CRASH COURSE
For 2025 Exams

Fast - Track to Excellence with our Specialized

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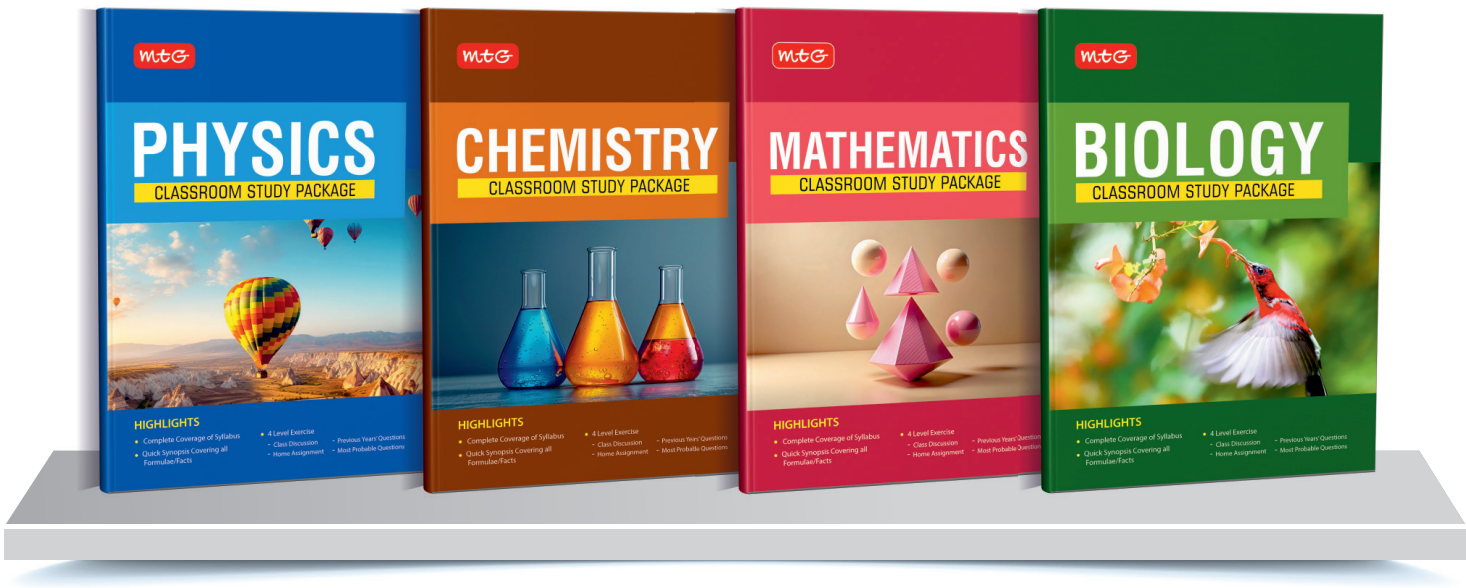
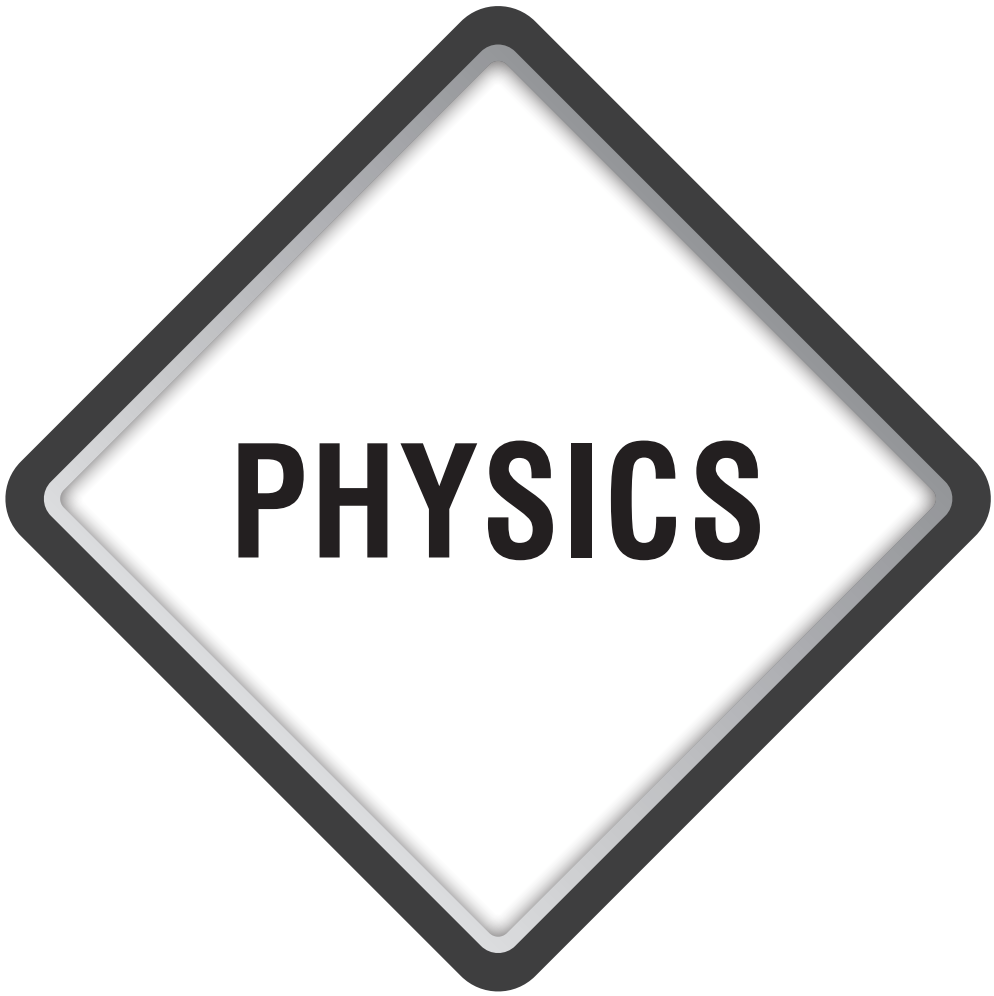
for 2025 Exams



USER BENEFITS

- **Comprehensive Syllabus Coverage:** The crash course will provide a thorough review of the entire syllabus subjectwise, ensuring that all key topics are covered and no important concepts are missed.
- **Quick Synopsis for Revision:** With concise summaries of all important formulas and facts, the crash course will help students revise quickly and efficiently, reinforcing core concepts and principles.
- **Structured 4-Level Exercises:** It is designed to incorporate a multi-level exercise approach, gradually increasing in difficulty to strengthen understanding and problem-solving skills.
  - **Class Discussions (15 MCQs):** Interactive class discussions included to clarify doubts, deepen understanding, and enhance retention of the material. Solutions of this section are provided in separate soft file.
  - **Home Assignments (15 MCQs):** Students will receive practice assignments designed to consolidate learning and reinforce the topics covered in each session.
  - **Previous Years' Questions (10 MCQs):** This section includes practice problems based on previous years' exam questions, providing students with an idea of the question patterns and marking schemes.
  - **Most Probable Questions (10 MCQs):** This section includes questions that might appear in upcoming exams, helping students focus their efforts effectively.

This series aims to optimize students' preparation in a short span, making it ideal for last-minute revision or quick concept reinforcement.


PHYSICS

CHAPTER 1

Units and Measurement

Physical Quantities

These are quantities that are used to describe the laws of Physics. Physical quantities may be divided into six categories :

(i) Constant or ratio (ii) Scalars
(iii) Vectors (iv) Phasors
(v) Tensors (vi) Conversion factors

Physical quantities may be divided into fundamental and derived quantities.

Fundamental quantities : The quantities that do not depend upon any other quantity, are called fundamental or absolute or basic quantities. Length, mass, time, temperature, electric current, luminous intensity and amount of a substance are the seven fundamental quantities.

Derived quantities : The physical quantities derived from fundamental quantities are called derived quantities like velocity, acceleration, force, momentum, etc.

Units

The fixed and definite quantity taken as standard of reference with which other quantities of the same kind are measured is defined as a unit.

Fundamental units : The units of fundamental quantities are called fundamental units. For example, units of length, mass and time or those of fundamental physical quantities.

Physical quantity	SI unit	Dimensional symbol	Unit symbol
Length	metre	L	m
Mass	kilogram	M	kg
Time	second	T	s
Temperature	Kelvin	K	K
Electric current	Ampere	A	A
Luminous intensity	Candela	I	Cd
Amount of substance	mole	mol	mol
Supplementary units			
Angle	radian	—	rad
Solid angle	stredian	—	sr

Derived units : Units of derived physical quantities are called derived units. For example, units of velocity, density, force, momentum and volume.

The International System of Units

In earlier time scientist of different countries were using different systems of units for measurement. Some of these systems are :

CGS System : In this system centimetre, gram and second are the fundamental units of length, mass and time respectively. It is a metric system of units. It is also known as Gaussian system of units.

FPS system : In this system foot, pound and second are the fundamental units of length, mass and time respectively. It is not a metric system of units. It is also known as British system of units.

MKS system : In this system metre, kilogram and second are the fundamental units of length, mass and time respectively. It is also a metric system of units.

International System of Units (SI) : The system of units which is at present internationally accepted for measurement is the Système Internationale d' Unites (French for International System of Units), abbreviated as SI. The SI, with standard scheme of symbols, units and abbreviations, was developed and recommended by General Conference on Weights and Measures in 1971 in France for international usage in scientific, technical, industrial and commercial work. It is based on the seven fundamental units or base units and two supplementary units.

Seven base quantities, their units with definitions:

Base quantity	SI Units		
	Name	Symbol	Definition
Length	metre	m	The metre is the length of the path travelled by light in vacuum during a time interval of 1/299,792,458 of a second.

Mass	kilogram	kg	The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be $6.62607015 \times 10^{-34}$ when expressed in the unit J s, which is equal to kg m^2s^{-1}, where the metre and the second are defined in terms of c and $\Delta\nu cs$.
Time	second	s	The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.
Electric current	ampere	A	The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge e to be $1.602176634 \times 10^{-19}$ when expressed in the unit C, which is equal to A s, where the second is defined in terms of $\Delta\nu cs$.
Thermodynamic temperature	kelvin	K	The kelvin, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant K to be $1.380649\ 10^{-23}$ when expressed in the unit J K^{-1}, which is equal to kg $m^2\ s^{-2}\ k^{-1}$, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu cs$.
Amount of substance	mole	mol	The mole is the amount of substance of a system, which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12.
Luminous intensity	candela	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

- There are two more supplementary units that are defined for plane angle and solid angle.
  - Plane angle $(d\theta) = \dfrac{\text{Length of arc } (ds)}{\text{radius } (r)}$
  - Solid angle $(d\Omega)$
    $= \dfrac{\text{Intercepted area } (dA) \text{ of spherical surface}}{\text{radius } (r)}$

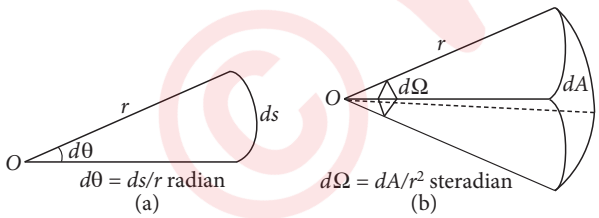


Figure (a) shows the description of plane angle $d\theta$ and figure (b) shows the description of solid angle $d\Omega$.

  - **Radian (rad) :** It is defined as the plane angle subtended at the centre of circle, by an arc of the circle equal in length to its radius.
  - **Steradian (sr) :** It is defined as the solid angle subtended at the centre of a sphere by an area of the sphere equal to square of its radius.
- The main advantages of SI over the other systems of units are the following :
  - SI is a coherent system of units.
  - SI is a rational system of units.
  - SI is an absolute system of units.
  - SI is a metric system.

Errors in Measurement

Let a physical quantity a be measured n times. Let the measured values be a_1, a_2, a_3 ..... a_n. To eliminate random error, their arithmetic mean is taken as the true value.

$$\bar{a} = \frac{a_1 + a_2 + ... a_n}{n} = \frac{1}{n}\sum_{i=1}^{n} a_i$$

Absolute error : The magnitude of the difference between the true value and the measured value is called absolute error. Such errors are given by

$$\Delta a_1 = \bar{a} - a_1 ; \Delta a_2 = \bar{a} - a_2 ; \Delta a_3 = \bar{a} - a_3 ; \ldots . \Delta a_n = \bar{a} - a_n$$

Mean absolute error : The arithmetic mean of the positive magnitudes of all the absolute errors is called mean absolute error.

$$\Delta\bar{a} = \frac{|\Delta a_1| + |\Delta a_2| + \ldots + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n} |\Delta a_i|$$

Relative error : It is the ratio of the mean absolute error to the mean value.

Percentage error : The relative error expressed in percent is called the percentage error.

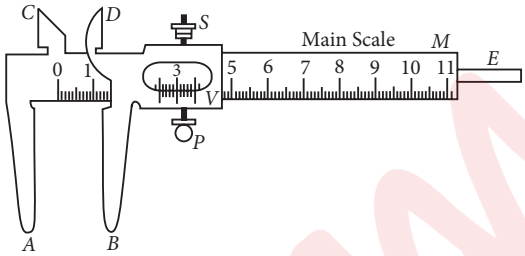
$$\text{Percentage error} = \frac{\Delta\bar{a}}{a} \times 100\%$$

Propagation of Errors in Mathematical Operations

Operation	Formula Z	Absolute error ΔZ	Relative error $\Delta Z/Z$	Percentage error $\Delta Z/Z \times 100\%$
Sum	$A + B$	$\Delta A + \Delta B$	$\frac{\Delta A + \Delta B}{A + B}$	$\frac{\Delta A + \Delta B}{A + B} \times 100\%$
Difference	$A - B$	$\Delta A + \Delta B$	$\frac{\Delta A + \Delta B}{A - B}$	$\frac{\Delta A + \Delta B}{A - B} \times 100\%$
Multiplication	$A \times B$	$A\Delta B + B\Delta A$	$\frac{\Delta A}{A} + \frac{\Delta B}{B}$	$\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) \times 100\%$
Division	$\frac{A}{B}$	$\frac{B\Delta A + A\Delta B}{B^2}$	$\frac{\Delta A}{A} + \frac{\Delta B}{B}$	$\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) \times 100\%$
Power	A^n	$nA^{n-1}\Delta A$	$n\frac{\Delta A}{A}$	$n\frac{\Delta A}{A} \times 100\%$
Root	$A^{1/n}$	$\frac{1}{n}A^{\frac{1}{n}-1}\Delta A$	$\frac{1}{n}\frac{\Delta A}{A}$	$\frac{1}{n}\frac{\Delta A}{A} \times 100\%$

Least Count

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



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

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

Therefore, $M - V = M - \frac{a}{b}M$

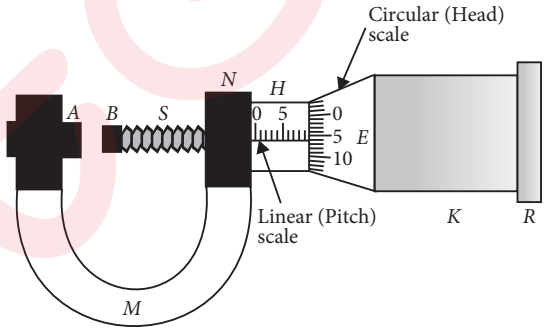
or $M - V = \left(\frac{b-a}{b}\right)M$

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

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

Least Count of Screw Gauge

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}$$



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

$$\text{Pitch} = \frac{\text{Distance moved by the screw on the linear scale}}{\text{Number of full rotations given}}$$

Significant Figures

Rules to Find the Significant Figures

Rule-1 : All non-zero digits are significant. *e.g.* 1324 has four significant figures.

Rule-2 : All zeros occuring between two non-zero digits are significant. *e.g.* 120024 has 6 significant digits.

Rule-3 : If the number is less than 1, the zero(s) on the right of decimal point is significant, but to the left of the first non-zero digit are not significant. *e.g.* 0.00064 has two significant digits.

Rule-4 : In a number without a decimal point the terminal or trailing zero(s) are not significant. *e.g.* 227800 has four significant digits.

Rule-5 : In a number with a decimal point the trailing zero(s) are significant. *e.g.* 3.200 or 0.05400 have four significant digits each.

Note : The power (or exponent) of 10 is irrelevant to the determination of significant figures. For example, 3.100×10^2 has 4 significant figures.

Rules for Arithmetic Operation with Significant Figures

- In both, addition and subtraction the final result should retain as many decimal places as there are in the number with least decimal places.
  e.g. 24.36 + 0.0623 + 256.2 = 280.6223
  The result should be rounded off to 280.6
- In multiplication or division, the final result should retain as many significant figures as there are in the original number with the least significant figures.
  e.g. 4.6 × 0.128 = 0.5888
  The result should be rounded off to 0.59

Rounding of the uncertain digits

Rule-1 : If the digit to be dropped is less than 5, then the preceding digit is left unchanged.

e.g. 8.22 is rounded off to 8.2.

Rule-2 : If the digit to be dropped is more than 5, then the preceding digit is raised by one.

e.g. x = 6.87 is rounded off to 6.9.

Rule-3 : If the digit to be dropped is 5 followed by digit other than zero, then the preceding digit is raised by one.

e.g. 7.851 is rounded off to 7.9.

Rule-4 : If the digit to be dropped is 5 or 5 followed by zero, then preceding digit is left unchanged, if it is even.

e.g. 5.250 is rounded off to 5.2.

Rule-5 : If the digit to be dropped is 5 or 5 followed by zero, then the preceding digit is raised by one, if it is odd.

e.g. 3.750 is rounded off to 3.8.

Dimensions of Physical Quantities

Dimensions of a physical quantity are the powers to which the basic units should be raised to represent its (derived) unit.

(a) In mechanics we need to give the dimensions of mass, length and time (M, L, T).

(b) In heat and thermodynamics, we need to mention the dimensions of mass, length, time and temperature (M, L, T, θ or K). Sometimes the dimensions of quantity of matter may also be involved.

(c) In electricity and magnetism, we need to give the dimensions of mass, length, time and current (M, L, T, I or A).

Dimensional Formulae and Dimensional Equations

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 acceleration is $[M^0L^1T^{-2}]$.

The equation obtained by equating a physical quantity with its dimensional formula is called a **dimensional equation.**

e.g. Dimensional equation for acceleration is,

$[a] = [M^0L^1T^{-2}]$

Similarly, dimensional equation for density is,

$[\rho] = [M^1L^{-3}T^0]$

Dimensional Analysis and Its Applications

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

This is based on the 'principle of homogeneity of dimensions'. According to this principle the dimensions of each term on both sides of an equation must be the same *i.e.*, [LHS] = [RHS].

This principle is based on the fact that only quantities of same kind can be added or subtracted. For example, if we have an equation like $A = B + C$, the quantities A, B and C must have the same dimensions. A dimensionally correct equation may or may not be physically correct.

Example

Consider the formula

$$S = ut - \left(\frac{1}{4}\right)at^2$$

Dimensionally, $[L] = [LT^{-1}][T] - [LT^{-2}][T^2]$

i.e., $[L] = [L] - [L]$

As in the above equation dimensions of each term on both sides are same, so this equation is dimensionally correct. However, from equations of motion we know that

$$S = ut + \left(\frac{1}{2}\right)at^2$$

So the given equation is physically wrong though it is correct dimensionally.

(ii) Deducing relationship among the physical quantities

If one knows the quantities on which a particular physical quantity depends and if one guesses that this dependence is of product type, method of dimension may be helpful in the derivation of the relation.

Example

The time period of a simple pendulum depends upon (i) mass m of the bob (ii) length l of the string and (iii) acceleration due to gravity g.

Hence, $T = K\, m^a l^b g^c$ ...(1)

where K is a dimensionless constant and a, b and c are the unknown numbers.

Taking dimension of both sides, we get

$[T] = [M]^a [L]^b [LT^{-2}]^c$

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

Equating the dimensions of M, L and T on both sides, we get

$a = 0; b + c = 0$ and $-2c = 1$

$$\therefore \quad a = 0, \ b = \frac{1}{2} \text{ and } c = -\frac{1}{2} \qquad \text{....(2)}$$

Putting the values of *a, b, c* in equation (1), we get

$$T = K\sqrt{\frac{l}{g}}$$

It is found that $K = 2\pi$

$$\therefore \quad \text{Time period} = T = 2\pi\sqrt{\frac{l}{g}}$$

(iii) To convert a physical quantity from one system of units to the other.

This is based on the fact that magnitude of a physical quantity remains same whatever system is used for measurement *i.e.*

magnitude = numerical value (n) × unit (u) = constant

or $n_1u_1 = n_2u_2$

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

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

Example

Pressure is given by $P = \frac{F}{A}$

Thus dimensional formula of pressure is

$$[P] = \frac{[F]}{[A]} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

In SI units, 1 pascal = (1 kg) (1 m)$^{-1}$ (1 s)$^{-2}$

In CGS units, 1 CGS pressure = (1 g) (1 cm)$^{-1}$ (1 s)$^{-2}$

$$\text{Thus, } \frac{1 \text{ pascal}}{1 \text{ CGS pressure}} = \left(\frac{1\text{ kg}}{1\text{ g}}\right)\left(\frac{1\text{ m}}{1\text{ cm}}\right)^{-1}\left(\frac{1\text{ s}}{1\text{ s}}\right)^{-2}$$

$$= (10^3)\,(10^2)^{-1} = 10$$

or 1 pascal = 10 CGS pressure

(iv) To find the dimensions of constants in a relation

Sometimes a physical relation contains constants. By using the dimensional formula of the various physical quantities, we evaluate the constant.

Example

(i) For Newton's law of gravitation, we have

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

$$\therefore \quad [G] = \frac{[F][r^2]}{[m_1][m_2]} = \frac{[MLT^{-2}][L^2]}{[M][M]}$$

or $[G] = [M^{-1}L^3T^{-2}]$

(ii) According to Planck,

$$E = h\upsilon \text{ or } h = \frac{E}{\upsilon} \quad \therefore \quad [h] = \frac{[E]}{[\upsilon]} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$$

or $[h] = [ML^2T^{-1}]$

Class Discussion

1. The system of units is a complete set of
(a) base units only
(b) derived units only
(c) both base units and derived units
(d) CGS system

2. Spot out the odd one.
(a) calorie (b) kilowatt hour
(c) joule (d) watt

3. Two resistors of resistances $R_1 = (300 \pm 3)\ \Omega$ and $R_2 = (500 \pm 4)\ \Omega$ are connected in series. The equivalent resistance of the series combination is
(a) $(800 \pm 1)\ \Omega$ (b) $(800 \pm 7)\ \Omega$
(c) $(200 \pm 7)\ \Omega$ (d) $(200 \pm 1)\ \Omega$

4. The numbers 3.845 and 3.835 on rounding off to 3 significant figures will give
(a) 3.85 and 3.84 (b) 3.84 and 3.83
(c) 3.85 and 3.83 (d) 3.84 and 3.84

5. The number of significant figures in the numbers 4.8000×10^4 and 48000.50 are respectively
(a) 5 and 6 (b) 5 and 7 (c) 2 and 7 (d) 2 and 6

6. Which of the following physical quantities has neither units nor dimensions?
(a) Relative velocity (b) Relative density
(c) Angle (d) Energy

7. Which of the following pairs does not have similar dimensions?
(a) Stress and pressure
(b) Tension and surface tension
(c) Angle and strain
(d) Planck's constant and angular momentum

8. The pitch of a screw gauge is 1 mm and there are 100 divisions on the circular scale. In measuring the diameter of a sphere there are six divisions on the linear scale and forty divisions on circular scale coincides with the reference line. The diameter of the sphere is
(a) 2.1 mm (b) 4.2 mm (c) 6.4 mm (d) 8.2 mm

9. A force F is given by $F = at + bt^2$, where t is time. The dimensions of a and b are
(a) $[MLT^{-3}]$ and $[MLT^{-4}]$ (b) $[MLT^{-4}]$ and $[MLT^{-3}]$
(c) $[MLT^{-1}]$ and $[MLT^{-2}]$ (d) $[MLT^{-2}]$ and $[MLT^0]$

10. The mass of a box measured by a grocer's balance is 2.3 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. The total mass of the box is
(a) 2.3 kg (b) 2.34 kg
(c) 2.340 kg (d) 2.3403 kg

11. Which of the following relations is dimensionally correct?
(a) 1 u = 931.5 MeV (b) 1 u = 931.5 MeV/c^2
(c) 1 u = 1.67 $\times 10^{-27}$ J (d) None of these

12. The length and breadth of a metal sheet are 2.214 m and 2.002 m respectively. The area of this sheet up to four correct significant figures is
(a) 4.43 m^2 (b) 4.432 m^2
(c) 4.4324 m^2 (d) 4.432428 m^2

13. Identify the pair whose dimensions are equal
(a) torque and work (b) stress and energy
(c) force and stress (d) force and work

14. Statement I : If the units of force and length are doubled, the unit of energy will be 4 times.
Statement II : The unit of energy is independent of the unit of force and length.
(a) Both Statement I and Statement II are correct.
(b) Statement I is correct but Statement II is incorrect.
(c) Both Statement I and Statement II are incorrect.
(d) Statement I is incorrect but Statement II is correct.

15. The dimensional formula of physical quantity is $[M^a L^b T^c]$. Then that physical quantity is
(a) surface tension if $a = 1, b = 1, c = -2$
(b) force if $a = 1, b = 1, c = 2$
(c) angular frequency if $a = 0, b = 0, c = -1$
(d) spring constant if $a = 1, b = -1, c = -2$

Home Assignment

1. If the energy, $E = G^p h^q c^r$, where G is the universal gravitational constant, h is the Planck's constant and c is the velocity of light, then the values of p, q and r are, respectively
(a) – 1/2, 1/2 and 5/2 (b) 1/2, – 1/2 and – 5/2
(c) – 1/2, 1/2 and 3/2 (d) 1/2, – 1/2 and – 3/2

2. From the point of view of significant figures which of the following statements are correct?
(i) 10.2 cm + 8.0 cm = 18.2 cm
(ii) 2.53 m – 1.2 m = 1.33 m
(iii) 4.2 m × 1.4 m = 5.88 m^2
(iv) 3.6 m ÷ 1.75 s = 2.1 m s^{-1}
(a) (i) and (iv) only (b) (ii) and (iii) only
(c) (iv) only (d) (ii) and (iv) only

3. Match the column-I with column-II.

Column-I (Physical quantity)		Column-II (Dimensional formulae)	
(A)	Permittivity of free space	(P)	$[M^0L^0T^{-1}]$
(B)	Radiant flux	(Q)	$[ML^3T^{-3}A^{-2}]$
(C)	Resistivity	(R)	$[ML^2T^{-3}]$
(D)	Hubble constant	(S)	$[M^{-1}L^{-3}T^4A^2]$

(a) (A) – (P), (B) – (Q), (C) – (R), (D) – (S)
(b) (A) – (Q), (B) – (P), (C) – (S), (D) – (R)
(c) (A) – (S), (B) – (R), (C) – (Q), (D) – (P)
(d) (A) – (R), (B) – (S), (C) – (P), (D) – (Q)

4. Match List-I with List-II.

List-I		List-II	
(A)	Spring constant	(P)	$[T^{-1}]$
(B)	Angular speed	(Q)	$[MT^{-2}]$
(C)	Angular momentum	(R)	$[ML^2]$
(D)	Moment of Inertia	(S)	$[ML^2T^{-1}]$

Choose the correct answer from the options given below.
(a) (A) – (S); (B) – (P); (C) – (R); (D) – (Q)
(b) (A) – (Q); (B) – (R); (C) – (P); (D) – (S)
(c) (A) – (Q); (B) – (P); (C) – (S); (D) – (R)
(d) (A) – (P); (B) – (R); (C) – (Q); (D) – (S)

5. A quantity f is given by $f = \sqrt{\frac{hc^5}{G}}$, where c is speed of light, G universal gravitational constant and h is the Planck's constant. Dimension of f is that of
(a) area (b) volume
(c) momentum (d) energy

6. In the relation $P = \frac{\alpha}{\beta} e^{-\frac{\alpha z}{k\theta}}$, P is pressure, z is distance, k is Boltzmann constant and θ is the temperature. The dimensional formula of β will be
(a) $[M^0L^2T^0]$ (b) $[ML^2T]$
(c) $[ML^0T^{-1}]$ (d) $[M^0L^2T^{-1}]$

7. If $A = B + \frac{C}{D+E}$, the dimensions of B and C are $[M^0LT^{-1}]$ and $[M^0LT^0]$, respectively. Find the dimensions of A, D and E.
(a) $[A] = [M^0L^0T^{-1}]$, $[D] = [T]$, $[E] = [LT]$
(b) $[A] = [MLT^0]$, $[D] = [T^2]$, $[E] = [T^2]$
(c) $[A] = [M^0LT^{-1}]$, $[D] = [MT]$, $[E] = [MT]$
(d) $[A] = [M^0LT^{-1}]$, $[D] = [T]$, $[E] = [T]$

8. Statement-1 : If two quantities have same dimensions, they may or may not represent the same physical content.
Statement-2 : Physical quantities have a single dimensional formula.

(a) Statement-1 is true, Statement-2 is true ; Statement-2 is the correct explanation of Statement-1.
(b) Statement-1 is true, Statement-2 is true ; Statement-2 is not the correct explanation of Statement-1.
(c) Statement-1 is true, Statement-2 is false.
(d) Both statement-1 and statement-2 are false.

9. The smallest division on main scale of a vernier callipers is 1 mm and 10 vernier divisions coincide with 9 scale divisions. While measuring the length of a line, the zero mark of the vernier scale lies between 10.2 cm and 10.3 cm and the third division of vernier scale coincide with a main scale division. The length of the line is
(a) 10.23 cm (b) 12.12 cm (c) 9.13 cm (d) 7.25 cm

10. Assertion : When we change the unit of measurement of a quantity, its numerical value changes.
Reason : Smaller the unit of measurement smaller is its numerical value.
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If assertion is false but reason is true.

11. In a new system of units, unit of mass is 10 kg, unit of length is 1 km and unit of time is 1 minute. The value of 1 joule in this new hypothetical system is
(a) 3.6×10^{-4} new units (b) 6×10^{7} new units
(c) 10^{11} new units (d) 1.67×10^{4} new units

12. In an experiment, the percentage of error occurred in the measurement of physical quantities A, B, C and D are 1%, 2%, 3% and 4% respectively. Then the maximum percentage of error in the measurement X, where $X = \frac{A^2 B^{1/2}}{C^{1/3} D^3}$, will be
(a) 10% (b) (3/13)% (c) 16% (d) –10%

13. A metal wire has mass (0.4 ± 0.002) g, radius (0.3 ± 0.001) mm and length (5 ± 0.02) cm. The maximum possible percentage error in the measurement of density will nearly be
(a) 1.6% (b) 1.4% (c) 1.2% (d) 1.3%

14. Using the principle of homogeneity of dimensions, which of the following is correct?
(a) $T^2 = \frac{4\pi^2 r^3}{GM}$ (b) $T^2 = 4\pi^2 r^2$
(c) $T^2 = \frac{4\pi^2 r^3}{G}$ (d) $T = \frac{4\pi^2 r^3}{G}$

15. A physical quantity P is described by the relation $P = a^{1/2} b^2 c^3 d^{-4}$. If the relative errors in the measurement of a, b, c and d respectively, are 2%, 1%, 3% and 5%, then the relative error in P will be
(a) 25% (b) 12% (c) 8% (d) 32%

Previous Year's Questions

1. To find the spring constant (k) of a spring experimentally, a student commits 2% positive error in the measurement of time and 1% negative error in measurement of mass. The percentage error in determining value of k is
(a) 4% (b) 1% (c) 3% (d) 5%

2. Match List-I with List-II.

List-I (Number)		List-II (Significant figure)	
(A)	1001	(I)	3
(B)	010.1	(II)	4
(C)	100.100	(III)	5
(D)	0.0010010	(IV)	6

Choose the correct answer from the options given below :
(a) (A)-(II), (B)-(I), (C)-(IV), (D)-(III)
(b) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)
(c) (A)-(I), (B)-(II), (C)-(III), (D)-(IV)
(d) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)

3. If G be the gravitational constant and u be the energy density then which of the following quantity have the dimensions as that of the $\sqrt{uG}$.
(a) Gravitational potential.
(b) Pressure gradient per unit mass.
(c) Energy per unit mass.
(d) Force per unit mass.

4. The quantities which have the same dimensions as those of solid angle are
(a) strain and angle (b) stress and angle
(c) strain and arc (d) angular speed and stress

5. The resistance $R = \frac{V}{I}$ where V = (200 ± 5) V and I = (20 ± 0.2) A, the percentage error in the measurement of R is
(a) 5.5% (b) 7% (c) 3% (d) 3.5%

6. The dimensions of mobility of charge carriers are
(a) $[M^{-2}T^2A]$ (b) $[M^{-1}T^2A]$
(c) $[M^{-2}T^3A]$ (d) $[M^{-1}T^3A]$

7. The true length of a wire is 3.678 cm. When the length of this wire is measured using instrument A, the length of the wire is 3.5 cm. When the length of the wire is measured using instrument B, it is found to have length 3.38 cm. Then the
(a) measurement with A is more accurate and precise.
(b) measurement with A is more accurate while measurement with B is more precise.
(c) measurement with B is more accurate and precise.
(d) measurement with A is more precise while measurement with B is more accurate.

8. A simple pendulum experiment is performed for the value of '*g*', the acceleration due to the Earth's gravity. The measured value of length of the pendulum is 25 cm with an accuracy of 1 mm and the measured time for 100 oscillations is found to be 100 sec with an accuracy of 1 sec. The percentage uncertainty in the determination of '*g*' is

(a) 9.8 (b) 0.98 (c) 4.8 (d) 2.4

9. Let $x=\left[\frac{a^2b^2}{c}\right]$ be the physical quantity. If the percentage error in the measurement of physical quantities *a*, *b* and *c* is 2, 3 and 4 percent respectively. Then percentage error in the measurement of *x* is

(a) 7% (b) 14% (c) 21% (d) 28%

10. Statement (I) : Planck's constant and angular momentum have same dimensions.

Statement (II) : Linear momentum and moment of force have same dimensions.

In the light of the above statements, choose the correct answer from the options given below :

(a) Both Statement I and Statement II are false.
(b) Statement I is true but Statement II is false.
(c) Both Statement I and Statement II are true.
(d) Statement I is false but Statement II is true.

Most Probable Questions

1. Which of the following sets has different dimensions?

(a) Pressure, Young's modulus, stress
(b) Emf, potential difference, electric potential
(c) Heat, work done, energy
(d) Dipole moment, electric flux, electric field

2. In an experiment, the following observation's were recorded : $L = 4.612$ m, $M = 5.00$ kg, $l = 0.067$ cm, Diameter, $D = 0.044$ cm.

Taking $g = 9.81$ m s^{-2} using the formula $Y=\frac{4MgL}{\pi D^2 l}$, the maximum permissible error in *Y* is

(a) 7.96% (b) 4.56% (c) 6.40% (d) 8.42%

3. The position of a particle at time *t* is given by the relation $x(t)=\left(\frac{v_0}{\alpha}\right)(1-e^{-\alpha t})$, where v_0 is a constant and $\alpha > 0$. The dimensions of v_0 and α are respectively

(a) $[M^0LT^{-1}]$ and $[T^{-1}]$ (b) $[M^0LT^0]$ and $[T^{-1}]$
(c) $[M^0LT^{-1}]$ and $[LT^{-2}]$ (d) $[M^0LT^{-1}]$ and $[T]$

4. Height of liquid in a capillary tube is given as, $h=\frac{2S\cos\theta}{r\rho g}$ where *S* is the surface tension of liquid, *r* is the radius of capillary tube, ρ is density and *g* is acceleration due to gravity then dimensional formula for *S* is

(a) $[ML^0T^{-2}]$ (b) $[M^0LT^{-2}]$
(c) $[ML^2T^{-2}]$ (d) $[M^0L^0T^{-3}]$

5. The van der Waal's equation of state for some gases can be expressed as $\left(P+\frac{a}{V^2}\right)(V-b)=RT$, where *P* is the pressure, *V* the molar volume and *T* is the absolute temperature of the given sample of gas and *a*, *b* and *R* are constants. The dimensions of *a* are

(a) $[ML^5T^{-2}]$ (b) $[ML^{-1}T^{-2}]$
(c) $[L^3]$ (d) $[L^6]$

6. A physical quantity *A* is related to four observations *a*, *b*, *c* and *d* as follows, $A=\frac{a^2b^3}{c\sqrt{d}}$. The percentage errors of measurement in *a*, *b*, *c* and *d* are 1%, 3%, 2% and 2% respectively. What is the percentage error in the quantity *A*

(a) 12 % (b) 7 % (c) 5 % (d) 14 %

7. Out of the following, the only pair that does not have identical dimensions is

(a) angular momentum and Planck's constant
(b) moment of inertia and moment of a force
(c) work and torque
(d) impulse and momentum

8. If *P*, *Q*, *R* are physical quantities having different dimensions, which of the following combinations can never be a meaningful quantity ?

(a) $\frac{(P-Q)}{R}$ (b) $PQ - R$
(c) $\frac{PQ}{R}$ (d) $\frac{(PR-Q^2)}{R}$

9. The de-Broglie wavelength associated with a particle of mass *m* and energy *E* is $\frac{h}{\sqrt{2mE}}$. The dimensional formula of Planck's constant *h* is

(a) $[M^2L^2T^{-2}]$ (b) $[ML^2T^{-2}]$
(c) $[MLT^{-2}]$ (d) $[ML^2T^{-1}]$

10. Assertion : According to the principle of homogeneity of dimensions, only that formula is correct in which the dimensions of L.H.S. equal to dimensions of R.H.S.

Reason : The time period of a pendulum is given by the formula, $T=2\pi\sqrt{\frac{g}{l}}$.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

Hints & Explanations

Home Assignment

1. (a) : $E = G^p h^q c^r$ ...(i)

$[M^1L^2T^{-2}] = [M^{-1}L^3T^{-2}]^p [ML^2T^{-1}]^q [LT^{-1}]^r$

$= [M^{-p+q} L^{3p+2q+r} T^{-2p-q-r}]$

Applying principle of homogeneity of dimensions, we get

$-p + q = 1$ ...(ii)

$3p + 2q + r = 2$ ...(iii)

$-2p - q - r = -2$ ...(iv)

Adding (iii) and (iv), we get $p + q = 0$ ...(v)

Adding (ii) and (v), we get $q = \frac{1}{2}$

From (ii), we get $p = q - 1 = \frac{1}{2} - 1 = -\frac{1}{2}$

Put in (iii), we get $-\frac{3}{2} + 1 + r = 2, r = \frac{5}{2}$

2. (a) : In addition or subtraction, the final result should retain as many decimal places as are there in the number with the least decimal places.

In multiplication or division, the final result should retain as many significant figures as are there in the original number with the least significant figures.

Hence, according to above rules (i) and (iv) are correct.

3. (c) : Permittivity of free space

$$= \frac{\text{Charge} \times \text{Charge}}{4\pi \times \text{Electrical force} \times (\text{Distance})^2}$$

$$[\varepsilon_0] = \frac{[AT][AT]}{[MLT^{-2}][L]^2} = [M^{-1}L^{-3}T^4A^2]$$

(A – S)

$$\text{Radiant flux} = \frac{\text{Energy emitted}}{\text{Time}} = \frac{[ML^2T^{-2}]}{[T]} = [ML^2T^{-3}]$$

(B – R)

$$\text{Resistivity} = \frac{\text{Resistance} \times \text{Area}}{\text{Length}}$$

$$[\rho] = \frac{[ML^2T^{-3}A^{-2}][L^2]}{[L]} = [ML^3T^{-3}A^{-2}]$$

(C – Q)

$$\text{Hubble constant} = \frac{\text{Recession speed}}{\text{Distance}} = \frac{[LT^{-1}]}{[L]} = [M^0L^0T^{-1}]$$

(D – P)

4. (c) : Spring constant, $K = \frac{F}{x} = \frac{[M^1L^1T^{-2}]}{[L^1]} = [M^1T^{-2}]$

Angular speed, $\omega = \frac{v}{r} = \frac{L^1T^{-1}}{L^1} = T^{-1}$

Angular momentum, $L = mvr = [M^1L^2T^{-1}]$

Moment of Inertia, $I = mr^2 = [M^1L^2T^0]$

5. (d) : $f = \sqrt{\frac{hc^5}{G}}$

$[h] = [M^1L^2T^{-1}]$, $c = [LT^{-1}]$, $[G] = [M^{-1}L^3T^{-2}]$

$$[f] = \left[\frac{ML^2T^{-1}L^5T^{-5}}{M^{-1}L^3T^{-2}}\right]^{1/2}$$

$[f] = [M^2L^4T^{-4}]^{1/2} = [ML^2T^{-2}]$

It is the dimensions of energy.

6. (a) : In the given equation, $\frac{\alpha z}{k\theta}$ should be dimensionless.

$$\alpha = \frac{k\theta}{z} \text{ or } [\alpha] = \frac{[ML^2T^{-2}K^{-1}][K]}{[L]} = [MLT^{-2}]$$

$$P = \frac{\alpha}{\beta} \text{ or } [\beta] = \left[\frac{\alpha}{P}\right] = \frac{[MLT^{-2}]}{[ML^{-1}T^{-2}]} = [M^0L^2T^0]$$

7. (d) : As $A = B + \frac{C}{D+E}$

$\therefore$ $[D] = [E]$

$$\therefore \quad [A] = [B] = \left[\frac{C}{D+E}\right] = \left[\frac{C}{D}\right] = \left[\frac{C}{E}\right]$$

$\therefore$ $[A] = [B] = [M^0LT^{-1}]$

$$\left[\frac{C}{D}\right] = [A] = [M^0LT^{-1}]$$

$$[D] = [E] = \left[\frac{C}{LT^{-1}}\right] = \left[\frac{M^0LT^0}{M^0LT^{-1}}\right] = [T]$$

8. (b) : Although both work and torque have the same dimensions namely ML^2T^{-2}, they represent different physical quantities.

Statement-1 and, Statement-2 are true, but statement 2 is not the correct explanation for statement-1.

9. (a) : Least count (L.C)

$$= \frac{\text{Smallest division on main scale}}{\text{Number of divisions on vernier scale}}$$

$$= \frac{1}{10}\text{ mm} = 0.1\text{ mm} = 0.01\text{ cm}$$

Length of the line = $(10.2 + 3 \times 0.01)$ cm = 10.23 cm

10. (c) : If u_1 and u_2 are the units to measure a quantity Q and n_1, n_2, the numerical values respectively then we know that $Q = n_1u_1 = n_2u_2$. Since the quantity Q does not change, irrespective of the units used to measure it, Q = constant. So, nu = constant $\Rightarrow n \propto \frac{1}{u}$ *i.e.* smaller the unit of measurement, greater is the corresponding numerical value.

11. (a) : The dimensional formula of energy is $[ML^2T^{-2}]$.

$$n_2 = 1\left[\frac{1\text{ kg}}{10\text{ kg}}\right]^1\left[\frac{1\text{ m}}{1\text{ km}}\right]^2\left[\frac{1\text{ s}}{1\text{ min}}\right]^{-2}$$

$$= \frac{1}{10} \times \frac{1}{10^6} \times \frac{1}{(60)^{-2}} = \frac{3600}{10^7} = 3.6 \times 10^{-4}$$

12. (c) : $X = \dfrac{A^2 B^{1/2}}{C^{1/3} D^3}$

Maximum percentage error in X

$$\left(\frac{dX}{X}\right) \times 100 = \left(2\frac{dA}{A} + \frac{1}{2}\frac{dB}{B} + \frac{1}{3}\frac{dC}{C} + 3\frac{dD}{D}\right) \times 100$$

$$= 2 \times 1 + \frac{1}{2} \times 2 + \frac{1}{3} \times 3 + 3 \times 4 = 16\%$$

13. (a) : Volume of the wire, $V = \pi r^2 L$

Density of the wire $\rho = \dfrac{m}{V} = \dfrac{m}{\pi r^2 L}$

For percentage error,

$$\frac{\Delta\rho}{\rho} \times 100 = \frac{\Delta m}{m} \times 100 + 2 \times \frac{\Delta r}{r} \times 100 + \frac{\Delta L}{L} \times 100$$

$$\therefore \quad \frac{\Delta\rho}{\rho} \times 100 = \frac{0.002}{0.4} \times 100 + 2 \times \frac{0.001 \times 100}{0.3} + \frac{0.02}{5} \times 100$$

$$= 0.5 + 0.67 + 0.4 = 1.57 \simeq 1.6\%$$

14. (a) : $T^2 = \dfrac{4\pi^2 r^3}{GM}$

Taking dimensions on both sides, we get

$$[T]^2 = \frac{[L]^3}{[M^{-1}L^3T^{-2}M]} = [M^0L^0T^2] \qquad \therefore \text{ LHS = RHS}$$

Now, for $T^2 = 4\pi^2 r^2$

Taking dimensions on both sides,

$[T]^2 = [L^2]$ $\qquad \therefore$ LHS $\neq$ RHS

Now, for $T^2 = \dfrac{4\pi^2 r^3}{G}$

Taking dimensions on both sides,

$$[T]^2 = \frac{[L]^3}{[M^{-1}L^3T^{-2}]} = [M^1L^0T^2] \qquad \therefore \text{ LHS} \neq \text{RHS}$$

Now, for $T = \dfrac{4\pi^2 r^3}{G}$

Taking dimensions on both sides,

$$[T] = \frac{[L^3]}{[M^{-1}L^3T^{-2}]} = [ML^0T^2] \qquad \therefore \text{ LHS} \neq \text{RHS.}$$

$[ML^2T^{-2}]/[L^2T^{-2}] = [M]$

15. (d) : Here, $P = a^{1/2}\, b^2\, c^3\, d^{-4}$

$$\frac{\Delta P}{P} = \frac{1}{2}\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + 3\frac{\Delta c}{c} + 4\frac{\Delta d}{d}$$

$$\text{or} \quad \left(\frac{\Delta P}{P} \times 100\right)\% = \left(\frac{1}{2}\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + 3\frac{\Delta c}{c} + 4\frac{\Delta d}{d}\right) \times 100\%$$

$$\therefore \quad \text{Relative error in } P = \left(\frac{1}{2} \times 2 + 2 \times 1 + 3 \times 3 + 4 \times 5\right)\%$$

$$= 32\%$$

Previous Year's Questions

1. (d) : Time period of a spring, $T = 2\pi\sqrt{\dfrac{k}{m}}$

where m is the mass of spring and k is the spring constant.

$$\therefore \quad \frac{\Delta T}{T} \times 100 = \frac{1}{2}\frac{\Delta k}{k} \times 100 + \frac{1}{2}\frac{\Delta m}{m} \times 100$$

$$\text{or} \quad 2 = \frac{1}{2} \times \frac{\Delta k}{k} \times 100 - \frac{1}{2} \times 1$$

$$\text{or} \quad 2 = \frac{1}{2}\left[\frac{\Delta k}{k} \times 100 - 1\right] \text{ or } \quad \frac{\Delta k}{k} \times 100 = 2 \times 2 + 1 = 5$$

$\therefore$ Percentage error in k is 5%.

2. (a) : (A) 1001 has 4 significant figure.
(B) 010.1 has 3 significant figure.
(C) 100.100 has 6 significant figure.
(D) 0.0010010 has 5 significant figure.

3. (d) : Dimensions of gravitational constant,
$[G] = [M^{-1}L^3T^{-2}]$

Dimensions of energy density

$$[u] = \frac{[E]}{V} = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$$

Dimensions of $\sqrt{uG}$,

$$[\sqrt{uG}] = \left[\sqrt{[ML^{-1}T^{-2}] \times [M^{-1}L^3T^{-2}]}\right]$$

$$= \left[\sqrt{[L^2T^{-4}]}\right] = [LT^{-2}]$$

The dimensions of $\sqrt{uG}$ is same as the dimensions of Force per unit mass. So, option (d) is correct.

4. (a) : Solid angle is the ratio of area to the square of perpendicular distance.

$$\Omega = \frac{S}{r^2} = \frac{M^0L^2T^0}{M^0L^2T^0} = [M^0L^0T^0]$$

$$\text{Strain} = \frac{\Delta L}{L} = \frac{M^0L^1T^0}{M^0L^1T^0} = [M^0L^0T^0]$$

$$\text{Angle} = \frac{\text{Arc}}{\text{length}} = \frac{M^0L^1T^0}{M^0L^1T^0} = [M^0L^0T^0]$$

5. (d) : Given : $V = (200 \pm 5)$ V ; $I = (20 \pm 2)$ A

As, $R = \dfrac{V}{I}$

To find % error in R; $\dfrac{\Delta R}{R} \times 100 = \dfrac{\Delta V}{V} \times 100 + \dfrac{\Delta I}{I} \times 100$

$$= \frac{5}{200} \times 100 + \frac{0.2}{20} \times 100 = 2.5 + 1 = 3.5\%$$

6. (b) : Mobility, $\mu = \dfrac{\text{Drift velocity } (v_d)}{\text{Electric field } (E)}$

$$\therefore \quad [\mu] = \frac{[v_d]}{[E]} = \frac{[M^0LT^{-1}]}{[MLT^{-3}A^{-1}]} = [M^{-1}T^2A]$$

7. (b) : True value = 3.678 cm

Accuracy of a measurement is a measure of how close the measured value is to the true value of the length. Here, measured value i.e., 3.5 cm is more closer to true value (3.678 cm) as compared to 3.38 cm.

Hence, 3.5 cm measured by instrument A is more accurate.

Now, precision tells us to what resolution the value is calculated. The more number of digits after decimal, the

more is the precision of the measurements. Here, 3.38 cm has 2 digits after the decimal as compared to 3.5 cm which has only 1 digit after the decimal. Hence, the 3.38 cm measured by the instrument *B* is more precise measurement.

8. (d) : Measured length of pendulum,
$l = (25 \pm 0.1)$ cm
Measured time for 100 oscillations, $t = (100 \pm 1)$ s

$\therefore$ Time period, $T = \frac{(100 \pm 1)}{100}$ or $T = (1 \pm 0.01)$s

We know that, time period of a simple pendulum is given by, $T = 2\pi\sqrt{\frac{l}{g}}$

or $g = \frac{l}{T^2}(2\pi)^2$ or $\frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$

$= \frac{0.1}{25} + 2 \times \frac{0.01}{1} = 0.004 + 0.02 = 0.024$

or $\frac{\Delta g}{g} \times 100 = 2.4\%$

9. (b) : Percentage error in x is given by

$$\frac{\Delta x}{x} \times 100 = \left(2\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + \frac{\Delta c}{c}\right) \times 100$$

$$\Rightarrow \quad \frac{\Delta x}{x} = 2 \times 2 + 2 \times 3 + 4$$

$$\frac{\Delta x}{x} \times 100 = 14\%$$

10. (b) : Plank's constant and angular momentum have same dimensions as, $L = mvr = n\hbar$.
Dimension of linear momentum, $[P] = [MLT^{-1}]$
Dimension of moment of force $(\tau) = [ML^2T^{-2}]$
Hence, statement II false.

Most Probable Questions

1. (d) : (a) Pressure, Young's modulus and stress have same dimensional formula

$$[P] = [Y] = [\sigma] = \frac{[\text{Force}]}{[\text{Area}]} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

(b) emf, potential difference and electric potential have dimensional formula

$$[\varepsilon] = [\Delta V] = [V] = \frac{[\text{Energy}]}{[\text{Charge}]} = \frac{[ML^2T^{-2}]}{[AT]} = [ML^2T^{-3}A^{-1}]$$

(c) Heat, work done and energy all have the dimensional formula of energy.
(d) Dipole moment = charge × distance
$= [AT] \times [L] = [LTA]$

Electric field $[E] = \frac{[F]}{[q]} = \frac{[MLT^{-2}]}{[AT]} = [MLT^{-3}A^{-1}]$

Electric flux $[\phi] = [E][A] = [MLT^{-3}A^{-1}][L^2] = [ML^3T^{-3}A^{-1}]$

2. (c) : $Y = \frac{4MgL}{\pi D^2 l}$. So maximum permissible error in Y is

$$\frac{\Delta Y}{Y} \times 100 = \left(\frac{\Delta M}{M} + \frac{\Delta g}{g} + \frac{\Delta L}{L} + \frac{2\Delta D}{D} + \frac{\Delta l}{l}\right) \times 100$$

$$\left(\frac{1}{500} + \frac{1}{981} + \frac{1}{4612} + 2 \times \frac{1}{44} + \frac{1}{67}\right) \times 100$$

$= (0.064 \times 100) = 6.4\%$

3. (a) : Dimension of $\alpha t = [M^0L^0T^0]$ $\therefore$ $[\alpha] = [T^{-1}]$

Again $\left[\frac{v_0}{\alpha}\right] = [L]$, so $[v_0] = [LT^{-1}]$

4. (a) : $[S] = \left[\frac{hr\rho g}{2\cos\theta}\right] = [L \times L \times ML^{-3} \times LT^{-2}] = [ML^0T^{-2}]$

5. (a) : $[P] = \left[\frac{a}{V^2}\right]$, $a = [P][V^2]$

$$[a] = \left[\frac{\text{force}}{\text{Area}} \times (\text{Volume})^2\right] = \frac{[MLT^{-2}] \times [L^6]}{[L^2]}$$

$[a] = [ML^5T^{-2}]$

6. (d) : Percentage error in A

$$= \left(2 \times 1 + 3 \times 3 + 1 \times 2 + \frac{1}{2} \times 2\right)\% = 14\%.$$

7. (b) : Moment of inertia $(I) = Mr^2$
$\therefore$ $[I] = [ML^2]$
Moment of force $F = [ML^2T^{-2}]$
Hence, moment of inertia and moment of force does not have same dimension.

8. (a) : Physical quantities having different dimensions cannot be added or subtracted.
As P, Q and R are physical quantities having different dimensions, therefore they can neither be added nor be subtracted.

9. (d) : $\lambda = \frac{h}{\sqrt{2mE}}$

$[h] = [\lambda \sqrt{2mE}] = [L(M \cdot ML^2T^{-2})^{1/2}] = [LMLT^{-1}]$
$= [ML^2T^{-1}]$

10. (c) : Let us write the dimension of various quantities on two sides of the given relation.
L.H.S. $= T = [T]$,

$$\text{R.H.S.} = 2\pi\sqrt{g/l} = \sqrt{\frac{[LT^{-2}]}{[L]}} = [T^{-1}]$$

($\because$ 2π has no dimensions). As dimensions of L.H.S. is not equal to dimensions of R.H.S. Therefore, according to principle of homogeneity of dimensions the relation $T = 2\pi\sqrt{\frac{g}{l}}$ is not valid.

❍❍❍

CHAPTER 1

Units and Measurement

Solutions (Class Discussion)

1. (c) : System of units is a complete set of fundamental and derived unit.

2. (d) : Calorie, kilowatt hour, joule all are the units of energy whereas watt is the unit of power.

3. (b) : The equivalent resistance of series combination is

$R_s = R_1 + R_2 = 300\ \Omega + 500\ \Omega = 800\ \Omega$

The error in equivalent resistance is given by

$\Delta R = (\Delta R_1 + \Delta R_2) = (3 + 4)\ \Omega = 7\ \Omega$

Hence, the equivalent resistance along with error is $(800 \pm 7)\ \Omega$.

4. (d) : The number 3.845 rounded off to three significant figures becomes 3.84 since the preceding digit is even. On the other hand, the number 3.835 rounded off to three significant figures becomes 3.84 since the preceding digit is odd.

5. (b) : As per rules of significant figures, 4.8000×10^4 has 5 significant figures and 48000.50 has 7 significant figures.

6. (b) : Relative density is the ratio of two like quantities. Therefore, it has neither unit nor dimensions.

7. (b) : Tension is force and surface tension is force/length. So they do not have the same dimensions.

8. (c) : $\text{L.C.} = \frac{1}{100} = 0.01\ \text{mm}$

Linear scale reading = 6(pitch) = 6 mm

Circular scale reading = $40 \times 0.01 = 0.4$ mm

$\therefore$ Total reading = (6 + 0.4) = 6.4 mm

9. (a) : From $F = at + bt^2$

$$[a] = \frac{[F]}{[t]} = \frac{[\text{MLT}^{-2}]}{[\text{T}]} = [\text{MLT}^{-3}]$$

$$[b] = \frac{[F]}{[t^2]} = \frac{[\text{MLT}^{-2}]}{[\text{T}^2]} = [\text{MLT}^{-4}]$$

10. (a) : Here, mass of the box, $m = 2.3$ kg

Mass of one gold piece, $m_1 = 20.15$ g = 0.02015 kg

Mass of other gold piece, $m_2 = 20.17$ g = 0.02017 kg

$\therefore$ Total mass = $m + m_1 + m_2$

= 2.3 kg + 0.02015 kg + 0.02017 kg = 2.34032 kg

As the result is correct only upto one place of decimal, therefore, on rounding off, we get total mass = 2.3 kg

11. (b) : 1 u = 931.5 MeV/c^2.

12. (b) : As area = length × breadth, as per rules numerical value of area has four significant digits. Therefore, (b) is the correct choice.

13. (a) : Torque and work have same dimensions.

14. (b) : Energy = force × distance; so when the units of force and length or distance are doubled, the unit of energy will become 4 times that of its initial value.

15. (c) : Angular frequency = $2\pi \times$ Frequency

$= [\text{T}^{-1}] = [\text{M}^0\text{L}^0\text{T}^{-1}]$ $\quad \therefore \ a = 0, b = 0, c = -1$

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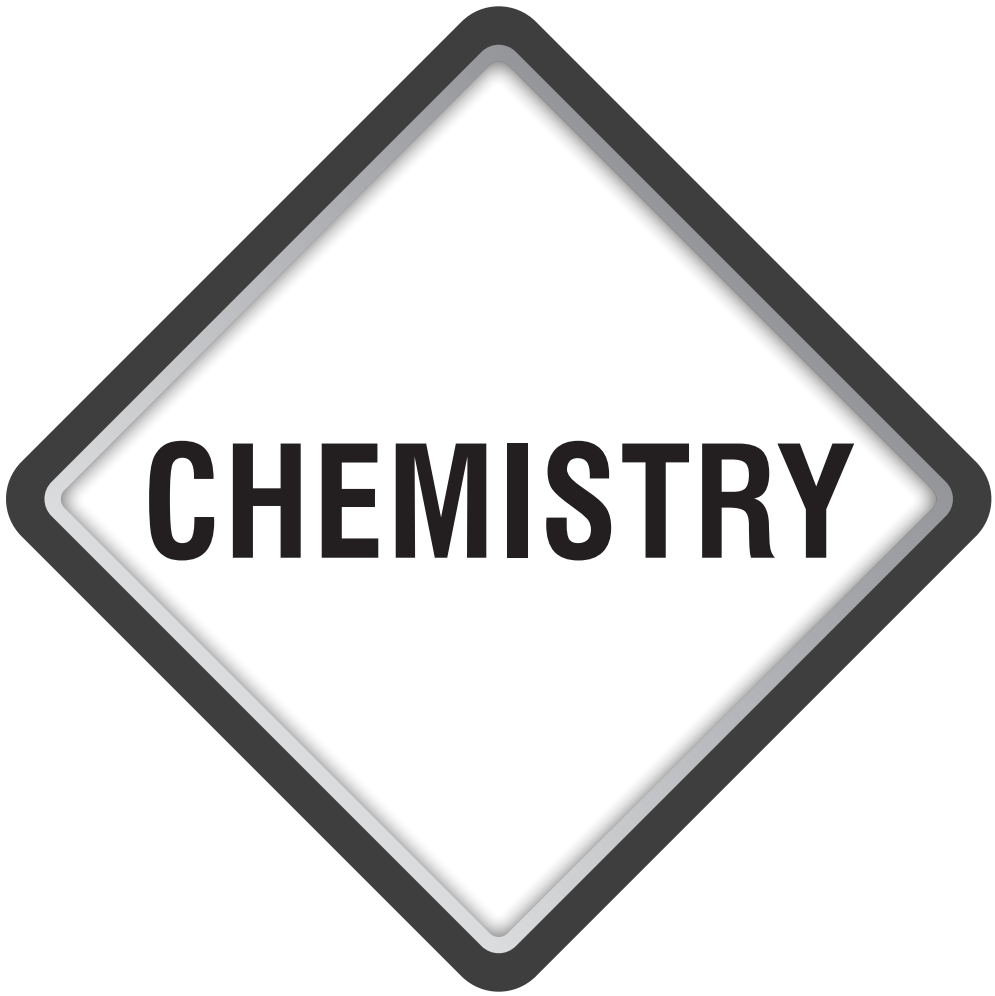

CHEMISTRY

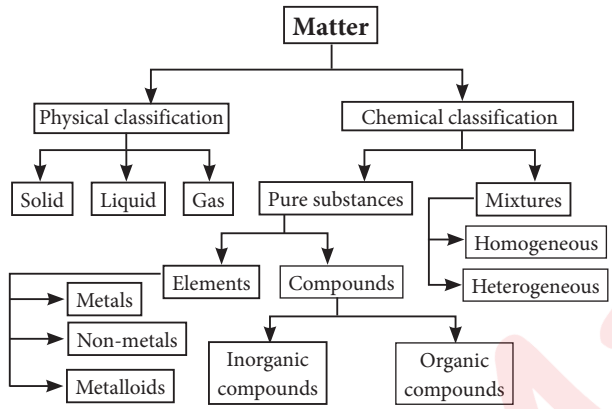
CHAPTER 1

Some Basic Concepts of Chemistry

Matter

Anything which occupies space and has mass is called matter. It is made up of small particles which have spaces between them. The matter particles attract each other and are in a state of continuous motion.

Classification of Matter



Atoms and Molecules

- An atom is the smallest particle of an element which can take part in a chemical reaction. It may or may not be capable of independent existence.
- A molecule is the smallest particle of an element or a compound which is capable of independent existence.

Elements → Pure substance that contains only one kind of atoms → C, H, O, etc.

Compounds → Pure substance which is formed by combining two or more elements in a definite ratio → CO_2, H_2O

Mixtures → Made by mixing two or more substances in any ratio.
→ Air, tap water

Units and Measurements

- The units of mass, length and time are called **fundamental units** since they are independent units and cannot be derived from any other units. They are also called **base units**.
- The units for other quantities which can be derived from fundamental units are called **derived units.**
- The units adopted by the General Conference on Weights and Measures are known as **SI units**.

S.I. Units (International System of Units)

- The International System of Units (SI, in French Systeme Internationale) or metric system, is a decimal system of unit for measurement of mass, length, time (fundamental units) and other physical quantities (desired units).

The SI system has seven base units that are listed in the following table :

Physical quantity	Symbol for quantity	Name of unit	Symbol for unit
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	second	s
Thermodynamic temperature	T	kelvin	K
Electric current	I	ampere	A
Luminous intensity	I_v	candela	cd
Amount of substance	n	mole	mol

Precision and Accuracy

Every experimental measurement has some amount of uncertainty associated with it. However, one would always like the results to be precise and accurate.

- **Precision :** It refers to the closeness of various measurements for the same quantity.
- **Accuracy :** It is the agreement of a particular value to the true value of the result.

Significant Figures

- Significant figures are meaningful digits which are known with certainty. The uncertainty is indicated by writing the certain digits and the last uncertain digit.
- **Rules for determining the number of significant figures:**
  - All non-zero digits are significant.
  - A zero becomes significant when it comes in between two non-zero numbers.
  - Zeros at the beginning of a number are not significant.
  - All zeros to the right of a number are significant.

Dimensional Analysis

- The expression of any particular quantity in terms of fundamental quantity is known as **dimensional analysis.**

- This is done by using conversion factor (C.F.), which is a factor equal to one that converts a quantity in one unit to the same quantity in another unit. Some conversion factors are as follows :
  $1\ J = 10^7$ erg, 1 atm = 760 torr = 760 mm Hg

Laws of Chemical Combination

Law of Conservation of Mass

It states that during any physical or chemical change, total mass of products is equal to the total mass of reactants.

Law of Definite Proportions

It states that a given compound always contains exactly the same definite proportion of elements by weight.

Law of Multiple Proportions

It states that when two or more elements combine to form two or more compounds, the different weights of one of the elements which combine with the fixed weight of the other element bear a simple whole number ratio to one another.

Gay Lussac's Law of Gaseous Volumes

It states that under similar conditions of temperature and pressure, whenever gases react together, the volumes of the reacting gases as well as products bear a simple whole number ratio.

Avogadro's Law

"Equal volumes of gases under similar conditions of temperature and pressure should contain equal number of molecules".

Dalton's Atomic Theory

In 1808, a Greek philosopher, John Dalton published 'A new system of chemical philosophy' in which he proposed the atomic theory of nature which is known as Dalton's atomic theory.

Postulates of Dalton's Atomic Theory

- The matter is made up of extremely small, indivisible particles known as atoms.
- Atoms can neither be created nor destroyed, *i.e.*, atoms are indestructible.
- The formation of new products (compounds) results from the rearrangement of existing atoms (reactants).
- Atoms of same or different elements combine in fixed ratios to form compounds.
- All the atoms of an element have identical properties including mass and size but atoms of two different elements differ in properties and have different mass and size.

Atomic and Molecular Masses

Atomic Mass

Atomic mass of an element is a number which indicates as to how many times an atom of that element is heavier, on an average, as compared with 1/12 of the mass of an atom of carbon-12 ($^{12}_{6}C$). Since the atomic mass is a ratio, it has no unit. However it is expressed in amu (atomic mass unit) or u (unified mass).

$$1 \text{ amu} = \frac{1}{12} \times \text{mass of C-12 atom}$$

$$= \frac{1}{12} \times \frac{12 \text{ g}}{6.022 \times 10^{23}} = 1.66 \times 10^{-24} \text{ g}$$

- **Gram atomic mass:** It is the mass in gram of one mole of atoms in a monoatomic element. It is numerically equal to the atomic mass in amu.
  No. of gram atoms or mole atoms

$$= \frac{\text{Mass of an element (in g)}}{\text{Gram atomic mass}}$$

- **Atomic mass unit :** One atomic mass unit is defined as a mass exactly equal to one-twelfth the mass of one carbon-12 atom.
  $1 \text{ amu} = 1.66056 \times 10^{-24}$ g

$$\text{At. mass of element} = \frac{\text{Mass of one atom of the element}}{1 \text{ amu}}$$

- **Average atomic mass :** Average atomic mass of an element can be calculated as,
  Average atomic mass

$$= \frac{\text{R.A.}(1) \times \text{At. mass } (1) + \text{R.A. } (2) \times \text{At. mass } (2)}{\text{R.A. } (1) + \text{R.A. } (2)}$$

  Here R.A. = Relative abundance

Molecular Mass

The molecular mass of a substance also called as molecular weight is obtained by multiplying the atomic mass of each element by the number of its atoms and then adding them together.

- **Gram molecular mass :** The molecular mass of a substance expressed in grams is called its gram molecular mass.
  e.g., Molecular mass of $CaCO_3$ = 100 u
  Gram molecular mass of $CaCO_3$ = 100
  - No. of g molecules or mole molecules

$$= \frac{\text{Mass of substance in g}}{\text{Gram molecular mass}}$$

  - Mass of substance in g
    = No. of g molecules × Gram molecular mass

Formula Mass

- The smallest unit of an ionic compound is a formula unit. The mass of this formula unit is called the formula mass.
- The formula mass of a substance is the sum of the atomic masses of all atoms in a formula unit of the substance expressed in amu.

Mole Concept and Molar Masses

- A mole (mol) is defined as the number of atoms in 12.00 g of carbon-12. The number of atoms in 12 g of carbon-12 has been found experimentally to be 6.022×10^{23}. This number is also known as **Avogadro's number**.
- The mass of one mole atoms of any element is exactly equal to the atomic mass in grams (gram-atomic mass or gram atom) of that element.

- One mole of any substance will have mass equal to formula mass of that substance expressed in grams.
- Number of moles of a substance

$$= \frac{\text{Mass of substance in gram}}{\text{Molecular mass of substance in gram}}$$

$$= \frac{\text{No. of particles}}{6.022 \times 10^{23}}$$

- Mass of one atom of an element

$$= \frac{\text{Gram atom of an element}}{6.022 \times 10^{23}}$$

- Mass of one molecule of a substance

$$= \frac{\text{Gram-molecular mass of the substance}}{6.022 \times 10^{23}}$$

- Number of molecules

$$= \frac{\text{Volume of gas in litres at NTP}}{22.4} \times 6.022 \times 10^{23}$$

Percentage Composition

- Percentage composition of the element is the relative mass of each of the constituent element in 100 parts of it. It can be calculated if we know the molecular mass of compound.
- Suppose the molecular mass of a compound be M and X be the mass of an element in the molecule.
  % of element

$$= \frac{\text{Mass of the element}}{\text{Molecular mass of compound}} \times 100 = \frac{X}{M} \times 100$$

Empirical Formula

It represents the simplest relative whole number ratio of atoms of each element present in the molecule of the substance. For example, CH is the empirical formula of benzene.

Determination of empirical formulae

- The percentage composition of the compound is determined by quantitative analysis.
- The percentage of each element is divided by its atomic mass. It gives atomic ratio of the elements present in the compound.
- The atomic ratio of each element is then divided by the minimum value of atomic ratio as to get the simplest ratio of atoms of elements present in the compound.
- If the simplest ratio is fractional, then value of simplest ratio of each element is multiplied by a smallest integer to get a simplest whole number for each of the element.
- To get the empirical formula, symbols of various elements present are written side by side with their respective whole number ratio as subscript to the lower right hand corner of the symbol.

Molecular Formula

- It represents the exact number of the atoms of the elements present in its one molecule. The sum of atomic masses of the atoms representing molecule, is called molecular mass.
- **Relationship between empirical and molecular formula :**
  Molecular formula = Empirical formula × n
  where n is simple whole number having value of 1, 2, 3, ... etc., and can be calculated as

$$n = \frac{\text{Molecular formula mass}}{\text{Empirical formula mass}}$$

Chemical Equations

- A chemical equation is a symbolic representation of a true chemical change.
- The substance which is converted to another substance is known as **reactant**.
- The substance which is formed during chemical change is known as **product**.
- The symbols of reactants are written on the left hand side of ⟶ sign and the symbols of products on the right hand side.

$$\underbrace{2H_2 + O_2}_{\text{Reactants}} \rightarrow \underbrace{2H_2O}_{\text{Product}}$$

Stoichiometry and Stoichiometric Calculations

One of the most important aspects of a chemical equation is that when it is written in the balanced form, it gives quantitative relationship between the various reactants and products in terms of moles, molecules, masses and volumes. This is called stoichiometry (Greek word meaning 'to measure an element').

Limiting Reagent

- The reagent which gets consumed and limits the amount of product formed is the limiting reagent. With the help of limiting reagent, the amount of the excess reagent which has been utilised and the amount remaining can be calculated.

Reactions in Solutions

A majority of reactions in the laboratories are carried out in solutions. Therefore, it is important to understand as how the amount of substance is expressed when it is present in the solution. The concentration of a solution can be expressed by the following terms:

- **Molarity (M)**

$$\text{Molarity } (M) = \frac{\text{Number of moles of solute}}{\text{Volume of solution (in L)}}$$

- **Normality (N)**

$$\text{Normality} = \frac{\text{Number of gram-equivalents of solute}}{\text{Volume of solution (in L)}}$$

Normality = Molarity × Valency factor

$N = M \times n$

- **Molality (m)**

$$\text{Molality} = \frac{\text{Number of moles of solute}}{\text{Weight of solvent (in kg)}}$$

- **Mole Fraction (x)**
  Suppose a solution contains components A and B,
  Mole fraction of A (x_A)
  $$= \frac{\text{No. of moles of } A\ (n_A)}{\text{No. of moles of } A\ (n_A) + \text{No. of moles of } B\ (n_B)}$$
  $$x_A = \frac{n_A}{n_A + n_B}$$
  Similarly, $x_B = \frac{n_B}{n_A + n_B}$
  Also, $x_A + x_B = 1$
- **Percent by Mass**
  $$\text{Percent by mass} = \frac{\text{Weight of solute}}{\text{Weight of solution}} \times 100$$

Class Discussion

1. Statement I : When a concentrated solution is diluted by adding more water, molarity of the solution remains constant.
Statement II : Number of moles of a solute divided by volume is equal to the molarity.
(a) Both Statement I and Statement II are correct.
(b) Statement I is correct but Statement II is incorrect.
(c) Both Statement I and Statement II are incorrect.
(d) Statement I is incorrect but Statement II is correct.

2. How many moles of electron would weigh one kilogram?
(a) 6.022×10^{23} (b) $\frac{1}{9.108} \times 10^{23}$
(c) $\frac{6.022 \times 10^{54}}{9.108}$ (d) $\frac{1}{9.108 \times 6.022} \times 10^{8}$

3. Which of the following statements best explains the law of conservation of mass?
(a) 100 g of water is heated to give steam.
(b) A sample of N_2 gas is heated at constant pressure without any change in mass.
(c) 36 g of carbon combines with 32 g of oxygen to form 68 g of CO_2.
(d) 10 g of carbon is heated in vacuum without any change in mass.

4. The mass of 10 molecules of naphthalene ($C_{10}H_8$) is
(a) 2.12×10^{-22} g (b) 2.12×10^{-21} g
(c) 2.12×10^{-23} g (d) 1280 g

5. A molal solution is one that contains one mole of a solute in
(a) 1000 g of the solvent (b) one litre of the solvent
(c) one litre of the solution (d) 22.4 litres of the solution.

6. Law of constant composition does not hold good for
(a) exothermic compounds
(b) stoichiometric compounds
(c) endothermic compounds
(d) non-stoichiometric compounds.

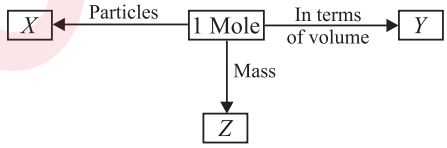
7. Which of the following gases will have least volume if 10 g of each gas is taken at same temperature and pressure?
(a) CO_2 (b) N_2 (c) CH_4 (d) HCl

8. Match the mass of elements given in column I with the number of moles given in column II and select the correct option.

Column I		Column II	
(A)	28 g of He	(p)	2 mol
(B)	46 g Na	(q)	7 mol
(C)	60 g of Ca	(r)	1 mol
(D)	27 g of Al	(s)	1.5 mol

(a) A – (s), B – (r), C – (q), D – (p)
(b) A – (p), B – (r), C – (q), D – (s)
(c) A – (r), B – (q), C – (p), D – (s)
(d) A – (q), B – (p), C – (s), D – (r)

9. Fill in the blanks by choosing the correct options.



	X	*Y*	*Z*
(a)	6.022×10^{23} molecules	22.4 L at any pressure	Gram molecular mass
(b)	6.022×10^{23} atoms/molecules	22.4 L at NTP	Gram atomic mass
(c)	6.022×10^{23} atoms	22.4 L at any temperature	1 gram mole
(d)	6.022×10^{23} particles	11.2 L at NTP	Molar volume

10. The empirical formula of a compound is CH_2O_2. What could be its molecular formula?
(a) $C_2H_2O_2$ (b) $C_2H_2O_4$
(c) $C_2H_4O_4$ (d) CH_4O_4

11. 6.022×10^{20} molecules of urea are present in 100 mL solution. The mole of urea in solution is
(a) 0.1 (b) 0.01
(c) 0.02 (d) 0.001

12. Which of the following statements about Avogadro's hypothesis is correct?
(a) Under similar conditions of temperature and pressure, gases react with each other in simple ratio.
(b) Under similar conditions of temperature and pressure, equal volumes of all gases contain same number of molecules.

(c) At NTP all gases contain same number of molecules.
(d) Gases always react with gases only at the given temperature and pressure.

13. The mass of one molecule of carbon dioxide is
(a) 26.49×10^{24} g (b) 44 g
(c) 7.30×10^{-23} g (d) 22 g

14. 12 g of Mg (atomic mass = 24) on reacting completely with acid gives hydrogen gas, the volume of which at STP would be
(a) 22.4 L (b) 11.2 L
(c) 44.8 L (d) 6.1 L

15. Which of the following statements illustrates the law of multiple proportions?
(a) An element forms two oxides, XO and XO_2 containing 50% and 60% oxygen respectively. The ratio of masses of oxygen which combines with 1 g of element is 2 : 3.
(b) Hydrogen sulphide contains 5.89% hydrogen, water contains 11.1% hydrogen and sulphur dioxide contains 50% oxygen.
(c) 3.47 g of $BaCl_2$ reacts with 2.36 g Na_2SO_4 to give 3.88 g $BaSO_4$ and 1.95 g NaCl.
(d) 20 mL ammonia gives 10 volumes N_2 and 30 volumes H_2 at constant temperature and pressure.

Home Assignment

1. How many grams of H_2SO_4 are present in 0.25 mole of H_2SO_4?
(a) 2.45 (b) 24.5 (c) 0.245 (d) 0.25

2. If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change
(a) the mass of one mole of carbon
(b) the ratio of chemical species to each other in a balanced equation
(c) the ratio of elements to each other in a compound
(d) the definition of mass in units of grams.

3. With increase of temperature, which of these changes?
(a) Molality
(b) Weight fraction of solute
(c) Fraction of solute present in water
(d) Mole fraction

4. In a mixture of gases, the volume content of a gas is 0.06% at STP. Calculate the number of molecules of the gas in 1 L of the mixture.
(a) 1.613×10^{23} (b) 6.022×10^{23}
(c) 1.61×10^{27} (d) 1.61×10^{19}

5. How many atoms are contained in one mole of sucrose ($C_{12}H_{22}O_{11}$)?
(a) $20 \times 6.022 \times 10^{23}$ atoms/mol
(b) $45 \times 6.022 \times 10^{23}$ atoms/mol
(c) $5 \times 6.022 \times 10^{23}$ atoms/mol
(d) None of these

6. Cortisone is a molecular substance containing 21 atoms of carbon per molecule. The mass percentage of carbon in cortisone is 69.98%. Its molar mass is
(a) 176.5 (b) 252.2 (c) 287.6 (d) 360.1

7. **Assertion :** Combustion of 16 g of methane gives 18 g of water.
Reason : In the combustion of methane, 2 moles of water and 1 mole of carbon dioxide are produced.
(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

8. n g of substance X react with m g of substance Y to form p g of substance R and q g of substance S. This reaction can represented as, $X + Y = R + S$. The relation which can be established in the amount of the reactants and the products will be
(a) $n - m = p - q$ (b) $n + m = p + q$
(c) $n = m$ (d) $p = q$

9. Two elements 'P' and 'Q' combine to form a compound. Atomic mass of 'P' is 12 and 'Q' is 16. Percentage of 'P' in the compound is 27.3. What will be the empirical formula of the compound?
(a) P_2Q_2 (b) PQ (c) P_2Q (d) PQ_2

10. 5 mol of SO_2 and 5 mol of O_2 are allowed to react to form SO_3 in closed vessel. At the equilibrium stage, 60% of SO_2 is used up. The total number of moles of SO_2, O_2 and SO_3 in the vessel now is
(a) 10.5 (b) 3.9 (c) 10.0 (d) 8.5

11. Given that 10 g of a dibasic acid (mol. mass =100) are present in 500 mL aqueous solution. The density of the solution is 1.02 g mL^{-1}. Match the entries of column I with appropriate entries of column II and choose the correct option.

	Column-I		Column-II
(A)	Normality of the solution	(i)	0.98
(B)	Molality of the solution	(ii)	0.996
(C)	Mole fraction of solvent	(iii)	0.2
(D)	Mass fraction of solvent	(iv)	0.4

(a) (A) → (i), (B) → (iv), (C) → (iii), (D) → (ii)
(b) (A) → (iv), (B) → (iii), (C) → (ii), (D) → (i)
(c) (A) → (ii), (B) → (iv), (C) → (i), (D) → (iii)
(d) (A) → (i), (B) → (iii), (C) → (iv), (D) → (ii)

12. The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is
(a) 40 (b) 10 (c) 20 (d) 30

13. 10 g $CaCO_3$ on heating leaves behind a residue weighing 5.6 g. Carbon dioxide released into the atmosphere at STP will be
(a) 2.24 L (b) 4.48 L
(c) 1.12 L (d) 0.56 L.

14. The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 mL of 2 M HCl will be
(a) 0.975 M (b) 0.875 M
(c) 1.00 M (d) 1.75 M

15. What volume of hydrogen gas, at 273 K and 1 atm pressure will be consumed in obtaining 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen?
(a) 89.6 L (b) 67.2 L (c) 44.8 L (d) 22.4 L

Previous Years' Questions

1. 1 gram of sodium hydroxide was treated with 25 mL of 0.75 M HCl solution, the mass of sodium hydroxide left unreacted is equal to
(a) 750 mg (b) 250 mg
(c) zero mg (d) 200 mg

2. Haemoglobin contains 0.34% of iron by mass. The number of Fe atoms in 3.3 g of haemoglobin is
(Given : At. mass of Fe is 56 u, $N_A = 6.022 \times 10^{23}\ mol^{-1}$)
(a) 1.21×10^5 (b) 12.0×10^{16}
(c) 1.21×10^{20} (d) 3.4×10^{22}

3. The highest number of helium atoms is in
(a) 4 mol of helium
(b) 4 u of helium
(c) 4 g of helium
(d) 2.271098 L of helium at STP

4. If a substance '*A*' dissolves in solution of a mixture of '*B*' and '*C*' with their respective number of moles as n_A, n_B and n_C. Mole fraction of *C* in the solution is
(a) $\frac{n_C}{n_A - n_B - n_C}$ (b) $\frac{n_C}{n_A + n_B + n_C}$
(c) $\frac{n_C}{n_A \times n_B \times n_C}$ (d) $\frac{n_B}{n_A + n_B}$

5. Choose the incorrect statement about Dalton's Atomic Theory.
(a) Chemical reactions involve reorganization of atoms.
(b) Matter consists of indivisible atoms.
(c) Compounds are formed when atoms of different elements combine in any ratio.
(d) All the atoms of a given element have identical properties including identical mass.

6. A compound *X* contains 32% of *A*, 20% of *B* and remaining percentage of *C*. Then, the empirical formula of *X* is
(Given atomic masses of *A* = 64; *B* = 40; *C* = 32 u)
(a) A_2BC_2 (b) ABC_3 (c) AB_2C_2 (d) ABC_4

7. SO_2Cl_2 on reaction with excess of water results into acidic mixture, $SO_2Cl_2 + 2H_2O \longrightarrow H_2SO_4 + 2HCl$
16 moles of NaOH is required for the complete neutralisation of the resultant acidic mixture. The number of moles of SO_2Cl_2 used is
(a) 16 (b) 8 (c) 4 (d) 2

8. The right option for the mass of CO_2 produced by heating 20 g of 20% pure limestone is
(Atomic mass of Ca = 40)
$[CaCO_3 \xrightarrow{1200\ K} CaO + CO_2]$
(a) 2.64 g (b) 1.32 g (c) 1.12 g (d) 1.76 g

9. The number of moles of methane required to produce 11 g $CO_{2\,(g)}$ after complete combustion is
(Given molar mass of methane in g mol^{-1} : 16)
(a) 0.35 (b) 0.5 (c) 0.25 (d) 0.75

10. The amount of zinc required to produce 224 mL of H_2 at STP on treatment with dilute H_2SO_4 will be
(a) 65 g (b) 0.065 g (c) 0.65 g (d) 6.5 g

Most Probable Questions

1. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction
$4HCl_{(aq)} + MnO_{2(s)} \rightarrow 2H_2O_{(l)} + MnCl_{2(aq)} + Cl_{2(g)}$
How many grams of HCl will react with 5.0 g of manganese dioxide?
(a) 6.4 g HCl (b) 4.8 g HCl
(c) 8.4 g HCl (d) 7.2 g HCl

2. Match the column I with column II and select the correct option.

Column I		Column II	
P.	1.4 g of nitrogen gas	1.	1.204×10^{24} atoms
Q.	64 g of sulphur (S_8)	2.	3.34×10^{25} molecules
R.	1 litre of water	3.	5.38×10^{24} electrons
S.	20 lit of NH_3 at STP	4.	4.215×10^{23} electrons

(a) P-2, Q-4, R-3, S-1 (b) P-4, Q-1, R-2, S-3
(c) P-1, Q-3, R-4, S-2 (d) P-3, Q-2, R-1, S-4

3. Suppose the chemists would have choosen 10^{20} as the number of particles in a mole, the mass of 1 mole of oxygen gas would be
(a) 5.32×10^{-43} g (b) 5.32×10^{-3} g
(c) 5.32×10^{-23} g (d) 5.32×10^{3} g

4. Assertion: 1 mole O_3= N molecules of O_3 = $3N$ atoms of O = 48 g.
Reason: A mole is the amount of matter that contains as many as objects as the number of atoms exactly in 12 g C12.
(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

5. One mole of P_4 molecules contains
(a) 1 molecule (b) 4 molecules
(c) $\frac{1}{4} \times 6.022 \times 10^{23}$ atoms (d) 24.092×10^{23} atoms.

6. How many oxygen atoms will be present in 88 g of CO_2?
(a) 24.088×10^{23} (b) 6.023×10^{23}
(c) 44×10^{23} (d) 22×10^{24}

7. 0.6 g of carbon was burnt in air to form CO_2. The number of molecules of CO_2 introduced into air will be
(a) 6.02×10^{22} (b) 3.01×10^{22}
(c) 6.02×10^{23} (d) 3.01×10^{23}

8. The number of water molecules is maximum in
(a) 1.8 gram of water (b) 18 gram of water
(c) 18 moles of water (d) 18 molecules of water.

9. Match the column I with column II and select the correct option.

Column I		Column II	
(i)	88 g of CO_2	(A)	0.25 mol
(ii)	6.022×10^{23} molecules of H_2O	(B)	2 mol
(iii)	5.6 litres of O_2 at STP	(C)	1 mol
(iv)	96 g of O_2	(D)	6.022×10^{23} molecules
(v)	1 mole of any gas	(E)	3 mol

(a) (i) - (B), (ii) - (C), (iii) - (A), (iv) - (D), (v) - (E)
(b) (i) - (A), (ii) - (D), (iii) - (E), (iv) - (B), (v) - (E)
(c) (i) - (C), (ii) - (E), (iii) - (A), (iv) - (D), (v) - (B)
(d) (i) - (B), (ii) - (C), (iii) - (A), (iv) - (E), (v) - (D)

10. What is the ratio of the masses of oxygen that are combined with 1.08 g of nitrogen in the compounds N_2O_3 and NO?
(a) 2 : 3 (b) 1 : 3
(c) 3 : 2 (d) 1 : 2

Hints & Explanations

Home Assignment

1. (b)

2. (a) : Mass of 1 mol (6.022×10^{23} atoms) of carbon = 12 g
If Avogadro number is changed to 6.022×10^{20} atoms then
mass of 1 mol of carbon $= \frac{12 \times 6.022 \times 10^{20}}{6.022 \times 10^{23}} = 12 \times 10^{-3}$ g

3. (c) : Volume increases with rise in temperature.

4. (d) : Volume of gas in 1 L = $\frac{0.06}{100} = 6 \times 10^{-4}$ L
Number of molecules of $CO_2 = n \times N_A$
$= \frac{6 \times 10^{-4}}{22.4} \times 6.022 \times 10^{23} = 1.61 \times 10^{19}$

5. (b) : Total atoms in 1 molecule of $C_{12}H_{22}O_{11}$
$= 12 + 22 + 11 = 45$
$\therefore$ Total atoms in 1 mole of $C_{12}H_{22}O_{11}$
$= 45 \times 6.022 \times 10^{23}$ atoms/mol.

6. (d) : Let molar mass be M.
Mass of 21 carbon atoms = 252

$$\% \text{ of carbon} = \frac{252 \times 100}{M} = 69.98$$

$\therefore$ $M = 360.1$

7. (d) : 16 g of methane gives 36 g of water.

8. (b) : $\underset{n\text{ g}}{X} + \underset{m\text{ g}}{Y} \rightleftharpoons \underset{p\text{ g}}{R} + \underset{q\text{ g}}{S}$
By law of conservation of mass, $n + m = p + q$.

9. (d) :

Element	%	No. of moles	Mole ratio	Whole no. ratio
P	27.3	27.3/12 = 2.27	1	1
Q	72.7	72.7/16 = 4.54	2	2

Empirical formula = PQ_2

10. (d)

11. (b)

12. (d) : Haber's process, $N_2 + 3H_2 \rightarrow 2NH_3$
2 moles of NH_3 are formed by 3 moles of H_2.
$\therefore$ 20 moles of NH_3 will be formed by 30 moles of H_2.

13. (a)

14. (b) : $M_{mix}V_{mix} = M_1V_1 + M_2V_2$

$$M_{mix} = \frac{M_1V_1 + M_2V_2}{V_{mix}} = \frac{0.5 \times 750 + 2 \times 250}{1000} = 0.875 \text{ M}$$

15. (b) : $2BCl_3 + 3H_2 \longrightarrow 6HCl + 2B$

or $BCl_3 + \frac{3}{2}H_2 \longrightarrow 3HCl + B$

10.8 g boron requires $H_2 = \frac{3}{2} \times 22.4$ L

21.6 g boron will require $H_2 = \frac{3}{2} \times \frac{22.4}{10.8} \times 21.6 = 67.2$ L

Previous Years' Questions

1. (b) : Molarity $= \frac{\text{Moles}}{\text{Volume (mL)}} \times 1000$

For HCl,

No. of moles $= \frac{M \times V(\text{mL})}{1000} = \frac{0.75 \times 25}{1000} = \frac{0.75}{40}$

Mass of HCl reacted $= \frac{0.75}{40} \times 36.5 = 0.684$ g

According to balanced equation

$\underset{1 \text{ mole}\ (40\text{ g})}{NaOH} + \underset{1 \text{ mole}\ (36.5\text{ g})}{HCl} \rightarrow NaCl + H_2O$

36.5 g HCl reacts with 40 g NaOH

0.684 g HCl will react with $\frac{40}{36.5} \times 0.684 = 0.75$ g

NaOH left unreacted = 1 – 0.75 = 0.25 g or 250 mg

2. (c) : 100 g of Hb (Haemoglobin) contain 0.34 g of Fe

1 g of Hb contain $\frac{0.34}{100}$ g of Fe

3.3 g of Hb contain $\frac{3.3 \times 0.34}{100}$ g of Fe = 0.01122 g of Fe

Now, 56 g of Fe contain = 6.022×10^{23} atoms

1 g of Fe contain = $\frac{6.022 \times 10^{23}}{56}$ atoms

$= 0.1075 \times 10^{23}$ atoms

0.01122 g of Fe contain = $0.01122 \times 0.1075 \times 10^{23}$

$= 0.00120615 \times 10^{23}$ atoms

$= 1.21 \times 10^{20}$ atoms

3. (a) : 4 mol of helium = $4 \times N_A$ atoms

4 u of helium = 1 atom

4 g of helium = 1 mol = N_A atoms

2.271098 L of helium = $\frac{2.271098}{22.7}$ mol = 0.1 mol

$= 0.1\ N_A$ atoms

4. (b) : Mole fraction is the ratio of number of moles of a particular component to the total number of moles of the solution. Thus, mole fraction of C in the solution

$= \frac{n_C}{n_A + n_B + n_C}$

5. (c) : According to Dalton's Atomic Theory, compounds are formed when atoms of different elements combine in a fixed ratio.

6. (b) :

Element	%	At. Mass	Molar Ratio	Simplest Ratio
A	32	64	$\frac{32}{64} = \frac{1}{2}$	1
B	20	40	$\frac{20}{40} = \frac{1}{2}$	1
C	48	32	$\frac{48}{32} = \frac{3}{2}$	3

Thus, empirical formula of compound is ABC_3.

7. (c) : $\underset{x \text{ mole}}{SO_2Cl_2} + 2H_2O \longrightarrow \underset{x \text{ mole}}{H_2SO_4} + \underset{2x \text{ mole}}{2HCl}$

(i) $\underset{x \text{ mole}}{H_2SO_4} + \underset{2x \text{ mole}}{2NaOH} \longrightarrow Na_2SO_4 + 2H_2O$

(ii) $\underset{2x \text{ mole}}{HCl} + \underset{2x \text{ mole}}{NaOH} \longrightarrow NaCl + H_2O$

Total number of moles of NaOH required = $4x = 16$

$\Rightarrow \quad x = 4$.

8. (d) : $\underset{40 + 12 + 16 \times 3 = 100\text{ g}}{CaCO_3} \xrightarrow{1200\text{ K}} \underset{40 + 16 = 56\text{ g}}{CaO} + \underset{44\text{ g}}{CO_2}$

100 g $CaCO_3$ produced CO_2 gas = 44 g

20 g $CaCO_3$ will produce CO_2 gas $= \frac{44}{100} \times 20 = 8.8$ g

If sample is 100% pure, CO_2 produced = 8.8 g

If sample is 20% pure, CO_2 produced $= \frac{8.8}{100} \times 20 = 1.76$ g

9. (c) : $\underset{1 \text{ mol or } 16\text{ g}}{CH_4} + 2O_2 \longrightarrow \underset{1 \text{ mol or } 44\text{ g}}{CO_2} + 2H_2O$

$11\,\text{g}\,CO_2 = \frac{11}{44} = 0.25\,\text{mol}\,CO_2$

1 mole CO_2 is produced by complete combustion of 1 mole CH_4.

$\therefore$ 0.25 mol CO_2 is produced by complete combustion of 0.25 mol CH_4.

10. (c) : $\underset{65\text{ g}}{Zn} + H_2SO_4 \rightarrow ZnSO_4 + \underset{22400\text{ mL}}{H_2}$

Since 65 g of zinc reacts to liberate 22400 mL of H_2 at STP, therefore amount of zinc needed to produce 224 mL of H_2 at STP $= \frac{65}{22400} \times 224 = 0.65$ g

Most Probable Questions

1. (c)

2. (b) : 1.4 g nitrogen gas contains

$= \frac{6.022 \times 10^{23} \times 1.4}{28}$ molecules $= 3.011 \times 10^{22}$ molecules

$= 3.011 \times 10^{22} \times 14$ electrons $= 4.215 \times 10^{23}$ electrons

64 g of S_8 contains $= \frac{6.022 \times 10^{23} \times 64 \times 8}{256}$ atoms

$= 1.2044 \times 10^{24}$ atoms

Mass of 1 lit of water = 1000 mL × 1 g/mL = 1000 g

1000 g water contains = $\frac{6.022\times10^{23}\times1000}{18}$ molecules

$= 3.34 \times 10^{25}$ molecules

20 L NH_3 contains = $\frac{6.022\times10^{23}\times20}{22.4}$ molecules

$= 5.376 \times 10^{23}$ molecules $= 5.376 \times 10^{23} \times 10$ electrons

$= 5.38 \times 10^{24}$ electrons

3. **(b) :** $\frac{32\times10^{20}}{6.022\times10^{23}} = 5.32\times10^{-3}$ g

4. **(a) :** Reason is correct explanation for the assertion.

5. **(d) :** 1 mole of $P_4 = N_A$ molecules of P_4
$= 4\ N_A$ atoms of $P_4 = 24.092 \times 10^{23}$ atoms of P_4.

6. **(a) :** Mole of $CO_2 = \frac{88}{44} = 2$ mole

Molecule of CO_2 contains, two oxygen atoms.
2 mole of CO_2 contain, oxygen atom

$= 2 \times 2 \times 6.022 \times 10^{23} = 24.088 \times 10^{23}$

7. **(b) :** $C + O_2 \longrightarrow CO_2$
12 g of C gives $CO_2 = 44$ g

0.6 g of C will give $CO_2 = \frac{44}{12} \times 0.6 = 2.2$ g

Moles of $CO_2 = \frac{2.2}{44} = 0.05$

No. of molecules $= 0.05 \times 6.022 \times 10^{23}$
$= 3.01 \times 10^{22}$

8. **(c) :** 1.8 gram of water = $\frac{6.022\times10^{23}}{18} \times 1.8$

$= 6.022 \times 10^{22}$ molecules

18 gram of water = 6.022×10^{23} molecules
18 moles of water = $18 \times 6.022 \times 10^{23}$ molecules

9. **(d) :** (i) 44 g of CO_2 = 1 mol
88 g of CO_2 = 2 mol

(ii) 6.022×10^{23} molecules of H_2O = 1 mol of H_2O

(iii) 22.4 L of O_2 at STP = 1 mol

5.6 L of O_2 at STP = $\frac{1}{22.4} \times 5.6 = 0.25$ mol

(iv) 32 g of O_2 = 1 mol

96 g of $O_2 = \frac{1}{32} \times 96 = 3$ mol

(v) 1 mole of any gas = 6.022×10^{23} molecules

10. **(c) :** In N_2O_3, ratio of mass of O by mass of N

$= \frac{48.0\text{ g}}{28.0\text{ g}} = 1.71$

In NO, ratio of mass of O by mass of N = $\frac{16.0\text{ g}}{14.0\text{ g}} = 1.14$

Ratio of masses of oxygen that are combined with 1.08 g of nitrogen in N_2O_3 and NO = $\frac{1.71/1.08}{1.14/1.08} = \frac{3}{2}$

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CHAPTER 1

Some Basic Concepts of Chemistry

Solutions (Class Discussion)

1. (d) : Molarity equation is written as $M_1V_1 = M_2V_2$ thus if the V_2 changes M_2 also changes.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{volume of solution in litre}}$$

2. (d)

3. (c) : The amount of products formed is equal to the amount of the reactants reacted.

4. (b) : Molar mass of $C_{10}H_8 = 10 \times 12 + 8 \times 1 = 128$

$$\text{Mass of 10 molecules of } C_{10}H_8 = \frac{128}{6.022 \times 10^{23}} \times 10 = 2.12 \times 10^{-21} \text{ g}$$

5. (a) : A molal solution is one that has a molality (m) = 1 *i.e.*, it contains 1 mole (gram molecular mass) of the solute in 1000 g (1 kg) of the solvent.

6. (d)

7. (a) : $\text{Number of moles} \propto \frac{1}{\text{Molecular mass}}$

Molecular mass of CO_2 = 44, N_2 = 28,
CH_4 = 16, HCl = 36.5
Thus, CO_2 will have least volume.

8. (d)

9. (b) : 1 mol = 6.022×10^{23} atoms/molecules
1 mol = Molar volume = 22.4 L at NTP
1 mol = Gram atomic mass or gram molecular mass

10. (c) : Since empirical formula is multiplied by n to get molecular formula.
CH_2O_2 will give only $C_2H_4O_4$ as its molecular formula.
$(CH_2O_2)_n$ where n = 1, 2, 3, … etc.

11. (d) : Mole of urea

$$= \frac{6.022 \times 10^{20}}{6.022 \times 10^{23}} = 10^{-3} = 0.001$$

12. (b)

13. (c) : Mass of one molecule of CO_2

$$= \frac{44}{6.022 \times 10^{23}} = 7.30 \times 10^{-23} \text{ g}$$

14. (b) : $\underset{\substack{1 \text{ mol} \\ (24 \text{ g})}}{Mg} + \underset{\text{Acid}}{2HX} \longrightarrow MgX_2 + \underset{\substack{1 \text{ mol} \\ (22.4 \text{ L})}}{H_2}$

Thus, 12 g Mg gives 11.2 L of hydrogen gas.

15. (a) : In XO, 50 g element combines with 50 g oxygen.
∴ 1 g element combines with 1 g oxygen.
In XO_2, 40 g element combines with 60 g oxygen.
∴ 1 g element combines with 1.5 g oxygen.
Thus, ratio of masses of oxygen which combines with 1 g of element is 1 : 1.5 or 2 : 3. This is in accordance with the law of multiple proportions.
In (b) the law of reciprocal proportions is followed.
In (c) law of conservation of mass is followed while in (d) Avogadro's law is followed.

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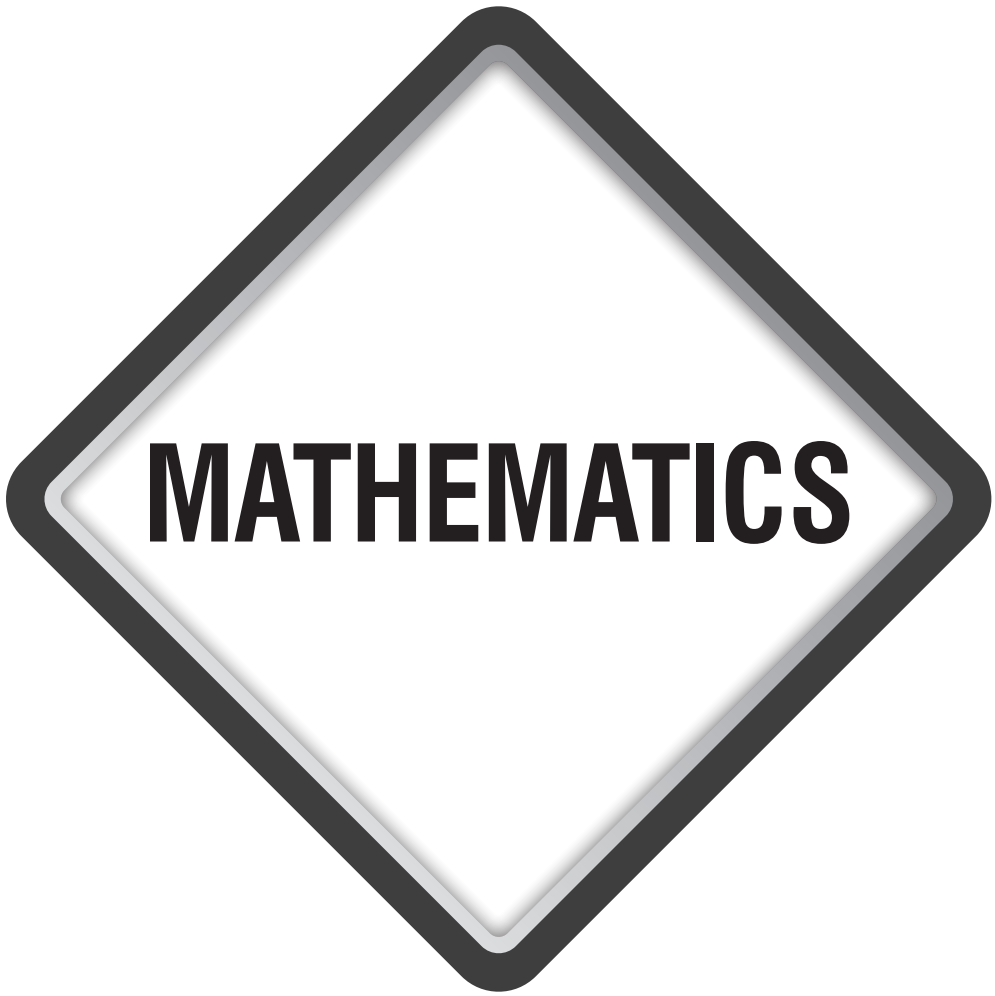

MATHEMATICS

CHAPTER 1

Sets

Definition : A well defined collection of objects is called a set.

Examples of Sets

S. No.	Set	Description
1.	N	The set of all natural numbers
2.	Z	The set of all integers
3.	Q	The set of all rational numbers
4.	R	The set of all real numbers
5.	Z^+	The set of all positive integers
6.	Q^+	The set of all positive rational numbers
7.	R^+	The set of all positive real numbers

- Sets are usually denoted by capital letters A, B, C, X, Y, Z etc.
- **Members of a Set :** All the entries in a set are called its members or elements or objects.
- The elements of a set are represented by small letters a, b, c, x, y, z, etc.
- If a is an element of a set A, then we write '$a \in A$'. We say it that 'a belongs to A'.
- If b is not an element of a set A, then we write '$b \notin A$'. We say it that 'b does not belong to A'.

Representation of a Set

S. No.	Method	Description	Example
1.	Roster or Tabular Form	All the members of the set are listed, the elements are being separated by commas and are enclosed within braces { }.	The set of perfect square natural numbers less than or equal to 50 is represented by {1, 4, 9, 16, 25, 36, 49} and W = {0, 1, 2, 3,.....}
2.	Set-builder Form	One or more variables (say x, y, etc.) are taken to represent all the properties possessed by every element of the set.	The set of all real numbers greater than –1 and less than or equal to 1 can be written as $\{x \in R : -1 < x \leq 1\}$ and $Q = \{x : x = \frac{m}{n}$; where m and n are integers and $n \neq 0$.

Note : In roster form each element is written only once. *E.g.*, the set of all the letters of the word 'MUSSOORIE' is {M, U, S, O, R, I, E}.

Types of Sets

Empty Set

A set consisting of no elements is called an empty set or a void or null set, it is denoted by ϕ or { }.

Example : $A = \{x : x$ is a natural number, $2 < x < 3\}$.

Singleton Set

A set is called singleton set if it contains a single element.

Example : $A = \{9\}$ is a singleton set.

Finite and Infinite Sets

- A set in which the process of counting of elements surely comes to an end, is called a finite set.
- A set which is not finite is called an infinite set.

Example : Let $A = \{1, 3, 5\}$ and $B = \{1, 3, 5, ... \}$
Here, the set A is finite set and B is infinite set.

Equal Sets

Two sets A and B are said to be equal, written as $A = B$, if every element of A is in B and every element of B is in A. Elements in both sets are same.

Equivalence Sets

Two finite sets are said to be equivalent, if they have the same number of distinct elements *i.e.*, $n(A) = n(B)$. Elements in both sets are different.

Example : If $A = \{1, 2, 3\}$, $B = \{a, b, c\}$ and $C = \{1, 2, 3\}$

Here sets A and C are equal, A and B are equivalent.

Note : Equal sets are always equivalent but equivalence sets are not always equal.

Disjoint Sets

Two sets are said to be disjoint if no elements are common in both sets.

Example : Let $P = \{a, b, c, d\}$, $Q = \{e, f, g\}$. Clearly P and Q have no element in common. So, P and Q are disjoint sets.

Subset

Let A and B are two sets given in such a way that every element of A is in B, then we say that A is a subset of B and we write $A \subseteq B$. If A has n elements, then number of subsets of set A is 2^n.

Super Set

If $A \subseteq B$, then B is called super set of A.

Proper Subset

- If A and B are two sets such that A is a subset of B and $A \neq B$, then we say that A is a proper subset of B and we write $A \subset B$.
- If A has n elements, then number of proper subsets is $2^n - 1$.

Note : The element of a set may be listed in any order.

- No set is a proper subset of itself.
- ϕ is a subset of every set.
- Every set is a subset of itself.

Universal Set

All sets under investigation in any application of set theory are assumed to be contained in some large fixed set called the universal set, which is denoted by U.

Intervals as Subsets of R (The Set of Real Numbers)

There are various infinite sets which can be described as subset of R(the set of real numbers), some of them are given below.

Let $a, b \in R$ and $a < b$. Then,

(i) The set $\{x : x \in R \text{ and } a < x < b\}$ is an infinite subset of R, as it contains all the numbers lying between a and b. This subset is known as **open interval** and is denoted by (a, b) or $]a, b[$.

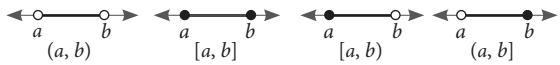
(ii) The set $\{x : x \in R \text{ and } a \leq x \leq b\}$ is an infinite subset of R, as it contains all the numbers lying between a and b, including a and b. This subset is known as **closed interval** and is denoted by $[a, b]$.

(iii) The set $\{x : x \in R \text{ and } a \leq x < b\}$ is an infinite subset of R, as it contains all the numbers lying between a and b, including a but excluding b. This subset is known as **semi-open** or **semi-closed** interval and is denoted by $[a, b)$ or $[a, b[$.

Note : The another form of this subset is $\{x : x \in R \text{ and } a < x \leq b\}$, which contains all the numbers lying between a and b, including b but excluding a. This is denoted by $(a, b]$ or $]a, b]$.

Graphical Representation

On real line (number line), various types of intervals described above as subsets of R, can be graphed as shown below.



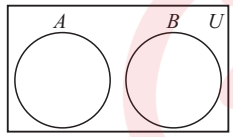
Venn Diagrams

This is a pictorial representation of various relationships between sets. It consists of rectangles and closed curves usually circles.

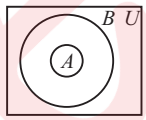
In venn diagrams, the universal set U is represented by the rectangle and its subsets are represented by circles (a closed curve).

- If two sets A and B are joint, but $A \neq B$, then we draw their venn diagram as

- If A and B are disjoint, then their venn diagram can be shown as



- If A is the proper subset of B, then their venn diagram can be shown as



Operations on Sets

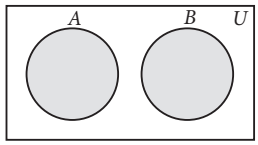
Union of Sets

The union of two sets A and B, denoted by $A \cup B$, is the set consisting of all the elements of A and B (Common elements being taken only once).

$A \cup B = \{x : x \in A \text{ or } x \in B\}$ and read as 'A union B'.

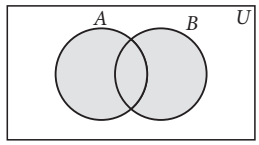
For example ; If $A = \{1, 2, 3, 4\}$ and $B = \{3, 4, 5, 6\}$, then $A \cup B = \{1, 2, 3, 4, 5, 6\}$.

- The union of two sets A and B can be represented by a Venn diagram. The shaded portion represents $A \cup B$.



$A \cup B$

(When nothing is common)



$A \cup B$

(When something is common)

Properties of Union of Sets

- $A \cup B = B \cup A$ (Commutative law)
- $(A \cup B) \cup C = A \cup (B \cup C)$ (Associative law)
- $A \cup \phi = A$ (Law of identity element, ϕ is the identity of $\cup$)
- $A \cup A = A$ (Idempotent law)
- $U \cup A = U$ (Law of U)

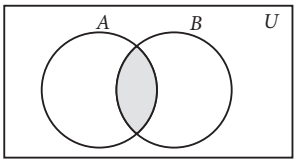
Intersection of Sets

The intersection of two sets A and B, denoted by $A \cap B$, is the set consisting of all those elements which are common to both A and B.

$A \cap B = \{x : x \in A \text{ and } x \in B\}$ and read as 'A intersection B'.

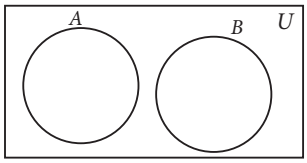
For example ; If $A = \{1, 2, 5, 6\}$ and $B = \{2, 3, 4, 5\}$, then $A \cap B = \{2, 5\}$

- The intersection of two sets A and B can be represented by a Venn diagram. The shaded portion represents $A \cap B$.



$A \cap B$

(When something is common)



$A \cap B$

(When nothing is common)

Properties of Intersection of Sets

- $A \cap B = B \cap A$ (Commutative law)
- $(A \cap B) \cap C = A \cap (B \cap C)$ (Associative law)
- $\phi \cap A = \phi$, $U \cap A = A$ (Law of ϕ and U)
- $A \cap A = A$ (Idempotent law)
- $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$ (Distributive law) *i.e.*, $\cap$ distributes over $\cup$.

Note: If A and B are two disjoint sets, then $A \cap B = \phi$,

Difference of Sets

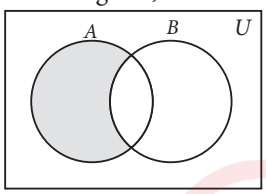
The difference of two sets, $A - B$ is the set consisting of all those elements of A, which are not in B.

$A - B = \{x : x \in A \text{ and } x \notin B\}$ and $B - A = \{x : x \in B \text{ and } x \notin A\}$

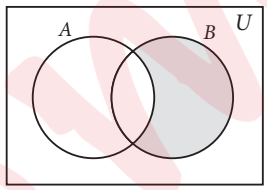
For example ; $A = \{1, 2, 4, 5, 6\}$ and $B = \{4, 6, 7, 8, 9\}$

$\therefore \quad A - B = \{1, 2, 5\}$

- The difference of two sets A and B can be represented by Venn diagram, as shown below :



$A - B$



$B - A$

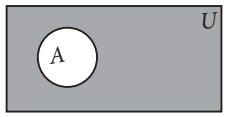
Properties of Difference of Sets

- $A - A = \phi$
- $A - \phi = A$
- $A - (B \cap C) = (A - B) \cup (A - C)$
- $A - (B \cup C) = (A - B) \cap (A - C)$

- **Symmetric Difference of Sets :** Let A and B be two sets. The symmetric difference of sets A and B is the set $(A - B) \cup (B - A)$ and is denoted by $A \Delta B$.
  $A \Delta B = (A - B) \cup (B - A) = \{x : x \notin A \cap B\}$

Complement of a Set

If U be the universal set and let A be a proper subset of U *i.e.*, $A \subset U$, then complement of A with respect to U is the set of elements which belongs to U but not present in A.



denotes A'

We denote it as A^c or A' or $\overline{A}$ or $U - A$,

$A' = \{x : x \in U \text{ but } x \notin A\}$

$\therefore \quad x \in A' \Leftrightarrow x \notin A$

Properties of Complement of Sets

- **Complement laws :**
  - $A \cup A' = U$
  - $A \cap A' = \phi$
- **De Morgan's law :**
  - $(A \cup B)' = A' \cap B'$
  - $(A \cap B)' = A' \cup B'$
- Law of double complement : $(A')' = A$
- Laws of empty set and universal set : $\phi' = U$ and $U' = \phi$

Application of Sets

If A, B, C are finite sets and U be the finite universal set, then (n denotes cardinality)

(i) $n(A \cup B) = n(A) + n(B) - n(A \cap B) = n(A-B) + n(B-A) + n(A \cap B)$, if $A \cap B \neq \phi$

(ii) $n(A \cup B) = n(A) + n(B)$, if $A \cap B = \phi$

(iii) $n(A - B) = n(A) - n(A \cap B) = n(A \cap B')$

(iv) $n(B - A) = n(B) - n(A \cap B) = n(B \cap A')$

(v) $n(A') = n(U) - n(A)$

(vi) $n((A \cup B)') = n(A' \cap B') = n(U) - n(A \cup B)$

(vii) $n((A \cap B)') = n(A' \cup B') = n(U) - n(A \cap B)$

(viii) $n(A \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(B \cap C) - n(A \cap C) + n(A \cap B \cap C)$

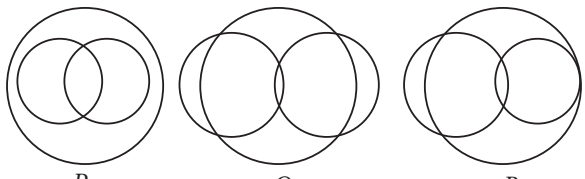
Class Discussion

1. A set T is given as $T = \{x \in R | (x - 3) = (x + 4)^2, x < 2\}$. Which of these would be TRUE about the set T?

(a) T is an empty set (b) T is a singleton set

(c) $x = 3$ is a member of T (d) $x = -4$ is a member of T

2. In a school, there are three types of games to be played. Some of the students play two types of games, but none play all the three games. Which Venn diagrams can justify the above statement?



P Q R

(a) Q and R (b) P and Q

(c) P and R (d) None of these

3. If $A = \{x \mid x \in N, x \text{ is a prime number less than } 12\}$ and $B = \{x \mid x \in N, x \text{ is a factor of } 10\}$, then $A \cap B =$
(a) $\{2\}$ (b) $\{2, 5\}$
(c) $\{2, 5, 10\}$ (d) $\{1, 2, 5, 10\}$

4. Let $U = R$. If $A = \{x \in R : 0 < x < 2\}$, $B = \{x \in R : 1 < x \leq 3\}$, then which of the following is correct?
(a) $A' = \{x \in R : x \leq 0 \text{ or } x \geq 2\}$
(b) $B' = \{x \in R : x \leq 1 \text{ or } x > 3\}$
(c) $A \cap B = \{x \in R : 1 < x < 2\}$
(d) All of these

5. For the two non-empty sets A and B, $(A \cap B) \cup (A \cap \bar{B}) \cup (\bar{A} \cap B) =$
(a) $A \cup B$ (b) A (c) $A \cap B$ (d) B

6. Which of the following is/are empty set?
$A = \{x : x^2 + x + 2 = 0 \text{ and } x \in Z\}$
$B = \{x : x \text{ is an odd prime number and } 20 \leq x < 23\}$
(a) A (b) B
(c) Both A and B (d) None of these

7. Which sets are subsets of one and another?
$A = \{x : x \in R \text{ and } x \text{ satisfy } x^2 - 8x + 12 = 0\}$, $B = \{2, 4, 6\}$, $C = \{2, 4, 6, 8\}$, $D = \{6\}$
(a) $D \subset A$, $D \subset B$ and $D \subset C$
(b) $A \subset D$, $B \subset D$ and $D \subset C$
(c) $D \subset A$, $B \subset D$ and $D \subset C$
(d) None of these

8. If sets A and B are defined as
$A = \left\{(x, y) \mid y = \frac{1}{x}, 0 \neq x \in R\right\}$,
$B = \{(x, y) \mid y = -x, x \in R\}$, then
(a) $A \cap B = A$ (b) $A \cap B = B$
(c) $A \cap B = \phi$ (d) $A \cup B = A$

9. Let Z denote the set of all integers and $A = \{(a, b) : a^2 + 3b^2 = 28, a, b \in Z\}$ and $B = \{(a, b) : a > b, a, b \in Z\}$. Then the number of elements in $A \cap B$ is
(a) 2 (b) 3 (c) 6 (d) 5

10. Let X be the set $\left\{1, \pi, \left\{42, \sqrt{2}\right\}, \{1, 3\}\right\}$. Which of the following statement(s) is/are true?
$P : \pi \in X; Q : \{1, 3\} \subseteq X; R : \{1, \pi\} \subseteq X$
(a) P only (b) Q only
(c) R only (d) P and R only

11. A survey shows that 63% of the Americans like cheese whereas 76% like apples. If x% of the Americans like both cheese and apples, then the value of x is
(a) $39 \leq x \leq 63$ (b) 63
(c) 39 (d) $139 \geq x$

12. Let $n(U) = 700$, $n(A) = 200$, $n(B) = 300$, $n(A \cap B) = 100$. Then, $n(A^c \cap B^c)$ equal to
(a) 400 (b) 600 (c) 300 (d) 200

13. Write the set builder form of $A = \{-1, 1\}$.
(a) $A = \{x : x \text{ is an integer}\}$
(b) $A = \{x : x \text{ is a root of the equation } x^2 + 1 = 0\}$
(c) $A = \{x : x \text{ is a real number}\}$
(d) $A = \{x : x \text{ is a root of the equation } x^2 = 1\}$

14. Let $A = \{\phi, \{\phi\}, \{\phi, \{\phi\}\}\}$, where ϕ is a null set, then
(a) $\phi \subseteq A$, $\phi \in A$, $\{\phi\} \in A$, $\{\phi\} \subseteq A$
(b) $\phi \in A$ but $\phi \not\subseteq A$
(c) $\{\phi\} \in A$ but $\{\phi\} \not\subseteq A$
(d) A is a null set

15. Let A, B, C be three non-void subsets of set S. Let $(A \cap C) \cup (B \cap C') = \phi$ where C' denote the complement of set C in S. Then
(a) $A \cap B = \phi$ (b) $A \cap B \neq \phi$
(c) $A \cap C = A$ (d) $A \cup C = A$

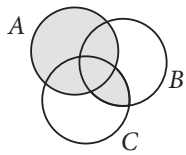
Home Assignment

1. Consider the following relations
I. $A - B = A - (A \cap B)$
II. $A = (A \cap B) \cup (A - B)$
III. $A - (B \cup C) = (A - B) \cup (A - C)$
Which of these is/are correct ?
(a) Both I and III
(b) Only II
(c) Both II and III (d) Both I and II

2. Let A, B, C are three non-empty sets. If $A \subset B$ and $B \subset C$, then $A \cup B =$
(a) A (b) C (c) $B \cup C$ (d) $B \cap C$

3. If the set of natural numbers is the universal set, $A = \{x : x + 5 = 8 \text{ and } x \in U\}$, $B = \{x : 2x + 5 = 9 \text{ and } x \in U\}$, $C = \{x : x \geq 7 \text{ and } x \in U\}$ and $D = \{x : x \in N \text{ and } 2x + 1 = 10\}$, then which of the following are true?
(i) $A' = \{1, 2, 3, 4, ...\}$ (ii) $B' = \{2, 3, 4, 5, 6, ...\}$
(iii) $C' = \{7, 8, 9, 10, ...\}$ (iv) $D' = \{5, 6, 7, 8, ...\}$
(a) (i) and (ii) (b) (ii) and (iii)
(c) (iii) and (iv) (d) None of these

4. What does the shaded region in the venn diagram given below represent?
(a) $A \cap (B' \cap C')$
(b) $A \cup (A' \cap B \cap C)$
(c) $A \cup (A \cap B) \cup (A \cap C)$
(d) $A \cup (B - C)$



5. In a certain town 25% families own a cell phone, 15% families own a scooter and 65% families own neither a cell phone nor a scooter. If 1500 families own both a cell phone and a scooter, then the total number of families in the town is
(a) 10,000 (b) 20,000 (c) 30,000 (d) 40,000

6. Let $A_1, A_2, A_3, ..., A_{100}$ be 100 sets such that $n(A_i) = i + 1$ and $A_1 \subset A_2 \subset A_3 \subset .... \subset A_{100}$, then how many elements $\bigcup_{i=1}^{100} A_i$ contains?
(a) 99 (b) 100 (c) 101 (d) 102

7. If $A = \{(x, y) : x^2 + y^2 \le 1, x, y \in R\}$ and $B = \{(x, y) : x^2 + y^2 \le 4, x, y \in R\}$, then
(a) $B \subset A$ (b) $A = B$
(c) $A \subset B$ (d) None of these

8. The roster form of $B = \left\{w : \frac{w-2}{w+3} = 3,\ w \in R\right\}$ is
(a) 11 (b) $\left\{-\frac{11}{2}\right\}$ (c) –11 (d) $\left\{-\frac{2}{11}\right\}$

9. There is a group of 265 persons who like either singing or dancing or painting. In this group 200 like singing, 110 like dancing and 55 like painting. If 60 persons like both singing and dancing, 30 like both singing and painting and 10 like all three activities, then the number of persons who like only dancing and painting is
(a) 10 (b) 20 (c) 30 (d) 40

10. If A and B are two non-empty sets, then $A \cap (A \cup B)'$ equals
(a) ϕ (b) A
(c) B (d) None of these

11. If a set A has 4 elements, then the total number of proper subsets of set A, is
(a) 16 (b) 14
(c) 15 (d) 17

12. If $n(P) = 8$, $n(Q) = 10$ and $n(R) = 5$ ('n' denotes cardinality) for three disjoint sets P, Q, R then $n(P \cup Q \cup R) =$
(a) 23 (b) 20 (c) 18 (d) 15

13. P and Q be two non-empty subsets of a set R, such that P is not a subset of Q. Then
(a) P and Q are disjoint sets.
(b) Q is a subset of P.
(c) P and Q' are non disjoint sets.
(d) P is a subset of Q'.

14. If A, B and C are finite sets and if $n(X)$ denotes number of elements in finite set X, then $n(A \cap (B \cup C)) =$
(a) $n(A \cap B) + n(A \cap C) - n(A \cap B \cap C)$
(b) $n(A \cap B) + n(A \cap C) + n(A \cap B \cap C)$
(c) $n(A \cap B) - n(A \cap C) + n(A \cap B \cap C)$
(d) $n(A \cap B) + n(A \cup C) - n(A \cap B \cap C)$

15. Let $A = \{x \in \mathbb{Z} : -1 \le x < 4\}$ and let $B = \{x \in \mathbb{Z} : 0 < \frac{x}{2} \le 3\}$. Then $A \cap B$ is equal to
(a) {1, 2, 3} (b) {2, 3}
(c) {1, 2, 3, 4} (d) {2, 3, 4}

Previous Years' Questions

1. Which of the following is an empty set?
(a) $\{x : x^2 - 9 = 0, x \in R\}$
(b) $\{x : x^2 - 1 = 0, x \in R\}$
(c) $\{x : x^2 = x + 2, x \in R\}$
(d) $\{x : x^2 + 1 = 0, x \in R\}$

2. Let A and B be two finite sets with m and n elements respectively. The total number of subsets of the set A is 56 more than the total number of subsets of B. Then the distance of the point $P(m, n)$ from the point $Q(-2, -3)$ is
(a) 6 (b) 8 (c) 10 (d) 4

3. The number of subsets containing exactly 4 elements of the set {2, 4, 6, 8, 10, 12, 14, 16, 18} is equal to
(a) 126 (b) 63 (c) 189 (d) 58

4. Let $A = \{n \in [100, 700] \cap N : n$ is neither a multiple of 3 nor a multiple of 4$\}$. Then the number of elements in A is
(a) 280 (b) 300 (c) 310 (d) 290

5. For two sets A and B we have $n(A \cup B) = 50$, $n(A \cap B) = 12$ and $n(A - B) = 15$. Then $n(B - A)$ is equal to
(a) 27 (b) 35 (c) 38 (d) 23

6. If A = {1, 2, 3, ... 10} then number of subsets of A containing only odd numbers is
(a) 31 (b) 32 (c) 27 (d) 30

7. Consider the two sets :
$A = \{p \in R \mid$ both the roots of $\alpha^2 - (p + 1)\alpha + p + 4 = 0$ are real$\}$
$B = [-3, 5)$
Which of the following is not true ?
(a) $A - B = (-\infty, -3) \cup (5, \infty)$
(b) $A \cap B = \{-3\}$
(c) $B - A = (-3, 5)$
(d) $A \cup B = R$

8. Let $A = \{x \in R : |x + 1| < 2\}$ and $B = \{x \in R : |x - 1| \ge 2\}$. Then which one of the following statements is not true?
(a) $A - B = (-1, 1)$
(b) $B - A = R - (-3, 1)$
(c) $A \cap B = (-3, -1]$
(d) $A \cup B = R - [1, 3)$

9. Let $S = \left\{x \in [-6, 3] - \{-2, 2\} : \frac{|x+3|-1}{|x|-2} \ge 0\right\}$ and $T = \left\{x \in Z : x^2 - 7|x| + 9 \le 0\right\}$. Then the number of elements in $S \cap T$ is :
(a) 7 (b) 5 (c) 4 (d) 3

10. An organization awarded 48 medals in event 'A', 25 in event 'B' and 18 in event 'C'. If these medals went to total 60 men and only five men got medals in all the three events, then, how many received medals in exactly two of three events?
(a) 10 (b) 9 (c) 21 (d) 15

Most Probable Questions

1. If $n(U) = 700$, $n(A) = 200$, $n(B) = 240$, $n(A \cap B) = 100$, then $n(A' \cup B')$ is equal to
(a) 260 (b) 560 (c) 360 (d) 600

2. If A and B are two disjoint sets, then $(A \cup B')' \cap (A' \cup B)'$ is
(a) Null set (b) Universal set
(c) A' (d) B'

3. Two finite sets with m, n elements are such that the total number of subsets of the first set is 224 more than the total number of subsets of the second. The values of m and n are
(a) 5, 7 (b) 4, 8 (c) 8, 5 (d) 8, 7

4. The set $(A \cup B \cup C) \cap (A \cap B' \cap C')' \cap C'$ is equal to
(a) $B \cap C'$ (b) $A \cap C$ (c) $B \cup C'$ (d) $A \cap C'$

5. Let F_1 be the set of parallelograms, F_2 be the set of rectangles, F_3 be the set of rhombuses, F_4 be the set of squares and F_5 be the set of trapeziums in a plane. Then, F_1 may be equal to
(a) $F_2 \cap F_3$ (b) $F_3 \cap F_4$
(c) $F_2 \cup F_5$ (d) $F_2 \cup F_3 \cup F_4 \cup F_1$

6. On its annual sports day, a school awarded 35 medals in athletics, 15 in judo and 18 in swimming. If these medals goes to a total of 58 students and only three of them got medals in all the three sports. The number of students who received medals in exactly two of the three sports are
(a) 9 (b) 4 (c) 5 (d) 7

7. A market research group conducted a survey of 2500 consumers and reported that 1620 consumers like product p_1 and 1500 consumers like product p_2, then (Note : A and B denote the set of consumers who like products p_1 and p_2 respectively)
(a) $n(A \cap B) \geq 620$ (b) $n(A \cap B) \leq 1500$
(c) $620 \leq n(A \cap B) \leq 1500$ (d) All of these

8. Out of all the patients in a hospital 89% are found to be suffering from heart ailment and 98% are suffering from lungs infection. If K% of them are suffering from both ailments, then K can not belong to the set
(a) {79, 81, 83, 85} (b) {84, 87, 90, 93}
(c) {80, 83, 86, 89} (d) {84, 86, 88, 90}

9. Let $\bigcup_{i=1}^{50} X_i = \bigcup_{i=1}^{n} Y_i = T$, where each X_i contains 10 elements and Y_i contains 5 elements. If each element of the set T is an element of exactly 20 of sets X_i' s and exactly 6 of sets Y_i's, then n is equal to
(a) 45 (b) 30 (c) 50 (d) 15

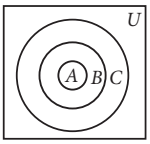
10. In a certain town, 25% of the families own a phone and 15% own a car, 65% families own neither a phone nor a car and 2000 families own both a car and a phone. Consider the following three statements :
(1) 5% families own both a car and a phone.
(2) 35% families own either a car or a phone.
(3) 40,000 families live in the town.
Then
(a) only (1) and (2) are correct
(b) only (1) and (3) are correct
(c) only (2) and (3) are correct
(d) all (1), (2) and (3) are correct

Hints & Explanations

Home Assignment

1. **(d) :** Let us consider the sets
$A = \{1, 2, 4\}$, $B = \{2, 5, 6\}$ and $C = \{1, 5, 7\}$
I. $A - B = \{1, 4\}$ and $A - (A \cap B) = \{1, 2, 4\} - \{2\} = \{1, 4\}$
$\therefore \quad A - B = A - (A \cap B)$
II. $(A \cap B) \cup (A - B) = \{2\} \cup \{1, 4\} = \{1, 2, 4\} = A$
III. $A - (B \cup C) = \{1, 2, 4\} - \{1, 2, 5, 6, 7\} = \{4\}$
and $(A - B) \cup (A - C) = \{1, 4\} \cup \{2, 4\} = \{1, 2, 4\}$
$\therefore \quad A - (B \cup C) \neq (A - B) \cup (A - C)$

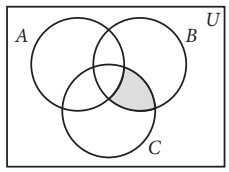
2. **(d) :**



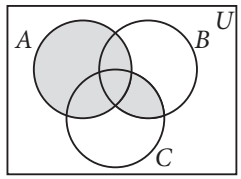
Clearly, $A \cup B = B$ and $B \cap C = B$
$\therefore \quad A \cup B = B \cap C$

3. **(d) :** U = Set of natural numbers
$A = \{x : x + 5 = 8\} = \{3\}$, $A' = U - A = \{1, 2, 4, 5, 6, ...\}$
$B = \{x : 2x + 5 = 9\} = \{2\}$, $B' = U - B = \{1, 3, 4, 5, 6, ...\}$
$C = \{x : x \geq 7\} = \{7, 8, 9, 10, ...\}$, $C' = U - C = \{1, 2, 3, 4, 5, 6\}$
$D = \{x : x \in N \text{ and } 2x + 1 = 10\} = \phi$
$D' = U - D = U$

4. **(b) :** $A' \cap B \cap C$:



$A \cup (A' \cap B \cap C)$:



5. (c) : Let P = Set of families who own cell phone
S = Set of families who own a scooter and x be the total number of families in the town.

Then, $n(P) = \frac{25}{100}x$, $n(S) = \frac{15}{100}x$, $n(P \cap S) = 1500$

and $n(P \cup S) = x - \frac{65}{100}x = \frac{35x}{100}$

$\because \quad n(P \cup S) = n(P) + n(S) - n(P \cap S)$

$\therefore \quad \frac{35x}{100} = \frac{25x}{100} + \frac{15x}{100} - 1500 \Rightarrow 1500 = \frac{5}{100}x$

$\Rightarrow \quad x = 30000$

6. (c): $\bigcup_{i=1}^{100} A_i = A_{100}$

$\therefore \quad n\left(\bigcup_{i=1}^{100} A_i\right) = n(A_{100}) = 100 + 1 = 101$

7. (c) : The set A consists of all the points which lie inside the circle $x^2 + y^2 = 1$ and set B consists of all the points which lie inside the circle $x^2 + y^2 = 4$. Clearly, the set B contain all the elements of A.

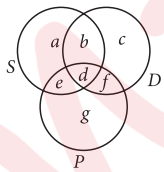
$\therefore \quad A \subset B$

8. (b) : We have, $\frac{w-2}{w+3} = 3, w \in R$

$\Rightarrow \quad w - 2 = 3w + 9 \Rightarrow 2w = -11$

$\Rightarrow \quad w = \frac{-11}{2} \quad \therefore \quad B = \left\{\frac{-11}{2}\right\}$

9. (a) : $a + b + c + d + e + f + g = 265$
$a + b + d + e = 200$
$b + c + d + f = 110$
$d + e + f + g = 55$
$b + d = 60, d + e = 30, d = 10$ On solving,



a	b	c	d	e	f	g
120	50	40	10	20	10	15

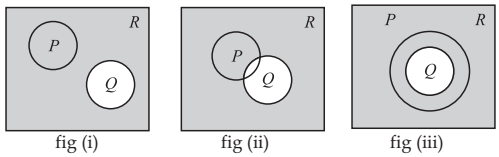
$\therefore$ Number of persons who like only dancing and painting = $f = 10$

10. (a) : $A \cap (A \cup B)' = A \cap (A' \cap B')$
[Using De-Morgan law $(A \cup B)' = A' \cap B'$]
$= (A \cap A') \cap B' = \phi \cap B' = \phi$

11. (c) : $n(A) = 4$ (given)
$\therefore$ Total no. of subsets of $A = 2^4 = 16$
$\therefore$ No. of proper subsets of $A = 16 - 1 = 15$

12. (a) : We have, $n(P) = 8$, $n(Q) = 10$ and $n(R) = 5$
Since P, Q and R are disjoint sets.
$\therefore \quad n(P \cap Q) = n(Q \cap R) = n(R \cap P) = n(P \cap R \cap Q) = 0$
Now, $n(P \cup Q \cup R) = n(P) + n(Q) + n(R) - n(P \cap Q) - n(Q \cap R) - n(R \cap P) + n(P \cap Q \cap R)$
$= 8 + 10 + 5 - 0 - 0 - 0 + 0 = 23$

13. (c) :



In the above Venn diagrams shaded portions represent Q'. So, P and Q' are non disjoint sets.

14. (a) : $n(A \cap (B \cup C)) = n((A \cap B) \cup (A \cap C))$
$= n(A \cap B) + n(A \cap C) - n(A \cap B \cap C)$

15. (a) : $A = \{x \in Z : -1 \le x < 4\} \Rightarrow A = \{-1, 0, 1, 2, 3\}$

$B = \left\{x \in Z : 0 < \frac{x}{2} \le 3\right\} \Rightarrow B = \{1, 2, 3, 4, 5, 6\}$

$\therefore \quad A \cap B = \{1, 2, 3\}$

Previous Years' Questions

1. (d) : Consider option (a),
$\{x : x^2 - 9 = 0, x \in R\} = \{3, -3\} \neq \phi$
option (b), $\{x : x^2 - 1 = 0, x \in R\} = \{-1, 1\} \neq \phi$
option (c), $\{x : x^2 = x + 2, x \in R\} = \{-1, 2\} \neq \phi$
option (d), $\{x : x^2 + 1 = 0, x \in R\}$
There does not exist any $x \in R$ for which $x^2 + 1 = 0$
Hence, this is an empty set.

2. (c) : Total number of subsets of set $A = 2^m$
Total number of subsets of set $B = 2^n$
According to question, $2^m - 2^n = 56$
$\Rightarrow \quad 2^n(2^{m-n} - 1) = 2^3 \times 7$
$\Rightarrow \quad 2^n = 2^3$ and $2^{m-n} = 8 = 2^3$
$\Rightarrow \quad n = 3$ and $m - n = 3 \Rightarrow m = 3 + n = 3 + 3 = 6$
$\therefore \quad m = 6$ and $n = 3$

Now, distance between the point $P(6, 3)$ and $Q(-2, -3)$ is given by $PQ = \sqrt{(6+2)^2 + (3+3)^2} = \sqrt{64 + 36} = 10$ units

3. (a) : Required number of subsets = ${}^9C_4 = 126$.

4. (b) : Multiples of 3 are 102, 105, …, 699
$a_n = 699 = 102 + (n - 1) \cdot 3$
$\Rightarrow \quad 597 = 3(n - 1) \Rightarrow n = 200$
Now, multiples of 4 are 100, 104, …, 700
$a_m = 700 = 100 + (m - 1) \cdot 4$
$\Rightarrow \quad m = 151$
Multiples of 3 and 4 are 108, 120, …, 696
$a_p = 696 = 108 + (p - 1) \cdot 12$
$\Rightarrow \quad p = 50$
$n(3 \cup 4) = n(3) + n(4) - n(3 \cap 4)$
$= n + m - p = 200 + 151 - 50 = 301$
$\therefore \quad$ The number of elements in $A = 601 - 301 = 300$

5. (d) : We have, $n(A \cup B) = 50$, $n(A \cap B) = 12$ and $n(A - B) = 15 = n(A \cap B^C) = n(A) - n(A \cap B)$
Now, $n(A \cup B) = n(A) + n(B) - n(A \cap B)$
$\Rightarrow \quad 50 = n(A) - n(A \cap B) + n(B)$
$\Rightarrow \quad 50 = 15 + n(B) \Rightarrow n(B) = 35$
Now, $n(B - A) = n(B) - n(A \cap B) = 35 - 12 = 23$

6. (b) : Number of odd numbers in the given set $A = 5$
$\therefore \quad$ Required number of subsets = $2^5 = 32$

7. (a) : We have, $A = \{p \in \mathbb{R} |$ both the roots of $\alpha^2 - (p + 1)\alpha + p + 4 = 0$ are real$\}$
$\therefore \quad (p + 1)^2 - 4(p + 4) \ge 0 \Rightarrow p^2 - 2p - 15 \ge 0$
$\Rightarrow \quad (p - 5)(p + 3) \ge 0 \Rightarrow p \in (-\infty, -3] \cup [5, \infty)$
Also, $B = [-3, 5)$
Now, $A - B = (-\infty, -3) \cup [5, \infty)$
$A \cap B = \{-3\}$
$B - A = (-3, 5)$
$A \cup B = \mathbb{R}$
Hence, option (a) is not true.

8. (b) : We have

$A = \{x \in R : |x+1| < 2\} = \{x \in R : -3 < x < 1\}$

$B = \{x \in R : |x-1| \geq 2\} = \{x \in R : x \leq -1 \text{ or } x \geq 3\}$

Now, (a) $A - B = (-1, 1)$

(b) $B - A = (-\infty, -3] \cup [3, \infty) = R - (-3, 3)$

(c) $A \cap B = (-3, -1]$

(d) $A \cup B = (-\infty, 1) \cup [3, \infty) = R - [1, 3)$

9. (d) : $S = \left\{x \in [-6, 3] - \{-2, 2\} : \frac{|x+3|-1}{|x|-2} \geq 0\right\}$

Case I : $|x| - 2 > 0$ and $|x + 3| - 1 \geq 0$

$\Rightarrow \quad |x| > 2 \quad \Rightarrow \quad x > 2$ or $x < -2$

and $|x+3| \geq 1 \quad \Rightarrow \quad x + 3 \geq 1$ or $x + 3 \leq -1$

$\Rightarrow \quad x \geq -2$ or $x \leq -4 \Rightarrow x \in [-6, -4] \cup (2, 3]$

Case II : $|x| - 2 < 0$ and $|x + 3| - 1 \leq 0$

$\Rightarrow \quad |x| < 2 \quad \Rightarrow \quad -2 < x < 2$

and $|x+3| \leq 1 \quad \Rightarrow \quad -1 \leq x + 3 \leq 1 \Rightarrow -4 \leq x \leq -2$

No common solution exists.

$\therefore \quad S = \{x \in [-6, -4] \cup (2, 3]\}$

Now, $T = \{x \in Z : x^2 - 7|x| + 9 \leq 0\}$, $x^2 - 7x + 9 \leq 0$, for $x \geq 0$

$\Rightarrow \quad x \in \{2, 3, 4, 5\}$ $x^2 + 7x + 9 \leq 0$, for $x < 0$

$\Rightarrow \quad x \in \{-5, -4, -3, -2\} \therefore T = \{-2, 2, -3, 3, -4, 4, -5, 5\}$

Thus, $S \cap T = \{-5, -4, 3\}$

$\Rightarrow \quad S \cap T$ contains 3 elements.

10. (c) : $n(A) = 48$

$n(B) = 25$

$n(C) = 18$

$n(A \cup B \cup C) = 60$ [Total]

$n(A \cap B \cap C) = 5$

$n(A \cup B \cup C)$

$= \Sigma n(A) - \Sigma n(A \cap B) + n(A \cap B \cap C)$

$\Rightarrow \quad \Sigma|A \cap B| = 48 + 25 + 18 + 5 - 60 = 36$

Number of men who received exactly 2 medals

$= \Sigma n(A \cap B) - 3n(A \cap B \cap C) = 36 - 15 = 21$

Most Probable Questions

1. (d) : $n(A' \cup B') = n(A \cap B)'$

$= n(U) - n(A \cap B) = 700 - 100 = 600$

2. (a) : Consider, $(A \cup B')' \cap (A' \cup B)'$

$= (A' \cap B) \cap (A \cap B')$ [Using De-Morgan's law]

$= B \cap A = \phi$ ($\because$ A and B are disjoint sets)

3. (c) : As number of elements in A and B are m, n respectively.

$\therefore$ Number of subsets of $A = 2^m$

Number of subsets of $B = 2^n$

According to the problem, $2^m - 2^n = 224 = 32 \times 7$

$\Rightarrow \quad 2^n(2^{m-n} - 1) = 2^5 \times (8 - 1)$

$\Rightarrow \quad 2^n(2^{m-n} - 1) = 2^5 \times (2^{8-5} - 1) \Rightarrow n = 5$ and $m = 8$

4. (a) : Clearly, $(A \cup B \cup C) \cap (A \cap B' \cap C')' \cap C'$

$= (A \cup (B \cup C)) \cap (A' \cup (B \cup C)) \cap C'$

[Using De-Morgan's law]

$= ((B \cup C) \cup A) \cap ((B \cup C) \cup A') \cap C'$

$= ((B \cup C) \cup (A \cap A')) \cap C'$ [Using distributive law]

$= ((B \cup C) \cup \phi) \cap C' = (B \cup C) \cap C'$

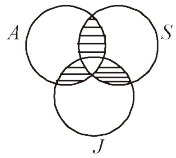
$= (B \cap C') \cup (C \cap C')$ (Using distributive law)

$= (B \cap C') \cup \phi = B \cap C'$

5. (d) : Every rectangle, rhombus, square in a plane is a parallelogram but every trapezium is not a parallelogram.

So, $F_2, F_3, F_4 \subseteq F_1$ but $F_5 \not\subseteq F_1$. Hence, $F_1 = F_2 \cup F_3 \cup F_4 \cup F_1$

6. (b) : Let A denote the set of students who received medal in athletics, J be the set of students who got medal in judo and S be the set of students who got medal in swimming.



Then, $n(A) = 35$, $n(J) = 15$, $n(S) = 18$

$n(A \cup J \cup S) = 58$ and $n(A \cap J \cap S) = 3$

Since, $n(A \cup J \cup S)$

$= n(A) + n(J) + n(S) - n(A \cap J) - n(A \cap S)$

$- n(J \cap S) + n(A \cap J \cap S)$

$\therefore \quad 58 = 35 + 15 + 18 + 3 - n(A \cap J) - n(A \cap S) - n(J \cap S)$

$\Rightarrow \quad n(A \cap S) + n(A \cap J) + n(J \cap S) = 71 - 58 = 13$

$\therefore$ Number of students who received medals in exactly two of the three sports

$= n(A \cap J) + n(J \cap S) + n(S \cap A) - 3n(A \cap S \cap J)$

$= 13 - 3 \times 3 = 13 - 9 = 4$

7. (d)

8. (a) : Let total number of patients in the hospital be 100 and also let $n(A)$ be the number of patients suffering from heart ailment, $n(B)$ be the number of patients suffering from lung infection. Then, $n(A \cap B)$ be the number of patients suffering from both ailments.

Also, $n(A) = 89$ and $n(B) = 98$

$\because \quad n(A \cap B) \leq n(A)$ and $n(A \cap B) \leq n(B)$

$\therefore \quad n(A \cap B) \leq 89$ ...(i)

Now, as $n(A) + n(B) - n(A \cap B) = n(A \cup B) \leq 100$

$\therefore \quad 89 + 98 - n(A \cap B) \leq 100$

$\Rightarrow \quad n(A \cap B) \geq 87$ ...(ii)

From (i) and (ii), we get

$87 \leq n(A \cap B) \leq 89$ or $87 \leq K \leq 89$

$\therefore$ No element of set given in option (a) satisfies this condition.

9. (b) : Given, $\bigcup_{i=1}^{50} X_i = \bigcup_{i=1}^{n} Y_i = T$ and each X_i contains 10 elements and each Y_i contains 5 elements.

Let set T has k elements.

Now, $\bigcup_{i=1}^{50} X_i = 50 \times 10 = 500$ and $\bigcup_{i=1}^{n} Y_i = n \times 5 = 5n$

A.T.Q., $20k = 500$ and $6k = 5n$

$\Rightarrow \quad k = \frac{500}{20}$ ...(i) and $k = \frac{5n}{6}$ ...(ii)

From (i) and (ii), we have

$\frac{5n}{6} = \frac{500}{20} \quad \Rightarrow \quad n = 30$

10. (d) : Let x be total number of families in the town. Let set P be the families who own a phone and set C be the families who own a car.

$n(P) = 25\%$, $n(C) = 15\%$, $n(P' \cap C') = 65\%$

$\Rightarrow n(P \cup C) = 35\%$.

Now, $n(P \cap C) = n(P) + n(C) - n(P \cup C) = 25 + 15 - 35 = 5\%$

Now, 5% of $x = 2000 \quad \Rightarrow \quad x = 40{,}000$

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CHAPTER
1

Sets

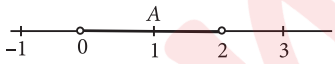
Solutions (Class Discussion)

1. **(a) :** We have, $T = \{x \in R : (x-3) = (x+4)^2, x < 2\}$
Now, if $x = 1$, we have
$1 - 3 = (1 + 4)^2$ which is not true.
$\because$ Square of a number can't be negative.
$\therefore$ T is an empty set.

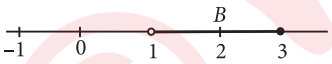
2. **(d) :** In all the figures, the intersection of 3 circles is not empty.

3. **(b) :** $A = \{x | x \in N, x$ is a prime number less than $12\}$
$\Rightarrow$ $A = \{2, 3, 5, 7, 11\}$
$B = \{x | x \in N, x$ is a factor of $10\}$
$\Rightarrow$ $B = \{1, 2, 5, 10\}$
$\therefore$ $A \cap B = \{2, 5\}$

4. **(d) :** $A' = R - A = \{x \in R : x \le 0$ or $x \ge 2\}$

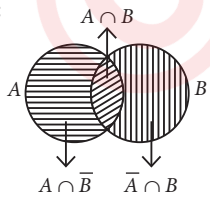


$B' = R - B = \{x \in R : x \le 1$ or $x > 3\}$



$A \cap B = \{x \in R : x \in A$ and $x \in B\} = \{x \in R : 1 < x < 2\}$

5. **(a) :**



$\therefore$ $(A \cap \bar{B}) \cup (\bar{A} \cap B) \cup (A \cap B) = A \cup B$

6. **(c) :** Consider the equation $x^2 + x + 2 = 0$
This equation is not satisfied by any integral value of x.
$\therefore$ A is an empty set.
Also, there is no odd prime number between 20 an 23.
$\therefore$ B is also an empty set.

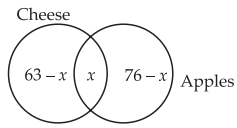
7. **(a) :** Given, $A = \{x : x \in R$ and x satisfy $x^2 - 8x + 12 = 0\}$
$\because$ $x^2 - 8x + 12 = 0 \Rightarrow (x-2)(x-6) = 0 \Rightarrow x = 2, 6$
$A = \{6, 2\}$, $B = \{2, 4, 6\}$, $C = \{2, 4, 6, 8\}$ and $D = \{6\}$
Clearly, every element of A is in B and C.
$\therefore$ $A \subset B$ and $A \subset C$
Again, every element of B is in C
$\therefore$ $B \subset C$
Also, every element of D is in A, B and C.
$\therefore$ $D \subset A$, $D \subset B$ and $D \subset C$

8. **(c) :** Let $x \in R$
Since, $-x \neq \frac{1}{x}$
$\therefore$ There is no common element in A and B.
$\Rightarrow$ $A \cap B = \phi$

9. **(c) :** $A = \{(a, b) : a^2 + 3b^2 = 28, a, b \in Z\}$
(a, b) can be $(1, 3), (-1, 3), (1, -3), (-1, -3), (5, 1), (-5, 1), (5, -1), (-5, -1), (4, 2)\ (-4, 2), (4, -2), (-4, -2)$
$\therefore$ $n(A) = 12$, $n(B) = \infty$
So, $A \cap B = \{(a, b) : a^2 + 3b^2 = 28$ and $a > b, a, b \in Z\}$
$\Rightarrow$ $n(A \cap B) = 6$

10. **(d) :** We have, $1 \in X, \pi \in X, \{42, \sqrt{2}\} \in X, \{1, 3\} \in X$
So, only P and R are true.

11. **(a) :** $63 - x + x + 76 - x \le 100$
$\Rightarrow$ $x \ge 39$
But $63 - x \ge 0$
$\Rightarrow$ $x \le 63$
$\therefore$ $39 \le x \le 63$



12. **(c) :** Clearly, $n(A \cup B) = n(A) + n(B) - n(A \cap B)$
$= 200 + 300 - 100 = 400$
$\therefore$ $n(A^c \cap B^c) = n((A \cup B)^c) = n(U) - n(A \cup B)$
$= 700 - 400 = 300$

13. (d) : Since, $x = -1$ and $x = 1$ are roots of the required equation.

$\therefore$ $(x + 1)$ and $(x - 1)$ are factors of equation.

$\therefore$ $(x+1)(x-1) = 0 \Rightarrow x^2 - 1 = 0$ is required equation.

$\therefore$ Set builder form of given set A is

$A = \{x : x$ is a root of the equation $x^2 = 1\}$

14. (a) : We have, $A = \{\phi, \{\phi\}, \{\phi, \{\phi\}\}\}$

Clearly, $\phi \subseteq A$, as empty set is a subset of every set.

Also, $\phi \in A \Rightarrow \{\phi\}$ is a subset of A and $\{\phi\} \in A$.

15. (a) : We have, $(A \cap C) \cup (B \cap C') = \phi$

$\Rightarrow$ $A \cap C = \phi$ and $B \cap C' = \phi \Rightarrow B \subset C$ $[\because B \neq \phi]$

$\Rightarrow$ $A \cap C = \phi$ and $B \cap C = B \Rightarrow A \cap B = \phi$

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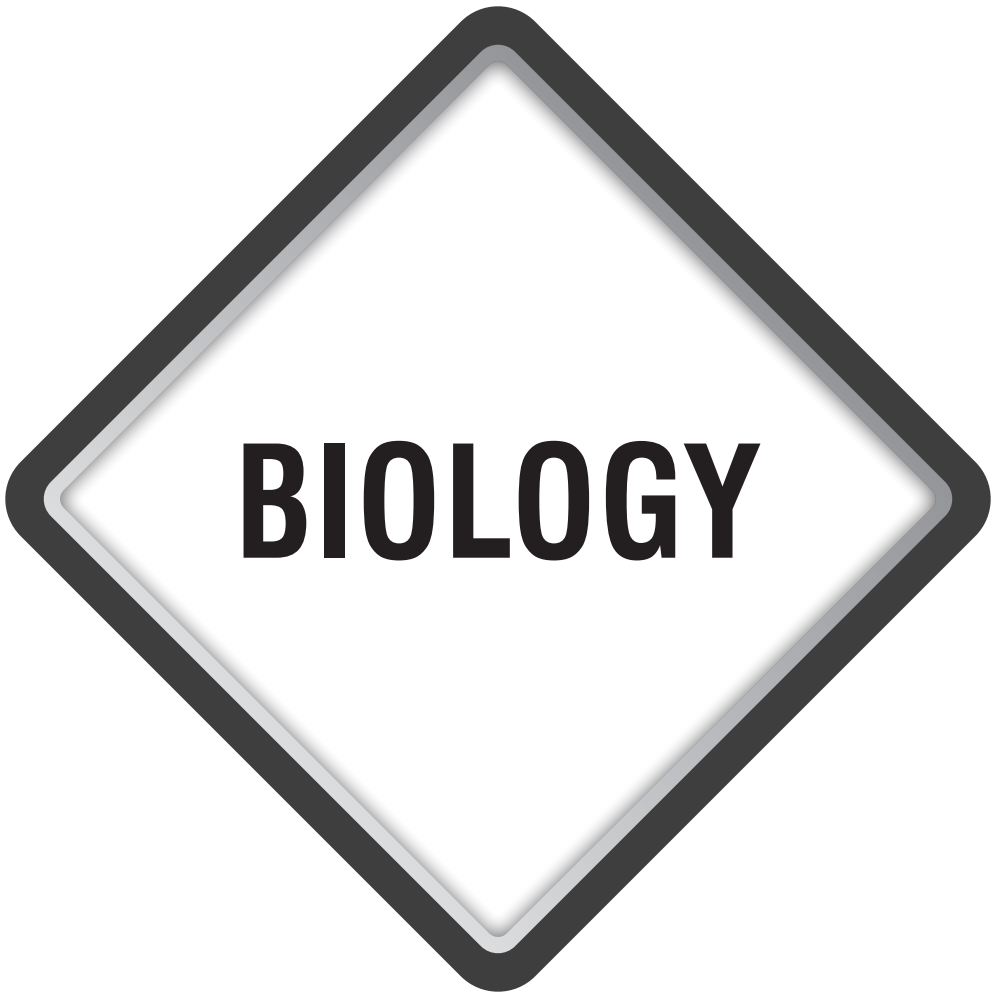

BIOLOGY

CHAPTER 1

The Living World

- The wide range of living types is amazing. The extraordinary habitats of living organisms, such as cold mountains, deciduous forests, oceans, fresh water lakes, deserts or hot springs, leave us speechless. The ecological conflict and cooperation among members of a population and among populations of a community or even the molecular traffic inside a cell make us deeply reflect on – what indeed is life? As biologists, after observing the surrounding the focus must shift on What is living?

What is 'Living'?

- Being alive is defined as unique, complex organisation of molecules expressing itself through chemical reactions which lead to growth, development, responsiveness, adaptation and reproduction.
- Each living organism has certain distinctive functions and features that separate it from non-living things, such as:
  - **Growth** which is permanent, irreversible increase in mass (determinate, *e.g.*, humans or indeterminate, *e.g.*, plants) in multicellular organisms and increase in number of individuals in unicellular ones.
  - **Reproduction** for continuity of life.
  - **Metabolic functions,** either catabolic (breaking down) or anabolic (building up).
  - Definite **cellullar organisation**.
  - Ability of **movement** and **locomotion**.
  - **Adaptability** to increase survival rate.
  - **Respiration** for energy generation (aerobic/ anaerobic).
  - Maintenance of **homeostasis** in body.
  - **Consciousness**, *i.e.*, the **ability to sense** their surroundings and respond accordingly.
  - **Ageing** after a growth period and then natural death.

Diversity in the Living World

- The living world comprises infinite varieties of microorganisms, plants (flora) and animals (fauna).
- The number of species that are known and described ranges between **1.7 – 1.8 million**. This diversity of life forms is termed as **biodiversity**.
- Due to such a large diversity of life forms, a proper system of classification is a must because it is not possible to study every organism. Classification helps in knowing the relationships amongst different groups of organisms.
- The plants and animals are identified by their local names. These local names would vary from place to place. There would be confusion created to identify organisms by their local name as it varies from place to place.
- Hence, there is a need to standardise the naming of living organisms such that a particular organism is known by the same name all over the world. This process is called **nomenclature**. Nomenclature or naming is only possible when the organism is described correctly by **identification**.
- Taxonomy is defined as the science dealing with identification, nomenclature and classification of organisms. It is the study of rules, principles and practices of classification, identification and nomenclature of organisms.
- Fundamental concepts of taxonomy are:
  - **Classification –** It is the arrangement of organisms into convenient categories or groups on the basis of their similarities and differences in certain easily observable but fundamental characters. Thus, it involves hierarchy of steps in which each step represents a rank or category.
  - **Identification –** It is used to determine the exact place or position of an organism in the set plan of classification.
  - **Nomenclature –** The process of giving scientific names to plants and animals is called nomenclature.

Table : Differences between systematics and taxonomy

S.No.	Systematics	Taxonomy
(i)	It takes into account evolutionary relationships between organisms.	It takes into account the external and internal structures, along with the structure of cell, development process and ecological information of organisms.
(ii)	It is used in identification, nomenclature and classification.	It is used in characterisation, identification and nomenclature.

- In Binomial nomenclature system given by Linnaeus, each organisms is given only one name consisting of two components. The **first component** is **generic name** and the **second component** represents the **specific epithet**.
- Scientific names are based on agreed principles and criteria :
  - For Plants – International Code of Botanical Nomenclature (ICBN)
  - For Animals – International Code of Zoological Nomenclature (ICZN)
- Universal rules of nomenclature are as follows:
  (i) Biological names are generally in Latin and written in italics. They are Latinised or derived from Latin irrespective of their origin.
  (ii) The first word in a biological name represents the genus while the second component denotes the specific epithet.
  (iii) Both the words in a biological name, when handwritten, are separately underlined, or printed in italics to indicate their Latin origin.
  (iv) The first word denoting the genus starts with a capital letter while the specific epithet starts with a small letter. It can be illustrated with the example of *Mangifera indica*.
  (v) Name of the author appears after the specific epithet, *i.e.*, at the end of the biological name and is written in an abbreviated form, *e.g.*, *Mangifera indica* Linn. It indicates that this species was first described by Linnaeus.
- The word systematics is derived from the Latin word '*systema*' which means systematic arrangement of organisms. Linnaeus used '*Systema Naturae*' as the title of his publication. The scope of systematics was later enlarged to include identification, nomenclature and classification. Systematics takes into account evolutionary relationships between organisms.

Taxonomic Categories

- Classification involves hierarchy of steps in which each step represents a rank or category. It is not a single step process. Since the category is a part of overall taxonomic arrangement, it is called the **taxonomic category** and all categories together constitute the **taxonomic hierarchy**. Each category, referred to as a unit of classification, in fact, represents a rank and is commonly termed as **taxon**.

Species

- Species occupies a key position in classification. It is the **lowest taxonomic category**. A species may have subgroups, called subspecies or varieties, showing certain distinct features of their own. In *Mangifera indica* (mango), *Solanum tuberosum* (potato) and *Panthera leo* (lion), all the three names *indica*, *tuberosum* and *leo*, represent the specific epithets, while the first words *Mangifera*, *Solanum* and *Panthera* are genera and represent another higher level of taxon or category. Each genus may have one or more than one specific epithets representing different organisms, but having morphological similarities. For example, *Panthera* has another specific epithet called *tigris* and *Solanum* includes species like *nigrum* and *melongena*.

Genus

- Genus comprises a group of related species which has more characters in common in comparison to species of other genera. Genera are aggregates of closely related species. For example, potato and brinjal are two different species but both belong to the genus *Solanum*. Lion (*Panthera leo*), leopard (*P. pardus*) and tiger (*P. tigris*) with several common features, are all species of the genus *Panthera*. This genus differs from another genus *Felis* which includes cats.

Family

- Family is a group of related genera but with lesser number of similarities as compared to genus and species. Families are characterised on the basis of both vegetative and reproductive features for a plant species. Among plants for example, three different genera *Solanum*, *Petunia* and *Datura* are placed in the Family Solanaceae. Among animals for example, genus *Panthera*, comprising lion, tiger, leopard is put along with genus, *Felis* (cats) in the Family Felidae. Cat and dog are separated into two different families – Felidae and Canidae, respectively according to their features.

Order

- The categories like species, genus and families are based on a number of similar characters. Generally, order and other higher taxonomic categories are identified based on the aggregates of characters. It is the assemblage of families which exhibit a few similar characters. The similar characters are less in number as compared to different genera included in a family. Plant families like Convolvulaceae, Solanaceae are included in the Order Polymoniales mainly based on the floral characters. The animal Order Carnivora, includes families like Felidae and Canidae.

Class

- Class is the category that includes related orders. For example, Order Primata comprising monkey, gorilla and gibbon is placed in Class Mammalia along with

order Carnivora that includes animals like tiger, cat and dog. Class Mammalia has other orders also.

Phylum

- Classes comprising animals like fishes, amphibians, reptiles, birds along with mammals constitute the next higher category called Phylum. All these, based on the common features like presence of **notochord** and **dorsal hollow neural system**, are included in phylum Chordata. In case of plants, classes with a few similar characters are assigned to a higher category called **Division**.

Kingdom

- All animals belonging to various phyla are assigned to the **highest category** called Kingdom Animalia in the classification system of animals. The Kingdom Plantae, on the other hand, is distinct, and comprises all plants from various divisions. Henceforth, we will refer to these two groups as animal and plant kingdoms.

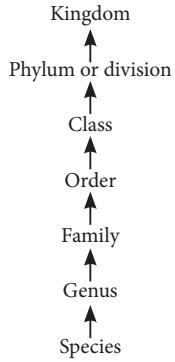


Fig.: Taxonomic categories showing hierarchial arrangement in ascending order

- As we go higher from species to kingdom, the number of common characteristics goes on decreasing. Lower the taxa, more are the characteristics that the members within the taxon share. Higher the category, greater is the difficulty of determining the relationship to other taxa at the same level.

Table : Organisms with their taxonomic categories

Common Name	Biological Name	Genus	Family	Order	Class	Phylum/ Division
Man	*Homo sapiens*	*Homo*	Hominidae	Primata	Mammalia	Chordata
Housefly	*Musca domestica*	*Musca*	Muscidae	Diptera	Insecta	Arthropoda
Mango	*Mangifera indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	Angiospermae

Class Discussion

1. Species are considered as
(a) real basic category of classification
(b) the highest category of classification
(c) combination of genera
(d) combination of family.

2. Diversity of organisms and their evolutionary relationship is studied scientifically under
(a) morphology
(b) anatomy
(c) taxonomy
(d) systematics.

3. 'X' is an arthropod that belongs to the Family Muscidae. The specific epithet for the given arthropod is *domestica*. X could be
(a) tse-tse fly (b) honeybee
(c) dragon fly (d) housefly.

4. The species given here belong to how many different families?

Man, Housefly, Mango, Wheat, Dog, Cat, Lion, Tiger, Potato, Brinjal, Leopard

(a) 4 (b) 7
(c) 5 (d) 6

5. The plants or animals group with most similar trait is
(a) genus (b) species
(c) order (d) taxon.

6. In binomial nomenclature, the scientific name of animals is represented by
(a) family and genus (b) genus and species
(c) order and family (d) genus and variation.

7. *Triticum aestivum* belongs to Class _____.
(a) Monocotyledonae (b) Dicotyledonae
(c) Anacardiaceae (d) Poaceae

8. A group of individuals, which are able to breed among themselves and produce their own kind is known as
(a) genus
(b) species
(c) family
(d) order.

9. A family in a taxonomic hierarchy
(a) is a group of related genera with more number of similarities as compared to genus and species
(b) it is characterised only on the basis of reproductive characters in plants
(c) has only upto three generas
(d) has less common characters than a species but more numbers of individuals.

10. In seasonal breeders, photoperiod affects _____.
(a) metabolism (b) consciousness
(c) growth (d) reproduction

11. Which of the following options represents the correct classification for the given animal?

	Phylum	Class	Order	Family	Genus	Species
(a)	Chordata	Vertebrata	Chiroptera	Felidae	*Canis*	*tigris*
(b)	Chordata	Mammalia	Carnivora	Felidae	*Panthera*	*tigris*
(c)	Vertebrata	Mammalia	Carnivora	Felidae	*Panthera*	*tigris*
(d)	Mammalia	Felidae	Carnivora	Feliaceae	*Panthera*	*leo*

12. Select the correct sequence in the taxonomic hierarchy in ascending order.
(a) Hominidae → *Homo* → Mammalia → Chordata → Primata
(b) *Homo* → Hominidae → Primata → Mammalia → Chordata
(c) Primata → Chordata → Mammalia → Hominidae → *Homo*
(d) Chordata → Mammalia → Primata → Hominidae → *Homo*

13. The common characteristics between tomato and potato will be maximum at the level of their
(a) family (b) order
(c) division (d) genus.

14. The animal, mammal and dog represent
(a) taxa at same levels
(b) genus of different species
(c) taxa at different levels
(d) species belonging to same phylum.

15. *Hydra* and yeast reproduce by
(a) budding (b) fission
(c) fragmentation (d) regeneration.

Home Assignment

1. Reproduction cannot be an all-inclusive defining characteristic of living organism as
(a) growth is not equivalent to increase in cell number in *Amoeba*.
(b) sterile organism like mule, worker honey bees, etc., exist in nature.
(c) non-living object is capable of reproducing or replicating by itself.
(d) some organisms can reproduce by fragmentation.

2. **Statement I :** For identification of all living organisms they must be described correctly.
Statement II : Nomenclature of living organisms is dependent upon identification.
(a) Both statements I and II are correct.
(b) Both statements I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement I is incorrect but statement II is correct.

3. The defining properties that differentiate living organisms from non-living organisms, without an exception are
(a) metabolism, cellular organisation, consciousness
(b) reproduction, cellular organisation, growth
(c) growth, reproduction, consciousness
(d) metabolism, reproduction, consciousness.

4. Match column I with column II and select the correct option.

	Column I (Generic name)		Column II (Specific epithet)
A.	*Mangifera*	(i)	*nigrum*
B.	*Solanum*	(ii)	*indica*
C.	*Panthera*	(iii)	*domestica*
D.	*Musca*	(iv)	*tigris*

(a) A-(iv), B-(i), C-(iii), D-(ii)
(b) A-(i), B-(ii), C-(iii), D-(iv)
(c) A-(iii), B-(iv), C-(ii), D-(i)
(d) A-(ii), B-(i), C-(iv), D-(iii)

5. Taxonomic category 'Family' ends with suffix
(a) – aceae (b) – ata
(c) – eae (d) –ales.

6. Assertion : Order is a taxonomic category that includes one or more class.
Reason : All the genera in a family have some similar features and co-related characters.
(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

7. In *Mangifera indica*, *Solanum tuberosum* and *Panthera leo*, the word *indica*, *tuberosum* and *leo* represent
(a) genus (b) specific epithet
(c) order (d) class.

8. Which of the following common features of organisms would place them under the same taxonomic category 'Phylum Chordata'?
(a) Notochord and dorsal hollow neural system
(b) Absence of notochord and ventral hollow nerve cord
(c) Notochord and ventral hollow neural system
(d) Notochord and dorsal double neural system

9. Read the following statements and select the correct ones.
(i) Growth is irreversible increase in mass of an individual.
(ii) Metabolic reactions can be demonstrated outside the body in isolated cell-free systems.
(iii) 'Response to stimuli' is a defining property of living organisms.
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i) and (iii) (d) (i), (ii) and (iii)

10. Which of the following is the basis of modern taxonomic studies?
(i) External and internal structure
(ii) Structure of cell
(iii) Development process
(iv) Ecological information of organism
(a) (i), (ii) and (iii) only (b) (ii), (iii) and (iv) only
(c) (i), (iii) and (iv) only (d) (i), (ii), (iii) and (iv)

11. Match column I with column II and select the correct option.

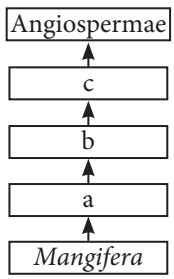
	Column I		**Column II**
A.	Genus	(i)	Assemblage of families
B.	Family	(ii)	Group of related species
C.	Order	(iii)	Assemblage of orders
D.	Class	(iv)	Group of related genera

(a) A-(iii), B-(i), C-(iv), D-(ii)
(b) A-(iv), B-(iii), C-(i), D-(ii)
(c) A-(ii), B-(iv), C-(i), D-(iii)
(d) A-(iii), B-(i), C-(ii), D-(iv)

12. Refer to the various taxa of wheat classification and arrange them in correct sequence of taxonomic hierarchy starting from the lowest rank.
(i) Poaceae (ii) Monocotyledonae
(iii) Angiospermae (iv) Plantae
(v) Poales (vi) *Triticum*
(a) (vi) → (i) → (v) → (ii) → (iii) → (iv)
(b) (vi) → (ii) → (v) → (iv) → (iii) → (i)
(c) (iv) → (iii) → (ii) → (v) → (i) → (vi)
(d) (iv) → (ii) → (v) → (iii) → (i) → (vi)

13. Select the incorrect statements.
(A) Lower the taxon, more are the characteristics that the members within the taxon share.
(B) Order is the assemblage of genera which exhibit a few similar characters.
(C) Cat and dog are included in the same Family Felidae.
(D) Binomial nomenclature was introduced by Carolus Linnaeus.
(a) (A), (B) and (C) (b) (B), (C) and (D)
(c) (A) and (D) (d) (B) and (C)

14. Recognise the following flow diagram and find the correct option according to taxonomic hierarchy.



(a) 'a' is comparable to muscidae while 'b' is at the same level as that of primata.
(b) 'c' includes all the angiosperms having two cotyledons in their seeds.
(c) For wheat 'a' is poaceae, 'b' is Poales and 'c' is monocotyledonae.
(d) All of these

15. Select the incorrect statement.
(a) For plants, scientific names are based on principles and criteria provided by International Code for Biological Nomenclature.
(b) Scientific names ensure that each organism has only one name.
(c) Carolus Linnaeus has provided binomial nomenclature.
(d) Both (a) and (c)

Previous Years' Questions

1. In the taxonomic categories, which hierarchial arrangement in ascending order is correct in case of animals?
(a) Kingdom, Phylum, Class, Order, Family, Genus, Species
(b) Kingdom, Class, Phylum, Family, Order, Genus, Species
(c) Kingdom, Order, Class, Phylum, Family, Genus, Species
(d) Kingdom, Order, Phylum, Class, Family, Genus, Species

2. Which one of the following belongs to the Family Muscidae?
(a) House fly (b) Fire fly
(c) Grasshopper (d) Cockroach

3. Match column I with column II for housefly classification and select the correct option using the codes given below.

	Column I	Column II
A.	Family	(i) Diptera
B.	Order	(ii) Arthropoda
C.	Class	(iii) Muscidae
D.	Phylum	(iv) Insecta

(a) A-(iii), B-(i), C-(iv), D-(ii)
(b) A-(iii), B-(ii), C-(iv), D-(i)
(c) A-(iv), B-(iii), C-(ii), D-(i)
(d) A-(iv), B-(ii), C-(i), D-(iii)

4. Select the correctly written scientific name of Mango which was first described by Carolus Linnaeus.
(a) *Mangifera Indica*
(b) *Mangifera indica Car.* Linn.
(c) *Mangifera indica* Linn.
(d) *Mangifera indica*

5. Select the correctly matched pair of organisms with their order.
(a) *Musca domestica* – Diptera
(b) *Homo sapiens* – Poales
(c) *Mangifera indica* – Primata
(d) *Triticum aestivum* – Sapindales

6. Binomial nomenclature is introduced by
(a) Bentham and Hooker (b) Carolus Linnaeus
(c) John Ray (d) Lamarck.

7. Identify the 'order' from the following.
(a) Carnivora (b) Muscidae
(c) Insecta (d) *Panthera*

8. In a taxonomic hierarchy, the number of common characters will increase as we go from
(a) species to kingdom (b) kingdom to species
(c) class to order (d) genus to species.

9. Which one of the following organisms is scientifically correctly named, correctly printed according to the International Rules of Nomenclature and correctly described?
(a) *Musca domestica* - the common house lizard, a reptile
(b) *Plasmodium falciparum* - a protozoan pathogen causing the most serious type of malaria.
(c) *Felis tigris* - the Indian tiger, well protected in Gir forest.
(d) *E.coli* - full name *Entamoeba coli*, a commonly occurring bacterium in human intestine.

10. Which taxonomic term may be suggested for any rank in the classification?
(a) Class (b) Order
(c) Species (d) Taxon

Most Probable Questions

1. Select the odd one *w.r.t.* universal rule of nomenclature of biological names.
(a) They are binomial, *i.e.*, made up of two words.
(b) When handwritten, are separately underlined.
(c) First word represents specific epithet while second denotes genus.
(d) They are latin in origin.

2. The name of a plant order usually ends with
(a) –aceae (b) –ales
(c) –idae (d) –ae.

3. **Statement I :** Species is a group of individuals with fundamental similarities.
Statement II : *indica*, *leo* and *tuberosum* are specific epithet.
(a) Both statements I and II are correct.
(b) Both statements I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement I is incorrect but statement II is correct.

4. Which two features are known as the twin characteristics of growth?
(i) Increase in mass
(ii) Differentiation

(iii) Increase in number of individuals
(iv) Response to stimuli
(a) (i) and (ii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (i) and (iii)

5. Match the column I with column II and select the correct option.

	Column I (Order)		**Column II (Family)**
A.	Polymoniales	(i)	Felidae
B.	Carnivora	(ii)	Anacardiaceae
C.	Diptera	(iii)	Convolvulaceae
D.	Sapindales	(iv)	Muscidae

(a) A-(iii), B-(i), C-(iv), D-(ii)
(b) A-(iv), B-(iii), C-(i), D-(ii)
(c) A-(ii), B-(iv), C-(i), D-(iii)
(d) A-(iii), B-(i), C-(ii), D-(iv)

6. Select the incorrect statement, from the following.
(a) Increase in mass and increase in number are twin characteristics of growth.
(b) Consciousness is not a defining property of living organisms.
(c) Fungi and protonema of mosses multiply by fragmentation.
(d) All of these

7. ICBN stands for
(a) International Council for Botanical Nomenclature
(b) Indian Council and Botanical Nomenclature
(c) International Code for Biological Nomenclature
(d) International Code for Botanical Nomenclature.

8. Among the following, select the correct statements.
(A) In majority of higher plants and animals, growth and reproduction are mutually inclusive events.
(B) In non-living objects, growth is by accumulation of material on the surface.
(C) An isolated metabolic reaction outside the body of an organisms, performed in a test tube is neither living nor non-living.
(D) All organisms, from the prokaryotes to the most complex eukaryotes can sense and respond to environmental cues.
(a) B, C and D (b) A, B and C
(c) A, D and C (d) A, B, C and D

9. **Assertion :** Cats and dogs have some similarities.
Reason : Cats and dogs belong to the Family Felidae and Canidae respectively.
(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Assertion is false but reason is true.

10. Which of the following are the correct statements regarding systematics?
A. Systematics is derived from the Greek word 'systema'.
B. It deals with different kinds of organisms, their diversities and relationships among them.
C. The word systematics and taxonomy can be used interchangeably as both of them include similar characteristics.
D. It helps in developing evolutionary relationships.
(a) B and D (b) B and C
(c) A and C (d) A and D

Hints & Explanations

Home Assignment

1. **(b) :** Some organisms like mules, sterile worker bees, infertile human couples do not reproduce, thus, reproduction cannot be an all inclusive defining characteristic of living organisms.

2. **(a)**

3. **(a)**

4. **(d) :** *Mangifera - indica*
Solanum - nigrum
Panthera - tigris
Musca - domestica

5. **(a) :** Families end with the suffix 'aceae', for, *e.g.*, Solanaceae, Convolvulaceae, etc.

6. **(d) :** Family is a taxonomic category which contains one or more related genera. All the genera of a family have some common features or co-related characters. Order includes one or more related families. Class includes related orders.

7. **(b)**

8. **(a) :** Chordates comprise of following characters: notochord and dorsal hollow, single nerve cord.

9. **(d)**

10. **(d) :** The basis of modern taxonomic studies are external and internal structure, along with the structure of cell, development process and ecological information of organisms.

11. (c) : Genus - Group of related species
Family - Group of related genera
Order - Assemblage of families
Class - Assemblage of orders

12. (a)

13. (d) : Order being higher category is the assemblage of families which exhibit a few similar characteristics.
Dog belongs to Family Canidae while cat belongs to Family Feliadae.

14. (d) : 'a' represents family, 'b' represents order and 'c' represents class.

15. (a) : For plants, scientific names are based on principles and criteria provided by International Code of Botanical Nomenclature (ICBN).

Previous Years' Questions

1. (None of the options is correct) : Hierarchy of categories is the classification of organisms in a definite sequence of categories (taxonomic categories) in a descending order starting from Kingdom and reaching upto Species or an ascending order from Species to Kingdom. The number of similar characters of categories decreases from lowest rank (Species) to highest rank (Kingdom). The taxonomic hierarchy includes seven obligate categories– Kingdom, Division or Phylum, Class, Order, Family, Genus and Species.

2. (a) : Housefly (*Musca domestica*) belongs to Family Muscidae.

3. (a)

4. (c) : According to binomial nomenclature, the first word denoting the genus starts with a capital letter while the specific epithet starts with a small letter. *E.g.*, scientific name of mango is *Mangifera indica*. Name of the author appears after the specific epithet, *i.e.*, at the end of biological name and is written in an abbreviated form, *e.g.*, *Mangifera indica* Linn. It indicates that this species was first described by Linnaeus.

5. (a) : Poales is the order of *Triticum aestivum* (wheat), Primata is the order of *Homo sapiens* (man) and Sapindales is the order of *Mangifera indica* (mango).

6. (b)

7. (a) : Among the given options, carnivora is an order, Muscidae is a family, Insecta is a class and *Panthera* is a genus.

8. (b) : As we go from kingdom to species in a taxonomic hierarchy, the number of common characteristics will increase.

9. (b) : *Plasmodium falciparum* is a protozoan parasite, one of the species of *Plasmodium* that causes malaria in humans. Being digenetic, its life cycle is complete in two hosts — man and mosquito.

10. (d) : Taxon is a unit of classification which may represent any level of grouping of organisms based on certain easily observable common characteristics.

Most Probable Questions

1. (c) : In biological names, first word represents the genus while the second component denotes the specific epithet.

2. (b) : Order includes one or more related families, *e.g.*, the Family Solanaceae is placed in the Order Polemoniales along with four related families (Convolvulaceae, Boraginaceae, Hydrophyllaceae and Polemoniaceae). Name of a plant order usually ends with '-ales'.

3. (a) : Species refer to a group of organisms with fundamental similarities. A species is distinguished from the other closely related species based on distinct morphological differences, *e.g.*, *Mangifera indica* (Mango), *Solanum tuberosum* (potato) and *Panthera leo* (lion). All the three names, *indica*, *tuberosum* and *leo*, represent the specific epithets, while the first words *Mangifera*, *Solanum* and *Panthera* are genera.

4. (d) : Increase in mass and increase in number of individuals are twin characteristics of growth.

5. (a) : Polymoniales – Convolvulaceae
Carnivora – Felidae
Diptera – Muscidae
Sapindales – Anacardiaceae

6. (b) : Consciousness is a defining property of living organisms.

7. (d)

8. (a) : In majority of higher plants and animals, growth and reproduction are mutually exclusive events.

9. (b)

10. (a) : Systematics include identification, nomenclature, classification and evolutionary relationship among the organisms. The word is derived from Latin word 'systema'.

❍❍❍

CHAPTER

1 The Living World

Solutions (Class Discussion)

1. (a)

2. (d) : Systematics include identification, nomenclature and classification. It also takes into account evolutionary relationships between organisms.

3. (d) : 'X' is housefly, *Musca domestica,* an arthropod. It belongs to Family Muscidae.

4. (b) :

Species	**Family**
Man	Hominidae
Housefly	Muscidae
Mango	Anacardiaceae
Wheat	Poaceae/Graminae
Dog	Canidae
Cat, lion, tiger, leopard	Felidae
Potato, brinjal	Solanaceae

5. (b)

6. (b) : Binomial nomenclature is the method of naming organisms scientifically. This method was established by Linnaeus. Each newly described organism is given a scientific name which has two component the generic name and specific epithet.

7. (a)

8. (b) : According to the biological species concept, a species comprises a group of individuals that can freely breed among themselves and produce fertile offspring.

9. (d) : Families are characterised on the basis of vegetative as well as reproductive characters. It has less number of common characteristics.

10. (d)

11. (b)

12 (b)

13. (a) : Potato (*Solanum tuberosum*) and tomato (*Lycopersicum esculentum*) both belong to Family Solanaceae, which is commonly called as the "potato family". Many plants belonging to this family are sources of vegetables, fruits, etc.

14. (c)

15. (a)

❍❍❍