg column = 153.32 Pa

PRACTICE YOUR CONCEPTS

1. The accelaration due to gravity is 9.8 m s^{-2}. Give its value in ft s^{-2}

Sol. As 1m = 3.2 ft

$\therefore$ 9.8 m/s^2 = 9.8 × 3.28 ft/s^2 = 32.14 ft/s^2 $\approx$ 32 ft/s^2

2. Name the smallest and largest units of length.

Sol. **(fermi and parsec)**

3. Match the type of unit (column A) with its corresponding example (column B)

(A)	(B)
(a) Base unit	(i) N
(b) Derived unit	(ii) hp
(c) Improper unit	(iii) kg - wt
(d) Practical unit	(iv) rad
(e) Supplementary unit	(v) kg

Sol. (a) kg (b) N (c) kg – wt (d) hp (e) rad.

DIMENSIONS

Dimensions of a physical quantity are the powers (or exponents) to which the base quantities are raised to represent that quantity.

1. DIMENSIONAL FORMULA:

The *dimensional formula* of any physical quantity is that expression which represents how and which of the base quantities are included in that quantity.

It is written by enclosing the symbols for base quantities with appropriate powers in square brackets i.e. [ ]

e. g. Dim. formula of mass is $[M^1L^0T^0]$ and that of speed (= distance/time) is $[M^0L^1T^{-1}]$

PRACTICE YOUR CONCEPTS

4. Find out the dimensional formula of the following

(i) Density (ii) Velocity

(iii) Acceleration (iv) Momentum

(v) Angle (vi) Torque

Sol. (i) $[\text{Density}] = \frac{[\text{mass}]}{[\text{volume}]} = \frac{M}{L^3} = [M^1L^{-3}]$

(ii) Velocity $[v] = \frac{[\text{Displacement}]}{[\text{time}]}$

$= \frac{L}{T} = [M^0L^1T^{-1}]$

(iii) Acceleration $(a) = \frac{dv}{dt} = \frac{LT^{-1}}{T} = LT^{-2}$

(iv) Momentum (P) = mV = $[M^1L^1T^{-1}]$

(v) Angle (θ) = $\frac{[Arc]}{[radius]} = \frac{L}{L}$

= $[M^0L^0T^0]$ (Dimensionless)

(vi) Torque = Force × Arm length

= $[M^1L^1T^{-2}] \times [L] = [M^1L^2T^{-2}]$

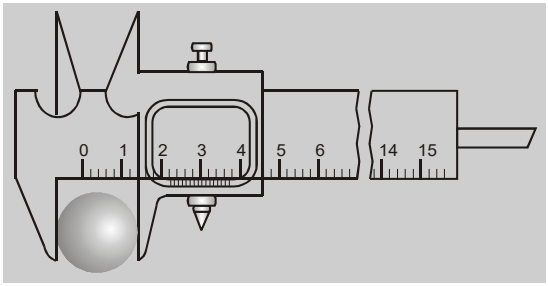
Different quantities with units. symbol and dimensional formula.

Quantity	Symbol	Formula	S.I. Unit	D.F.
Displacement	s	ℓ	Metre or m	M^0LT^0
Area	A	$\ell \times b$	(Metre)^2 or m^2	$M^0L^2T^0$
Volume	V	$\ell \times b \times h$	(Metre)^3 or m^3	$M^0L^3T^0$
Velocity	v	$v = \frac{\Delta s}{\Delta t}$	m/s	M^0LT^{-1}
Momentum	p	p = mv	kgm/s	MLT^{-1}
Acceleration	a		m/s^2	M^0LT^{-2}
Force	F	F = ma	Newton or N	MLT^{-2}
Impulse	-	F × t	N.sec	MLT^{-1}
Work	W	F . d	N . m	ML^2T^{-2}
Energy P.E. = mgh	KE or U	$K.E. = \frac{1}{2}mv^2$	Joule or J	ML^2T^{-2}
Power	P	$P = \frac{W}{t}$	watt or W	ML^2T^{-3}
Density	d	d = mass/volume	kg/m^3	$ML^{-3}T^0$
Pressure	P	P = F/A	Pascal or Pa	$ML^{-1}T^{-2}$
Torque	τ	$\tau = r \times F$	N.m.	ML^2T^{-2}
Angular displacement	θ	$\theta = \frac{arc}{radius}$	radian or rad	$M^0L^0T^0$
Angular velocity	ω	$\omega = \frac{\theta}{t}$	rad/sec	$M^0L^0T^{-1}$
Angular acceleration	α	$\alpha = \frac{\Delta\omega}{\Delta t}$	rad/sec^2	$M^0L^0T^{-2}$
Moment of Inertia	I	I = mr^2	kg-m^2	ML^2T^0
Frequency	ν or f	$f = \frac{1}{T}$	hertz or Hz	$M^0L^0T^{-1}$

LEAST COUNT

The smallest value of a physical quantity which can be measured accurately with an instrument is called the *least count* (L. C.) of the measuring instrument.

Least Count of vernier callipers :



Suppose the size of one main scale division (M.S.D.) is M units and that of one vernier scale division (V.S.D.) is V units. Also let the length of 'a' main scale divisions is equal to the length of 'b' vernier scale divisions.

$aM = bV \Rightarrow V = \frac{a}{b}M$

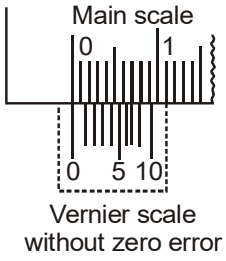
$\therefore M - V = M - \frac{a}{b}M$

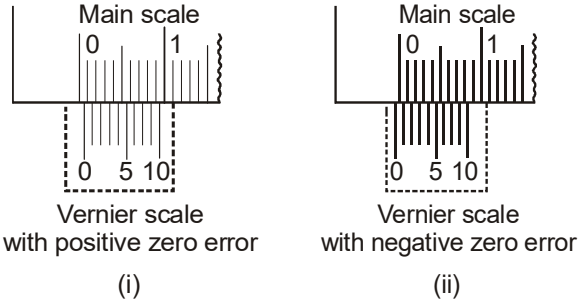
or $M - V = (\frac{b-a}{b})M$

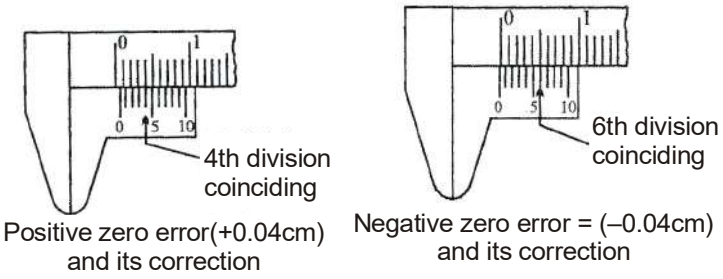
The quantity (M– V) is called *vernier constant* (V. C.) or *least count* (L. C.) of the vernier callipers.

$$L.C. = M - V = \left(\frac{b-a}{b}\right)M$$

Zero error :







If the zero marking of main scale and vernier callipers do not coincide, necessary correction has to be made for this error which is known as zero error of the instrument.
If the zero of the vernier scale is to the right of the zero of the main scale the zero error is said to be positive and the correction will be negative and vice versa.
The zero error is always subtracted from the reading to get the corrected value.
If the zero error is positive, its value is calculated as we take any normal reading. If the zero error negative (the zero of vernier scale lies to the left of the zero of main scale),
negative zero error
= – [Total no. of vsd – vsd coinciding] × L.C.

PRACTICE YOUR CONCEPTS

5. One cm on the main scale of vernier callipers is divided into ten equal parts. If 20 divisions of vernier scale coincide with 8 small divisions of the main scale. What will be the least count of callipers ?

Sol. 20 div. of vernier scale = 8 div. of main scale $\Rightarrow$ 1 V. S .D. = $\left(\frac{8}{20}\right)$ M. S. D.

$= \left(\frac{2}{5}\right)$M. S. D.

Least count = 1 M. S. D. – 1 V. S . D.

= 1 M. S. D. – $\left(\frac{2}{5}\right)$M. S. D.

$= \left(1-\frac{2}{5}\right)$ M. S. D.

$= \frac{3}{5}$ M .S .D.

$= \frac{3}{5} \times$ 0.1 cm = 0.06 cm $\quad (\because$ 1 M. S. D. $= \frac{1}{10}$ cm = 0.1 cm)

Note : for objective questions

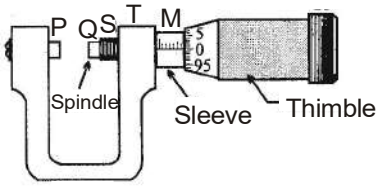
L.C. = M – V $= \left(\frac{b-a}{b}\right)M$

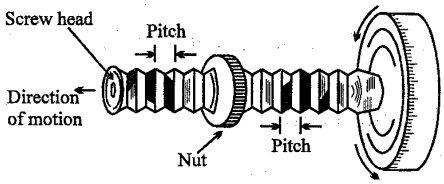
$= \left(\frac{20-8}{20}\right)\left(\frac{1}{10}\right)$cm

$= \frac{3}{50}$ cm = 0.06 cm

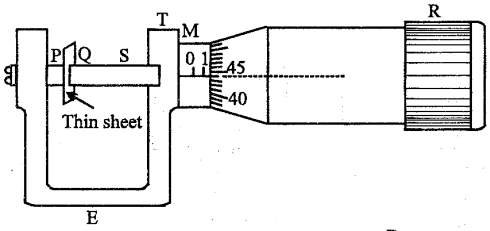
SCREW GAUGE
(OR MICROMETER SCREW)

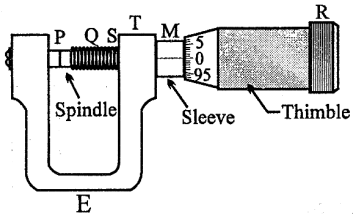
In general vernier callipers can measure accurately upto 0.01 cm and for greater accuracy micrometer screw devices e.g. screw gauge, spherometer are used. These consist of accurately cut screw which can be moved in a closely fitting fixed nut by running it axially. The instrument is provided with two scales :



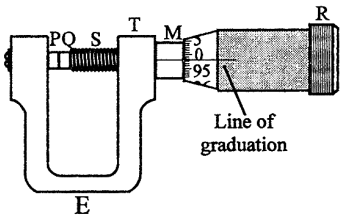


Principle of a micrometer

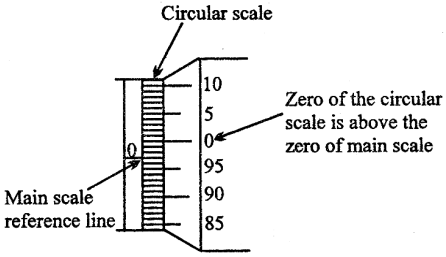


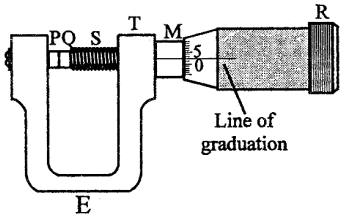


Screw gauge with no zero error

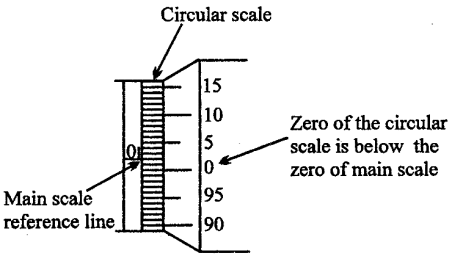


Negative zero error
(3 division error) i.e.,-0.003 cm





Positive zero error
(2 division error) i.e.,+0.002 cm



(i) The main scale (M) or pitch scale graduated along the axis of screw.
(ii) The cap-scale or head scale H round the edge of the screw head.
Constants of the Screw Gauge : -

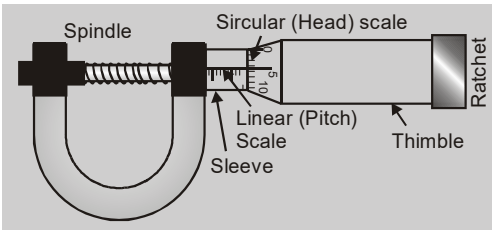
(a) **Pitch :** The translational motion of the screw is directly proportional to the total rotation of the head. The pitch of the instrument is distance between two consecutive threads of the screw which is equal to the distance moved by the screw due to one complete rotation of the cap. Thus for 10 rotation of cap = 5 mm, then pitch = 0.5 mm.

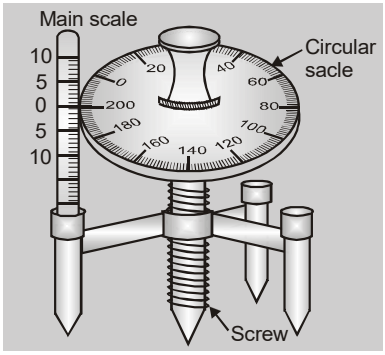
(b) **Least count :** In this case also, the minimum (or least) measurement (or count) of length is equal to one division on the head scale which is equal to pitch divided by the total cap divisions. Thus in the Afore said Illustration.; if the total cap division is 100, then least count = 0.5 mm/100 =0.005 mm

(c) **Measurement of length by screw gauge :**
L = n × pitch + f × least count, where n = main scale reading & f = caps scale reading

Zero Error : In a perfect instrument the zero of the head scale coincides with the line of gradiation along the screw axis with no zero-error, otherwise the instrument is said to have zero-error which is equal to the cap reading with the gap closed. This error is positive when zero line of reference line of the cap lies **below** the line of graduation and versa. The corresponding corrections will be just opposite.

Least Count of Screw Gauge or Spherometer:





$$\text{Least Count} = \frac{\text{Pitch}}{\text{Total no. of divisions on the circular scale}}$$

where pitch is defined as the distance moved by the screw head when the circular scale is given one complete rotation. i.e.

$$\text{Pitch} = \frac{\text{Distance moved by the screw on the linear scale}}{\text{No.of full rotations given}}$$

Note : With the decrease in the least count of the measuring instrument, the accuracy of the measurement increases and the error in the measurement decreases.

PRACTICE YOUR CONCEPTS

6. A spherometer has 100 equal divisions marked along the periphery of its disc, and one full rotation of the disc advances on the main scale by 0.01 cm. Find the least count of the system.

Sol. Given Pitch = 0.01 cm

$\therefore$ Least count

$$= \frac{\text{Pitch}}{\text{Total no. of divisions on the the circular scale}}$$

$$= \frac{0.01}{100} \text{ cm} = 10^{-4} \text{ cm}.$$

7. The n^{th} division of main scale coincides with $(n + 1)^{th}$ division of vernier scale. Given one main scale division is equal to 'a' units. Find the least count of the vernier.

Sol. (n + 1) divisions of vernier scale = n divisions of main scale

$\therefore$ 1 vernier division = $\frac{n}{n+1}$ main scale division

Least count = 1 M. S. D. – 1V. S. D.

= $(1-\frac{n}{n+1})$ M. S. D. = $(\frac{1}{n+1})$ M. S. D. = $\frac{a}{n+1}$

8. The least count of a stop watch is $\frac{1}{5}$ second. The time of 20 oscillations of a pendulum is measured to be 25 seconds. How much will be the percentage error in the measurement of time ?

Sol. Error in measuring 25 sec. = $\frac{1}{5}$ sec. = 0.2 sec.

$\therefore$ percentage error = $\frac{0.2}{25}\times 100$ = 0.8%

Note : The final absolute error in this type of questions is taken to be equal to the least count of the measuring instrument.

SIGNIFICANT FIGURES OR DIGITS

The *significant figures* (SF) in a measurement are the figures or digits that are known with certainity plus one that is uncertain.
Significant figures in a measured value of a physical quantity tells the number of digits in which we have confidence. Larger the number of significant figures obtained in a measurement, greater is its accuracy and vice versa.

1. Rules to find out the number of significant figures:

I Rule : All the non-zero digits are significant e.g. 1984 has 4 SF.
II Rule: All the zeros between two non-zero digits are significant. e.g. 10806 has 5 SF.

III Rule : All the zeros to the left of first non-zero digit are not significant. e.g.00108 has 3 SF.

IV Rule : If the number is less than 1, zeros on the right of the decimal point but to the left of the first non-zero digit are not significant. e.g. 0.002308 has 4 SF.

V Rule : The trailing zeros (zeros to the right of the last non-zero digit) in a number with a decimal point are significant. e.g. 01.080 has 4 SF.

VI Rule : The trailing zeros in a number without a decimal point are not significant e.g. 010100 has 3 SF. But if the number comes from some actual measurement then the trailing zeros become significant. e.g. m = 100 kg has 3 SF.

VII Rule : When the number is expressed in exponential form, the exponential term does not affect the number of S.F. For example in
$x = 12.3 = 1.23 \times 10^1 = .123 \times 10^2 = 0.0123 \times 10^3$
$= 123 \times 10^{-1}$ each term has 3 SF only.

2. Rules for arithmetical operations with significant figures :

I Rule : In addition or subtraction the number of decimal places in the result should be equal to the number of decimal places of that term in the operation which contain lesser number of decimal places. e.g. 12.587 – 12.5 = 0.087 = 0.1 ($\because$ second term contain lesser i.e. one decimal place)

II Rule: In multiplication or division, the number of SF in the product or quotient is same as the smallest number of SF in any of the factors. e.g. 5.0 × 0.125 = 0.625 = 0.62

IMPORTANT POINTS

To avoid the confusion regarding the trailing zeros of the numbers without the decimal point the best way is to report every measurement in *scientific notation* (in the power of 10). In this notation every number is expressed in the form $a \times 10^b$, where a is the base number between 1 and 10 and b is any positive or negative exponent of 10. The base number (a) is written in decimal form with the decimal after the first digit. While counting the number of SF only base number is considered (Rule VII).

The change in the unit of measurement of a quantity does not affect the number of SF. For example in 2.308 cm = 23.08 mm = 0.02308 m = 23080 μm each term has 4 SF.

PRACTICE YOUR CONCEPTS

9. Write down the number of significant figures in the following :
(a) 165 (b) 2.05
(c) 34.000 m (d) 0.005
(e) 0.02340 N m^{-1}

Sol. (a) 3SF (b) 3 SF
(c) 5 SF (d) 1 SF
(e) 4 SF

10. The length, breadth and thickness of a metal sheet are 4.234 m, 1.005 m and 2.01 cm respectively. Give surface area and volume of the sheet to correct number of significant figures.

Sol. length (ℓ) = 4.234 m breadth (b) = 1.005 m
thickness (t) = 2.01 cm = 2.01×10^{-2} m
Therefore area of the sheet
$= 2(\ell \times b + b \times t + t \times \ell)$
$= 2(4.234 \times 1.005 + 1.005 \times 0.0201 + 0.0201 \times 4.234)\ m^2$
$= 2(4.3604739)\ m^2 = 8.720978\ m^2$
Since area can contain a max^m of 3 SF (Rule II of article 4.2) therefore, rounding off, we get
Area = 8.72 m^2
Like wise volume = $\ell \times b \times t$
$= 4.234 \times 1.005 \times 0.0201\ m^3 = 0.0855289\ m^3$
Since volume can contain 3 SF, therefore, rounding off, we get
Volume = 0.0855 m^3

ROUNDING OFF

To represent the result of any computation containing more than one uncertain digit, it is *rounded off* to appropriate number of significant figures.

Rules for rounding off the numbers :

I Rule : If the digit to be rounded off is more than 5, then the preceding digit is increased by one.

e.g. $6.87 \approx 6.9$

II Rule: If the digit to be rounded off is less than 5, than the preceding digit is unaffected and is left unchanged. e.g. $3.94 \approx 3.9$

III Rule : If the digit to be rounded off is 5 then the preceding digit is increased by one if it is odd and is left unchanged if it is even. e.g. $14.35 \approx 14.4$ and $14.45 \approx 14.4$

PRACTICE YOUR CONCEPTS

11. The following values can be rounded off to four significant figures as follows :

(a) $36.879 \approx 36.88$
($\because 9 > 5 \therefore 7$ is increased by one i.e.I Rule)

(b) $1.0084 \approx 1.008$
($\because 4 < 5 \therefore 8$ is left unchanged i.e. II Rule)

(c) $11.115 \approx 11.12$
($\because$ last 1 is odd it is increased by one i.e.III Rule)

(d) $11.1250 \approx 11.12$
($\because$ 2 is even it is left unchanged i.e. III Rule)

(e) $11.1251 \approx 11.13$
($\because 51 > 50 \therefore$ 2 is incresed by one i.e. I Rule)

12. In ohm's law exp., reading of voltmeter across the resistor is 12.5 V and reading of current i = 0.20 Amp. Estimate the resistance in correct S.F.

Sol. $R = \frac{V}{i} = \frac{12.5 \rightarrow 3SF}{0.20 \rightarrow 2SF} = 62.5\Omega \xrightarrow[\text{to 2S.F.}]{\text{roundoff}} 62\Omega$

13. Round off the following numbers as indicated:

(a) 25.653 to 3 digits

(b) 4.996×10^5 to 3 digits

(c) 0.6995 to 1digit

(d) 3.350 to 2 digits

(e) 0.03927 kg to 3 digits

(f) 4.085×10^8 s to 3 digits

Ans. (a) 25.7 (b) 5.00×10^5

(c) 0.7 (d) 3.4

(e) 0.0393 kg (f) 4.08×10^8 s

VECTOR AND SCALARS

SCALAR QUANTITIES

A physical quantity which can be described completely by its magnitude only and does not require a direction is known as a scalar quantity.

Examples : Distance, mass, time, speed, density, volume etc.

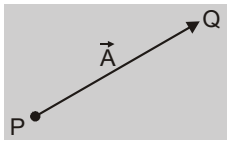
VECTOR QUANTITIES

A physical quantity which has magnitude and direction and obeys all the laws of vector algebra is called a vector quantity.

Examples : Displacement, velocity, acceleration, force etc.

REPRESENTATION OF A VECTOR

A vector is represented by a line headed with an arrow. Its length is



proportional to its magnitude.

$\vec{A}$ is a vector.

$\vec{A} = \overrightarrow{PQ}$

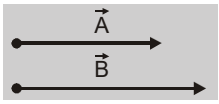
Magnitude of $\vec{A} = |\vec{A}|$ or $\vec{A} = |\overrightarrow{PQ}|$

Magnitude of a vector is always positive.

TYPES OF VECTORS

1. PARALLEL VECTORS :

Those vectors which have same direction are called parallel vectors.



Angle between two parallel vectors is always 0°

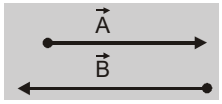
2. EQUAL VECTORS :

Vectors which have equal magnitude and same direction are called equal vectors

$\vec{A} = \vec{B}$

3. ANTI–PARALLEL VECTORS :

Those vectors which have opposite direction are called anti–parallel vector.



Angle between two anti–parallel vectors is always 180°

4. OPPOSITE (OR NEGATIVE) VECTORS :

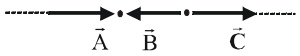
Vectors which have equal magnitude but opposite direction are called opposite vectors.

Here $\overrightarrow{AB}$ & $\overrightarrow{BA}$ are opposite vectors

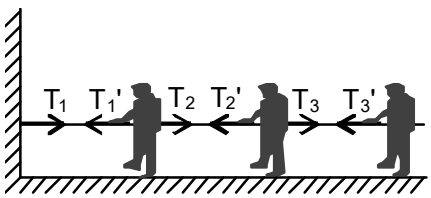
$$\overrightarrow{AB} = -\overrightarrow{BA}$$

5. COLLINEAR VECTORS :

If two or more vectors $\vec{A}, \vec{B}$ and $\vec{C}$ etc., pass through the same straight line, they are said to be collinear vectors. For instance, when several persons pull a straight string at its different points, the tensions T_1, T_1', T_2, T_2', ... T_3' etc., in the string are collinear.



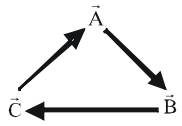
$\vec{A},\vec{B},\vec{C}$ act along the same line; the collinear vectors $\vec{A},\vec{B},\vec{C}$ need not point in same direction



All tensions T_1,T_1', T_2, T_2' etc., are collinear but not unidirectional

6. COPLANAR VECTORS :

If two or more vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ say lie in the same plane, they are said to be coplanar. Here $\vec{A}$, $\vec{B}$ and $\vec{C}$ are coplanar as they act (lie) in the plane of the paper.



The coplanar vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ lie in the plane of the paper.

7. CONCURRENT VECTORS :

If line of action of all vectors is passing through same point then vectors are called concurrent vector.

8. NULL OR ZERO VECTOR :

Vector whose magnitude is zero is called a null vector. Its direction is arbitrary and is not specified.

Example :- Sum of two vectors is always a vector. Therefore $\vec{(A)} + \vec{(-A)} = \vec{0}$

Here $\vec{0}$ is a zero vector or null vector.

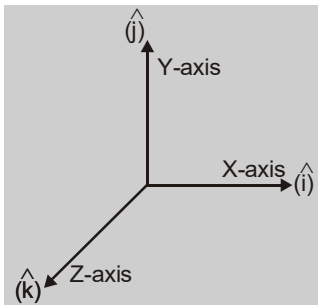
9. UNIT VECTOR :

A vector whose magnitude is 1, is called unit vector. A unit vector is represented by $\hat{A}$ (A cap or A hat or A caret).

$$\text{Unit Vector } \hat{A} = \frac{\text{Vector}}{\text{Magnitude of the vector}} = \frac{\vec{A}}{|\vec{A}|} \quad \therefore \quad \boxed{\vec{A} = A\hat{A}} \text{ or } \vec{A} = |\vec{A}|\hat{A}$$

Note : A unit vector is used to specify the direction of a vector.

Three Standard Unit Vectors :

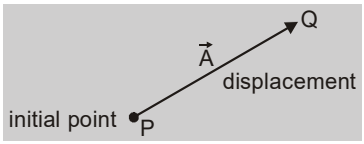


In x – y – z co-ordinate frame there are three unit vectors $\hat{i}$, $\hat{j}$ and $\hat{k}$ which are used to indicate X, Y and Z axes respectively. These three unit vectors are mutually perpendicular i.e. $\hat{i} \perp \hat{j} \perp \hat{k}$

10. POLAR VECTOR :

Vectors which have initial point or a point of application are called polar vectors.

Examples : Displacement, force etc.



11. AXIAL VECTOR :

These vectors are used in rotational motion to define rotational effects. Direction of these vectors is always along the axis of rotation in accordance with right hand screw rule or right hand thumb rule.

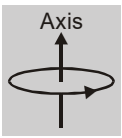


Fig. 2.10

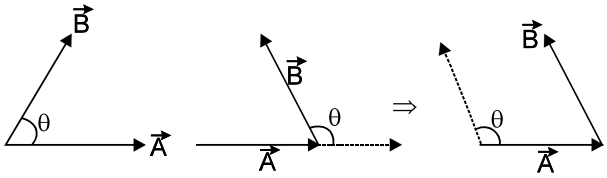
Examples : Small angular displacement $(\vec{d\theta})$, Angular velocity $(\vec{\omega})$, Angular momentum $(\vec{J})$, Angular acceleration $(\vec{\alpha})$ and Torque $(\vec{\tau})$

MULTIPLICATION OF A VECTOR BY A SCALAR

Multiplying a vector $\vec{A}$ with a positive number λ gives a vector $\vec{B}(=\lambda\vec{A})$ whose magnitude is changed by the factor λ but the direction is the same as that of $\vec{A}$. Multiplying a vector $\vec{A}$ by a negative number λ gives a vector $\vec{B}$ whose direction is opposite to the direction of $\vec{A}$ and whose magnitude is λ times $|\vec{A}|$.

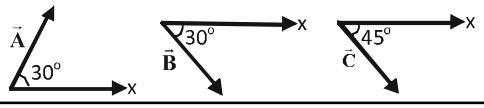
Angle between two vectors :

Angle between two vectors means smaller of the two angles between the vectors when they are placed tail to tail by displacing either of the vectors parallel to itself (i.e. $0 \le \theta \le \pi$).

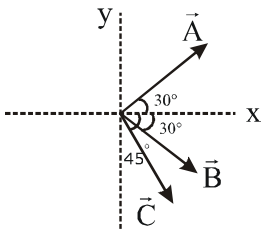


PRACTICE YOUR CONCEPTS

14. Three vectors $\vec{A}, \vec{B}, \vec{C}$ are shown in the figure. Find angle between (i) $\vec{A}$ and $\vec{B}$, (ii) $\vec{B}$ and $\vec{C}$, (iii) $\vec{A}$ and $\vec{C}$.



Sol. To find the angle between two vectors we connect the tails of the two vectors. We can shift $\vec{B}$ such that tails of $\vec{A}, \vec{B}$ and $\vec{C}$ are connected as shown in figure.



Now we can easily observe that angle between $\vec{A}$ and $\vec{B}$ is 60º, $\vec{B}$ and $\vec{C}$ is 15º and between $\vec{A}$ and $\vec{C}$ is 75º.

15. A unit vector along East is defined as $\hat{i}$. A force of 10^5 dynes acts West wards. Represent the force in terms of $\hat{i}$.

Sol. $\vec{F} = -10^5\ \hat{i}$ dynes

16. Find a vector that has the same direction as(–2, 4, 2) but has length 6.

Sol. Direction vector is = $\frac{-2\hat{i}+4\hat{j}+2\hat{k}}{2\sqrt{6}}$ then

vector is = $6 \times \frac{-2\hat{i}+4\hat{j}+2\hat{k}}{2\sqrt{6}}$

$= \sqrt{6}\ (-\hat{i}+2\hat{j}+\hat{k})$

17. A physical quantity (m = 3 kg) is multiplied by a vector $\vec{a}$ such that $\vec{F} = m\vec{a}$. Find the magnitude and direction of $\vec{F}$ if

(i) $\vec{a} = 3$ m/s^2 East wards

(ii) $\vec{a} = -4$ m/s^2 North wards

Sol. (i) $\vec{F} = m\vec{a} = 3 \times 3$ ms^{-2} East wards

= 9 N East wards

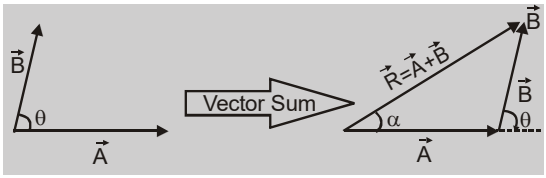
(ii) $\vec{F} = m\vec{a} = 3 \times (-4)$ N North wards

= –12N North wards = 12 N South wards

ADDITION OF TWO VECTORS

Sum of two vectors is also called ***resultant vector*** of these two vectors.

Triangle Law of Addition of Two Vectors :



If two vectors are represented by two sides of a triangle in same order then their sum or ***'resultant vector'*** is given by the third side of the triangle taken in opposite order of the first two vectors (closing side).

PROCESS :

(i) Shift one vector $(\vec{B})$, without changing its direction, such that its tail coincide with head of the other vector $(\vec{A})$.

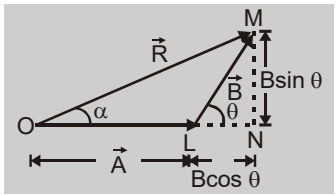
(ii) Now complete the triangle by drawing third side, directed from tail of $\vec{A}$ to head of $\vec{B}$ (it is in opposite order of $\vec{A}$ & $\vec{B}$ vectors).

(iii) Resultant $(\vec{R})$ = $\vec{A}+\vec{B}$. Length of $\vec{R}$ is the magnitude of vector sum i.e. $|\vec{A}+\vec{B}|$

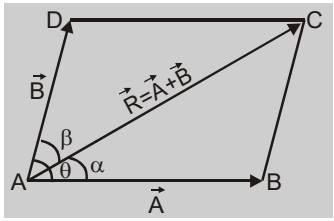
$\therefore \quad |\vec{R}| \neq |\vec{A}+\vec{B}| = \sqrt{A^2+B^2+2AB\cos\theta}$

Direction of resultant (sum) can be given by angle α.

$$\tan\alpha = \frac{B\sin\theta}{A+B\cos\theta}$$



Parallelogram Law of Addition of Two Vectors (Alternate Method) :



If two vectors are represented by two adjacent sides of a parallelogram which are directed away from their common point then their sum (i.e. resultant vector) is given by the diagonal of the parallelogram passing away through that common point.

Here $\overrightarrow{AB}+\overrightarrow{AD}=\overrightarrow{AC}=\overrightarrow{R}$ or $\vec{R}=\vec{A}+\vec{B}$

$R=\sqrt{A^2+B^2+2AB\cos\theta}$, $\tan\alpha=\frac{B\sin\theta}{A+B\cos\theta}$ & $\tan\beta=\frac{A\sin\theta}{B+A\cos\theta}$

IMPORTANT POINTS

1. Vector addition is commutative,
i.e. $\vec{A}+\vec{B}=\vec{B}+\vec{A}$

2. Vector addition is associative,
i.e $\vec{A}+(\vec{B}+\vec{C})=(\vec{A}+\vec{B})+\vec{C}$

3. Resultant of two vectors will be maximum when they are parallel i.e. angle between them is zero.

$R_{max}=\sqrt{A^2+B^2+2AB\cos0^\circ}$ or $R_{max}=\sqrt{(A+B)^2}$ ($\because$ cos0° = 1)

or R_{max} = A + B

4. Resultant of two vectors will be minimun when they are antiparallel i.e. angle between them is 180°.

$R_{min}=\sqrt{A^2+B^2+2AB\cos180^\circ}$

or $R_{min}=\sqrt{(A-B)^2}$ ($\because$ cos 180°= – 1)

or $R_{min}=A\sim B$ (Bigger — smaller)

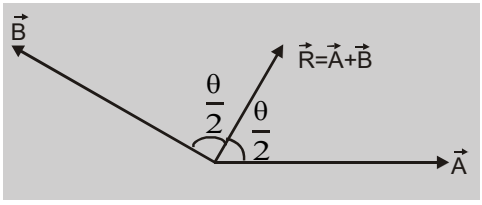
5. Resultant of two vectors of unequal magnitude can never be zero.

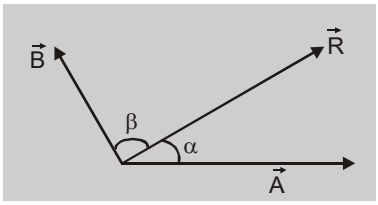
6. If vectors are of unequal magnitude then minimum three coplanar vectors are required for zero resultant.

7. Resultant of two vectors of equal magnitude will be along their bisector.

If $|\vec{A}|=|\vec{B}|$, then $\alpha=\beta=\frac{\theta}{2}$

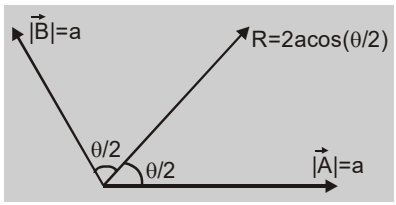
But if $|\vec{A}|>|\vec{B}|$, then angle $\alpha<\beta$





$\therefore$ $\vec{R}$ will incline more towards the vector of higher magnitude.

8. If two vectors have equal magnitude i.e. $|\vec{A}| = |\vec{B}|$ = a and angle between them is θ then resultant will be the bisector of $\vec{A}$ and $\vec{B}$ and its magnitude is equal to $2a\cos\left[\frac{\theta}{2}\right]$.



$|\vec{R}| = |\vec{A}+\vec{B}| = 2a\cos\left[\frac{\theta}{2}\right]$

Special Case : If θ = 120°

then R = $2a\cos\left[\frac{120^0}{2}\right]$ = a

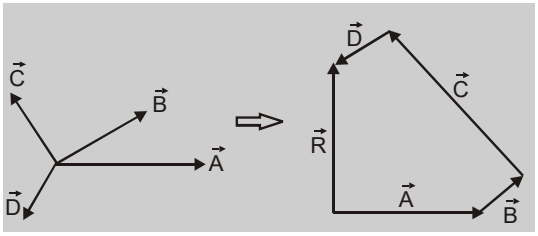
i.e. If $\theta = 120°$ then $|\vec{R}| = |\vec{A}+\vec{B}| = |\vec{A}| = |\vec{B}| = a$

9. If resultant of two unit vectors is another unit vector then the angle between them (θ) = 120°.

or

If the angle between two unit vectors (θ) = 120°, then their resultant is another unit vector.

ADDITION OF MORE THAN TWO VECTORS (LAW OF POLYGON):

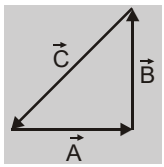


If some vectors are represented by sides of a polygon in same order, then their resultant vector is represented by the closing side of polygon taken in the opposite order.

Here $\vec{R} = \vec{A}+\vec{B}+\vec{C}+\vec{D}$

IMPORTANT POINTS

1. In a polygon if all the vectors are in same order then their resultant is a null vector.



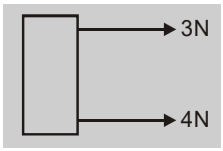
example in the given figure
$\vec{A}+\vec{B}+\vec{C}=\vec{0}$.

2. If n vectors of equal magnitude are arranged at equal angles of separation then their resultant is always zero.

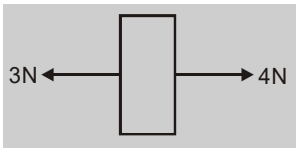
PRACTICE YOUR CONCEPTS

18. Two forces of magnitudes 3N and 4N respectively are acting on a body. Calculate the resultant force if the angle between them is-
(i) 0° (ii) 180° (iii) 90°

Sol. (i) If $\theta = 0°$ i.e.both the forces are parallel then R = A + B



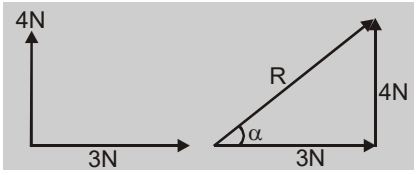
$\therefore$ Net force or resultant force (R)
= (3 + 4)N = 7N
Direction of resultant is along both the forces
(ii) If θ = 180° i.e. both the forces are antiparallel,



then R = A ~ B
$\therefore$ Net force or resultant force = (4 – 3)N = 1N
Direction of net force is along the bigger force means along 4N.

(iii) If θ = 90° i.e. both the forces are perpendicular

then $R=\sqrt{A^2+B^2+2AB\cos 90^\circ}$



$\therefore \quad = \sqrt{A^2 + B^2} = \sqrt{3^2 + 4^2} = 5N$

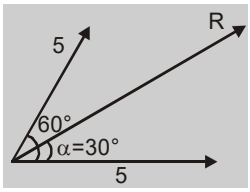
$\tan\alpha = \frac{4}{3}$ or $\alpha = \tan^{-1}\left(\frac{4}{3}\right) = 53^\circ$

i.e. magnitude of resultant is 5N which is acting at an angle of 53° from 3N force.

19. Two vectors having equal magnitude of 5 units, have an angle of 60° between them. Find the magnitude of their resultant vector and its angle from one of the vectors.

Sol. $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

If $|\vec{A}| = |\vec{B}|$ = a then R = $2a\cos\frac{\theta}{2}$



Here a = 5 unit and θ = 60°

$\therefore \quad R = 2\times5\times\cos\left(\frac{60^\circ}{2}\right) = 2\times5\times\frac{\sqrt{3}}{2} = 5\sqrt{3}$ unit

Since both the vectors have equal magnitude, resultant $(\vec{R})$ will be along their angle bisector.

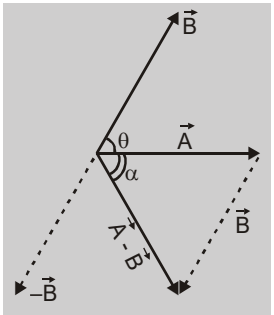
$\therefore$ Angle of $\vec{R}$ from each given vector = 30°

SUBTRACTION OF TWO VECTORS

Let $\vec{A}$ and $\vec{B}$ be two vectors. Their ***difference*** i.e. $\vec{A} - \vec{B}$ can be treated as sum of the vector $\vec{A}$ and vector $(-\vec{B})$ means

$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$

To subtract $\vec{B}$ from $\vec{A}$, invert the direction of $\vec{B}$ and add it to



vector $\vec{A}$ according to law of triangle.

Here $|\vec{A} - \vec{B}| = \sqrt{A^2 + B^2 - 2AB\cos\theta}$

where θ is the angle between $\vec{A}$ & $\vec{B}$.

Let angle of vector ($\vec{A} - \vec{B}$) from vector $\vec{A}$ be α

then $\tan\alpha = \frac{B\sin\theta}{A - B\cos\theta}$

IMPORTANT POINTS

1. The vector subtraction doesn't follow commutative law i.e. $\vec{A} - \vec{B} \neq \vec{B} - \vec{A}$

2. The vector subtraction doesn't follow associative law i.e. $\vec{A} - (\vec{B} - \vec{C}) \neq (\vec{A} - \vec{B}) - \vec{C}$

3. If two vectors have equal magnitude, i.e. $|\vec{A}| = |\vec{B}| = a$ and θ is the angle between them, then

$$|\vec{A} - \vec{B}| = \sqrt{a^2 + a^2 - 2a^2\cos\theta} = 2a\sin\left[\frac{\theta}{2}\right]$$

Special case : If $\theta = 60^\circ$ then $2a\sin\left(\frac{\theta}{2}\right) = a$ i.e. $|\vec{A} - \vec{B}| = |\vec{A}| = |\vec{B}| = a$ at $\theta = 60^\circ$

4. If difference of two unit vectors is another unit vector, then the angle between them is 60° or if two unit vectors are at angle of 60°, then their difference is also a unit vector.

5. In physics whenever we want to calculate change in a vector quantity, we have to use vector subtraction. For example, change in velocity $(\Delta\vec{V}) = \vec{V}_2 - \vec{V}_1$ or $\vec{V}_{final} - \vec{V}_{initial}$

6. If two vectors are such that their sum and their difference vectors have equal magnitude then angle between the given vectors (θ) = 90°.

$|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$

or $A^2 + B^2 + 2AB\cos\theta$

$= A^2 + B^2 - 2AB\cos\theta$

or $\cos\theta = 0$ or $\theta = 90^\circ$

7. If $\vec{A} + \vec{B} = \vec{A} - \vec{B}$ then $\vec{B} = \vec{0}$ (a null vector)

RESOLUTION OF VECTORS INTO RECTANGULAR, COMPONENTS AND VECTOR PRODUCT)

When a vector is split into components which are at right angles to each other, the components are called **rectangular or orthogonal components** of that vector.

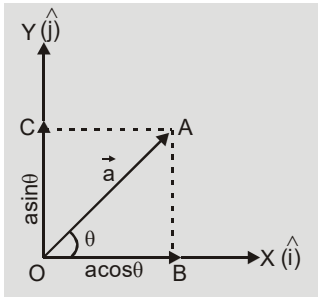
In ΔOAB, $\frac{OB}{OA} = \cos\theta$ or $OB = OA\cos\theta$

or $\boxed{a_x = a\cos\theta}$ and $\frac{AB}{OA} = \sin\theta$ or $AB = OA\sin\theta = OC$

or $\boxed{a_y = a\sin\theta}$

Now according to rule of vector addition

$\vec{OA} = \vec{OB} + \vec{OC}$ or $\boxed{\vec{a} = a_x\hat{i} + a_y\hat{j}}$



From Pythagorous theorem

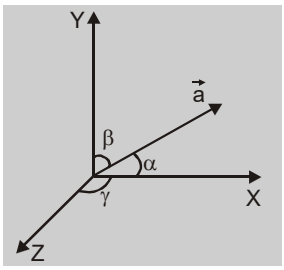
$$\boxed{a = \sqrt{a_x^{\,2} + a_y^{\,2}}}$$

Angle of $\vec{a}$ from x - axis is given by

$$\boxed{\tan\theta = \frac{a_y}{a_x}}$$

RECTANGULAR COMPONENTS OF A VECTOR IN THREE DIMENSIONS

In terms of x, y and z-components $\vec{a}$ is given as $\boxed{\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}}$ ...(1)



Magnitude of $\vec{a}$ is given as

$\boxed{a = \sqrt{a_{x^2} + a_{y^2} + a_{z^2}}}$ .....(2)

As shown in the figure, if $\vec{a}$ make angles α, β and γ

from x, y and z-axes respetively, then

$a_x = a\cos\alpha \Rightarrow \cos\alpha = \frac{a_x}{a}$

$a_y = a\cos\beta \Rightarrow \cos\beta = \frac{a_y}{a}$

and $a_z = a\cos\gamma \Rightarrow \cos\gamma = \frac{a_z}{a}$

here $\cos\alpha$, $\cos\beta$ and $\cos\gamma$ are called **directional cosines** of the vector.
Putting the value of a_x, a_y and a_z in eq. (2) we get

$a^2 = a^2\cos^2\alpha + a^2\cos^2\beta + a^2\cos^2\gamma$

or $\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$
or $(1 - \sin^2\alpha) + (1 - \sin^2\beta) + (1 - \sin^2\gamma) = 1$
or $3 - (\sin^2\alpha + \sin^2\beta + \sin^2\gamma) = 1$
or $\sin^2\alpha + \sin^2\beta + \sin^2\gamma = 2$

Note : "It means that the sum of the squares of the direction cosines of a vector is always one and the sum of the squares of the direction sines of a vector is always two."

PRACTICE YOUR CONCEPTS

20. If $\vec{P} = 3\hat{i} + 4\hat{j} + 12\hat{k}$ then find

(i) $|\vec{P}|$ and (ii) the direction cosines of the $\vec{P}$.

Sol. (i) $|\vec{P}| = P = \sqrt{P_x^2 + P_y^2 + P_z^2} = \sqrt{3^2 + 4^2 + 12^2}$

$= \sqrt{169} = 13$

(ii) $\cos\alpha = \frac{P_x}{P} = \frac{3}{13}, \cos\beta = \frac{P_y}{P} = \frac{4}{13}, \cos\gamma = \frac{P_z}{P} = \frac{12}{13}$

21. Find the angle made by $(\hat{i} + \hat{j})$ vector with X and Y axes respectively.

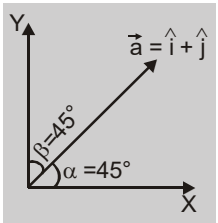
Sol. $\cos\alpha = \frac{a_x}{a}$ and $\cos\beta = \frac{a_y}{a}$

here $a = \sqrt{a_x^2 + a_y^2} = \sqrt{1^2 + 1^2} = \sqrt{2}$

$\cos\alpha = \frac{1}{\sqrt{2}}$

or $\alpha = 45°$

$\cos\beta = \frac{1}{\sqrt{2}}$



or $\beta = 45°$ i.e. $\hat{i} + \hat{j}$ is the bisector of X and Y axes.

22. Find the angle made by $\vec{A} = \hat{i} + \hat{j} + \hat{k}$ vector with X, Y and Z axes respectively.

Sol. $\cos\alpha = \frac{A_x}{A}$, $\cos\beta = \frac{A_y}{A}$, $\cos\gamma = \frac{A_z}{A}$

here $A_x = A_y = A_z = 1$

and $A = \sqrt{A_x^2 + A_y^2 + A_z^2} = \sqrt{1+1+1} = \sqrt{3}$

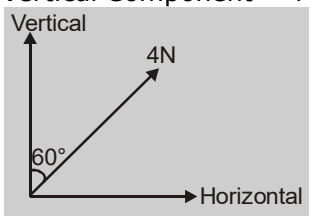
$\therefore \cos\alpha = \frac{1}{\sqrt{3}}$ or $\alpha = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$

$\cos\beta = \frac{1}{\sqrt{3}}$ or $\beta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$

$\cos\gamma = \frac{1}{\sqrt{3}}$ or $\gamma = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$

23. A force of 4N is inclined at an angle of 60° with the vertical. Find its components along horizontal and vertical directions.

Sol. Vertical Component = 4 cos 60° = 2N



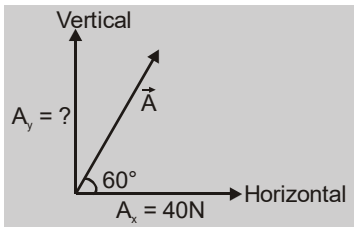
Horizontal component = 4 sin 60° = $2\sqrt{3}$N

24. A force is inclined at an angle of 60° with the horizontal. If the horizontal component of the force is 40N, calculate the vertical component.

Sol. A_x = 40N, A_y = ?, θ = 60°

As $A_x = A\cos\theta$

$\therefore$ 40 = A cos 60° or 40 = $\frac{A}{2}$ or A = 80N

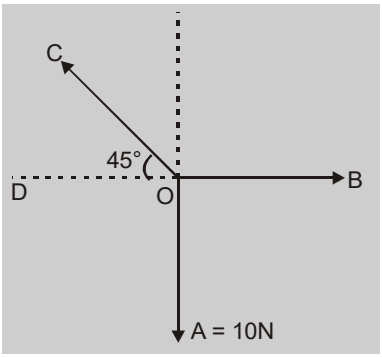


Now $A_y = A\sin 60° = \frac{A\sqrt{3}}{2} = \frac{80\sqrt{3}}{2} = 40\sqrt{3}$N

or $\tan 60° = \frac{A_Y}{A_X} \Rightarrow A_Y = 40\tan 60° = 40\sqrt{3}$ N

25. The sum of three vectors shown in figure, is zero.

(i) What is the magnitude of vector $\vec{OB}$?



(ii) What is the magnitude of vector $\vec{OC}$?

Sol. Resolve $\vec{OC}$ into two rectangular components.

OD = OC cos 45° and OE = OC sin 45°

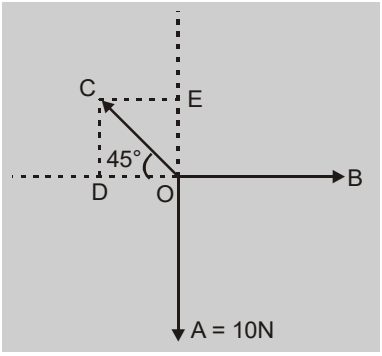
For zero resultant OE = OA

or OC sin 45° = 10N

$$OC \times \frac{1}{\sqrt{2}} = 10N$$

or $OC = 10\sqrt{2}N$

and OD = OB or OC cos 45° = OB



or $10\sqrt{2} \times \frac{1}{\sqrt{2}} = OB \text{ or } OB = 10N$

$\therefore OC = 10\sqrt{2}N \text{ and } OB = 10N$

MULTIPLICATION OF VECTORS

Vectors of different types can be multiplied to generate new physical quantities which may be a scalar or a vector. If, in multiplication of two vectors, the generated physical quantity is a scalar, then their product is called **scalar or dot product** and if it is a vector, then their product is called **vector or cross product**.

TYPES OF VECTOR PRODUCT

1. SCALAR PRODUCT OF TWO VECTORS

Definition :

The scalar product (or dot product) of two vectors is defined as the product of their magnitudes with cosine of the angle between them.

Thus if there are two vectors $\vec{A}$ and $\vec{B}$ having angle θ between them, then their scalar product is written as $\vec{A} \bullet \vec{B} = |A|\ |B| \cos\theta$

(i) It is always a scalar, which is positive if angle between the vectors is acute (i.e.$\theta < 90°$) and negative if angle between them is obtuse (i.e. $90° < \theta < 180°$).

(ii) It is commutative

i.e. $\vec{A} \bullet \vec{B} = \vec{B} \bullet \vec{A}$

(iii) It is distributive

i.e. $\vec{A} \bullet (\vec{B} + \vec{C}) = \vec{A} \bullet \vec{B} + \vec{A} \bullet \vec{C}$

(iv) According to definition

$\vec{A} \bullet \vec{B}$ = AB cos θ

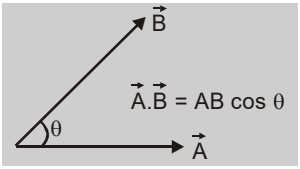


Fig. 2.22

The angle between the vectors $\theta = \cos^{-1}\left[\dfrac{\vec{A} \bullet \vec{B}}{|A|\ |B|}\right]$

(v) Scalar product of two vectors will be maximum when cos θ = max =1, i.e. θ =0°, i.e, vectors are parallel.

$\left(\vec{A} \bullet \vec{B}\right)_{max} = AB$

(vi) Scalar product of two vectors will be zero when cos θ = 0, i.e. θ =90°

therefore $\left(\vec{A} \bullet \vec{B}\right) = 0$

i.e., if the scalar product of two nonzero vectors is zero then vectors are orthogonal or perpendicular to each other.

(vii) In case of orthogonal unit vectors $\hat{i}, \hat{j}$ and $\hat{k}$ $\quad \hat{i} \bullet \hat{j} = \hat{j} \bullet \hat{k} = \hat{k} \bullet \hat{i} = 1 \times 1 \times \cos 90^0 = 0$

(viii) The scalar product of a vector by itself is termed as self dot product and is given by

$\vec{A} \bullet \vec{A} = AA\cos 0 = A^2$ or $\left|\vec{A}\right| = \sqrt{\vec{A} \bullet \vec{A}}$

(ix) In case of unit vector $\hat{n}$

$\hat{n} \bullet \hat{n} = 1 \times 1 \times \cos 0 = 1$

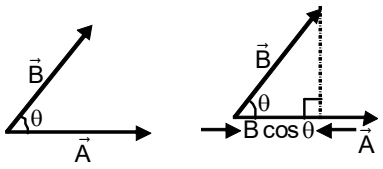
So $\hat{n} \bullet \hat{n} = \hat{i} \bullet \hat{i} = \hat{j} \bullet \hat{j} = \hat{k} \bullet \hat{k} = 1$

(x) In terms of components

$\vec{A} \bullet \vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k}) \bullet (B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$ or $\vec{A} \bullet \vec{B} = (A_xB_x + A_yB_y + A_zB_z)$

2. PROJECTION OF VECTORS

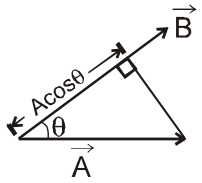
$\vec{A}\cdot\vec{B}$ = A (B cos θ) = B (A cos θ) Geometrically, B cos θ is the projection of $\vec{B}$ onto $\vec{A}$ and A cos θ is the projection of $\vec{A}$ onto $\vec{B}$ as shown. So $\vec{A}\cdot\vec{B}$ is the product of the magnitude of $\vec{A}$ and the component of $\vec{B}$ along $\vec{A}$ and vice versa.



* **Component of $\vec{B}$ along $\vec{A}$**

= B cosθ = $\frac{\vec{A}\cdot\vec{B}}{A}$ = $\vec{B}.\hat{A}$

* **Component of $\vec{A}$ along $\vec{B}$**



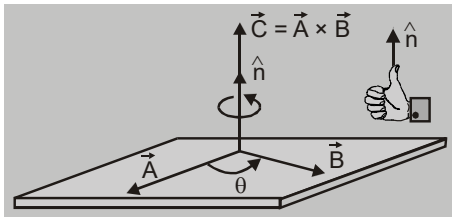
= A cosθ = $\frac{\vec{A}\cdot\vec{B}}{B}$

= $\vec{A}\cdot\hat{B}$

3. VECTOR PRODUCT OF TWO VECTORS

Definition :

The vector product or cross product of two vectors is defined as a



vector having magnitude equal to the product of their magnitudes with the sine of angle between them, and its direction is perpendicular to the plane containing both the vectors according to right hand screw rule or right hand thumb rule.

Thus, if $\vec{A}$ and $\vec{B}$ are two vectors, then their vector product i.e. $\vec{A}\times\vec{B}$ is a vector $\vec{C}$ defined by

$\vec{C} = \vec{A}\times\vec{B} = AB\sin\theta\,\hat{n}$

Right Hand Screw Rule :

The direction of $\vec{A}\times\vec{B}$, i.e., $\vec{C}$ is perpendicular to the plane containing vectors $\vec{A}$ and $\vec{B}$ and towards the advancement of a right handed screw rotated from $\vec{A}$ (first vector) to $\vec{B}$ (second vector) through the smaller angle between them. Thus, if a right handed screw whose axis is perpendicular to the plane formed by $\vec{A}$ and $\vec{B}$ is rotated from $\vec{A}$ to $\vec{B}$ through the smaller angle between them, then the direction of advancement of the screw gives the direction $\vec{A}\times\vec{B}$, [See Figure A]

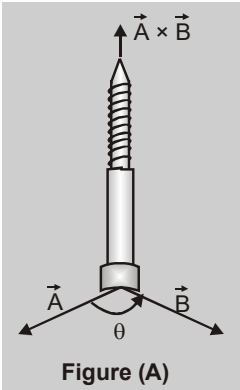


Figure (A)

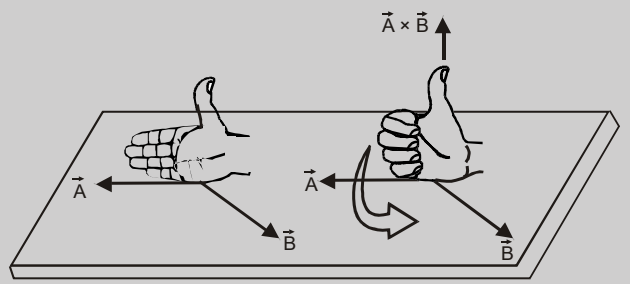


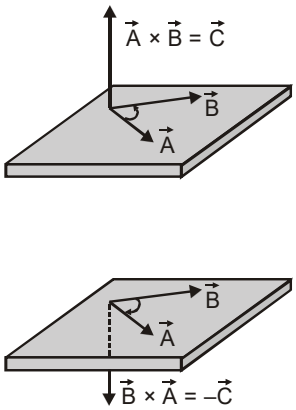
Figure (B)

Right Hand Thumb Rule : Place the vector $\vec{A}$ and $\vec{B}$ tail to tail. Now place stretched fingers and thumb of right hand, perpendicular to the plane of $\vec{A}$ and $\vec{B}$ such that the fingers are along the vector $\vec{A}$. If the fingers are now closed through smaller angle so as to go towards $\vec{B}$, then the thumb gives the direction of $\vec{A}\times\vec{B}$ i.e. $\vec{C}$ [See Figure B]

1. Vector product of two vectors is always a vector perpendicular to the plane containing the two vectors, i.e., orthogonal (perpendicular) to both the vectors $\vec{A}$ and $\vec{B}$.

2. Vector product of two vectors is not commutative i.e.

$\vec{A}\times\vec{B}\neq\vec{B}\times\vec{A}$ But $\left|\vec{A}\times\vec{B}\right|=\left|\vec{B}\times\vec{A}\right|=AB\sin\theta$



Note : $\vec{A}\times\vec{B}=-\vec{B}\times\vec{A}$

i.e., in case of vectors $(\vec{A}\times\vec{B})$ and $(\vec{B}\times\vec{A})$,

magnitudes are equal but directions are opposite

3. The vector product is distributive when the order of the vectors is strictly maintained, i.e.

$\vec{A}\times\left(\vec{B}+\vec{C}\right)=\vec{A}\times\vec{B}+\vec{A}\times\vec{C}$

4. According to definition of vector product of two vectors $\vec{A}\times\vec{B}=AB\sin\theta\hat{n}$

So, $|\vec{A}\times\vec{B}|=AB\sin\theta$

i.e. $\theta=\sin^{-1}\left[\frac{|\vec{A}\times\vec{B}|}{|\vec{A}|\,|\vec{B}|}\right]$

5. The vector product of two vectors will be maximum when sin θ = max. = 1, i.e., θ =90°

$|\vec{A}\times\vec{B}|_{max}$ = AB sin 90° = AB

i.e. vector product is maximum if the vectors are orthogonal (perpendicular).

6. The vector product of two non-zero vectors will be zero vector when sin θ = 0,

i.e. if, θ = 0° or 180° then $\vec{A}\times\vec{B}=\vec{0}$

Therefore if the vector product of two non-zero vectors is zero vector, then the vectors are collinear.

7. The self cross product, i.e. cross product of a vector by itself is a zero vector or a null vector.

i.e. $\vec{A}\times\vec{A} = AA\sin 0\hat{n} = \vec{0}$

8. In case of unit vector $\hat{n}$

$\hat{n}\times\hat{n} = 1\times 1\times\sin 0^0\ \hat{n} = \vec{0}$

so that $\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = \vec{0}$

9. In case of orthogonal unit vectors $\hat{i}, \hat{j}$ and $\hat{k}$; according to right hand thumb rule

$\hat{i}\times\hat{j} = \hat{k}$, $\hat{j}\times\hat{k} = \hat{i}$, $\hat{k}\times\hat{i} = \hat{j}$

and $\hat{j}\times\hat{i} = -\hat{k}$, $\hat{k}\times\hat{j} = -\hat{i}$, $\hat{i}\times\hat{k} = -\hat{j}$

10. In terms of components

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = \hat{i}(A_yB_z - A_zB_y) - \hat{j}(A_xB_z - A_zB_x) + \hat{k}(A_xB_y - A_yB_x)$$

11. A unit vector ($\hat{n}$) perpendicular to $\vec{A}$ as well as $\vec{B}$ is given by $\hat{n} = \dfrac{\vec{A}\times\vec{B}}{|\vec{A}\times\vec{B}|}$.

12. If $\vec{A}$, $\vec{B}$ and $\vec{C}$ are coplanar, then $\vec{A}.(\vec{B}\times\vec{C}) = 0$.

13. Angle between $(\vec{A}+\vec{B})$ and $(\vec{A}\times\vec{B})$ is 90°.

Examples of Vector Product :

(i) Torque $(\vec{\tau}) = \vec{r}\times\vec{F}$

(ii) Angular momentum $(\vec{J}) = \vec{r}\times\vec{p}$

(iii) Velocity $(\vec{v}) = \vec{\omega}\times\vec{r}$

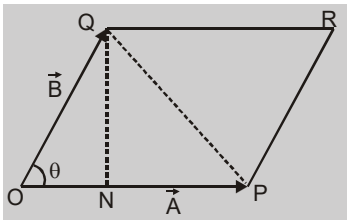
(iv) Accelaration $(\vec{a}) = \vec{\alpha} \times \vec{r}$

Here $\vec{r}$ is position vector or radius vector and $\vec{F}, \vec{p}$, $\vec{\omega}$ and $\vec{\alpha}$ are force, linear momentum, angular velocity and angular accelaration respectively.

GEOMETRICAL MEANING OF VECTOR PRODUCT OF TWO VECTORS

Area of ΔPOQ = $\frac{\text{base} \times \text{height}}{2}$

$= \frac{(OP)(NQ)}{2} = \frac{A \times B \sin\theta}{2} = \frac{1}{2}|\vec{A} \times \vec{B}|$



$\therefore$ Area of parallelogram OPRQ = 2

[area of Δ OPQ] = $|\vec{A} \times \vec{B}|$

Formulae to Find Area :

(1) If $\vec{A}$ & $\vec{B}$ are two sides of a triangle, then its area

$= \frac{1}{2}|\vec{A} \times \vec{B}|$

(2) If $\vec{A}$ & $\vec{B}$ are two adjacent sides of a parallelogram then its area = $|\vec{A} \times \vec{B}|$

(3) If $\vec{A}$ and $\vec{B}$ are diagonals of a parallelogram then its area = $\frac{1}{2}|\vec{A} \times \vec{B}|$

PRACTICE YOUR CONCEPTS

26. Can scalar product ever be negative ?

Sol. Yes. Scalar product will be negative if $\theta > 90°$.

$\because$ $\vec{P} \bullet \vec{Q} = PQ\cos\theta$

$\therefore$ When $\theta > 90°$ then $\cos\theta$ is negative

and $\vec{P}.\vec{Q}$ will be negative.

27. If $|\vec{A}+\vec{B}|=|\vec{A}-\vec{B}|$, then find the angle between $\vec{A}$ and $\vec{B}$.

Sol. $\because \quad |\vec{A}+\vec{B}|=|\vec{A}-\vec{B}|$

$\therefore \quad \sqrt{A^2+B^2+2AB\cos\theta}=\sqrt{A^2+B^2-2AB\cos\theta}$

or $A^2 + B^2 + 2AB \cos \theta = A^2 + B^2 - 2AB \cos \theta$

or $2AB \cos \theta = - 2AB \cos \theta$

or $4AB \cos \theta = 0$ or $\cos \theta = 0$

$\therefore \quad \theta = 90°$

28. If $\vec{A}=4\hat{i}+n\hat{j}-2\hat{k}$ and $\vec{B}=2\hat{i}+3\hat{j}+\hat{k}$, then find the value of n so that $\vec{A}\perp\vec{B}$.

Sol. Dot product of two mutually perpendicular vectors is zero

i.e. $\vec{A}.\vec{B}=0$

or $(4\hat{i}+n\hat{j}-2\hat{k}).(2\hat{i}+3\hat{j}+\hat{k})=0$

or $(4\times2)+(n\times3)+(-2\times1)=0$

or $3n = - 6$

or $n = - 2$

29. If $\vec{F}=(4\vec{i}-10\vec{j})$ and $\vec{r}=\left(5\vec{i}-3\vec{j}\right)$, then calculate torque.

Sol. Here $\vec{r}=5\vec{i}-3\vec{j}+0\vec{K}$

and $\vec{F}=4\hat{i}-10\hat{j}+0\hat{k}$

$\therefore \quad \vec{\tau}=\vec{r}\times\vec{F}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 5 & -3 & 0\\ 4 & -10 & 0\end{vmatrix}=\hat{i}(0-0)-\hat{j}(0-0)+\hat{k}(-50+12)=-38\hat{k}$

30. Find a unit vector perpendicular to both the vectors $(2\hat{i}+3\hat{j}+\hat{k})$ and $(\hat{i}-\hat{j}+2\hat{k})$.

Sol. Let $\vec{A}=2\hat{i}+3\hat{j}+\hat{k}$ and $\vec{B}=\hat{i}-\hat{j}+2\hat{k}$

A unit vector perpendicular to both $\vec{A}$ and $\vec{B}$ is given as $\hat{n} = \frac{\vec{A} \times \vec{B}}{|\vec{A} \times \vec{B}|}$

But $\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 1 \\ 1 & -1 & 2 \end{vmatrix}$

$= \hat{i}(6+1) - \hat{j}(4-1) + \hat{k}(-2-3)$

$= 7\hat{i} - 3\hat{j} - 5\hat{k}$

$\therefore \quad |\vec{A} \times \vec{B}| = \sqrt{7^2 + (-3)^2 + (-5)^2} = \sqrt{83}$ unit

$\therefore \quad \hat{n} = \frac{7\hat{i} - 3\hat{j} - 5\hat{k}}{\sqrt{83}}$

This is a unit vector perpendicular to both the given vectors.

31. The diagonals of a parallelogram are vectors $\vec{A}$ and $\vec{B}$. If $\vec{A} = 5\vec{i} - 4\vec{j} + 3\vec{k}$ and $\vec{B} = 3\vec{i} - 2\vec{j} - \vec{k}$. Calculate the magnitude of area of this parallelogram.

Sol. When $\vec{A}$ and $\vec{B}$ are the diagonals of a parallelegram, then its

Area $= \frac{1}{2}|\vec{A} \times \vec{B}| = \frac{1}{2}\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 5 & -4 & 3 \\ 3 & -2 & -1 \end{vmatrix}$

$= \frac{1}{2}|\hat{i}(4+6) - \hat{j}(-5-9) + \hat{k}(-10+12)|$

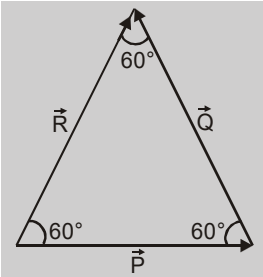
$= \frac{1}{2}|10\hat{i} + 14\hat{j} + 2\hat{k}| = \frac{1}{2}\sqrt{10^2 + 14^2 + 2^2}$

$= \frac{1}{2}\sqrt{300} = \frac{10}{2}\sqrt{3} = 5\sqrt{3}$ unit

32. Given that P = Q = R. If $\vec{P} + \vec{Q} = \vec{R}$ then the angle between $\vec{P}$ & $\vec{R}$ is θ_1. If $\vec{P} + \vec{Q} + \vec{R} = \vec{0}$ then the angle between $\vec{P}$ & $\vec{R}$ is θ_2. What is the relation between θ_1 and θ_2 :

(A) $\theta_1 = \theta_2$ (B) $\theta_1 = \frac{\theta_2}{2}$ (C) $\theta_1 = 2\theta_2$ (D) None of the above

Sol. Since P = Q = R



Therefore triangle formed by vectors $\vec{P},\vec{Q}$ and $\vec{R}$ will be equilateral triangle.

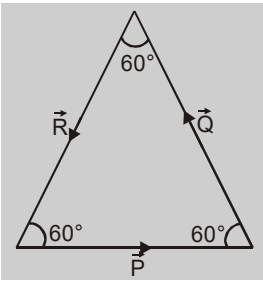
Now if $\vec{P}+\vec{Q}=\vec{R}$, then $\vec{P}$ & $\vec{Q}$ will be in same order and $\vec{R}$ will be in their reverse order.

From the diagram, angle between $\vec{P}$ & $\vec{R}=\theta=60°$

But if $\vec{P}+\vec{Q}+\vec{R}=\vec{0}$ then $\vec{P},\vec{Q}$ & $\vec{R}$ will be in same order

From the diagram, angle between

$\vec{P}$ & $\vec{R}=\theta_2=180°-60°=120°$



$$\frac{\theta_1}{\theta_2}=\frac{60°}{120°}=\frac{1}{2}$$

$$\Rightarrow \quad \boxed{\theta_1=\frac{\theta_2}{2}}$$

EXERCISE - I

MULTIPLE CHOICE QUESTIONS

1. Which of the following is not the name of a physical quantity ?
(A) kilogram (B) impulse
(C) energy (D) density

2. Light year is the unit of
(A) speed (B) mass
(C) distance (D) time

3. PARSEC is a unit of
(A) Time (B) Angle
(C) Distance (D) Velocity

4. Which of the following is not the unit of time
(A) solar day
(B) parallactic second
(C) leap year
(D) lunar month

5. Which of the following system of units is NOT based on the unit of mass, length and time alone
(A) FPS (B) SI
(C) CGS (D) MKS

6. The SI unit of the universal gravitational constant G is
(A) $Nm\ kg^{-2}$ (B) Nm^2kg^{-2}
(C) $Nm^2\ kg^{-1}$ (D) $Nmkg^{-1}$

7. Which of the following is not the unit of energy?
(A) watt-hour (B) electron-volt
(C) N × m (D) kg × m/sec^2

8. A physical quantity is measured and the result is expressed as nu where u is the unit used and n is the numerical value. If the result is expressed in various units then
(A) $n \propto$ size of u (B) $n \propto u^2$
(C) $n \propto \sqrt{u}$ (D) $n \propto 1/u$

9. If the unit of length is micrometer and the unit of time is microsecond, the unit of velcoity will be :
(A) 100 m/s (B) 10 m/s
(C) micrometers (D) m/s

10. One watt-hour is equivalent to
(A) 6.3×10^3 Joule
(B) 6.3×10^{-7} Joule
(C) 3.6×10^3 Joule
(D) 3.6×10^{-3} Joule

11. The angular frequency is measured in rad s^{-1}. Its dimension in length are :
(A) – 2 (B) –1
(C) 0 (D) 2

12. The pressure of 10^6 dyne/cm^2 is equivalent to
(A) 10^5 N/m^2 (B) 10^6 N/m^2
(C) 10^7 N/m^2 (D) 10^8 N/m^2

13. A dimensionless quantity :
(A) never has a unit (B) always has a unit
(C) may have a unit (D) does not exit

14. A unitless quantity :
(A) never has a nonzero dimension
(B) always has a nonzero dimension
(C) may have a nonzero dimension
(D) does not exit

Find significant figures in the following questions (15 to 17)

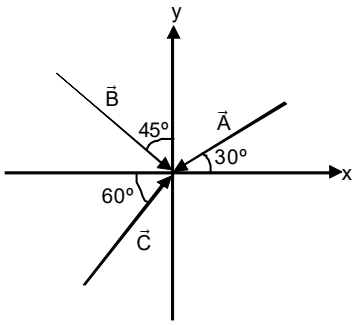
15. 0.007 gm
(A) 1 (B) 2 (C) 3 (D) 4

16. 2.64×10^{24} kg
(A) 1 (B) 2 (C) 3 (D) 4

17. 0.2370 gm/cm^3
(A) 1 (B) 2 (C) 3 (D) 4

Comprehension 18 to 20

Vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ are shown in figure. Find angle between



18. $\vec{A}$ and $\vec{B}$
(A) 105° (B) 110°
(C) 115° (D) 120°

19. $\vec{A}$ and $\vec{C}$
(A) 120° (B) 150°
(C) 175° (D) 190°

20. $\vec{B}$ and $\vec{C}$
(A) 90° (B) 120°
(C) 105° (D) 150°

21. Which of the following does not have the dimensions of force ?
(A) Potential gradient
(B) Energy gradient
(C) Weight
(D) Rate of change of momentum

22. For the resultant of two vectors to be maximum, what must be the angle between them :
(A) 0^0 (B) 60^0
(C) 90^0 (D) 180^0

23. Which one of the following statement is false:
(A) Mass, speed and energy are scalars
(B) Momentum, force and torque are vectors
(C) Distance is a scalar while displacement is a vector
(D) A vector has only magnitude where as a scalar has both magnitude and direction

24. Which of the following physical quantities is an axial vector ?
(A) displacement (B) force
(C) velocity (D) torque

25. A physical quantity which has a direction :
(A) must be a vector
(B) may be a vector
(C) must be a scalar
(D) none of the above

26. The minimum number of vectors of equal mangitude required to produce a zero resultant is :
(A) 2 (B) 3
(C) 4 (D) more than 4

27. How many minimum number of coplanar vectors having different magnitudes can be added to give zero resultant:-
(A) 2 (B) 3
(C) 4 (D) 5

28. How many minimum number of vectors in different planes can be added to give zero resultant:-
(A) 2 (B) 3
(C) 4 (D) 5

29. What is the maximum number of components into which a vector can be split ?
(A) 2 (B) 3
(C) 4 (D) Infinite

30. What is the maximum number of rectangular components into which a vector can be split in space ?
(A) 2 (B) 3
(C) 4 (D) Infinite

31. The vector sum of the forces of 10 newton and 6 newton can be :
(A) 2N (B) 8N
(C) 18N (D) 20N

32. Vector sum of two forces of 10N and 6N cannot be :
(A) 4N (B) 8N
(C) 12N (D) 2N

EXERCISE - II

1. In a certain system of units, 1 unit of time is 5 sec, 1 unit of mass is 20 kg and unit of length is 10m. In this system, one unit of power will correspond to
(A) 16 watts (B) 1/16 watts
(C) 25 watts (D) none of these

2. $\rho = 2\ g/cm^3$ convert it into MKS system -
(A) $2 \times 10^{-3}\ \frac{kg}{m^3}$ (B) $2 \times 10^{3}\ \frac{kg}{m^3}$
(C) $4 \times 10^{3}\ \frac{kg}{m^3}$ (D) $2 \times 10^{6}\ \frac{kg}{m^3}$

3. If the unit of force is 1 kilonewton, the length is 1 km and time is 100 second, what will be the unit of mass :
(A) 1000 kg (B) 10 kg
(C) 10000 kg (D) 100 kg

4. The value of $G = 6.67 \times 10^{-11}\ N\ m^2\ (kg)^{-2}$. Its numerical value in CGS system will be :
(A) 6.67×10^{-8} (B) 6.67×10^{-6}
(C) 6.67 (D) 6.67×10^{-5}

5. The density of mercury is 13600 kg m^{-3}. Its value of CGS system will be :
(A) 13.6 g cm^{-3} (B) 1360 g cm^{-3}
(C) 136 g cm^{-3} (D) 1.36 g cm^{-3}

6. If the acceleration due to gravity is 10 ms^{-2} and the units of length and time are changed to kilometre and hour, respectively, the numerical value of the acceleration is :
(A) 360000 (B) 72000
(C) 36000 (D) 129600

7. An experiment measures quantities a, b and c, and X is calculated from $X = ab^2/c^3$. If the percentage error in a, b and c are $\pm 1\%$, $\pm 3\%$ and $\pm 2\%$ respectively, the percentage error in X will be –
(A) $\pm 13\%$ (B) $\pm 7\%$
(C) $\pm 4\%$ (D) $\pm 1\%$

8. Zero error of an instrument introduces
(A) Systematic errors
(B) Random errors
(C) Both
(D) None

9. Which of the following is incorrect
(A) All derived quantities may be represented dimensionally in terms of the base quantities
(B) A base quantity cannot be represented dimensionally in terms of other base quantities
(C) The dimension of a derived quantity is never zero in any base quantity
(D) The dimension of a base quantity in other base quantities is always zero.

10. Dimensions of pressure is same as that of
(A) force per unit volume
(B) energy per unit volume
(C) force
(D) energy

11. What is the physical quantity whose dimensions are $M\ L^2\ T^{-2}$?
(A) kinetic energy (B) pressure
(C) momentum (D) power

12. Which one of the following has the dimensions of $ML^{-1}T^{-2}$?
(A) torque (B) surface tension
(C) viscosity (D) stress

13. Density of wood is 0.5 gm/cc in the CGS system of units. The corresponding value in MKS units is
(A) 500 (B) 5
(C) 0.5 (D) 5000

14. Following sets of three forces act on a body. Whose resultant cannot be zero ?
(A) 10, 10, 10 (B) 10, 10, 20
(C) 10, 20, 20 (D) 10, 20, 40

15. Which of the sets given below may represent the magnitudes of three vectors adding to zero :
(A) 2, 4, 8 (B) 4, 8, 16
(C) 1, 2, 1 (D) 0.5, 1, 2

16. What is the maximum number of rectangular components into which a vector can be split in its own plane ?
(A) 2 (B) 3
(C) 4 (D) Infinite

17. Given : $\vec{A} = 2\hat{i} + 3\hat{j}$ and $\vec{B} = 5\hat{i} - 6\hat{j}$. The magnitude of $\vec{A}+\vec{B}$ is
(A) 4 units (B) 10 units
(C) $\sqrt{58}$ units (D) $\sqrt{61}$ units

18. Given : $\vec{A} = 2\hat{i}-\hat{j}+2\hat{k}$ and $\vec{B} = -\hat{i}-\hat{j}+\hat{k}$. The unit vector of $\vec{A} - \vec{B}$ is
(A) $\frac{3\hat{i}+\hat{k}}{\sqrt{10}}$ (B) $\frac{3\hat{i}}{\sqrt{10}}$
(C) $\frac{\hat{k}}{\sqrt{10}}$ (D) $\frac{-3\hat{i}-\hat{k}}{\sqrt{10}}$

19. What is the angle between $(\hat{i}+\hat{j}+\hat{k})$ and $\hat{i}$?
(A) $\frac{\pi}{6}$ (B) $\frac{\pi}{4}$
(C) $\frac{\pi}{3}$ (D) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$

20. What is the component of $(3\hat{i}+4\hat{j})$ along $(\hat{i}+\hat{j})$?
(A) $\frac{1}{2}(\hat{j}+\hat{i})$ (B) $\frac{3}{2}(\hat{j}+\hat{i})$
(C) $\frac{5}{2}(\hat{j}+\hat{i})$ (D) $\frac{7}{2}(\hat{j}+\hat{i})$

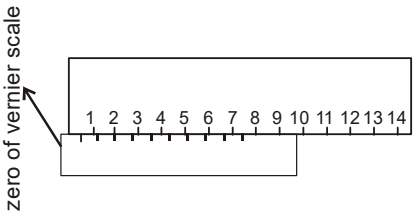
EXERCISE - III

1. A vernier callipers has 20 divisions on the vernier scale which coincide with 19 divisions on the main scale. The least count of the instrument is 0.1 mm. The main scale divisions are of
(A) 0.5 mm (B) 1 mm
(C) 2 mm (D) 1/4 mm

2. One centimetre on the main scale of vernier callipers is divided into ten equal parts. If 10 divisions of vernier scale coincide with 8 small divisions of the main scale, the least count of the callipers is
(A) 0.01 cm (B) 0.02 cm
(C) 0.05 cm (D) 0.005 cm

3. A student measured the diameter of a wire using a screw gauge with least count 0.001 cm and listed the measurements. The correct measurement is –
(A) 5.3 cm (B) 5.32 cm
(C) 5.320 cm (D) 5.3200 cm

4. The VC shown in the diagram has zero error in it. It is given that 9 msd = 10 vsd. (i) What is the magnitude of the zero error? (1 msd = 1 mm) (ii) The observed reading of the length of a rod measured by this VC comes out to be 5.4 mm. If the vernier had been error free then reading of main scale would be ____ and the division of vernier scale coinciding would be ____.



(A) (i) x = – 0.5 msd, (ii) 1, 3
(B) (i) x = – 0.7 msd, (ii) 6, 1
(C) (i) x = – 0.5 msd, (ii) 3, 1
(D) (i) x = 0.5 msd, (ii) 5, 1

5. Which two of the following five physical parameters have the same dimensions ?
(a) energy density (b) refractive index
(c) dielectric constant (d) Young's modulus
(e) magnetic field
(A) (a) and (d) (B) (a) and (e)
(C) (b) and (d) (D) (c) and (e)

6. If the dimensions of a physical quantity are given by $M^aL^bT^c$, then the physical quantity will be :
(A) Force if a = 0, b = –1, c = – 2
(B) Pressure if a = 1, b = – 1, c = – 2
(C) Velocity if a = 1, b = 0, c = – 1
(D) Acceleration if a = 1, b = 1, c = – 2

7. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is :
(A) 0.5 mm (B) 1.0 mm
(C) 0.01 mm (D) 0.25 mm

8. Taking into account of the significant figures, what is the value of 9.99 m–0.0099 m?
(A) 9.980 m (B) 9.9 m
(C) 9.9801 m (D) 9.98 m

9. In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (= 0.5°), then the least count of the instrument is
(A) one minute (B) half minute
(C) one degree (D) half degree

10. If the angle between the vectors $\vec{A}$ and $\vec{B}$ is θ, the value of the product $\left(\vec{B}\times\vec{A}\right).\vec{A}$ is equal to
(A) $BA^2\cos\theta$ (B) $BA^2\sin\theta$
(C) $BA^2\sin\theta\cos\theta$ (D) zero

MOTION®

CHEMISTRY

CLASS - IX

BOOKLET - 1

CONTENTS

MATTER IN OUR SURROUNDING

IS MATTER AROUND US PURE

ANSWER KEY

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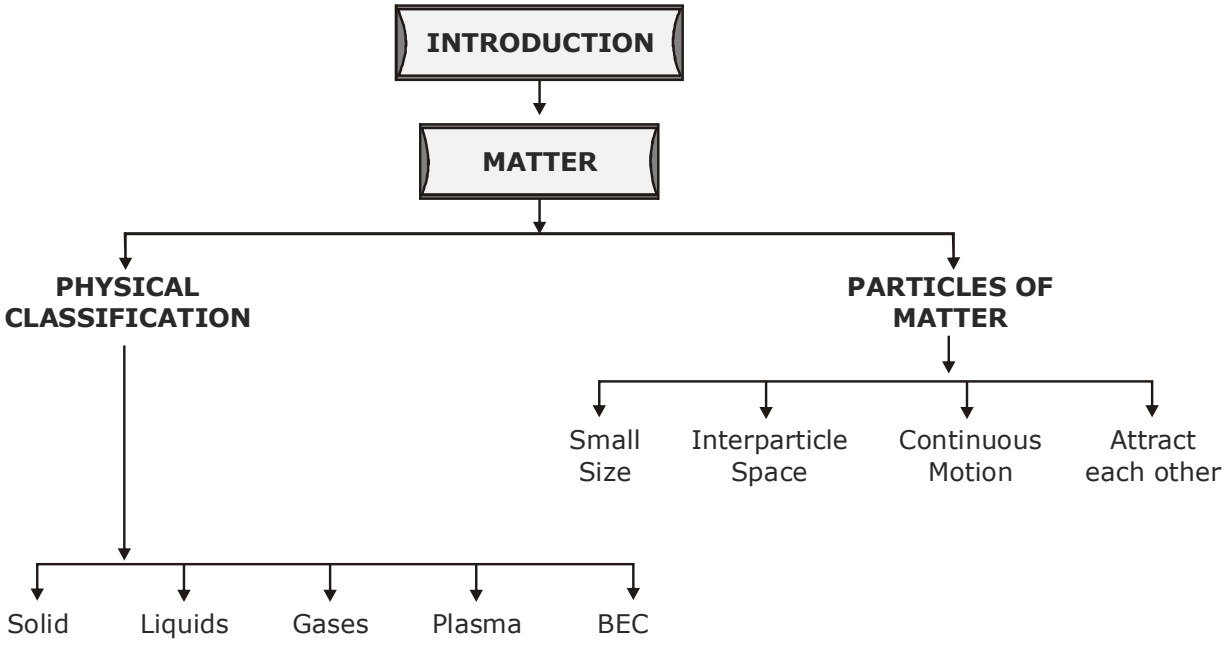
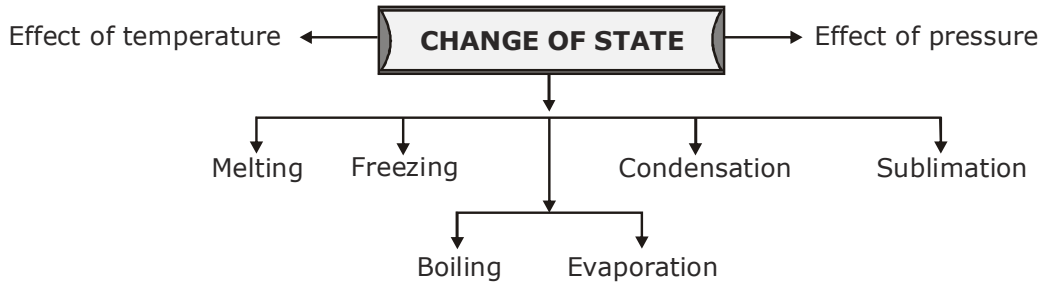
CHAPTER 1

MATTER IN OUR SURROUDING





INTRODUCTION

All the substances around us have different shape, size and texture. Everything in universe is made up of matter. The air we breathe, the food we eat, the water we drink, the pen with which we write, the book we read, are made up of matter. In this chapter, we shall discuss the matter in our surroundings.

MATTER

- **Matter :** Anything which occupies space has mass and offers resistance is called matter.
  It is interesting to note that even the bodies of living organisms are chemically made up of matter. Certain metal and non-metals are present inside the body of living beings. For example, **iron** is present in the respiratory pigment in blood called **haemoglobin**. Some non-metals present in the body are **nitrogen, oxygen, hydrogen, carbon and phosphorous.** They are used in different body functions.

Info Bubble

Matter is constantly changing. Plants grow by converting matter from the soil (water) and air into matter (food or carbohydrate) they can use. Water falls from the sky, evaporates and condenses again to form water (water cycle).

- **Material :–** The term used to describe a particular kind of matter, is called material e.g. – wood, water and marble etc.

Types of material :–

Homogeneous Material	Heterogeneous Material
They have same composition and properties e.g.: salt in water, alloys	They have different composition and properties For e.g.: In marble, presence of grey and red grains of other materials.

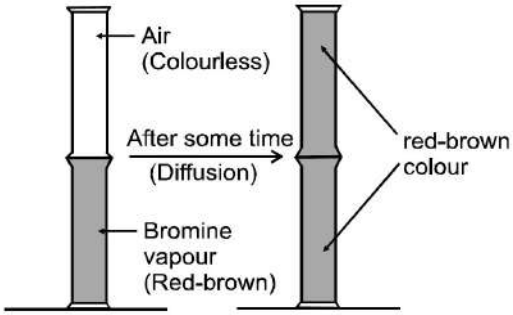
PHYSICAL NATURE OF MATTER

Matter is made up of small particles i.e., matter shows particulate nature. These particles are so small that they cannot be seen even with the help of powerful microscopes.
The particulate nature of matter can be proved by processes like Dissolution and Diffusion.

- **Dissolution :** The process in which two substance intermix to give a uniform solution is called dissolution. For example, common salt (NaCl) mixes with water to form a uniform solution. During this process, the particles of common salt get accomodated in the interparticle spaces of water.
- **Diffusion :** The process of intermixing of particles of two or more substances on their own is called diffusion.
  The rate of diffusion increases on heating that is why an incense stick gives smell only when we come close to it, but on lighting the stick we get smell even far away from it. The rate of diffusion increases with increase in temperature. Due to this reason, the perfumes spread quickly in summers as compared to winters. Due to diffusion, the gases intermix easily. Generally, the rate of diffusion is inversly related with density. The gases having low density diffuse quickly and the gases having high denstiy diffuse slowly.

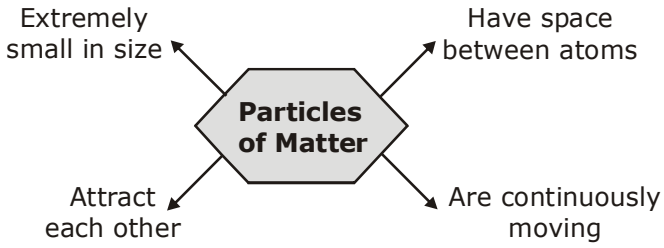
Info Bubble

Osmosis is a special case of diffusion which occurs only in liquids that are separated by a semi-permeable membrane. Examples, swelling of raisin when kept in water, death of earthworm on coming in contact with common salt.



Diffusion of bromine vapour into air

1. CHARACTERISTICS OF PARTICLES OF MATTER



(A) Size of Particles of Matter : The particles of matter are extremely small in size which cannot be seen even with powerful microscope.

(B) Interparticle Space (Intermolecular Space) : The particles of matter have spaces between them. The space between the particles is called interparticle space (intermolecular space or voids.)

(C) Motion of Particles : The particles of matter are in continuous motion. The following examples provide evidence of constant motion of the particles.

(i) Diffusion : The process of intermixing of particles of two or more substance on their own is called diffusion.

(ii) Brownian Motion : The continuous zig-zag motion of the particles is known as Brownian motion.

(D) Particles of Matter Attract Each other : Particles of matter always attract each other. The force of attraction between same kind of particles is called cohesive force while that between different kind of particles is called adhesive force.

Solids > Liquids > Gases

CLASSIFICATION OF MATTER

Since ancient times, human beings have been eager to understand surroundings. According to ancient Indian philosophers, all matter whether living or non-living is made up of five basic constituents commonly called "panch tatvas" i.e. air, earth, fire, sky and water. A similar classification of matter was also evolved by ancient Greek philosophers.

However, scientists have classified matter into the following two types on the basis of their properties.

1. **Physical Classification :** On the basis of physical properties, matter has been classified as solids, liquids and gases.
2. **Chemical Classification :** On the basis of chemical properties, matter has been classified as elements, compounds and mixture.

1. THE SOLID STATE

Ice, wood, coal, stone, iron, brick, chair, table etc. are some of the common solids around us. The solid have the following characteristics properties–

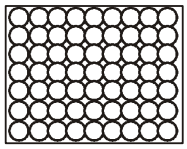
(A) They have fixed shape.

(B) They have fixed volume.

(C) They are rigid and have fixed boundaries.

(D) They are incompressible because intermolecular space is less.

(E) They have high density as compared to other states of matter.



Arrangement of particles in a solid

(F) They have strong force of attraction between the particles.

(G) The particles are closely packed in solid, therefore, there is less intermolecular space between the particles.

(H) The kinetic energy of particles in solid is very less. They vibrate only at their mean position that is why solids have rigid shape.

(I) Solid diffuse into solids to very less extent e.g. it is difficult to rub a blackboard on which something is written in chalk without cleaning for 10-15 days.

(J) Solids have high melting and boiling points as there are high interparticle forces of attraction in solids. Large amount of energy needs to be given to overcome strong interparticle forces.

(K) Crystalline or geometrical structure : In a solid, the constituent particles are arranged in a regular manner called lattice. Lattice is a three-dimensional arrangement of particles in the space. This explains why solids have a regular geometrical shape. Generally solid show crystalline structure.

Note:

- **Volume :** The space occupied by a substance is called volume. Its SI unit is cubic metre (m^3). Its common unit is litre. (1L = $1dm^3$, 1L = 1000 ml, 1ml = $1cm^3$).
- **Density :** The mass per unit volume of a substance is called density. Density = mass/volume. The SI unit of density is kg/m^3 whereas common unit is g/cm^3. (CGS unit)

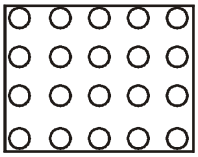
Info Bubble

Density is maximum in the solid state of a substance

- **Kinetic Energy :** The energy possessed by particles by virtue of their motion is called kinetic energy.

2. THE LIQUID STATE

Water, milk, fruit juice, ink, oils etc are some of the common liquids.
The liquids have the following characteristic properties–

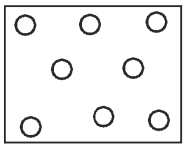


Arrangement of particles in a liquid

(A) Liquids do not have fixed shape or boundaries.
(B) They have fixed volume.
(C) They can flow i.e. they have fluidity.
(D) They have low compressibility but more than solids.
(E) They have lower density as compared to solids.
(F) The intermolecular forces of attraction are weaker as compared to solids.
(G) The intermolecular space is more than that of solids.
(H) The particles in liquid state can move freely and hence have higher kinetic energy than solids but less than that of gases.
(I) They show the property of intermixing and thus they can diffuse.
(J) Melting and boiling point : The melting and boiling point of a liquid is generally less than that of a solid. This is because of less interparticle forces in them.

3. THE GASEOUS STATE

Oxygen, carbondioxide, Nitrogen, Hydrogen, helium, stem and dry-ice,
The gaseous have the following characteristic properties–



Arrangement of particles in gases

(A) Gases do not have fixed shape i.e. they take the shape of container.
(B) They do not have fixed volume, therefore no definite boundaries.
(C) They can flow in all directions, hence gases also show fluidity.
(D) They are highly compressible.
(E) They have lower densities as compared to liquids and solids.
(F) They have higher kinetic energy as compared to liquids and solids.
(G) The rate of diffusion is fastest in gases.
(H) There is weak intermolecular force of attraction.
(I) Melting and boiling point : At normal atmospheric pressure, the melting and boiling points of a gas are below room temperature.

Info Bubble

The temperature at which all the three states of water co-exist is called the triple point.eg. triple point of water is 273.16 K.

(J) There is large intermolecular space, therefore, gases can be easily compressed.

(K) **Thermal expansion:** The gases show high thermal expansion because of very weak interparticle force of attraction in gases. The particles of gases continously strike on the walls of the container which causes pressure on the walls.

Info Bubble

It is assumed that ordinary matter consists almost entirely 99.99% of empty space.

COMPARISON OF CHARACTERISTIC PROPERTIES OF SOLIDS, LIQUIDS AND GASES

	Property	Solids	Liquids	Gases
1	**Shape**	Definite	Take the shape of the container, but do not necessarily occupy all of it.	Take the shape of the container by occupying whole of the space available to them.
2	**Volume**	Definite	Definite	Take the volume of the container.
3	**Interparticle forces of attraction**	Very strong	Weaker	Negligible
4	**Compressibility**	Almost nil	Almost nil	Very large
5	**Fluidity or Rigidity**	Rigid	Fluid	Fluid
6	**Density**	Large	Large	Very small
7	**Melting and boiling points**	Very high	Comparatively higher than gases	Low
8	**Diffusion**	Generally do not diffuse	Diffuse slowly	Diffuse rapidly
9	**Free surfaces**	Any number of free surfaces	Only one free surface	No free surface.
10	**Filling a container**	Solids cannot fill the container	Liquids fill container according to the volume of liquid	Gases fill entire space of a container
11	**Kinetic energy**	Molecules of solid has least K.E.	Molecules of liquid has more K.E. than solids	Molecules of gases have maximum K.E.

PRACTICE YOUR CONCEPTS

1. Sodium salt and sugar have similar appearance. Why are these classified as different substances?

Ans. The substances are not classified only by their appearance. These are classified by their properties such as density, boiling point or melting point, conductivity, thermal capacity and other chemical properties. Sugar and sodium chloride have different physical and chemical properties and so are different substances.

2. Describe an experiment to show that matter is composed of particles.

Ans. Take a 100 mL beaker half filled with water. Add some salt to it and stir with a rod. It will be observed that salt disappears without changing the volume of water. This means that the particles of salt get into the spaces between particles of water. This shows that both salt and water are made up of lots of particles and particles of salt have spread throughout the particles of water.

3. What do you mean by diffusion? Explain giving an example.

Ans. Particles of matter are always in a state of motion. They move to interact with other particles and distribute themselves equally in all available space. This intermixing of particles of two substances on their own is called diffusion. Particles of a gas diffuse faster than particles of a liquid.

4. Give an example of (i) a liquid diffusing into a solid, (ii) solid diffusing into a liquid and (iii) Solid diffusion into a solid.

Ans. (i) Liquid diffusing into solid: If we put a drop of ink on the centre of a clean blotting paper, we find the liquid spreads out by diffusing into the blotting paper which is a solid.
(ii) Solid diffusing into liquid: When we put a crystal of potassium permanganate in water, slowly the colour of potassium permanganate spreads throughout water.
(iii) Diffusion of a solid into a solid: Diffusion of solids into solids is very very slow. So diffusion of a solid into other solids is rare and very small.

5. What are 'intermolecular forces'? How are these related to the three states of matter?

Ans. The force operating between the particles of a matter is called intermolecular force. In solids, intermolecular forces are strong and this keeps the constituent particles quite close to each other and thus make the substance rigid (high density) and incompressible. This also results in highly ordered arrangement of the particles (called lattice) giving regular geometric shapes to solids.

INTERCONVERSION OF STATES OF MATTER

All the three states of matter are interconvertible i.e. matter can be changed from one state to another. The physical factors responsible for the change in state are **temperature** and **pressure**.

1. BY ALTERING TEMPERATURE

Temperature : The degree of hotness or coldness is called temperature. The device by which the temperature can be measured is called thermometer.

Scales of Temperature : Generally, three scales are applied for the measurement of temperature.
(i) Celsius Scale (°C) (ii) Kelvin Scale (K) or absolute Scale
(iii) Fahrenheit scale (°F)
The SI unit of temperature is **Kelvin.**
Kelvin scale is also called **thermodynamic scale.** Generally, the chemical/lab thermometer is calibrated in Celsius scale and clinical thermometer is calibrated in Fahrenheit scales. In glass thermometer, mercury is used because it does not stick to the glass.

$K = °C + 273$

$°C = K - 273$

$°F = \frac{9}{5}(°C) + 32$

At –40 °C reading of both the Celsius and Fahrenheit are equal.

Significance of temperature : Change in state takes place with increase or decrease in temperature as it affects intermolecular forces of attraction.

(A) Solid-Liquid interconversion :

$$\text{Solid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Liquid}$$

- **Solid $\longrightarrow$ liquid**

(i) Melting : The process in which solid changes into liquid is called melting.

Cause of melting : We know that when temperature increases, the kinetic energy of the particles also increases and when it overcomes the intermolecular attraction of solid particles, the particles start moving freely. Their condition becomes like liquid state and the solid gets converted into liquid. It means that on heating, the close packing is changed into loose packing. The process of melting is also called fusion.

(ii) **Melting Point :** The temperature at which solid changes into liquid at normal atmospheric pressure completely is called melting point.

Melting point of solids gives indication of the strength of intermolecular forces of attraction. Higher the melting point, more will be intermolecular forces of attraction.

Significance of melting point :

- **To know the strength of force of attraction :** The melting point is helpful is knowing the strength of force of attraction among the particles of the matter. Higher the melting point, stronger will be the force of attraction among the particles of matter.
- **To check the purity :** it is helpful in checking the purity of a given solid because, we know that pure substances have constant melting points.
- **Nature of matter :** It is helpful in detecting the nature of the matter.

(iii) **Latent (hidden) heat of fusion :** The amount of energy that is required to change 1kg of a solid into liquid at atmospheric pressure without any change of temperature at its melting point is called latent heat of fusion.

Have you ever observed, which one is more cooler between ice cubes and water 0°C? (we know, at 0°C, water and ice both can exist). Put some ice cubes on one palm and water at zero degree Celsius on other palm. The ice cubes cause more cooling sensation as compared to water at zero degree Celsius. Do you know why ?

Reason : Ice cubes take more heat as compared to water at zero degree Celsius because some extra heat is required to melt the ice and this extra amount of heat is called latent of fusion. The amount of heat (in joules) required to change one kg of soild into liquid state at atmospheric pressure without changing its temperature, i.e., at its melting point, is called latent heat of fusion.

For example, the latent heat of fusion of ice is 3.35×10^5 J/kg. It means that this amount of heat is required to melt one kg of ice into water at zero degree Celsius without changing its temperature.

1 kg of ice at 0°C is able to withdraw from any other body, 3.35×10^5 J more heat than 1 kg of water at the same temperature (0°C) could do.

ACTIVITY - 1

AIM : To demonstrate that the temperature remains constant during the change of state.

Material required : Crushed ice, beakers, thermometer, water, glass stirrer, bunsen burner, tripod stand, clamp, wire gauze

Procedure :

- Take a beaker and put some ice cubes in it.
- Suspend a laboratory thermometer in such a way that its bulb touches the ice.
- Start heating the beaker on a low flame.

• Record the temperature when the ice starts melting and the temperature when all ice converts into water.
• Take another beaker and add 150 mL of water into it.
• Heat the beaker containing water till it starts boiling. Stir the water with glass rod while boiling.
• Record the temperature till most of the water gets vaporised.

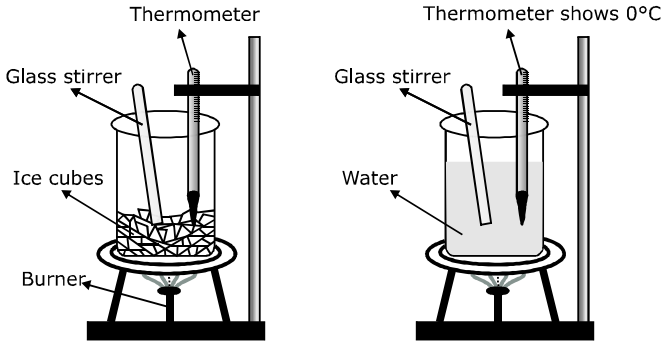


Figure showing conversion of ice into water

Observe the above activity carefully and answer these questions :

(i) What do you observe when the ice starts melting ?
(ii) If further heat is supplied after melting of ice, then what change will you observe ?
(iii) What do you observe when water starts boiling ?
(iv) What interpretation can be made from these observations ?

Observation and discussion :

- We know that the temperature at which any solid melts is called its melting point. When any solid starts melting, the temperature becomes constant due to latent heat of fusion. The supplied heat is utilised to overcome the force of attraction between the particles of solid. This temperature remains constant till the whole ice melts.
- If further heat is supplied after the melting of ice, the temperature starts increasing till it reaches the boiling point.
- At the boiling point, again the temperature becomes constant till the whole water gets vaporised due to latent heat of vaporisation. Because in this case also, the heat supplied is utilised to overcome the force of attraction between the particles of liquid.

Conclusion :

The temperature remains constant during the change of state in melting or boiling, till the whole solid melts or the whole liquid gets vaporised. The supplied heat is utilised in overcoming the force of attraction between the particles and, hence, no net change in temperature is observed in the thermometer.

- **Liquid $\longrightarrow$ Solid**

Freezing : The process of conversion of matter from liquid state to solid state at specific conditions of temperature and pressure is called freezing. It is reverse process of fusion/melting.

Freezing point : The definite temperature at which a liquid changes into solid state by giving out heat energy at 1 atmoshphere is called the freezing point.

(B) Liquid - Gas Interconversion

$$\text{Liquid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Gas}$$

- **Liquid $\longrightarrow$ gas**

(i) **Boiling :** The process of converting liquid into vapour is called boiling. It is bulk phenomenon i.e particles from inside the liquid gain enough energy to change into vapour state. It takes place only at boiling point.

Cause of boiling : When a liquid is heated, the kinetic energy of the particles of liquid increases and these particles start-moving faster. When boiling point is attained, the particles acquire sufficient energy to overcome the force of attraction which holds them and get separted into individual particles to look like gas particles.

(ii) **Boiling Point :** The temperature at which a liquid changes into gas or vapour is known as boiling point. It also indicates strength of intermolecular force of attractions. Greater then intermolecular forces of attractions, higher will be the boiling point. The boiling point of water is 100ºC (373K).

Significance of boiling point :

- **To know the strength of force of attraction :** The boling point is helpful is knowing the strength of force of attraction among the particles of the matter. Higher the boling point, stronger will be the force of attraction among the particles of matter.
- **To check the purity :** it is helpful in checking the purity of a given solid because, we know that pure substances have constant boiling points.
- **Nature of matter :** It given information about the volatile nature of the liquid. Lower the boiling point is, more will be its volatility. For example, the boiling point of water is 100ºC and that of alcohol (spirit) is 78ºC can you guess, which will be more volatile in nature ? The alcohol will be more volatile.

(iii) **Latent (hidden) Heat of Vaporisation :** The amount of energy that is required to change 1kg of liquid into vapours at atmospheric pressure without any change in temperature at its boiling point is called latent heat of vaporisation.

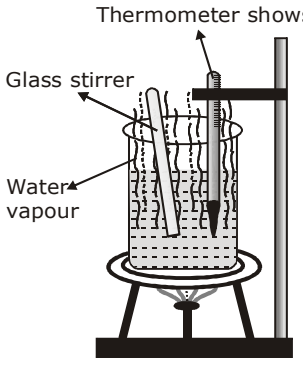


Figure showing change of liquid water into vapour

The steam at 100° C have more heat as compared to boiling water. This extra heat is in the form of latent heat. The amount of heat required to convert one kg of liquid into gaseous state at atmospheric pressure without changing its temperature, i.e., at its boiling point is called the latent heat of vaporisation. So, till the boiling point is attained, the given heat is utilised to increase the kinetic energy of the particles. When that boiling point is attained, the supplied heat is used to convert liquid into vapour.

Info Bubble
Before performing minor surgery, surgeons spray ether on a portion of skin. As ether has very low boiling point so it takes heat from body and evaporates. Skin becomes numb due to this lowering of temperature.

Once the water begins to boil, temperature remains constant at 100°C until all the water changes into the steam. The latent heat of vaporisation of water is 22.6×10^5 J/kg.
It means, this much amount of heat is required to change 1 kg of water into gaseous state without changing its temperature. **When steam falls on our skin it condenses to form water as it gives out 22.6×10^5 Joules per kg more heat than boiling water at the same temperature. Due to this reason, steam causes severe burns as compared to boiling water.**

Why temperature remains constant during Melting and Boiling ? Where does the heat energy go ?:
Temperature remains constant during melting and boiling of matter as heat energy is used up in overcoming the force of attraction between its particles and hence the change is state occurs. Heat supplied during melting and boiling remains hidden and is known as **latent heat** or **silent heat.**

Info Bubble
Ice is rubbed on the burnt portion of body because due to burning, the temperature of injured skin is increased but when ice is rubbed, the excess heat is taken from the skin as latent heat of fusion of water.

The amount of heat required to change one kg of matter into another state without changing its temperature at normal atmospheric pressure is called latent heat.

- **Gas ⟶ liquid**

Condensation : Condensation may be defined as the process, in which a gaseous state is converted into liquid state by lowering down its temperature at normal atmospheric pressure.

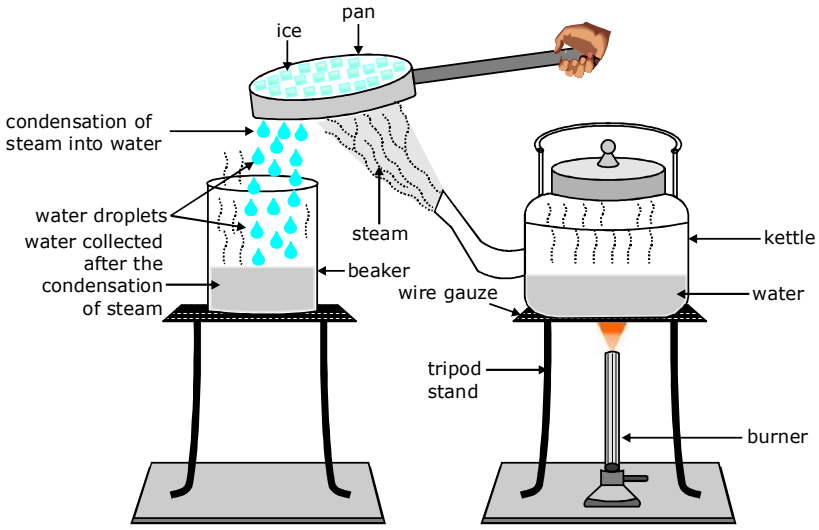


Figure showing condensation of water vapour

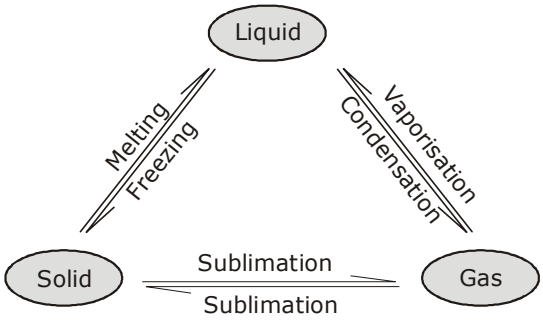
Liquefaction of Gases : Gases can be liquified at low temperature and high pressure, e.g., H_2, N_2 and O_2 can be liquified at low temperature at high pressure. NH_3 can be liquified at room temperature.

(C) Solid - gas interconversion :

$$\text{Solid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Gas}$$

(i) Sublimation : The process in which a solid directly converts into gaseous state on heating, or vice-versa on cooling without changing into liquid state, is called sublimation.

The solid which can show the sublimation are called **sublime**. Solid obtained due to sublimation is called **sublimate**. The examples of substances which show sublimation are camphor, iodine crystals, mint crystals, dry ice (formed by sublimation of CO_2 gas), ammonium chloride, naphthalene balls, etc.



Interconversion of states of matter

PRACTICE YOUR CONCEPTS

6. Give one similarity between a liquid and a gas and one dissimilarity.

Ans. Similarity: Both liquids and gases are fluids and assumes the shape of the container.
Dissimilarity: A gas can be compressed easily whereas a liquid cannot.

7. What property of the gas is utilized when natural gas is supplied for vehicles?

Ans. A gas is highly compressible and a large quantity of it can be compressed to a small manageable volume. Therefore, natural gas is compressed and is supplied for use by vehicles in the name of CNG (compressed natural gas).

8. How is pressure developed in a container full of a gas?

Ans. In the container, the gaseous particles are free to move. These move at high speed and collide with other particles or walls of the container. The bombardment of the particles on the walls of the container produces a steady force that depends on the temperature. This force per unit area is called as pressure of the gas.

9. When ice at –10°C is slowly heated, temperature of ice gradually increases till at 0°C, the temperature of the system remains constant when the ice changes into water and then further rises. Explain the observation.

Ans. At 0°C, when the ice melts, the temperature of the system does not change though the heat is continuously supplied. The given heat is used up in overcoming the force of intermolecular attraction. This results in the conversion of ice into water. As this heat energy is absorbed by ice without any rise in temperature of the system, this heat is considered as hidden in the system and is known as latent heat.

10. What produces more severe burns, boiling water or steam. Give reason for your answer.

Ans. Though steam is more energetic than boiling water but boiling water causes more severe burns than steam because of larger time in contact with the skin.

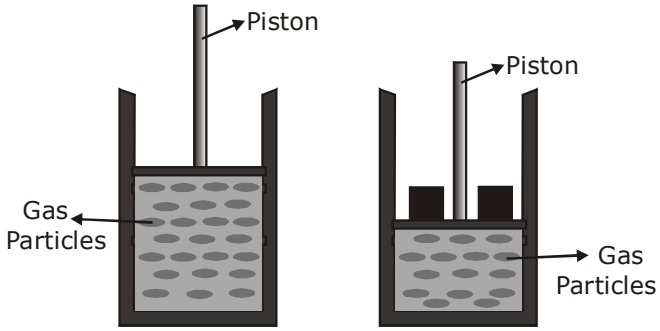
2. BY ALTERING PRESSURE

Pressure : It is defined as force exerted per unit area, e.g., gases exert pressure on the walls of the container. The kinetic energy of the particles in gaseous state is maximum. The particles are in state of constant random motion therefore, they collide with themselves as well as with the walls of the container and exert pressure.

Unit of pressure is Pascal (Pa), 1 atm = 1.01×10^5 Pa

The pressure exerted by the air around us is called **atmospheric pressure**. This pressure changes from place to place. The pressure decreases with the increases in altitude. Due to this reason, the pressure on mountains is low and in coastal areas, the pressure is high. The instrument used to measure the atmospheric pressure is called **barometer.**

When we apply pressure and compress the gas, intermolecular force of attraction increases and molecules come close to each other. It may be changed into liquid depending upon temperature and nature of the gas.



By applying pressure particles of matter can be brought close together

(A) The three states of matter differ in the intermolecular forces and intermolecular distances between the constituent particles.

(B) Gases are compressible because on applying pressure, the space between the gaseous particles decreases. Therefore, gases can be compressed readily.

(C) When we apply pressure and reduce temperature the gases can be converted into liquids i.e. gases will be liquefied.

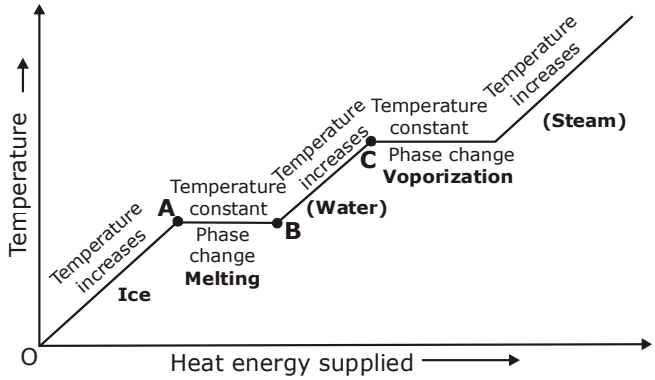
(D) The process of conversion of a gas into a liquid by increasing pressure or decreasing temperature is called **liquefacation.**

STUDY OF TEMPERATURE AS FUNCTION OF TIME DURING CHANGE OF STATE

When a substance is heated to change its state from one state to other, then its temperature remains constant from the moment, change of state starts to the moment till whole of the substance changes its state.

Suppose, a solid is heated, then first its state change from solid to liquid and on further heating, liquid changes into gaseous state.

The variation of temperature with the time can be plotted as :



For part OA, the temperature increases till the point A, from point A, the solid starts to change into liquid (temperature at point A is the melting point of the soild).

For part AB, temperature reamins constant during this time, the soild is changing into liquid.

From point B, temperature starts rising that means whole of the solid has been changed to liquid.

From part BC, temperature starts rising from point B to point C, at point C temperature becomes constant, that means the liquid starts to change into gas (temperature at point C is the boiling point of the liquid). Now the temperature will become constant, till whole of the liquid change into gas.

Quantity	Unit	Symbol
Temperature	kelvin	K
Length	metre	m
Mass	kilogram	kg
Weight	newton	N
Volume	cubic metre	m^3
Density	kilogram per cubic metre	kg m^{-3}
Pressure	pascal	Pa

PRACTICE YOUR CONCEPTS

11. Classify your body contents in three states.

Ans. Bones and teeth - solids
Blood and water - liquids
Air - gas

12. Why do solids and liquids have open surface while gases do not?

Ans. We know that particles of matter are constantly moving. In solids, the constituent particles are able to vibrate only due to high intermolecular forces of attraction. In liquids, the particles are able to move but the forces of attraction are strong enough to keep these stick together. Thus in solids and liquids, the particles stay together and form a surface. In gases, the intermolecular forces of attraction are very weak and hence the particles move without any restriction in random motion. These thus occupy any available space and move away if there is an open space. That is why gases do not have open surface.

13. Why are liquids and gases called fluids?

Ans. Liquids and gases have a tendency to flow. Liquids can flow from higher level to lower level. The gases flow in all available directions. Due to this tendency of flowing, both of them are called fluids.

14. How does the rate of diffusion change with (i) density of liquid (ii) temperature? Give examples.

Ans. (i) Rate of diffusion decreases with density of a liquid. Honey is denser than ink. If you add a drop of ink and honey in two separate jars filled with water, it will be observed that honey takes longer time to reach the bottom of the jar as compared to that taken by ink.

(ii) Diffusion increases with rise of temperature. For example, liquid mix faster at higher temperature.

15. 5gm each of nitrogen gas is contained in three vessels A, B, C with volume 1 litre, 1.5 litre and 2.0 litre at the same temperature. How will you measure the volume of the gas in each vessel? Explain.

Ans. The volume of 5g of nitrogen would be 1, 1.5, 2 litres respectively in the vessels A, B and C. The volume of any amount of the gas would be the volume of the containing vessel.

EVAPORATION

The process of conversion of a liquid into the gaseous form (vapour) at any temperature below its boiling point is called evaporation. This is a continuous process.

1. CHARACTERISTICS OF EVAPORATION

(A) In the process of evaporation, the liquid changes into vapour (or gas) even below its boiling point.

(B) Evaporation is an endothermic process, therefore, it causes cooling.

(C) Evaporation is a surface phenomenon.

2. FACTORS AFFECTING EVAPORATION

(A) Exposed surface area of the liquid : More is the exposed surface area of a liquid, the more is the rate of evaporation.

For Examples :

(a) Drying of wet clothes (b) Drying of grains. (c) Rapid cooling of hot tea.

(B) Temperature of liquid : Higher the temperature of a liquid, more is the rate of evaporation.

For Examples : Rate of Evaporation

(a) Formation of water vapour above a hot cup of tea.

(b) Feeling more cold after a hot water bath than a cold water bath.

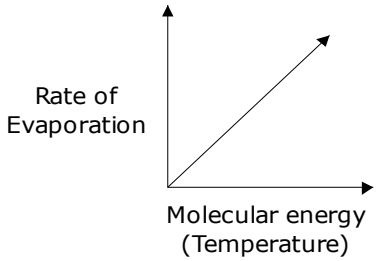
Temperature of the surroundings : Higher the temperature of the surroundings, more is the rate of evaporation.

For Examples :

(a) Quick drying of wet clothes in summer as compared to winter.

(b) Frequent watering of plants in summer.

(c) Water keeps cool in the earthen pitchers during summer.



(C) Humidity : Rate of evaporation decreases with increase in humidity.

For Examples :

(a) By humidity, we mean the amount of water vapours present in air. It may be noted that air around us can hold only a certain definite amount of water vapours at a particular temperature. In case the humidity of air is already high, i.e., the amount of water vapours in the air is already high, it can hold only a little more amount of water vapours to reach that optimum level, therefore, the rate of evaporation decreases.

(b) It is because of this reason that clothes get dried slowly during rainy season when the humidity of air is high than in dry weather when the humidity is low. Similarly, we sweat a lot in hot and humid weather than in dry weather. The reason being that in hot and humid weather, the air around us has already a high percentage of water vapours, therefore, the sweat that sweat that comes out of our skin does not evaporate and remains sticking to our body.

(D) Wind speed : Moving air increases the rate of evaporation.

For Examples :

(a) One feels comfortable under a moving fan in summer.

(b) Rapid drying of clothes on windy days.

(c) Cooling caused by desert coolers in hot summer.

(E) Nature of the substance: Greater the volatile nature of the substance,higher will be the rate of evaporation.The higher the boiling point of the liquid is,the lesser will be its volatile nature.The lower the boiling point is,more will be evaporation takes place.

Evaporation causes cooling:–

During evaporation, cooling is always caused. This is because evaporation is a phenomenon in which only the high energy particles leave the liquid surface. As a result, the particles having low energy are left behind. Therefore, the average molecular energy of the remaining particles left in the liquid state is lowered. As a result, there is decrease in temperature on the part of the liquid that is left. Thus evaporation causes cooling.

Note:

Rate of evaporation $\propto$ surface area.

Rate of evaporation $\propto \frac{1}{\text{Humidity}}$.

Rate of evaporation $\propto$ wind speed.

Example :–

(i) When we pour some acetone on our palm, we feel cold. This is because the particles gain energy from our palm or surroundings and leave the palm feeling cool.

(ii) We sprinkle water on the roof or open ground after a sunny hot day. This cools the roof or open ground. This is because the large latent heat of vaporization of water helps to cool the hot surface.

	Boiling (Vaporation)		Evaporation
1	A process in which a substance changes its state from the liquid state to the gaseous state	**1**	Evaporation is a process whereby the water changes into vapour without boiling
2	Quick	**2**	Slow
3	Bubbles are formed	**3**	No bubbles formed
4	Occurs throughout the liquid	**4**	Takes place only from the exposed surface of the liquid
5	Occurs at a definite temperature boiling point	**5**	Occurs at all temperature
6	Source of energy needed	**6**	Energy supplied by surroundings

PRACTICE YOUR CONCEPTS

16. How do you differentiate between a gas and a vapour?

Ans. The word vapour is used to describe those gases that usually exist as liquid at room temperature. Water particles in gaseous state are called vapours. Oxygen at room temperature exists as gas particles.

17. What is the difference between latent heat of fusion and latent of solidification?

Ans. Latent heat of fusion and solidification are equal in amount but opposite in sign. Latent heat of fusion is the amount of energy required when 1 kg of ice converts into water at 0°C. Whereas latent heat of solidification is the amount of energy given out when 1 kg of water freezes at 0°C.

18. Why does evaporation causes cooling of a liquid system?

Ans. Due to evaporation, only high energy particles leave the surface. This results in decreases of average kinetic energy of the particles in the system. Kinetic energy is related to temperature. As a result there is a drop in temperature of the system. Thus evaporation causes cooling.

19. Why do wet clothes kept in shade dry slowly on a rainy day even in summer?

Ans. During rainy day, the humidity of air increases i.e. air is quite saturated with water vapour or air cannot hold more water vapour. Therefore, rate of evaporation of water from wet clothes decreases. So wet clothes dry slowly in rainy day.

20. Why do we see water droplets on the outer surface of a glass containing ice-cold water?

Ans. The air around ice-cold water container contains water vapours which have higher energy than ice-cold water. Therefore, water vapour present in the air loses energy when come in contact with cold water. These are then converted into liquid state, which we see as water droplets.

21. Why should we wear cotton clothes in summer?

Ans. In summer we fell hot. The body temperature should remain constant. In order to keep body cool, the water from the body gets evaporated and gets deposited on the body surface as sweat. Cotton is a good absorber of water and is thus more comfortable in summer.

PLASMA

- Plasma is superheated matter - so hot that the electrons are ripped away from the atoms forming on ionized gas.
- Plasma is often called - the fourth state of matter, along with solid, liquid and gas. Just as a liquid will boil, changing into a gas when energy is added, heating a gas will form a plasma - a mixture of positivily charged particles (ions) and negatively charged particles (electrons).

Info Bubble

We are quite familiar with plasma TVs. Due to the presence of charged particles, it conducts electricity.

- Plasma are a lot like gases, but the atoms are different because they are made up of free electrons and ions of the element.
- It comprise over 99% of the visible universe.
- Examples of plasma is a neon sign. Just like a fluorescent light, neon signs are glass tubes filled with gas.

This charging up creates glowing plasma inside the tube or bulb. The plasma glows with a special colour depending upon the nature of the gas. The sun and stars glow because of presence of plasma in them. The plasma is created in stars due to very high temperature.

BOSE-EINSTEIN CONDENSATE (B.E.C.)

- It is named after Satyendra Nath Bose and Albert Einstein. It is the fifth state of matter which is formed from matter that has been cooled to near absolute zero (–273ºC). When a group of atoms is cooled to a very low temperature, the velocity decreases because they have very low energies.
- In this state, the whole matter behaves as a single component or atom because the kinetic energy of the atoms becomes so low that there is hardly any vibration show by the atoms. This is also called **gaseous super fluid.**

PRACTICE YOUR CONCEPTS

22. Give reasons:

(i) Solid carbon dioxide (dry ice) is stored under high pressure.

(ii) At many places, especially in rural areas, people often sprinkle water on the ground in front of their homes during hot summer evenings.

Ans. (i) This is because solid carbon dioxide on decreasing pressure gets converted into gaseous carbon dioxide.

(ii) The water from the ground gets evaporated taking the latent heat of vaporisation from the ground and surrounding air which then becomes cool.

23. Is it true to say that fluorescent tube contains plasma? Explain.

Ans. It is not correct to say that fluorescent tube contains plasma. In fact, fluorescent tube contains helium or some other rare gas. The particles of the gas gets ionized, i.e., charged in the presence of high voltage applied. These charged particles are called plasma which actually glow.

24. Do all particles or plasma glow similarly?

Ans. The plasma glows with different colours depending on the nature of the containing gas. Neon sign bulb (containing neon gas) glows differently than a fluorescent tube (containing helium gas).

25. What is the differece between a gas and plasma?

Ans. Gas consists of particles which are neutral and are associated with energies comparable with atmospheric temperature.

Plasma contains super energenic particles in the form of ionized gases.

26. Why do the sun or the stars glow?

Ans. Because of the high temperature inside sun or stars, particles of hydrogen gas or helium get ionized and plasma is created. The plasma helps the sun or stars to glow.

ON YOUR TIPS

- Anything that occupies space, has mass and offers resistance is called matter.
- A substance is a form of matter that has a definite composition and distinct properties.
- Matter can exist in three states – solid, liquid and gases.
- The strengths of intermolecular forces in solids, liquids and gases are different.
- A soild has a definite shape and volume.
- A liquid has no definite shape, but has a fixed volume.
- A gas has neither a definite shape nor a definite volume.
- Solids have high melting and boiling points.
- Solids are incompressible.
- The process of conversion of a soild directly into its vapour is called sublimation.
- The conversion of a liquid into solid by cooling is called freezing. The temperature at which a liquid solidifies is called its freezing point.
- The conversion of a liquid into vapour below is boiling point is called evaporation, the particles from the surface of the liquid escape into atmosphere.
- A liquid boils when the pressure of its vapour becomes equal to the atmopheric pressure.
- The temperature at which a liquid begins to boil under the prevalling atmospheric pressure is called the boiling point of the liquid.
- The temperature at which a solid converts into liquid state is called the melting point of the soild.

- The transformation of a gas or vapour into liquid is called condensation.
- Particles of matter are constantly moving.
- Rise of temperature makes the particles move faster.
- The compressibility of a liquid is very low.
- The extent of diffusion of a solid into a liquid is more than that of a solid into another solid.
- Aquatic plants and animals survive on the carbon dioxide and oxygen dissolved in water.
- Higher the wind velocity, higher is the rate of evaporation.
- The compressibility of a gas is very high.
- Matter changes its state with the change in temperture.
- The amount of heat energy absorbed when a substance changes from solid to liquid at its melting point is called the latent heat of fusion of the soild.
- The amount of heat energy absorbed when a substance changes from liquid to vapour at its boiling point is called the latent heat of vaporization of the liquid.
- Black or dark-coloured objects absorb more heat than white or light-coloured objects.

NCERT QUESTIONS WITH SOLUTION

1. Convert the following temperature to the Celsius scale-
(i) 293 K (ii) 410 K

Sol. (i) 293 – 273 = 20°C
(ii) 470 – 273 = 197°C

2. Convert the following temperature to the kelvin scale.
(i) 25°C (ii) 373°C

Sol. (i) 25 + 273 = 298K
(ii) 373 + 273 = 646K

3. Arrange the following substances in the increasing order of forces of attraction between the particles of water, sugar and oxygen.

Sol. Oxygen, water and sugar.

4. What is the physical state of water at
(a) 25°C (b) 0°C (c) 100°C

Sol. (a) At 25°C, water is in liquid state.
(b) At 0°C, water is in solid state, provided heat is removed from it.
(c) At 100°C, water is in gaseous state, provided heat is supplied to it.

5. Give two reasons to justify –
(a) Water at room temperature is a liquid.
(b) An iron almirah is solid at room temperature.

Sol. **(a)**
(i) Intermolecular forces are less.
(ii) Intermolecular spaces and kinetic energy is more.
Thus, the molecule of water can interchange their spaces and hence water is in liquid state at room temperature.
(b)
(i) Intermolecular forces are very large.
(ii) Intermolecular spaces, as well as, kinetic energy are very small.

6. Ice at 273 K more effective in cooling, than water at the same temperature, why?

Sol. One kilogram of ice at 273 K, needs 3,36000 J of heat energy in order to form water at 273 K. As the ice can extract out large amount of heat energy on melting to form water at the same temperature, therefore, it is more effective in cooling.

7. What produces more severe burns, boiling water or steam?

Sol. Steam will produce more severe burns than boiling water. It is because, 1 g of steam at 373 K (100°C) contains 2260 J of heat energy more in the form of latent heat of vaporization as compared to water at 373 K(100°C). Thus steam produces more severe burns.

8. Naphthalene balls disappear with time without leaving any solid why?

Sol. Naphthalene is volatile solid and has a tendency to sublime, therefore, it changes into vapours completely which disappear into the air and no solid is left.

9. We can get the smell of perfume sitting several metres away. Explain

Sol. This is because perfumes contain volatile solvent which carries pleasent smelling vapour. They diffuse quite fast and can reach to people sitting several metres away.

10. Give reasons :
(a) A gas fills completely the vessel, in which it is kept.
(b) A gas exerts pressure on the walls of the container.
(c) A wooden table should be called a solid.

(d) We can easily move our hand in air, but to do the same through a solid block of wood, we need a karate expert.

Sol. (a) The molecules of a gas have large intermolecular spaces and kinetic energy, but extermely small intermolecular forces. Thus, the molecules of the gas spread in the entire space of the containing vessel on account of high kinetic energy and practically to intermolecular forces, hence fill entire space of the vessel.

(b) The molecules of a gas have very large kinetic energy. When these molecules strike against the walls of containing vessel, they exert certain average force per unit area. As the force per unit area is known as pressure, therefore, the gases exert pressure on the sides of the containing vessel.

(c) Solids are rigid, incompressible and have definite shape and volume. Since the table has all the above mentioned properties, therefore, it is solid.

(d) The intermolecular forces between the molecules of a gas are almost negligible and intermolecular spaces are very large. Thus, we can easily move our hand in air, without any appreciable force.

The intermolecular forces between the molecules of a solid are very large and intermolecular spaces are very small. Thus, a lot of force is required to separate the molecules of a solid. It is for the same reasons that we need karate expert to break a block of wood.

11. The mass per unit volume of a substance is called density. (Density = Mass / Volume). Arrange the following in the order of increasing density :

air, exhaust from chimneys, honey, water, chalk, cotton and iron.

Sol. Exhaust from chimneys, air, cotton, water, honey and iron.

e.g.

(i) CNG (compressed Natural gas) is used as fuel in internal combustion engines.

(ii) Oxygen in compressed form is supplied to hospitals for serious patients in cylinders.

(iii) LPG (Liquefied petroleum gas) which is used in home for cooking.

(iv) The gases exhibit the property of diffusing very fast into other gases.

12. The diver is able to cut through water in a swimming pool.

Sol. **Explanation** :– The diver is able to cut through water in the swimming pool because matter is not continuous, but it is made up of particles which have vacant spaces between them moreover, the attractive forces between molecules of water are not very strong. The diver can easily cut through water by applying force to displace water and occupy its place.

13. Why ice floats on water?

Sol. Solids generally have higher density than the liquids but ice due to its specific structure has larger interparticle spaces and hence has lower density than liquid water. As a result ice floats on water.

14. How gases can be liquefied by applying pressure?

Sol. Gases can be liquefied by applying high pressure on it. This can be done by taking gas in a cylinder fitted with piston. On applying pressure, interparticle distance decreases and gas particles come so close that they strongly start attracting one another and form a liquid.

Temperature and pressure are the two factors which decide whether a given substance would be in a solid, liquid or gaseous state.

15. Why does surgeons apply ether on the part of our body which is to be operated ?

Sol. Ether is very volatile substance. It was a very low boiling point. When it is sprayed on the skin, it evaporates quite rapidly, taking heat from the skin. As a result, the temperature of the skin becomes so low that it becomes numb. When a minor cut is made on the skin, the person does not feel much pain due to its numbness. Due to these reasons surgeons apply ether on the part of our body which is to be operated.

16. How does an air conditioner work ?

Sol. An air conditioner works on the principle of thermodynamics. It takes the heat from air which is inside the room and transfers it outside the room.

17. Why is dry ice a better option for food preservation at low temperature ?

Sol. Dry ice is a better option for food preservation because it can produce much lower temperature as compared to ordinary ice. Therefore, it is more effective in cooling. It does not cause wetting of food materials also because it shows sublimation.

18. Comment on the following statements :
(a) Evarporation produces cooling.
(b) Rate of evaporation of an aqueous solution decreases with increases in humidity.
(c) Sponge though compressible is a soild.

Sol.
(a) We know that evaporation is an endothermic process which means heat energy is required for evaporation. So, the surface from where the evaporation is taking place will lose the heat of become cool. Thus, evaporation causes cooling.
(b) By humidity, we mean that the amount of moisture present in the air. When humidity increases, the air becomes saturated with moisture (water vapour) at given temperature and cannot hold more moisture. Therefore, the rate of evaporation decreases.
(c) As we know that sponge is porous solid which means it has a number of tiny holes is which air is entrapped. When the sponge is compressed, the air comes out and its volume decreases. Therefore, sponge is soild even though it is compressible.

EXERCISE – I

MULTIPLE CHOICE QUESTIONS

1. When salt is dissolved in water :-
(A) Boiling point increases
(B) Boiling point does not change
(C) Boiling point decreases
(D) None of the above

2. Triple point of water is :-
(A) 373.16 K (B) 273.16° F
(C) 273.16 K (D) 273.16 F

3. The process for the change of a solid directly into its vapour is called –
(A) Evaporation (B) Ebullition
(C) Condensation (D) Sublimation

4. When water particles condenses on air on dust, it forms :-
(A) mist (B) fog
(C) frost (D) Vapour

5. Which is more effective in cooling ?
(A) Water at 0°C (B) Water at 100°C
(C) Ice at 0°C (D) All of these

6. The temperature at which Celsius and Fahrenheit scales show the same reading is:
(A) 40° K (B) 100° F
(C) – 40° C (D) – 100°C

7. Latent heat of fusion for ice is :-
(A) 80 gm cal^{-1} (B) 80 cal / gm
(C) 19 J cal^{-1} (D) None of these

8. The SI unit of temperature is :-
(A) °C (B) °F
(C) K (D) All of the above

9. The solid state of CO_2 is called :-
(A) Tear gas (B) Cooking gas
(C) Dry ice (D) Laughing gas

10. Corresponding temperature in the Kelvin scale for 104° F is :-
(A) 313 K (B) 203 K
(C) 308 K (D) 377 K

11. When the vapour pressure of a liquid is equal to its atmospheric pressure, then it :-
(A) Freezes
(B) Evaporates
(C) Boils
(D) Does not undergo any change

12. When ice is converted into water :-
(A) Heat is absorbed
(B) Heat is released
(C) Temperature increases
(D) Temperature decreases

13. Which of the following has the strongest interparticle force at the room temperature?
(A) Nitrogen (B) Mercury
(C) Iron (D) Chalk

14. What is volume of gases?
(A) Definite
(B) Almost Nil
(C) Large
(D) Take the volume of container

15. The change of state from solid to liquid is known as –
(A) Condensation (B) Boiling
(C) Melting (D) None of these

16. The boiling point of water on kelvin scale is–
(A) 573 K (B) 273 K
(C) 373 K (D) 100 K

17. The process of change of a liquid into vapour at any temperature is called –
(A) Diffusion (B) Evaporation
(C) Cooling (D) Heating

18. Which factor affects Evaporation –
(A) Temperature (B) Surface area
(C) Both (A) & (B) (D) None of these

19. On increasing the temperature of the liquid the rate of evaporation is –
(A) Increase (B) Decreases
(C) No change (D) None of these

20. Fluids are –
(A) Liquids and gases
(B) Solids and gases
(C) Liquids and solids
(D) Only solids

21. Which substance undergo sublimation process–
(A) Naphthalene (B) CO_2
(C) Ice (D) N_2

22. Condensation process is –
(A) Change of state from gas to liquid
(B) Change of state from liquid to gas
(C) Change of state from gas to solid
(D) Change of state from solid to liquid

23. The temperature at which liquid starts boiling at atmospheric pressure known as –
(A) Melting point (B) Boiling point
(C) Latent heat (D) Condensation

24. The melting point of ice is –
(A) 0°C (B) 4°C
(C) 5°C (D) None of these

25. The physical state of matter which can be easily compressed –
(A) Liquid (B) Gas
(C) Solid (D) None of these

26. Name the process by which a drop of ink spreads in a beaker of water –
(A) Diffusion (B) Vaporization
(C) Condensation (D) Sublimation

27. The temperature at which a solid changes into liquid at atmospheric pressure is called–
(A) Melting point
(B) Boiling point
(C) Diffusion
(D) Evaporation

28. Convert the temperature of 373°C to the kelvin scale ?
(A) 646 K (B) 546 K
(C) 300 K (D) 500 K

29. Convert the temperature of 270 K to the celsius scale –
(A) –3°C (B) –4°C
(C) 2°C (D) 5°C

30. Plasma is the..... state of matter –
(A) First (B) Second
(C) Third (D) Fourth

31. Liquids have:
(A) fixed volume and fixed shape
(B) fixed shape and no fixed volume
(C) fixed volume and no fixed shape
(D) neither fixed volume nor fixed shape

32. Materials existing as liquids have:
(A) boiling point and melting point above room temperature
(B) boiling point and melting point below room temperature
(C) boiling point above room temperature and melting point below room temperature
(D) boiling point and melting point below room temperature

33. Intermolecular force of attraction is maximum in–

(A) solids (B) liquids

(C) gases (D) plasma particles

34. When we add sugar in water particles of sugar disappear because they

(A) are very small

(B) get into the spaces between water particles

(C) are moving

(D) are colourless

35. One small crystal of potassium permanganate may contain particles:

(A) more than 10^3 (B) more than 10^4

(C) more than 10^5 (D) more than 10^6

36. Which of the following pairs will not exhibit diffusion?

(A) Hydrogen, oxygen

(B) Oxygen, water

(C) Salt, sand

(D) Sugar crystal, water

37. Which of the following substances is not a solid?

(A) Butter (B) Glass

(C) Sponge (D) Rubber band

38. Which one of the following properties is not characteristic of liquids?

(A) Fluidity (B) Definite shape

(C) Definite volume (D) Compressibility

39. Large volume of compessed natural gas (CNG) is available in small cylinders to us due to its property of–

(A) high inflammability

(B) easy availability

(C) high compressibility

(D) low density

40. Gases are liquidified under:

(A) high pressure, high temperature

(B) high pressure, low temperature

(C) low pressure, high temperature

(D) low pressure, low temperature

41. Which of the following statements is/are correct ?

(A) Intermolecular forces of attraction in solids are maximum.

(B) Intermolecular forces of attraction in gases are minimum.

(C) Intermolecular spaces in solids are minimum.

(D) All of the above

42. What happens to the volume of the aqueous solution when small amount of sugar is dissolved in it ?

(A) Volume increases

(B) Volume decreases

(C) Volume first increases then decreases.

(D) No change in volume.

43. The boiling point of alcohol is 78°C. What will be the temperature in Kelvin scale ?

(A) 373 K (B) 351 K

(C) 375 K (D) 78 K

44. Which of these choices will not change the state of matter?

(A) Temperature (B) Crushing a crystal

(C) Pressure (D) Electricity

45. Which of the following will respond to sublimation ?

(A) Common salt

(B) Sugar

(C) Camphor

(D) Potassium nitrate

46. The melting point of bromine is - 7°C and its boiling point is 59 °C. What is the state of bromine at room temperature?
(A) Liquid
(B) Solid
(C) Gas
(D) Mixture of liquid and gas

47. Dogs stretch out their tongues generally in summer because
(A) Evaporation leads cooling
(B) Of condensation of water vapour
(C) Of freezing of saliva
(D) Their body temperature are high

48. Arrange the following in the increasing order of forces of attraction :
(A) water, air, sugar
(B) O_2, H_2O, sugar
(C) salt, air, fruit juice
(D) sugar, oil, air

49. In which state of a substance, it has the shape ?
(A) Liquid (B) Liquid & Gas
(C) Gas (D) Solid

50. When the solid melts, its temperature :
(A) increases
(B) decreases
(C) remain constant
(D) first increases then decrease

ASSERTION-REASON

In the following questions , a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(A) If both assertion and reason are true and reason is the correct explanation of assertion.
(B) If both assertion and reason are true but reason is not a correct explanation of assertion.
(C) If assertion is true and reason is false.
(D) If both assertion and reason are false.

1. **Assertion :** Camphor disappears without leaving any residue.
Reason : Camphor undergoes sublimation.

2. **Assertion :** Liquids diffuse less easily as compared to gases.
Reason : Intermolecular forces are greater in gases.

3. **Assertion :** Ice floats on the surface of water.
Reason : The density of both water and ice is same.

4. **Assertion :** The intermolecular forces in solid state are stronger than those in the liquid state.
Reason : The space between the particles of matter is called intermolecular space.

5. **Assertion :** The rate of evaporation increases with increase in temperature.
Reason : Increase in temperature increases the kinetic energy of the particles.

FILL IN THE BLANKS

1. .....of water is very slow on a humid day.
2. .....occurs throughout the body of a liquid.
3. The conversion of a liquid into its vapour at its boiling point is called.....
4. The rate of evaporation of a liquid ..... with increases in humidity.
5. Evaporation of a liquid at its boiling point does not lead to.....
6. The process by which the liquid state of a substance changes into the gaseous state below its boiling point is called.....
7. Solid carbon dioxide is called.....
8. The kinetic energy of particles in the.....state of a substance is maximum.
9. When ice melts there is a ..... in volume.
10. The sun and stars glow because of the presence of .....in them.

TRUE OR FALSE

1. Matter does not exist without mass.

2. The gaseous state of a substance has the maximum fluidity.

3. A substance is said to be a solid when its melting point lies below the room temperature at the normal pressure.

4. Liquids with low boiling points have greater tendency to evaporate.

5. Cooling takes place when a boiling liquid evaporates.

6. Calcium carbonate cannot exist in the liquid or the gaseous state.

7. Hydrogen gas kept in a vessel spreads throughout the space of the vessel.

8. Temperature has no effect upon the rate of diffusion.

9. Interparticle space of the gas is low.

10. Evaporation is a bulk phenomena.

MATCH THE COLUMN

1. Match the names given in column A with the properties given in Column B.

	Column A	**Column B**
(a)	Naphthalene	(i) Solid
(b)	Mercury	(ii) Compressible
(c)	Stone	(iii) Sublimable
(d)	Sponge	(iv) Liquid
(e)	Wood	(v) Incompressible

2. Match the following and choose the correct answer.

Column A	**Column B**
(a) Evaporation	(i) Liquid to gas at a fixed temperature
(b) Vaporisation	(ii) Solid to gas
(c) Sublimation	(iii) Gas to solid
(d) Hoar frost	(iv) Liquid into gas at any temperature

VERY SHORT ANSWER TYPE QUESTIONS

1. Define matter.

2. What is plasma?

3. What is Bose-Einstein condensate [BEC]?

4. Why do we see water droplets on the outer surface of a glass container of ice cold water?

5. Define specific heat of substance.

6. Define latent heat of a substance.

7. Out of solid, liquid and gas which have definite volume but do not have fixed shape?

8. Give one example of cooling caused by evaporation in our daily life.

9. What is the boiling point of water is SI unit ?

10. A substance in incompressible even when it's sujbected to a very high pressure. What is the physical state of the substance ?

11. A substance has neither a definite shape nor a definite volume. Name the physical state of the substance.

12. Name the process that occurs when a pellet of camphor left exposed to air slowly disappears.

13. A drop of water when spilled on floor spreads out. What is this due to?

14. A liquid is converted into vapour below its boiling point. What is the process called?

15. What is the space between the particles of a matter called?

16. The temperature of a liquid at its boiling point if does not change. What is this due to?

17. Identify the physical state of matter in which layers of particles slip over each other.

18. Two solids A and B melt at 120°C and 150°C respectively. Which one of them has more intermolecular forces of attraction?

19. The rate of evaporation of a liquid decreases on a rainy day. Give reason.

20. Name the property which is shown by ammonium chloride but not by sodium chloride.

SHORT ANSWER TYPE QUESTIONS

1. Give reasons for the following observation:
The smell of hot sizzling food reaches you several metres away, but to get the smell from cold food you have to go close.

2. What produce more severe burns boiling water or steam?

3. Give two factors which determine the rate of diffusion of a liquid in another liquid.

4. Arrange the solids, liquids and gases in order of –
(A) increasing intermolecular space
(b) Increasing intermolecular force

5. Which phenomenon occurs during the following changes :
(a) Formation of clouds
(b) Drying of wet clothes
(C) Size of naphthalene balls decreases

6. A rubber band is a solid, but it can change its shape. Why ?

7. How much should be substracted from Kelvin temperature to convert a temperature from Kelvin to Celsius scale ?

8. What is diffusion ? Which diffuses more a soild or gas ?

9. What are liquids ? Give any two main characteristics of liquid state.

10. The kinetic energy of the particle in soild state is less than in the liquid state. Comment.

11. Why does water kept in earthen pot become cool during summer ?

12. Why does the temperature of a substance at its melting point show no change, even when it is being heated?

13. Explain why does food get quickly cooked in a pressure 'Cooker.

14. Why does an air cooler produce better cooling on a dry day?

15. Can a solid diffuse into another ? Give an example.

LONG ANSWER TYPE QUESTIONS

1. Give reasons :
(a) A gas fills completely the vessel in which it is kept.
(b) A gas exerts pressure on the walls of the container.

2. What is mean by evaporation? How is this process different from boiling?

3. Write any four factors which can decide the states of matter.

4. What is sublimation? Give an example with illustration.

5. How are particles of matter affected with increasing or reducing pressure on the matter at a given temperature?

ACTIVITY BASE QUESTION

1. What happens to the boiling point of a liquid when atmospheric pressure decreases ?

2. What happens to the melting point of ice when pressures is increased ?

3. What happens to the melting point of solids with the increases in pressure ?

4. What is the latent heat of fusion of ice ?

EXERCISE – II

1. When a tea spoon of solid sugar is dissolved in a glass of liquid water, what phase or phases are present after mixing ?
(A) Liquid only
(B) Still solid and liquid
(C) Solid only
(D) None of these

2. K.E. of molecular motion appears as
(A) pressure (B) P.E.
(C) temperature (D) all of these

3. Based on the statements given here choose the correct answer.
P. Some sugar can be added to a full glass of water without causing overflow.
Q. A liquid seems to be continuous even-though space is present between the molecules.
(A) P and Q are true and Q explains P
(B) P and Q are true but Q does not explain P
(C) Only P is true
(D) Only Q is true

4. The correct statement amongst the following is -
(A) Gases have high density rates.
(B) diffusion also takes place in liquids.
(C) diffusion of liquid and a gas is known as intimate mixing.
(D) all of these

5. When we put some crystals of potassium permanganate in a beaker containing water, we observe that after some time whole water has turned pink. This is due to
(A) boiling
(B) melting of potassium permanganate crystals
(C) sublimation of crystals
(D) diffusion

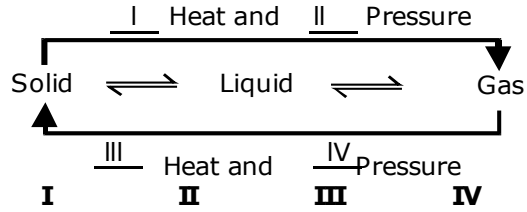
6. Non-reacting gases have a tendency to mix with each other. This phenomenon is know as -
(A) chemical reaction
(B) diffusion
(C) effusion
(D) explosion

7. Match the following and choose the correct answer :

a. Solid	I. Super energetic particles
b. Liquid	II. No shape nor fixed volume at a given pressure
c. Gas	III. Has definite shape
d. Plasma	IV. Definite volume with less molecular forces than that in solids.

(A) a-i, b-ii, c-iii, d-iv
(B) a-iii, b-iv, c-ii, d-i
(C) a-iii, b-iv, c-i, d-ii
(D) a-i, b-iv, c-ii, d-iii

8. What are I, II, III and IV ? **[NSO-2014]**



	I	II	III	IV
(A)	Increase	Increase	Decrease	Decrease
(B)	Decrease	Decrease	Increase	Increase
(C)	Increase	Decrease	Decrease	Increase
(D)	Decrease	Increase	Decrease	Increase

9. The process of evaporation is employed to separate a substance from its mixture if :
(A) substance is soluble in water
(B) substance is soluble in water but does not decompose on heating
(C) substance is soluble in water but can decompose on heating
(D) substance is soluble in water but sublimes on heating

10. Which of the following apparatus is required to determine the boiling point of water ?
(A) Tripod stand, conical flask, thermometer, wire gauze, stand with clamp, pair of tongs
(B) Funnel, burner, clamp and stand, test tube, thermometer, wire gauze, stand with clamp.
(C) Boiling tube beaker, thermometer, burner, cork with one hole, stand with clamp, wire gauze.
(D) Round bottom flask, burner, thermometer, wire gauze, stand with clamp, cork with two holes, glass tube.

11. In order to find the boiling point of water, one of the precautions is that the bulb of the thermometer should not touch the side of the beaker. This precaution is taken beause:
(A) Sides of the beaker are at slightly higher temperature
(B) Sides of the beaker are at slightly lower temperature
(C) The bulb of the thermometer is likely to break
(D) None of these

12. In the determination of the melting point of ice, the ice is contaminated with some non-volatile impurities like common salt. The melting point of ice will.
(A) increase
(B) decrease
(C) not change
(D) may increase or decrease

13. The water boils when :
(A) Saturated vapour pressure of water becomes equal to the atmospheric pressure
(B) Boiling point of water becomes more than atmospheric pressure
(C) Saturated vapour pressure of water is less than atmospheric pressure
(D) Vapour pressure of water becomes more than atmospheric pressure

14. 250 mL milk + 770 cubic meter milk =
(A) 1020 mL
(B) 1020 cubic meters
(C) 250.00077 mL
(D) 770.00025 cubic meters

15. Anne filled 1L of air in a jar of capacity 750 ml. Volume of air in the jar is
(A) 1000 mL (B) 875 mL
(C) 750 mL (D) 250 mL

16. Energy of particles in steam at 373 K
(A) > Energy of particles in water at 373K.
(B) < Energy of particles in water at 373 K.
(C) = Energy of particles in water at 373 K.
(D) Energies cannot be compared.

17. Rate of evaporation is highest in
(A) an open vessel of diameter 25 cm.
(B) an open vessel of diameter 30 cm.
(C) an open vessel of diameter 27.5 cm.
(D) an open vessel of radius 26 cm.

18. The boiling point of a gas is –80°C. This temperature is equivalent to -
(A) –93 K (B) 193 K
(C) 353 K (D) –353 K

19. A diver is able to cut through water in a swimming pool. It illustrates that
(A) Particles of liquids have space in between them
(B) Particles of liquids possess kinetic energy
(C) Particles of liquids have weak attractive forces
(D) Both (A) and (C)

20. Read the given passage and fill in the blanks by selecting an appropriate option. __(i)__ is highest in solids while __(ii)__ is highest in gases. Gases and liquids both have high __(iii)__ .

	(i)	**(ii)**	**(iii)**
(A)	Fluidity	Density	Compressibility
(B)	Density	Fluidity	Rigidity
(C)	Rigidity	Fluidity	Density
(D)	Rigidity	Compressibility	Fluidity

21. Which of the following statement are correct?

I. Temperature changes during the change of a state.

II. Dry ice gets converted directly into gaseous state under normal atmosphere conditions

III. Higher boiling point of liquid indicates weaker intermolecular forces.

IV. Latent heat of vaporisation is generally higher than the latent heat of fusion for a substance.

(A) I and IV only (B) II and IV only

(C) II and III only (D) III and IV only

22. Read the given statements and mark the correct option. **[NSO-2016]**

Statement 1 : Pieces of dry ice gradually get smaller when left at room temperature.

Statement 2 : Dry ice undergoes sublimation.

(A) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.

(B) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.

(C) Statement 1 is true and statement 2 is false.

(D) Both statements 1 and 2 are false.

23. Select the incorrect statements(s).

I. Rapid formation and breaking of bubbles in the bulk of a liquid being heated is called evaporation.

II. The spreading out and mixing of a substance with another substance due to motion of its particles is called diffusion.

III. Petrol evaporates faster than water because interparticle forces are stronger in water.

IV. Ice-cream feels colder than ice cold water because of latent heat of fusion.

(A) I and IV only

(B) I only

(C) II, III and IV only

(D) III and IV only

24. Which of the following correctly represents the given substances in increasing order of kinetic energy of their particles ?

(A) Brick, water, air, honey

(B) Honey, water, air, brick

(C) Air, water, honey, brick

(D) Brick, honey, water, air

25. An organic compound 'X' has a melting point of –33°C and a boiling point of 66°C. Which of the following is true about this substance?

(A) At –100°C, X exists in solid state.

(B) At 0°C, X exists in liquid state.

(C) At 90°C, X exists in gaseous state.

(D) All of these

26. Choose the correct statements about the plasma state of matter.

I. Plasma state consists of super energetic and super excited particles.

II. The particles of plasma state are in the form of ionised gases.

III. The plasma is created on stars.

IV. Colour of plasma glow depends on the temperature of gas only.

(A) I, II & III only (B) I & II only

(C) II & III only (D) I, II, III & IV

27. A thermometer is inserted into a beaker filled with ice at 0ºC. The beaker is heated slowly. The temperature does not rise for some time. This is because -

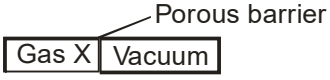
(A) ice is very cold

(B) heat was used for changing ice at 0ºC to water at 0ºC

(C) the density of water is more than ice

(D) the density of water is less than the ice

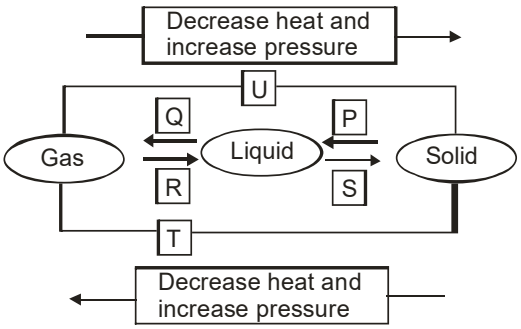
28. The given apparatus is used to study the diffusion of a number of gases at the same temperature and pressure.



Which of the following pairs of gases would diffuse into the vacuum at the same speed ? [Given: Atomic mass of H = 1u, C = 12u, N = 14 u, S = 32 u, O = 16 u]

(A) NH_3 and H_2 (B) CO and SO_2
(C) CO and N_2 (D) NH_3 and N_2

29. Observe the given diagram showing changes in states of matter carefully. **[NSO-2016]**



Which of the following is correct identification for processes P to U ?

(A) Q → Vaporisation, S → Liquefication, U → Solidification
(B) P → Melting, Q → Condensation, S → Solidification
(C) S → Sublimation, P → Liquefication, U → Solidification
(D) P → Fusion, R → Condensation, T → Sublimation

30. Solid $\underset{b}{\overset{a}{\rightleftharpoons}}$ Liquid $\underset{d}{\overset{c}{\rightleftharpoons}}$ Gas

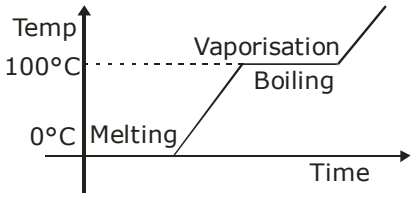
a, b, c and d are respectively

(A) a-sublimation, b-condensation, c-solidifiation, d-fusion
(B) a-sublimation, b-condensation, c-fusion, d-solidification
(C) a-fusion, b-sublimation, c-vaporisation, d-condensation
(D) a-fusion, b-solidification, c-vaporisation, d-condensation

EXERCISE – III

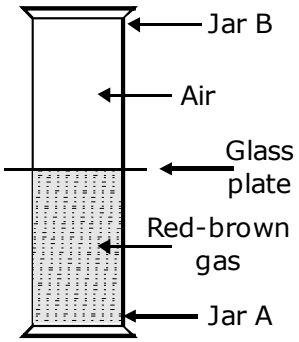
1. Based on the statement given here choose the correct answer.
P. If e increase the temperature of a gas inside a container, its pressure also increase.
Q. Upon heating, the rate of collisions of the gas molecules increase and increase the impact of force on the walls of the container.
(A) Both P & Q are true and Q explains P.
(B) Both P and Q are true but Q does not explain.
(C) Only P is true
(D) Only Q is true

2. In an experiment of conversion of ice into water and water into vapour, observations were recorded and a graph was plotted for temperature against time as shown below. From the graph it can be concluded that **[NSEJS - 2013]**



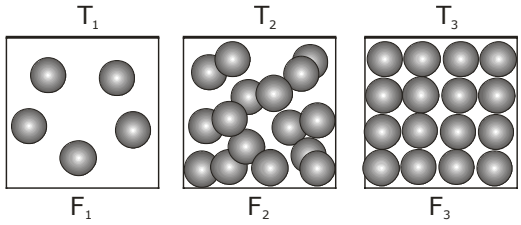
(A) ice takes time to heat up to 0°C.
(B) during melting and boiling temperature does not rise.
(C) process of boiling takes longer time than the process of melting.
(D) all of these

3. If we remove the glass plate, the process taking place is -



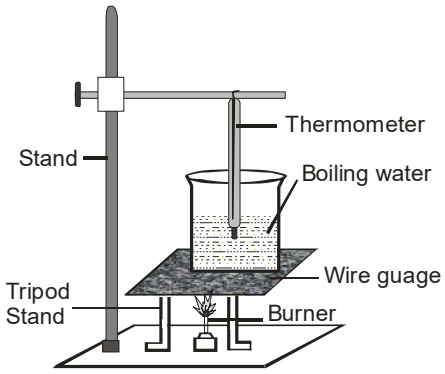
(A) condensation (B) sublimation
(C) diffusion (D) evaporation

4. The microscopic view of three different substances are shown in the given diagram. Where T_1, T_2 and T_3 are temperature and F_1, F_2 and F_3 are the forces of attraction of the particles of the respective states. Choose the correct order among the following.

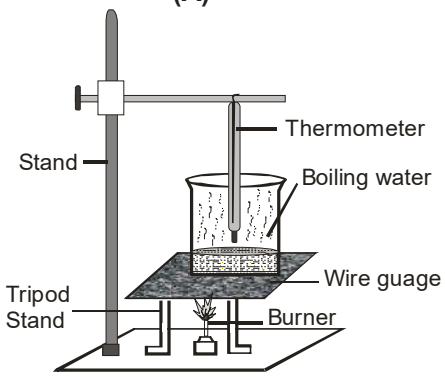


(A) $T_1 < T_2 < T_3$ and $F_1 < F_2 < F_3$
(B) $T_1 > T_2 > T_3$ and $F_1 > F_2 > F_3$
(C) $T_1 < T_2 < T_3$ and $F_1 > F_2 > F_3$
(D) $T_1 > T_2 > T_3$ and $F_1 < F_2 < F_3$

5. Two students Arpit and Rakshita are asked to arrange the apparatus to determine the boiling point of water. They arranged the apparatus as shown below by figures A and B respectively : **[NTSE Stage 2 - 2014]**



(A)



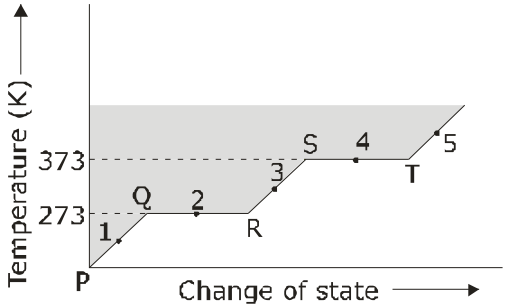
(B)

The diagram in which the apparatus is correctly arranged is :
(A) A only
(B) B only
(C) both A and B
(D) neither A nor B

6. A thermometer has 20 equal divisions between 90ºC and 100ºC marks. A student while determining the boiling point of water finds that the mercury thread becomes stationary at the 19th mark above 90ºC. He should record the boiling point of water as:
(A) 90.19°C (B) 99.5°C
(C) 109°C (D) 119°C

7. Which of the following represents the correct increasing order of the densities of given substances ?
(A) Cotton < Exhaust from chimneys < Honey < Iron < Air
(B) Air < Exhaust from chimneys < Cotton < Honey < Iron
(C) Cotton < Air < Exhaust from chimneys < Iron < Honey
(D) Air < Cotton < Exhaust from chimneys < Iron < Honey

8. Study the given heating curve of substance X carefully and select the correct statement.



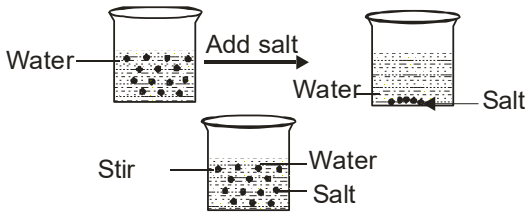
(A) Substance X exists in solid state at point 1, in liquid state at point 3 and in gaseous state at point 5.
(B) QR represents latent heat of fusion, while ST represents latent heat of vaporisation.
(C) At QR, matter exists both in solid and liquid states, while at ST matter exists both in liquid and gaseous states.
(D) All of these

9. Match column I with column II and select the correct option from the given codes.

Column I	Column II
P. Hot tea poured in saucer gets cooled faster	**(i)** Evaporation increases with increase in temperature.
Q. We feel more cold after a hot water bath than a cold water bath.	**(ii)** Evaporation increases with decrease in humidity.
R. Water remains cool in earthen pitcher during dry hot day.	**(iii)** Evaporation increases with increase in wind speed.
S. We feel comfortable under a moving fan in summer.	**(iv)** Evaporation increases with increase in surface area.

(A) P-(ii), Q-(i), R-(iii), S-(iv)
(B) P-(iii), Q-(iv), R-(ii), S-(i)
(C) P-(iv), Q-(i), R-(ii), S-(iii)
(D) P-(iv), Q-(ii), R-(iii), S-(i)

10. An experiment is performed as shown in the given figure. **[NSEJS - 2015]**



The conclusion we can draw from the given experiment is that
(A) Nature of matter is continuous
(B) Matter is madeup of particles
(C) Particles of salt get into the spaces
(D) Both (B) and (C).

11. Fill in the blanks P, Q, R and S left in the table with appropriate words.

Properties	Solid	Liquid	Gas
Interparticle spaces	Very less	Comparatively large	P
Intermolecular forces	Q	Weak	Very weak
Compressibility	R	Very small	High
Diffusion	Negligible	S than gases	Very fast

	P	Q	R	S
(A)	Very large	Strong	Negligible	Slower
(B)	Large	Weak	Small	Faster
(C)	Less	Strong	High	Slower
(D)	Large	Strong	Strong	Faster

12. A brief information about three substances is given in the table.

Substance	Melting point	Boiling point
P	23°C	60°C
Q	10°C	20°C
R	65°C	110°C

Which of the following is correct about these substances ?

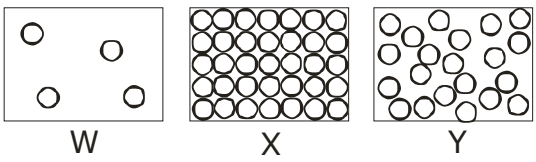
(A) At room temperature, substance P will have fixed volume but no fixed shape.

(B) At room temperature substance Q will have maximum space between the particles

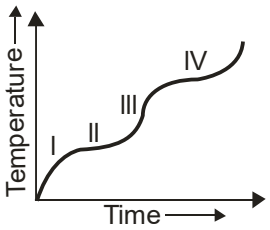
(C) At room temperature substance R will have strongest interparticle forces.

(D) None of these

13. Diagrams W, X and Y show how the particles of a substance are packed at different temperaure. **[NTSE Stage 2 - 2016]**



The given graph shows the temperature changes which occur on warming the substance.

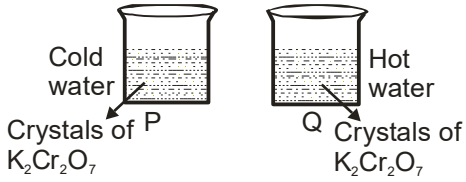


In which region of the graph would all the particles be packed as in Y ?

(A) I (B) II

(C) III (D) IV

14. The crystals of $K_2Cr_2O_7$ give reddish orange color when dissolved in water. What will you observe when crystals are dropped in water in the given two cases after 10 seconds ?



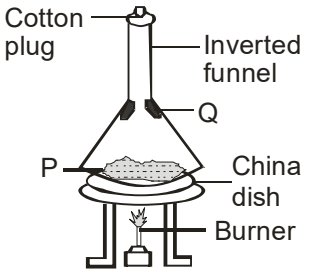
(A) Intensity of color in beaker P < intensity of colour in beaker Q

(B) Intensity of color in beaker Q < Intensity of color in beaker P

(C) Intensity of colour does not depend upon the temperature of the water

(D) Both have same intensity

15. Identify P and Q in the given figure.



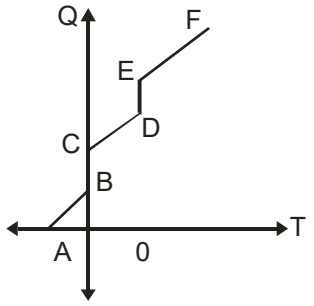
(A) P - Mixture of camphor and anthracene
Q - Solid anthracene
(B) P - Mixture of sugar and water
Q - Solid sugar
(C) P - Mixture of sugar and anthracene
Q - Solid anthracene
(D) P - Mixture of sugar and Na_2SO_4
Q - Solid Na_2SO_4

16. Match the following:

Column I	**Column II**
(a) Maximum diffusion	(i) Sublimable
(b) Sweating	(ii) Solid state
(c) Ammonium chloride	(iii) Diffusion
(d) Maximum density	(iv) Matter
(e) Intermixing of particles of two different types of matter on their own	(v) Gaseous state
(f) Has mass and volume	(vi) Cooling effect

(A) a-(v), b-(vi), c-(i), d-(ii), e-(iii), f-(iv)
(B) a-(v), b-(i), c-(vi), d-(iii), e-(ii), f-(iv)
(C) a-(v), b-(vi), c-(i), d-(ii), e-(iv), f-(iii)
(D) a-(v), b-(vi), c-(iv), d-(i), e-(ii), f-(iii)

17. During the phase transition of a substance the temperature (T) versus heat energy (Q) graph is shown below. Identify the regions of the graph which show an increase in only PE.



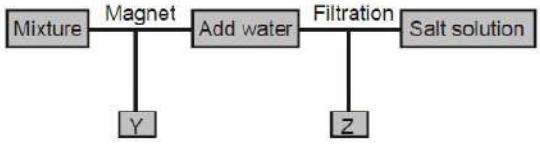
(A) AB, BC (B) BC, DE
(C) CD, EF (D) All of regions

18. A gaseous mixture of A, B and C is passed through water. The gaseous mixture B and C remains. If this gaseous mixture of B and C is subjected to sudden expansion followed by application of high pressure, B liquifies leaving behind C. Identify the set of gases.
(A) SO_3, NO_2, O_2 (B) Cl_2, SO_2, H_2
(C) CO_2, CO, N_2 (D) NH_3, N_2, H_2

19. A mixture of three liquids X, Y and Z when subject to fractional distillation, the order in which the vapours condense back to liquid state in fractionating tower is Y, X and Z. Arrange them in the correct order of vapour pressure.
(A) Z < X < Y (B) Y < X < Z
(C) X < Z < Y (D) X < Y < Z

20. Arrange the following changes of energy during following phase transition in a proper order.
Ice (0°C) → water (50°C) → ice(0°C)
(A) potential energy increase and kinetic energy remains constant
(B) potential energy decrease and kinetic energy remains constant
(C) potential energy increase and kinetic energy increase
(D) potential energy decrease and kinetic

21. The class teacher conducted an experiment in the class to separate the constituents of a mixture. The flow chart of the process is shown here. What are Y and Z respectively?

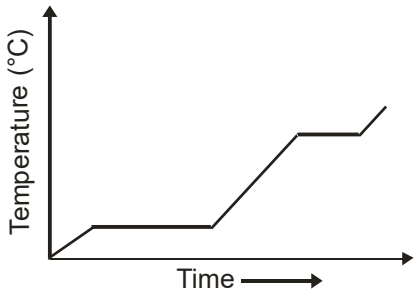


(A) Iron nails and sugar
(B) Sugar and salt
(C) Iron nails and sand
(D) Sand and salt

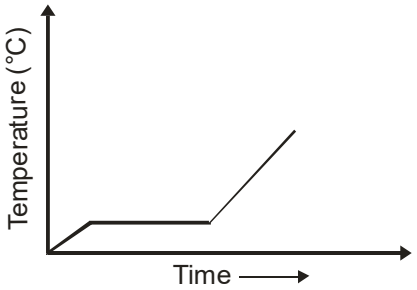
22. Charring of sugar in concentrated sulphuric acid is due to **[IJSO-Stage-I/2012-13]**
(A) Oxidation of sugar
(B) Reduction of sugar
(C) Hydrolysis of sugar
(D) Dehydration of sugar

23. Ice at -10°C is heated slowly until water formed start boiling. What kind of temperature-time graph will explain the correctly? **[NSTSE-2015]**

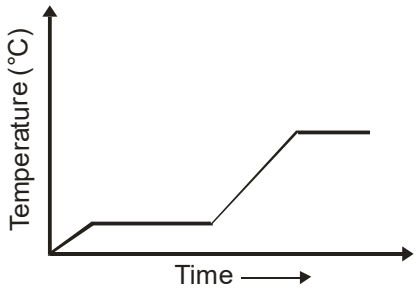
(A)



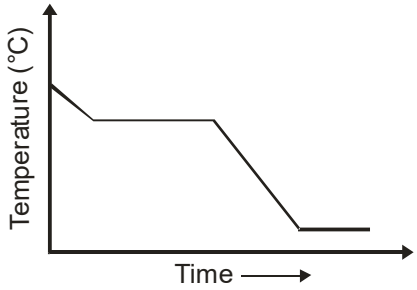
(B)



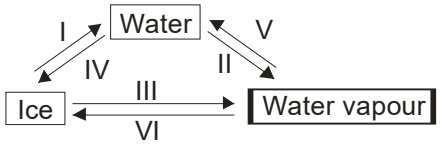
(C)



(D)



24. Observe the given figure carefully.



Which of the following statements is incorrect? **[NSO-2016]**

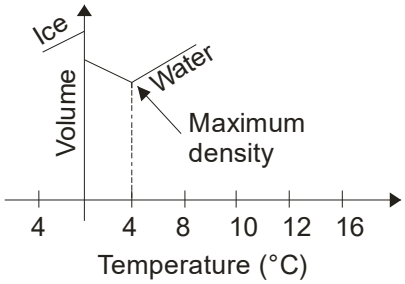
(A) Processes I, II and III are endothermic while processes IV, V and VI are exothermic.

(B) Water vapours formed during process II when come in contact with skin give out 22.5×10^5 J/kg more heat than the boiling water.

(C) Latent heat for process I is 3.34×10^5 J/kg

(D) None of these

25. Study the graph and select the correct statement. **[NSTSE-2017]**



(A) When water is cooled to 4°C, it contracts

(B) At 0°C, water freezes

(C) Volume of ice > volume of water

(D) All of these

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BIOLOGY

CLASS - IX

BOOKLET - 1

CONTENTS

FUNDAMENTAL UNIT OF LIFE

TISSUES

IMPROVEMENT IN FOOD RESOURCES

ANSWER KEY

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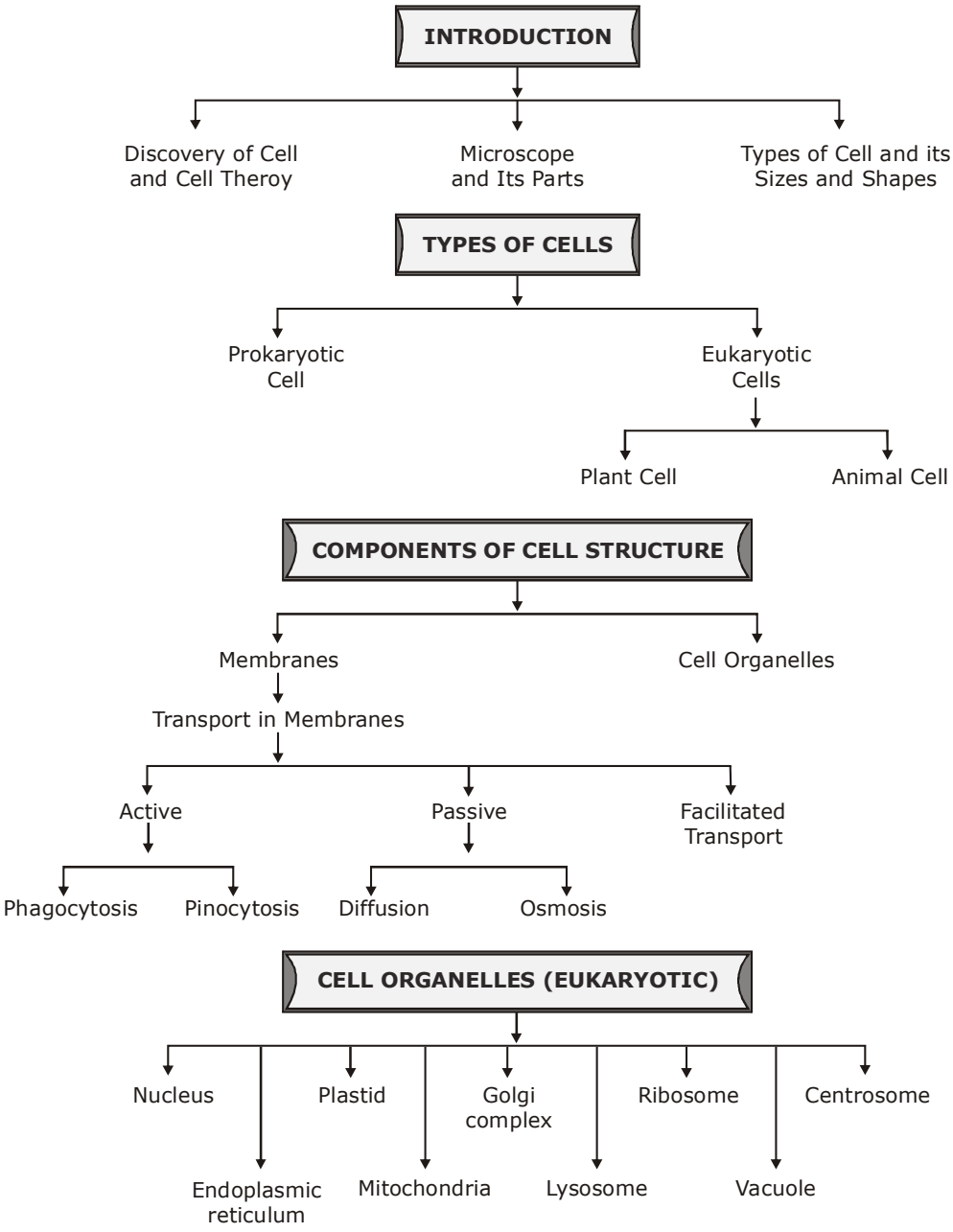
CHAPTER 1

FUNDAMENTAL UNIT OF LIFE



INTRODUCTION

Inspite of much diversity in the Living organisms with regard to structure, functions, habitat, habits etc one thing is common in all of them without exception is that they all are made up of cell (single cell or numerous cell). The word cell is derived from latin word **"cellula"** meaning small room.

A cell may be defined as the smallest unit of structure and functions of living organisms.

Smallest 'unit of structure' means, the smallest structures by the union of which the body of an organism is constructed.

'Unit of function' means any function performed by an organism or organ is the activity of its constituent cells. The cell may also be defined as a small speck of nucleated protoplasm bounded by cell membrane or plasma membrane, and is capable of independent existence and perpetuation.

CYTOLOGY

The cell and its structures are studied under a branch of biology called cytology.

Definition :- The structural & functional unit of living beings is called cell.

DISCOVERY OF CELL

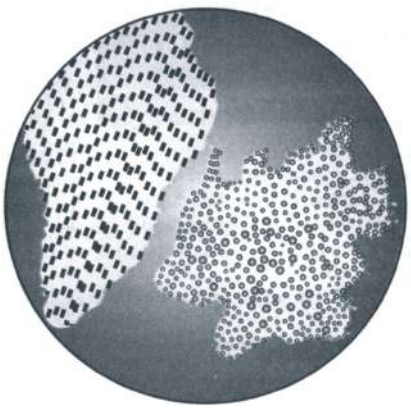
1. **Robert Hooke (1665) :–** An English man and first curator of **Royal society of London** observed a thin transverse section of bark of a tree under self designed microscope.

   He noticed **honey - comb like compartments.**

   He coined the term cell .

   He wrote a book - **Micrographia.**

   He actually observed dead cells.



Cork section shown in Robert Hooke's Microscope

2. **Antonie Van Leeuwenhoek (1674)** was first to observe living cells like bacteria [from tartar of teeth], erythrocytes [fish].
3. **N. Grew (1682) :–** Proposed cell concept which states that **cell is the unit of structure of organisms.**
4. **Cell is called structural & functional unit of life because –**
   (A) All the living organisms are composed of one or more cells.
   (B) All the cells have similar basic structure.
   (C) Similar cell organelles of different cells perform similar functions.
5. **Purkinje** (1839) coined the term **'protoplasm'** for the fluid substance of the cell.
6. **Knoll and Ruska (1932)** of Germany designed the electron microscope which was employed to study the ultrastructure (fine structure) of cell and various cell organelles in 1940s.

MICROSCOPE

It is an instrument which is used to study those objects that cannot be seen with the naked eye or with the help of a hand lens. A microscope has more than one lens. The 1st compound microscope was built by **F. Janssen and Zacharias Janssen (1590).**

1. STRUCTURE OF MICROSCOPE: The microscope used in schools is called compound microscope, a compound microscope has following parts:

(A) Base: It is the basal, metallic, horse-shoe shaped structure. It bears the whole weight of microscope.

(B) Handle: It is the curved part to hold the microscope. It is also called as arm.

(C) Stage: It is a strong metallic, rectangular, horizontal plate fixed to the handle.

(D) Stage Clips: Two clips are attached to stage used for holding the slide in position.

(E) Condenser: Condenser is present below the stage for concentrating the light rays.

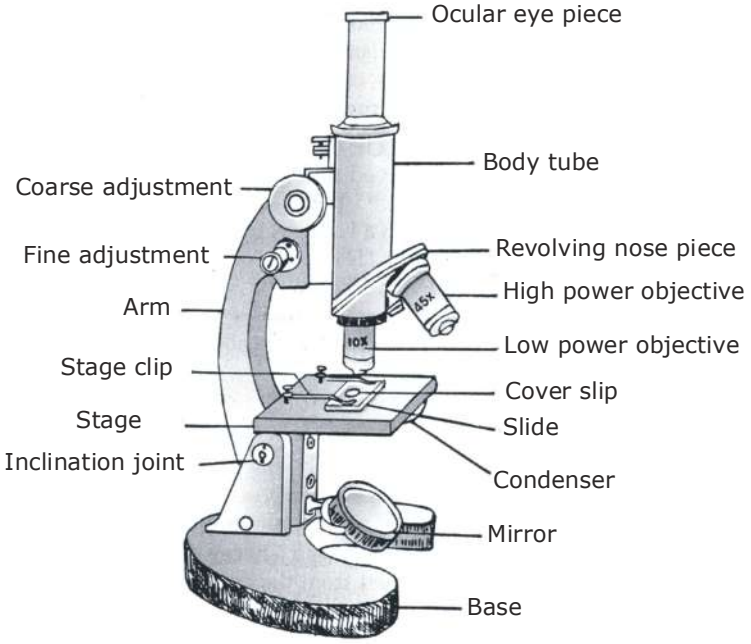
(F) Body tube: It is wide, hollow tube attached to the upper part of the arm. To this tube lenses are attached.

(G) Adjustment Screw:

(i) Coarse adjustment: It is bigger sized screw used to move the body tube up and down.

(ii) Fine adjustment: It is a smaller sized screw for fine focussing.

(H) Reflecting Mirror: It is meant for reflecting the light rays, so that light passes through the object which is to be seen.



Parts of an ordinary compound microscope

CELL THEORY

Schleiden (1838) and **Schwann(1839)** together formulated the cell theory. This theory however, did not explain as to how new cells were formed. **Rudolf Virchow** (1855) first explained that cells divided and new cells are formed from pre-existing cells **(Omnis cellula-e cellula)**. He modified the hypothesis of **Schleiden and Schwann** to give the cell theory a final shape. Cell theory as understood today is:

1. **All plants and animals are composed of cells.**
2. **Cells are the basic unit of life.**
3. **All cells arise from pre-existing cells.**

Note: Viruses are the exception of cell theory.

Info Bubble

- Viruses lie on the borderline, separating the living organisms from the non-living things. They are considered neither living nor non- living and thus are acellular.
- Viruses are acellular i.e., they lack cytoplasm and membrane-bound cell organelles. They do not have their own metabolic machinery. Hence, they do not show characteristics of life until they enter any living cell. Viruses use cellular machinery of the host for their multiplication.

CELL SIZE AND SHAPE

1. **Size of cell –** Normal size in human 20 µm to 30 µm in diametre.
   - **(A) Largest cell :** In animals – Ostrich egg [15 cm is diametre]
     In plants – *Acetabularia* [6-10 cm]
   - **(B) Longest cell :** In animals – Nerve cell [upto 1mt]
     In plants – Hemp fibre
   - **(C) Smallest cell :** PPLO – Pleuro Pneumonia Like Organism [***Mycoplasma*** – 0.1 to 0.5 µm.]

2. **Shape of cell –** Shape of cell mainly depends upon the specific function it performs.
   - (A) Elongated – Nerve cell
   - (B) Discoidal/saucer – RBC
   - (C) Spindle – Muscle cell
   - (D) Spherical – Eggs.
   - (E) Branched – Pigment cell of the skin.
   - (F) Slipper shaped – *Paramecium*
   - (G) Cuboidal – Germ cells of gonads.
   - (H) Polygonal – Liver cells.

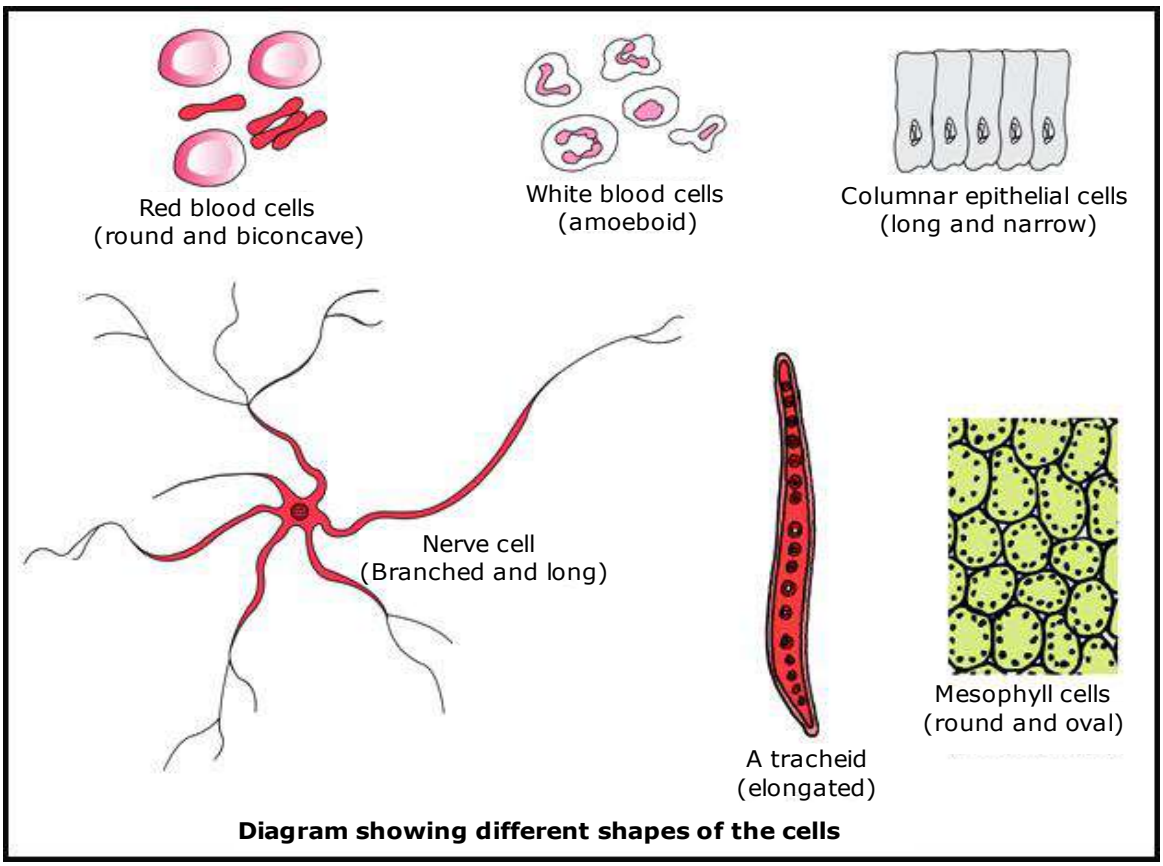
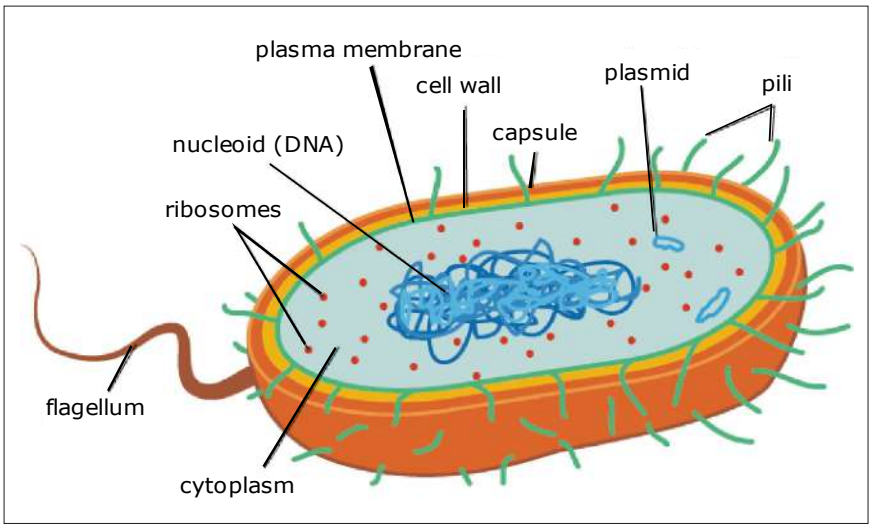


Diagram showing different shapes of the cells

TYPES OF CELL

1. ON THE BASIS OF TYPE OF ORGANIZATION, CELLS ARE OF TWO TYPES:

(A) Prokaryotic cells: These are primitive and incomplete cells, they have less developed nucleus without nuclear membrane and nucleolus e.g. Bacteria.



(B) Eukaryotic cells: These are well developed cells. They have advanced nucleus with nuclear membrane. Example plant & animal cells.

2. ON THE BASIS OF DIFFERENTIATION:

(A) Undifferentiated: These are unspecialized cells by which mitotic divisions give rise to new cells for the formation and maintenance of tissues.

(B) Differentiated: These are specialized cells formed from the unspecialized cells by change in structure and function during development and growth of an organism.

(C) Dedifferentiated: These are specialized cells reverted to a more generalized (embryonic, actively dividing state. Dedifferentiation often occurs for regeneration.

3. ON THE BASIS OF NUMBER OF CELLS ORGANISMS CAN BE CATEGORIZED AS :

(i) Unicellular organisms : These are organisms which made up of single cell only. This single cell Performs all the vital body functions of an organism. E.g. Amoeba.

(ii) Multicellular organisms : These are the organisms which made up of numerous cells. These cells then combine to form an organ and group of organs performing different functions forms an organ system which further forms an organism. E.g. plants and animals.

DIFFERENCES BETWEEN PLANT CELL & ANIMAL CELL

	PLANT CELL	ANIMAL CELL
1.	The plasma membrane of a plant cell is surrounded by a rigid cell wall made up of cellulose.	Cell wall is absent.
2.	Plastids (leucoplasts, chloroplasts, chromoplasts) are present in plant cells.	Plastids are absent.
3.	Vacuoles are present in abundance. They are larger in size.	Vacuoles are less in number and smaller in size.
4.	Plant cells have many simpler units of Golgi complex, called **dictyosomes**.	Animal cells have a single highly elaborate Golgi complex.
5.	Centrioles have not been found in plant cells (except in a few lower plants).	Animal cells possess centrioles.
6.	Cytokinesis takes place by cell-plate formation.	Cytokinesis takes place by constriction during cell division.

DIFFERENCES BETWEEN PROKARYOTIC & EUKARYOTIC CELLS

Feature	Prokaryotic cell	Eukaryotic cell
Cell size	Average diameter 0.5-5μm	Diameter varies between. 1μm-40 μm
Protoplasm	Relatively rigid, resistant to desiccation (drying) and can withstand wide changes in pressure and temperature.	More fluid and sensitive to drying and to changes in temperature and pressure.
Nucleus	**Lacks true nucleus**; circular DNA lies naked in the cytoplasm, no chromosomes, nucleolus or nuclear membrane, **nucleoplasm** undifferentiated from cytoplasm.	**True nucleus** bound by nuclear membrane contains linear DNA associated with proteins and RNA (forming chromosomes), nucleolus and nuclear membrane present, nucleoplasm distinct.
Organelles	Membrane-bound organelles like Golgi bodies, plastids, mitochondria and Endoplasmic Reticulum (ER) are absent.	Membrane-bound organelles are present.
Cell division	Divides by simple fission, spindle is not formed, no mitosis and meiosis.	Divides by mitosis or by meiosis.
Respiration	Respiratory enzymes are located on the plasma membrane.	Mitochondria are the site of aerobic respiration.
Photosynthesis	No organized chloroplast, photosynthesis takes place on photosynthetic membranes which lie freely in the cytoplasm.	Organized chloroplasts (containing stacked membranes called grana) take part in photosynthesis.
Examples	Bacteria and cyanobacteria (blue-green algae).	Plant and Animal cell.

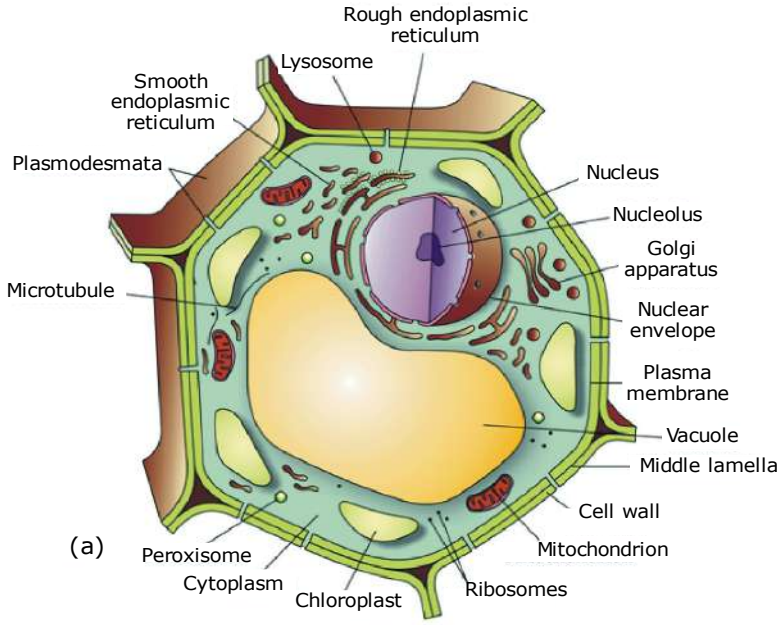


Figure : - Plant cell

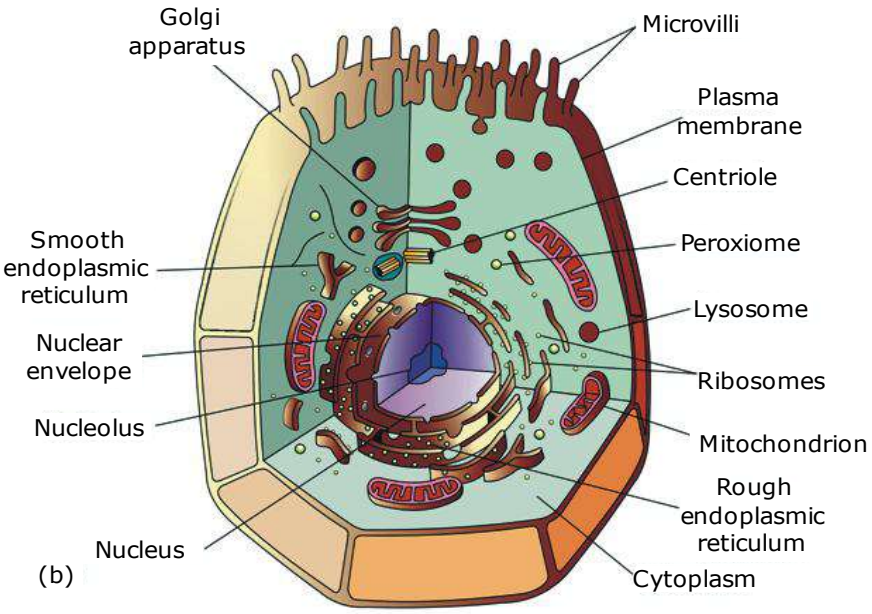


Figure : - Animal Cell

PRACTICE YOUR CONCEPTS

1. The smallest cell in the living world is–

(A) Ostrich egg (B) Mycoplasma

(C) Nerve cell (D) Cork cell

2. The shape of an erythrocyte is–

(A) Spherical (B) Polygonal

(C) Discoidal (D) Cuboidal

3. Which of the following is a unicellular organism ?

(A) *Spirogyra*

(B) *Amoeba*

(C) *Rhizopus*

(D) *Mucor*

4. Electron microscope was developed by–

(A) Robert Hooke

(B) Purkinje

(C) Huxley

(D) Knoll and Ruska

5. The idea *'Omnis cellula-e-cellula'* which means that all living cells arise from pre-existing cells was given by–

(A) Robert Brown

(B) Rudolf Virchow

(C) Purkinje

(D) Schleiden

[Sol : 1. (B), 2. (C), 3. (B), 4. (D), 5. (B)]

COMPONENTS OF A CELL

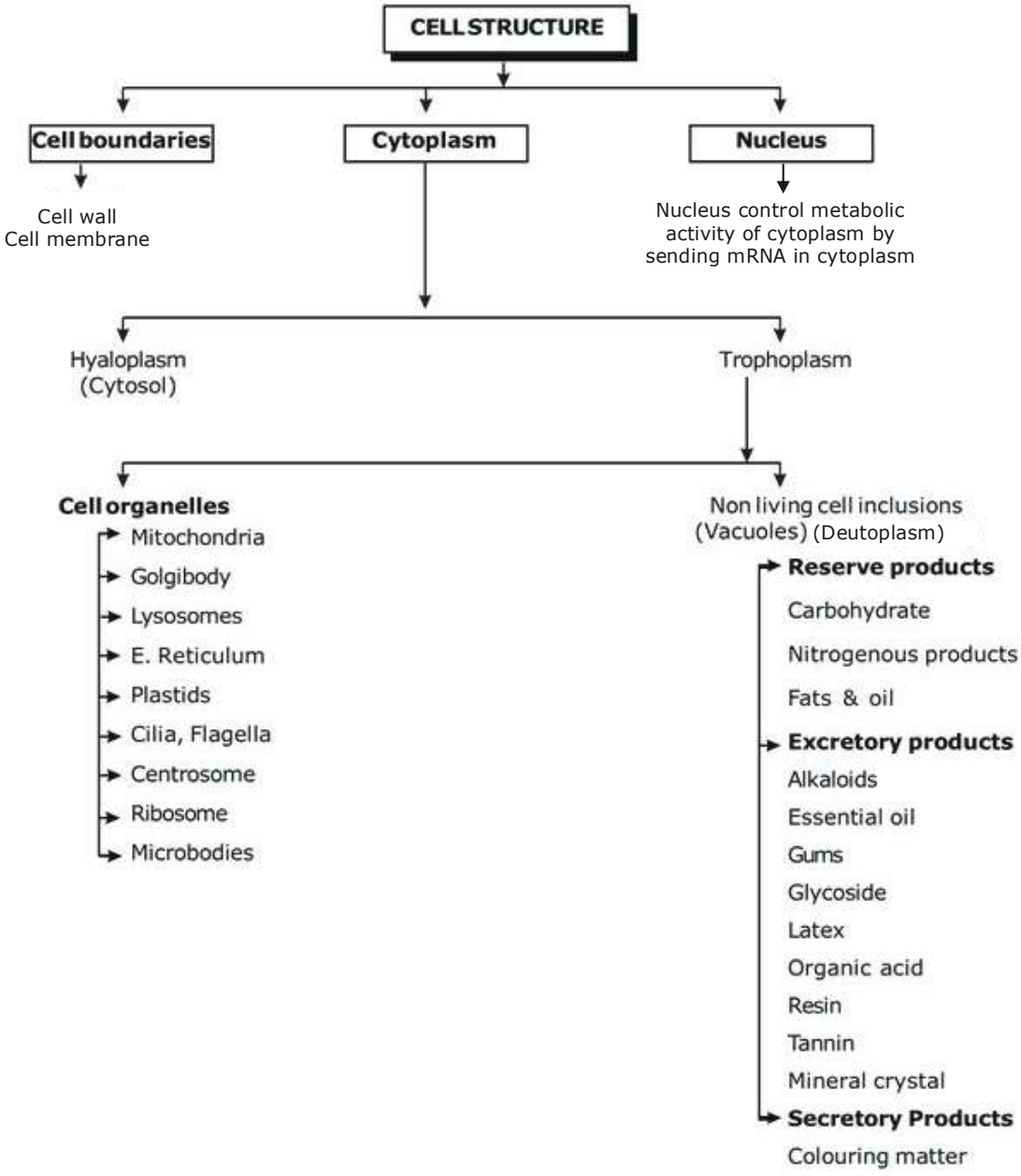
There is an occurrence of division of labour within a cell as they all got certain specific components called "Cell organelles" each of them performs a specific function.

The three basic components of all the cells are

(i) PM (Plasma Membrane)

(ii) Nucleus

(iii) Cytoplasm



TYPES OF MEMBRANES

1. **IMPERMEABLE MEMBRANE :-** If the membrane does not allow passage of substances (solvent and solute) through it.
2. **PERMEABLE MEMBRANE :-** If the membrane allows free passage of solute and solvent through it.
3. **SEMIPERMEABLE MEMBRANE :-** If the membrane allows passage to solvents but prevents the passing of solutes.

4. SELECTIVELY PERMEABLE MEMBRANE :- If the membrane allows the passage of solvent and few selected solutes.

5. ADVANTAGE OF SEMIPERMEABILITY MEMBRANE :- Semipermeability ensures that

(A) The useful molecules enter the cell,

(B) The metabolic intermediates remain within the cell

(C) The secretions and wastes leave the cell.

Thus, semipermeability of cell membranes enables the cell to maintain homeostasis, i.e., a constant internal environment inspite of the changes outside it.

The substances generally drawn in the cell include :

(i) Raw materials for metabolism, viz. food stuffs, water, salts and oxygen.

(ii) Regulatory substances, e.g., vitamins and hormones.

The substances generally turned out of the cells include :

(i) The products of metabolism, namely, nitrogenous wastes and carbon dioxide.

(ii) Secretions.

Following mechanisms are involved in the entry or exit of various materials across plasma membrane.

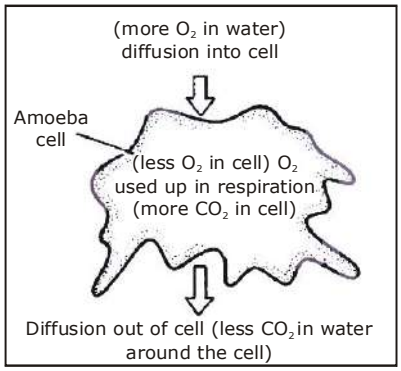
(i) Physical Processes :- These processes are slow and do not expend energy. These occur down the concentration gradient and do not use carrier proteins. Physical processes include.
(i) Diffusion (ii) Osmosis.

(ii) Biological processes :- These processes are rapid and often use energy in the form of ATP. These can occur down as well as against the concentration gradient and often use carrier proteins. Biological processes include:-

- Mediated transport
  (A) Facilitated transport / diffusion (B) Active transport
- Endocytosis (Pinocytosis and Phagocytosis)
- Exocytosis

6. DIFFUSION :- The process by which a substance uniformly spreads into another substance by random movement of its particles from a region of higher concentration to a region of its lower concentration due to their kinetic energy is called diffusion.

It is faster in gaseous phase than in liquid phase or solid phase.



Significance of diffusion :-

(A) Diffusion helps in the distribution of various substances throughout the cytoplasm of the cell without much delay.

(B) It helps in the exchange of respiratory gases (oxygen and carbon dioxide) between the body cells and their environment.

(C) Various materials such as gases, liquids and solids dissolve in the medium, i.e., air or liquid by diffusion.

(D) Loss of water in vapour form from the aerial parts of the plants (transpiration) occurs through diffusion.

(E) Flowers of plants spread aroma through diffusion. It attracts insects and other animals for pollination.

7. OSMOSIS :- The diffusion of water or solvent through a semipermeable membrane from a solution of lower concentration of solutes to a solution of higher concentration of solutes to which the membrane is relatively impermeable is called osmosis.

Osmosis is of two types :

(A) Endosmosis : It is the entry of water molecules into the cells through semipermeable plasma membrane when surrounded by hypotonic solution.

(B) Exosmosis : It is the exit of water molecules from the cells through semipermeable plasma membrane when surrounded by hypertonic solution.

ACTIVITY - 1

Experiment : Demonstration of osmosis in the laboratory.

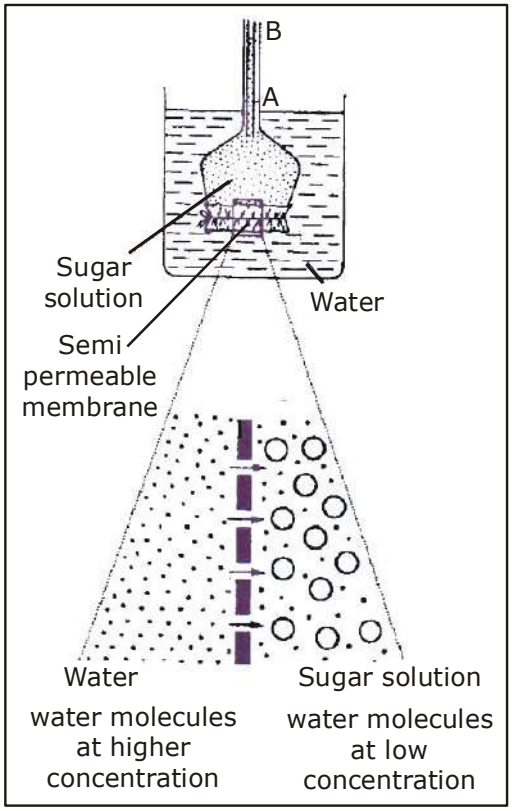
Requirements : Funnel fitted with a semipermeable membrane, beaker, sugar solution, water.

Procedure : Take sugar solution in a funnel fitted with a semipermeable membrane upto mark 'A' and place it in an inverted position in a beaker filled with clean water as shown in figure. After some time, observe the level of sugar solution in the funnel.

Result :- You would find that the sugar solution has risen from level 'A' to a new level 'B'.

Explanation and conclusion : Sugar solution in the funnel and water in the beaker are separated by a semipermeable membrane. The fitted membrane is permeable to small water molecules but is relatively impermeable to large sugar molecules dissolved in water.

Due to difference in the concentration of solute on the two sides of semipermeable membrane, water molecules have moved from the solution having lower concentration of solutes (e.g., water in this experiment) to the solution having higher concentration of solutes [e.g. sugar solution] due to osmosis has risen to new level 'B'.



8. TYPES OF SOLUTIONS :

(i) **Hypotonic :** If the external solution has lower solute (or higher solvent) concentration than the cell, then it is called a hypotonic solution or in other words, the solution is said to be more dilute than the cytoplasm of the cell.

(ii) **Isotonic :** If the external solution has a similar solute or solvent concentration as the cell, then it is called an isotonic solution.

(iii) **Hypertonic :** If the external solution has a higher solute (or lower solvent) concentration than the cell, then it is called a hypertonic solution or in other words, the solution is said to be more concentrated than the cytoplasm of the cell.

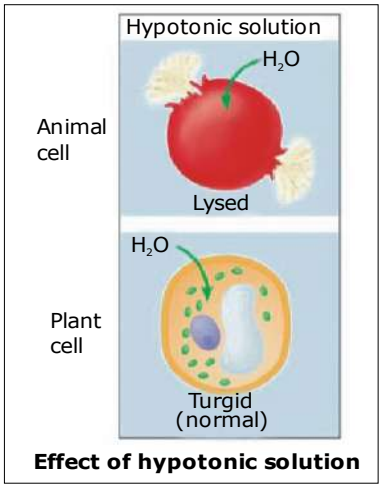
Let us study, what happens when a cell (plant and animal) is placed in a hypotonic, isotonic or hypertonic solution.

(i) **Hypotonic solution :** In this case, the external medium surrounding the cell has a higher concentration of water than the cell and therefore, **the cell gains water by osmosis.**

During osmosis, the water molecules (solvent) are free to cross the plasma membrane in both the directions. However, more water will flow into the cell due to osmosis as compared to what flows out of the cell. This process of entry of water into a cell through osmosis is called **endosmosis.**

When an animal cell is placed in a hypotonic solution, it swells up due to endosmosis and builds a pressure against the cell membrane. The swollen cell bursts under pressure, as the plasma membrane cannot withstand such a high pressure whereas, when a plant cell is placed in a hypotonic solution, water moves inside the cell due to osmosis and the cell swells up, building a pressure against the cell wall. But, the swollen plant cell does not burst as it consists of a rigid cell wall which can withstand high pressure. The cell wall exerts an equal pressure against the swollen cell and prevents the plant cell from bursting. Thus, the net result is that the plant cell swells up, i.e., it becomes turgid.

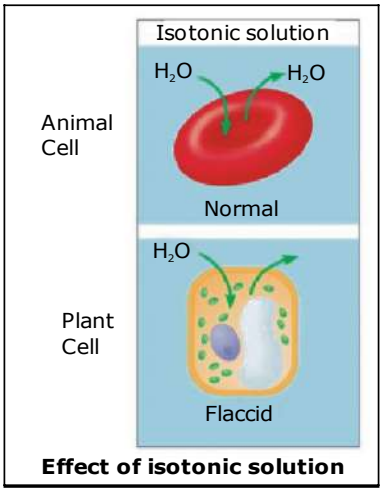
Hence, animal cells when placed in a hypotonic solution burst due to absence of cell wall, but plant cells do not.



Effect of hypotonic solution

(ii) **Isotonic solution :** In this case, the external medium has the same concentration of water as that of the cell, and thus, there is no net gain or loss of water from the cell. This is because net movement of water is nil.

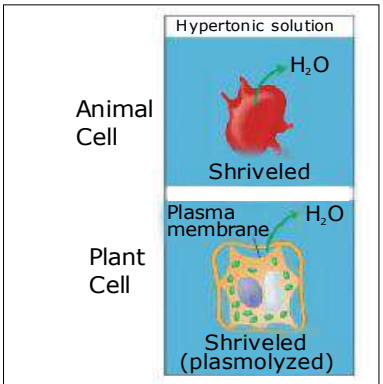
Though, the water crosses the cell membrane in both directions, but the amount of water moving inside the cell is equal to the amount of water moving out and therefore, **the size of the cell remains the same.**



Effect of isotonic solution

(iii) **Hypertonic solution :** In this case, the external medium has a lower concentration of water than the cell and therefore, the cell will lose water to the surrounding medium by osmosis.

The net result is that the cell shrinks. The process of withdrawal of water from a cell throug osmosis is called **exosmosis.** In this condition, plant cell is said to be **plasmolysed** and animal cell is said to be **crenated** (wrinkled appearance).



Effect of hypertonic solution

Plasmolysis : When a living plant cell loses water through osmosis, there is shrinkage or contraction of the protoplasm away from the cell wall. This phenomenon is called **plasmolysis.** Plant cells possess a rigid cell wall and therefore, when the cell loses water, the plasma membrane shrinks and moves away from the cell wall. If a plasmolysed cell is again kept in a hypotonic solution, it will again gain water due to endosmosis and would become turgid. This process is called **deplasmolysis.**

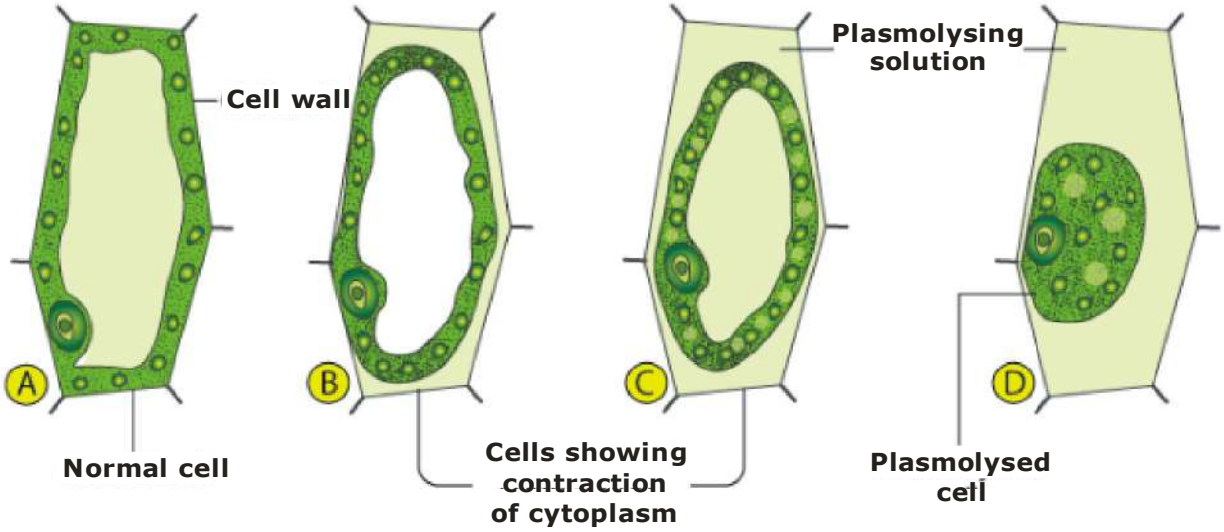


Fig. : Plasmolysis : A- turgid or normal plant cell; B-D : successive stages in the shrinkage of cell content (protoplasm) from the cell wall

Animal cell like RBCs burst and haemolyse when placed in a hypotonic solution. They shrink and show crenation when placed in hypertonic solution. Their size remains normal when placed in an isotonic solution like **Ringer's solution.**

Other examples of osmosis :-

1. Fresh water unicellular organisms (e.g., ***Amoeba, Paramoecium***) continuously gain water in their bodies due to osmosis. These organisms have mechanisms (e.g., contractile vacuoles) to throw out excess of water from their bodies.

2. Most plant cells have the tendency to gain water due to osmosis.

3. Absorption of water by the plant roots from the soil through root hairs is also an example of osmosis.

4. Certain plant movements (e.g., seismonastic movements in 'touch-me-not' plant) occur due to loss or gain of water.

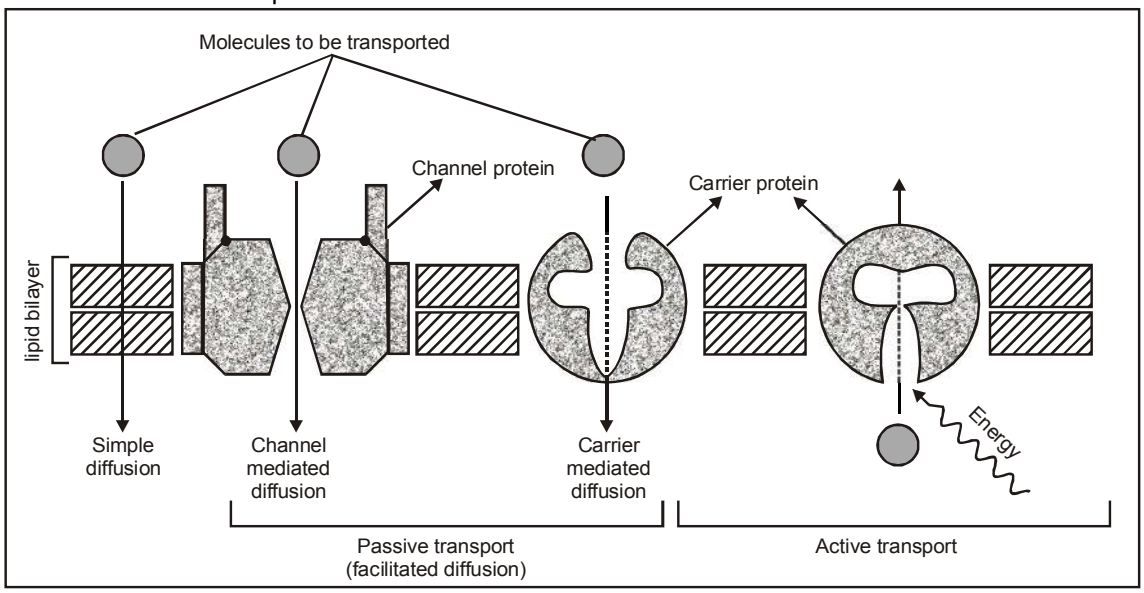
5. Stomata are present in the leaves. They open and close at different times of the day due to osmotic movements of water.

6. In plants cells, tissues and soft organs (leaves, young shoots, flowers) maintain turgidity or stretched form due to osmotic absorption of water.

DIFFERENCES BETWEEN DIFFUSION AND OSMOSIS		
S.No	**Diffusion**	**Osmosis**
1	Diffusion can occur both in air and liquid (water) medium	Osmosis occurs only in liquid medium
2	It involves movement of molecules (Solids, liquids or gases) from the region of their higher concentration to the region of their lower concentration.	It involves movement of solvent molecules only from the region of their higher concentration to the region of their lower concentration.
3	It can occur without or through a semipermeable membrane.	It always takes place through a semipermeable membrane.
4	It equalizes the concentration of diffusable molecules throughout the medium.	It does not equalize the concentration of solvent molecules in the medium involved.
5	It is dependent upon the kinetic energy of the molecules of diffusing substance only.	Though it is the diffusion of solvent molecules only, yet it is influenced by the presence of solutes in the system.

9. MEDIATED TRANSPORT :

Type of transport of materials across the plasma membrane with the help of carrier proteins is called mediated transport.



Types of mediated transport

Mediated transport is of following two types :

(A) **Facilitated transport :-** In this case, transport proteins (e.g. permeases) assist molecules to diffuse through the membrane down the concentration gradient, i.e., from the region of higher concentration to the region of lower concentration across the membrane. It is, therefore, also termed as **facilitated diffusion.** No cellular energy is used in such transport. A carrier protein combines with a specific substance (e.g., glucose) to be transported and moves it down the concentration gradient from one side of membrane to another through a channel formed by it.

In liver and red blood cells, facilitated transport moves glucose across the cell membrane by specific carrier protein molecule in both directions, depending upon whether glucose concentration is higher inside or outside the membrane.

(B) **Active transport :-** In this case, carrier proteins move substances against the concentration gradient, i.e., from lower concentration to higher concentration. This "uphill" transport involves work and always requires energy provided by ATP (Adenosine Triphosphate).

DIFFERENCES BETWEEN ACTIVE TRANSPORT AND DIFFUSION			
S. No.	**Active Transport**	**S. No**	**Diffusion**
1	It is a rapid process.	1	It is a slow process.
2	It can move materials through a biomembrane against the concentration gradient.	2	It can move materials across a biomembrane down the concentration gradient.
3	It takes place in one direction only.	3	It takes place in both directions.
4	It needs carrier proteins to occur.	4	It occurs without carrier proteins.
5	It uses energy of ATP.	5	It does not use energy.
6	It brings about selective uptake of materials.	6	It allows all transmissible molecules to pass through membranes
7	It leads to accumulation of materials in the cells.	7	It does not accumulate materials in the cells.

10. BULK TRANSPORT :-

Animal cells can also actively take in and turn out materials in masses. Such materials include macromolecules, lipid droplets and solid particles. Items of this size cannot cross the phospholipid bilayer by diffusion or with the help of transport proteins. Special processes are involved in the transport of such large quantities of materials.

These include endocytosis (phagocytosis) and exocytosis.

11. ENDOCYTOSIS :-

The term endocytosis refers to invagination of a small region of plasma membrane, and ultimately forming an intracellular membrane-bound vesicle. Endocytosis is not shown by plant cells because of their rigid cell wall and internal turgor pressure. Depending upon the intake of fluid droplet or solid particles, endocytosis is of two types :

(A) Pinocytosis :- The non-specific intake of a tiny droplet of extracellular fluid by a cell through the cell membrane which cannot otherwise pass through it. It is also, therefore, termed as **cell drinking**. It was first observed in *Amoeba*.

(B) Phagocytosis :- Phagocytosis is the intake of solid particles by a cell through cell membrane. It is also called cell eating. Phagocytosis is the major feeding method in many unicellular organisms (e.g., *Amoeba* and simple metazoa (sponges)).

DIFFERENCES BETWEEN PINOCYTOSIS AND PHAGOCYTOSIS

S. No.	Pinocytosis	S. No	Phagocytosis
1	It is the intake of extracellular fluid droplets.	1	It is the intake of extracellular particles
2	Cell membrane invaginates to take up the material.	2	Cell membrane grows around the particle as pseudopodia.
3	Microfilaments play no role in endocytosis.	3	Microfilaments play an important role in phagocytosis.
4	It is a nutritive process.	4	It is a nutritive and defensive process.
5	Pinocytotic vesicles are only 0.1 µm wide.	5	Phagocytotic vesicles are 1 to 2 µm or more wide.

12. EXOCYTOSIS :-

Exocytosis is the process that involves fusion of membrane of the exocytotic vesicle with the plasma membrane to extrude its contents to the surrounding medium.

This process is also called **cellular vomiting** or **ephagy** and the vesicles that turn out the materials are termed **exocytotic vesicles.**

Exocytosis process is responsile for :

(A) Removal of undigested food left in the food vacuoles in the cells.

(B) Secretion of substances such as hormones, enzymes, and

(C) Replacement of internalized membrane by the fusion of exocytotic vesicles with the cell membrane.

CELL MEMBRANE OR PLASMA MEMBRANE

Each cell (prokaryotic as well as eukaryotic is surrounded by a covering called **plasma membrane** or ***plasmalemma or cell membrane.*** Most cell organelles in eukaryotic cells (e.g., Mitochondria, Plastids, Golgi apparatus, Lysosomes, Endoplasmic reticulum, Peroxisomes, Vacuoles etc. are enclosed by subcellular unit membranes. These membranes, thus, compartmentalise the cell.

Molecular Structure of Plasma membrane.

Plasma membrane is a living, ultra-thin, elastic, selectively permeable membrane. Chemically, it is composed of phospholipids, proteins, oligosaccharides and cholesterol (Only in Eukaryotic cell).

Fluid Mosaic Model :- In 1972, **S.J. Singer and G. Nicolson** proposed fluid mosaic model **to explain the structure and functions of plasma membrane.** According to this model, the plasma membrane is made up of a **phospholipid bilayer** and two types of **protein molecules** 'floating about' in the fluid phospholipid bilayer.

Presence of lipids and proteins provides flexibility to the plasma membrane. Proteins present in the membrane serve as:-

1. **Enzymes** catalysing chemical reactions within the membrane.
2. **Transport proteins** (permeases) for movement of water soluble ions.
3. **Pumps** for active transport of materials
4. **Receptor proteins** (e.g., glycoproteins on the cell surface) to recognize and bind specific molecules such as hormones.

Fluid mosaic model is also described as "a number of protein icebergs floating in the sea of lipids'.

Functions of plasma membrane

(A) It gives a definite shape to the cell.

(B) It provides protection to the internal contents of the cell.

(C) It regulates entry and exit of substances in and out of the cell.

(D) It can internalize solid and liquid materials by infolding or extending around them. This is a process of active intake of materials.

(E) In animal cells, it is involved in adhesion, recognition and in the formation of vesicles, cilia, flagella, microvilli, etc.

(F) Plasma membrane acts as a mechanical barrier to protoplasm so after rupturing or breakdown of plasma membrane, the protoplasmic contents will be dispersed in the surrounding medium.

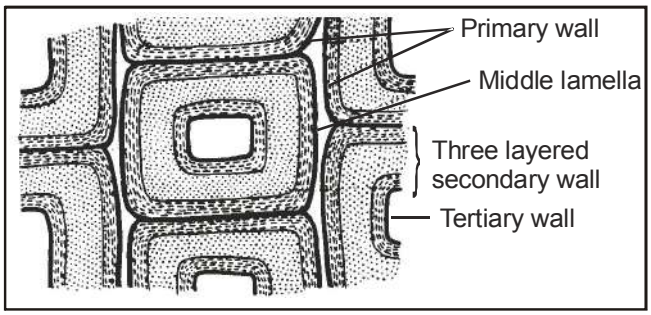
CELL WALL

Discovered by **Robert Hooke**

- The outermost covering of the plant cell is called *cell wall*.
- It is absent in animal cell.
- It is rigid, thick, porous and non-living structure. It become impermeable due to deposition of cell wall materials.

1. **MIDDLE LAMELLA :** Common layer between two plant cells is called middle lamella. It consists Ca & Mg pectates (Plant cement). Fruits becomes soft and juicy due to dissolve of middle lamella.

(A) **Cell wall**
- **Primary wall** : Outermost layer
- **Secondary wall** : Rigid, thick (absent in meristem cells)
- **Tertiary wall** : Present only in tracheids of gymnosperm.



(B) Cellulose is a main constituent of cell wall but in addition to cellulose – Hemicellulose, cutin, pectin, Lignin, Suberin are also presents in cell wall

(C) Network of cellulose fibre forms skeleton of cell wall.

(D) **Composition:–**
(i) Cellulose + Hemicellulose-**in plants**
(ii) Chitin – **in fungi**
(iii) Peptidoglycan – **in bacteria**

Functions of cell wall :–

(i) It determines the shape of the plant cell.
(ii) It prevents desiccation of cell. [desiccation means drying up of cells]
(iii) It protects the plasma membrane and internal structures of the cell.
(iv) It helps in the transport of various substances in and out of the cell.
(v) It does not allow too much of water to come in. In this way it prevents the cytoplasm from becoming too dilute.

CYTOPLASM

1. Cytoplasm was discovered by Kolliker in 1862.

2. It is the site for both biosynthetic and catabolic pathways.

3. It can be divided into two parts:

(A) Cytosol: Aqueous soluble part contains various fibrous proteins forming cytoskeleton.

(B) Cytoplasmic Inclusion: In the cell cytoplasm, there are present numerous living and non-living structures, collectively called cytoplasmic inclusions.

(i) The living cytoplasmic inclusions are called cell organelles or protoplasmic inclusions.

(ii) The non-living structures are called Deutoplasmic or ergastic bodies.

4. Role of Cytoplasm:

(A) Participates in intracellular distribution of nutrients, metabolites and enzymes.

(B) Helps in exchange of materials between cell organelle.

(C) Acts as a site of chemical reactions like glycolysis (step of respiration), synthesis of fatty acids.

CELL ORGANELLES

1. These are living sub-cellular structures of the cytoplasm and are also called protoplasmic bodies or organoids. These include-

2. Single membranous: Endoplasmic reticulum, Golgi apparatus, Lysosomes, peroxisomes, Glyoxysomes etc.

3. Double membranous: Plastid and Mitochondria

4. Non-membranous: Ribosomes

NUCLEUS

1. INTRODUCTION :

The nucleus is the most important component of the cell and controls all functional activities of the cell.

2. HISTORICAL ACCOUNT :

Robert Brown (1831) discovered a dense, spherical body in the cells of an 'orchid' and named it as 'Nucleus'.

3. ULTRASTRUCTURE :

Nuclear membrane/Nuclear envelope/Karyotheca

Nuclear sap/ Nucleoplasm/karyolymph

Nucleolus

Chromatin threads

(A) Nuclear envelope : Nucleus is surrounded by two membranes, that separates nucleoplasm from cytoplasm. The nuclear membrane has minute pores. These are called nucleo-pores.

(B) Nucleoplasm : The part of protoplasm which is enclosed by nuclear membrane is called nucleoplasm. It contains chromatin threads and nucleolus.

(C) Nucleolus : Discovered by Fontana. Usually one nucleolus is present in each nucleus but sometimes more than one nucleoli are present. It is a store house of RNA.

(D) Chromation threads : A darkly stained network of long and fine threads called chromatin threads. Chromatin threads are intermingled with one another forming a network called chromation reticulum. Whenever the cell is about to divide the chromatin material gets organized into chromosomes.

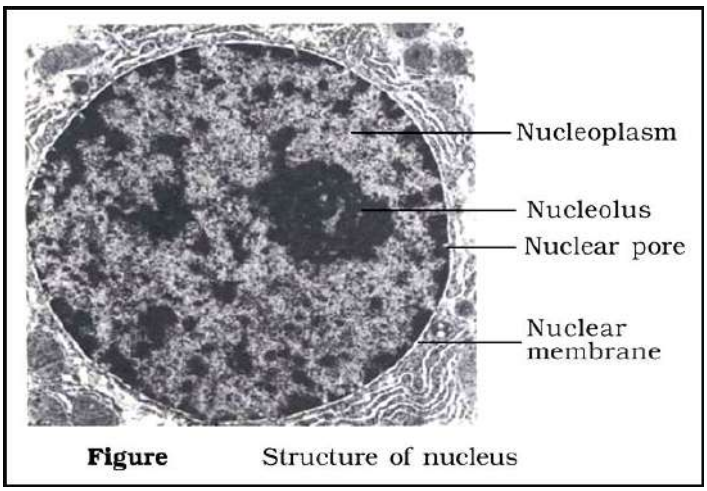
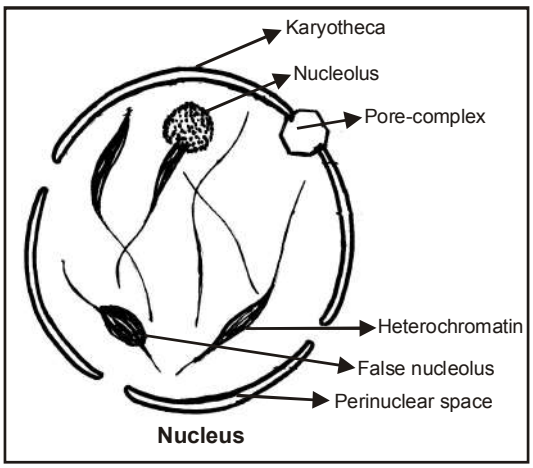


Figure Structure of nucleus



Chromosome : Chromosomes are rod like structure visible only during **cell division.** Chromosomes contain information for inheritance of characters from parents to the offsprings in the form of **DNA (Deoxyribo Nucleic Acid) molecules.** DNA molecules contain the information necessary for constructing and organising cells. The chromosomes consist of two arms (two similar threads) called **chromatids.** These chromatids are held together by a small constriction, called **centromere** or **primary constriction.** The chromosomes contain **genes** which are defined as the **functional unit of DNA or chromosome.** They contain information necessary for synthesizing proteins which help to control different cellular activities. Genes are located at a specific position (locus) on the chromosome.

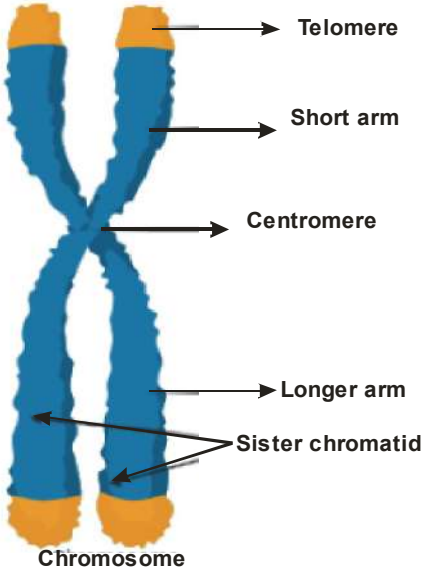


Fig. : A chromosome

CHROMOSOME NUMBER

The chromosome number varies from one species to another but, is **fixed for each species.** In most organisms, chromosomes occur in **pair.** In each pair, one chromosome is inherited from the father while the other is inherited from the mother. The organisms with two set of chromosmes are called **diploid** (2n) organisms e.g. humans containing 23 pairs or 46 chromosomes.

Only a single set of chromosomes is present in the gametes of diploid organisms. This condition is known as **haploid (n)** condition.

A Genome is the complete set of genetic information in an organism.

Functions of Nucleus :

(i) The nucleus control all metabolic activities of the cell.

(ii) It regulates the cell cycle.

(iii) It brings about growth of the cell by directing the synthesis of structural proteins.

(iv) It takes part in the formation of ribosomes.

(v) It contains genetic information and is concerned with the transmission of hereditary traits from one generation to another.

Info Bubble

- **Chromatin threads are made up of –**
  (i) DNA **(ii)** Protein [Histone protein]
- **Gene:–** The segment of DNA and act as unit of heredity
- **ATP:–** Adenosine triphosphate. It is also known as energy currency. It provides energy to perform bio-synthesis & mechanical work.
- **Homologous chromosomes:–** All chromosomes are found in pair and the chromosomes of a pair are called homologous chromosomes.
- **Non-homologous chromosomes:–** Chromosomes of different pair.
  - The nucleus of prokaryotes is also known as **nucleoid.**
  - Nucleus is also called **director of cell** as it controls most of the cellular activities.
  - Nucleus is absent in **sieve tubes of vascular plants & mature RBC's of mammals.** Mammalian RBC also lacks Golgibodies, mitochondria, ER, lysosomes.

ENDOPLASMIC RETICULUM

1. INTRODUCTION :

In the cytoplasm some closed or open, branched cavities are present which are bounded by membranes to form a network of membranous system called **Endoplasmic Reticulum.**

2. HISTORICAL ACCOUNT :

K.R.Porter (1948) reported this net-like system under electron microscope.

3. ULTRASTRUCTRURE :

A system of membranes attached to the nucleus and present in the cytoplasm is called E.R.

The Endoplasmic Reticulum (ER) is divided into two parts

- It is the netowork of membranes present in the cytoplasm.
- It was discovered by Porter, Claude and Fullan.
- **These are present in all cells except prokaryotes and mammalian erythrocytes.**

- They are made up of three components:

(A) Cisternae:

(i) These are long, flattened, parallelly arranged, unbranched tubules.

(ii) These form successive layers of nucleus.

(iii) These are found in cells which are active in protein synthesis and are 40 - 50 μm in diameter.

(B) Vesicles: These are rounded or spherical. They are found synthetically active cells.

(C) Tubules: These are small, smooth walled and have tubular spaces. These are found in non secretory as well as steroid synthesizing cells.

(i) Rough Endoplasmic Reticulum (RER)

(ii) Smooth Endoplasmic Reticulum (SER)

(i) RER possesses rough wall because ribosomes remain attached on the surface. **RER** is present in cells which are involved in protein synthesis.

(ii) **SER** mainly present in cells which are involved in lipoproteins and glycogen synthesis. It perfoms **detoxification**.

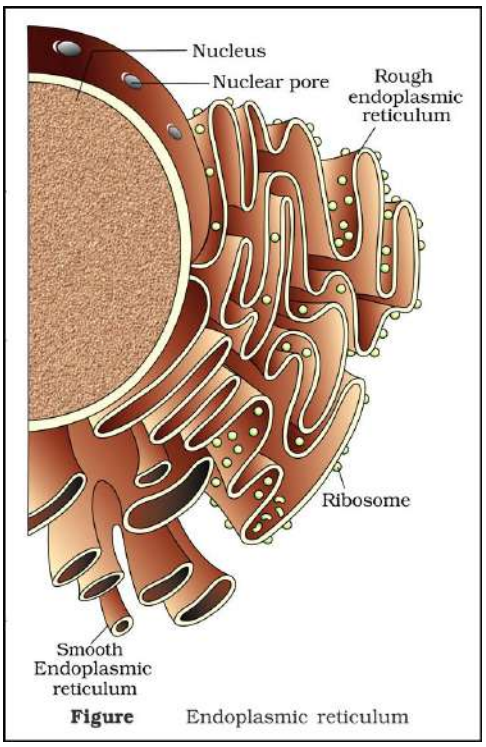
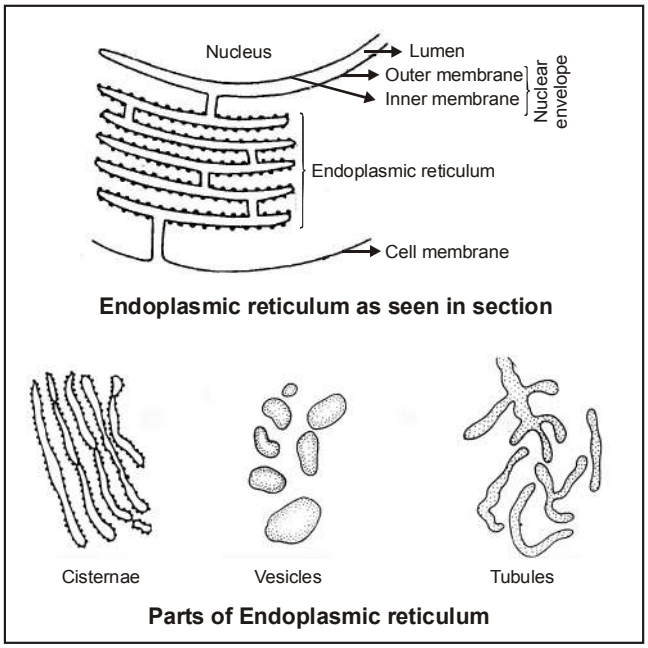
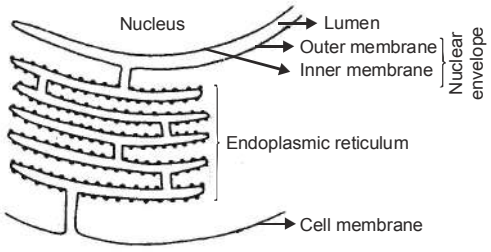
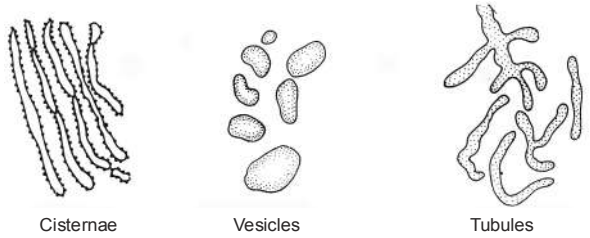


Figure Endoplasmic reticulum

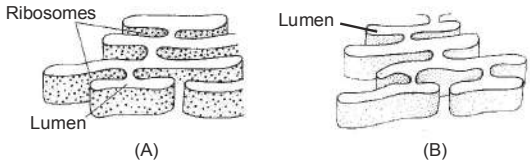




Endoplasmic reticulum as seen in section



Parts of Endoplasmic reticulum



(A) : Rough endoplasmic reticulum
(B) : Smooth endoplasmic reticulum

Functions of Endoplasmic Reticulum :

(i) It forms supporting skeleton framework of the cell.
(ii) Certains enzymes present in smooth E.R. synthesis fats (lipids), steroids and cholesterol.
(iii) Rough E.R. is concerned with protein synthesis.
(iv) Smooth E.R. is involved in the process of detoxification.
(v) ER serves as channels for the transport of materials (proteins) between various regions of the cytoplasm.
(vi) Lipids from SER and some proteins from RER helps in building the cell membrane. This process is known as **membrane biogenesis.**

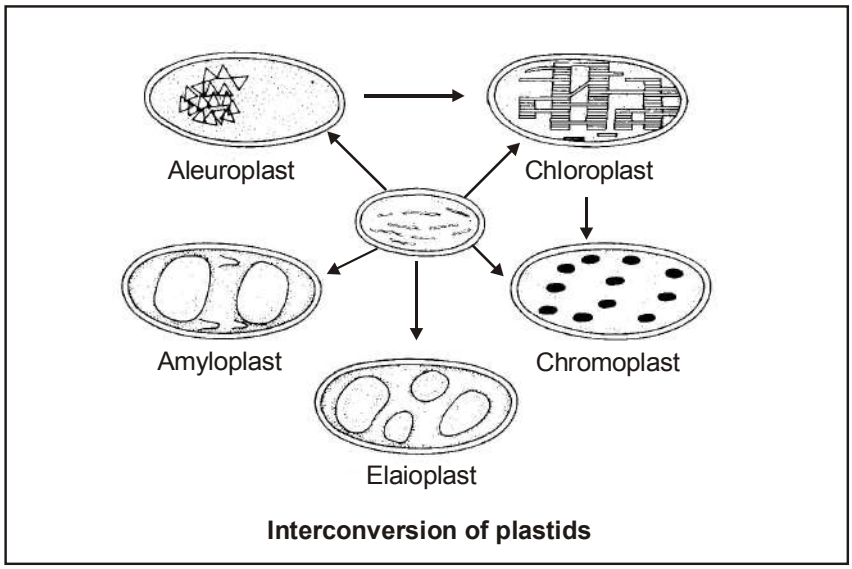
PLASTID

Plants and some protists have several types of double membrane bound organelles called plastids, which harvest solar energy, manufacture nutrient molecules and store materials.

Plastid term was coined by E. Haeckel.

Plastids generally contain pigments and may synthesize & accumulate various substances. Depending upon the type of pigment present in them they are of following three types.

S.NO.	LEUCOPLAST	CHROMOPLAST	CHLOROPLAST
1	Non Pigmented White in colour	Coloured pigments All colours except green	Green pigment chlorophyll is found in them.
2	Generally found in underground parts important for food storage. E.g. Aleuroplast (Protein), Elaioplast (Oil), Amyloplast (Starch)	Found in flowers, Fruits, Leaves etc.	Found in aerial parts of plant which are green in colour



Interconversion of plastids

Functions :

(i) Chromoplasts provide colour to fruits and flowers to attract animals for pollination and fruit dispersal.

(ii) Leucoplasts take part in storage of protein, starch and oil.

(iii) Chloroplasts trap solar energy to manufacture food through the process of photosynthesis. Hence, chloroplasts are also known as **'kitchen of the cell'.**

(iv) Chloroplasts help to maintain the balance between the two gases (oxygen and carbon dioxide) by utilizing CO_2 and releasing O_2 during photosynthesis.

1. CHLOROPLAST:

(A) Introduction: It is a double membranous discoidal structure, found only in plant cells.

Chloroplast was discovered by A.V. Leeuwenhoek and named by Schimper.

Besides being discoidal or rhombic in plant cells they occur in variable shapes like in algae they can be 'U' shaped, spiral, coiled, ribbon shaped etc.

In each thylakoid Quantasomes are present which are called as Photosynthetic units.

Each quantasome possesses 230 chlorophyll molecules.

(B) Internal Structure: Each chloroplast consists of two parts.

(i) Grana: It constitutes the lamellar system. These are found layered on top of each other, these stacks are called as Grana.

- Each granum of the chloroplast is formed by superimposed closed compartments called Thylakoids.
- **Functions:** Grana are the sites of light reaction of photosynthesis as they contain phtosynthetic pigment chlorophyll.

(ii) Stroma : It is a granular transparent substance also called as matrix.

Grana are embedded in it. Besides grana they also contain lipid droplets, starch grains, ribosomes etc.

Function: This is the site of dark reaction of photosynthesis.

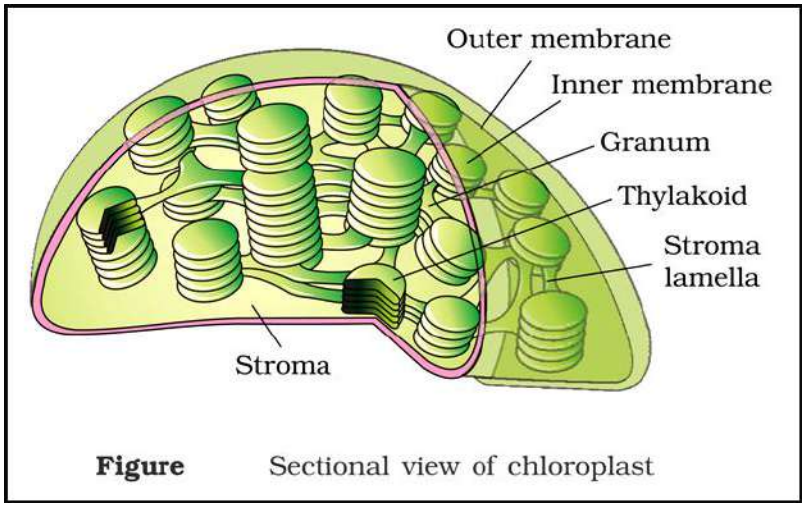
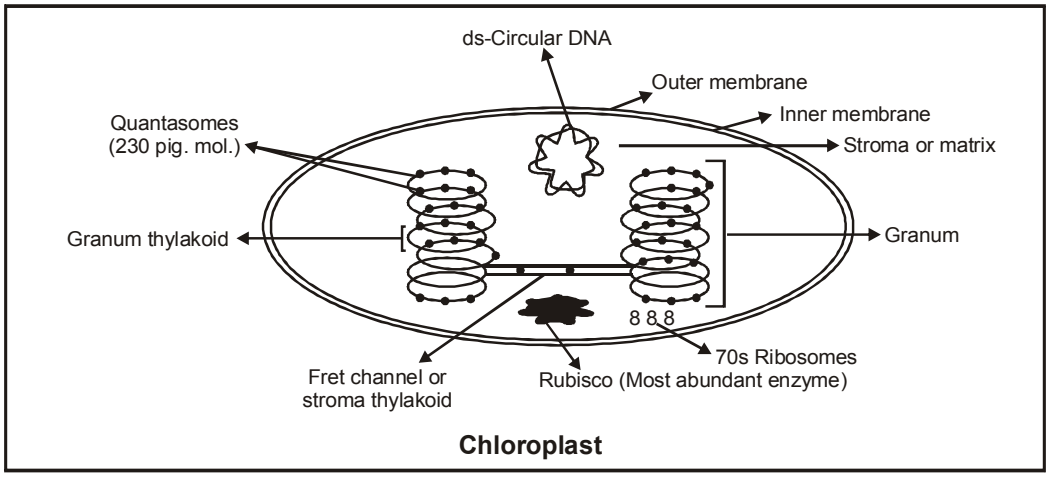
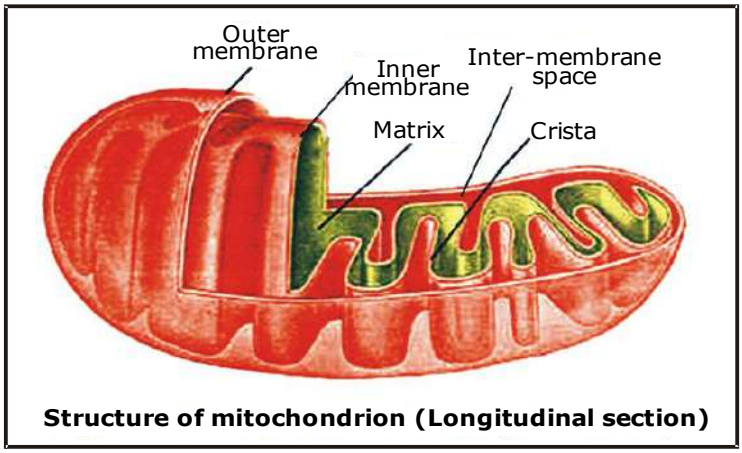


Figure Sectional view of chloroplast

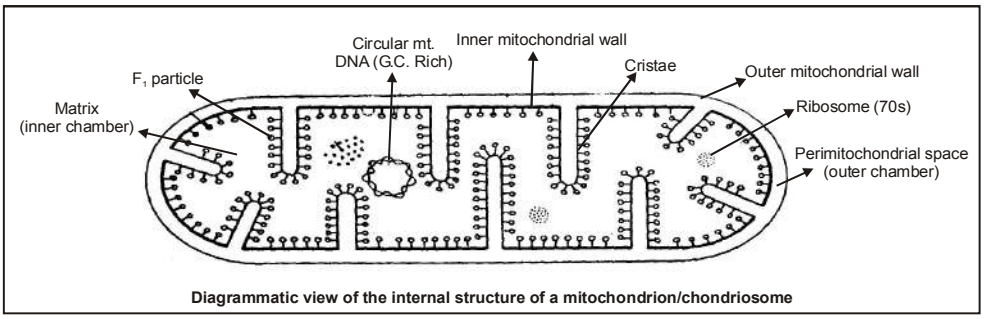


Chloroplast

MITOCHONDRIA



Structure of mitochondrion (Longitudinal section)



Diagrammatic view of the internal structure of a mitochondrion/chondriosome

1. Introduction: It was first seen by **Kolliker** in insect cells and named by **Benda**.

- It is a rod shaped structure found in cytoplasm of all eukaryotic cell except mammalian RBC's. These are also absent in prokaryotes.
- Maximum mitochondria are found in metabolically active cells.
- It is also called as "Power House of the Cell" or the "Storage Battery".
- Maternal inheritance (an oganisms generally receives mitochondria from its mother)

2. Internal Structure: It is double membranous structure where outer membrane has specific proteins while inner membrane is folded inside to form chambers called Cristae.

"Cristae" are the infoldings of inner mitochondrial membrane that possess enzymes for respiratory cycles like Kreb Cycle. **ATP synthesizing units are called Oxysomes or $F_0 - F_1$ Particles.**

- Space between inner and outer mitochondrial membranes is called as perimitochondrial space. The fluid present in mitochondria is called as matrix.

Functions:

(i) Its main function is to produce and store the energy in the form of ATP.

(ii) It is the site of Kreb's cycle of respiration, as it contains enzymes for Kreb cycle.

(iii) Oxysome contains enzymes for ATP production.

GOLGI COMPLEX

Discovered by **Camillio Golgi (1898)** in nerve cells of owl.

Other names:–

(i) Lipochondrion **(ii) Idiosome**

(iii) Baker's body - In fungus **(iv) Dalton complex**

(v) Dictyosomes – In plants

Golgibody is single membrane bound cell organelle.

1. Position:– It is located near the nucleus.

(A) The cytoplasm surrounding Golgi body have fewer or no other organelles. It is called **Golgi ground substance or zone of exclusion.**

(B) Golgi bodies are **pleomorphic structures**, becaue component of golgi body are differ in structure & shape in different cells.

2. Structure:– It is formed of four types of contents.

(A) Cisternae – These are long flattened and unbranched saccules. 4 to 8 saccules are arranged in a stack.

(B) Tubules – These are branched and irregular tube like structures associated with cisternae.

(C) Vacuoles – Large spherical structures associated to tubules.

(D) Vesicles – Spherial structures arise by budding from tubules. Vesicles are filled with secretory materials.

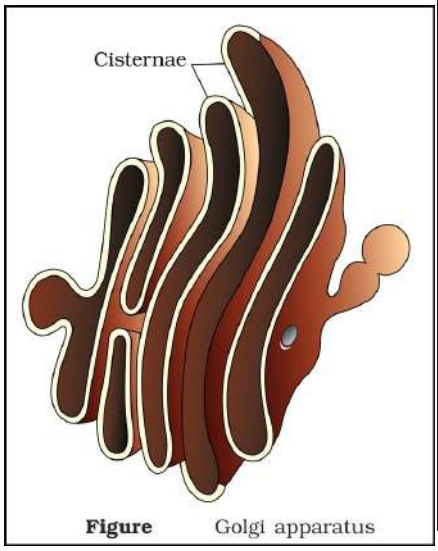
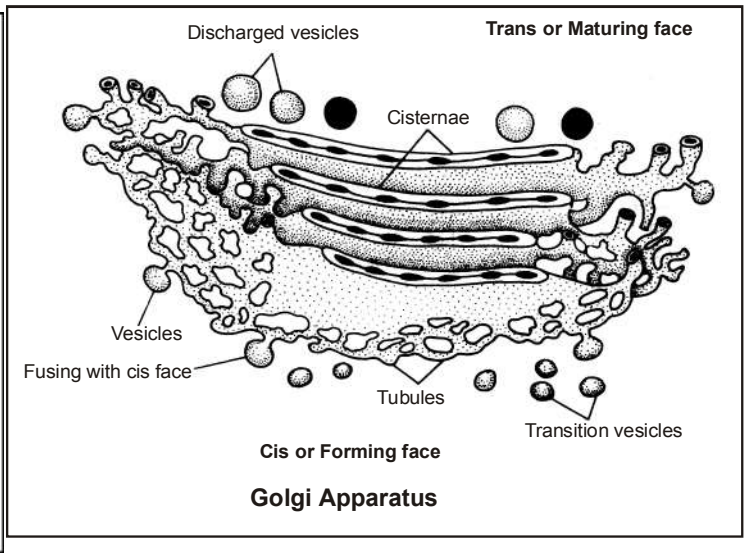


Figure Golgi apparatus



Golgi Apparatus

Function:–

(i) It involved in cell-secretion and acts as storage, modification and condensation or **packaging membrane**.

(ii) It forms the **Acrosome** of sperm [**Acrosome :-** A bag like structure filled with lytic enzymes which dissolve egg membrane at the time of fertilization]

(iii) It forms the lysosomes and secretory vesicles.

(iv) It is the site for formation of glycolipids and glycoproteins.

(v) Synthesis of cell wall material (Polysaccharide synthesis)

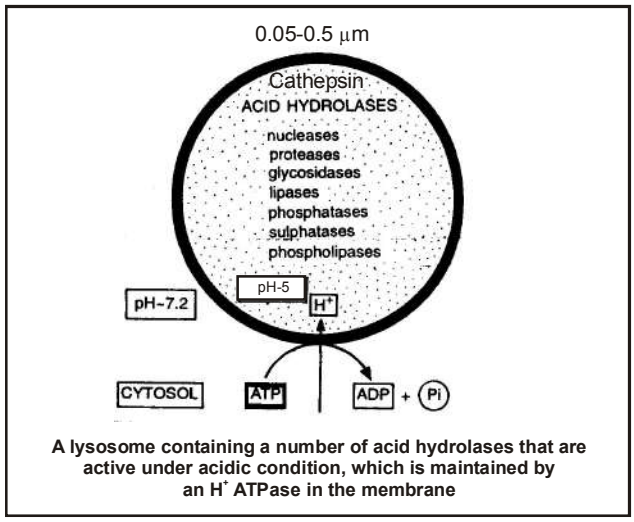
(vi) Cell plate formation (phragmoplast) during cell formation.

(vii) **Cortical granules of egg** are secreted by Golgi body.

LYSOSOME

INTRODUCTION: First observed and the term coined by **Christian De Duve (1955)**

- Lysosomes are spherical bag like structures [0.1 – 0.8 μm] which is covered by single unit membrane.**With the exception of mammalian RBC** they are reported from all cells. Lysosomes are filled about 50 different types of digestive enzymes termed as **acid hydrolases.**
- **Lysosomes are highly polymorphic cell organelle**. Because, during functioning, lysosomes have different morphological and physiological states.



A lysosome containing a number of acid hydrolases that are active under acidic condition, which is maintained by an H^+ ATPase in the membrane

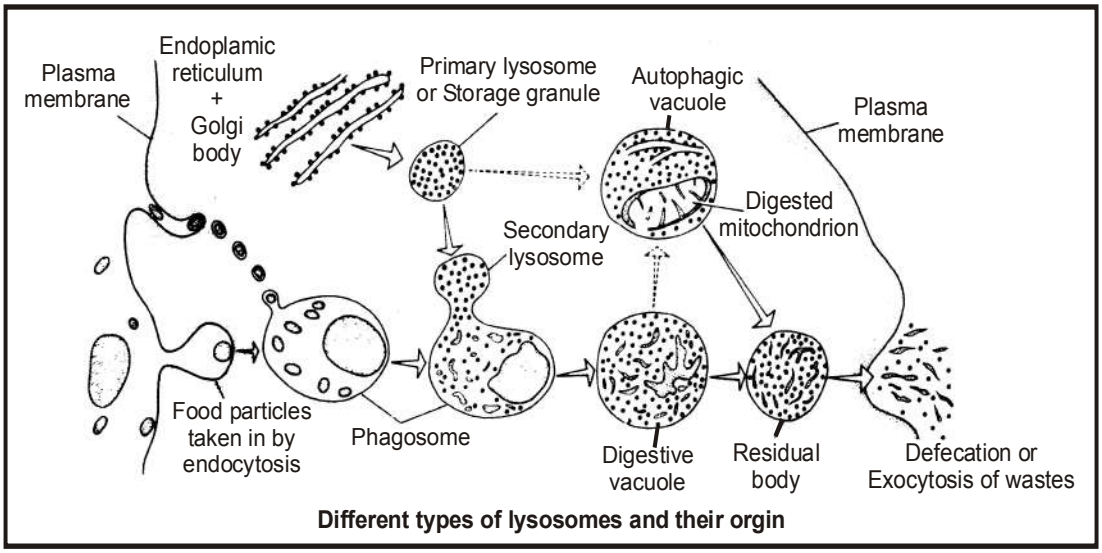
Functions :–

(i) **Heterophagy :–** It involves in digestion of foreign materials received in cell.

(ii) **Autophagy :–** Digestion of old or dead cell organelles.

(iii) **Cellular digestion (Autolysis) :–** Sometimes all lysosomes of a cell burst to dissolve the cell completely.

That's why lysosomes are also known as **suicidal bags.**



Different types of lysosomes and their orgin

RIBOSOME-ENGINE OF CELL

1. **INTRODUCTION:** Chemically a ribosome is made of proteins and RNA.

First reported by **Claude** and named by **G. Palade**.

They are small granular structures visible only under electron microscope.

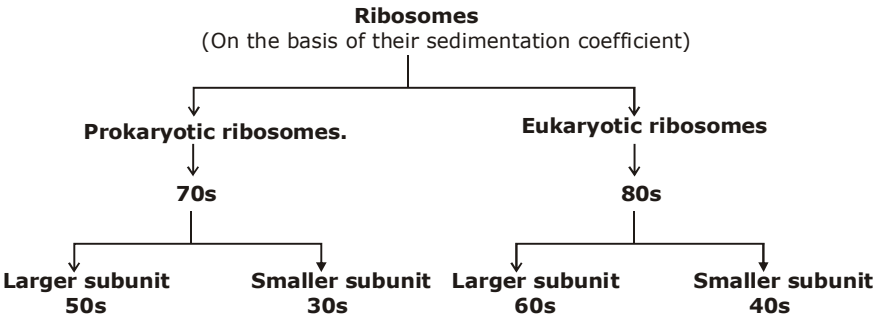
They are the only organelles which are present in all types of cells.

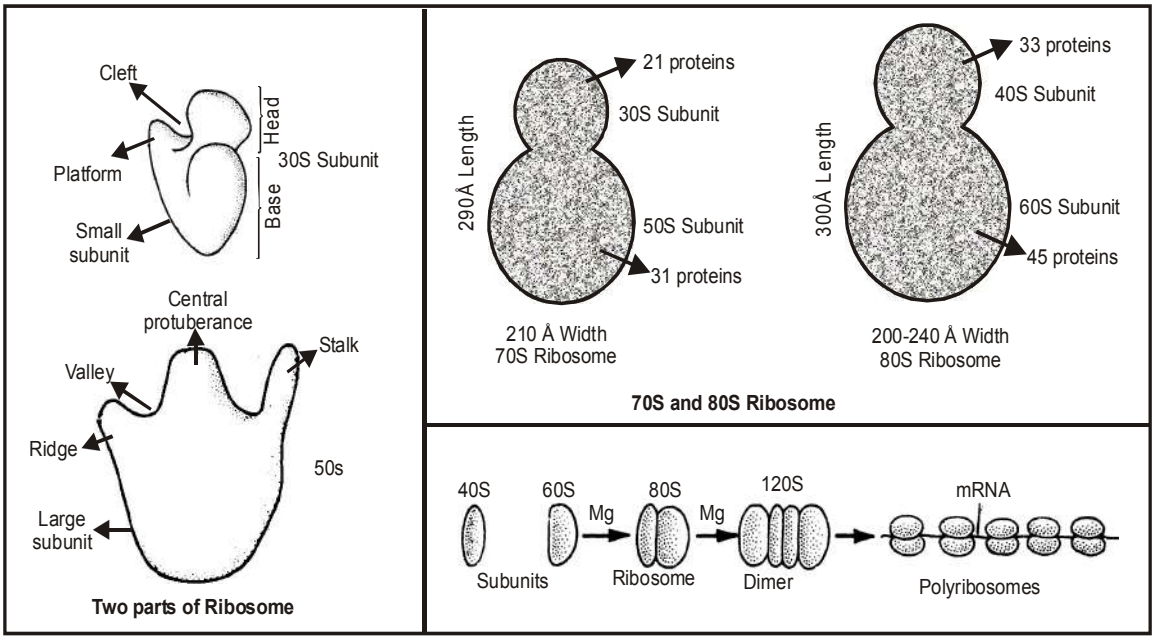
They help in protein synthesis and are known as 'protein factories'.

2. INTERNAL STRUCTURE: Each ribosomes consists of two unequal subunits, larger dome shaped and small ovoid.

The size of ribosome is determined by sedimentation coefficient in the centrifuge.

The cytoplasmic ribosomes of eukaryotes are 80S and in prokaryotes and cell organelles like mitochondria and chloroplast it is 70S type. The two sub units of 80S ribosomes are 60S and 40S while 70S type ribosomes have 50S and 30S subunits.





- **Magnesium ion [Mg^{++}] is essential for binding of both the sub units of ribosome.**

Functions :–

Site of protein synthesis, so these are also called **protein factories**.

VACUOLES

1. INTRODUCTION: Vacuoles of animal cells arise from Golgi-complex.

Tonoplast:– ***Plasma membrane that covers the vacuole is called tonoplast.***

Vacuoles are of three types :-

1. **Food vacuole** – The vacuole which contain food material.
2. **Sap vacuole** – The vacuole which is filled by liquid material [sap]
3. **Contractile vacuole** – The vacuole that concern with osmoregulation e.g. *Amoeba*

Functions :–

(i) Storage of food, water and other substances.

(ii) They help in the elimination of excess water from the cell **(osmoregulation)**, and maintains internal pressure of the cell.

CENTROSOME

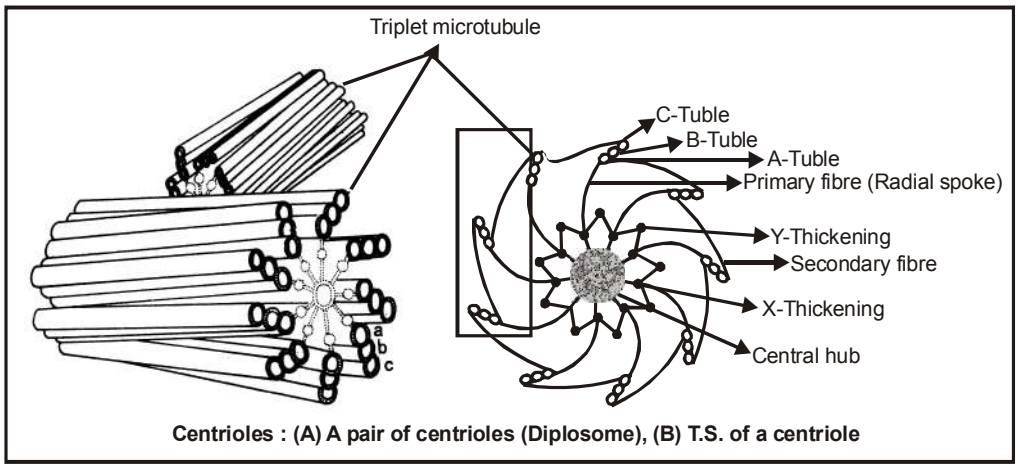
1. INTRODUCTION: Discovered by **Benden. Boveri** named it as centrosome.

Centrosome is generally found in animal cells. Only few type of a plant cells show its presence.

It is situated near the nucleus of the cell and shaped like star.

Each centrosome has two centrioles. The two centrioles are placed perpendicular to each other.

Cytoplasm which surrounds centrioles called as **"Centrosphere"**. Centrioles and centrosphere collectively called **centrosome or microcentrum or diplosome.**



Centrioles : (A) A pair of centrioles (Diplosome), (B) T.S. of a centriole

Function :–

(i) In animal cells centrioles play an important role in initiation of cell division by arranging spindle fibres between two poles of cell.

(ii) The location of centrioles during cell division decides the **plane of division.**

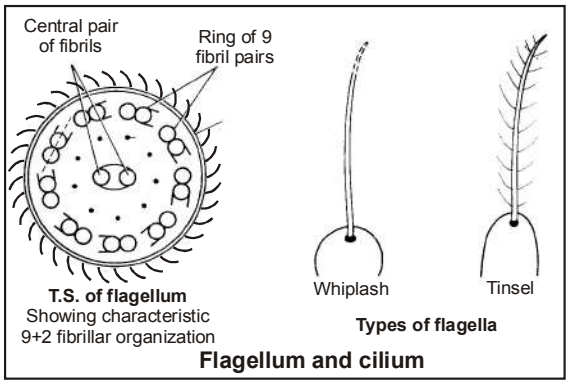
(iii) It form the **basal granule of cilia and flagella** in micro-organisms, zoo-spores & motile gametes.

(iv) Form tail of sperm.

CYTOSKELETON (CILIA AND FLAGELLA)

1. INTRODUCTION:

- In many eukaryotic as well as prokaryotic cells of both plants and animals a cytoskeleton has been reported in recent years.
- The elements of this cytoskeleton are proteins.
- The cytoskeleton consists of following two elements within a cell.
  (A) Microtubules
  (B) Microfilaments
- Cilia and flagella of eukaryotic cells are microscopic, contractile & filamentous process of cytoplasm.
- Cilia is shorter than flagella and are numerous.



Flagellum and cilium

(A) Microtubules : These are cylindrical structures formed by the polymerization of two-part subunits of globular protein tubulin into helical stacks.

(i) Historical Account : The term **'microtubule'** was coined by **Slautterback** in 1963.

(ii) Ultrastructure :

- Microtubules radiate from each end of the cell which helps in the movement of chromosomes.
- These are found in many plant and animal cells.

Function :

(i) Microtubules help in the structure and movement of cillia and flagella.

(ii) It also play a role in cell division.

(B) Microfilaments :

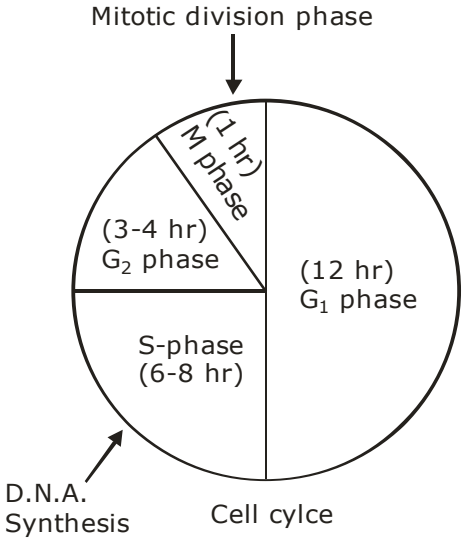
Ultrastructure : These are long and helically interwined polymers. Microfilaments are made up of protein **actin.**

Function :

These filaments help in cell movement and in formation of cell furrow and cell plate.

CELL DIVISION

Cell division was first observed by Nageli in plant cell (1842) and it was first studied by Prevost and Dumas in the fertilized egg of frog.



➢ **Cell Cycle :** It is a series of programmed cyclic changes by which the cell duplicates its contents and divides into two daughter cells. Cell cycle was discovered by Howard and Pelc.It is divided into two phases :

1. Long non dividing (I – phase) or interphase.
2. Short dividing M – phase or mitotic phase.

1. Long non dividing (I – phase) or interphase or preparatory phase : Interphase divided in the following steps.

- **G_1** (First growth phase),
- **S**(Synthesis phase),
- **G_2** (Second growth phase)

2. Short dividing M – phase : It is the phase of cell division. It consists of karyokinesis (nuclear division) and cytokinesis (cytoplasmic division). It is of three types:

I. MITOSIS :

- Term mitosis was given by Flemming.
- It is also called as somatic division as it occurs during formation of body cells.
- It is an equational division in which a parent cell divides into two identical daughter cells, each of them contains the same number of chromosomes as are present in parent cell.
- It occurs in two steps :

(i) Karyokinesis

(ii) Cytokinesis

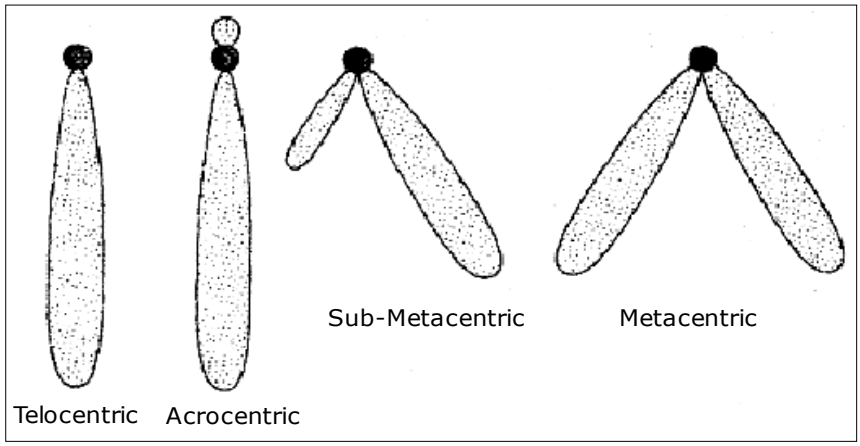
(i) Karyokinesis : Division of nucleus. It is divided in four steps :

(A) Prophase : Longest phase of cell division. In this chromatin condensed into chromosomes and nuclear membrane disappears.

(B) Metaphase : Chromosomes are arranged at the equator & forming a metaphase plate. Chromosomes are shortest and thickest in this stage. This phase is most suitable for study of chromosomes.

(C) Anaphase : Shortest phase of cell division.

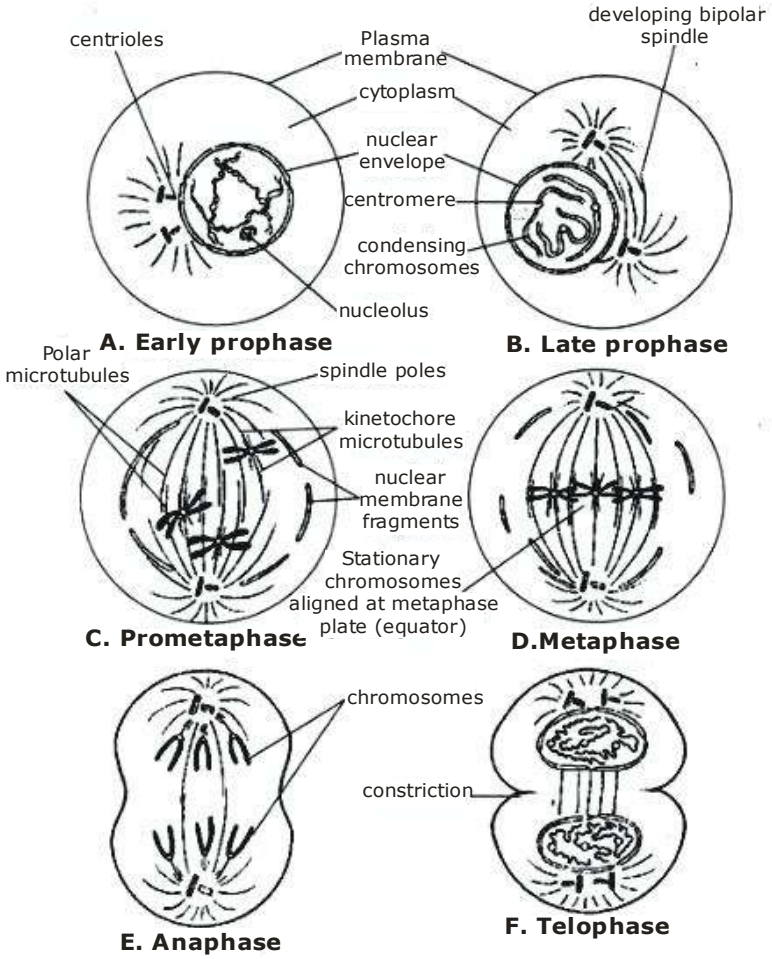
- Chromosomes are appeared in different shapes.
- V – Shaped (Metacentric)
- L – Shaped (Submetacentric)
- J – Shaped (Acrocentric)
- I – Shaped (Telocentric)



(D) Telophase : It is reverse of prophase.

(ii) Cytokinesis : It is referred to the division of cytoplasm. In animals cell it is occurs by formation of cleavage furrow in the middle by constriction in plasma membrane. In plants it cytokinesis occurs by cell plate formation.

Note : Colchicine is a mitotic poison. It blocks the completion of metaphase.



- **Significance of mitosis :** It is essential for growth, repair, differentiation, maintenance of chromosome number etc.

II. MEIOSIS :

- It occurs only once in the life cycle of organism.
- It is a double division in which a diploid cell divides twice to form four haploid cells.
- It can be studied in anthers of unopened flowers in plants and in testis of grasshopper in animals. It consists of two phases :

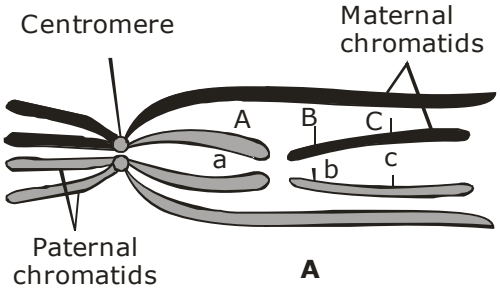
(i) Interphase : Size of nucleus increases to three times. It also involves G_1 – S – phase in meiosis-I and G_1 – G_2 in meiosis-II.

(ii) M – phase : It occurs in two steps

(A) Meiosis – I, (B) Meiosis – II

(A) Meiosis – I : It is also called as reduction division. Diploid stage changes to haploid stage. It occurs in four steps.

- **Prophase – I :** It is the longest phase of meiosis. It has following stages :
- **Leptotene :** Chromatin fibres condense to form chromosomes.There are two chromosomes of each type which are diploid and are called as "homologous chromosomes".
- **Zygotene :** Synaptonemal complex is formed between two homologous chromosomes.
- **Pachytene :** The exchange of segments between non sister chromatids of chromosome is called as crossing over.
- **Diplotene :** Synaptonemal complex is dissolved, tetrads are cleared. At some places nonsister chromatids of two homologous chromosomes remain attached to form a chiasmata.



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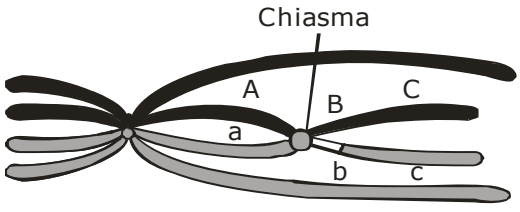

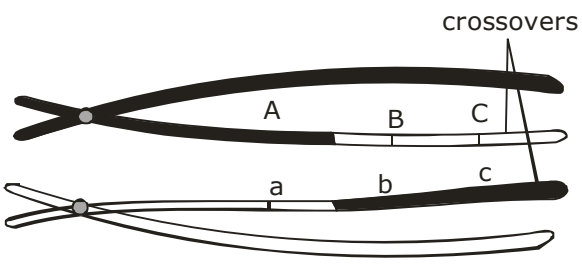

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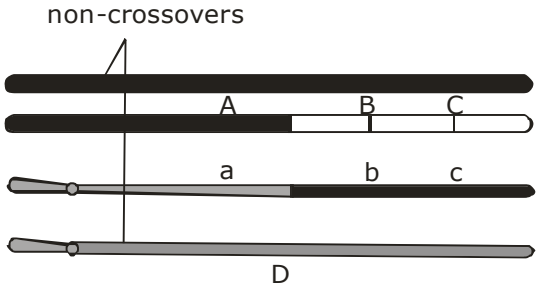
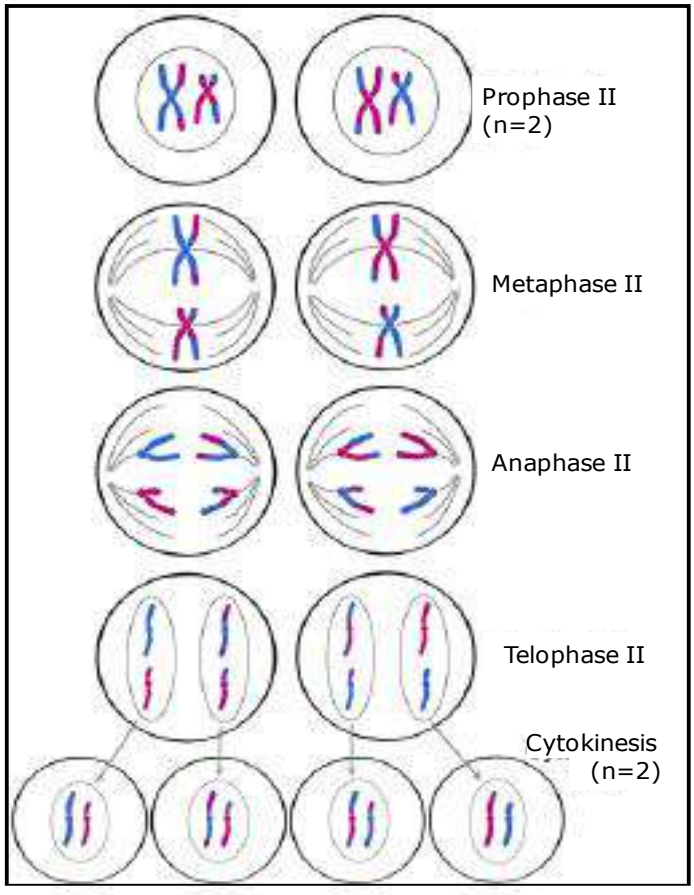


D

- **Diakinesis :** Chiasmata shifts towards ends, nucleolus degenerates.
- **Metaphase – I :** Spindles are formed and bivalents form a double whorl or double metaphase plate.
- **Anaphase – I :** Chiasmata disappears, homologous chromosomes separate by disjunction forming dyads. They move towards poles and form two groups of haploid chromosomes.
- **Telophase–I :** Chromosomes elongate, nucleoplasm & nuclear envelope reappears.

(B) **Meiosis – II :** It is also called as equational division and maintains the haploid number of chromosomes. No replication of DNA occurs in this stage (It is similar to mitosis)

- Prophase – II • Metaphase – II • Anaphase – II • Telophase – II
- **Significance of meiosis** : It produces variations and essential for sexual reproduction. It maintains the chromosome number in each generation of living organisms.



III. **Amitosis :** It was discovered by Remak. In this division, cells are divided into two cells without any particular pattern. E.g. prokaryotic cells.

Differences between mitotic and meiotic cell division

Mitosis	Meiosis
It occurs in all somatic cells.	It occurs in reproductive cells (germ cells)
In the resultant daughter cells, the number of chromosomes remains the same (i.e., diploid(2n), hence, called equational division.	In resultant daughter cells, the number of chromosomes reduces to half (i.e., haploid(n), called reductional division.
By mitosis two daughter cells are produced.	By meiosis four daughter cells are produced.
During mitosis no crossing over takes place.	During meiosis crossing over takes place.
Daughter cells have identical chromosomes which are also identical to that of parent cell (i.e. remains constant)	Chromosomes of the daughter cells are with combined components (genes) of both parents (i.e., genetic variability occurs)

PRACTICE YOUR CONCEPTS

6. Red blood cells when placed in a hypotonic solution will _____. This process is known as _____.
(A) Shrink, crenation (B) Swell up, plasmolysis
(C) Turgid, deplasmolysis (D) Burst, haemolysis

7. A plant cell becomes turgid due to–
(A) Plasmolysis (B) Exosomosis
(C) Endomosis (D) Electrolysis

8. Which of the following compounds forms an integral component of cell wall in bacteria ?
(A) Cellulose (B) Chitin
(C) Calcium pectate (D) Peptidoglycan

9. A chromatid is made up of–
(A) DNA (B) DNA + histone proteins
(C) RNA (D) RNA + histone proteins

10. Fluid mosaic model of plasma membrane as given by–
(A) Rudolf Virchow (B) Schleiden and Schwann
(C) Knoll and Ruska (D) Singer and Nicolson

11. Elaioplasts are reservoirs of–
(A) Oil (B) RNA (C) Protein (D) Enzyme

12. Amyloplasts are the plastids that store–
(A) Starch (B) Lipids (C) Proteins (D) Both (A) and (B)

13. Ribosomes are present inside certain other cell organelle(s), like–
(A) Plastids (B) Lysosomes (C) Mitochondria (D) Both (A) and (C)

14. The powerful oxidative enzyme present in peroxisomes is–
(A) Hydrolase (B) Catalase (C) Pepsin (D) Trypsin

[Sol : 6. (D), 7. (C), 8. (D), 9. (B), 10. (D), 11, (A), 12. (A), 13. (D), 14. (B)]

PRACTICE YOUR CONCEPTS

15. What is the role of membrane carbohydrate in cell-cell recognition?

Sol Short chains of sugars are linked to proteins and lipids on the exterior side of the plasma membrane, where they help in interaction with the surface molecules of other cells.

16. Which of these is an essential component of cell. Cell membrane or cell wall?

Sol A cell can exist without cell wall like animal cell but cannot exist without cell membrane because cell is a tiny mass of protoplasm covered by plasma membrane.

17. Bacteria do not have chloroplasts but some bacteria are photoautotrophic in nature and perform photosynthesis? Which part of bacterial cell perform this?

Sol Photoautotrophic bacteria possess photosynthetic pigments inside small vesicles which may be attached to plasma membrane.

ON YOUR TIPS

- All cells arise from pre-existing cells.The growth of the cells is mainly based on the cell division.
- All living organisms from the amoeba to man or algae to big trees are composed of individual units called cells.
- The cell is the basic unit of life and is a physical entity.
- A multicellular organism has various types of cells.
- Ribosomes are non membranous organelles found in all cells.
- Cell wall is the outermost layer in the plant cell.
- Cell membrane is the outermost layer in the animal cell and present inside the plant cell wall.
- Cytoplasm contains and supports the cell organelles.
- Endoplasmic reticulum is of two types:
  - (A) Rough Endoplasmic Reticulum
  - (B) Smooth Endoplasmic Reticulum
- Mitochondria breakdown sugars and release the energy for use by the cell.
- Chloroplasts use the sun's energy to make food for plant through photosynthesis.
- Ribosomes help in synthesis of protein.
- Centriole are present only in an animal cell. They help in cell division.
- Microtubule, microfilament forms the cytoskeleton of the cell.
- Cilia and flagella helps in locomotion.

NCERT QUESTIONS WITH SOLUTION

1. Who discovered cell and how ?

Sol. Robert Hooke discovered cells with the help of his self-designed microscope. In 1665, Robert Hooke was examining a thin slice of cork and he saw that the cork resembled the structure of a honeycomb consisting of many campartments.

2. Why is the cells called the structural and functional unit of life?

Sol. Each living cell has the capacity to perform certain basic functions that are characteristic of all living forms. Each living cell has got certain specific components within it known as cell organelles. Each kind of cell organelle performs a special function, such as making new material in the cell, clearing up the waste material from the cell and so on. A cell is able to live and perform all its functions because of these organelles. These organelles together constitute the basic unit called the cell.

3. How do substances like CO_2 and water move in and out of the cell ?

Sol. Substances like CO_2 (which is cellular waste and requires to be excreted out by the cell) accumulates in high concentrations inside the cell. In the cell's external environment, the concentration of CO_2 is low as compared to that inside the cell. As soon as there is a difference of concentration of CO_2 inside and outside a cell, CO_2 moves out of the cell, from a region of low concentration outside the cell by the process of diffusion.

4. Why is the plasma membrane called as selectively permeable membrane ?

Sol. The plasma membrane allows or permits the entry and exit of some materials in and out of the cell. It also prevents movement of some other materials. The cell membrane, therefore, is called as selectively permeable membrane.

5. Fill in the gaps in the following table illustrating differences between prokaryotic and eukaryotic cells.

Sol.

Prokaryotic Cell	**Eukaryotic Cell**
Size : Generally small (1 – 10 µm) 1µm = 10–6m	Size : Generally large (5–100µm.)
Nuclear region : _____(a)_____ and known as _____(b)_____	Nuclear region : well defined and surrounded by a nuclear membrane
Chromosome single	More than one chromosome.
Membrane bound cell organelles absent.	_____(c)_____ _____(d)_____.

6. Can you name the two organelles we have studied that contains their own genetic material?

Sol. Mitochondrion and Plastid.

7. If the organisation of a cell is destroyed due to some physical or chemical influence, what will happen?

Sol. Each living cell has the capacity to perform certain basic functions due to its cell organelles which are responsible for its organisation. If this organisation of a cell is destroyed, then cell will not be able to perform certain basic functions and ultimately it will die soon.

8. Why are lysosomes known as suicidal bags ?

Sol. Lysosomes contain powerul digestive enzymes capable of breaking down all organic material whenever there is disturbance in the cellular metabolism, i.e., when the cell gets damaged, then these lysosomes may burst and the enzymes digest their own cell. Therefore, lysosomes are also known as the 'suicidal bags' of a cell.

9. Where are protein synthesised inside the cell ?

Sol. Ribosomes (which are attached to the surface of Rough Endoplasmic Reticulum) are the sites of protein manufacture inside the cell.

10. Make a comparision and write down ways in which plant cells are different from animal cells.

Sol.

Plant Cell	Animal Cell
A cell wall is made up of cellulose, is present outside the plasma membrane.	Cell wall is absent.
Plastids (chloroplast, leucoplasts and chromoplasts) are present.	Plastids are absent.
Vacuoles are present usually a large cell vacuole lies in the centre.	Vacuoles are either absent or very small.
Centriole is absent (except in few lower plants).	Centriole with centrosome is present
They are usually regular in shape.	They are usually irregular ir shape.
Reserve food occurs in the form of starch.	Food is stored in the form of glycogen.
Lysosomes are either absent or very few in number.	Lysosomes are prominen and more in number.

11. How is a prokaryotic cell different from a eukaryotic cell.

Sol.

Prokaryotic Cell	Eukaryotic Cell
Size : Generally (1 – 10μm) 1 μ m = 10^{-6} m	Size : Generally large (5 – 100 μm).
Nuclear region : Undefined nuclear region containing only nucleic acids (genetic material) and known as nucleoid	Nuclear region : Well defined and surrounded by a nuclear membrane.
Chromosome : single.	More than one chromosomes
Membrane bound cell organelles absent.	Membrane bound cell organelles present.

12. What would happen if the plasma membrane ruptures or breaks down ?

Sol. If the plasma membrane ruptures or breaks down, then following things may happen :

(i) There will be no difference between the contents of the cell and its external environment.

(ii) Since plasma membrane is selectively permeable and allows only useful substances to enter inside the cell. When it may get ruptured, then all the useful substances will also move out of the cell.

(iii) The cell will lose its shape.
Ultimately all the metabolic activities of the cell will get affected and cell may even die.

13. What would happen to the life of a cell if there was no Golgi apparatus ?

Sol. The following things may happen in the cell if there was no golgi apparatus :

(i) There will be effect on the packaging and dispatching of different types of proteins to various targets inside and outside the cell.

(ii) The products of the cell cannot be stored and modified further.

(iii) The formation of complex sugars from simple sugars cannot take place.

14. Which organelle is known as the power house of the cell ? Why ?

Sol. Mitochondria are known as the power house of the cell. These organelles contain many oxidative enzymes which oxidise the food and convert it into energy currency of the cell in the form of ATP (Adenosine tri phosphate). This energy (in the form of ATP) is used by body for making new chemical compounds and for doing mechanical work. Due to this reason, mitochondria are generally referred to as 'power house of the cell'.

15. Where do the lipids and proteins constituting the cell membrane get synthesised ?

Sol. Lipids are synthesised in Smooth Endoplasmic Reticulum (SER) while proteins are synthesised in the ribosomes which are attached to the Rough Endoplasmic Reticulum (RER).

16. How does an Amoeba obtain its food ?

Sol. Amoeba acquires its food through the process of endocytosis. This process takes place due to the flexible nature of cell membrane which forms the structure of amoeba. The flexible nature of cell membrane enables the amoeba to engulf in food and other material from its external environment.

17. What is osmosis ?

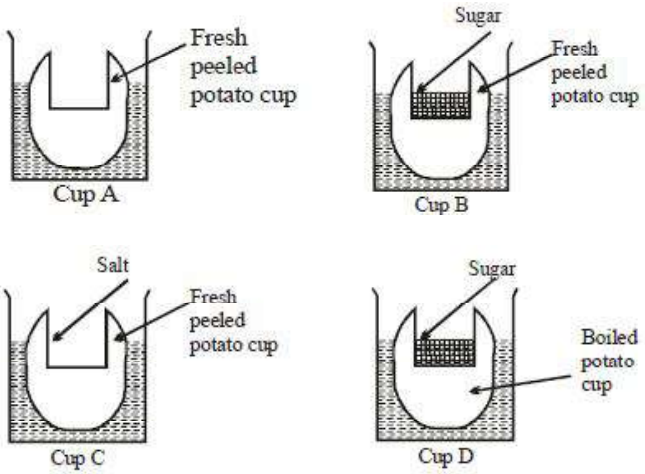
Sol. Osmosis is the passage of water or any solvent (diffusion) from a region of its higher concentration to its lower concentration through a semipermeable membrane. Thus, osmosis is a special type of diffusion through a selectively permeable membrane.

18. Carry out the following osmosis experiment : Take four peeled potato halves and scoop each one out to make potato cups. One of these potato cups should be made from a boiled potato. Put each potato cup in a trough containing water. Now :

(A) Keep cup A empty.
(B) Put one teaspoon sugar in cup B.
(C) Put one teaspoon salt in cup C.
(D) Put one teaspoon sugar in the boiled potato cup D.

Keep these for two hours. Then observe the four potato cups and answer the following :

(i) Explain why water gathers in the hollowed portion of B and C.
(ii) Why is potato A necessary for this experiment ?
(iii) Explain why water does not gather in the hollowed out portions of A and D.



Sol. (i) The water gathers in the hollowed portion of B and C due to the process of osmosis. Since the concentration of solute (sugar in cup B and salt in cup C is higher inside the cup as compared to the water which is outside the cup. Therefore, water (solvent) from its higher concentration (outside the cup) will move towards the lower concentration (inside the cup). This process of osmosis (moving in of solvent) is known as endosmosis.

(ii) Potato A acts as a control for the experiment. This is very necessary for comparing the results of the experiment.

(iii) Water does not gather in the hollowed out portions of A and D because of the following reasons.

(A) The hollowed portion of potato A is empty. Thus, there is no concentration difference and, therefore, no osmosis takes place.

(B) The hollowed portion of potato D contains sugar inside it but this potato is boiled one. Therefore, osmosis will not take place as its semipermeable membrane is destroyed by boiling.

19. Which type of cell division is required for growth and repair of body and which type is involved in formation of gametes?

Sol.

1. When a parent cell divides into two or more daughter cells, cell division has taken place.
2. Usually, cell division happens as part of a longer cell cycle.
3. All cells divide in two during reproduction, with each parental cell producing two daughter cells.
4. Cell division can occur in two different ways : mitosis and meiosis.
5. The form of cell division known as mitosis is responsible for the body's expansion and repair.
6. Gametes are created as a result of the cell division process known as meiosis.

EXERCISE - I

MULTIPLE CHOICE QUESTIONS

1. Double membrane is absent in –
(A) Mitochondrion (B) Chloroplast
(C) Nucleus (D) Lysosome

2. Animal cell is limited by–
(A) Plasma membrane
(B) Shell membrane
(C) Cell wall
(D) Basement membrane

3. The radiant energy of sunlight is converted to chemical energy and stored as –
(A) AMP (B) ADP
(C) ATP (D) APP

4. Root hair absorbs water from soil through –
(A) Osmosis (B) Active transport
(C) Diffusion (D) Endocytosis

5. The barrier between the protoplasm and outer environment in a plant cell is –
(A) Cell membrane (B) Nuclear membrane
(C) Cell wall (D) Tonoplast

6. An animal cell differs from a plant cell in respect of –
(A) ER (B) Cell wall
(C) Ribosomes (D) Cell membrane.

7. If the nucleus is a cell's "control centre" and chloroplasts its "solar collectors". Which of the following might be called the cell's combination "food processor" and "garbage disposer"?
(A) Lysosome (B) Ribosome
(C) Golgi apparatus (D) Nucleolus

8. The longest cell in human body is –
(A) Neuron (B) Muscle fibre
(C) Epithelial cell (D) Bone cell

9. Identify human cells which lack nucleus–
(A) WBC (B) RBC
(C) Platelets (D) Nerve cells

10. The energy currency of a cell is –
(A) ADP (B) AMP
(C) ATP (D) CTP

11. Which organelle releases oxygen?
(A) Ribosome (B) Golgi apparatus
(C) Mitochondria (D) Chloroplast

12. The term "protoplasm" to the living substance present inside the cell, was given by
(A) Robert Hooke (B) Robert Brown
(C) J.E. Purkinje (D) W.Flemming

13. Ribosomes are the centre for –
(A) Respiration (B) Photosynthesis
(C) Protein synthesis (D) Fat synthesis

14. Lysosomes are the reservoirs of
(A) Fat
(B) RNA
(C) Secretory glycoproteins
(D) Hydrolytic enzymes

15. The membrane surrounding the vacuole of a plant cell is called
(A) Tonoplast
(B) Plasma membrane
(C) Nuclear membrane
(D) Cell wall

16. Centriole is associated with –
(A) DNA synthesis
(B) Reproduction
(C) Spindle formation
(D) Respiration

17. The cell organelle associated with cell secretion is
(A) Plastids
(B) Mitochondria
(C) Golgi apparatus
(D) Nucleolus

18. Which of the following is an inclusion?
(A) Mitochondrion (B) Lysosome
(C) Golgi complex (D) Starch grain

19. Which of the following would not be considered part of a cell's cytoplasm?
(A) Ribosome (B) Nucleus
(C) Mitochondrion (D) Microtubule

20. Which of the following is called the brain of the cell?
(A) Nucleus (B) Mitochondria
(C) Ribosomes (D) Plasma membrane

21. Which one is not a part of nucleus?
(A) Chromatin (B) Nucleolus
(C) Centrosome (D) Nucleoplasm

22. The common feature amongst nucleus, chloroplast and mitochondrion is –
(A) DNA (B) Lamellae
(C) Cristae (D) All of these

23. Nucleus is separated from surrounding cytoplasm by a nuclear envelope which is–
(A) Single and porous
(B) Double and porous
(C) Single and nonporous
(D) Double and nonporous

24. Nucleoplasm is continuous with cytoplasm through –
(A) Centriole
(B) Golgi apparatus
(C) Nuclear pores
(D) Endoplasmic reticulum

25. Nucleolus was discovered by
(A) Fontana (B) Schleiden
(C) Altmann (D) Robert Brown

ASSERTION-REASON

In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(A) If both assertion and reason are true and reason is the correct explanation of assertion.

(B) If both assertion and reason are true but reason is not the correct explanation of assertion.

(C) If assertion is true but reason is false.

(D) It both assertion and reason are false.

1. **Assertion :** A cell membrane shows fluid behaviour.
Reason : A membrane is a mosaic of lipids and proteins.

2. **Assertion :** Mitochondria are known as 'power house' of the cell.
Reason : Mitochondria are used to bring about energy requiring activities of the cell.

3. **Assertion :** Plasma membrane is selectively permeable.
Reason : Plasma membrane allows some molecules to pass through more easily than others.

4. **Assertion :** Mitochondria provide important (k) Energy production intermediates for the synthesis of several biochemicals.
Reason : Mitochondria are capable of self duplication.

5. **Assertion :** Plant cell does not burst on account of endosmosis when kept in hypotonic solution.
Reason : Plant cell possess large vacuoles that remove excess water entering the cell and prevent it from bursting.

FILL IN THE BLANKS

1. The _____ are an exception to cell theory.
2. The nuclear region of prokaryotic cells is called _____.
3. The term protoplasm was coined by _____.
4. Ultrastructure of cell organelles can be studied by _____.
5. An ostrich egg is the _____ animal cell.
6. Amoeba can change their _____ continuously.
7. Cell is the basic _____ and _____ unit of all living organisms.
8. Cellular organelles called _____ are often referred to as suicidal bags.
9. Ribosomes are concerned with the synthesis of _____.
10. Function of mitochondria is _____ production.

TRUE/FALSE

1. Viruses are non-cellular living organisms.
2. Amoeba is a multicellular organism.
3. Plant cells are bounded by a wall composed of cellulose.
4. Cellulose is a protein.
5. Plasma membrane is present in all cells.
6. Blue green algae have prokaryotic cells.
7. All kinds of plastids have pigments.
8. Nucleolus has a limiting membrane.
9. Outer and inner membranes of chloroplasts have chlorophyll pigment.
10. Ribosomes are made up of deoxyribonucleic acid and proteins.

MATCH THE COLUMN

1.

Column I	Column II
(i) Robert Hooke	(a) nucleus
(ii) Robert Brown	(b) protoplasm
(iii) Von Mohl	(c) cell wall
(iv) Cellulose	(d) carbohydrate

2.

Column I	Column II
(i) Mitochondria	(a) Cell sap
(ii) Lysosome	(b) Cell's control centre
(iii) Vacuole	(c) Garbage disposer
(iv) ER	(d) Formation of Golgibody & Lysosome
(v) Nucleus	(e) Tonoplast
	(f) Suicidal bags
	(g) Having circular DNA
	(i) Having Linear DNA
	(j) Detoxification

VERY SHORT ANSWER TYPE QUESTIONS

1. What is hypotonic solution ?
2. What is hypertonic solution ?
3. What is isotonic solution ?
4. Cell wall is made up of which component ?
5. Give an example of unicellular organism.
6. Give an example of multicelluar organism.
7. What is active transport ?
8. What is the intracellular source of digestive enzyme ?
9. What is endocytosis ?
10. What is the function of mitochondria ?

SHORT ANSWER TYPE QUESTIONS

1. All activities inside the cell and interaction of the cell with its environment are possible due to some features found in almost every cell. Name any two such features.
2. (A) Name the different cell organelles which perform functions like protein/lipids make, specific digestion, and energy generation.
   (B) Which ER plays a crucial role in detoxifying many poisons and drugs ?

3. What type of enzymes are present in the lysosomes? What is their function? Which cell organelles manufacture these enzymes?
4. Write the composition of a chromosome. Name the part of a cell where it is formed.
5. Name the two cell organelles that contain their own DNA and ribosomes. What is the site of respiration to fullfill energy demands within the cell ? In which form energy is stored in a cell?

LONG ANSWER TYPE QUESTIONS

1. Why is mitochondria called power house of the cell? Give three similarities and one difference between mitochondria and plastid.
2. What are the main functions of each of the cell components?
3. What is the structure of mitochondria?
4. Explain main functional regions of cell with the help of a diagram.

PRACTICAL / ACTIVITY BASED QUESTIONS

1. Preetha was observing live cells of onion in the biology laboratory and she observed cell wall, cytoplasm and nucleus clearly. Suddenly her friend who was doing chemistry experiment spoiled a few drops of salt water on the slide. After some time Preetha observed the slide and found some changes.
   (i) What would have been the change in the live cells of onion peel after adding salt water?
   (ii) Name the type of process.
   (iii) What values shown by Preetha?
2. In a discussion one of the friends of Rani asked where do the lipids and proteins present in the cell membrane get synthesised? Rani answered this question very clearly. Her friend was satisfied after hearing answer and thanked Rani. Answer the following questions based on above information.
   (i) How did Rani answer this question?
   (ii) What are the values shown by Rani?
3. Osmosis with an egg–
   (A) Remove the shell of an egg by dissolving it in dilute hydrochloric acid. The shell is mostly calcium carbonate. A thin outer skin now encloses the egg. Put the egg in pure water and observe after 5 minutes. What do we observe? The egg swells because water passes into it by osmosis.
   (B) Place a similar de-shelled egg in a concentrated salt solution and observe for 5 minutes. The egg shrinks. Why? Water passes out of the egg solution into the salt solution because the salt solution is more concentrated.
4. Put dried raisins or apricots in plain water and leave them for some time. Then place them into a concentrated solution of sugar or salt. You will observe the following:
   (A) Each gains water and swells when placed in water.
   (B) However, when placed in the concentrated solution it loses water, and consequently shrinks.

EXERCISE - II

1. Endoplasmic reticulum is more developed in–
(A) Green cells (B) Young cells
(C) Mature cells (D) Bacteriophage

2. GERL system was proposed by–
(A) Aschoff (B) Metchnikoff
(C) Novikoff (D) None of these

3. During ultracentrifugation the ER and bodies associated with it are separated as a fraction known as–
(A) Microsome (B) Polysome
(C) Quantosome (D) Episome

4. Lipids and proteins constituting the cell membrane are synthesized at :
[Chandidarh/NTSE Stage-I/2013]
(A) Mitochondria
(B) Endoplasmic reticulum
(C) Golgi apparatus
(D) Lysosomes

5. Zone of exclusion is associated with–
(A) Golgi complex
(B) Endoplasmic reticulum
(C) Mitochondria
(D) Chloroplast

6. In which of the following cell organelle, both the photo and thermochemical reactions occur–
(A) Lysosome (B) Chloroplast
(C) Mitochondria (D) Ribosome

7. Anthocyanins are pigments which are–
(A) Water soluble and located in chromoplasts
(B) Water insoluble and located in chromoplasts
(C) Water insoluble and located in cell sap
(D) Water soluble and located in cell sap

8. Chromatophores contain–
(A) Chlorophyll
(B) Pigments other than chlorophyll
(C) Chlorophyll and other pigments where colour of chlorophyll is masked by another pigment
(D) None of the above

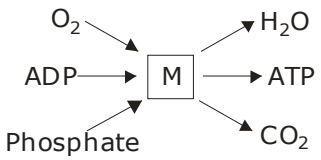
9. The main difference between chlorophyll 'a' and 'b' is–
(A) Chlorophyll 'a' is linear chain compound and 'b' is branched chain
(B) Chlrophyll 'a' has no Mg+ ion in centre of molecule
(C) In chlorophyll 'a' there is CH_3 group whereas in 'b' it is -CHO group
(D) All of the above

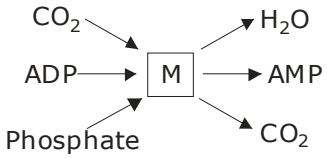
10. The mitochondrial DNA differs from the nuclear DNA because of–
(A) Being linear
(B) Having A = T and C - G
(C) Lacking binding histones
(D) Being highly twisted

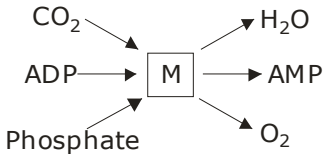
11. F_1 particles are also called–
(A) Electron transport particles
(B) Elementary particles
(C) Cytochromes
(D) Cristae

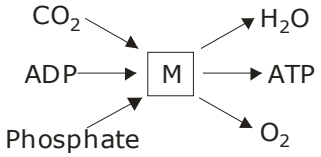
12. Mitochondria supply most of the necessary biological energy by–
(A) Breaking down of sugar
(B) Oxidizing substrates of TCA cycle
(C) Reducing NADP
(D) Breaking down of protein

13. Which of the following representation correctly explain the function of mitochondrion– **[NSEJS - 2013]**

(A) 

(B) 

(C) 

(D) 

14. Which of the following properties is attributed to the respones to changes in external and internal environment by protoplasm–
(A) Reproducibility (B) Mutability
(C) Irritability (D) Adaptability

15. Normal pH of Protoplasm is–
(A) 7.8 (B) 6.8
(C) 5 (D) 6.5

16. The best material for demonstrating streaming movement of protoplasm within living cells is–
(A) Onion peel
(B) Staminal hairs of *Tradescantia*
(C) Pith cells
(D) Cortical cells

17. Cell organelle that allows certain substances to enter or come out from the cell is **[Raj/NTSE Stage-I/2013]**
(A) Ribosome (B) Golgi body
(C) Centrosome (D) Plasma membrane

18. Beet root if kept in cold water anthocyanin does not come out due to plasma membrane–
(A) Differentially permeable
(B) Impermeable to anthocyanins
(C) Permeable to anthocyanins
(D) Dead

19. The common component of nuclear membrane of organelles like Mitochondria, Endoplasmic reticulum and Nucleus is . **[Bihar/NTSE Stage I/2015]**
(A) Lipoprotein (B) Glycoprotein
(C) Nucleoprotein (D) Glycolipid

20. The cell organelle storing substances like starch, oil and proteins is – **[NTSE/Stage - I/2014]**
(A) Vacuole (B) Lysosome
(C) Golgi body (D) Plastid

21. The pair of organelles which are able to make their own protein is **[Raj/NTSE Stage-I/2016]**
(A) Mitochondria, Lysosome
(B) Ribosome, Lysosome
(C) Plastid, Mitochondria
(D) Plastid, Golgi body

22. Which among the following statements regarding plasma membrane is correct–
(A) Its outer and inner layer are electron dense while middle layer is electron transparent
(B) Its outer and middle layer are electron transparent while inner layer is electron dense
(C) Its outer and inner layer are electron transparent while middle one is electron dense
(D) All layers are electron dense

23. Biological membranes are composed of–
(A) 40% proteins and 60% lipids
(B) 50% proteins and 50% lipids
(C) 70% proteins and 30% lipids
(D) 60% proteins and 40% lipids

24. The strength and rigidity of a cell wall is due to the substance known as–
(A) Suberin (B) Cellulose
(C) Lignin (D) Pectin

25. The possibility of being outermost layer of cell is highest for which of the following –
(A) Plasmalemma (B) Cell membrane
(C) Middle lamella (D) Primary wall

26. Tonofibrils are related to–
(A) Nuclear membrane
(B) Chloroplast
(C) Mitochondria
(D) Plasmodesmata

27. The branch which deals with the study of cell structure and function is known as–
(A) Histology (B) Ecology
(C) Morphology (D) Cytology

28. The word "Prokaryote" means a cell–
(A) With many nuclei
(B) With one nucleus
(C) With diffused nucleus
(D) Without chloroplast

29. Which of the following represents the correct sequence of relative sizes in descending order– **[NTSE Stage 2 - 2015]**
(A) Cell, nucleus, chromosome, water molecule, oxygen atom
(B) Cell, nucleus, water molecule, oxygen atom, chromosome
(C) Chromosome, cell, nucleus, water molecule, oxygen atom
(D) Cell, nucleus, water molecule, chromosome, oxygen atom

30. If living cells similar to those found on earth, were found on another planet where there was no oxygen. Which cell organelle would most probably be absent–
(A) Cell membrane (B) Ribosomes
(C) Mitochondria (D) None of these

EXERCISE - III

1. Unicellular algae X and Y of the same species were taken and chloroplasts were removed from cell X. After some time, they both were kept in bright sunlight for few hours and then iodine test was performed on them. What will be the results ?

(A) Both X and Y will turn blue-black.

(B) Cell X will turn blue-black.

(C) Cell Y will turn blue-black.

(D) Both X and Y will remain as they originally were.

2. Read the given statement and select the option that correctly identifies them as true (T) and false (F) ones.

(i) Granum is the site of dark reaction during photosythesis, whereas stroma is the site of light reaction during photosynthesis.

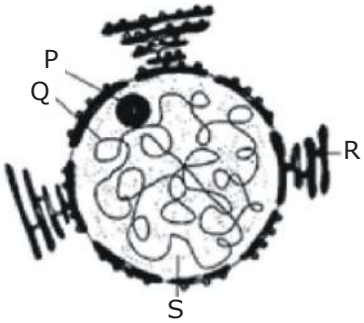
(ii) Lysosomes play an important role during metamorphosis in frog.

(iii) Each 70S ribosome consists of a large 50S subunit and a small 30S subunit.

(iv) The chromosome in which the centromere is near the end and consequently its one arm is very short and the other arm very long, is called acrocentric chromosome.

	(i)	(ii)	(iii)	(iv)
(A)	T	T	F	F
(B)	F	T	T	T
(C)	F	F	F	T
(D)	T	F	T	F

3. All members of the Gupta family can roll their tongue. Which of the parts labelled in the given figure carries information regarding this characteristic ? **[NSO - 2014]**



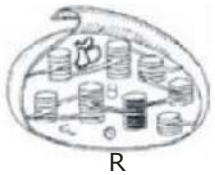
(A) P (B) Q

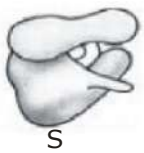
(C) R (D) S

4. Among the following cell organelles P, Q, R and S, which is the odd one out ?


P


Q


R


S

(A) S, because the others are membrane bound cell organelles.

(B) P, because the others are involved in cell secretion.

(C) R, because the others ar involved in protein storage.

(D) Q, because the others are involved in energy production.

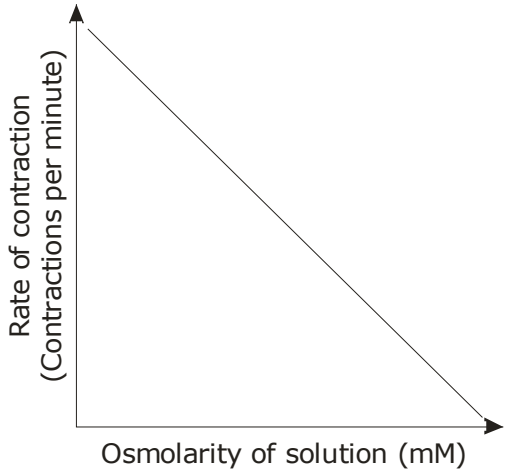
5. Four strips are cut from a fresh potato. The length of each strip is measured. One strip is placed in water and others in different concentrations of sugar solution. After an hour the strips were measured again. The results are shown in the table. Which of the liquids P, Q, R and S is water ?

Liquid	Original length of strip (mm)	Final length of strip (mm)
P	75	75
Q	78	80
R	82	80
S	86	85

(A) P (B) Q

(C) R (D) S

6. A unicellular protist X, which has contractile vacuole to remove excess intracellular water, was placed in salt solution of increasing osmolarity. The given graph shows the rate of contraction of vacuole to pump out excess water against osmolarity of solution. Select the option that gives the correct explanation of the data. **[NSEJS - 2012]**



(A) In an isotonic solution there is no diffusion of water in or out of the X, so the contraction rate is zero.

(B) At higher osmolarity, more salt diffuses into X, therefore lower rates of contractions are required.

(C) The rate of contraction increases as osmolarity decreases because amount of water entering X by osmosis increases.

(D) The contractile vacuole is less efficient in solution of high osmolarity because of reduced respiration and less production of ATP.

7. The acidic condition within the lysosome is maintained by:

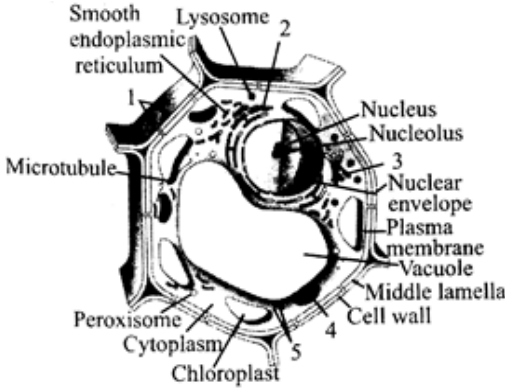
(A) Digestive enzymes synthesised on RER.

(B) Pumping Cl^- ion out of lysosome.

(C) Pumping protons (H^+) into the lysosome.

(D) All of the above

8. The following diagram shows some of the missing structures in a plant cell (1-5). Choose the correct option. **[NSO - 2016]**



(A) 1 - Plasmodesmata, 2 - Rough endoplasmic reticulum, 3 - Golgi apparatus, 4 - Mitochondrion, 5 Ribosomes

(B) 1 - Desmosome, 2 - Rough endoplasmic reticulum, 3 - Golgi apparatus, 4 - Mitochondrion, 5 Ribosomes

(C) 1 - Plasmodesmata, 2 - Smooth endoplasmic reticulum, 3 - Golgi apparatus, 4 - Mitochondrion, 5 Ribosomes

(D) 1 - Tight junction, 2 - Rough endoplasmic reticulum, 3 - Golgi apparatus, - 4 Mitochondrion, 5 - Ribosomes

9. Prokaryotic cell does not have:

(A) Nucleolus

(B) Membrane bound organelles

(C) Centrioles

(D) All of the above

10. Order the following terms in a way that depicts how vesicles are transported to membranes, are likely to move through the cell.

(i) ER
(ii) Nuclear envelope
(iii) Golgi apparatus
(iv) Vesicle
(v) Plasma membrane.
(A) (i), (ii), (iii), (iv), (v)
(B) (i), (iv), (ii), (iv), (iii), (iv), (v)
(C) (ii), (iii), (i), (iv), (v)
(D) (ii), (i), (iv), (iii), (iv), (v)

11. Sodium and potassium pumps are common in many cells. Which of the following are necessary for the pumps to work?
(A) ATP-driven pumping proteins.
(B) A signal to activate the pumps.
(C) A concentration gradient to work against.
(D) All of the above

12. Peroxisomes, in plant cells, are involved in–
(A) Photooxidation
(B) Photorespiration
(C) Photophosphorylation
(D) Photolysis of water

13. The cells are held together by a Ca-pectate layer called.
(A) Primary cell wall
(B) Secondary cell wall
(C) Middle lamella
(D) Tertiary cell wall

14. According to Danielli and Davson, the phospholipid bilayer is covered on either side by:
(i) Hydrated globular proteins
(ii) a-globular proteins
(iii) 3-globular proteins
(iv) Only spectrin protein with sialic acid
(A) (i) and (ii) (B) (ii) and (iii)
(C) (iii) and (iv) (D) (i) and (iv)

15. Channel proteins allow ions that would not normally pass through the cell membrane to go through the channel. What properties of the proteins are responsible for this?
(A) The channels are often composed of charged or polar R groups.
(B) The channels are often composed of hydrophobic R groups.
(C) Both (A) and (B)
(D) None of the above

16. Karyolymph is a–
(A) Nuclear sap (B) SPM membrane
(C) Nuclear pore (D) None of these

17. The nuclear spindle consists of–
(A) One type of fibre
(B) Two types of fibres
(C) Three types of fibres
(D) Four types of fibres

18. Watson has calculated the nuclear pores of the mammalian cells to be ..... of the total surface area of the nucleus
(A) 5 percent (B) 50 percent
(C) 25 percent (D) 10 percent

19. Pars amorpha is associated with–
(A) Nucleus (B) Chloroplast
(C) Mitochondria (D) Nucleolus

20. Histone proteins found in nuclei of eukaryotes are–
(A) Acidic (B) Basic
(C) Neutral (D) Amphoteric

21. Amount of which one of the following is more in the nucleus but less in the chromosome–
(A) DNA
(B) RNA
(C) Histone proteins
(D) Non-histone proteins

22. In nucleoplasm, a conspicuous body of spherical shape attached to a particular chromosome on a definite position is called–
(A) Plasmid (B) Karyolymph
(C) Nucleolus (D) Nuclear reticulumg

23. Width of perinuclear space is–
(A) 30 to 50 Å
(B) 50 to 80 Å
(C) 100 to 300 Å
(D) 300 to 1000 Å

24. Who showed that the nuclear membrane has many pores or circular structures or annuli–
(A) Fawcell (B) Strasburger
(C) Butchen (D) Callan and Tomlin

25. The main structure of centriole is–
(A) 9 + 3 fibrils
(B) 9 + 2 fibrils
(C) Nine triplets
(D) 13 globular subunits

26. Each peripheral fibril on the centriole is made up of–
(A) 1 microtubule (B) 2 microtubule
(C) 3 microtubule (D) 4 microtubule

27. A centrosome is–
(A) A cytoplasmic organelle present in plant cells
(B) A cytoplasmic organelle present in animal cells
(C) A cytoplasmic organelle present in plant and animal cells
(D) A nuclear structure present in animal cells

28. Flagella with single strand and composed of flagellin is found in–
(A) Prokaryotes
(B) Eukaryotes
(C) Both (A) and (B)
(D) None of these

29. Select the correct answer among the following statements.
1. Microtubules structural components of cilia
2. Centrioles store hydrolytic enzymes
3. Peroxisomes store oil protein and starch in plants–
(A) 1, 2 and 3 are correct
(B) 1 and 2 are correct, 3 is false
(C) 1 is correct, 2 and 3 are false
(D) 1 and 3 are correct, 2 is false

30. Three of the following statements regarding cell organelles are correct while one is wrong. Which one is wrong–
(A) Lysosomes are double membrane vesicles budded off from golgi apparatus and contain digestive enzymes
(B) Endoplasmic reticulum consists of a network of membranous tubules and helps in transport, synthesis and secretion
(C) Leucoplast are bound by two membranes lack pigment but contain their own DNA and protein synthesizing machinery
(D) Sphaerosomes are single membrane bound and are associated with synthesis and storage of lipids

31. The cellular role for lysosome is not–
(A) Ingestion of foreign bodies
(B) Digestion of aged organelles
(C) Cell destruction during development
(D) Osmoregulation

32. The cell organelle showing extensive polymorphism is–
(A) Dictyosomes (B) Chloroplasts
(C) Lysosomes (D) Ribosomes

33. The "marker'' enzyme of lysosome is–
(A) Lysozyme (muramidase)
(B) Acid protease
(C) Acid phosphatase
(D) Beta-galactosidase

34. 'Palade granules' are–
(A) Ribosomes
(B) Microbodies
(C) Sulphur granules
(D) Lipid granules

35. Which of the following cell organelle lacks DNA and bounding membrane–
(A) Ribosome
(B) Plastid
(C) Nucleolus
(D) Plasmid

36. Which of the following affects the association and dissociation of sub-units of ribosomes–
(A) Mg (B) Ca
(C) Fe (D) K

37. In prokaryotic ribosome RNA - protein ratio is–

(A) 2 : 1 (B) 1 : 1

(C) 3 : 1 (D) None of these

38. Which of the following pairs is correct–

(A) Svedberg unit - Biomembranes

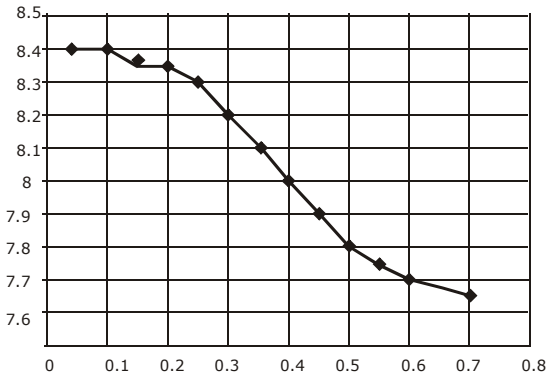
(B) Polyribosomes - RNA

(C) Dictyosomes - Suicidal sacs

(D) Cisternae - Mitochondria

39. Thin cuboidal strips are made by slicing a potato. They are all made to be exactly 8 cm long and 2 mm wide. Each strip is placed in sugar solutions of different concentration. After soaking it for 5 hours, their lengths are measured again. The following graph shows the results of the experiment. What concentration of sugar solution is isotonic with the conntents of the cells of the potato.

[IJSO/Stage-I/2016]



(A) 0.2 (B) 0.4

(C) 0.6 (D) 0.1

40. A 4 um long bacterial cell was magnified and drawn to a dimension of 6 cm. How many times has it been magnified ?

[NSEJS/Stage-I/2019-20]

(A) 1.5×10^3 (B) 15×10^4

(C) 1.5×10^4 (D) 1.5

41. Descriptions of four biological samples (I - IV) are given below.

[NSEJS/Stage-I/2020-21]

I: Can be viewed using a light microscope with a total magnification of 1000x; possesses cell wall and does not possess mitochondria.

II. Can be seen using a light microscope with a total magnification 100x; possesses cell wall and has nucleus.

III. Need electron microscope for viewing; can be found attached to the membrane system in the cytoplasm.

IV. Needs electron microscope for viewing; cannot replicate on its own, needs other specific cells for replication.

I.II. III, and IV respectively represent.

(A) virus, plant cell, ribosome; bacteria.

(B) plant cell: bacteria: vacuole, virus.

(C) bacteria, plant cell; ribosome, virus.

(D) bacteria; protist; plant cell vacuole; mitochondria.

42. If the gamete of a tetraploid plant contains 26 chromosomes, the number of chromatids in cells of the plant during metaphase of mitosis and metaphase II of meiosis will be, respectively,

[NSEJS/Stage-I/2021-22]

(A) 104 and 104 (B) 52 and 26

(C) 104 and 52 (D) 26 and 26

43. Which of the following molecules are primarily responsible for structural support and motility?

[NSEJS/Stage-I/2021-22]

(A) Pectin (B) Tubulin alpha

(C) Lamins (D) Desmin

MOTION®

MATHEMATICS

CLASS - IX

BOOKLET - 1

CONTENTS

NUMBER SYSTEM

POLYNOMIALS

COORDINATE GEOMETRY

LINEAR EQUATION IN TWO VARIABLES

Motion Education, 394 - Rajeev Gandhi Nagar, Kota-5 (Raj.)
: 1800-212-1799, 8003899588 | url : www.motion.ac.in | : info@motion.ac.in

EUCLID'S GEOMETRY

LINES AND ANGLES

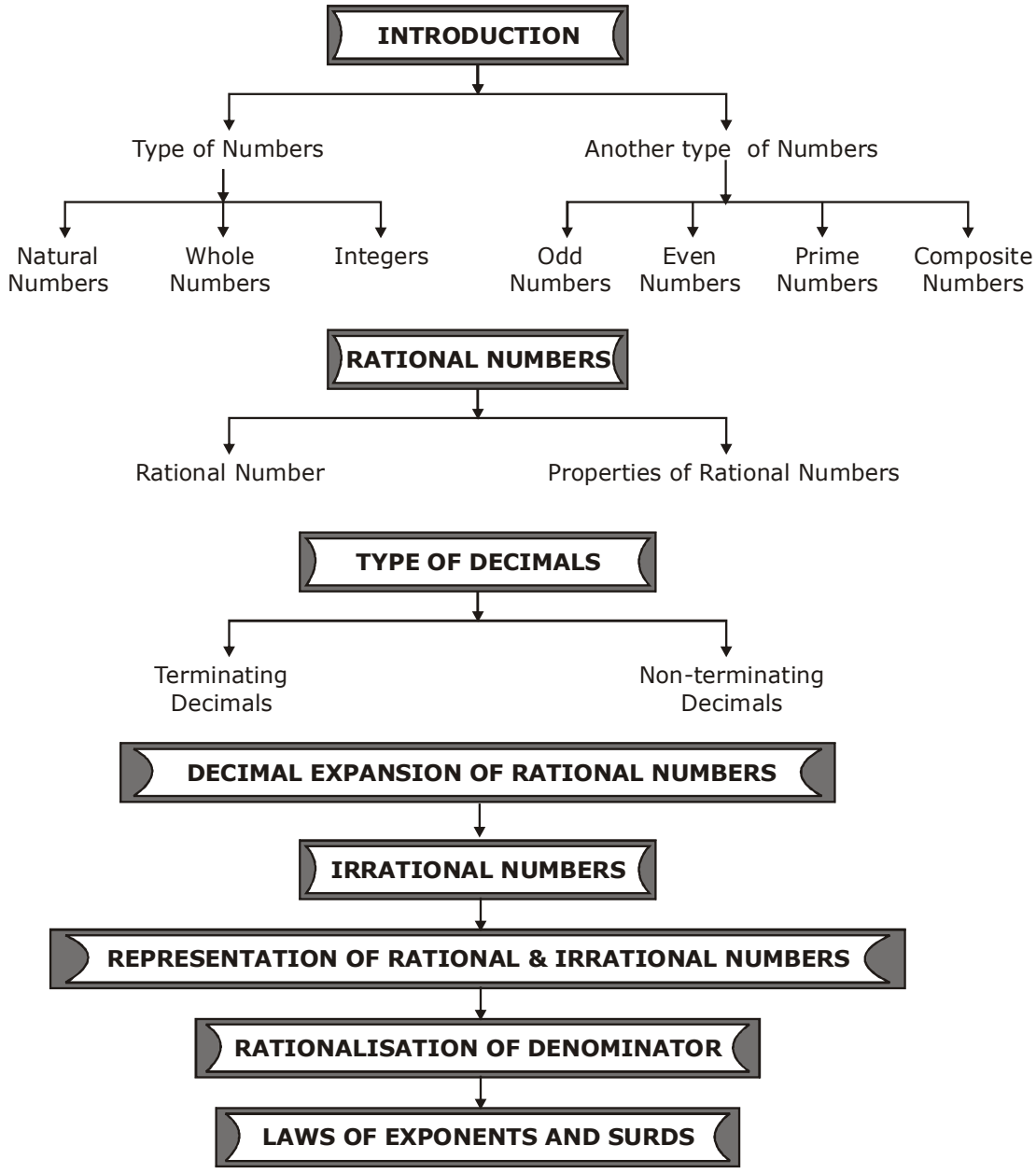
TRIANGLES

QUADRILATERALS

ANSWER KEY

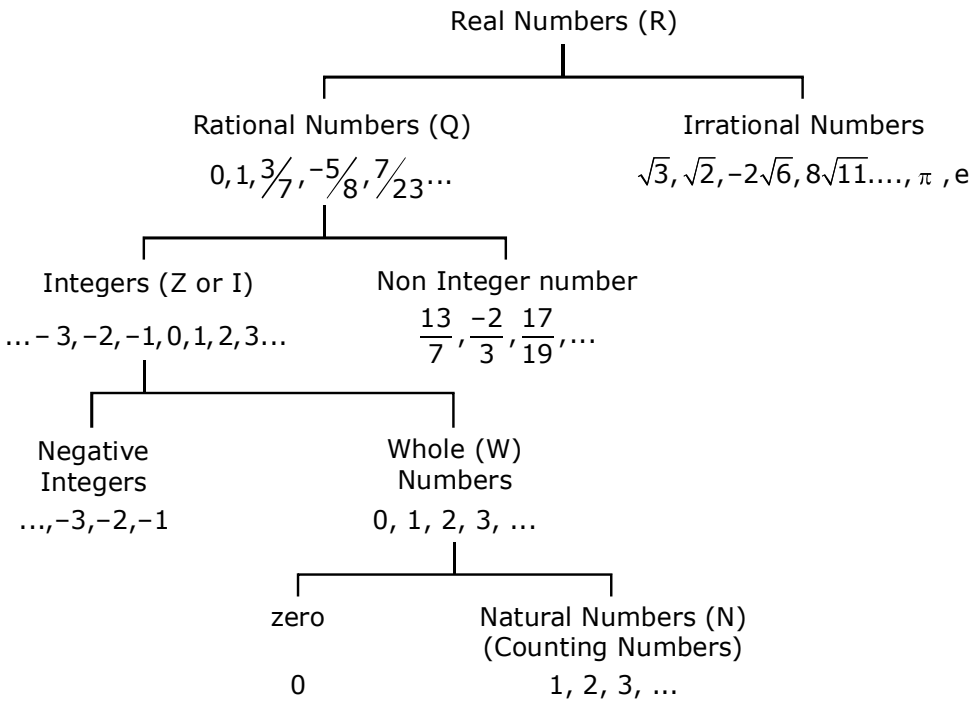
CHAPTER 1

NUMBER SYSTEM



INTRODUCTION

A number is a mathematical object used to count, label and measure. We have studied different types of numbers such as Natural numbers, Whole numbers in earlier classes. Here we will explore about Rational numbers, irrational numbers, Real numbers and their properties.



TYPES OF NUMBERS

◈ **Natural Numbers (N) :**

Counting numbers are known as natural numbers. Thus 1, 2, 3, 4, …etc. are natural numbers.

- ✯ The first and the least natural number is 1 (one)
- ✯ Consecutive natural nos. differ by 1 (one).

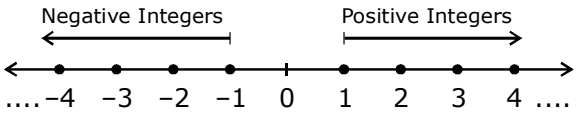
◈ **Whole numbers (w) :**

All natural numbers together with '0' form whole numbers. Thus 0, 1, 2, 3, 4, … etc. one are whole numbers.

- ✯ The first and the least whole number is zero.
- ✯ Consecutive whole number differe by one.

◈ **Integers (I or Z) :**

All natural numbers 0 and negative of natural numbers form integers for example. ……–4, –3, –2, –1, 0, 1, 2, 3, 4, … etc are integers.



(Number line)

- ✯ 0 is neither a negative nor a positive number. It is a neutral number.
- ✯ On the right hand side of 0 the integers are positive integers
- ✯ On the left hand side of 0 the integers are negative integers

Info Bubble

- "0" is neither positive, nor negative.
- Non-negative integers : 0, 1, 2, ...
- Non-positive integers : ..... - 3, - 2, - 1, 0,
- Positive integers : 1, 2, 3, ...
- Negative integers : ..... - 3, - 2, - 1.

ANOTHER TYPES OF NUMBER

◈ **Odd Numbers**

A number not divisible by 2 is called odd number.

- ✯ 1, 3, 5, 7, 9 ..... etc.

◈ **Even Numbers**

A number divisible by 2 is called even number.

- ✯ 2, 4, 6, 8 ..... etc.

◈ **Prime numbers (P) :**

A natural number, which is greater than 1 and divisible by one or by itself only, is called a prime number. For eg : 2, 3, 5, 7, 11, ……

- ✯ The smallest prime number is 2
- ✯ Except 2 ; all other prime numbers are odd.

◈ **Composite number (C) :**

A natural number, which is greater than 1 and is not prime, is called a composite number. Thus 4, 6, 8, 9, 10, 12, 14, ……

- ✯ The smallest composite number is 4.
- ✯ A composite number can be even or odd.
- ✯ It has atleast three distinct factor.
- ✯ 1 is neither prime nor composite.

◈ **Co-prime numbers :**

If the H.C.F. of the given numbers (not necessarily prime) is 1 then they are known as co-prime numbers

Thus (6 and 25), (3 and 5) are co-prime numbers as they don't have any common factor other than 1.

- ✯ Two consecutive natural numbers are co-prime.

◈ **Twin prime numbers :**

The term twin primes is used for a pair of odd prime numbers that differ by two.

✯ 5 and 7 are twin primes

◈ **Imaginary Numbers:** All the numbers whose square is negative are called imaginary numbers.

✯ 4i, – 8i, i, ... where $i = \sqrt{-1}$ ($i^2 = -1$)

◈ **Complex Numbers :** The real and imaginary numbers together makes complex number. It is denoted by Z = a +ib where a is real part and b is imaginary part of Z and a, b $\in$ R. here i is called iota.

◈ **Perfect Numbers :** If the sum of all factors of a number is twice the number then this number is called perfect number.

✯ 6, 28... are perfect numbers.

RATIONAL NUMBER

◈ **Rational Numbers (Q) :**

The numbers of the form $\frac{p}{q}$, where p and q are integers and $q \neq 0$, are known as rational numbers.

or

A number is rational if and only if its decimal representation is terminating or non-terminating but recurring

Ex. $\frac{2}{5}$, 3, $\frac{5}{1}$, 1.75, 1.666……, 4.23535, ……, $\frac{7}{9}$

every integer is also a rational number.

◈ **Characteristics of Rational numbers.**

(i) Every rational number is expressible either as a terminating decimal or as a repeating decimal.

(ii) Every terminating decimal is a rational number.

(iii) Every repeating decimal is a rational number

◈ **Properties of Rational Numbers**

(i) Commutative Property of Addition: a + b = b + a.

(ii) Associative Property of Addition: a + (b + c) = (a + b) + c

(iii) Identity property of Addition: a + 0 = 0 + a = a where 0 is called the identity element for addition of rational numbers and -a is called the additive inverse of a".

(iv) Commutative Property of Multiplication: ab = ba

(v) Associative Property of Multiplication: a (bc) = (ab) c

(vi) Identity element of Multiplication: a × 1 = 1 × a = a where 1 is called the multiplicative identity and 1/a is called multiplicative inverse of a.

(vii) Distributive Property of multiplication over addition: a × (b + c) = (a × b) + (a × c)

Info Bubble

- Zero has no reciprocal.
- 1 and –1 are the only rational numbers having their reciprocals as themselves.

◈ **Inserting many Rational Numbers between Two Given Distinct Rational Numbers**

Between any two distinct rational numbers x and y, there exists infinitely many rational numbers.

Method 1: let m and n be two rational numbers such that m<n, then $q_1 = \frac{(m+n)}{2}$

q_1 is the rational number between m and n. $m < q_1 < n$.
now $q_2 = m + q_1/2$
and $q_3 = q_1 + n/2$....
repeate the process to get as many as rational numbers between two rational number m and n.

Method 2: let m and n be two rational numbers such that m<n. make the denominators equal. if we wish to find n rational numbers than multiply numerator and denominator by n+1. Then write numbers between them.

PRACTICE YOUR CONCEPTS

1. Find five rational numbers between 4 and 5.

Ans. five rational number between 4 and 5 are

$a_1 = \frac{4+5}{2} = \frac{9}{2}$ $\quad 4 < \frac{9}{2} < 6$

$a_2 = \frac{4+\frac{9}{2}}{2} = \frac{17}{4}$ $\quad 4 < \frac{17}{4} < \frac{9}{2} < 5$

$a_3 = \frac{\frac{9}{2}+5}{2} = \frac{19}{4}$ $\quad 4 < \frac{17}{4} < \frac{9}{2} < \frac{19}{4} < 5$

$a_4 = \frac{4+\frac{17}{4}}{2} = \frac{33}{8}$ $\quad 4 < \frac{33}{8} < \frac{17}{4} < \frac{9}{2} < \frac{19}{4} < 5$

$a_5 = \frac{\frac{19}{4}+5}{2} = \frac{39}{8}$ $\quad 4 < \frac{33}{8} < \frac{17}{4} < \frac{9}{2} < \frac{19}{4} < \frac{39}{8} < 5$

2. Insert 4 rational numbers between 2/3 and 5/3 .

Ans. here both the numbers have same denominators.

$\therefore$ We multiply numerator and denominator of each number by (4 + 1) = 5

so, the numbers are 10/15 and 25/15

Any 5 integers between 10 and 25 are 11, 12, 13, 14, 15.

$\therefore$ Required rational numbers between the two given numbers are 11/15, 12/15, 13/15, 14/15 ,15/15.

Decimal representation of Rational numbers.

TYPES OF DECIMAL

- **Pure recurring decimals:** a decimal number in which all the digits after the decimal point are repeated.
- **Mixed recurring decimals:** a decimal number in which at least one digit after the decimal point is not repeated.
- **Conversion of Terminating Decimal Numbers into Rational Numbers of the form p/q :**

  Step. 1 : Count the number of numerals to the right of the decimal point. Let it be m.

  Step. 2: Drop the decimal point and in the denominator write 1 followed by m zeros.

  Step. 3: Simplify the fraction by cancelling the common factors.
- **Conversion of Pure Recurring Decimal to the form p/q.**

  Step.1 : Obtain the repeating decimal and put it equal to x.

  Step 2 : Write the number in decimal form by removing bar from the top of repeating digits and listing repeating digits at least twice : e.g. write x = 0.7 as x = 0.777 .....

  Step 3 : Determine the numbers of digits having bar on their heads.

  Step 4 : If the repeating decimal has 1 place repetition, multiply by 10, a two place repetition, multiply by 100, a three place repetition, multiply by 1000 and so on.

  Step 5 : Subtract the number in step 2 from the numbers obtained in step 4.

  Step 6 : Divide both sides of the equation by the coefficient of x.

  Step 7 : Write the rational number in its simplest form.
- **Conversion of a Mixed Recurring Decimal to the form p/q.**

  Step 1 : Obtain the mixed recurring decimal and write it equal to x.

  Step 2 : Determine the number of digits after the decimal point which do not have bar on them. Let there be n digits without bar just after the decimal point.

  Step 3 : Multiply both sides of x by 10^n, so that only the repeating decimal is on the right side of the decimal point.

  Step 4 : Use the method of converting pure recurring decimal to the form p/q and obtain the value of x.
- **Terminating decimals :**

  The decimal expansion ends after a finite number of steps of division. Such decimal expansions are called terminating decimals

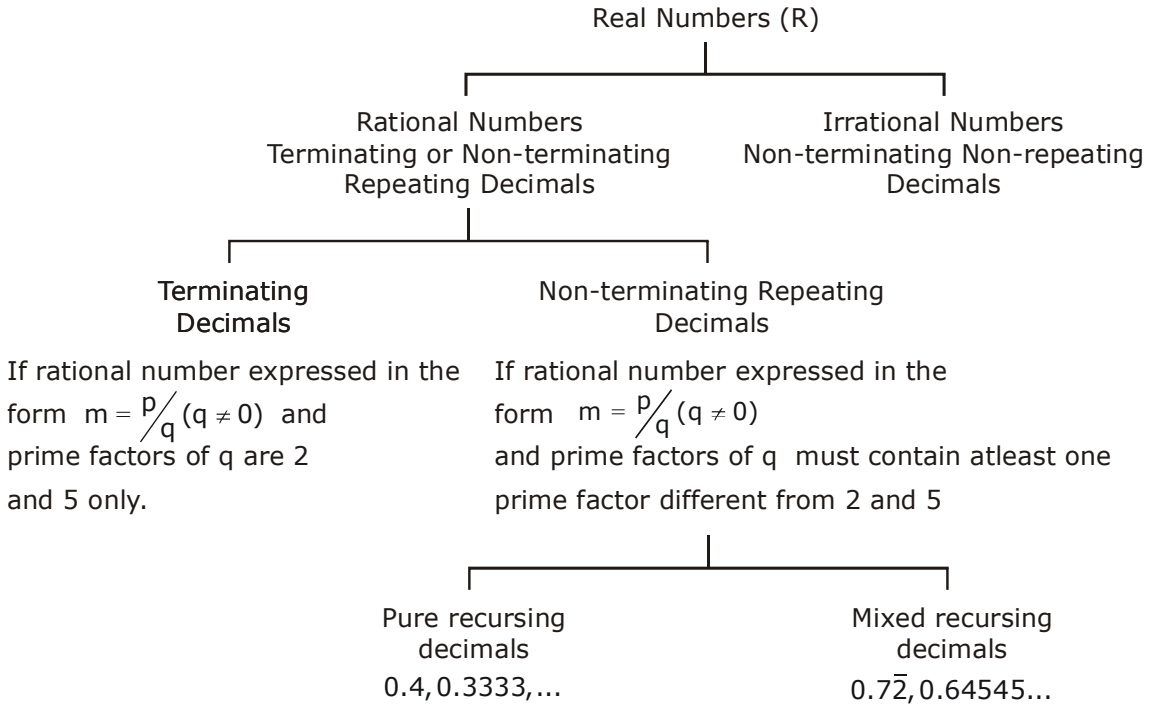
  For example : $\frac{2}{5} = 0.4$, $\frac{33}{8} = 4.125$ and so on.

◈ **Non-terminating decimals :**

The decimal expansions never come to an end. Such decimal expansions are called non-terminating decimals.

For example = $\frac{2}{11}$ = 0.1818..., $\frac{16}{45}$ =0.3555.....

DECIMAL EXPANSION OF RATIONAL NUMBERS



PRACTICE YOUR CONCEPTS

3. Convert $\frac{237}{16}$ in the decimal form.

Ans.

$$
\begin{array}{r}
16\overline{)237}\,(14.8125 \\
-16 \\
\hline
77 \\
-64 \\
\hline
130 \\
128 \\
\hline
20 \\
-16 \\
\hline
40 \\
-32 \\
\hline
80 \\
-80 \\
\hline
00
\end{array}
$$

$\therefore \quad \frac{237}{16} = 14.8125$

4. Convert 0.0025 into the form $\frac{p}{q}$.

Ans. m = 4

$\therefore 0.0025 = \frac{25}{10000} = \frac{1}{400}$

5. Convert $0.\overline{225}$ inot the form $\frac{p}{q}$.

Ans. $x = 0.\overline{225}$

$\therefore x = 0.225225225.....$ ...(i)

Here after decimal point 3 digits are recursing so, multiply both side of eq. (i) by 1000

$\therefore 1000x = 225.225225$ ...(ii)

Substracting (i) from (ii)

$1000x - x = 225.225225 - 0.225225...$

$\therefore 999x = 225$

$\therefore x = \frac{225}{999} = \frac{75}{333} = \frac{25}{111}$

6. Convert $\mathbf{0.7\overline{283}}$ into the form $\frac{p}{q}$.

Ans. The given number is $0.7\overline{283} = 0.7283283....$

Let, $x = 0.7283283...$ ...(i)

Here after decimal there is only one digit namely 7, which is not recurring.

$\therefore$ We multiply both sides of equation (i) by 10 to get $10x = 7.283283...$ ...(ii)

Now after decimal 3 digits are recurring (283).

$\therefore$ We multiply both sides of equation (ii) by 1000 to get, $10000x = 7283.283...$ ...(iii)

Subtracting equation (ii) from equation (iii), we get $90x = 7276$

$\Rightarrow x = \frac{7276}{9990} = \frac{3638}{4995}$ which is the required form of the number.

IRRATIONAL NUMBERS

A number which can't be put in the form p/q, where p and q are integers and $q \neq 0$, is called an irrational number

or

A number whose decimal expression is non-terminating and non recurring is called an irrational number.

Eg : $\sqrt{3}, \sqrt{43}, 2\sqrt{7}, \pi, ...$

◈ **Properties of irrational numbers :**

(i) The negative of an irrational number is an irrational number.

(ii) The sum of a rational and an irrational number is an irrational number.

(iii) The product of a non-zero rational number with an irrational number is always an irrational number.

REAL NUMBERS

Rational numbers and irrational numbers taken together form real numbers. Every real number corresponds to a point on the line and converse is also true.

◈ **Absolute value of Real Number**

There is a point on number line l which corresponds to the number x. The distance of this point x from the point 0 (zero) is called the absolute value of x.

The absolute value of number positive or negative is always non-negative. The absolute value of numbers is written as |x|. It is defined as

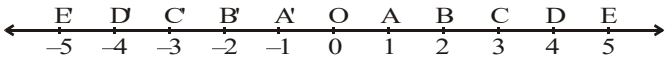
If $x \geq 0$ then $|x| = x$

If $x < 0$ then $|x| = -x$, |x| represents the positive values only.

REPRESENTATION OF RATIONAL AND IRRATIONAL NUMBERS ON NUMBER LINE

We have learnt how to represent integers on the number line.

Draw any line. Take a point O on it. Call it 0(zero). Set of equal distances on the right as well as on the left of O. Such a distance is known as a unit length. Clearly, the points A, B, C, D represent the integers 1, 2, 3, 4 respectively and the point A', B', C' D' represent the integers –1, –2, –3, –4 respectively



Thus, we may represent any integer by a point on the number line. Clearly, every positive integer lies to the right of O and every negative integer lies to the left of O.

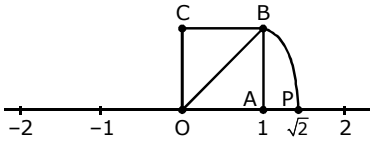
Similarly we can represent rational numbers.

PRACTICE YOUR CONCEPTS

7. Locate $\sqrt{2}$ on the number line.

Ans. **Step 1 :** Draw the number line with O representing the number 0 and A representing the number 1.

Step 2 : Construct a square OABC with each side equal to 1 unit.



By the Pythagorean theorem :

$OB^2 = OA^2 + AB^2$

$= 1^2 + 1^2$

$= 1 + 1 = 2$

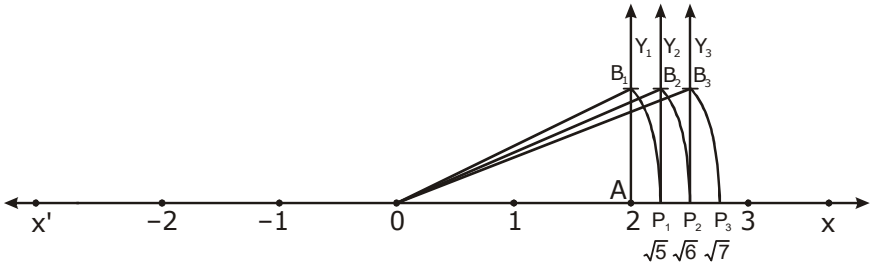
$OB = 2$

Step 3 : With O as centre and OB as radius, draw an arc to meet the number line at point P.

Since OP = OB = $\sqrt{2}$, the point P represents 2 on the number line.

8. Locate $\sqrt{5}$, $\sqrt{6}$, $\sqrt{7}$ on number line.

Ans. We know that $5 = 2^2 + 1^2$. So on real number line X'OX, take a point A so that OA = 2 units. At A, draw a ray AY_1 perpendicular to real number line. Now with A as centre and 1 unit as radius draw an arc intersecting ray AY_1 at B_1. Join OB_1. With O as centre and OB_1 as radius draw an arc intersecting number line at P_1. P_1 is the point on number line representing $\sqrt{5}$ i.e., $OP_1 = \sqrt{5}$.



Representing $\sqrt{5}$, $\sqrt{6}$, $\sqrt{7}$ on number line.

Now at P_1 draw ray P_1Y_2 perpendicular to number line and with P_1 as centre and 1 unit as radius draw an arc intersecting P_1Y_2 at B_2. Join OB_2. With O as centre and OB_2 as radius draw an arc intersecting the number line at P_2. P_2 is the point representing the location of $\sqrt{6}$. Again at P_2 draw a ray P_2Y_3 perpendicular to number line and cut an arc at B_3 on it with arc radius 1 unit and centre as P_2. Join OB_3. With O as centre and OB_3 as radius draw another arc intersecting the number line at P_3. P_3 is the point corresponding to $\sqrt{7}$.

9. With the help of examples show that the quotient of two irrational numbers can be rational or irrational.

Ans. Consider two irrational numbers a = $3\sqrt{2}$ and b = $5\sqrt{2}$ then their quotient $\frac{a}{b} = \frac{3\sqrt{2}}{5\sqrt{2}} = \frac{3}{5}$ which is rational, while if we take two numbers as c = $3\sqrt{6}$ and d = $\sqrt{8}$ both of which are irrational then their quotient $\frac{c}{d} = \frac{3\sqrt{6}}{\sqrt{8}} = \frac{3\sqrt{6}}{2\sqrt{2}} = \frac{3}{2} \times \sqrt{\frac{6}{2}} = \frac{3\sqrt{3}}{2}$ which is an irrational number.

RATIONALISATION OF DENOMINATOR

To make the denominator free from square root we multiply both numerator and the denominator by a suitable factor. this factor is called rationalising factor and this process is called rationalisation.

PRACTICE YOUR CONCEPTS

10. Rationalise $\frac{2}{\sqrt{5}-\sqrt{2}}$

Ans. $\frac{2}{\sqrt{5}-\sqrt{2}} = \frac{2(\sqrt{5}+\sqrt{2})}{(\sqrt{5}-\sqrt{2})(\sqrt{5}+\sqrt{2})}$

$= \frac{2(\sqrt{5}+\sqrt{2})}{5-2}$

$= \frac{2(\sqrt{5}+\sqrt{2})}{3}$

11. If $x = 2 + \sqrt{3}$, find the value of $x^2 + \frac{1}{x^2}$.

Ans. $x = 2 + \sqrt{3} \Rightarrow \frac{1}{x} = \frac{1}{2+\sqrt{3}} \times \frac{(2-\sqrt{3})}{(2-\sqrt{3})} = \frac{2-\sqrt{3}}{2^2-(\sqrt{3})^2} \quad \therefore \frac{1}{x} = \frac{2-\sqrt{3}}{4-3} = 2-\sqrt{3}$

Also $\left(x+\frac{1}{x}\right)^2 = x^2 + \frac{1}{x^2} + 2 \quad \therefore x^2 + \frac{1}{x^2} = \left(x+\frac{1}{x}\right)^2 - 2 = \left(2+\sqrt{3}+2-\sqrt{3}\right)^2 - 2 = 4^2 - 2 = 16 - 2 = 14.$

12. If $x = \frac{\sqrt{5}+\sqrt{2}}{\sqrt{5}-\sqrt{2}}$ and $y = \frac{\sqrt{5}-\sqrt{2}}{\sqrt{5}+\sqrt{2}}$, find the value of $3x^2 + 4xy + 3y^2$.

Ans. $x = \frac{\sqrt{5}+\sqrt{2}}{\sqrt{5}-\sqrt{2}} \times \frac{\sqrt{5}+\sqrt{2}}{\sqrt{5}+\sqrt{2}} = \frac{(\sqrt{5}+\sqrt{2})^2}{(\sqrt{5})^2-(\sqrt{2})^2} = \frac{(\sqrt{5})^2+(\sqrt{2})^2+2\sqrt{5}\times\sqrt{2}}{5-2} = \frac{5+2+2\sqrt{10}}{3} = \frac{7+2\sqrt{10}}{3}$

$y = \frac{\sqrt{5}-\sqrt{2}}{\sqrt{5}+\sqrt{2}} \times \frac{\sqrt{5}-\sqrt{2}}{\sqrt{5}-\sqrt{2}} = \frac{(\sqrt{5}-\sqrt{2})^2}{(\sqrt{5})^2-(\sqrt{2})^2} = \frac{(\sqrt{5})^2+(\sqrt{2})^2-2\sqrt{5}\sqrt{2}}{5-2} = \frac{5+2-2\sqrt{10}}{3} = \frac{7-2\sqrt{10}}{3}$

$\therefore \quad x + y = \frac{7+2\sqrt{10}}{3} + \frac{7-2\sqrt{10}}{3} = \frac{7+2\sqrt{10}+7-2\sqrt{10}}{3} = \frac{14}{3}$ Also, $xy = \frac{\sqrt{5}+\sqrt{2}}{\sqrt{5}-\sqrt{2}} \times \frac{\sqrt{5}-\sqrt{2}}{\sqrt{5}+\sqrt{2}} = 1$

Hence $3x^2 + 4xy + 3y^2 = 3(x^2 + y^2) + 4xy = 3\left[(x+y)^2 - 2xy\right] + xy$

$= 3\left[\left(\frac{14}{3}\right)^2 - 2.(1)\right] + 4.(1) \quad = 3\left[\frac{196}{9} - 2\right] + 4 \quad = 3\left[\frac{196-18}{9}\right] + 4 \quad = \frac{178}{3} + 4 \quad = \frac{178+12}{3} = \frac{190}{3}$

13. If $x = \frac{1}{\sqrt{5}+2}$, find the value of $x^2 + 4x - 1$ and $x^3 - 2x^2 - 25x + 7$.

Ans. $x = \frac{1}{\sqrt{5}+2} \times \frac{\sqrt{5}-2}{\sqrt{5}-2} = \frac{\sqrt{5}-2}{(\sqrt{5})^2-(2)^2} = \frac{\sqrt{5}-2}{5-4} = \sqrt{5}-2 \Rightarrow x+2 = \sqrt{5} \Rightarrow (x+2)^2 = (\sqrt{5})^2 \Rightarrow x^2 + 4x + 4 = 5$

$\Rightarrow x^2 + 4x - 1 = 0$ Also $x^3 - 2x^2 - 25x + 7 = (x^2 + 4x - 1)(x - 6) + 1$

(Here we observe that if $(x^3 - 2x^2 - 25x + 7)$ is divided by $x^2 + 4x - 1$, quotient is $x - 6$ and remainder = 1. So we can use dividend = divisor × quotient + remainder, to get the above relationship.)

$\therefore \quad x^3 - 2x^2 - 25x + 7 = 0 \times (x - 6) + 1 = 1.$

LAWS OF EXPONENTS AND SURDS

◈ **Product of Powers**

$a^m \times a^n = a^{m+n}$

Ex. **(i)** $2^3 \times 2^8 = 2^{11}$

(ii) $\left(\frac{5}{3}\right)^7 \times \left(\frac{5}{3}\right)^1 = \left(\frac{5}{3}\right)^8$

(iii) $(\sqrt{3})^3 \times (\sqrt{3})^2 = (\sqrt{3})^5$

◈ **Quotient of Powers**

$a^m \div a^n = a^{m-n}$ $(\therefore a \neq 0)$

Ex. **(i)** $2^3 \div 2^5 = 2^{-2} = 1/4$

(ii) $(\sqrt{2})^8 \div (\sqrt{2})^3 = (\sqrt{2})^5$

$a^0 = 1$ $(a \neq 0)$

$a^{-n} = \frac{1}{a^n}$ **$(a \neq 0)$**

◈ **Power of Power**

$(a^m)^n = a^{mn}$

Ex. **(i)** $(7^2)^3 = 7^6$

(ii) $(\sqrt{3})^3 = 3^{3/2}$

Power of Product

$(ab)^n = a^n \times b^n$

$(a.b.c.d....z)^n = a^n.b^n.c^n.....z^n$

Ex. $(32)^3 = (8 \times 4)^3 = 8^3 \times 4^3$

◈ **Power of Quotient**

$$\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$$

Ex. $$\left(\frac{4}{3}\right)^7 = \frac{4^7}{3^7}$$

$$\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$$

If $a^m = a^n$ then m =n if $a \neq 0, 1, -1$

If $a^m = b^m$ then a = b (when m is odd)

a = ±b (when m is even)

◈ **Laws of radicals :**

(i) $\left(\sqrt[n]{a}\right)^n = a$ (ii) $\sqrt[n]{a} \times \sqrt[n]{b} = \sqrt[n]{ab}$ (iii) $\frac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\frac{a}{b}}$

(iv) $\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a} = \sqrt[n]{\sqrt[m]{a}}$ (v) $\frac{\sqrt[p]{a^n}}{\sqrt[p]{a^m}} = \sqrt[p]{a^{n-m}}$ (vi) $\sqrt[p]{a^n \times a^m} = \sqrt[p]{a^{n+m}}$

(vii) $\sqrt[p]{(a^n)^m} = \sqrt[p]{a^{nm}}$

◈ **Indentities related to square roots :**

(i) $\sqrt{a} \times \sqrt{b} = \sqrt{ab}$ and $\sqrt{ab} = \sqrt{a} \cdot \sqrt{b}$ (ii) $\frac{\sqrt{a}}{\sqrt{b}} = \sqrt{\frac{a}{b}}$ and $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$

(iii) $\left(\sqrt{a} + \sqrt{b}\right)\left(\sqrt{a} - \sqrt{b}\right) = \left(\sqrt{a}\right)^2 - \left(\sqrt{b}\right)^2 = a - b$ (iv) $\left(a + \sqrt{b}\right)\left(a - \sqrt{b}\right) = a^2 - \left(\sqrt{b}\right)^2 = a^2 - b$

(v) $(\sqrt{a}+b)(\sqrt{a}-b)=a-b^2$

(vi) $\left(\sqrt{a}+\sqrt{b}\right)^2=a+2\sqrt{ab}+b$

(vii) $\left(\sqrt{a}-\sqrt{b}\right)^2=a-2\sqrt{ab}+b$

(viii)

$(\sqrt{a}+\sqrt{b})(\sqrt{c}+\sqrt{d})=\sqrt{ac}+\sqrt{ad}+\sqrt{bc}+\sqrt{bd}$

Ex. **Convert $\sqrt[4]{1875}$ into mixed surd.**

Sol. $1875 = 3 \times 5^4$

$\therefore \sqrt[4]{1875}=\sqrt[4]{5^4\times 3}$

$= 5\times\sqrt[4]{3}$

$= 5\sqrt[4]{3}$

ON YOUR TIPS

- Negative of an irrational number is an irrational number.
- The sum or difference of a rational number and an irrational number is an irrational number.
- The product of a non-zero rational number and an irrational number is an irrational number.
- The sum, difference, product and quotient of two irrational numbers need not be an irrational number.
- There are an infinite number of rational (irrational) numbers between two rational (or irrational) numbers.
- If a is a positive rational number and n is a positive integer such that the n^{th} root of a is an irrational number, then $a^{1/n}$ is called a surd eg. $\sqrt{7}$, $\sqrt{3}$, $\sqrt{11}$ etc
- If $\sqrt[n]{a}$ is a surd, or radical then 'n' is known as order or index of surd and 'a' is known as radicand.
- A surd which has unity only as rational factor is called a pure surd.
  Eg. $\sqrt{5}$, $\sqrt{11}$, $\sqrt{7}$, $\sqrt{335}$, ...
- A surd which has a rational factor other than unity is called a mixed surd.
  Eg . $2\sqrt{5}$, $3\sqrt{11}$, ...

- Surds having same irrational factors are called similar or like surds.
- Only similar surds can be added or subtracted by adding or subtracting their rational parts.
- Surds of same order can be multiplied or divided.
- If the surds to be multiplied or to be divided are not of the same order, we first reduce them to the same order and then multiply or divide.
- The two irrational numbers whose product is a rational number, are called rationalising factor of each other. For eg : $x - \sqrt{y}$ is called rationalising factor $x + \sqrt{y}$.

  Similarly $\sqrt{3}$ is a R.F. of $6\sqrt{3}$ Similarly $5^{\frac{1}{3}}$ is a R.F. of $5^{\frac{2}{3}}$
- The surds which differ only in sign (+ or −) between the terms connecting them, are called conjugate surds eg. $\sqrt{5}+\sqrt{3}$ and $\sqrt{5}-\sqrt{3}$ or $2+\sqrt{5}$ and $2-\sqrt{5}$ are conjugate surds (binomial).

  ✯ Sum and product of two cojugate binomial factors are always rational numbers.

NCERT QUESTIONS WITH SOLUTIONS

EXERCISE 1.1

1. Is zero a rational number ? Can you write it in the form $\frac{p}{q}$, where p and q are integers and q $\neq$ 0 ?

Sol. Yes, zero is a rational number. We can write zero in the form $\frac{p}{q}$ whose p and q are integers and q $\neq$ 0.
so, 0 can be written as

$\frac{0}{1} = \frac{0}{2} = \frac{0}{3}$ etc

2. Find six rational numbers between 3 and 4.

Sol. **Hint :** first rational number between 3 and 4

$= \frac{3+4}{2} = \frac{7}{2}$

3. Find five rational numbers between $\frac{3}{5}$ and $\frac{4}{5}$.

Sol. **Hint :** Let $a = \frac{3}{5}, b = \frac{4}{5}, n = 5$

$$d = \frac{b-a}{n+1} = \frac{\frac{4}{5}-\frac{3}{5}}{5+1} = \frac{1}{30}$$

so, Rational number are

a + d, a + 2d, a + 3d.....

4. State whether the following statements are true or false ? Give reasons for you answers.

(i) Every natural number is a whole number.

(ii) Every integer is a whole number.

(iii) Every rational number is a whole number.

Sol. (i) True, the collection of whole number contain all natural number.

(ii) False, –2 is not whole number

(iii) False, $\frac{1}{2}$ is a rational number but not whole number.

EXERCISE 1.2

1. State whether the following statements are true or false ? Justify your answers.

(i) Every irrational number is a real number.

(ii) Every point on the number line is of the form $\sqrt{m}$, where m is a natural number.

(iii) Every real number is an irrational number.

Sol. (i) True, since collection of real number consist of rational and irrational.

(ii) False, because no negative number can be the square root of any natural number.

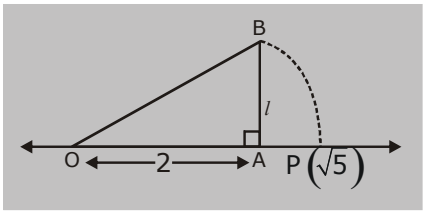
(iii) False, 2 is real but not irrational.

2. Are the square roots of all positive integers irrational ? If not, give an example of the square root of a number that is a rational number.

Sol. No, $\sqrt{4} = 2$ is a rational number.

3. Show that how $\sqrt{5}$ can be represnted on the number line.

Sol. Draw a number line. Take O as origin. It represents 0. Let OA = 2 units and draw AB ^ OA such that AB = 1 unit. Join OB



By Pythagoras theorem,

$OB^2 = OA^2 + AB^2$

$\Rightarrow$ $OB^2 = 2^2 + 1^2$

$\Rightarrow$ $OB^2 = 4 + 1$

$\Rightarrow$ $OB^2 = 5$

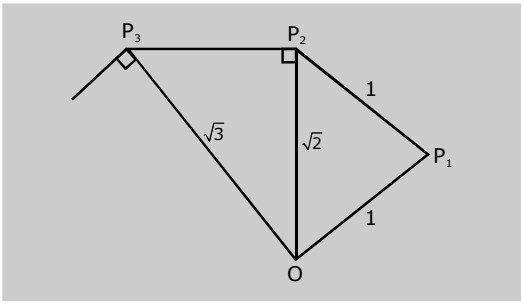
$\Rightarrow$ OB = $\sqrt{5}$ units

with O as centre and OB as radius, draw an arc which cuts the number line at P, then

OP = OB = $\sqrt{5}$ units

Thus P represents $\sqrt{5}$ on the number line.

4. Class room activity (Constructing the 'square root spiral'): Take a large sheet of paper and construct the 'square root spiral' in the following fashion. Start with a point O and draw a line segment OP_1 of unit length. Draw a line segment P_1P_2 perpendicular to OP_1 of unit length (see figure). Now draw a line segment P_2P_3 perpendicular to OP_2. Then draw a line segment P_3P_4 perpendicular to OP_3. Continuing in this manner, you can get the line segment $P_{n-1}P_n$ by drawing a line segment of unit length perpendicular to OP_{n-1}. In this manner, you will have created the points P_2, P_3, ..., P_n, ... and joined them to create a beautiful spiral depicting $\sqrt{2}, \sqrt{3}, \sqrt{4}, ...$



Sol. Do as directed.

EXERCISE 1.3

1. Write the following in decimal form and say what kind of decimal expansion each has :

(i) $\frac{36}{100}$ (ii) $\frac{1}{11}$ (iii) $4\frac{1}{8}$

(iv) $\frac{3}{13}$ (v) $\frac{2}{11}$ (vi) $\frac{329}{400}$

Sol. (i) $\frac{36}{100} = 0.36 (\text{Terminating})$

(ii) $\frac{1}{11} = 0.090909.....$ (Non terminating Repeating)

$$\begin{array}{r} 0.090909.... \\ 11\overline{)1.00000} \\ -99 \\ \hline 100 \\ 99 \\ \hline 100 \\ 99 \\ \hline 1 \end{array}$$

(iii) $4\frac{1}{8} = \frac{33}{8}$ = 4.125 (terminating decimal)

(iv) $\frac{3}{13}$ = 0.230769230769.....

= $0.\overline{230769}$ (Non Terminating repeating)

(v) $\frac{2}{11} = 0.1818..... = 0.\overline{18}$

(Non Terminating repeating)

(vi) $\frac{329}{400}$ = 0.8225 terminating

2. You know that $\frac{1}{7} = 0.\overline{142857}$. Can you predict what the decimal expansions of $\frac{2}{7}, \frac{3}{7}, \frac{4}{7}, \frac{5}{7}, \frac{6}{7}$ are without actually doing the long division ? if so, how ?

Sol. Yes, we can predict what the decimal expansions of $\frac{2}{7}, \frac{3}{7}, \frac{4}{7}, \frac{5}{7}, \frac{6}{7}$ are without actually doing the long division.

Now 1 divide by 7

$$\begin{array}{r} 0.142857 \\ 7\overline{)1.0} \\ 0 \\ \hline 10 \\ 7 \\ \hline 30 \\ 28 \\ \hline 20 \\ 14 \\ \hline 60 \\ 56 \\ \hline 40 \\ 35 \\ \hline 50 \\ 49 \\ \hline 1 \end{array}$$

We observe that remainder repeat after six division. So, it has repeating block of six

digits. The given rational numbers $\frac{2}{7}, \frac{3}{7}, \frac{4}{7}, \frac{5}{7}$ and $\frac{6}{7}$ will also have repeating block of six digit in the decimal expansions. So, to obtain the decimal expansions of given rational numbers, multiplying $0.\overline{142857}$ successively by 2, 3, 4, 5 and 6 as follows

$$\frac{2}{7} = 2 \times \frac{1}{7} = 2 \times 0.\overline{142857} = 0.\overline{285714}$$

$$\frac{3}{7} = 3 \times \frac{1}{7} = 3 \times 0.\overline{142857} = 0.\overline{428571}$$

$$\frac{4}{7} = 4 \times \frac{1}{7} = 4 \times 0.\overline{142857} = 0.\overline{571428}$$

$$\frac{5}{7} = 5 \times \frac{1}{7} = 5 \times 0.\overline{142857} = 0.\overline{714285}$$

and $\frac{6}{7} = 6 \times \frac{1}{7} = 6 \times 0.\overline{142857} = 0.\overline{857142}$

3. Express the following in the form $\frac{p}{q}$, where p and q are integers and $q \neq 0$.

(i) $0.\overline{6}$ (ii) $0.4\overline{7}$

Sol. (i) Let $x = 0.\overline{6} = 0.6666...$ (i)

Multiplying equation (i) by 10, we get

$$10x = 6.\overline{6} \quad \text{(ii)}$$

Subtracting equation (i) from (ii), we get

$$\begin{array}{r} 10x = 6.\overline{6} \\ \underline{x = 6.\overline{6}} \\ 9x = 6.0 \end{array}$$

$$\Rightarrow \quad x = \frac{6}{9} = \frac{2}{3}$$

Hence, $0.\overline{6} = \frac{2}{3}$

(ii) Let $x = 0.4\overline{7} = 0.47777...$ (i)

Since, there is one non-repeating digit after the decimal.

Therefore, multiplying equation (1) by 10. So that the digit shifted before the decimal, we get

$$10x = 4.\overline{7} = 4.7777... \quad \text{(ii)}$$

Multiplying the equation (ii) by 10, we get

$$100x = 47.\overline{7} \quad \text{(iii)}$$

Subtracting equation (ii) from (iii), we get

$$\begin{array}{r} 100x = 47.\overline{7} \quad \text{(iii)} \\ \underline{-10x = -4.\overline{7} \quad \text{(ii)}} \\ 90x = 43.0 \end{array}$$

$$\Rightarrow \quad x = \frac{43}{90}$$

Hence, $0.4\overline{7} = \frac{43}{90}$

4. Express 0.99999... in the form $\frac{p}{q}$. Are your surprised by your answer ? With your teacher and classmates discuss why the answer makes sense.

Sol. Let $x = 0.99999... = 0.\overline{9}$ (i)

Multiplying equation (i) by 10, we get

$$10x = 9.99999... = 9.\overline{9} \quad \text{(ii)}$$

Subtracting equation (i) from (ii), we get

$$\begin{array}{r} 10x = 9.\overline{9} \quad \text{(iii)} \\ \underline{-x = -0.\overline{9} \quad \text{(ii)}} \\ 9x = 9 \end{array}$$

$$x = \frac{9}{9} = 1$$

Hence $0.99999... = 1$

We observe that there is no gap between 1 to 0.99999... and hence they are equal.

5. Look at serveral example of rational numbers in the form $\frac{p}{q}(q \neq 0)$, where p and q are integers with no common factors other than 1and having terminating decimal

representations (expansion). Can you guess what property q must satisfy ?

Sol. Let us consider the various rational numbers be $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{23}{25}, \frac{12}{125}$, etc.

In all these rational number multiplying the denominator by such numbers so that it becomes 10 or power of 10, we get

$$\frac{1}{2} = \frac{1\times5}{2\times5} = \frac{5}{10} = 0.5$$

$$\frac{1}{4} = \frac{1\times25}{4\times25} = \frac{25}{100} = 0.25$$

$$\frac{1}{8} = \frac{1\times125}{8\times125} = \frac{125}{1000} = 0.125$$

$$\frac{7}{20} = \frac{7\times5}{20\times5} = \frac{35}{100} = 0.35$$

$$\frac{23}{25} = \frac{23\times4}{25\times4} = \frac{92}{100} = 0.92$$

$$\frac{12}{125} = \frac{12\times8}{125\times8} = \frac{96}{100} = 0.096$$

In these cases we observe that to obtain a terminating decimal form of given rational numbers we have to multiplied the denomiantor of these rational numbers by a suitable integer. But it is possible when denominator of given rational number be 2 5 as the prime factor, where m and n are non-negative integers, Thus we have the following property:

If the prime factorization of denominator of given rational numbers is of the form 2 5, where m, n are non-negative integers, then it can be represented as a terminating decimal.

6. What can the maximum number of digits be in the repeating block of the digits in the decimal expansion of $\frac{1}{17}$? Perform the division to check your answer.

Sol. Since Non zero remainders of 17 are 16 in numbers So, maximum number of digits posible in the repeating block is 16. By long division method, we have

```
17 ) 1 (0.0588235294117647
     0
     10
      0
     100
      85
     150
     136
      40
      34
      60
      51
       90
       85
        50
        34
       160
       153
         70
         68
          20
          17
           30
           17
          130
          119
           110
           102
             80
             68
              120
              119
                10
                 0
                100
                 85
                  150
                  136
                   140
                   136
                     4
```

We observe that the remainder start repeating after 16 divisions.

Hence, $\frac{1}{17} = 0.\overline{0588235294117647}$

7. Write the numbers whose decimal expansions are non-terminating non recurring.

Sol. Threen numbers whose decimal expansions are non-terminating non-recurring are .01001000100001..., 0.202002000200002... and 0.003000300003...

8. Find three different irrational numbers between rational number $\frac{5}{7}$ and $\frac{9}{11}$.

Sol. We have, $\frac{5}{7} = 0.714285714...$

$\frac{9}{11} = 0.81818181...$

Three irrational numbers between 0.714285714... and 0.81818181... are:
0 . 7 5 0 7 5 0 0 7 5 0 0 0 7 5 0 0 0 0 7 5 . . . ,
0.767076700767000767... and
0.808008000800008...

Hence, three irrational number between $\frac{5}{7}$ and $\frac{9}{11}$ are 0.750750075000075000075...,
0.767076700767000767...
and 0.808008000800008...

9. Classify the following numbers as rational or irrational number.

(i) $\sqrt{23}$ (ii) $\sqrt{225}$ (iii) 0.3796
(iv) 7.478478... (v) 1.101001000100001...

Sol. (i) Since 23 is not a perfect square.

So $\sqrt{23}$ is an irrational number.

(ii) $\sqrt{225} = \sqrt{3 \times 3 \times 5 \times 5}$
$= 3 \times 5$
$= 15$, which is a rational number.

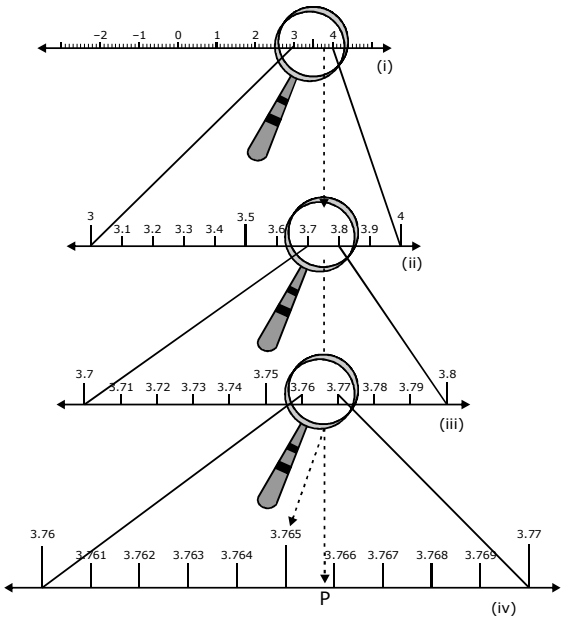
Hence, $\sqrt{225}$ is a rational number.

(iii) 0.3796 is a terminating decimal expansion, so it is a rational number.
(iv) 7.478478... is non-terminating repeating decimal expansion, so it is a rational number.
(v) 1.101001000100001... is non-terminating non-repeating decimal expansion, so it is an irrational number.

EXERCISE 1.4

1. Visualise 3.765 on the number line, using succesive magnification.

Sol. For visualizing the representation of 3.765 on the number line, we observe that 3.765 is located between 3 and 4. We divide it into 10 equal parts and mark each point of divisions as shown in the figure 1.12. In the next step, we locate 3.765 between 3.7 and 3.8. To get more accurate visualization of the representation, we divide this portion of the number line into 10 equal part and use a magnifying glass to visulize that 3.765 between 3.76 and 3.77. To visualize 3.765 more accurately, we divide again the portion between 3.76 and 3.77 into ten equal parts and visualize the representation of 3.765 as show in the figure.

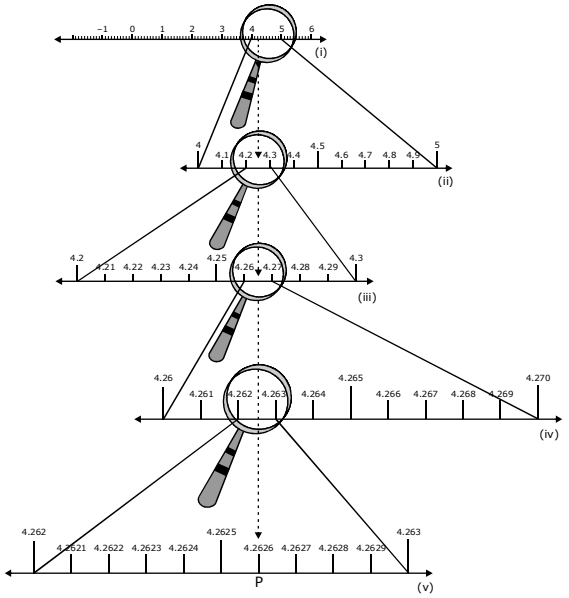


2. Visualise $\overline{4.26}$ on the number line, upto 4 decimal places.

Sol. We have, $\overline{4.26} = 4.2626$

For visualizing the representation of $\overline{4.26}$ on the number line, we observe that $\overline{4.26}$ is located between 4 and 5. We divide it into 10 equal parts and mark each point of divisions as shown in figure 1.13. In the next step, we locate $\overline{4.26}$ between 4.2 and 4.3. To get more accurate visualization of the representation, we divide this portion of the

number line into 10 equal parts and use a magnifying glass to visualize that $4.\overline{26}$ lies between 4.26 and 4.27.To visualize $4.\overline{26}$ more accurately, we again divide this portion between 4.26 and 4.27 ten equal parts and use a magnifying glass to visualize that $4.\overline{26}$ between 4.262 and 4.263. Now visualize $4.\overline{26}$ still more accuretely, we divide this portion between 4.262 and 4.263 into 10 equal parts and visualize the representation of $4.\overline{26}$ as shown in the figure.



EXERCISE 1.5

1. Classify the following numbers as rational or irrational :

(i) $2-\sqrt{5}$ (ii) $(3+\sqrt{23})-\sqrt{23}$

Sol. (i) $\because$ 2 is a rational number and $\sqrt{5}$ is an irrational number

$\therefore$ $2-\sqrt{5}$ is an irrational number.

(ii) $(3+\sqrt{23})-\sqrt{23}$

$\Rightarrow$ $(3+\sqrt{23})-\sqrt{23}$ = 3 is a rational number.

2. Simplify each of the following expressions

(i) **$(3+\sqrt{3})(2+\sqrt{2})$**

(ii) **$(3+\sqrt{3})(3-\sqrt{3})$**

Sol. (i) $(3+\sqrt{3})(2+\sqrt{2}) = 3(2+\sqrt{2})+\sqrt{3}(2+\sqrt{2})$

$= 6+3\sqrt{2}+2\sqrt{3}+\sqrt{6}$

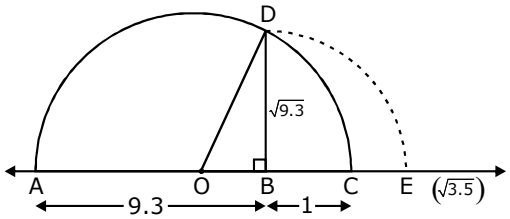
(ii) $(3+\sqrt{3})(3-\sqrt{3}) = (3)^2-(\sqrt{3})^2$ = 9 – 3 = 6

3. Recall, π is defined as the ratio of the circumference (say c) of a circle to its diameter (say d). That is, $\pi = \frac{c}{d}$. This seems to contradict the fact that π is irrational. How will you resolve this contradiction ?

Sol. $\frac{c}{d}=\frac{22}{7}$ which is approximate value of π . Circumference itself is irrational quantity if d is rational. So π is irrational

4. Represents $\sqrt{9.3}$ on the number line.

Sol. Draw a line AB of length 9.3 units. Produce AB to C such that BC = 1 unit. Find the mid-point of AC and marked that point O. Draw a semicircle with centre O and radius OA. Draw a line perpendicular to AC passing through B and intersecting the semicircle at D, then DB = $\sqrt{9.3}$ units. Now B as centre and BD as radius, draw an arc meeting AC produced at E, then BE = BD = $\sqrt{9.3}$ units.



5. Rationalise the denominators of the following

(i) $\frac{1}{\sqrt{7}}$ (ii) $\frac{1}{\sqrt{7}-\sqrt{6}}$

(iii) $\frac{1}{\sqrt{5}+\sqrt{2}}$ (iv) $\frac{1}{\sqrt{7}-2}$

Sol. (i) $\frac{1}{\sqrt{7}} = \frac{1}{\sqrt{7}} \times \frac{\sqrt{7}}{\sqrt{7}} = \frac{\sqrt{7}}{7}$

(ii) $\frac{1}{\sqrt{7}-\sqrt{6}} = \frac{1}{\sqrt{7}-\sqrt{6}} \times \frac{\sqrt{7}+\sqrt{6}}{\sqrt{7}+\sqrt{6}} = \frac{\sqrt{7}+\sqrt{6}}{7-6}$

$= \frac{\sqrt{7}+\sqrt{6}}{1} = \sqrt{7}+\sqrt{6}$

(iii) $\frac{1}{\sqrt{5}+\sqrt{2}} = \frac{1}{\sqrt{5}+\sqrt{2}} \times \frac{\sqrt{5}-\sqrt{2}}{\sqrt{5}-\sqrt{2}} = \frac{\sqrt{5}-\sqrt{2}}{5-2}$

$= \frac{\sqrt{5}-\sqrt{2}}{3}$

(iv) $\frac{1}{\sqrt{7}-2} = \frac{1}{\sqrt{7}-2} \times \frac{\sqrt{7}+2}{\sqrt{7}+2} = \frac{\sqrt{7}+2}{7-4}$

$= \frac{\sqrt{7}+2}{3}$

EXERCISE – I

MULTIPLE CHOICE QUESTIONS

1. The sum of rational and irrational number is always
(A) rational (B) irrational
(C) both (D) can't say

2. The product of rational and irrational number is always
(A) rational (B) irrational
(C) both (D) can't say

3. Which of the following is a pure surd ?
(A) $4\sqrt{3}$ (B) $3\sqrt[3]{5}$
(C) $\sqrt{2}$ (D) $\frac{3}{4}\sqrt{8}$

4. Representation of $3.\overline{6}$ in rational form
(A) $\frac{11}{3}$ (B) $\frac{3}{11}$
(C) $\frac{36}{10}$ (D) $\frac{33}{10}$

5. The irrational number between 2 and 3 is
(A) $\sqrt{2}$ (B) $\sqrt{3}$
(C) $\sqrt{5}$ (D) $\sqrt{11}$

6. The equivalent rational form of $17.\overline{6}$ is
(A) $\frac{53}{3}$ (B) $\frac{88}{5}$
(C) $\frac{44}{25}$ (D) none

7. 2.003 can be expressed in the rational form as
(A) $\frac{2003}{100}$ (B) $\frac{2003}{1000}$
(C) $\frac{2003}{10000}$ (D) $\frac{2003}{10}$

8. A rational number can be expressed as a terminating decimal if the denominator has factors
(A) 2 or 5 (B) 2, 3 or 5
(C) 3 or 5 (D) none of these

9. Express 0.75 as rational number.
(A) $\frac{75}{99}$ (B) $\frac{75}{90}$
(C) $\frac{3}{4}$ (D) None

10. $0.\overline{018}$ can be expressed in the rational form as
(A) $\frac{18}{1000}$ (B) $\frac{18}{990}$
(C) $\frac{18}{9900}$ (D) $\frac{18}{999}$

11. The irrational numbers between $\sqrt{2}$ and $\sqrt{3}$ are
(A) $2^{\frac{1}{2}} \times 6^{\frac{1}{4}}$ (B) $3^{\frac{1}{4}} \times 3^{\frac{1}{6}}$
(C) $6^{\frac{1}{8}} \times 3^{\frac{1}{4}}$ (D) none

12. The ascending order of the following surds $\sqrt[3]{2}$, $\sqrt[6]{3}$, $\sqrt[9]{4}$ is
(A) $\sqrt[9]{4}, \sqrt[6]{3}, \sqrt[3]{2}$ (B) $\sqrt[9]{4}, \sqrt[3]{2}, \sqrt[6]{3}$
(C) $\sqrt[3]{2}, \sqrt[6]{3}, \sqrt[9]{4}$ (D) $\sqrt[6]{3}, \sqrt[9]{4}, \sqrt[3]{2}$

13. The number $(\sqrt{2}+\sqrt{3})^2$ is
(A) rational number (B) irrational number
(C) can't say (D) none

14. The rationalising factor of $2\sqrt[3]{5}$ is
(A) $\sqrt[3]{5}$ (B) $\sqrt[3]{5^2}$
(C) 5^2 (D) 5^3

15. If $\frac{-3}{5}=\frac{-24}{x}$, then x is

(A) 40 (B) – 40
(C) ± 40 (D) none

16. If $x = 3+\sqrt{8}$ then $x^3+\frac{1}{x^3}$ =

(A) 216 (B) 198
(C) 192 (D) 261

17. The value of $\sqrt{8}+\sqrt{18}$ is

(A) $\sqrt{26}$ (B) $2(\sqrt{2}+\sqrt{3})$
(C) 7 (D) $5\sqrt{2}$

18. If $x = \sqrt{3}+\sqrt{2}$ then $x^2+\frac{1}{x^2}$ is

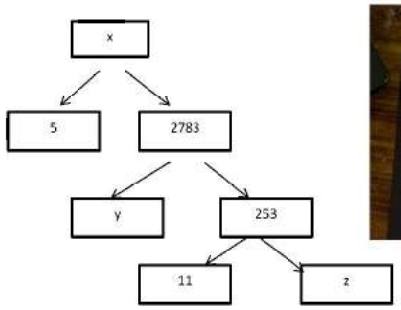
(A) $2\sqrt{3}$ (B) 10
(C) 12 (D) 14

19. The greater among $\sqrt{17}-\sqrt{12}$ and $\sqrt{11}-\sqrt{6}$ is

(A) $\sqrt{17}-\sqrt{12}$ (B) $\sqrt{11}-\sqrt{6}$
(C) both are equal (D) can't say

(Direction Q.20 to 23):

A Mathematics Exhibition is being conducted in your School and one of your friends is making a model of a factor tree. He has some difficulty and asks for your help in completing a quiz for the audience.
Observe the following factor tree and answer the following:



20. What will be the value of x?

(A) 15005 (B) 13915
(C) 56920 (D) 17429

21. What will be the value of y?

(A) 23 (B) 22
(C) 11 (D) 19

22. What will be the value of z?

(A) 22 (B) 23
(C) 17 (D) 19

23. According to Fundamental Theorem of Arithmetic 13915 is a
(A) Composite number
(B) Prime number
(C) Neither prime nor composite
(D) Even number

(Direction Q.24 to 26):

To enhance the reading skills of grade X students, the school nominates you and two of your friends to set up a class library. There are two sections- section A and section B of grade X. There are 32 students in section A and 36 students in section B.

24. What is the minimum number of books you will acquire for the class library, so that they can be distributed equally among students of Section A or Section B?

(A) 144 (B) 128

(C) 288 (D) 272

25. If the product of two positive integers is equal to the product of their HCF and LCM is true then, the HCF (32 , 36) is

(A) 2 (B) 4

(C) 6 (D) 8

26. 36 can be expressed as a product of its primes as

(A) $2^2 \times 3^2$ (B) $2^1 \times 3^3$

(C) $2^3 \times 3^1$ (D) $2^0 \times 3^0$

ASSERTION-REASON

In the following questions, a statement of assertion (A) is followed by a statement of reason (R).

(A) If both Assertion & Reason are true and the reason is the correct explanation of the assertion.

(B) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion.

(C) If Assertion is true statement but Reason is false.

(D) If both Assertion and Reason are false statements.

27. **Assertion:** Every whole number is not a natural number.
Reason: 0 is not a natural number.

28. **Assertion:** Rational numbers are always closed under division except the denominator should not be equal to zero.
Reason: $\sqrt{n}$ is a rational number if n is a perfect square.

SUBJECTIVE QUESTIONS

VERY SHORT ANSWER TYPE QUESTIONS:

1. Find the value $\sqrt{12} \times \sqrt{8}$.

2. Find the value of $(256)^{0.16} \times (256)^{0.09}$.

3. Simplify : $\left(\frac{81}{16}\right)^{-3/4} \times \left(\frac{25}{9}\right)^{-3/2}$

4. Simplify : $5\sqrt{8} + 2\sqrt{32} - 2\sqrt{2}$.

5. Simplify : $8\sqrt{3} - 2\sqrt{3} + 4\sqrt{3}$

SHORT ANSWER TYPE QUESTIONS:

6. If $x = 3 + 2\sqrt{2}$, then find whether $x + \frac{1}{x}$ is rational or irrational.

7. Simplify by rationalising the denominator :

$\frac{6 - 4\sqrt{3}}{6 + 4\sqrt{3}}$.

8. If $x = 2 + \sqrt{3}$, find the value of $x^2 + \frac{1}{x^2}$.

9. Represent $\sqrt{10.5}$ on the number line.

10. Express $18.\overline{48}$ in the form of $\frac{p}{q}$ where p and q are integers and $q \neq 0$.

11. Evaluate : $\left[81^{\frac{1}{2}}\left(64^{\frac{1}{3}} + 125^{\frac{1}{3}}\right)\right]^{\frac{1}{4}}$

LONG ANSWER TYPE QUESTIONS:

12. Find the rational number a and b such that

$$\frac{2+5\sqrt{7}}{2-5\sqrt{7}} = a + \sqrt{7}b$$

13. Find the values of a and b is

$$\frac{7+3\sqrt{5}}{3+\sqrt{5}} - \frac{7-3\sqrt{5}}{3-\sqrt{5}} = a + \sqrt{5}b$$

14. Simplify : $\frac{2\sqrt{6}}{\sqrt{2}+\sqrt{3}} + \frac{6\sqrt{2}}{\sqrt{6}+\sqrt{3}} - \frac{8\sqrt{3}}{\sqrt{6}+\sqrt{2}}$.

15. If $a = \frac{2-\sqrt{5}}{2+\sqrt{5}}$ and $b = \frac{2+\sqrt{5}}{2-\sqrt{5}}$, find $a^2 - b^2$

16. If $\frac{9^n \times 3^2 \times (3^{-n/2})^{-2} - 27^n}{3^{3m} \times 2^3} = \frac{1}{27}$, prove that m – n = 1.

EXERCISE – II

NTSE (STAGE -1) AND OTHER OLYMPIAD

1. If $2^x = 4^y = 8^z$ and $\frac{1}{2x}+\frac{1}{4y}+\frac{1}{6z}=\frac{24}{7}$, then the value of z is- **(Raj. NTSE Stage-1 2005)**

(A) $\frac{7}{16}$ (B) $\frac{7}{32}$

(C) $\frac{7}{48}$ (D) $\frac{7}{64}$

2. If $a^x = b$, $b^y = c$ and $c^z = a$, then value of xyz is **(Raj. NTSE Stage-1 2007)**

(A) 1 (B) 0

(C) –1 (D) a+b+c

3. If $a^x = b$, $b^y = c$ and $c^z = a$, then the value of $x^2y^2z^2$ is ..... **(M.P. NTSE Stage-1 2013)**

(A) $a^2b^2c^2$ (B) 1

(C) 4 (D) $\frac{1}{a^2b^2c^2}$

4. The value of $\left(\frac{x^b}{x^c}\right)^{\frac{1}{bc}}.\left(\frac{x^c}{x^a}\right)^{\frac{1}{ca}}.\left(\frac{x^a}{x^b}\right)^{\frac{1}{ab}}$ on simplifying is: **(Raj. NTSE Stage-1 2015)**

(A) x (B) 1/x

(C) 1 (D) –1

5. If $x = 2+\sqrt{3}$ and xy = 1 then

$\frac{x}{\sqrt{2}+\sqrt{x}}+\frac{y}{\sqrt{2}-\sqrt{y}}$ = ...

(Bihar NTSE Stage-1 2015)

(A) $\sqrt{2}$ (B) $\sqrt{3}$

(C) 1 (D) None of these

6. Simply form of $\frac{\sqrt{5}-2}{\sqrt{5}+2}+\frac{\sqrt{5}+2}{\sqrt{5}-2}$ is .....

(M.P. NTSE Stage-1 2015)

(A) $9+\sqrt{5}$ (B) 18

(C) $18+\sqrt{5}$ (D) 9

7. If $N=\frac{\sqrt{3+2\sqrt{2}}+\sqrt{3-2\sqrt{2}}}{\sqrt{\sqrt{3}+1}}-2\sqrt{\sqrt{3}-1}$, then N equals to

(A) 0 (B) $2\sqrt{2}-1$

(C) $2\sqrt{2}$ (D) $\sqrt{2}$

8. The simplified value of

$\frac{1}{\sqrt{2}+\sqrt{3}-\sqrt{5}}+\frac{1}{\sqrt{2}-\sqrt{3}-\sqrt{5}}$ is

(Delhi NTSE Stage-1 2015)

(A) 1 (B) 0

(C) $\sqrt{2}$ (D) $\frac{1}{\sqrt{2}}$

9. What is the square root of $9+2\sqrt{14}$?

(Bihar NTSE Stage-1 2016)

(A) $1+2\sqrt{2}$ (B) $\sqrt{3}+\sqrt{6}$

(C) $\sqrt{2}+\sqrt{7}$ (D) $\sqrt{2}+\sqrt{5}$

10. What is the value of $2.\overline{6}-1.\overline{9}$?

(Bihar NTSE Stage-1 2016)

(A) $0.\overline{6}$ (B) $0.\overline{9}$

(C) $0.\overline{7}$ (D) 0.7

11. An equivalent expression of $\frac{5}{7+4\sqrt{5}}$ after rationalizing the denominator is

(Gujarat NTSE Stage-1 2016)

(A) $\frac{20\sqrt{5}-35}{31}$ (B) $\frac{20\sqrt{5}-35}{129}$

(C) $\frac{35-20\sqrt{5}}{31}$ (D) $\frac{35-20\sqrt{5}}{121}$

12. If $a = \sqrt{6} + \sqrt{5}$; $b = \sqrt{6} - \sqrt{4}$, the find the value of $2a^2 - 5ab + 2b^2$

(Maharashtra NTSE Stage-1 2016)

(A) 36 (B) 37
(C) 39 (D) 41

13. $\sqrt{m^4n^4} \times \sqrt[6]{m^2n^2} \times \sqrt[3]{m^2n^2} = (mn)^k$, then find the value of k.

(Maharashtra NTSE Stage-1 2017)

(A) 6 (B) 3
(C) 2 (D) 1

14. If $a^m.a^n = a^{mn}$, then $m(n - 2) + n(m - 2)$ is

(A) $\frac{2n+4}{n-1}$ (B) 0

(C) $\frac{n(2n+4)}{n-1}$ (D) $\frac{n+1}{n-1}$

15. If $4^{44} + 4^{44} + 4^{44} + 4^{44} = 4^x$, then x is

(A) 45 (B) 44
(C) 176 (D) 11

16. For an integer n, the statements are given below:

I. If n is odd, $(n + 1)^2$ is even

II. If n is even, $(n - 1)^2$ is odd

III. If n is even, $\sqrt{n-1}$ is irrational

Which of the above is true?

(A) I and III (B) I and II
(C) II and III (D) All of these

17. The largest number by which the expression $n^3 - n$ is divisible for all the possible integral values of n is

(A) 2 (B) 3
(C) 4 (D) 6

18. If $\sqrt{10 - x\sqrt{21}} = \sqrt{7} - \sqrt{3}$, then the value of x is

(A) 7 (B) 2
(C) 3 (D) 4

19. If $4^x - 4^{x-1} = 24$, then $(2x)^x$ equals to

(A) $8\sqrt{5}$ (B) $25\sqrt{5}$

(C) $\sqrt{5}$ (D) 125

20. The value of $\frac{1}{2+\sqrt{3}} + \frac{2}{\sqrt{5}-\sqrt{3}} + \frac{1}{2-\sqrt{5}}$ is

(A) 3 (B) 2
(C) 1 (D) 0

21. If $2^a = 3^b = 6^c$, then the value of c is

(A) $\frac{ab}{a-b}$ (B) $\frac{a+b}{ab}$

(C) $\frac{a-b}{ab}$ (D) $\frac{ab}{a+b}$

22. The value of $4.\overline{6} + 0.\overline{2}$ is

(A) $\frac{14}{3}$ (B) $\frac{2}{9}$

(C) $\frac{28}{27}$ (D) $\frac{44}{9}$

EXERCISE – III

NTSE (STAGE -2) AND JEE LEVEL

1. If a and b are natural numbers such that $\left(\frac{1}{a}\right)^{\frac{1}{b}} = 0.\overline{3}$, then the value of a^{a+b} is **[NTSE Stage-II/2007]**

(A) 81 (B) 24
(C) 192 (D) 375

2. Calculate the value of

$7^{\log_3 5} + 3^{\log_5 7} - 5^{\log_3 7} - 7^{\log_5 3}$

(A) 1 (B) 0 (C) $7^{\log_3 5}$ (D) None

3. If $a^x = \sqrt{b}$, $b^y = \sqrt[3]{c}$ and $c^z = \sqrt{a}$, then the value of xyz is **[NTSE Stage-II/2010]**

(A) $\frac{1}{2}$ (B) $\frac{1}{3}$

(C) $\frac{1}{6}$ (D) $\frac{1}{12}$

4. If aabb is a four digit number and also a perfect square then the value of a + b is **[NTSE Stage-II/2011]**

(A) 12 (B) 11
(C) 10 (D) 9

5. If the sum of three consecutive odd numbers is a perfect square between 200 and 400, then the root of this sum is **[NTSE Stage-II/2011]**

(A) 15 (B) 11
(C) 10 (D) 9

6. Unit's digit in the number $(12357)^{655}$ is **[NTSE Stage-II/2011]**

(A) 1 (B) 3
(C) 7 (D) 9

7. If $a = \log_{12} 18$ & $b = \log_{24} 54$, then find the value of ab + 5(a – b).

(A) 0 (B) 1 (C) 2 (D) None

8. Given two 4-digit numbers abcd and dcba. If a + d = b + c = 7, then their sum is not divisible by **[NTSE Stage-II/2012]**

(A) 7 (B) 11
(C) 101 (D) 111

9. Value of the expression : **[NTSE Stage-II/2014]**

$$\frac{1}{\sqrt{11-2\sqrt{30}}} - \frac{3}{\sqrt{7-2\sqrt{10}}} - \frac{4}{\sqrt{8+4\sqrt{3}}}$$

(A) $\sqrt{30}$ (B) $2\sqrt{10}$
(C) 1 (D) 0

10. On dividing a natural number by 13, the remainder is 3 and on dividing the same number by 21, the remainder is 11. If the number lies between 500 and 600, then the remainder on dividing the number by 19 is **[NTSE Stage-II/2016]**

(A) 4 (B) 6
(C) 9 (D) 13

11. If $\log_x \log_{18}(\sqrt{2}+\sqrt{8}) = \frac{1}{3}$. Then the value of $1000\,x$ is equal to

(A) 8 (B) 1/8
(C) 1/125 (D) 125

12. The sum of all the possible remainders, which can be obtained when the cube of a natural number is divided by 9, is **[NTSE Stage-II/2017]**

(A) 5 (B) 6
(C) 8 (D) 9

13. Given that $\frac{1}{7} = 0.\overline{142857}$, which is a repeating decimal having six different digits. If x is the sum of such first three positive integers n such that $\frac{1}{n} = 0.\overline{abcdef}$, where a, b, c, d, e and f are different digits, then the value of x is **[NTSE Stage-II/2018]**

(A) 20 (B) 21
(C) 41 (D) 42

14. The value of the expression $\log_{10}(\tan 6°) + \log_{10}(\tan 12°) + \log_{10}(\tan 18°) + \ldots\ldots\ldots + \log_{10}(\tan 84°)$ is
(A) a whole number
(B) an irrational number
(C) a negative integer
(D) a rational number which is not an integer

15. Find the value of the expression

$$\frac{2}{\log_4 (2000)^6} + \frac{3}{\log_5 (2000)^6}.$$

(A) 6 (B) $\frac{1}{6}$

(C) 5 (D) $\frac{1}{5}$

16. $\frac{1}{1+\log_b a+\log_b c} + \frac{1}{1+\log_c a+\log_c b} + \frac{1}{1+\log_a b+\log_a c}$ has the value equal to

(A) abc (B) $\frac{1}{abc}$

(C) 0 (D) 1

17. The number $\log_2 7$ is
(A) an integer
(B) a rational number
(C) an irrational number
(D) a prime number

18. $\frac{1}{\log_{\sqrt{bc}} abc} + \frac{1}{\log_{\sqrt{ca}} abc} + \frac{1}{\log_{\sqrt{ab}} abc}$ has the value equal to

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

19. Let ABC be a triangle right angled at C. The value of $\frac{\log_{b+c} a + \log_{c-b} a}{\log_{b+c} a \cdot \log_{c-b} a}$ ($b + c \neq 1$, $c - b \neq 1$) equals

(A) 1 (B) 2
(C) 3 (D) 1/2

20. Let $N = \frac{\log_3 135}{\log_{15} 3} - \frac{\log_3 5}{\log_{405} 3}$. Then N is

(A) a natural number (B) a prime number
(C) a rational number (D) an integer

21. Let $a = \log 3$, $b = \frac{\log 3}{\log(\log 3)}$

(all logarithms on base 10) the number a^b is
(A) an odd integer
(B) an even integer
(C) a prime number
(D) a composite number

MOTION

HINDI

CLASS - IX

(भाग – 'ब')

CONTENTS

स्पर्श भाग – 1 – गद्य खण्ड

स्पर्श भाग – 1 – पद्य खण्ड

संचयन भाग – 1

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व्याकरण

स्पर्श – गद्य खण्ड

CHAPTER 1

धूल

लेखक – रामविलास शर्मा

I. पाठ का सार

प्रश्नः रामविलास शर्मा द्वारा रचित 'धूल' नामक निबंध का सारांश लिखिए।

उत्तरः 'धूल' नामक निबंध में सहज ग्रामीण संस्कृति की महिमा पर प्रकाश डाला गया हैं। निबंध का सार इस प्रकार हैं–

धूल का सौंदर्य– हिंदी कविता की एक सुंदर पंक्ति हैं– 'जिसके कारण धूल भरे हीरे कहलाए।' इसमें जिस धूल–भरे हीरे का वर्णन किया गया हैं, वह हीरे से भी बढ़कर हैं। गांव का कोई भी बच्चा धूल–भरा ही अच्छा लगता हैं। बालक कृष्ण के मुँह पर सुशोभित धूल के सामने आधुनिक सौंदर्य सामग्री कुछ नहीं हैं।

वर्तमान अभिजात सभ्यता– हमारी आज की सभ्यता धूल से बचना चाहती हैं। इसलिए वह बच्चों को धूल से बचाती हैं। उसे डर हैं कि धूल में उनकी कृत्रिम चमक फीकी पड़ जाएगी। जिस कवि ने यह लिखा– 'धन्य–धन्य वे हैं नर मैले जो करत गात कनिया लगाय धूरि ऐसे लरिकान की।' वह भी धूल के प्रति हीनता से ग्रस्त हैं। वह धूल से तन को मैला मानता हैं। फिर ऐसा कवि अखाड़े की मिटटी को देखकर तो उकाई भरने लगेगा। परंतु अखाड़े की मिट्टी मनुष्य के लिए दुर्लभ हैं। मनुष्य पसीने–पसीने होकर इस मिटटी में खेलता हैं तथा इसी से अपने शरीर का निर्माण करता हैं।

मिट्टी की महिमा– मिट्टी और शरीर दोनों असार जरूर हैं किंतु जीवन के सभी सार तत्व इसी से बने हैं। रूप, रस, गंध, स्पर्श– सब मिटटी की देन हैं। धूल इसी मिट्टी की आभा हैं। मिट्टी शब्द हैं तो धूल रस हैं, मिट्टी देह हैं तो धूल प्राण हैं।

धूल क्या हैं– गाँवों में भूलकर भी धूल की जगह गर्द का प्रयोग नहीं किया जाता। आज धूल 'गोधूलि' शब्द में समा चुकी हैं। अमराइयों के पीछे छिपे हुए सूर्य की किरणों में जो धूल चमकती हैं, सूर्यास्त के बाद जो धूल रूई के बादल की भांति आकाश में छा जाती हैं, चांदनी रात में गाड़ियों के गुजरने के बाद जो धूल का गुब्बार छा जाता हैं, जो शिशु के मुख तथा फूलों की पंखुडियों पर सौंदर्य की परत बनकर छा जाती हैं, उसी को धूल कहते हैं।

'गोधूली' ग्रामीण संस्कृति की संपति हैं। यह शहरों को नसीब नहीं हैं। यह गो–गोपालों के चरणों की धूल हैं, हाथी–घोडों के चलने से उठी धूल नहीं हैं। शहर में 'गोधूलि–बेला' शब्द का प्रयोग करना बिल्कुल निरर्थक हैं।

धूल की महिमा– धूल हीनता की नहीं, महिमा की प्रतीक हैं। लोग अपनी श्रद्धा–भक्ति और स्नेह प्रकट करने के लिए इसे माथे पर लगाते हैं। सती, योद्धा या जन्मभूमि पर लौटने वाले प्राणी–सभी इसे अपने मस्तक पर धारण करते हैं।

हमारी देशभक्ति की मांग हैं कि हम इस धूल से जुडें। हम कांच को प्यार करने वाले सभ्य लोग धूल में लिपटे हीरे की कांति को पहचानें। एक दिन ये हीरे अपने अमरता का प्रमाण देंगे। अगर ये उलटकर चोट करने लगें तो कांच और हीरे का भेद पता चल जाएगा। तब हम विवश होकर हीरे से लिपटी हुई धूल को माथे से लगाएंगे।

II. अर्थग्रहण संबंधी प्रश्नोत्तर

प्रश्नः निम्नलिखित गद्यांशों को पढकर नीचे लिखे प्रश्नों के उत्तर दीजिए–

1. हिंदी कविता की सबसे सुंदर पंक्तियों में से एक यह हैं :

'जिसके कारण धूलि भरे हीरे कहलाए।'

हीरे के प्रेमी तो शायद उसे साफ–सुथरा, खरीदा हुआ, आँखों में चकाचौंध पैदा करता हुआ देखना पसंद करेंगें। परंतु हीरे से भी कीमती जिस नयन तारे का जिक्र इस पंक्ति में किया गया हैं वह धूलि भरा ही अच्छा लगता हैं।

जिसका बचपन गांव के गलियारे की धूल में बीता हो, वह इस धूल के बिना किसी शिशु की कल्पना कर ही नहीं सकता। फूल के ऊपर जो रेणु उसका श्रृंगार बनती हैं, वहीं धूल शिशु के मुँह पर उसकी सहज पार्थिवता को निखार देती हैं। अभिजात वर्ग ने प्रसाधन–सामग्री में बडे–बडे आविष्कार किए, लेकिन बालकृष्ण के मुँह पर छाई हुई वास्तविक गोधूलि की तुलना में वह सभी सामग्री क्या धूल नहीं हो गई?

प्रश्नः (क) पाठ तथा उसके लेखक का नाम बताइए।

(ख) इसका आशय स्पष्ट कीजिए।

(ग) यहाँ 'धूलि भरे हीरे' किन्हें कहा गया हैं और क्यों?

(घ) धूल किस प्रकार श्रृंगार बनती हैं?

(ड) 'गोधूलि' और 'धूल होना' के प्रयोग का अंतर स्पष्ट कीजिए।

(च) आज की प्रसाधन–सामग्री और गोधूलि में किसे अच्छा कहा गया हैं और क्यों?

(छ) 'हीरे के प्रेमी' किन्हें कहा गया हैं? इसमें निहित व्यंग्य स्पष्ट कीजिए।

उत्तरः (क) पाठ– **धूल,** लेखक– **रामविलास शर्मा।**

(ख) रामविलास शर्मा कहते हैं– हिंदी साहित्य में बहुत सुंदर पंक्तियाँ लिखी गई हैं। उनमें एक सुंदर पंक्ति का आशय हैं– वह धूल धन्य हैं जिसके कारण बालकों को धूल भरे हीरे कहा गया हैं। सचमुच धूल में सने बालक धूल–भरे हीरे कहलाने के योग्य हैं। जो लोग हीरे के प्रेमी हैं, वे हीरे को साफ–सुथरा, तराशा हुआ और चमकता हुआ ही पसंद करते हैं। परंतु नन्हें बालक, जो लोगों की आँखो के तारे होते हैं, वे धूल–भरे ही अच्छे लगते हैं।

जिसका बचपन गाँवों के धूल–भरे गलियारों में बीता हो, वह किसी ऐसे शिशु की कल्पना भी नहीं कर सकता जिस पर गांव की धूल ने अपना श्रृंगार न किया हो। फूल के ऊपर धूल की एक परत जमती हैं जो उसका श्रृंगार करती हैं। वह धूल शिशु के मुँह पर सुशोभित होकर उसके स्वाभाविक सौंदर्य को बढा देती हैं। वह बालक के दिव्य रूप पर लोकिकताकी छाप अंकित कर देती हैं। उच्च वर्ग ने श्रृंगार की सामग्री बनाने की दिशा में नई–नई खोजें कीं। किंतु वे सब मिलकर भी उस धूल के श्रृंगार का मुकाबला नहीं कर सकतीं जो गोधूलि की बेला में बालक कृष्ण के मुख पर विराजती हैं। आशय यह हैं कि ध ूल को स्वाभाविक श्रृंगार बनावटी श्रृंगार सामग्री से कहीं बढकर हैं।

(ग) यहाँ गांव के धूल से सने बालकों को 'धूल भरे हीरे' कहा गया हैं।

क्यों–धूल से सनकर बालकों की शोभा बढ जाती हैं। वे और अधिक सुंदर जान पडते हैं। इसलिए उन्हें –धूलि भरे हीरे' कहा गया हैं।

(घ) जो बालक गांव के गलियारों में पलते हैं, वे सहज रूप से धूल में खेलते हैं। जिस प्रकार फूल के ऊपर जमी रेणु फूल को सुंदर बना देती हैं, उसी प्रकार गांव के नन्हें बालकों के तन पर भी धूल के कण सुशोभित होते हैं। उसके कारण बालक की स्वाभाविक सुंदरता तथा उनकी शारीरिक क्रांति और अधिक निखर उठती हैं।

(ड) 'गोधूलि' का अर्थ हैं– संध्या के समय गाय के पैरों के उठने वाली धूल। यह धूल बहुत बारीक होती हैं और वातावरण में छा जाती हैं। इसे सुंदर माना जाता हैं। इसलिए गोधूलि तथा गोधूलि–बेला की प्रशंसा की जाती हैं। 'धूल होना' बेकार होने या हीन होने के अर्थ में प्रयुक्त हुआ हैं।

(च) आज की प्रसाधन सामग्री और गोधूलि में से लेखक ने 'गोधूलि' को अधिक सुंदर कहा हैं।

क्यों–प्रसाधन–सामग्री का सौंदर्य बनावटी हैं, जबकि गोधूलि का सौंदर्य स्वाभविक हैं गोधूलि से सनकस्बालक की शारीरिक कांति और अधिक निखर उठती हैं।

(छ) 'हीरे के प्रेमी' धन के लोभी लोगों को कहा गया हैं। वे बनावटी चमक–दमक को महत्व देते हैं। ऐसे लोग स्वाभाविक सौंदर्य का महत्व नहीं जानते।

2. हमारी सभ्यता इस धूल के संसर्ग से बचना चाहती हैं। वह आसमान में अपना घर बनाना चाहती हैं, इसलिए शिशु भोलानाथ से कहती हैं, धूल में मत खेलो। भोलानाथ के संसर्ग से उसके नकली सलमे–सितारे धुंधले पड जाएगें। जिसने लिखा था–
''धन्य–धन्य वे हैं पर मैले जो करत गात कनिया लगाय धूरि ऐसे लरिकान की, ''उसने भी मानो धूल भरे हीरों का महत्व कम करने में कुछ उठा न रखा था। 'धन्य–धन्य' में ही उसने बडप्पन को विज्ञापित किया, फिर 'मैले' शब्द से अपनी हीनभावना भी व्यंजित कर दी, अंत में ,ऐसे लरिकान' कहकर उसने भेद–बुद्धि का परिचय भी दे दिया। वह हीरों का प्रेमी हैं, धूलि भरे हीरों का नहीं।

प्रश्नः (क) पाठ तथा उसके लेखक का नाम बताइए।

(ख) इसका आशय स्पष्ट कीजिए।

(ग) इसमें आज की सभ्यता पर क्या व्यंग्य हैं ?

(घ) इसमें 'भोलानाथ' किसे कहा गया हैं और क्यों ?

(ड) आज की सभ्यता भोलानाथ को धूल के संसर्ग से क्यों रोकती हैं ?

(च) लेखक को मैले शब्द में हीनता क्यों प्रतीत होती हैं ?

उत्तरः (क) पाठ– **धूल,** लेखक– **रामविलास शर्मा।**

(ख) आज की शहरी सभ्यता धूल में खेलने से बचना चाहती हैं। वह अपना घर धरती पर नहीं, आसमान में बसाना चाहती हैं। आशय यह हैं कि आज के लोग साफ–सुथरी जिंदगी जीना चाहते हैं। इसलिए वे अपने घर के मस्त–भोले बालकों को कहते हैं कि धूल में मत खेलो। उन्हें डर हैं कि धूल में खेलने से उन्होनें जो बनावटी सौंदर्य बनाया हैं, वह बिगड जाएगा। उनके द्वारा सजाए हुए सलमे–सितारे धरती की धूल में मैले हो जाएंगे।

एक कवि ने अपनी कविता में ये भाव प्रकट किए– ''जो लोग धूल–धूसरित बालकों को गोद में लेकर अपना तन मैला कर लेते हैं, वे धन्य हैं।'' दिखने में यह लगता हैं कि ये धूल और धूल में खेलने वाले बच्चों के प्रशंसक हैं, किन्तु सच यह हैं कि ये उनका महत्व घटाने में लगे हुए हैं। 'धन्य–धन्य' कहकर उन्होनें धूल से प्यार करने वाले लोगों का सम्मान किया। परंतु 'मैले' शब्द द्वारा उन्होनें यह हीन भावना व्यक्त कर दी कि धूल से शरीर गंदा होता हैं। यह तो धूल का अपमान हैं। इस पंक्ति के अंतिम अंश में उन्होनें 'ऐसे लरिकान' कहकर लडकों में भी भेदभाव उत्पन्न कर दिया। 'ऐसे लडके' से कुछ लडके विशेष हो गए। वास्तव में, जिस कवि ने यह पंक्ति लिखी हैं, वह भी हीरों का प्रेमी हें, अर्थात् साफ–सुथरी शहरी जीवन–शैली का प्रशंसक हैं। उसे गांव में रहने वाले धूल–धूसरित लोग यानि धूल–भरे हीरे नहीं सुहाते।

(ग) इस गद्यांश में आज की सभ्यता पर कटु व्यंग्य हैं। आज के सभ्य लोग धूल–मिटटी से घृणा करते हैं। वे बनाव श्रृंगार और नकली साज–सज्जा को महत्व देते हैं। वे ऊपरी चमक–दमक में ही सौंदर्य मानते हैं।

(घ) इस गद्यांश में भोले शिशु को भोलानाथ कहा गया हैं।

क्यों– शिशुओं को भोलानाथ इसलिए कहा गया हैं क्योंकि वे भोले निश्छल होते हैं। वे चमक–दमक की बजाय सहज धूल–मिटटी के प्रेमी होते हैं। भगवान शिव भी अपने तन पर भभूत मलते थे। गांव के बालक भी शिव की तरह सहजता के प्रेमी होते हैं।

(ड) आज की सभ्यता चमक–दमक और बाहरी बनाव–श्रृंगार की प्रेमी हैं। वह धूल–मिटटी से बचती हैं। उसे धूल में खेलना मैला होना लगता हैं। बच्चों को धूल–मिटटी में खेलता देख उन्हें अपने कपडे भी मैले होने का डर सताता हैं।

(च) लेखक को 'मैले' शब्द में हीनता प्रतीत होती हैं। वह धूल–मिटटी को गंदगी या मैल नहीं मानता। वह धूलको पवित्र श्रृंगार मानता हैं। इसलिए जिन लोगों के कपडे इस धूल में सनकर मैले हो जाते हैं, उन्हें वह हीनता का शिकार मानता हैं।

3. शिशु भोलानाथ के संसर्ग से तो 'मैले जो करत गात' की नौबत आई, अखाडे की मिट्टी में सनी हुई देह से तो कहीं उबकाई ही आने लगे। जो बचपन में धूल से खेला हैं, वह जवानी में अखाडे की मिट्टी में सनने से कैसे वंचित रह सकता हैं? रहता हैं तो उसका दुर्भाग्य हैं और क्या! यह साधारण धूल नहीं हैं, वरन् तेल और मटठे से सिझाई हुई वह मिट्टी हैं, जिसे देवता पर चढाया जाता हैं संसार में ऐसा सुख दुर्लभ हैं। पसीने से तर बदन पर मिट्टी ऐसे फिसलती हैं, जैसे आदमी कुआँ खोदकर निकला हो। उसकी मांसपेशियां फूल उठती हैं, आराम से वह हरा होता हैं, अखाडे में निर्द्वंद्व चारों खाने चित लेटकर अपने को विश्वविजयी लगाता हैं। मिट्टी उसके शरीर को बनाती हैं क्योंकि शरीर भी तो मिट्टी का ही बना हुआ हैं।

शरीर और मिट्टी को लेकर संसार की असारता पर बहुत कुछ कहा जा सकता हैं परंतु यह भी ध्यान देने की बात हैं कि जितने सारतत्व जीवन के लिए अनिवार्य हैं, वे सब मिट्टी से ही मिलते हैं।

प्रश्नः (क) अखाडे की मिट्टी की क्या विशेषता हैं?

(ख) गद्यांश में किस सुख को दुर्लभ बताया हैं?

(ग) किन सार तत्वों को जीवन के लिए अनिवार्य बताया गया हैं?

उत्तरः (क) अखाडे की मिट्टी तेल और मटठे से सिझाई हुई होती हैं। उसे तन से लगाकर आदमी हृष्ट–पुष्ट होता हैं।

(ख) अखाडे की मिट्टी में सनने का सुख संसार में दुर्लभ हैं।

(ग) जीवन के लिए अन्न, फल–फूल और भोजन अनिवार्य हैं। उसमें मिलने वाले तत्वों से मानव–शरीर निर्मित होता हैं।

4. हमारी देशभक्ति धूल को माथे से न लगाए तो कम–से–कम उस पर पैर तो रखे। किसान के हाथ–पैर, मुँह पर छाई हुई यह धूल हमारी सभ्यता से क्या कहती हैं? हम कांच को प्यार करते हैं, धूलि भरे हीरे में धूल ही दिखाई देती हैंभीतर की कांति आंखों से ओझल रहती हैं, लेकिन ये हीरे अमर हैं और एक दिन अपनी अमरता का प्रमाण भी देगें। अभी तो उन्होनें अटूट होने का ही प्रमाण दिया हैं– 'हीरा वही घन चोट न टूटे।'' वे उलटकर चोट भी करेगें और तब कांच और हीरे का भेद जानना बाकी न रहेगा। तब हम हीरे से लिपटी हुई धूल को भी माथे से लगाना सीखेगें।

प्रश्नः **(Set I)**

(क) लेखक देशभक्ति का हवाला देकर हमसे क्या अपेक्षा रखता हैं ?

(ख) 'हमें धूलि भरे हीरे में धूल दिखाई देती हैं'– व्यंग्य स्पष्ट कीजिए।

(ग) अमर हीरे किन्हें कहा गया हैं ?

(घ) 'हीरा वही घन चोट न टूटे' का आशय स्पष्ट कीजिए। यह उक्ति ग्रामीण लोगों पर किस तरह लागू होती हैं ?

(ड) कांच और हीरा क्रमशः किसके प्रतीक हैं? इनका भेद कब पता चलेगा ?

उत्तरः (क) लेखक देशभक्ति का हवाला देकर हमसे यह अपेक्षा करता हैं कि हम अपने देश की धूल को चाहे माथे से न लगाएं, किंतु उस पर पैर तो रखें। हम मिट्टी के संपर्क में रहें। उस पर विहार करें, विचरण करें।

(ख) लेखक इस पंक्ति में व्यंग्य करता हैं कि हमें धूलि–भरे हीरे में हीरे की चमक नहीं दिखाई देती, बल्कि धूल दिखाई देती हैं। आशय यह हैं कि हमें ग्रामीण लोगों की सहजता और सच्चाई नहीं नजर आती, उनमें फुहडता नजर आती हैं।

(ग) ग्रामीण लोगों को अमर हीरे कहा गया हैं। लेखक के अनुसार, उनका जीवन हीरे की चमक की भांति गुणवान अैर शक्तिमय हैं। वे मन तथा तन से भी सुदृढ हैं।

(घ) हीरा वही हैं जो घन की चोट खाकर भी न टूटने पाए। आशय यह हैं कि हीरा बहुत मतबूत होता हैं। यह उक्ति भारत के ग्रामीणों पर पूरी तरह लागू होती हैं। वे संकट और कष्ट सहकर भी हार नहीं मानते, बल्कि और अधिक मजबूत हो जाते हैं।

(ड) 'कांच' शहरी सभ्यता का प्रतीक हैं और 'हीरा' ग्रामीण सभ्यता का। शहरी सभ्यता के लोग बाहरी चकाचौंध को महत्व देते हैं और ग्रामीण जन भीतरी शक्ति को। जब कभी हीरा कांच पर उलटकर चोट करेगा, अर्थात् ग्रामीण जन क्रांति के लिए उठ खडे होगें, तब पता चलेगा कि इनमें कितनी शक्ति हैं। तब बनावटी चकाचौंध वाले कांच– जेसे लोगों की दुर्बलता भी प्रकट हो जाएगी।

प्रश्नः **(Set II)**

(क) धूल हमारी सभ्यता से क्या कहती हैं?

(ख) हीरा अपनी अमरता का प्रमाण कैसे देगा?

(ग) लेख और लेखक का नाम लिखें।

उत्तरः (क) धूल हमारी सभ्यता से कहती हैं कि इसे चाहे माथे से न लगाओं किंतु इस पर पैर तो रखो। आशय यह हैं कि धूल की महिमा को स्वीकारा करो।

(ख) हीरा घन की चोट खाकर भी अटूट रहेगा और उलटकर चोट भी करेगा। तभी वह अपनी अमरता का प्रमाण देगा।

(ग) लेख– धूल, लेखक– रामविलास शर्मा।

III. पाठ्य पुस्तक के प्रश्न–अभ्यास

प्रश्न.1 हमारी सभ्यता धूल से क्यों बचना चाहती हैं?

उत्तरः हमारी सभ्यता धूल को गर्द समझती हैं। वह बनावटी प्रसाधन–सामग्री और सलमे–सितारों में ही सौंदर्य मानती हैं। गांव की धूल में उन सलमे–सितारों के धुंधले पड़ने की आशंका होती हैं। इसलिए वह धूल से अर्थात् ग्राम्य संस्कृति से बचना चाहती हैं।

प्रश्न.2 अखाडे की मिट्टी की क्या विशेषता होती हैं?

उत्तरः अखाडे की मिट्टी विशेष होती हैं। वह तेल और मट्ठे से सिझाई हुई होती हैं। जब यह पसीने से लथपथ शरीर पर फिसलती हैं तो ऐसा लगता हैं कि मानों आदमी कुआं खोदकर निकला हो।

प्रश्न.3 इस पाठ में लेखक ने नगरीय सभ्यता पर क्या व्यंग्य किया हैं?

उत्तरः लेखक ने नगरीय सभ्यता को बनावटी, नकली तथा चकाचौंध–भरी कहा हैं। नगर के लोग मिट्टी को मैल कहकर उससे दूर रहते हैं। इस कारण वे धूल में सनने का तथा स्वाभाविक खेलों का आनंद नहीं ले पाते।

प्रश्न.4 लेखक बालकृष्ण के मुँह पर छाई गोधूलि को श्रेष्ठ क्यों मानता हैं?

उत्तरः लेखक बालकृष्ण के मुँह पर छाई गोधूलि को श्रेष्ठ मानता हैं। उसके अनुसार, इसके कारण उसकी आंतरिक आभा और भी खिल उठती हैं। बालक का धूल–धूसरित मुख बनावटी श्रृंगार प्रसाधनों से कहीं अधिक मनमोहक होता हैं। यह वास्तविक होने के कारण कृत्रिम सौंदर्य–सामग्री से अधिक श्रेष्ठ होता हैं। इसमें बालक की सहज पार्थिवता, अर्थात् शारीरिक कांति जगमगा उठती हैं। इसकी तुलना में बनावटी सजाव–श्रृंगार कहीं नहीं टिकता।

प्रश्न.5 लेखक ने धूल और मिट्टी में क्या अंतर बताया हैं?

उत्तरः लेखक ने मिट्टी और धूल में अंतर बताया हैं। उसके अनुसार मिट्टी शरीर हैं तो धूल प्राण हैं। मिट्टी शब्द हैं तो धूल उससे उत्पन्न रस हैं। मिट्टी चांद हैं तो धूल उसकी चांदनी हैं। दूसरे शब्दों में, मिट्टी की आभा का दूसरा नाम हैं– धूल। कहने का आशय यह हैं कि धूल में चमक होती हैं, आभा होती हैं। मिट्टी की पहचान उसकी धूल से होती हैं।

प्रश्न.6 ग्रामीण परिवेश में प्रकृति धूल के कौन–कौन से सुंदर चित्र प्रस्तुत करती हैं?

अथवा

'धूल' पाठ के प्राकृतिक सौंदर्य का चित्रण कीजिए।

उत्तरः ग्रामीण परिवेश में प्रकृति धूल के द्वारा अनेक सुंदर चित्र प्रस्तुत करती हैं। जब अमराइयों के पीछे छिपे सूर्य की किरणें धूल पर पडती हैं तो ऐसा लगता हैं कि मानो आकाश में सोने की परत छा गई हो। सूर्यास्त के बाद लीक पर गाड़ी के निकल जाने के बाद धूल आसमान में ऐसे छा जाती हैं मानो रूई के बादल छा गए हों। या यों लगता हैं मानो वह ऐरावत हाथी के जाने के लिए बनाया गया तारों भरा मार्ग हो। चांदनी रात में मेले पर जाने वाली गाडियों के पीछे धूल ऐसे उठती हैं मानो कवि कल्पना उडान पर हो।

प्रश्न.7 'हीरा' वही घन चोट न टूटे' का संदर्भ पाठ के आधार पर स्पष्ट कीजिए।

उत्तरः इस उक्ति का अर्थ हैं– हीरा वही हैं जो घन की चोट खाकर भी न टूटे। आशय यह हैं कि असली हीरा सुदृढ होता हैं। पाठ के संदर्भ में इसका अर्थ हैं– ग्रामीण लोग हीरे की भांति सुदृढ होते हैं। वे संकटों की मार से हारते नहीं हैं। जिन्हें इस देश की धूल मिट्टी से प्यार हैं, वे हर संकट में और अधिक मजबूत होकर उभरते हैं।

प्रश्न.8 कविता को विडंबना मानते हुए लेखक ने क्या कहा हैं?

उत्तरः लेखक ने किसी पुस्तक विक्रेता द्वारा दिए गए निमंत्रण पत्र में गोधूलि–बेला का उल्लेख देखा तो उसे लगा कि यह कविता की विडंबना हैं। कवियों ने कविता में बार–बार गोधूलि की इतनी महिमा गाई हैं कि पुस्तक–विक्रेता महोदय उस शब्द का प्रयोग कर बैठे। परंतु सच यह हैं कि शहरों में न तो गाएँ होती हैं, न गोधूलि–बेला। अतः यह गोधूलि शब्द केवल कविता के गुणगान को सुनकर प्रयुक्त हुआ हैं।

IV. अन्य महत्वपूर्ण परीक्षोपयोगी प्रश्नोत्तर

प्रश्न.1 गोधूलि गांव की ही संपत्ति क्यों हैं?

अथवा

गोधूलि को गांव की संपत्ति मानने के पीछे तर्क क्या हैं?

उत्तरः गोधूलि गांव की ही संपत्ति इसलिए हैं क्योंकि गाएँ और ग्वाले गाँवों में ही होते हैं। वहीं धूल–भरे गलियारे होते हैं जिन पर से साँझ के समय धूल उठती हैं। शहर में यह सब नहीं होता। इसलिए गोधूलि केवल गाँव की ही संपत्ति हैं।

प्रश्न.2 इस पाठ के लेखक ने नगरीय सभ्यता पर क्या–क्या व्यंग्य किए हैं?

उत्तरः इस पाठ में लेखक ने नगरीय सभ्यता पर निम्नलिखित व्यंग्य किए हैं–

- नगरीय सभ्यता बनावटी जिंदगी जीती हैं। उसके पास सौंदर्य और श्रंगार के नकली साधन तो हैं किंतु भीतरी अभा नहीं हैं। दूसरे शब्दों में, नगरीय सभ्यता कांच के समान नकली, कमजोर और बनावटी हैं तो ग्रामीण सभ्यता हीरे के समान असली, ठोस तथा सहज हैं।
- नगरीय सभ्यता धूल के श्रृंगार से वंचित रह जाती हैं। इसलिए मिट्टी के खेलों से भी वंचित रह जाती हैं।

प्रश्न.3 अखाड़े की मिट्टी में सनी हुई देह से शहरियों को उबकाई क्यों आने लगती हैं?

उत्तरः शहरी लोग चमक–दमक भरी बनावटी जिंदगी को महत्व देते हैं। वे धूल को गंदगी मानकर उससे दूर रहते हैं। इसलिए उन्हें अखाडे की मिट्टी में सनी देह से उबकाई आती हैं।

प्रश्न.4 'नीच को धूरि समान' वेद वाक्य नहीं हैं। स्पष्ट कीजिए।

उत्तरः 'नीच को धूरि समान' उक्ति से लगता हैं कि धूल नीच होती हैं। परंतु यह वाक्य कोई प्रामाणिक कथन नहीं हैं। यह कथन मिथ्या हैं। इसमें धूल की महिमा कम करके दिखाई गई हैं। कितने ही लोग ऐसे हैं जो धूल को महिमाशाली मानते हैं।

प्रश्न.5 मनुष्य का सबसे बड़ा दुर्भाग्य किसे बताया गया हैं और क्यों?

उत्तरः धरती की धूल और अखाड़े की मिट्टी से दूर रहने को मनुष्य का सबसे बड़ा दुर्भाग्य कहा गया हैं। लेखक के अनुसार, अखाड़े की मिट्टी में सनना मनुष्य का सबसे बडा सुख हैं। जो इस सुख से दूर हैं, वह दुर्भाग्यशाली हैं।

प्रश्न.6 नगर में रहने वाले लोग धूल का अनादर कैसे करते हैं?

उत्तरः नगर में रहने वाले लोग धूल से दूर रहते हैं। वे कांच की बनावटी चमक से प्रेम करते हैं। वे अखाडे की मिट्टी से भी दूरी रखते हैं। इस प्रकार वे धूल का अनादर करते हैं।

प्रश्न.7 'गोधूलि' से आप क्या समझते हैं?

उत्तरः 'गोधूलि' से अर्थ हैं– संध्या के समय गांवों में गायों के चलने से आकाश में उठने वाली धूल। जिस वक्त यह धूल उठती हैं, उस वेला को गोधूलि की वेला कहते हैं।

प्रश्न.8 धूल की उपयोगिता पर प्रकाश डालिए?

उत्तरः धूल के मुख्यतः दो रूप हैं– मिट्टी और धूलि। मिट्टी से ही हमारे भोजन का उत्पादन होता हैं। हमारे रस, रूप, गंध सभी इसी मिट्टी से पैदा होते हैं। अखाडे की मिट्टी हमारे शरीर को हष्ट–पुष्ट रखती हैं। 'गोधूलि' अपने–आप में बहुत मनोहारी होती हैं। वह प्राकृतिक रूप से बहुत सुंदर होती हैं।

प्रश्न.9 लेखक के अनुसार धूल क्या हैं? बालक धूलि भरे ही क्यों अच्छे लगते हैं?

उत्तरः लेखक के अनुसार, मिट्टी की आभा को धूल कहते हैं। यह मिट्टी का श्रृंगार हैं धूल–धूसरित बालक बहुतसुंदर प्रतीत होते हैं। उनका सौंदर्य सहज होता हैं।