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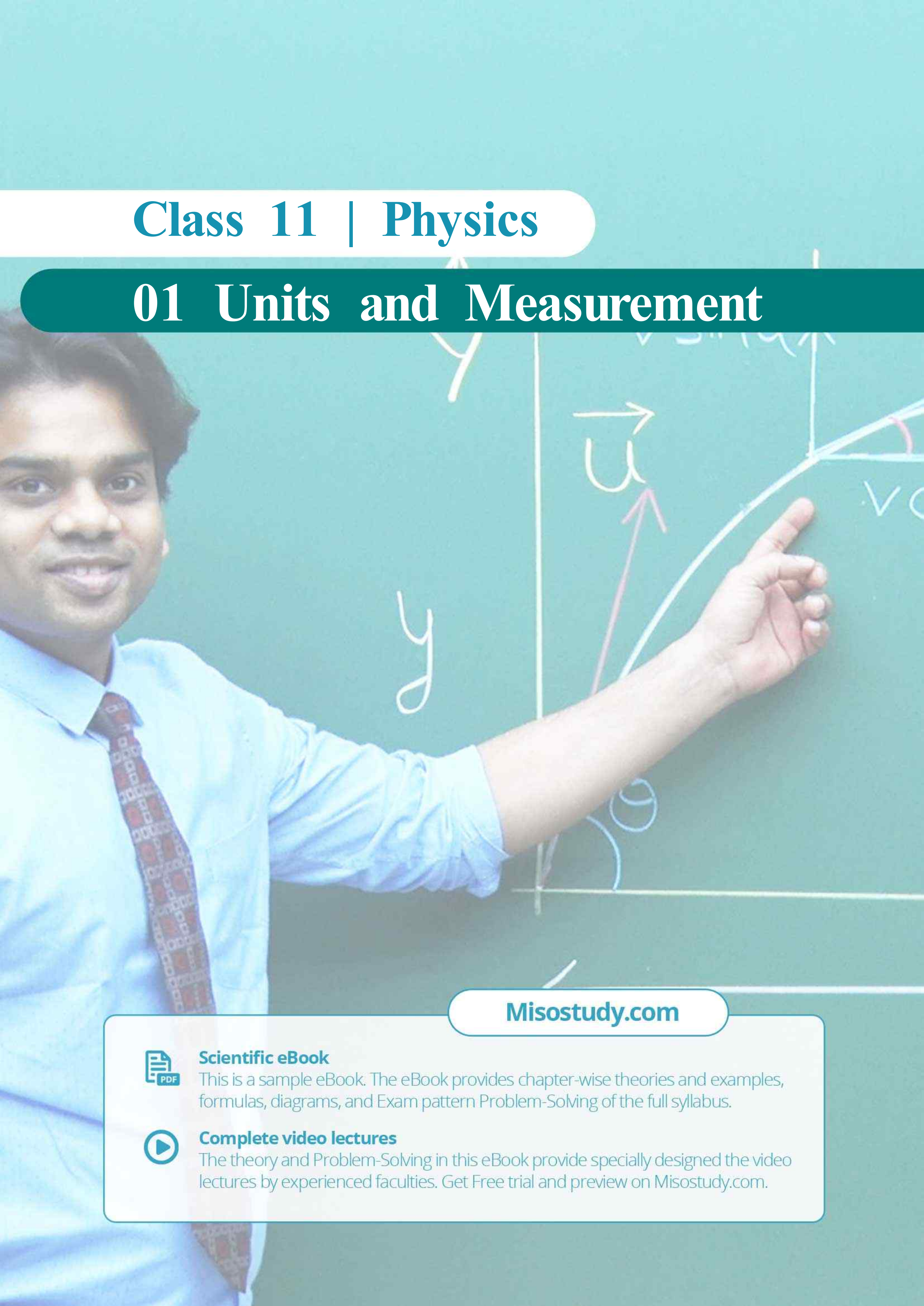


Class 11 | Physics

01 Units and Measurement

01. 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 :

(A) Based on their directional properties

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

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

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

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

(B) Based on their dependency

I. 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.

II. 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, acceleration, force, pressure, etc.

Example Classify the quantities displacement, mass, force, time, speed, velocity, acceleration, pressure and work under the following categories:

(a) base and scalar
(b) base and vector
(c) derived and scalar
(d) derived and vector

Solution

(a) mass, time
(b) displacement
(c) speed, pressure, work
(d) force, velocity, acceleration

02. 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

(i) 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.

(ii) CGS or Gaussian system : In this system the fundamental quantities are length, mass and time and their respective units are centimeter (cm), gram (g) and second (s).

(iii) 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.

(iv) **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 tow 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

03. Classification of Units

The units of physical quantities can be classified as follows :

(i) Fundamental or base units

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

(ii) 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 $= \dfrac{\text{unit of distance}}{\text{unit of time}} = \dfrac{\text{metre}}{\text{second}} = \text{m/s}$

Some derived units are named in honour of great scientists.

e.g. unit of force – newton (N), unit of frequency – hertz (Hz), etc.

(iii) Supplementary units

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

- **radian :** 1 radian is the angle subtended at the centre of a circle by and arc equal in length to the radius of the circle.
- **steradian :** 1 steradian is the solid angle subtended at the centre of a sphere, by the surface of the sphere which is equal in area to the square of the radius of the sphere.

(iv) 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.

Conversion factors

To convert a physical quantity from one set of units to the other, the required multiplication factor is called *conversion factor*.

Magnitude of a physical quantity = numeric value (n) × unit (u)

While conversion from one set of units to the other the magnitude of the quantity must remain same. Therefore

$$n_1u_1 = n_2u_2 \qquad \text{or} \qquad nu = \text{constant} \qquad \text{or} \qquad n \propto \frac{1}{u}$$

This is the numeric value of a physical quantity is inversely proportional to the base unit.

e.g. 1m = 100 cm = 3.28 ft = 39.4 inch
(SI) (CGS) (FPS)

Example The acceleration due to gravity is 9.8 m s^{-2}. Given its value in ft s^{-2}

Solution As 1m = 3.2 ft

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

04. Dimensions

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

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. Dimensional formula of mass in $[M^1L^0\ T^0]$ is the dimensional formula of the force and the dimensions of force are 1 in mass, 1 in length and −2 in time

05. Applications of Dimensional Analysis

(i) To convert a physical quantity from one system of units to the other :

This is based on a fact that magnitude of a physical quantity remains same whatever system is used for measurement i.e. magnitude = numeric value (n) × unit (u) = constant or $n_1u_1 = n_2u_2$

So if a quantity is represented by $[M^aL^bT^c]$

Then $$\boxed{n_2 = n_1\left(\frac{u_1}{u_2}\right) = n_1\left(\frac{M_1}{M_2}\right)^a\left(\frac{L_1}{L_2}\right)^b\left(\frac{T_1}{T_2}\right)^c}$$

Here

n_2 = numerical value in II system
n_1 = numerical value in I system
M_1 = unit of mass in I system
M_2 = unit of mass in II system
L_1 = unit of length in I system
L_2 = unit of length in II system
T_1 = unit of time in I system
T_2 = unit of time in II system

Example Convert 1 newton (SI unit of force) into dyne (CGS unit of force)

Solution The dimensional equation of force is $[F] = [M^1\ L^1\ T^{-2}]$

Therefore if n_1, u_1, and n_2, u_2, corresponds to SI & CGS units respectively, then

$$n_2 = n\left[\frac{M_1}{M_2}\right]^1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2} = 1\left[\frac{kg}{g}\right]\left[\frac{m}{cm}\right]\left[\frac{s}{s}\right]^{-2} = 1\times 1000\times 100\times 1 = 10^5 \ \therefore$$

1 newton = 10^5 dyne.

(ii) To check the dimensional correctness of a given physical relation

If in a given relation, the terms on both the sides have the same dimensions, then the relation is dimensionally correct. This is known as the principle of homogeneity of dimensions.

Example Check the accuracy of the relation $T = 2\pi\sqrt{\frac{L}{g}}$ for a simple pendulum using

Solution The dimensions of LHS = the dimension of T = $[M^0\ L^0\ T^1]$

The dimensions of RHS $= \left(\frac{\text{dimensions of length}}{\text{dimensions of acceleration}}\right)^{1/2}$ ($\because$ 2π is a dimensionless constant)

$$= \left[\frac{L}{LT^{-2}}\right]^{1/2} = [T^2]^{1/2} = [T] = [M^0 L^0 T^1]$$

Since the dimensions are same on both the sides, the relation is correct.

(iii) To derive relationship between different physical quantities

Using the same principle of homogeneity of dimensions new relations among physical quantities can be derived if the dependent quantities are known.

Example It is known that the time of revolution T of a satellite around the earth depends on the universal gravitational constant G, the mass of the earth M, and the radius of the circular orbit R. Obtain an expression for T using dimensional analysis.

We have $[T] = [G]^a [M]^b [R]^c$

Solution $[M]^0 [L]^0 [T]^1 = [M]^{-a} [L]^{3a} [T]^{-2a} \times [M]^b \times [L]^c = [M]^{b-a} [L]^{c+3a} [T]^{-2a}$

Comparing the exponents

For $[T]: 1 = -2a \Rightarrow a = -\frac{1}{2}$ For $[M]: 0 = b - a \Rightarrow b = a = -\frac{1}{2}$

For $[L]: 0 = c + 3a \Rightarrow c = -3a = \frac{3}{2}$

Putting the values we get $T \propto G^{-1/2} M^{-1/2} R^{3/2} \Rightarrow T \propto \sqrt{\frac{R^3}{GM}}$

The actual expression is $T = 2\pi\sqrt{\frac{R^3}{GM}}$

Dimensions of trigonometric, exponential, logarithmic function etc.

All trigonometric, exponential and logarithmic functions and their arguments are dimensionless.

NOTE ☞ Trigonometric function sinθ and its argument θ are dimensionless.

06. Limitations of this Method

- In Mechanics the formula for a physical quantity depending one more than three physical quantities cannot be derived. It can only be checked.
- This method can be used only if the dependency is of multiplication type. The formulae containing exponential, trigonometrical and logarithmic functions cant't be derived using this method. Formulae containing more than one term which are added or subtracted like $s = ut + at^2/2$ also can't be derived.
- The relation derived from this method gives no information about the dimensionless constants.
- If dimensions are given, physical quantity may not be unique as many physical quantities have the same dimensions.
- It gives no information whether a physical quantity is a scalar or a vector.

07. Significant Figures or Digits

The significant figure (SF) in a measurement are the figure or digits that are known with certainity plus one that is uncertain.

Significant figures in a measured value of a physical quantity tell the number of digits in which we have confidence. Larger the number of significant figure obtained in a measurement, greater is its accuracy and vice versa.

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 $x = 12.3 = 1.23 \times 10^1 = 0.123 \times 10^2 = 0.0123 \times 10^3 = 123 \times 10^{-1}$ each term has 3 SF only.

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. $4.0 \times 0.12 = 0.484 = 0.48$

- 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 × 10b, 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 effect the number of SF. For example in 2.308 cm = 23.08 mm = 0.02308 m = 23080 μm each term has 4 SF.

Example 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}
(f) 26900
(g) 26900 kg

Solution

(a) 165	3 SF (following rule I)
(b) 2.05	3 SF (following rule I & II)
(c) 34.000 m	5 SF (following rule I & V)
(d) 0.005	1 SF (following rules I & IV)
(e) 0.02340 N m^{-1}	4 SF (following rule I, IV & V)
(f) 26900	3 SF (see rule VI)
(g) 26900 kg	5 SF (see rule VI)

08. 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 than the preceding digit is increased by one if it odd and is left unchanged if it is even. e.g. $14.35 \approx 14.4$ and $14.45 \approx 14.4$

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

Solution 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 $= 2\,(l \times b + b \times t + t \times l)$

$= 2\,(4.234 \times 1.005 + 1.005 \times 0.0201 + 0.0201 \times 4.234)\ m^2$

$= 2\,(4.3604739)\ m^2 = 8.720978\ m^2$

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 $= l \times b \times t = 4.234 \times 1.005 \times 0.0201\ m^3 = 0.0855289\ m^3$

Since volume can contain 3 SF, therefore, rounding off, we get

Volume = $0.0855\ m^3$

09. Order of Magnitude

Order of magnitude of a quantity is the power of 10 required to represent that quantity. This power is determined after rounding off the value of the quantity properly. For rounding off, the last digit is simply ignored if it is less than 5 and, is increased by one if it is 5 or more than 5.

- When a number is divided by 10^x (where x is the order of the number) the result will always lie between 0.5 and 5 i.e. $0.5 \le N/10^x < 5$

Example Order of magnitude of the following values can be determined as follows :

(a) 49 $= 4.9 \times 10^1 \approx 10^1$

Solution $\therefore$ Order of magnitude = 1

(b) 51 $= 5.1 \times 10^1 \approx 10^2$

Solution $\therefore$ Order of magnitude = 2

(c) 0.049 $= 4.9 \times 10^{-2} \approx 10^{-2}$

Solution $\therefore$ Order of magnitude = −2

(d) 0.050 $= 5.0 \times 10^{-2} \approx 10^{-1}$

Solution $\therefore$ Order of magnitude = −1

(e) 0.051 $= 5.1 \times 10^{-2} \approx 10^{-1}$

Solution $\therefore$ Order of magnitude = −1

- **Accuracy, Precision of Instruments and Errors in Measurement**

  Accuracy and Precision

  The result of every measurement by any measuring instrument contains some uncertainty. This uncertainty is called error. Every calculated quantity which is based on measured value, also has an error. Every measurement is limited by the reliability of the measuring instrument and skill of the person making the measurement. If we repeat a particular measurement, we usually do not get precisely the same result as each result is subjected to some experimental error. This imperfection in measurement can be described in terms of accuracy and precision. The accuracy of a measurement is a measure of how close the measured value is to the true value of the quantity. Precision tells us to what resolution or limit the quantity is measured, we can illustrate the difference between accuracy and precision with help of a example. Suppose the true value of a certain length is 1.234 cm. In one experiment, using a measuring instrument of resolution 0.1 cm, the measured value is found to be 1.1cm, while in another experiment using a measuring device of greater resolution of 0.01m, the length is determined to be 1.53cm. The first measurement has move accuracy (as it is closer to the true value) but less precision (as resolution is only 0.1 cm), while the second measurement is less accurate but more precise.

10. Errors

The difference between the true value and the measured value of a quantity is known as the error of measurement.

Errors may arise from different sources and are usually classified as follows

Systematic or Controllable Errors

Systematic errors are the errors whose causes are known. They can be either positive or negative. Due to the known causes these errors can be minimised. Systematic errors can further be classified into three categories

(i) **Instrumental errors :-** These errors are due to imperfect design or erroneous manufacture or misuse of the measuring instrument. These can be reduced by using more accurate instruments.

(ii) **Environmental errors :-** These are due to the changes in external environmental conditions such as temperature, pressure, humidity, dust vibrations or magnetic and electrostatic fields.

(iii) Observational errors :- These errors arise due to improper setting of the apparatus or carelessness in taking observations.

Random Errors

These errors are due to unknown causes. Therefore they occur irregularly and are variable in magnitude and sign. Since the causes of these errors are not known precisely they can not be eliminated completely. For example, when the same person repeats the same observation in the same conditions, he may get different readings different times.

Random errors can be reduced by repeating the observation a large number of times and taking the arithmetic mean of all the observations. This mean value would be very close to the most accurate reading.

NOTE ☞ If the number of observations is made n times then the random error reduces to $\left(\frac{1}{n}\right)$ times.

Gross Errors : Gross errors arise due to human carelessness and mistakes in reading the instruments or calculating and recording the measurement results.

For example :-

(i) Reading instrument without proper initial settings.

(ii) Taking the observations wrongly without taking necessary precautions.

(iii) Exhibiting mistakes in recording the observations.

(iv) Putting improper values of the observations in calculations.

These errors can be minimised by increasing the sincerity and alertness of the observer.

11. Representation of Errors

Errors can be expressed in the following ways

Absolute Error (Δa) : The difference between the true value and the individual measured value of the quantity is called the absolute error of the measurement.

Suppose a physical quantity is measured n times and the measured values are a_1, a_2, a_3 ....a_n. The arithmetic mean (a_m) of these values is

$$a_m = \frac{a_1 + a_2 + a_3 + \dots\dots\dots a_n}{n} = \frac{1}{n}\sum_{i=1}^{n} a_i \qquad \text{...(i)}$$

If the true value of the quantity is not given then mean value (a_m) can be taken as the true value. Then the absolute errors in the individual measured values are

$$\triangle a_1 = a_m - a_1$$
$$\triangle a_2 = a_m - a_2$$
$$\dots\dots\dots\dots\dots\dots\dots\dots$$
$$\dots\dots\dots\dots\dots\dots\dots\dots$$
$$\triangle a_n = a_m - a_n$$

The arithmetic mean of all the absolute errors is defined as the final or mean absolute error $(\Delta a)_m$ or Δa of the value of the physical quantity a

$$(\triangle a_m) = \frac{|\triangle a_1| + |\triangle a_2| + \dots\dots\dots + |\triangle a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n} |\triangle a_i| \qquad \text{...(ii)}$$

So if the measured value of a quantity be 'a' and the error in measurement be Δa, then the true value (a_t) can be written as

$a_t = a \pm \Delta a$ ...(iii)

Relative or Fractional Error : It is defined as the ratio of the mean absolute error ($(\Delta a)_m$ or $\overline{\Delta a}$) to the true value or the mean value (a_m or $\bar{a}$) of the quantity measured.

$$\text{Relative or fractional error} = \frac{\text{Mean absolute error}}{\text{Mean value}} = \frac{(\Delta a)_m}{a_m} \text{ or } \frac{\overline{\Delta a}}{\bar{a}} \quad ...(iv)$$

When the relative error is expressed in percentage, it is known as percentage error, percentage error = relative error × 100

$$\text{or} \quad \text{percentage error} = \frac{\text{mean absolute error}}{\text{true value}} \times 100\% = \frac{\overline{\Delta a}}{a} \times 100\% \quad ...(v)$$

12. Propagation of Errors in Mathematical Operations

Rule I : The maximum absolute error in the sum or difference of the two quantities is equal to the sum of the absolute errors in the individual quantities.
If $X = A + B$ or $X = A - B$ and if ± ΔA and ± ΔB represent the absolute errors in A and B respectively, then the maximum absolute error in $X = \Delta X = \Delta A + \Delta B$ and

$$\text{Maximum percentage error} = \frac{\Delta X}{X} \times 100 \quad ...(i)$$

The result will be written as $X \pm \Delta X$ (in terms of absolute error)

or $X \pm \frac{\Delta X}{X} \times 100\%$ (in terms of percentage error)

Rule II : The maximum fractional or relative error in the product or division of quantities is equal to the sum of the fractional or relative errors in the individual quantities.
If $X = A \times B$ or $X = A/B$

$$\text{then} \quad \frac{\Delta X}{X} = \pm\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) \quad ...(ii)$$

Rule III : The maximum fractional error in a quantity raised to a power (n) is n times the fractional error in the quantity itself, i.e.

$$\text{If} \quad X = A^n \quad \text{then} \quad \frac{\Delta X}{X} = n\left(\frac{\Delta A}{A}\right) \quad ...(viii)$$

$$\text{If} \quad X = A^p B^q C^r \quad \text{then} \quad \frac{\Delta X}{X} = \left[p\left(\frac{\Delta A}{A}\right) + q\left(\frac{\Delta B}{B}\right) + r\left(\frac{\Delta C}{C}\right)\right]$$

$$\text{If} \quad X = \frac{A^p B^q}{C^r} \quad \text{then} \quad \frac{\Delta X}{X} = \left[p\left(\frac{\Delta A}{A}\right) + q\left(\frac{\Delta B}{B}\right) + r\left(\frac{\Delta C}{C}\right)\right]$$

IMPORTANT POINTS

- Systematic errors are repeated consistently with the repetition of the experiment and are produced due to improper conditions or procedures that are consistent in action whereas random errors are accidental and their magnitude and sign cannot be predicated from the knowledge of the measuring system and conditions of measurement.
  Systematic errors can therefore be minimised by improving experimental techniques, selecting better instruments and improving personal skills whereas random errors can be minimised by repeating the observation several times.
- Mean absolute error has the units and dimensions of the quantity itself whereas fractional or relative error is unitless and dimensionless.
- Absolute errors may be positive in certain cases and negative in other cases.

Example The initial and final temperatures of water as recorded by an observer are (40.6 ± 0.2)ºC and (78.3 ± 0.3)ºC. Calculate the rise in temperature with proper error limits.

Solution Given $\theta_1 = (40.6 \pm 0.2)^\circ C$ and $\theta_2 = (78.3 \pm 0.3)^\circ C$

Rise in temp. $\theta = \theta_2 - \theta_1 = 78.3 - 40.6 = 37.7^\circ C$.

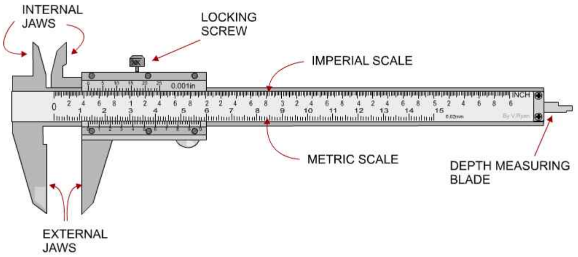
$\Delta\theta = \pm(\Delta\theta_1 + \Delta\theta_2) = \pm(0.2 + 0.3) = \pm 0.5^\circ C$ $\quad\therefore$ rise in temperature = $(37.7 \pm 0.5)^\circ C$

13. Least Count

The smallest value of a physical quantity which can be measured accurately with and 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.



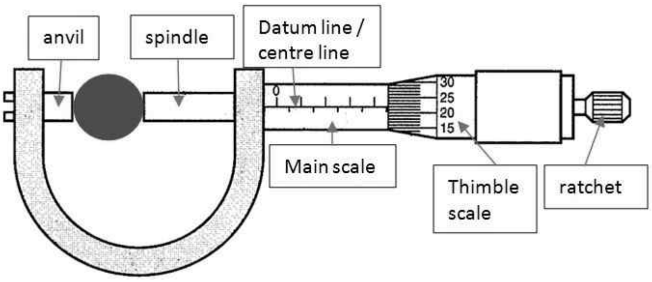
$$aM = bV \quad \Rightarrow \quad V = \frac{a}{b}M$$

$$\therefore \qquad M - V = M - \frac{a}{b}M \text{ or } \qquad M - V = \left(\frac{b-a}{b}\right)M$$

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

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

Least Count of screw gauge or spherometer



$$\text{Least Count} = \frac{\text{Pitch}}{\text{Total number of divisions on the circul scale}}$$

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.

Example 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 ?

Solution 20 div. of vernier scale = 8 div. of main scale $\Rightarrow 1\,\text{V.S.D.} = (\frac{8}{20})\,\text{M.S.D.} = (\frac{2}{5})\text{M.S.D.}$

Least count = 1 M. S. D. − 1 V. S. D. = 1 M. S. D. − $(\frac{2}{5})$M. S. D. = $(1-\frac{2}{5})$ M. S. D.

$$= \frac{3}{5}\,\text{M.S.D.} = \frac{3}{5} \times 0.1\,\text{cm} = 0.06\,\text{cm}$$

$(\because 1\,\text{M.S.D.} = \frac{1}{10}\,\text{cm} = 0.1\,\text{cm})$

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

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Exercise (1)

1. A physical quantity of the dimension of length that can be formed out of c, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]
   (a) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
   (b) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
   (c) $\frac{1}{c^2}\left[\frac{e^2}{G\,4\pi\varepsilon_0}\right]^{1/2}$
   (d) $\frac{1}{c}G\frac{e^2}{4\pi\varepsilon_0}$

2. If dimensions of critical velocity v_c of a liquid flowing through a tube are expressed as $[\eta^x\ \rho^y\ r^z]$, where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by
   (a) 1, −1, −1
   (b) −1, −1, 1
   (c) −1, −1, −1
   (d) 1, 1, 1

3. In an experiment, four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated $P = \frac{a^3b^2}{cd}$%. Error in P is
   (a) 14%
   (b) 10%
   (c) 7%
   (d) 4%

4. If energy (E), velocity (v) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be
   (a) $[Ev^{-2}T^{-1}]$
   (b) $[Ev^{-1}T^{-2}]$
   (c) $[Ev^{-2}T^{-2}]$
   (d) $[E^{-2}v^{-1}T^{-3}]$

5. Dimensions of resistance in an electrical circuit, in terms of dimension of mass M, of length L, of time T and of current I, would be
   (a) $[ML^2T^{-3}I^{-1}]$
   (b) $[ML^2T^{-2}]$
   (c) $[ML^2T^{-1}I^{-1}]$
   (d) $[ML^2T^{-3}I^{-2}]$

6. Which two of following five physical parameters have the same dimensions?
   (i) Energy density
   (ii) Refractive index
   (iii) Dielectric constant
   (iv) Young's modulus
   (v) Magnetic field

   (a) (ii) and (iv)
   (b) (iii) and (v)
   (c) (i) and (iv)
   (d) (i) and (v)

7. In a vernier callipers N divisions of vernier scale coincide with $N-1$ divisions of main scale (in which length of one division is 1 mm). The least count of the instrument should be
   (a) N
   (b) $N-1$
   (c) $\frac{1}{10N}$
   (d) $\frac{1}{(N-1)}$

8. The dimensional formula for permeability of free space, μ_0 is
   (a) $[MLT^{-2}A^{-2}]$
   (b) $[ML^{-1}T^{2}A^{-2}]$
   (c) $[ML^{-1}T^{-2}A^{2}]$
   (d) $[MLT^{-2}A^{-1}]$

9. If p represents radiation pressure, c represents speed of light and S represent radiation energy striking unit area per sec. The non-zero integers x, y, z such that $p^x S^y c^z$ is dimensionless are
   (a) $x = 1,\ y = 1,\ z = 1$
   (b) $x = -1,\ y = 1,\ z = 1$
   (c) $x = 1,\ y = -1,\ z = 1$
   (d) $x = 1,\ y = 1,\ z = -1$

10. A certain body weighs 22.42 g and has a measured volume of 4.7 cc. The possible error in the measurement of mass and volume are 0.01 g and 0.1 cc. Then, maximum error in the density will be
   (a) 22%
   (b) 2%
   (c) 0.2%
   (d) 0.02%

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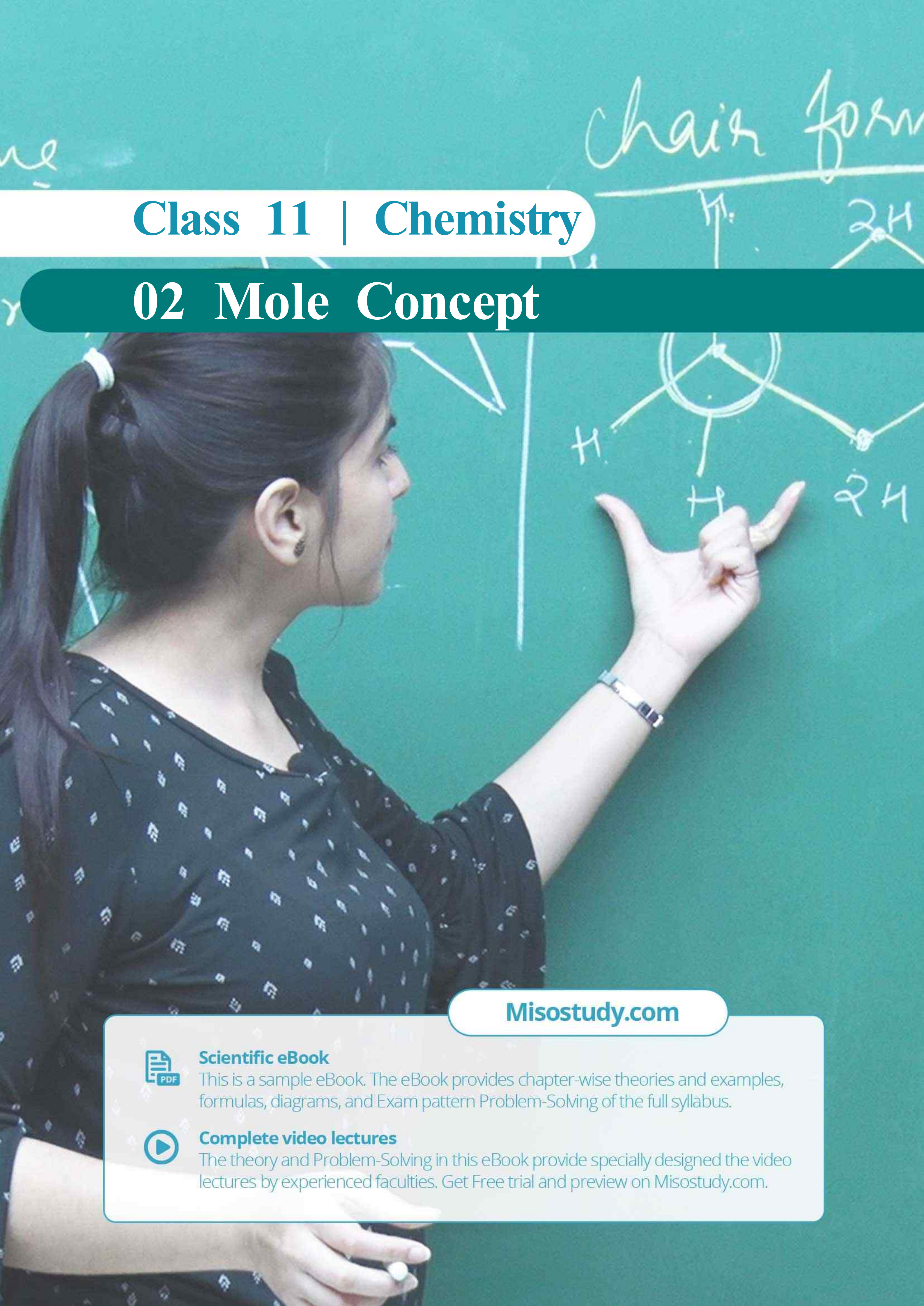
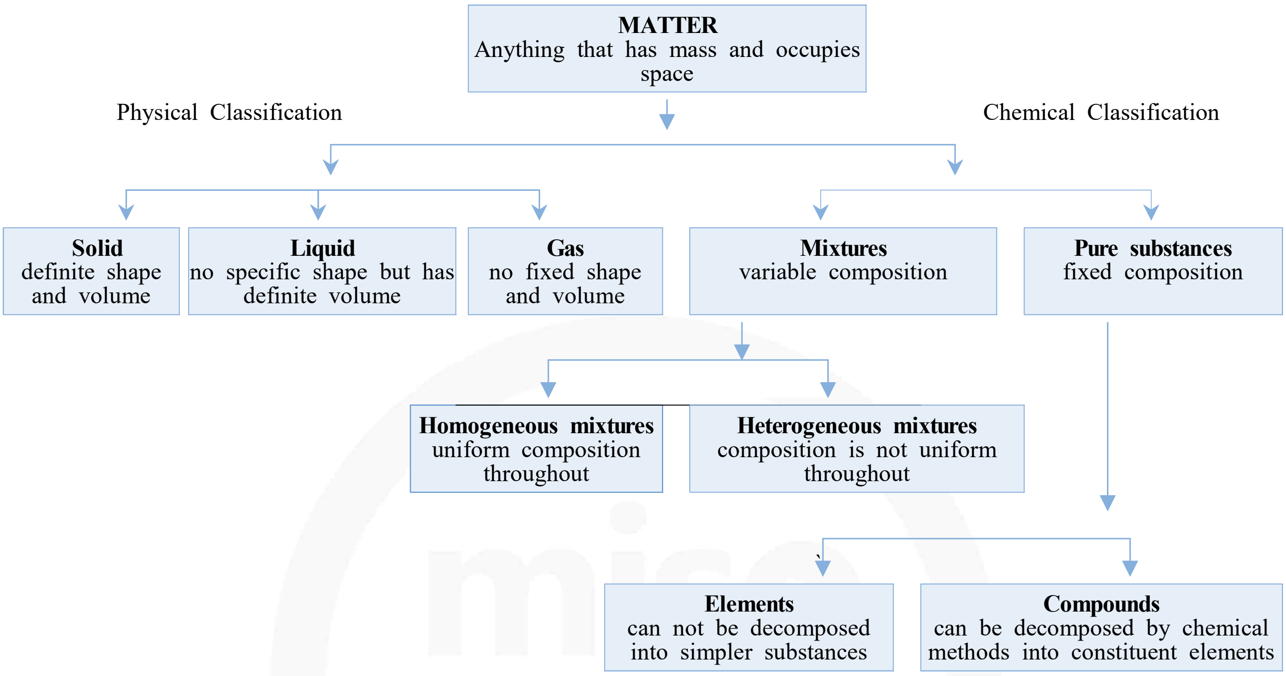


Class 11 | Chemistry

02 Mole Concept

01. Classification of matter

Chemistry deals with the composition, structure and properties of matter. These aspects can be best described and understood in terms of basic constituents of matter: **atoms** and **molecules.** That is why chemistry is called the science of atoms and molecules.



Matter

The thing which occupy space and have mass, which can be felt by our five sense is called as matter. Matter is further classified into two categories :

a. Physical classification
b. Chemical classification

02. Prefixed Used With Units

The S.I. system recommends the multiples such as 10^3, 10^6, 10^9 etc. and fraction such as 10^{-3}, 10^{-6}, 10^{-9} etc. i.e. the powers are the multiples of 3. These are indicated by special prefixes. These along with some other fractions or multiples in common use, along with their prefixes are given below in Table and illustrated for length (m).

※TABLE : SOME COMMONLY USED PREFIXES WITH THE BASE UNIT

Prefix	Symbol	Multiplication Factor	Example
deci	d	10^{-1}	1 decimetre (dm) = 10^{-1} m
centi	c	10^{-2}	1 centimetre (cm) = 10^{-2} m
milli	m	10^{-3}	1 millimetre (mm) = 10^{-3} m
micro	μ	10^{-6}	1 micrometre (μm) = 10^{-6} m
nano	n	10^{-9}	1 nanometre (nm) = 10^{-9} m
pico	p	10^{-12}	1 picometre (pm) = 10^{-12} m
femto	f	10^{-15}	1 femtometre (fm) = 10^{-15} m
atto	a	10^{-18}	1 attometre (am) = 10^{-18} m
deka	da	10^{1}	1 dekametre (dam) = 10^{1} m
hecto	h	10^{2}	1 hectometre (hm) = 10^{2} m
kilo	k	10^{3}	1 kilometre (km) = 10^{3} m
mega	M	10^{6}	1 megametre (Mm) = 10^{6} m
giga	G	10^{9}	1 gigametre (Gm) = 10^{9} m
tera	T	10^{12}	1 teremetre (Tm) = 10^{12} m
peta	P	10^{15}	1 petametre (Pm) = 10^{15} m
exa	E	10^{18}	1 exametre (Em) = 10^{18} m

As volume is very often expressed in litres, it is important to note that the equivalence in S.I. units for volume is as under: 1 litre (1 L) = 1 dm^3 = 1000 cm^3 and 1 millilitre (1 ml) = 1 cm^3 = 1 cc

Example Convert 2 atm into cm of Hg.

Solution 2 atm = 2 × 76 cm of Hg = 152 cm of Hg {1 atmosphere = 76 cm of Hg

03. Different types of masses

One mole

Avogadro's Number (N_A)=6.023×10^{23}. It is the number of atoms present in exactly 12 g of (C^{12}) isotope.

Atomic Weight (*A*)

Atomic weight is the relative weight of one atom of an element with respect to a standard weight.

$$A=\frac{\text{Weight of one atom of an element}}{\frac{1}{12}\text{th part by weight of an atom of }(\mathrm{C}^{12})\text{ isotope}}$$

amu (atomic mass unit)

$$1\text{ amu }=\frac{1}{12}\text{th part by weight of an atom of }(\mathrm{C}^{12})\text{ isotope}$$

$$=\frac{1}{N_A}g=1.66\times10^{-24}g$$

Atomic weight (*A*)×amu =Absolute atomic weight.

NOTE ☞ Atomic weight is a relative weight that indicates the relative heaviness oof one atom of an element with respect to amu weight. Atomic weight has no unit because it is the ratio of weights. One mole of an amu = 1.00 g.

Change of Scale for Atomic Weight

If an amu is defined differently as (1/x)th part by weight of an atom of (C^{12})isotope rather (1/12)th part then the atomic weight (A') can be derived as:

$$A' = A\left(\frac{x}{12}\right)$$

Where, A = conventional atomic weight

Molecular Weight (MW)

Like atomic weight, it is the relative weight of a molecule or a compound with respect to amu weight.

$$\text{Molecular Weight} = \frac{\text{Weight of one molecule of a compound}}{\frac{1}{12}\text{th part by weight of an atom of } C^{12} \text{ isotope}}$$

Gram Atomic, Gram Molecular Weight (M)

It is the weight of 1.0 mole (Avogadro's numbers) of atoms, molecules or ions in gram unit. M = A amu × Avogadro number = A gram Hence, gram molecular weight (M) is numerically equal to the atomic weight or (molecular weight) in gram unit because 1.0 mole of amu is 1.0 g.

Example A piece of Cu contain 6.022×10^{24} atoms. How many mole of Cu atoms does it contain?

Solution

$$\text{No. of mole} = \frac{6.022 \times 10^{24}}{N_A} = \frac{6.022 \times 10^{24}}{6.022 \times 10^{23}} = 10 \text{ mole}$$

04. Law of conservation of mass (Lavoisier-1774):

In any physical or chemical change, mass can neither be created nor be destroyed.

It means:

Total mass of the reactants = total mass of the products.
This relationship holds good when reactants are completely converted into products.
In case the reacting material are not completely consumed the relationship will be-
Total mass of the reactants = Total mass of the products + mass of unreacted reactants.

Example 1.7 gram of silver nitrate dissolved in 100 gram of water is taken. 0.585 gram of sodium chloride dissolved in 100 gram of water is added it and chemical reaction occurs. 1.435 gm of AgCl and 0.85 gm $NaNO_3$ are formed. Show that these results illustrate the law of conservation of mass.

Solution Total masses before chemical change
= mass of $AgNO_3$ + mass of NaCl + mass of water
= 1.70 + 0.585 + 200g
= 202.285 g
Total masses after the chemical reaction
= mass of AgCl + mass of $AgNO_3$ + mass of water
= 1.435 + 0.85 + 200
= 202.258 g
Then, in this chemical change
Total masses of reactants = Total masses of product

05. Law of constant composition : [proust 1799]

A chemical compound always contains the same element combined together in fixed proportion by mass.

Example 1.08 gram of Cu wire was allowed to react with nitric acid. The resulting solution was dried and ignited when 1.35 gram of copper oxide was obtained. In another experiment 1.15 gram of copper oxide was heated in presence of Hydrogen yielding 0.92 gram of copper. Show that the above data are in accordance with law of constant composition?

Solution % of “Cu” in copper oxide in 1^{st} case $= \frac{1.08}{1.35} \times 100$

$= 80\%$

% of oxygen = 20%

% of “Cu” in copper oxide in 2^{nd} case $= \frac{0.92}{1.15} \times 100$

$= 80\%$

% of oxygen = 20%

06. Law of multiple proportion : [Dalton 1806]

When two elements combine to form two or more compounds, the different masses of one element which combine with a fixed mass of the other element, bear a simple ratio to one another.

Example Two compounds each containing only tin and oxygen had the following composition.

	Mass % of Tin	**Mass % of oxygen**
Compound A	78.77	21.23
Compound B	88.12	11.88

Show that these data illustrate the law of multiple proportion?

Solution **In compound A**

21.23 parts of oxygen combine with 78.77 parts of tin.

1 part of oxygen combine with $\frac{78.77}{21.23} = 3.7$ parts of Sn.

In compound B

11.88 parts of oxygen combine with 88.12 parts of tin.

1 part of oxygen combine with $\frac{88.12}{11.88} = 7.4$ parts of tin.

Thus the mass of Tin in compound A and B which combine with a fixed mass of oxygen are in the ratio 3.7:7.4 or 1:2. This is a simple ratio. Hence the data illustrate the law of multiple proportion.

07. Law of reciprocal proportion : [Richter 1794]

When two different elements combine with the same mass of a third element, the ratio on which the do so will be same or simple multiple if both directly combined with each other.

Example The % composition of NH_3, H_2O and N_2O_3 is as given below:

$NH_3 \rightarrow$ 82.35% N and 17.65 H.

$H_2O \rightarrow$ 88.9% O and 11.1 H

$N_2O_3 \rightarrow$ 63.15% O and 36.85% N

On the basis of above data prove the law of reciprocal proportion?

Solution 63.15 parts of oxygen combine with 36.85 parts of "N"

Therefore, 88.9 part of oxygen combine with $\left(\frac{36.85}{63.15} \times 88.9\right) = 51.87$ part of "Nitrogen"

Therefore ratio is $\frac{11.1}{11.1} : \frac{51.87}{11.1} = 1 : 4.67$

Now compare with the ratio of Nitrogen and Hydrogen in NH_3

$$\frac{17.65}{17.65} : \frac{82.35}{17.65} = 1 : 4.67$$

Hence the Law of reciprocal proportion is verified

08. Gay- Lussac's law of gaseous volumes [Gay-Lussac-1808]

When gases combined or produced in a chemical reaction, they do so in a simple ratio by volume provided all the gases are at same temperature and pressure.

09. Limiting Reagent

It is the reagent that is consumed completely during a chemical reaction. If the supplied mass ratio of reactants are not stoichiometric ratio, one of the reagent is consumed completely leaving parts of others unreacted. One that is consumed completely is known as limiting reagent.

'Limiting reagent determine the amount of product in a given chemical reaction'

Example If 20 gm of $CaCO_3$ is treated with 20 gm of HCl, how many grams of CO_2 can be generated according to following reaction?

$CaCo_3(g) + 2HCl(aq) \rightarrow CaCl_2(aq)+H_2O(\ell)+CO_2(g)$

Solution $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

1 mole $CaCO_3 \rightarrow$ 2 mole HCl

$\therefore$ 100 g $CaCO_3$ combine $\rightarrow 2 \times 36.5$ g HCl

$\therefore$ 20 g $\rightarrow \frac{2\times36.5\times20}{100} = 14.6\,\mathrm{HCl}$

$CaCO_3$ completely consumes in the reaction and HCl is in excess.
Therefore,
$CaCO_3 \rightarrow$ Limiting reagent
HCl $\rightarrow$ Excess reagent
Now
100 g $CaCO_3$ given 1 mole CO_2 (44g CO_2)
20 g $CaCO_3$ will give $\frac{20\times40}{100}$ = 8 g CO_2

10. Percentage yield

In general, when a reaction is carried out on the laboratory we do not obtain the theoretical amount of product. The amount of product that is actually obtained is called the actual yield. Knowing the actual yield and theoretical yield, the % yield can be calculated by the following formula-

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoritical yield}}\times100\%$$

Example For the reaction
$CaO+2HCl \rightarrow CaCl_2+H_2O$
1.12 gram of CaO is reacted with excess of hydrochloric acid and 1.85 gm $CaCl_2$ is formed. What is the % yield of the reaction?

Solution 1 mole CaO gives 1 mole $CaCl_2$
56 g CaO gives 111 g $CaCl_2$
1.12 g CaO will give $\frac{111\times1.12}{56}$ g $CaCl_2$ = 2.22 g $CaCl_2$

Now

$$\%\ \text{yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}}\times100$$

Actual yield = 1.85 gm
Theoretical yield = 2.22 gm

$$\%\ \text{yield} = \frac{1.85}{2.22}\times100 = 83.33\%$$

11. Percentage Purity

Depending upon the mass of the product, the equivalent amount of reactant present can be determined with the help of given chemical equation. Knowing the actual amount of the reactant taken and the amount calculated with the help of a chemical equation, the purity van be determined, as

$$\text{Percentage purity} = \left[\frac{\text{Amount of reactant calculated from the chemical equation}}{\text{Actual amount of reactant taken}}\right]\times100\%$$

Example Calculate the amount of (CaO) in kg that can be produced by heating 200 kg lime stone that is 90% pure $CaCO_3$.

Solution $CaCO_3 \rightarrow CaO + CO_2$

1 mole $CaCO_3$ gives 1 mole CaO

100 g $CaCO_3$ gives 56 g CaO

$$\left(\frac{200\times 90\times 1000}{100}\right)\text{g } CaCO_3 \text{ gives } = \frac{180000\times 56}{100}\text{g } CaO$$

$$= \frac{1800\times 56}{100}\text{g } CaO$$

$$= \frac{1008}{10}\text{g } CaO$$

$$= 100.8 \text{ g } CaO$$

12. Types of Average masses

Average Atomic Mass

Average atomic mass =

Let a sample contains n_1 mole of atomic mass M_1 and n_2 mole of atoms with atomic mass M_2 then

$$M_{av} = \frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}$$

Average Molecular Mass

Average molecular mass =

Let a sample contains n_1 mole of molecules with molecular mass M_1 and n_2 mole of molecules with molecular mass M_2 ,then

$$\mathrm{M} = \frac{\mathrm{n_1 M_1 + n_2 M_2}}{\mathrm{n_1 + n_2}}$$

Example Find the average atomic mass of a mixture containing 25% by mole Cl^{37} and 75% by mole Cl^{35}?

Solution $n_1 = 25$ $n_2 = 75$ $M_1 = 37$ $M_2 = 35$

$$\mathrm{M_{av}} = \frac{25\times 37 + 75\times 35}{25+75} = 35.5$$

13. Empirical & molecular formula

The empirical formula of a compound is a chemical formula showing the relative number of atoms in the simplest ratio. An empirical formula represents the simplest. whole number ratio of various atoms present in a compound.
The molecular formula gives the actual number of atoms of each element in a molecule. The molecular formula shows the exact number of different types of atoms present in a molecule of a compound. The molecular formula is an integral multiple of the empirical formula.

i.e. molecular formula=empirical formula × n where $n = \dfrac{\text{molecular formula mass}}{\text{empirical formula mass}}$

Example An organic substance containing carbon, hydrogen and oxygen gave the following percentage composition.
C=40,684% ; H=5,085% ; and O=54,228%
The molecular weight of the compound is 118 g. Calculate the molecular formula of the compound.

Solution **Step-1 :** To calculate the empirical formula of the compound.

Element	**Symbol**	**percentage of element**	**At. mass of element**	**Relative no. of atoms=** $\dfrac{\text{Percentage}}{\text{At. mass}}$	**Simplest atomic ratio**	**Simplest whole no. atomic ratio**
Carbon	C	40.678	12	$\dfrac{40.678}{12} = 3.390$	$\dfrac{3.390}{3.389} = 1$	2
Hydrogen	H	5.085	1	$\dfrac{5.085}{1} = 5.085$	$\dfrac{5.085}{3.389} = 1.5$	3
Oxygen	O	54.228	16	$\dfrac{54.228}{16} = 3.389$	$\dfrac{3.389}{3.389} = 1$	2

∴ Empirical Formula is $C_2\ H_3\ O_2$

Step-2 : To calculate the empirical formula mass. The empirical formula of the compound is $C_2\ H_3\ O_2$.
Empirical formula mass = $(2 \times 12) + (3 \times 1) + (2 \times 16) = 59$.

Step-3 : To calculate the value of 'n' $n = \dfrac{\text{Molecular mass}}{\text{Empirical formula mass}} = \dfrac{118}{59} = 2$

Step-4 : To calculate the molecular formula of the salt.
Molecular formula $= n = (\text{Empirical formula}) = 2 \times C_2H_3O_2 = C_4H_6O_4$
Thus the molecular formula is $C_4H_6O_4$

14. Vapour Density

Some times in numericals molecular mass of volatile substance is not given, instead vapour density is given. Vapour density van be defined as

$$\text{V.D.} = \frac{\text{Density of gas at a given T and P}}{\text{Density of } H_2 \text{ at same T and P}}$$

or, $$\text{V.D.} = \frac{M_{gas}}{2}$$

$$M_{gas} = 2 \times \text{V.D.}$$

15. Eudiometry – Gas Analysis

The study of gaseous reactions is done in a eudiometer tube with the help of Gay-Lussac's law and Avogadro's law. Eudiometer tube is a closed graduated tube open at one end. The other end is a closed one which is provided with platinum terminals for passing electricity for electric spark, through the known volume of mixture of gases and known volume of oxygen gas. Volume of CO_2 formed is determined by absorbing in KOH solution, O_2 is determined by dissolving unreacted O_2 in alkaline pyrogallol and water vapours formed are determined by nothing contraction in volume caused due to cooling.

16. Avogadro's Law

In 1812, Amadeo Avogadro stated that samples of different gases which contain the same number of molecules (any complexity, size, shape) occupy the same volume at the same temperature and pressure.
For ideal gas at constant Temperature & Pressure, pressure is directely proportional to no. of moles

17. Some Absorbents of Gases

The absorbent which is used for specific gas is listed below

Absorbent	**Gas or gases absorbed**
Turpentine oil	O_3
Alkaline pyrogallol	O_2
Ferrous sulphate solution	NO
Heated magnesium	N_2
Heated palladium	H_2
Ammonical coprous chloride	O_2, CO, C_2 H_2 or $CH \equiv CH$
Copper sulphate solution	H_2S, PH_3, AsH_3
Conc. H_2SO_4	H_2O I.e., moisture, NH_3.
NaOH or KOH solution	CO_2, NO_2, SO_2, X_2, all acidic oxides

18. Volume Expansion and Contraction In The Eudiometer Tube

$aA(g) + bB(g) \qquad cC(g) + dD(g)$

$\triangle n_g$ = No. of gaseous products–No. of gaseous reactants = (c+d)–(a+b)

(a) If $\triangle n_g > 0$, then expansion will occur
(b) If $\triangle n_g = 0$, No contraction/expansion (volume remains constant)
(c) If $\triangle n_g < 0$, then contraction will occur

19. Assumptions

(i) All gases are assumed to be ideal.
(ii) Nitrogen gas formed during reaction will not react with any other gas.
(iii) The volume of solids and liquids are negligible in comparision to the volume of gas.

20. General Reactions for Combustion of Organic Compounds

(i) When an organic compound is hydrocarbon :

$$C_xH_Y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(ii) When an organic compound contain carbon, hydrogen and oxygen :

$$C_xH_yO_z + \left(x + \frac{y}{4} - \frac{z}{2}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(iii) When an organic compound contain carbon, hydrogen and nitrogen :

$$C_xH_yN_z + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O + \frac{z}{2}N_2$$

Example 10 ml of a mixture of CO, CH_4 and N_2, exploded with excess of oxygen, gave a contraction of 6.5 ml. There was a further contraction of 7 ml. when the residual gas was treated with KOH. What is the composition of the original mixture?

Solution $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

x ml $\quad \frac{x}{2}$ml $\qquad x$ ml

y ml $\quad$ 2y ml $\qquad y$ ml

volume of oxygen used = $2y + \frac{x}{2}$ml

Total volume of all gases before combustion = $10 + 2y + x/2$

21. Percentage

Concentration of solution is the amount of solute dissolved in a known amount of the solvent or solution. The concentration of solution can be expressed in various ways as discussed below.

It refers to the amount of the solute per 100 parts if the solution. It can also be called as parts per hundred (pph). It can be expressed by any of following four methods:

(i) **Weight by weight percentage (%w/w)** $= \dfrac{\text{Wt. of solute (g)}}{\text{Wt. of solution (g)}} \times 100$

e.g., 10%Na_2CO_3 solution w/w means 10 g of Na_2CO_3 is dissolved in 100 g of the solution. (It means 10 g Na_2CO_3 is dissolved in 90 of solvent)

(ii) **Weight by volume percent (%w/v)** $= \dfrac{\text{Wt. of solute (g)}}{\text{Wt. of solution (cm}^3)} \times 100$

e.g., 10%Na_2CO_3 (w/v) means 10 g Na_2CO_3 is dissolved in 100 cm^3 of solution

(iii) **Volume by volume percent (%v/v)** $= \dfrac{\text{Volume of solute (cm}^3)}{\text{Volume of solution (cm}^{3)}} \times 100$

e.g.,10% ethanol (v/v) means 10 cm^3 of ethanol dissolved in 100 cm^3 of solution.

(iv) **Volume by volume percent (%v/v)** $= \dfrac{\text{Vol. of solute}}{\text{Wt. of solution}} \times 100$

e.g.,10% ethanol (v/w) means 10 cm^3 of ethanol dissolved in 100 g of solution.

Example Concentrated nitric acid used as laboratory reagent is usually 69% by mass of nitric acid. Calculate the volume of the solution which contains 23 g nitric acid. The density of concentrated acid is 1.41 g cm^{-3}.

Solution 69 g of HNO_3 in 100 g solution

given density = 1.41 g/cc

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

$$\text{volume} = \frac{\text{mass}}{\text{volume}} = \frac{10000}{1.41}\text{ cc}$$

Now,

$$69 \text{ g } HNO_3 \text{ is in } \frac{10000}{141} \text{ volume solution}$$

$$23 \text{ g } HNO_3 \rightarrow \frac{23}{69} \times \frac{10000}{141} \text{ volume solution} = \mathbf{23.64\ cm^3}$$

22. Molarity (M)

The number of moles of solute dissolved in one litre solution is called its molarity.

$$\text{Molarity} = \frac{\text{Number of moles of solute}}{\text{volume of solution in litres}} = \frac{n}{V}$$

$$\text{weight of solute in gram} = \frac{\text{Molarity} \times \text{Volume of solution in mL} \times \text{molecular weight}}{1000}$$

$$\text{Molarity} = \frac{\text{Numbers of moles of solute} \times 1000}{\text{Volume of solution in mL}}$$

$$= \frac{\text{weight of solute in grams} \times 1000}{\text{Molecular weight} \times \text{Volume of solution in mL}}$$

$$= \frac{\text{strength of solution in gram/litre}}{\text{Molecular weight of solute}} = \text{Normality} \times \frac{\text{Equivalent weight of solute}}{\text{Molecular weight of solute}}.$$

Example A bottle of commercial sulphuric acid (density 1.787 g ml^{-1}) is labelled as 86% by weight. What is the molarity of acid?

Solution 86 g H_2SO_4 is in 100 g solution

Now

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

$$1.78 = \frac{100}{V}$$

$$V = \frac{10000}{1.78} = 56.18 \text{ ml.}$$

Again

$$\text{molarity(M)} = \frac{\text{no. of moles of } H_2SO_4 \times 1000}{\text{Volume of sol. in ml.}}$$

$$= \frac{\left(\frac{86}{98}\right) \times 1000}{56.18} = \mathbf{15.62\ M}$$

23. Molarity (m)

The number of moles or gram molecules of solute dissolved in 1000 gram of the solvent is called molality of the solution.

$$\text{Molality of a solution} = \frac{\text{Number of moles of solute}}{\text{Amount of solvent in kg}} = \frac{\text{Number of moles of solute} \times 1000}{\text{Amount of solved in gram}}$$

It is independent of temperature.

24. Parts per million (ppm) and parts per billion (ppb)

When a solute is present in very small quantity, it is convenient to express the concentration in parts per million and parts per billion. It is the number of parts of solute per million (10^6) or per billion (10^9) parts of solution. It is independent of the temperature.

$$\text{ppm} = \frac{\text{Mass of solute component}}{}$$

$$\text{ppb} = \frac{\text{Mass of solute component}}{}$$

Example Calculate the parts per million of SO_2 gas in 250 ml water (density 1g cm^{-3}) containing 5×10^{-4} g of SO_2 gas.

Solution Mass of SO_2 gas = 5×10^{-4} g; Mass of H_2O = Volume×Density
= 250 cm^3×1g cm^3 = 250 g

$$\therefore \text{Parts per million of } SO_2 \text{ gas} = \frac{5\times10^{-4}}{250g} \times 10^6 = \mathbf{2}$$

25. Formality (F)

Formality of solution may be defined as the number of gram formula units of the ionic solute dissolved per litre of the solution. It is represented by **F.** Commonly, the term formality is used to express the concentration of the ionic solids which do not exist as molecules but exist as network of ions. A solution containing one gram formula mass of solute per liter of the solution has formality equal to one and os called **Formal solution.** It may be mentioned here that the formality of a solution changes with change in temperature.

$$\text{Formality(F)} = \frac{\text{Number of gram formula units of solute}}{\text{Volume of solution in litres}}$$

$$= \frac{\text{Mass of ionic solute (g)}}{\text{gram formula unit mass of solute} \times \text{Volume of solution (l)}}$$

Example What will be the formality of KNO_3 solution having strength equal to 2.02 g per litre?

Solution Strength of KNO_3 =2.02 gL^{-1} and g formula weight of KNO_3 =101 g

$$\therefore \text{Formality of } KNO_3 = \frac{\text{strength in } gl^{-1}}{\text{g. formula wt. of } KNO_3} = \frac{2.02}{101} = \mathbf{0.02F}$$

26. Mole fraction (x)

The ratio of moles of one component to the total number of moles of all the components present in the solution, is called the mole fraction of that component.

Mole fraction of solute X_A is given by $X_A = \frac{n_A}{n_A + n_B}$

Mole fraction of solute X_B is given by $X_B = \frac{n_B}{n_A + n_B}$

where n_A is moles of solute A and n_B is moles of solvent B.

27. Mass Fraction

Mass fraction of a component in a solution is the mass of the component divided by the total mass of the solution. For a solution containing w_A gm of A and w_B gm of B.

Mass fraction of A= $\frac{W_A}{W_A+W_B}$ Mass fraction of B= $\frac{W_B}{W_A+W_B}$

NOTE ☞ It may be notes that molarity, mole fraction, mass fraction etc. are preferred to molarity, normality, formality etc. Because the former involve the weights of the solute and solvent where as later involve volumes of solutions. Temperature has no effect on weights but it has significant effect on volumes.

28. Equivalent Weight

Equivalent weight of an element is that part by weight which combines with 1.0 g of hydrogen or 8.0 g of oxygen or 35.5 g of chlorine.

(i) Equivalent weight of a salt (EW) $= \dfrac{\text{Molar mass}}{\text{Net positive (or nagative) valency}}$

e.g. Equivalent weight $\quad CaCl_2 = \dfrac{M}{2}$, $Alcl_3 = \dfrac{M}{3}$, $Al_2(So_4)_3 = \dfrac{M}{6}$

(ii) Equivalent weight of acids $= \dfrac{\text{Moller mass}}{\text{Basicity}}$

e.g. Equivalent weight $\quad HCl = M(\text{basicity} = 1);\ H_2SO_4 = \dfrac{M}{2}(\text{basicity} = 2)$

$H_3PO_4 = \dfrac{M}{3}(\text{basicity} = 3)$

(iii) Equivalent weight of bases $= \dfrac{\text{Moller mass}}{\text{Acidity}}$

e.g. Equivalent weight $\quad NaOH = M,\ Ca(OH)_2 = \dfrac{M}{2},\ Al(OH)_3 = \dfrac{M}{3}$

The number of gram-equivalents (Eq)

$$\text{Equivalent} = \frac{\text{Weight of compound}}{\equiv \text{valent weight}} = \frac{w}{\text{Equivalent weight}}$$

Mole Equivalent Relationship In a given weight (w) of sample, number of moles (n) and number of equivalents (eq) are related as

$$n = \frac{w}{m} \text{ and } Eq = \frac{w}{\text{Equivalent weight}}$$

$$\boxed{\frac{Eq}{n} = \frac{M}{\text{Equivalent weight}} = n - \text{factor}}$$

n-factor For salt, it is valency, for acid it is basicity, for base it is acidity.

Normally/Molarity Relationship

$$N = \frac{Eq}{V} \text{ and } M = \frac{n}{V} \Rightarrow \frac{N}{M} = \frac{Eq}{n} = \frac{MW}{EW} = n - \text{factor}$$

29. Relation Between Molarity And Normality

$S = \text{Molarity} \times \text{molecular weight of solute}$ and $S = \text{Normality} \times \text{equivalent weight of solute.}$

So we can write

$\text{Molarity} \times \text{molecular weight of solute} = \text{Normality} \times \text{equivalent weight of solute.}$

$$\text{Normality} = \frac{\text{molarity} \times \text{molecular weight of solute}}{\text{equivalent weight of solute}} = \frac{\text{molarity} \times \text{molecular weight of solute}}{(\text{moleculer weight of solute}/\text{valency factor}}$$

$\text{Normality} = \text{molarity} \times \text{valency factor}$

$N = M \times n \quad ; \quad N > M$

Example Calculate the molarity and molality of a solution of H_2SO_4 (sp. gr.=1.98) containing 27% H_2SO_4 by mass.
3.3 M, 3.77 M

Solution

$$\text{Vol of 100 g of 27\% } H_2SO_4 = \frac{\text{wt.}}{\text{d}} = \frac{100}{1.098} \text{ ml}$$

$$M_{H_2SO_4} = \frac{\text{wt./mol.wt.}}{\text{vol, of solution (litre)}} = \frac{27 \times 1.198 \times 1000}{98 \times 100} = \mathbf{3.3 mol\ L^{-1}}$$

$$M_{H_2SO_4} = \frac{\text{wt./mol.wt.}}{\text{vol, of solvent (kg)}} = \frac{27 \times 1000}{(100-27) \times 98} = \mathbf{3.77 mol\ Kg^{-1}}$$

30. Dilution Formula

If a concentrated solution is diluted, following formula work

$M_1 V_1 = M_2 V_2$

(M_1 and V_1 are the molarity and volumes before dilution and M_2 and V_2 are molarity and volumes after dilution)

31. Mixing of two or more solutions of different molarities

If two or more solutions of molarities $(M_1, M_2, M_3, \ldots)$ are mixed together, molarity of the

resulting $$M = \frac{M_1 V_1 + M_2 V_2 + M_3 V_3 \ldots}{V_1 + V_2 + V_3 \ldots}$$

solution can be worked out as :

32. Strength of H_2O_2 solution

The strength of H_2O_2 is aqueous solution is expressed in the following two ways:

(i) Percentage strength

The mass of H_2O_2 present in 100 ml of the aqueous solution is termed as percentage strength. For example, a 25% solution (w/v) of H_2O_2 means that 25 grams of H_2O_2 are present in 100 ml of the solution.

(ii) Volume strength

Strength of the sample of H_2O_2 is generally expressed in terms of the volume of oxygen at 0°C and 1 atm that one volume of the sample of hydrogen peroxide gives on heating. The commercial samples are marked as '10 volume'. '15 volume' or '20 volume'. 10 volume means that one volume of the sample of hydrogen peroxide gives 10 volumes of oxygen at 0°C and 1 atm. 1 ml of a 10 volume solution of H_2O_2 will liberate 10 ml of oxygen at 0°C and 1 atm.

33. Percentage labelling of oleum

Oleum is fuming sulphuric acid which contains extra SO_3 dissolved in H_2SO_4 . To convert this extra SO_3 into H_2SO_4, water has to be added ($SO_3+H_2O \rightarrow H_2SO_4$). The amount of sulphuric acid obtained when just sufficient water is added into 100 g of oleum so that all SO_3 present in it is converted into H_2SO_4 is called percentage labelling of oleum.

34. Relationship Between Different Concentration Terms

(i) $N = M \times n \text{ factor}$

(ii) $M = \dfrac{md}{1 + mM_2/1000}$

(iii) $m = \dfrac{1000 \times x_2}{x_1 M_1}$

(iv) $M = \dfrac{1000 \times dx_2}{x_1 M_1 + x_1 M_1}$

(v) $d = M\left(\dfrac{1}{m} + \dfrac{M_2}{1000}\right)$

(vi) $\text{Volume strength of } H_2O_2 = 5.6 \times N = \dfrac{5.6 \times \text{Percentagestrength}}{\text{Eq. wt. of } H_2O_2\,(17)} \times 10$

(vii) $\text{Volume strength of } H_2O_2 = 11.2 \times M = \dfrac{11.2 \times \text{Percentagestrength} \times 10}{\text{Mol. wt. of } H_2O_2\,(34)}$

(viii) In oleum labelled as $(100 + x)\%$

$\%\text{ of free } SO_3 = \left(\dfrac{80 \times x}{18}\right)\text{(w/w)}$

where N=Normality

M = Molarity

d = density of solution

x_2 = Mole fraction of solute

M_1= Molecular mass of solvent

m = molarity

M_2= Molecular mass of solute

x_1 = Mole fraction of solvent

d = Density of solution

NEET Pattern
Exercise (1)

1. Which has maximum molecules?
   (a) 7 g N_2O
   (b) 20 g H_2
   (c) 16 g NO_2
   (d) 16 g SO_2

2. Haemoglobin contains 0.334% of iron by weight. The molecular weight of haemoglobin is approximately 67200. The number of iron atoms (Atomic weight of Fe is 56) present in one molecule of haemoglobin is
   (a) 4
   (b) 6
   (c) 3
   (d) 2

3. If the weight of metal chloride is x gram containing y gram of metal, the equivalent weight of metal will be
   (a) $E=\frac{x}{y}\times 35.5$
   (b) $E=\frac{8(y-x)}{x}$
   (c) $E=\frac{y}{(x-y)}\times 35.5$
   (d) $E=\frac{8(x-y)}{y}$

4. An organic compound containing C and H gave the following analysis C = 40%, H = 6.7%. Its empirical formula would be
   (a) CH_4
   (b) CH_2O
   (c) $C_2H_4O_2$
   (d) C_2H_4

5. 2.5 litre of 1 M NaOH solution mixed with another 3 litre of 0.5 M NaOH solution. Then find out molarity of resultant solution.
   (a) 0.80 M
   (b) 1.0 M
   (c) 0.73 M
   (d) 0.50 M

6. The total number of electrons in 2.0 g of D_2O to that in 1.8 g of H_2O
   (a) Double
   (b) Same
   (c) Triple
   (d) One fourth

7. If the weight of metal oxide is x g containing of y g of oxygen, the equivalent weight of metal will be
   (a) $E = \frac{8x}{y}$
   (b) $E = \frac{8(y-x)}{x}$
   (c) $E = \frac{y}{8}$
   (d) $E = \frac{8(x-y)}{y}$

8. The number of significant figures in 2.653×10^4 is
   (a) 8
   (b) 4
   (c) 7
   (d) 1

9. Mole fraction of solute in aqueous solution of 30% NaOH.
   (a) 0.16
   (b) 0.05
   (c) 0.25
   (d) 0.95

Assertion-Reason Type Questions

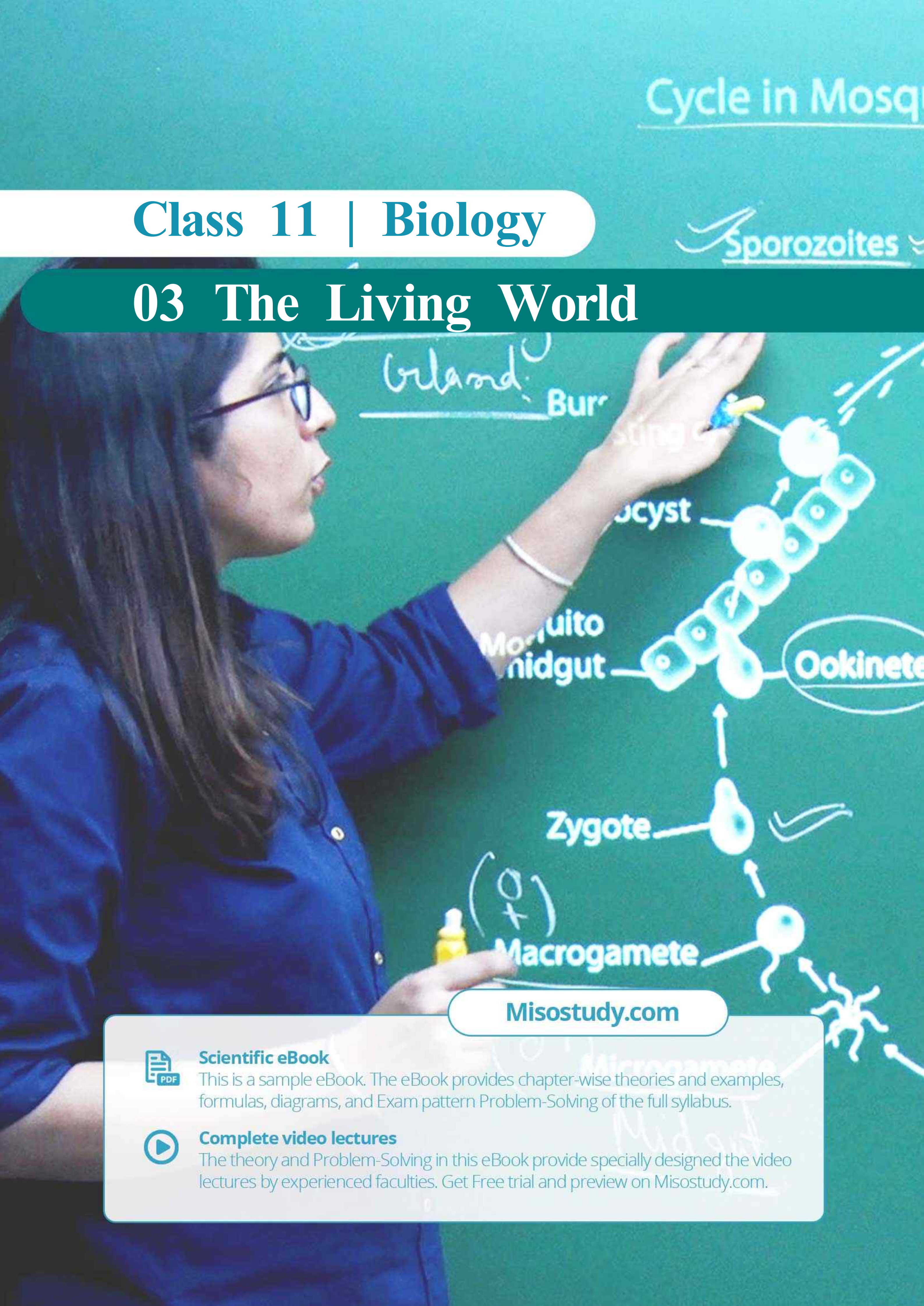
10. In the following questions, a statements of assertion (A) is followed by a statement of reason (R)
   (i) If both Assertion & Reason are true and the reason is the correct explanation of the assertion, then mark (a).
   (ii) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion, then mark (b).
   (iii) If Assertion is true statement but Reason is false, then mark (c).
   (iv) If both Assertion and Reason are false statement, then mark (d).

   A: In the reaction

   $$2NaOH + H_3PO_4 \longrightarrow Na_2HPO_4 + 2H_2O,$$

   equivalent weight of H_3PO_4 is $\frac{M}{2}$, where M is its molecular weight.

   R : Equivalent weight $= \frac{\text{Molecular weight}}{n-\text{factor}}$



Class 11 | Biology

03 The Living World

01. Introduction

- Biology; Bios = life, Logos = Study, means study of life is biology.
- **"Biology** is the science of life forms and living processes"
- **Systematic** and **monumental** description of life forms made human to make a detailed system of identification, nomenclature and classification of organisms i.e. **Taxonomy.**
- Hence the study of identification, nomenclature and identification is called taxonomy.
- All the organisms have been evolved by a very long and complex process of **evolution**, so they all are related to each other by sharing of some **common genetic material** but up to varying degrees. This sharing may be less or more among different cases..
- When human came to know this fact then he humbled and led to cultural movements for conservation of **biodiversity.**
- Sharing of common characters was also proved when human studied the similarities among living organisms both **horizontally** and **vertically.**
- The living world is full of amazing diversity of living organisms.
- The diversity of habitats of organisms is also very vast and amazing.
- This diversity makes us deeply reflect on "What indeed is life" ? This question actually asks to solve two problems.
  - **(i)** First is a technical → What living is as opposed to the non living means **Living v/s Non living.**
  - **(ii)** Second is a philosophical one → what the **purpose of life** is?
    As scientists we will try to solve the first question, because the second question is more related to philosophy rather science.

02. Characters of Living Organism

Following are the main characters of "living"-

GROWTH
REPRODUCTION } Not the defining properties/characters/features

METABOLISM
CELLULAR ORGANISATION
CONSCIOUSNESS } Defining properties/characters/features

The character which has no exception is called as **defining property** of life.

Growth

- Increase in mass or overall size of a tissue or organism or its parts is called growth.
- Increase in mass and increase in number of individuals are twin characters of growth.
- Growth is an irreversible permanent increase in size of an organ or its parts or even of an individual cell.
- Growth is of two types :
  - **(a) Intrinsic growth :-** This growth is from inside of the body of living organisms.
  - **(b) Extrinsic growth :-** This growth is from outside i.e. accumulation of material on any body surface Non living exhibits this type of growth.

- Growth is of two types :
  - **(a)** **Indeterminate growth = Unlimited growth** → Growth which occurs continuously throughout their life span is indeterminate growth or unlimited growth. It occurs in plants and not in animals.
  - **(b)** **Determinate growth = Limited growth** → Growth which occurs only up to a certain age is determinate growth or Limited growth. It occurs in animals. However, cell division occurs in certain tissues to replace lost cells.
- In majority of higher plants and animals, growth and reproduction are mutually **exclusive events.**
- Because both living and nonliving exhibit growth so it can not be taken as defining property.
- Growth from inside (intrinsic growth) can be taken as **defining property.**

Reproduction

Reproduction is one of the fundamental characteristics of living organisms. It can be defined as the production of new individuals of same kind by the grown up individuals. It is characteristic exhibited by living organisms which can produce new young ones of their own kind. There are two modes of reproduction — **asexual** and **sexual.**

- In lower organisms like yeasts and Hydra, budding takes place in which new individuals are produced by the formation of an outgrowth known as 'bud'.
- Fragmentation is another mode of asexual reproduction, as in this, body of an organism (parent body) breaks up into two or more parts (known as fragments) each of which grows into a new individual. It is also quite common in filamentous algae, fungus, bryophytes (at protonema stage which occurs during life cycle in mosses).
- Planaria (flat worms) exhibit an extraordinary ability to regenerate its lost body parts completely (which is known as true regeneration).
- This is a method of reproduction as new planarians develop by splitting of parent planarian body either lengthwise or transversely. In higher organisms like plants, animals sexual mode of reproduction is quite common which involves formation of gametes (i.e., sex cells) from two parents of opposite sexes but same species. These gametes then fuse to form zygote (2n) which develops to form a new organism of same kind.
- Hence, reproduction is shown by all living organisms except a few which are either sterile or infertile, like mule, worker-bees, infertile human couples, etc. do not reproduce at all.
- Hence, reproduction can be regarded as characteristic of living organisms but it is not their exclusive defining characteristic.

Metabolism :

- The sum total all the chemical reactions occuring in our body is metabolism.
- All living organisms, both unicellular and multicellular exhibit metabolism.
- No non-living object shows metabolism.
- In this way metabolism is a defining character of living organisms because it has no exceptions.
- Now we have known most of the chemical or metabolic reactions occuring in our body so we can demonstrate many of them in a cell free medium or in a test tube in lab.

- The isolated metabolic reaction outside the body of an organism, performed in a test tube (in-vitro) is neither living nor nonliving.
- These isolated reaction can be regarded as living things, but they are definitely living reactions because they are similar to the reactions performing in our body.
- Here we should not forget the fact that metabolism is the total sum of all the chemical reactions performing in our body, it is not the sum of few or more living reactions.
- All organisms are made of small or big chemicals perform thousands of reactions and form some other chemicals also in the bodies of living organisms.
- All plants, animals, fungi and microbes exhibit metabolism.

Consciousness

- Most obvious and technically complicated feature of all living organism. All living organisms are able to detect changes, i.e., sense their surroundings and can also respond to them. This is known as sensitivity which is defined as the ability to detect changes in the environment and to give response towards it accordingly. Any change that can be detected by an organism is called stimulus. This can be physical (like intensity, duration, direction of light, sound, change in temperature, duration of day length, i.e., photoperiod, etc.), chemical (like acids, pollutants, etc.) or biological (like other organisms).
- Besides, human being is the only organism, who is aware of himself. He has self-consciousness too with awareness of the surroundings. He relate his mind to the changes taking place in the world. He is an intelligent animal with thoughts, feelings and self-hood. sensitivity or awareness is regarded as defining property of living organisms as non-living things do not have power of sensing their surroundings and give response according to it. However, patients lying in coma in hospitals virtually supported by machines which replace heart and lungs are neither living nor dead otherwise brain-dead.

03. Diversity In The Living World

- We consider vast areas like forest, desert, plateau etc. we find that number and kinds of living organisms increase many folds. These different kinds of plants, animals and other organisms are referred to as **'Biodiversity'** of this earth.
- **Biodiversity** is the number and various kinds of organisms found on earth. It stands for the variability found among living organisms inhabiting this world.
- **Biodiversity (Greek word bios = life; diversity = forms) or biological diversity** can be defined as the vast array of species of microorganisms, algae, fungi, plants, animals occuring on the earth either in the terrestrial or aquatic habitats and the ecological complexes of which they are a part.
- According to IUCN (International Union of Conservation of Nature and Natural resources), currently known and described species of all organisms are between **1.7-1.8 million**. These millions of plants, animals and other organisms in the world cannot be recognised, studied or described by an individual on its own.

- There is need to standardize the names of all living organisms after proper identification, in order to study such diverse life forms. Therefore, for better understanding of biodiversity scientists have established a definite system of principles, procedures and terms which identifies, categories and assigns specific name to each and every organism known to us. Such systems are acceptable to all biologists all over the world.
- The scientific need for simple, stable and internationally accepted systems for naming the living organisms of the world has generated, a process called **"Nomenclature"**. And, before assigning a specific name to an organism, one should determine or know its kind or features correctly, so that one can identify it in each every part of the world. This is known as **"Identification"**

04. Taxonomy

- This word was proposed by **A.P. De Candolle** in his book **"Theories elementaire de la botanique"** (Theory of elementary botany)
- **Taxonomy includes study of following 4 points**

Characterization - Identification of character
Identification - Identification of living organisms
Nomenclature - Nomenclature of living organisms
Classification - Classification of living organisms in groups

05. Systematics

(i) The term **"Systematics"** was pro posed by **Linnaeus**. The word systematics is derived from the latin word "systema" which means systematic arrangement of organisms.
(ii) **According to G. Simpson** : Systematics is the study of diversity of organisms and all their comparative and evolutionary relationship.

NOTE ☞ It includes description of external morphological characters of plants of living organisms.
eg. Morphological characters of Root, Stem, Leaves, Flowers.

06. New Systematics or Neosystematics or Biosystematics

- **Neo-systematics** – A new branch – Name given by **Julian Huxley (1940)**
- It includes description of all the characters **(external + internal)**
  e.g. Anatomical characters, Histological characters, Embryological characters, Identical characters

- It is used to know the **inter-relationship** between living organisms.

NOTE ☞ New systematics is mainly based on **evolutionary** as well as **genetic relationship** as compared to morphological characters.

07. Types of Taxonomy

- **Alpha taxonomy or classical taxonomy :** It is based on **external morphology** of plants.
- **Bete taxonomy or Explorative taxonomy :** Besides external **morphology** it also includes **internal** characters like embryological, cryological, anatomical characters etc.
- **Omega taxonomy or Encyclopaedic taxonomy :** Omega taxonomy have widest scope. It is based on **all the information** or data available about plants.
- **Chemotaxonomy :** The uses of chemical characters of plants in classification or in solving taxonomic problems is called chemotaxonomy or chemical taxonomy. It is based on the **chemical constituents** of plants. The fragrance and taste vary from species to species.

  The basic chemical compounds used in chemotaxonomy are **alkaloids, carotenoides, tannins,** polysaccharide, nucleic acids, fatty acids, amino acids, **aromatic compounds** etc.

- **Cytotaxonomy :** The use of cytological characters of plants in classification or in solving taxonomic problems is called cytotaxonomy.

- Following characters are used in cytotaxonomy
  - ❖ **Chromosome number.**
  - ❖ Chromosome morphology – including chromosome size, total length of chromatin, arms ratio, primary and secondary constriction.
  - ❖ Heterochromatin.
  - ❖ **Chromosome behaviour at meiosis.**
  - ❖ Polyploidy – autopolyploidy, allopolyploidy and aneuploidy.
  - ❖ Chromosomal aberrations.
  - ❖ Different type of cytochromes.

  Cytological data have been used in many cases to find out the affinities among genera.

- **Karyotaxonomy :** Based on characters of **nucleus and chromosomes.** Pattern of **chromosomal bands** (dark bands and light bands) is most specific character.
- **Adansonian system or Phenetic Classification or Numerical Classification.**
  - ❖ Proposed by **"Sokel** and **Sneath"**
  - ❖ In it plants are classified on the basis of number of similarities and dissimilarities.
  - ❖ In this, importance to any one character is not given, **all characters have same importance.**
    While in **natural** classification **floral characters** have importance than morphological characters.

08. Significance of Taxonomy

- Most significant feature is **identification** of living organism.
- With the help of taxonomy **diversity** of living being can be studied easily.
- Maximum diversity of living beings are found in **tropical rain forests.**
- These forest have heavy rain fall through out the year.
- In **India** maximum tropical rain forest are found in **Andaman & Nicobar** and in all **eastern states** (Assam, Meghalaya, West Bengal etc.)
- At present, 300 lakh **(30 million)** type of living organism are found on our earth.
- 17 lakh **(1.7 million)** type of living organism have been **discovered till now.**
- Out of them **12 lakh** types are **animal** and **5 lakh** types are **plants.**

09. Taxonomic Category

Classification is not a single step process but involves heirarchy of steps in which each step represent a rank or category.

- **Species :**
  Taxonomic studies consider a group of individual organism with fundamental similarities as a species. One should be able to distinguish one species from the other closely related species based on the distinct morphological difference.
- **Genus :**
  Genus comperises a group of related species which has more characters in common in comparison to species of other genera.
- **Family :**
  Family has a group of related genera with still less number of similarities as compared to genus and species. Families are characterized on the basis of both vegetative and reproductive feature of plant species.
  For example :Three different genera **Solanum, Petunia** and **Datura** are included in family solanaceae.
- **Order :**
  Order being a higher category is the assemblage of families which exhibit a few similar character.
  For example : Plant families like **convolvulaceae, Solanaceae** are included in the order **polymoniales mainly based on the floral characters.**
- **Class :**
  Class includes organism of related orders having less similarities than orders.
- **Division :**
  Division includes all organisms belonging to different classes having a few common characters. There 7 main taxonomic categories. They are obligate or essential or broad categories i.e. they are strictly used at the time of any plant classification. There are some extra or sub categories, like sub division, sub order, sub family, etc. They are used only when they are needed.

Biggest group →
- Kingdom
- Division/Phylum
- Class
- Order - Cohort
- Family
- Genus
- Species

❖ The classification of any plant or animal is written in **descending** or ascending order.

❖ Hierarchy – **Descending** or ascending arrangement of taxonomic categories is known as hierarchy.

❖ **Species :** Smallest taxonomic category → It is basic unit of classification.

NOTE ☞ As we go higher from species to kingdom, number of common characters decreases. Lower the taxa more are the characteristics that the members with in the taxon share. Higher the category, greater is the difficulty of determining the relationship to other taxa at the same level.

Suffix for taxa (Taxon)		
Division	—	phyta
Sub div	—	phytina
Class	—	opsida, phyceae, ae
Order	—	ales
Sub-order	—	ineae
Family	—	aceae
Sub Family	—	oideae

NOTE ☞ There is no suffix for Genus, Species and Kingdom.

10. Nomenclature

- **Polynomical system :**
  - ❖ According to this system name of any plant consists of many words.
  - ❖ For eg. Caryophyllum → Caryophyllum saxatilis folis gramineus umbellatis corymbis
  - ❖ Based of morphology mainly

- **Trinomical system :**
  - ❖ Proposed by **Lamarck.**
  - ❖ According to this system name of any plant or species is composed of three names-
    - **Generic name**
    - **Specific epithet**
    - **Subspecific name (Name of variety)**

- ❖ When members of any species have large variations then trinomial system is used.
- ❖ On the basis of dissimilarities this species is classified into sub species. eg.
  Brassica oleracea var. botrytis (Cauliflower)
  Brassica oleracea var. capitata (Cabbage)
  Brassica oleracea var. caulorapa (Knol-Khol)

- **Binomial system :**
  - ❖ Binomial system was first proposed by **Gaspard Bauhin** in his book -**"Pinax Theatre Botanica"**
  - ❖ **Carolus Linnaeus :** Linnaeus used this nomenclature system for the first time on large scale and proposed scientific name of all the plants and animals.
  - ❖ **Linnaeus** is the **founder** of binomial system.
  - ❖ Linnaeus proposed scientific name of plants in his book **"Species Plantarum"**
  - ❖ It was published on **1 May, 1753.** So this was the initiation of binomial system for plants.
  - ❖ So any name proposed (for plants) before this date is **not** accepted today.
  - ❖ **Linnaeus** proposed scientific name of animals in his book **"Systema Naturae"** (10th edition).
  - ❖ This 10th edition of **Systema Naturae** was first published on **1 August, 1758.**
  - ❖ So initiation of binomial system **for animals** is believed to be started on **1 August, 1758.**

11. ICBN

- **Main rules of ICBN :**
  - ❖ According to binomial system name of any species consists of two components or words.
    - Generic name   Name of genus
    - Specific epithet

e.g.   **Solanum tuberosum** (Potato)   **Mangifera indica** (Mango)

↓ ↓ ↓ ↓

Generic name   Specific epithet   Generic name   Specific epithet

- ❖ In plant nomenclature (ICBN) tautonyms are not valid i.e. generic name and specific epithet should not be same in plants.
  eg. Mangifera mangifera
  But tautonyms are valid in animal nomenclature (ICZN-International Code of Zoological Nomenclature)
  eg. Naja naja (Indian cobra), Rattus rattus (Rat)
- ❖ First letter of generic name should be in capital letter and first letter of specific epithet should be in small letter.
  eg. Mangifera indica

- ❖ But if specific epithet is based on the name of any person, its first letter should be in capital letter.
  eg. Isoetes Pantii
- ❖ When written with free hand or typed, then generic name and specific epithet should be separately underlined.
  But during printing name should be in italics to indicate their latin orgin.
- ❖ Name of scientist (who proposed nomenclature) should be written in short after the specific epithet.
  eg. Mangifera indica Linn.
- ❖ Name of scientist should be neither underlined nor in italics, but written in Roman letters (simple alphabets)
- ❖ Sciectific names should be derived from Latin (usually) or Greek languages because they are dead languages.
- ❖ Type specimen (Herbarium Sheet) of newly discovered plant should be placed in herbarium (Dry garden).

12. Classification

According to **"A.P. de Candolle",** Classification is of two types

(i) Empirical Classification **(ii) Rational Classification**

- **Empirical Classification :**
  - ❖ In this type, the actual nature or character of plants is not considered.
  - ❖ Plants are classified on the basis of their alphabetical order.
  - ❖ In this way plants are classified into 26 groups.

- **Rational Classification**
  In this classification, plants are classified on the basis of their actual character or nature i.e. by viewing the characters.

Types of rational classification

(iii) Practical classification

In this type of classification, plants are classified on the basis of their economic importance.
e.g. Oil yielding plants → Coconut, Walnut, Soyabean
Fibre yielding plants → Jute, Cotton
Medicinal plants → Rauwolfia, Cinchona, Eucalyptus

> ***NOTE*** ☞ In this classification, any one plant can be a member of more than one group.
> **eg.** Turmeric : Multi uses plant, it gives both medicines and spices.

(iv) Artificial classification :

In this type of classification plants are classified on the basis of one or two morphological characters. i.e. over all morphology is not considered.

for e.g. - Classification proposed by Linnaeus is Artificial

Linnaeus classified plant kingdom on the basis stamen into 24 classes.

NOTE ☞ Linnaeus classification is also called sexual classification.

NOTE ☞ Linnaeus divided flowering plants into 23 classed starting with class monandria with a single stamen (eg. Canna) and plants with twenty or more stamens attached with calyx were assigned to class **Icosandria.** He also included all non-flowering plants such as algae, fungi, mosses and ferns in a separate class called cryptogamia.

(v) Natural classification:

In this type, plants are classified on the basis of their complete morphological characters of stem, root, leaves, flowers etc.

Importance —

Natural classification is believed to be the best classification, because it represents the natural similarities and dissimilarities of plants i.e. it represents the interrelationship among plants.

In this classification, the plants belonging to the same group shows many similarities, while in artificial classification, the plants belonging to the same group shows only, 1 or 2 similar characters. They have many dissimilarities.

Natural classification is of two types

- **Natural formal**
- **Natural phylogenetic**

(a) Natural formal → In this classification, the phylogeny of the plant is not considered i.e. only the morphology of the plant is considered.

(b) Natural phylogenetic → In this classification, both morphology and phylogeny are considered. In phylogenetic classification, the plants are arranged on the basis of their evolution.

Thallophyta → Bryophyta → Pteridophyta → Gymnosperm → Angiosperm (most advanced plants)
Note : Phylogenetic classification also known as cladistic classification

(vi) Adansonian system or phenetic classification or Numerical classification :

In it plants are classified on the basis of numbers of similarities and dissimilarities. This classification is easily carried out by using computers and it is based on all observable characteristics. In this classification number and codes are assigned to all the characters and the data are prepared and then processed. Those organism which have maximum similarities are placed in same group. In this way each character is given equal importance and at the same hundreds of characters can be considered.

NOTE ☞ In this classification importance to any one character is not given, all characters have same importance. While in natural classification floral (reproductive) characters have more importance than vegetative (root, stem and leaves) characters.

13. Taxonomical Aids

- Accurate classification and identification of organisms is required which needs field studies and intensive laboratory work. This is done after collection of actual specimens of plants and animal species which is the primary source of all taxonomic studies.
- Hence, these taxonomical studies help in
  Fundamental study of different living organisms.
  Also aid in their systematic study.
  Information gathered is stored with specimens for future studies.

Herbarium

- It is defined as "store house of collected plant specimens that are dried, pressed and preserved on sheets". Further, these sheets are arranged in the sequence of a universally accepted system of classification.
- Such herbaria serve as quick source of reference in taxonomical studies. It also provides information about the local flora as well as flora of distant areas. This information is also useful in locating wild varieties and relatives of economically important plants.
  List of some Herbaria of the world :
  (i) Royal Botanical Gardens, Kew (England)
  (ii) Central National Herbarium, Calcutta

14. Botanical Gardens

Botanical garden is an institution located in an enclosed piece of land which grows numerous kinds of plants obtained from different places for botanical studies. Each plant is first identified and then labelled indicating its botanical/scientific name and its family.

List of some Botanical Gardens
(i) Royal Botanical Garden, Kew (England)
(ii) National Botanica Garden, Lucknow
(iii) Indian Botanical Garden, Howrah
(iv) Lloyd Botanical Garden, Darjeeling

15. Museum

- Museum is a place used for storing, preservation and exhibition of both plants and animals. All educational institutes and universities maintain museums in their Botany and Zoology departments.
- A commonly used preservative solutions is "Formalin". Plants and animals specimen may also be preserved as dry specimens. For instances, insects are collected, killed and pinned before preserving them in special insect boxes while larger animals like reptiles, birds and mammals are usually stuffed and then preserved.
- National Museum of Natural History (NMNH) in Delhi is important from natural science point of view.

16. Zoological Parks

- Zoological parks commonly known as zoos are the places where live wild animals are kept in protected environment which is made similar to their natural habitats as much as possible. Here, they are provided with protection and care by human beings.
- These parks serve as ideal means to study and learn different food habits and behaviour of variety of animals. So, students should visit nearby zoos for knowledge and entertainment both.
- National Zoological Park (Delhi) is one of the finest zoos of Asia.

17. Key

- Key is an important taxonomic aid used for identification of plants and animals based on the **similarities** and **dissimilarities.** Actually, it is a set of alternate characters of different types arranged sequence wise in such a fashion that by selection and elimination one can quickly find out the name of the organism.
- The keys are based on the set of contrasting characters generally in a pair known as **"couplet".** Each character of the couplet or statement in the key is called as **"lead".**
- One has to choose correct option between two statements of characters of definite species so that the animal or plant is identified accurately. **Keys are generally analytical in nature.**

18. Flora, Manuals, Monographs and Catalogues

- These flora, manuals, monographs, etc. are recorded descriptions of plants, animals and other organisms. They provide correct identification and description of variety of living organisms.
  - ❖ **Flora :** It is a book containing information about plants found in a particular area. It gives the actual account of habitat and distribution of various plants of a given area. These provide the index to the plant species found in a particular area. For example, Flora of Delhi by J.K. Maheshwari.

- ❖ **Manual :** It is a book containing complete listing and description of the plants growing in a particular area. They provide useful information for identification of names of various species found in an area.
- ❖ **Monograph :** It contains information of any one taxon.
- ❖ **Catalogue :** It include the alphabetical arrangement of species of a particular place describing their features.

19. Species concept

John Ray : Proposed the term and concept of species.

- **Biological concept of species**
  - ❖ **Ernst Mayr** (Darwin of 20th century) proposed the biological concept of species.
  - ❖ Mayr defined the "species" in the form of biological concept.
  - ❖ According to Mayr "All the members that can interbreed among them self and can produce fertile offsprings are the members of same species"

    But this definition of Mayr was incomplete because this definition is applicable to sexually reproducing living beings because there are many organisms that have only asexual mode of reproduction.
    eg. Bacteria, Mycoplasma, BGA

  - ❖ The main character in determination of any species is interbreeding. But this character is not used in taxonomy. In taxonomy, the determination of species is mainly based on morphological characters.
  - ❖ In higher plants, the determination of species is mainly based on the morphology of flower (floral morphology). Because floral (reproductive) characters are more conservative as compared to vegetative (Root, Stem, Leaf) characters i.e. they do not show major changes.

- **Typological Concept**
  - ❖ It was proposed by **"Aristotle"** and **"Plato".**
  - ❖ This concept is based on single individual of a species.
  - ❖ According to this concept, **"There is a definite type or pattern of characters in the each species and every living organisms** and **all the members of species shows maximum resemblance with this pattern".**
  - ❖ The species in which one foxed pattern of characters is present are called as **monotypic** species.
    eg. Bacteria, Blue green algae
  - ❖ In many species, **more than one type** of pattern of characters are present. These are called **"Polytypic species"** or **"Macrospecies".**
    eg. **Brassica oleracea → Cauliflower, Cabbage, Knol-Khol.**

NEET Pattern
Exercise (1)

1. Which one of the following scientist's name is correctly matched with the theory put forth by him?
   (a) Weismann – Theory of continuity of germplasm
   (b) Pasteur – inheritance of acquired characters
   (c) De Vries – Natural selection
   (d) Mendel – Theory of pangenesis

2. Carbohydrates the most abundant biomolecules on earth, are produced by
   (a) all bacteria, fungi and algae
   (b) fungi, algae and green plant cells
   (c) some bacteria, algae and green plant cells
   (d) viruses, fungi and bacteria

3. Age of fossils in the past was generally determined by radio-carbon method and other methods involving radioactive elements found in the rocks. More precise methods, which were used recently and led to the revision of the evolutionary periods for different groups of organism, include
   (a) study of carbohydrates/proteins in fossils
   (b) study of the conditions of fossilisation
   (c) Electron Spin Resonance (ESR) and fossil DNA
   (d) study of carbohydrates/proteins in rocks

4. According to Oparin, which one of the following was not present in the primitive atmosphere of the earth?
   (a) Methane
   (b) Oxygen
   (c) Hydrogen
   (d) Water vapour

5. There is no life on moon due to the absence of
   (a) O_2
   (b) water
   (c) light
   (d) temperature

6. First life on earth was
   (a) cyanobacteria
   (b) chemoheterotrophs
   (c) autotrophs
   (d) photoautotrophs

7. If there was no CO_2 in the earth's atmosphere the temperature of earth's surface would be
   (a) higher than the present
   (b) less than the present
   (c) the same
   (d) dependent on the amount of oxygen in the atmosphere

8. The CO_2 content by volume, in the atmospheric air is about
   (a) 0.0314%
   (b) 0.34%
   (c) 3.34%
   (d) 4%

9. Glycogen is a polymer of
   (a) galactose
   (b) glucose
   (c) fructose
   (d) sucrose

10. A nucleotide is formed of
   (a) purine, pyrimidine and phosphate
   (b) purine, sugar and phosphate
   (c) nitrogen base, sugar and phosphate
   (d) pyrimidine, sugar and phosphate

Answer & Solution

Q1 (a)

Pasteur gave the Theory about the Germ Plasm, De Vries give the Theory about Mutation and mendel works on Theory of Inheritance. So the Weismann give the Theory of Continuity of germplasm, according to the germ-plasm theory, inheritance in a multicellular organism only takes place by means of the germ cells: the gametes, such as egg cells and sperm cells. Genetic information cannot pass from soma to germ-plasm and on to the next generation.

Q2 (c)

Some Photosynthetic Bacteria such as Rhodopseudomonas can prepare carbohydrates. but during this type of food synthesis O_2 is not evolved because in this case hydrogen donor is other than H_2O. Algae (blue and green-blue) and all green plant cells prepare their food (carbohydrate) through photosynthesis. Here, hydrogen ions are donated by water molecules by the process of photolysis of water, i.e. O_2 is released during this type of food synthesis.

Q3 (c)

Electron Spin Resonance (ESR) is a technique used to date newly formed materials, which Radiocarbon dating cannot, like carbonates, tooth enamel, or materials that have been previously heated like igneous rock. The age of substance can be determined by measuring the dosage of radiation since the time of its formation. DNA in ices and DNA in hydrated solids give nearly identical results, suggesting that the DNA strands in ices are as closely packed as those in the hydrated solid DNA samples. Our results suggest that previous reports of extensive electron-transfer distances for DNA in icy media are found to be better explained by substantial inter-double-strand electron transfer. this was best method which were used recently for study the evolutionary periods for different groups of organism.

Q4 (b)

According to Oparin, in the primitive Earth's surface, carbon, hydrogen, water vapour, and ammonia reacted to form the first organic compounds. He believed that organic molecules could be formed from abiogenic materials in the presence of an external energy source (e.g., ultraviolet radiation) and that the primitive atmosphere was reducing (having very low amounts of free oxygen) and contained ammonia and water vapour, among other gases. Both also suspected that the first life-forms appeared in the warm, primitive ocean and were heterotrophic (obtaining preformed nutrients from the compounds in existence on early Earth) rather than autotrophic (generating food and nutrients from sunlight or inorganic materials). So in the primitive environment Oxygen is absent.

Q5 (b)
Water is an essential constituent of cytoplasm of all living organisms it helps in distribution of substances within the organism elimination of waste products, body temperature maintenance etc. It is absent on moon. Anaerobic organisms can live in the absence of O_2. Light and temperature are already known to exist on moon. Lack of liquid water: Life, as we know it, requires liquid water to thrive. The lack of atmosphere means no greenhouse effect and very low pressure. The surface temperature is either extremely cold, or extremely hot- water cannot exist in a liquid state on the lunar surface.

Q6 (b)
Chemoautotrophs does carbon fixation on their own and chemoautotrophs gets the carbon from outside. If you consider the process of evolution, traits evolve over long periods of time and applying the principle of incremental complexity, the complex will follow simpler. Since autotrophs need more time to evolve complex mechanisms to synthesize carbon on their own compared to get it somewhere else, heterotrophs would have evolved first on the earth.

Q7 (b)
CO_2 keeps our earth warm by not letting earth's terrestrial radiation escape into space. It acts like a greenhouse. Remove this layer of insulation, out earth will become really cold. The amount of atmospheric CO_2, or carbon dioxide, is inextricably linked to climate. Average global carbon dioxide levels and average global temperatures go hand in hand, and temperature changes cause changes in precipitation. Concentrations of carbon dioxide in the atmosphere tend to fluctuate in a cyclical pattern over tens of thousands of years, as do worldwide periods of cold including Ice Ages and warmth.

Q8 (a)
Carbon dioxide (CO_2) is the 5th most abundant gas in the atmosphere and, together with water vapor, probably the best known of the greenhouse gases. Carbon dioxide levels in the atmosphere are not constant -- they have risen by nearly 40 percent since the Industrial Revolution, according to climate scientist Todd Sanford. They are small compared to the main atmospheric components of nitrogen and oxygen. Scientists express them as parts per million, or ppm. In March 2014, carbon dioxide levels were at 314 ppm, which is 0.0314 percent of the atmosphere. This roughly corresponds to a mass of 3 trillion tons. After nitrogen, oxygen, water vapor and argon, carbon dioxide is the fifth most abundant gas in the atmosphere.

Q9 (b)
Glycogen is a *readily mobilized storage form of glucose.* It is a very large, branched polymer of glucose residues that can be broken down to yield glucose molecules when energy is needed. Most of the glucose residues in glycogen are linked by α-1, 4-glycosidic bonds. Branches at about every tenth residue are created by α-1, 6-glycosidic bonds. Recall that α-glycosidic linkages form open helical polymers, whereas β linkages produce nearly straight strands that form structural fibrils, as in cellulose.

Q10 (c)
DNA is just a pattern made up of four different nucleotides. Each chain of the double helix is made up of repeating units called nucleotides. Each nucleotide consists of a sugar (deoxyribose) in

the middle of a phosphate group and a nitrogenous base. Nucleotides form a pair in a molecule of DNA where two adjacent bases form hydrogen bonds. The nitrogenous bases of the DNA always pair up in specific way, purine with pyrimidine (A with T, G with C), held together by weak hydrogen bonds. A single nucleotide is composed of three functional groups: a sugar, a triphosphate, and a nitrogenous (nitrogen-containing) base.