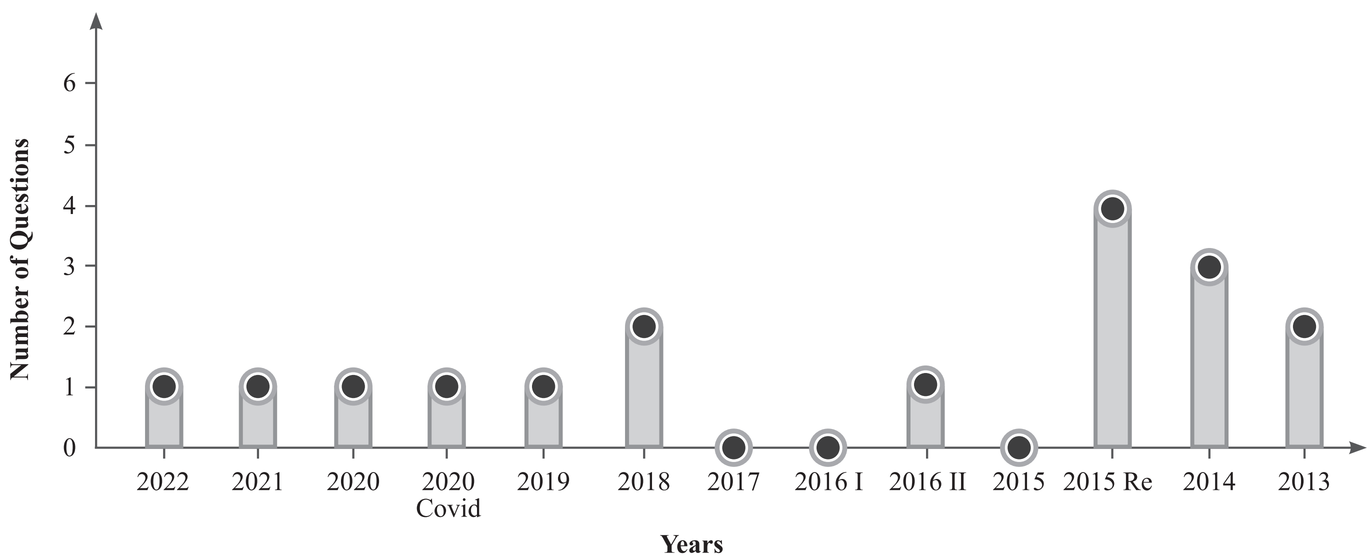
CHAPTER

1 Some Basic Concepts of Chemistry

Year Wise Number of Questions Analysis (2022-2013)



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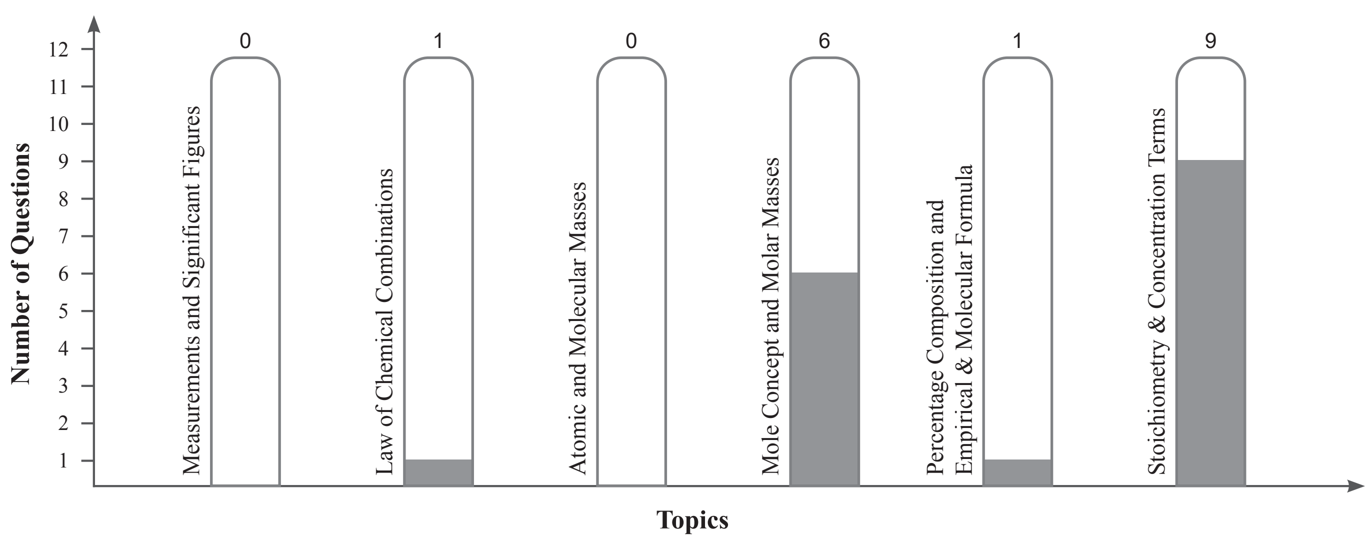


INTRODUCTION

Chemistry is the branch of science that studies the composition, properties and interaction of matter.

Anything that has mass and occupies space is called **matter**.

For example, book, pen, pencil, water, air, all living beings etc. are composed of matter. You know that they have mass and they occupy space.

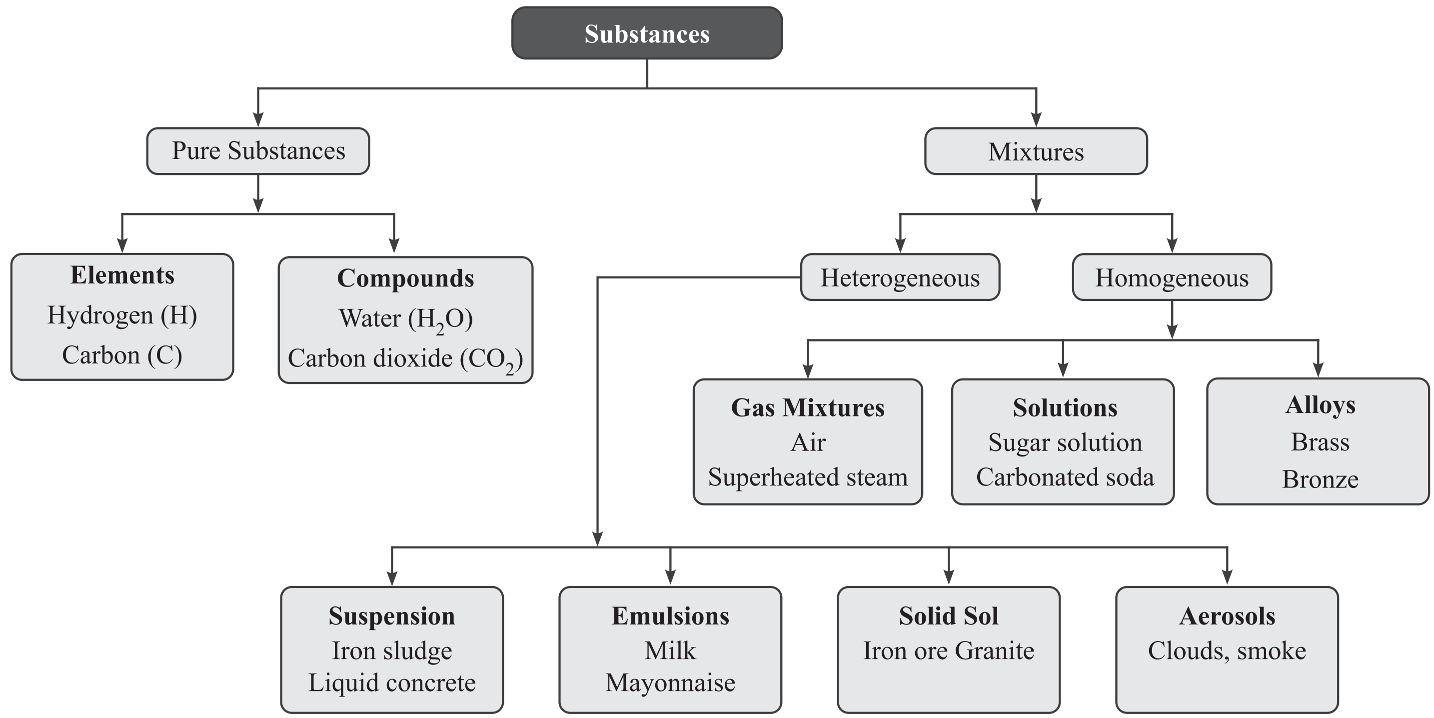
Material is another very common term used in chemistry. However, the term **material** has a limited meaning, which corresponds to matter having specific uses.

CLASSIFICATION OF MATTER

Matter can be classified in two ways:

(i) Physical classification of matter

(ii) Chemical classification of matter



Physical Classification of Matter

Depending upon the physical state of matter, it can be classified into three states, namely, **solid, liquid** and **gaseous state**.

Table: Properties of Solids, Liquids and Gases

Properties	Solid	Liquid	Gas
Shape	Definite	Indefinite	Indefinite
Volume	Definite	Definite	Indefinite
Attraction Force	Strongest	Moderate	Weakest
Examples	Sugar, Iron, Gold, Wood etc.	Water, Milk, oil, Mercury	Dihydrogen, Oxygen, Carbon dioxide, etc

$$\text{Solid} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Liquid} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{Gas}$$

These three states of matter are interconvertible by changing temperature and pressure.

Chemical Classification of Matter

The chemical classification of matter is based upon its composition. At the macroscopic or bulk level, matter can be classified as **mixture or pure substances**.

Mixtures

Mixtures are defined as the substances which are made up of two or more pure substances. They can posses variable composition and can be separated into constituent components by some suitable physical means/methods.

For Example: Alloys (Brass, Bronze) (Brass = Copper + Zinc) (Bronze = Copper + Tin), Water + alcohol, Water + Salt, Water + mustard Oil, Water + Sugar, Water + Kerosene.

A mixture may be homogeneous or heterogeneous.

In a **homogeneous mixture**, the components completely mix with each other and its composition is uniform throughout.

The components of such a mixture cannot be seen even under a microscope. Some examples of homogeneous mixtures are air, gasoline, sea water, brass, coloured glass, Alloys, Water + alcohol, Water + Salt, 22 carat Gold, Water + Sugar, etc.

In **heterogeneous mixtures**, the composition is not uniform throughout. These consist of two or more parts (called phases) which have different compositions.

For Example: Water + Sand, Water + Mustard oil, Milk, Blood, Air, plastic, smoke, petrol etc.

Pure Substances

It consist of single type of particles.

Pure substances can be further classified into elements and compounds.

1. **Element:** An element is the simplest form of a pure substance. It is defined as:

   The simplest form of a pure substance that can neither be decomposed into nor built from simpler substances by ordinary physical or chemical methods. For example Zn, B, Si.

2. **Compound:** A compound is defined as a pure substance that contains two or more than two elements combined together in a fixed proportion by mass and that can be break down into its constituent elements by suitable chemical methods.

Compounds are further classified into two categories.

1. **Organic Compound:** Obtained from living sources.

   For Example: Oils, fats, derivative of hydrocarbon.

2. **Inorganic Compound:** Obtained from non-living sources.

   For Example: HCl, H_2O, H_2SO_4, $HClO_4$, HNO_3 etc.

PROPERTIES OF MATTER AND THEIR MEASUREMENT

Physical and Chemical Properties

Physical properties are those properties that can be measured or observed without changing the identity or composition of the substance. Example: Colour, Odour.

Chemical properties are those in which a chemical change in the substance takes place. Example: pH, Heat of combustion.

Expressing a Physical Quantity

The value of a physical quantity is always expressed in two parts:

(i) Numerical value (ii) Unit

The International System of Units (SI Units)

The scientists have generally agreed to use the International System of Units abbreviated as SI units.

Table: Seven base units of SI system

Physical Quantity	Symbol for quantity	Name of Unit	Symbol
Length	l	Metre	m
Mass	m	Kilogram	kg
Time	t	Second	s
Thermodynamic Temperature	T	Kelvin	K
Electric current	I	Ampere	A
Amount of Substance	n	Mole	mol
Luminous Intensity	I_v	Candela	cd

Some Important Units

- $1Å = 10^{-10}m$; $1\ fm = 10^{-15}m$

  $1nm = 10^{-9}m$; $1\ \mu m = 10^{-6}m$

  $1pm = 10^{-12}m$; $1\ mm = 10^{-3}m$

Some Commonly Used Quantities

1. Mass and Weight

Mass of a substance is the amount of matter present in it. The SI unit of mass is kilogram.

Weight is the force exerted on an object by the pull of gravity.

2. Volume

Volume is the amount of space occupied by an object. So in SI system, volume has units cubic meter, m^3.

3. Density

Density of a substance is its amount of mass per unit volume. SI unit of density is kg/m^3

Density: It is of two type

- Absolute density $= \frac{\text{mass}}{\text{volume}}$
- Relative density or specific gravity

  $= \frac{\text{density of the substance}}{\text{density of water at 4°C}}$

We know that density of water at 4ºC = 1 g/ml.

For Gases

Absolute density (mass/volume) $= \frac{\text{Molar mass}}{\text{Molar volume}}$

Relative Density or Vapour Density

Vapour density is defined as the density of the gas with respect to that of hydrogen gas at the same temperature and pressure.

$$\text{Vapour density} = \frac{d_{gas}}{d_{H_2}} = \frac{PM_{gas}/RT}{PM_{H_2}/RT}$$

Where P is pressure of gas, M = mol. wt. of gas, R is the gas constant, T is the temperature.

$$V.D. = \frac{M_{gas}}{M_{H_2}} = \frac{M_{gas}}{2}$$

$\mathbf{M_{gas} = 2\ V.D.}$

Relative density can be calculated w.r.t. to other gases also.

4. Temperature

There are three common scales to measure temperature:

1. The SI scale or Kelvin scale measured in Kelvin (K)
2. Celsius scale measured in degree Celsius (°C).
3. Fahrenheit scale measured in degrees Fahrenheit (°F)

   (i) Conversion of celsius to Fahrenheit is

   $$°F = \frac{9}{5}(°C) + 32°$$

   (ii) Conversion of Fahrenheit to celsius

   $$°C = \frac{5}{9}[°F - 32°]$$

   (iii) Conversion of kelvin to celsius

   Kelvin temperature (K) = °C + 273.15

UNCERTAINTY IN MEASUREMENT

Significant Figures: The uncertainty in the experimental or the calculated values is indicated by mentioning the number of significant figures.

Significant figures are those 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:

1. All non-zero digits are significant. For example, 3.132 has four significant figures.
2. Zeros between two non zero digits are significant. For example, 3.01 has three significant figures.
3. The zeros preceding to the first non-zero number (i.e. to the left of the first non-zero number) are not significant. Such zeros indicate the position of decimal point. For example, 0.324 has three significant figures.
4. All zeros at the end or to the right of a number are significant provided they are on the right side of the decimal point. For example, 0.0200 has three significant figures.
5. Exponetial form: $N \times 10^n$, Where N shows the significant figure.
   E.g., 1.86×10^4 has three significant figure.
6. Rounding off the uncertain digit:
   (i) If the left most digit to be rounded off is more than 5, the preceding number is increased by one.
   E.g., 2.16 is rounded to 2.2
   (ii) If the left most digit to be rounded off is less than 5, the preceding number is retained.
   E.g., 2.14 is rounded off to 2.1
   (iii) If the left most digit to be rounded off is equal to 5, the preceding number is not changed if it is even and increased by one if it is odd.
   E.g., 3.25 is rounded off to 3.2
   2.35 is rounded off to 2.4

Accuracy and Precision

Accuracy is a measure of the difference between the experimental value or the average value of a set of measurements and the true value.

Precision refers to closeness of two or more measurements of the same quantity that agree with one another.

Train Your Brain

Example 1: Which of the following mixture(s) are homogeneous?

Tap water, Air, Soil, Smoke

Sol. Tap water, Air.

Example 2: Classify the following as pure substances or mixtures. Also separate the pure substances into elements and compounds and divide mixture, into homogeneous and heterogeneous categories:

(*i*) Graphite (*ii*) Milk
(*iii*) Air (*iv*) Oxygen
(*v*) 22 carat gold (*vi*) Iodized table salt
(*vii*) Wood (*viii*) Cloud

Sol. Element: (*i*), (*iv*)

Homogeneous Mixture : (*iii*), (*v*)

Heterogeneous Mixture : (*ii*), (*vi*), (*vii*), (*viii*)

Example 3: How many significant figure are there in each of the following numbers:

(*i*) 1.00×10^6 (*ii*) 0.00010 (*iii*) π

Sol. (*i*) Three (*ii*) Two (*iii*) An infinite number

Concept Application

1. Express the given number in the scientific notation: 0.0048
   (1) 4.8×10^{-3} (2) 4.8×10^{-2}
   (3) 48×10^{-3} (4) 4.8×10^{-4}
2. How many significant figures should be present in the answer to the following calculations?
   $$\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$$
   (1) 4 (2) 3
   (3) 2 (4) 1

LAWS OF CHEMICAL COMBINATIONS

The combination of elements to form compounds is governed by the following five basic laws.

Law of Conservation of Mass/Law of Indestructibility of Matter

Given by – Lavoisier

Tested by – Landolt

According to law of conservation of mass in all physical & chemical changes total mass of the system remains constant.

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

i.e. Total mass of the reactant = Total mass of the product.

This relationship holds good when reactants are completely converted into products.

If reactants are not completely consume then the relationship will be:

Total mass of reactant = Total mass of product + Mass of unreacted reactant

Key Note

- Nuclear reactions are exception to law of conservation of mass. In nuclear reaction mass + energy is conserved.
- According to the modern views, the law of conservation of mass is not always valid. The law hold good only in case of such chemical reactions where **there is no evolution of heat or light**.
- During **chemical processes**, the loss of mass is negligible. But in **nuclear reactions**, tremendous amount of energy is evolved. Consequently, the change in mass is quite significant. Thus, it is clear that the law of conservation of mass and law of conservation of energy are two ways of looking at the same law.
- Thus, combining the two we get general law known as **law of conservation of mass energy**. It states that, Mass and energy are inter convertible. But the total sum of mass and energy of the system remains constant.

Law of Definite Proportions

Given by → Joseph Proust: A chemical compound always contains same elements combined together in same proportion by mass. i.e, chemical compound has a fixed composition & it does not depends on the method of its preparation or the source from which it has been obtained.

Example: Carbon dioxide can be produced by different methods such as burning of carbon, heating lime stone etc. It has been observed that each sample of CO_2 contains carbon and oxygen combined in the ratio 3:8 by mass. This means that the composition of a compound always remain the same irrespective of the method by which it is prepared.

Law of Multiple Proportions

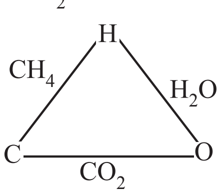
Given by → Dalton: According to this law, if two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of smallest whole numbers.

Example: Carbon (C) can combine with oxygen (O) to form more than one compound, namely CO, CO_2. Here ratio of masses of O that combine with fixed mass of C is 16:32 or 1:2.

Law of Reciprocal Proportion

Given by → Richter: The ratio of the weights of two elements A and B that combine separately with fixed weight of the third element C is either the same or some simple multiple of this ratio of the weights in which A and B combine directly with each other.

Example: The elements C and O combine separately with the third element H to form CH_4 and H_2O and they combine directly with each other to form CO_2 as shown in the below figure.



In CH_4, 12 parts by weight of carbon combine with 4 parts by weight of hydrogen. In H_2O, 2 parts by weight of hydrogen combine with 16 parts by weights of oxygen. Thus the weights of C and O which combine with fixed weight of hydrogen (say 4 parts of weight) are 12 and 32, i.e. they are in the ratio 12 : 32 or 3 : 8.

Now in CO_2, 12 parts by weight of carbon combine directly with 32 parts by weight of oxygen, i.e. they combine directly in the ratio 12 : 32 or 3 : 8 that is the same as the first ratio.

Gay Lussac's Law of Gaseous Volumes

Given by → Gay Lussac: He observed that when gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.

Example: $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

100 ml		50 ml		100 ml
2 volumes		1 volume		2 volumes
vol of H_2	:	vol of O_2	:	vol of steam
2	:	1	:	2

Avogadro Law

Avogadro proposed that equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

Example: 22.4 L of every gas at STP (Standard temperature and Pressure, ie. T = 273 K, P = 1 atm) contains equal number of molecules, which is equal to 6.022×10^{23}.

Train Your Brain

Example 4: 10 g of $CaCO_3$ on heating gives 4.4 g of CO_2 then determine weight of produced CaO in quintal.

(1) 5.6×10^{-5} quintal (2) 2.8×10^{-5} quintal
(3) 5.6×10^{-8} quintal (4) 2.8×10^{-8} quintal

Sol. (1) Total mass of reactant = 10 g

Mass of CO_2 = 4.4 g

Mass of produced CaO = x

According to law of conservation of mass

$$10 = 4.4 + x$$
$$10 - 4.4 = x$$
$$x = 5.6 \text{ g}$$

$\therefore$ 1 quintal = 100 kg

$\therefore$ 1 Kg = 1000 g

$$= 5.6 \text{ g} \times \frac{Kg}{1000} = 5.6 \times 10^{-3} \times \text{Kg}$$

$$= 5.6 \times 10^{-3} \times \frac{1}{100} \text{ quintal} = 5.6 \times 10^{-5} \text{ quintal}$$

Example 5: For the gaseous reaction $H_2 + Cl_2 \rightarrow 2HCl$

If 40 ml of hydrogen completely reacts with chlorine then find out the required volume of chlorine and volume of produced HCl?

Sol. According to Gay Lussac's Law:

$H_2 + Cl_2 \rightarrow 2HCl$

1 ml of H_2 will react will 1 ml of Cl_2 and 2 ml of HCl will be produced.

$\therefore$ 40 ml of H_2 will react with 40 ml of Cl_2 and 80 ml of HCl will produce.

Required vol. of Cl_2 = 40 ml

Produced vol. of HCl = 80 ml.

Concept Application

3. Element 'X' forms five stable oxides with oxygen of formula X_2O, XO, X_2O_3, X_2O_4, X_2O_5. The formation of these oxides explains:

(1) Law of definite proportions

(2) Law of partial pressure

(3) Law of multiple proportions

(4) Law of reciprocal proportions

4. One sample of atmospheric air is found to have 0.03% of CO_2 and another sample 0.04%. This is evidence that:

(1) The law of constant composition is not always true

(2) The law of multiple proportions is true

(3) Air is a compound

(4) Air is a mixture

DALTON'S ATOMIC THEORY

The assumption of Dalton's Atomic theory are:

1. Matter consists of indivisible atoms.
2. All the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.
3. Compounds are formed when atoms of different elements combine in a fixed ratio.
4. Chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

Dalton's theory could explain the laws of chemical combination.

The main failures of Dalton's atomic theory are:

1. It failed to explain how atoms of different elements differ from each other i.e., did not tell anything about structure of the atom.
2. It does not explain how and why atoms of different element combine with each other to form compound.
3. It failed to explain the nature of forces present between different atoms in a molecule.
4. It fails to explain Gay Lussac's law of combining volumes.
5. It did not make any difference between ultimate particle of an element that takes part in reaction (atoms) and ultimate particle that has independent existence (molecules).

ATOMIC AND MOLECULAR MASSES

Atomic Mass Unit

It is defined as exactly $\frac{1}{12}$th of the mass of a carbon-12 atom. It is represented as amu. [Now a new symbol 'u' called unified mass is used.]

Mass of 1 amu $= \frac{12}{6.022 \times 10^{23}} \times \frac{1}{12} = 1.67 \times 10^{-24}$ g

Today, 'amu' has been replaced by 'u' which is known as unified mass.

Average Atomic Mass

When we take into account the existence of the isotopes and their relative abundance (Percent occurrence), the average atomic mass of that element is calculated.

Average atomic mass of an element is the sum of the masses of its isotopes each multiplied by its natural abundance.

Mathematically, average atomic mass of X (A_x)

$$= \frac{a_1x_1 + a_2x_2 + ... + a_nx_n}{100}$$

a_1 = atomic mass; x_1 % occurence in nature

Key Note

- Relative atomic mass is nothing but the number of nucleons present in the atom.

Train Your Brain

Example 6: Naturally occuring chlorine is 75% Cl^{35} which has an atomic mass of 35 amu and 25% Cl^{37} which has a mass of 37 amu. Calculate the average atomic mass of chlorine:

(1) 35.5 amu (2) 36.5 amu

(3) 71 amu (4) 72 amu

Sol. (1) Average atomic mass

$$= \frac{\text{\% of I isotope} \times \text{its atoms mass} + \text{\% of II isotope} \times \text{its atomic mass}}{100}$$

$$= \frac{75 \times 35 + 25 \times 37}{100} = 35.5 \text{ amu}$$

Example 7: Indium (atomic mass = 114.82) has two naturally occurring isotopes, the predominant one form has isotopic mass 114.9041 and abundance of 95.72%. Which of the following isotopic mass is most likely for the other isotope?

(1) 112.94 (2) 115.90
(3) 113.90 (4) 114.90

Sol. (1) Let atomic weight of other isotope is 'M'

$$114.82 = \frac{114.9041 \times 95.72 + M \times 4.28}{100}$$

M = 112.94

Concept Application

5. A sample of carbon that contains 70% C_{12} and 30% C_{14}. What do you think is the average atomic mass of this sample?

(1) 10.2 (2) 12.6
(3) 18.5 (4) 15.8

6. An element, X has the following isotopic composition,

^{200}X : 90%

^{199}X : 8.0%

^{302}X : 2.0%

The weighted average atomic mass of the naturally-occurring element X is closed to

(1) 200 amu (2) 201 amu
(3) 202 amu (4) 199 amu

Gram Atomic Mass

When numerical value of atomic mass of an element is expressed in grams then the value becomes gram atomic mass (GAM)

GAM = Mass of 1 gram atom = Mass of 1 mole atoms

= Mass of N_A atoms = Mass of 6.022×10^{23} atoms

Molecular Mass

It is the sum of atomic masses of the elements present in a molecule. It is obtained by multiplying the atomic mass of each element by the number of its atoms and adding them together.

Formula Mass

In ionic compounds we use formula mass instead of molecular mass. **Formula mass** of an ionic compound is the sum of the atomic masses of all atoms in a formula unit of compound.

Key Note

Equivalent Mass (E.M.)

- E.M. of an element $= \frac{\text{Atomic mass}}{\text{Valency}}$
- E.M. of an acid $= \frac{\text{Molecular mass}}{\text{Basicity}}$
- E.M. of a base $= \frac{\text{Molecular mass}}{\text{Acidity}}$

MOLE CONCEPT AND MOLAR MASSES

'Mole' was introduced as the seventh base quantity for the amount of substance in SI system.

One mole is the amount of a substance that contains as many entities (atoms, molecules or other particles) as there are atoms in exactly 12 gm (or 0.012 kg) of ^{12}C isotope.

From mass spectrometer we found that there are 6.023×10^{23} atoms present in 12 gm of ^{12}C isotope. This number is known as avogadro constant ($N_A = 6.023 \times 10^{23}$).

Mole Concept in Gaseous Reaction

Molar volume is related to volume of one mole of gaseous substance. The volume occupied by 1 mol of a gaseous substance is called molar volume. 1 mole occupies 22.414 L or 22414 mL at STP ie. 273 K and 1 atm.

$$\text{Number of moles} = \frac{\text{Volume}}{\text{Molar volume}}$$

Molar Mass

The mass of 1 mol of a substance in grams is called its molar mass.

For Eg: Molar mass of Na_2CO_3

$= 2 \times 23 + 12 + 3 \times 16$

$= 106$ gm/mol

Mass-Mole-Number Relationship

$$\text{Number of moles} = \frac{\text{Mass}}{\text{Molar mass in g mol}^{-1}}$$

PERCENTAGE PURITY

Percentage purity is the percentage of a pure compound in an impure sample.

$$\% \text{ purity} = \frac{\text{mass of pure compound in sample}}{\text{total mass of impure sample}} \times 100$$

For eg: A 150.0g sample of an iron ore contains 88.2g of pure iron.

Its % purity:

$$= \frac{88.2}{150.0} \times 100$$

$= 58.8$ %

Train Your Brain

Example 8: Which of the following contains the greatest number of atoms?

(1) 1.0 g of butane (C_4H_{10})
(2) 1.0 g of nitrogen (N_2)
(3) 1.0 g of silver (Ag)
(4) 1.0 g of water (H_2O)

Sol. (1) No. of atom of $(C_4H_{10}) = \frac{1}{58} \times 14\ N_a$

(2) No. of atom of $(N_2) = \frac{1}{28} \times 2\ N_a$

(3) No. of atom of $(Ag) = \frac{1}{108} \times N_a$

(4) No. of atom of water $(H_2O) = \frac{1}{18} \times 3\ N_a$

Hence greatest No. of atoms = C_4H_{10}

Example 9: The number of sodium atoms in 2 moles of sodium ferrocyanide ($Na_4[Fe(CN)_6]$) is:

(1) 12×10^{23} (2) 26×10^{23}
(3) 34×10^{23} (4) 48×10^{23}

Sol. (4) 1 mole of $Na_4[Fe(CN)_6]$ contains 4 mole of Na So, 2 moles contains:

$= 8 \times N_A$ atoms of sodium
$= 8 \times 6.023 \times 10^{23}$
$= 48 \times 10^{23}$

Example 10: 5.6 litre of oxygen at STP contains:

(1) 6.02×10^{23} atoms (2) 3.01×10^{23} atoms
(3) 1.505×10^{23} atoms (4) 0.7525×10^{23} atoms

Sol. (2) 22.4 L of oxygen at STP contains 6.02×10^{23} molecules. 5.6 L of oxygen at STP contains 1.505×10^{23} molecules which contains 3.01×10^{23} atoms of oxygen.

Example 11: The molecular mass of H_2SO_4 is 98 amu. Calculate the number of moles of each element in 294 g of H_2SO_4.

Sol. Gram molecular mass of H_2SO_4 = 98 gm

Moles of $H_2SO_4 = \frac{294}{98} = 3$ moles

H_2SO_4	H	S	O
One molecule	2 atom	one atom	4 atom
$1 \times N_A$	$2 \times N_A$ atoms	$1 \times N_A$ atoms	$4 \times N_A$ atoms
∴ 1 mole	2 mole	1 mole	4 mole
∴ 3 mole	6 mole	3 mole	12 mole

Concept Application

7. 2 moles of N atoms at NTP occupy a volume of:

(1) 11.2 L (2) 44.8 L
(3) 22.4 L (4) 5.6 L

8. Which of the following contains the largest number of oxygen atoms? 1.0 g of O atoms, 1.0 g of O_2, 1.0 g of ozone O_3.

(1) O_2
(2) O_3
(3) O atom
(4) All have the same number of oxygen atoms

9. The total number of g-molecules of SO_2Cl_2 in 13.5 g of sulphuryl chloride is

(1) 0.1 (2) 0.2
(3) 0.3 (4) 0.4

10. 88 gm of CO_2 contains _____ moles of carbon.

(1) 2 (2) 3
(3) 4 (4) 5

PERCENTAGE COMPOSITION

We know that according to law of definite proportions any sample of a pure compound always possess constant ratio with their combining elements in terms of mass.

Mass percentage of an element

$$= \frac{\text{Mass of that element in the compound}}{\text{Molar mass of the compound}} \times 100$$

CHEMICAL FORMULA

It is of two types:

(*a*) **Empirical formula:** It represent the simplest whole number ratio of various atoms present in a compound. eg. EF of benzene (C_6H_6) is CH.

(*b*) **Molecular formula:** It shows the exact number of different types of atoms present in a molecule of a compound.
eg., MF of benzene is C_6H_6

Determination of Chemical Formula

(*a*) **Determination of Empirical Formula:**
Step (I): Determination of percentage of each element
Step (II): Determination of mole ratio
Step (III): Making it whole number ratio
Step (IV) : Simplest whole number ratio

(*b*) **Determination of Molecular Formula**
MF = (EF) × n;
Where n is a simple whole number.
Molecular formula = n × Empirical formula

Key Note

$$n = \frac{\text{Molecular weight}}{\text{Empirical weight}}$$

Train Your Brain

Example 12: Phosgene, a poisonous gas used during World war-I, contains 12.1% C, 16.2% O and 71.7% Cl by mass. What is the empirical formula of phosgene.

(1) $COCl_2$ (2) COCl

(3) $CHCl_3$ (4) $C_2O_2Cl_4$

Sol. (1)

Element	Symbol	% of element	A.mu of element	Relative no. of atoms	Simplest ratio	Simple whole no. atomic ratio
Carbon	C	12.1	12	$\frac{12.1}{12} = 1.01$	$\frac{1.01}{1.01} = 1$	1
Oxygen	O	16.2	16	$\frac{16.2}{16} = 1.01$	$\frac{1.01}{1.01} = 1$	1
Chlorine	Cl	71.7	35.5	$\frac{71.7}{35.5} = 2.02$	$\frac{2.02}{1.01} = 2$	2

Then empirical formula = $COCl_2$

Example 13: 1.615 g of anhydrous $ZnSO_4$ was left in moist air. After a few days its weight was found to be 2.875 g. What is the molecular formula of hydrated salt?

(At. masses: Zn = 65.5, S = 32, O = 16, H = 1)

Sol. Molecular mass of anhydrous $ZnSO_4$

= 65.5 + 32 + 4 × 16 = 161.5 g

So, 1.615 g of anhydrous $ZnSO_4$ combine with water

= 2.875 – 1.1615 = 1.260 g

1.615 g of anhydrous $ZnSO_4$ combine with water = 1.260 g

161.5 g of anhydrous $ZnSO_4$ combine with

$$= \frac{1.260}{1.615} \times 161.5 = 126 g$$

No. of moles of water = $\frac{126}{18} = 7$

Hence, Formula is $ZnSO_4 . 7H_2O$.

Concept Application

11. The empirical formula of a compound of molecular mass 120 is CH_2O. The molecular formula of the compound is

(1) $C_2H_4O_2$ (2) $C_4H_8O_4$

(3) $C_3H_6O_3$ (4) All of these

12. Calculate the molecular formula of compound which contains 20% Ca and 80% Br molecular weight of compound is 200.

(1) $Ca_{1/2}Br$ (2) $CaBr_2$

(3) CaBr (4) Ca_2Br

13. A hydrocarbon contains 75% of carbon. Then its molecular formula is:

(1) CH_4 (2) C_2H_4

(3) C_2H_6 (4) C_2H_2

14. A compound of X and Y has an equal mass of them. If their atomic weights are 30 and 20 respectively. The molecular formula of that compound (it's mol wt. is 120) could be:

(1) X_2Y_2 (2) X_3Y_3

(3) X_2Y_3 (4) X_3Y_2

FORMULAS

$$\text{Relative Atomic Mass} = \frac{\text{Mass of 1 atom of that element}}{\text{Mass of 1 atom of C} - 12 \text{ isotope}}$$

Atomic Mass = Relative atomic mass × 1 amu

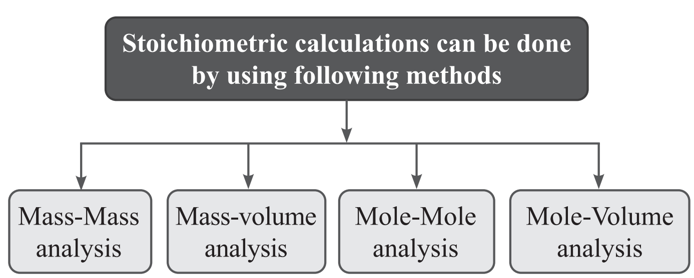
$$\text{Average atomic mass} = \frac{\Sigma_{i=1}^{n} \text{ atomic mass of isotope} \times \% \text{ abundance}}{100}$$

Molecular mass = sum of atomic masses of all atoms present in a molecule

$$\text{Mass \% of Element} = \frac{\text{Mass of element}}{\text{Molecular mass}} \times 100$$

Molecular formula = Empirical Formula × n

STOICHIOMETRY AND STOICHIOMETRIC CALCULATIONS



Chemical Equation and Balanced Chemical Equation

Chemical Reaction: It is a process in which two or more than two substances interact with each other where old bonds are broken and new bonds are formed.

Chemical equation is a scientific method of representing a chemical change in terms of symbols and formula of reactants and products involved in it.

e.g., $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

However, a balanced chemical equation gives us a lot of quantitative information, mainly the molar ratio in which reactants combine and the molar ratio in which products are formed.

Features of a Balanced Chemical Equation

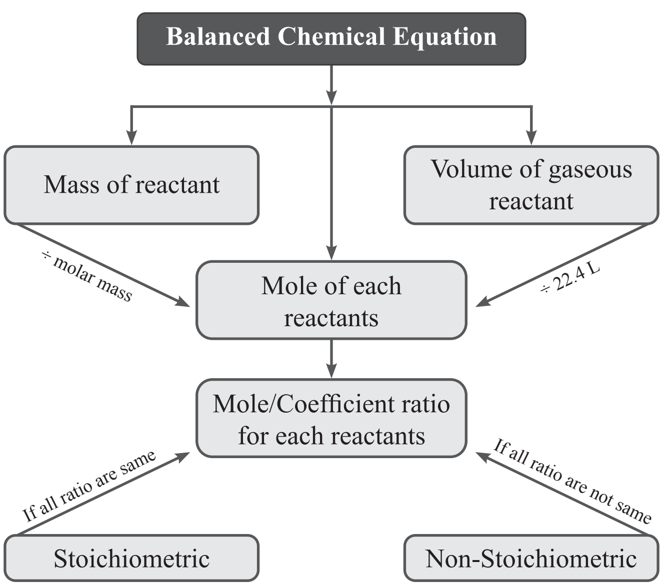
(*a*) It contains the same number of atoms of each element on both sides of equation. (POAC)

(*b*) It should follow law of charge conservation on either side.

(*c*) Physical states of all the reagents/reactants should be included in brackets.

(*d*) All reagents/reactants should be written in their standard forms (Molecular, Atomic,Solid etc.)

(*e*) The coefficients give relative molar ratios of each reagent/ reactant.



Stoichiometry deals with the calculation of masses and sometimes volumes of the reactants and products in a reaction. The coefficients of reactants and products in a balanced chemical equation is called the **stoichiometric coefficients**.

Steps:

1. Write the balanced chemical equation.
2. See the number of moles of various reactants that take part in the reaction and products formed.
3. Calculate the number of moles or amount of substance formed.

Interpretation of balanced chemical equations:

Once we get a balanced chemical equation then we can interpret a chemical equation by following ways:

- Mass - mass analysis
- Mass - volume analysis
- Mole - mole analysis

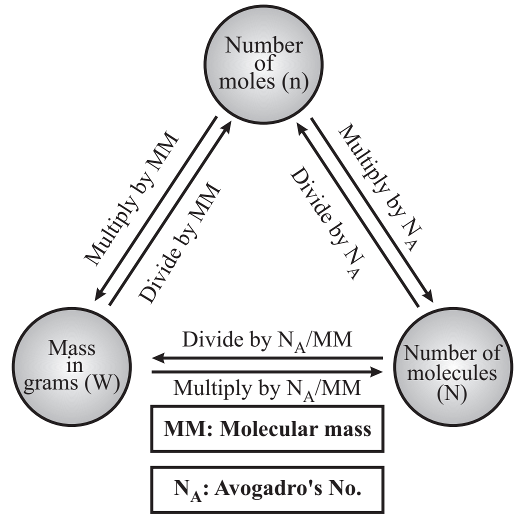


Fig.: Relation between Mass, No. of moles and No. of molecules

Mass-mass Analysis

In the following reaction

$$\text{Mass – mass ratio: } \underset{2\times122.5}{2KClO_3} \rightarrow \underset{2\times74.5}{2KCl} + \underset{3\times32}{3O_2} \quad \left(\begin{array}{l}\text{According to stoichiometry}\\ \text{of the reaction}\end{array}\right)$$

$$\text{or} \quad \frac{\text{Mass of } KClO_3}{\text{Mass of } KCl} = \frac{2\times122.5}{2\times74.5}, \quad \frac{\text{Mass of } KClO_3}{\text{Mass of } O_2} = \frac{2\times122.5}{3\times32}$$

Mass–Volume Analysis

Considering decomposition of $KClO_3$

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

Mass–Volume ratio: 2 × 122.5 g : 2 × 74.5 g : 3 × 22.4 litre at STP We can use two relation for volume of oxygen

$$\frac{\text{Mass of } KClO_3}{\text{volume of } O_2 \text{ at STP}} = \frac{2\times122.5}{3\times22.4\ lt} \quad ...(i)$$

$$\frac{\text{Mass of } KCl}{\text{volume of } O_2 \text{ at STP}} = \frac{2\times74.5}{3\times22.4\ lt} \quad ...(ii)$$

Mole-Mole Analysis

This is very much important for quantitative analysis point of view. Consider again the decomposition of $KClO_3$.

$2KClO_3 \rightarrow 2KCl + 3O_2$

In very first step of mole-mole analysis, you should read the balanced chemical equation like ***2 moles $KClO_3$ on decomposition gives us 2 moles KCl and 3 moles O_2*** and from the stoichiometry of reaction we can write

$$\frac{\text{Moles of } KClO_3}{2} = \frac{\text{Moles of } KCl}{2} = \frac{\text{Moles of } O_2}{3}$$

Now, For any general balanced chemical equation like:

$$a\,A + b\,B \rightarrow c\,C + d\,D$$

We can write,

$$\frac{\text{Moles of A reacted}}{a} = \frac{\text{moles of B reacted}}{b} = \frac{\text{moles of C formed}}{c} = \frac{\text{moles of D formed}}{d}$$

Key Note

- In fact mass-mass and mass-vol analysis are also interpreted in terms of mole-mole analysis. You can see in the following chart also.

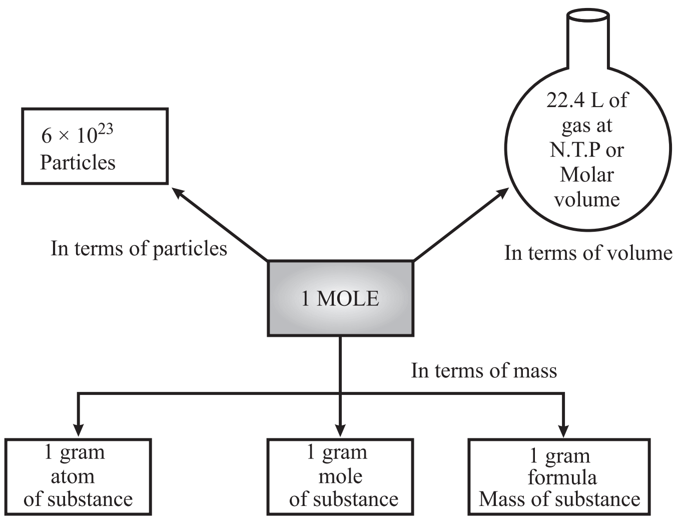


Fig.: Relation of mole in terms of mass, number and volume

Train Your Brain

Example 14: 367.5 gram $KClO_3$ (M = 122.5) when heated how many gram of KCl and oxygen is produced.

Sol. Balance chemical equation for heating of $KClO_3$ is

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

Mass-mass ratio: 2 × 122.5 g : 2 × 74.5 g : 3 × 32 g

$$\frac{\text{mass of } KClO_3}{\text{mass of } KCl} = \frac{2\times122.5}{2\times74.5} \Rightarrow \frac{367.5}{W} = \frac{122.5}{74.5}$$

W = 3 × 74.5 = 223.5 g

$$\frac{\text{Mass of } KClO_3}{\text{Mass of } O_2} = \frac{2\times122.5}{3\times32} \Rightarrow \frac{367.5}{W} = \frac{2\times122.5}{3\times32}$$

W = 144 g

Example 15: 367.5 g $KClO_3$ (M = 122.5) when heated, how many litre of oxygen gas is produced at STP

Sol.

$$\frac{\text{mass of } KClO_3}{\text{volume of } O_2 \text{ at STP}} = \frac{2\times122.5}{3\times22.4\,lt} \Rightarrow \frac{367.5}{V} = \frac{2\times122.5}{3\times22.4\,lt}$$

V = 3 × 3 × 11.2 ⇒ V = 100.8 lt

Concept Application

15. The equation:

$2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s)$ show that

(1) 2 moles of Al reacts with $\frac{3}{2}$ moles of O_2 to produce $\frac{7}{2}$ moles of Al_2O_3

(2) 2g of Al reacts with $\frac{3}{2}$ g of O_2 to produce 1 mole of Al_2O_3

(3) 2g mole of Al reacts with $\frac{3}{2}$ litres of O_2 to produce 1 mole of Al_2O_3

(4) 2 moles of Al reacts with $\frac{3}{2}$ moles of O_2 to produce 1 mole of Al_2O_3

16. The moles of O_2 required for reacting with 6.8 g of ammonia (......NH_3 + ... O_2 → ...... NO + ... H_2O) is

(1) 5 (2) 2.5

(3) 1 (4) 0.5

Limiting Reagent

- The reactant that gets consumed during the reaction & limits the amount of product formed is known as the limiting reagent.
- Limiting reagent is present in least stoichiometric amount and therefore, controls amount of product.
- The remaining or leftout reactant is called the excess reagent.
- If we are dealing with balanced chemical equation, then if number of moles of reactants are not in the ratio of stoichiometric coefficient of balanced chemical equation, then there should be one reactant which should be limiting reactant.

How to Find Limiting Reagent

Step-I Divide the given moles of reactant by the respective stoichiometric coefficient of that reactant.

Step-II See that for which reactant, this division comes out to be minimum. The reactant having minimum value is limiting reagent for you.

Step-III Now, if we have found limiting reagent, then our focus should be on limiting reagent to find the amount of the product.

Train Your Brain

Example 16: 6 moles of Na_2CO_3 and 4 moles of HCl are made to react. Find the volume of CO_2 gas produced at STP. The reaction is $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

Sol. From Step I & II

Na_2CO_3 HCl

$\frac{6}{1}=6 \quad \frac{4}{2}=2$ (division is minimum)

$\therefore$ HCl is limiting reagent

From Step III

$$\frac{\text{Mole of HCl}}{2}=\frac{\text{Moles of } CO_2 \text{ produced}}{1}$$

$\therefore$ mole of CO_2 produced $=\frac{4}{2}=2$

$\therefore$ volume of CO_2 produced at S.T.P. $= 2 \times 22.4 = 44.8$ lt.

Example 17: If 0.5 mol of $BaCl_2$ is mixed with 0.2 mole of Na_3PO_4, the maximum amount of $Ba_3(PO_4)_2$ that can be formed is :

Sol. 0.10 mol

	$3BaCl_2$ +	$2Na_3PO_4$ $\rightarrow$	$6NaCl$ +	$Ba_3(PO_4)_2$
molar ratio	3	2	6	1
initial moles	0.5	0.2	0	0

Limiting reagent is Na_3PO_4 hence it would be consumed, and the yield would be decided by it initial moles.

2 moles of Na_3PO_4 give 1 mole of $Ba_3(PO_4)_2$,

$\therefore$ 0.2 moles of Na_3PO_4 would give 0.1 mole of of $Ba_3(PO_4)_2$

Concept Application

17. 4 g of hydrogen is ignited with 4 g of oxygen, the amount of water formed is?

(1) 2.5 g (2) 0.5 g

(3) 4.5 g (4) 8 g

18. 0.5 mole of H_2SO_4 is mixed with 0.2 mole of $Ca(OH)_2$. The maximum number of moles of $CaSO_4$ formed is:

(1) 0.2 (2) 0.5

(3) 0.4 (4) 1.5

CONCENTRATION TERMS

The concentration of a solution or the amount of substance present in its given volume can be expressed in any of the following ways.

1. Mass percent or weight percent (w/w%)
2. Mole fraction
3. Molarity
4. Molality
5. Normality

Mass Percent

It is obtained by using the following relation:

$$\text{Mass percent} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

Mole Fraction

It is no. of moles of a certain component to the total no. of moles of the solution.

$$\text{Mole fraction of A} = \frac{\text{No. of moles of A}}{\text{No. of moles of solution}} = \frac{n_A}{n_A + n_B}$$

Mole fraction is a pure number. It will remain independent of temperature changes.

Molarity

It is defined as the number of moles of the solute in 1 litre of the solution. It is denoted by M

$$\text{Molarity (M)} = \frac{\text{No. of moles of solute}}{\text{Volume of solution in litre}}$$

Molarity is the unit that depends upon temperature. It varies inversely with temperature.

Mathematically: Molarity decreases as temperature increases.

$$\text{Molarity} \propto \frac{1}{\text{temperature}} \propto \frac{1}{\text{volume}}$$

If a particular solution having volume V_1 and molarity $= M_1$ is diluted to V_2 mL then

$M_1V_1 = M_2V_2$

M_2 : Resultant molarity

If a solution having volume V_1 and molarity M_1 is mixed with another solution of same solute having volume V_2 & molarity M_2 then $M_1V_1 + M_2V_2 = M_R(V_1 + V_2)$

$$M_R = \text{Resultant molarity} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$$

Molality

It is defined as the number of moles of solute present in 1 kg of solvent. it is denoted by m.

$$\text{Thus, Molality (m)} = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$$

Molality is independent of temperature changes.

There are other terms also used to express concentration of solution

Normality (N)

It is the number of gram equivalent of a solute dissolved per litre of the solution.

$$\text{Normality (N)} = \frac{\text{No. of gram equivalents of solute}}{\text{Vol. of solution in litres}}$$

$$\text{Gram equivalent} = \frac{\text{Mass of solute}}{\text{Equivalent weight}}$$

$$\text{Normality} = \frac{\text{Mass of solute in gram}}{\text{Equivalent weight in gram} \times \text{vol. of soltution in litres}}$$

Normality equation: $N_1V_1 = N_2 V_2$

Formality

$$\text{Formality} = \frac{\text{Wt. of ionic solute}}{\text{Formula Wt. of solute} \times \text{Vol. of solution in lit.}}$$

Train Your Brain

Example 18: 255 g of an aqueous solution contains 5 g of urea. What is the concentration of the solution in terms of molality. (Mol. wt. of urea = 60)

Sol. Mass of urea = 5 g

Molecular mass of urea = 60 g

Number of moles of urea = = 0.083

Mass of solvent = (255 – 5) = 250 g

∴ Molality of the solution

$$= \frac{\text{Number of moles of solute}}{\text{Mass of solvent in gram}} = \times 1000$$

$$= \frac{0.083}{250} \times 1000 = 0.332 \text{ m}$$

Example 19: 0.5 g of a substance is dissolved in 25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Sol. Mass of substance = 0.5 g

Mass of solvent = 25 g

∴ Percentage of the substance (w/w)

$$= \frac{0.5}{0.5+25} \times 100 = 1.96$$

Concept Application

19. What approximate volume of 0.40 M $Ba(OH)_2$ must be added to 50.0 mL of 0.30 M NaOH to get a solution in which the molarity of the OH^- ions is 0.50 M?

(1) 33 mL (2) 66 mL

(3) 133 mL (4) 100 mL

20. What volume of a 0.8 M solution contains 100 millimoles of the solute?

(1) 100 mL (2) 125 mL

(3) 500 mL (4) 62.5 mL

Equivalent Weight (E)

$$E = \frac{\text{Molecular weight}}{\text{n-factor}}$$

n-Factor

Species	n-factor
Element	Valency
Ion	Charge on ion
Acid	Basicity (no. of moles H^+ ion released by 1 mole of acid)
Base	Acidity (no. of moles OH^- ion released by 1 mole of base)
Salt	Total +ve or –ve charge produced by 1 mole of salt

Degree of Hardness of Water

$$\text{Hardness of water} = \frac{\text{mass of } CaCO_3}{\text{Total mass of water}} \times 10^6$$

Yield of Product

In many cases, the actual yield of a product is less than the theoretical maximum yield. The percentage yield of the product is thus defined as.

$$\text{\% yield of product} = \frac{\text{Actual yield}}{\text{Theoritical maximum yield}}$$

For eg: During a chemical reaction, 0.5g of product is formed. The max. calculated yield is 1.6g. The percent yield of the reaction will be:

$$= \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

$$= \frac{0.5}{1.6} \times 100$$

= 31.25 %

Train Your Brain

Example 20: What is the degree of hardness of a sample of water containing 48 mg of $MgSO_4$ (molecular mass 120) per kg of water?

(1) 10 ppm (2) 20 ppm

(3) 30 ppm (4) 40 ppm

Sol. (4) Degree of hardness is no. of parts of calcium carbonate or equivalent to various calcium and magnesium salts present in ppm.

48 mg of $MgSO_4$ present in 10^3g of water (Given)

So, 10^6g water will contain = 48000 mg of $MgSO_4$

= 48 g of $MgSO_4$

1 mole $MgSO_4$ = 1 mole of $CaCO_3$

$\because$ 120 g of $MgSO_4$ = 100 g of $CaCO_3$

$\therefore$ 48 g of $MgSO_4 = \frac{48 \times 100}{120} = 40$ g of $CaCO_3$

$\therefore$ Hardness of water = 40 ppm

Example 21: For the reaction,

$A + 2B \longrightarrow C + 2D$

The correct statement is

(1) Equivalents of A = 2 × Equivalents of B

(2) Moles of A reacted = Moles of D formed

(3) Equivalents of B = Equivalents of C

(4) Moles of B reacted = 2 × Moles of D formed

Sol. (3) $A + 2B \longrightarrow C + 2D$

Number of eq. of A = Number of eq. of B = Number of eq. of C = Number of eq. of D

Moles of A reacted = 2 × moles of D formed

Moles of B reacted = moles of D formed

Concept Application

21. The equivalent weight of phosphoric acid (H_3PO_4) in the reaction,

$NaOH + H_3PO_4 \longrightarrow NaH_2PO_4 + H_2O$ is:

(1) 25 (2) 49

(3) 59 (4) 98

22. Potassium chlorate decomposes upon slight heating in the presence of a catalyst, according to the reaction below:

$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$

In a certain experiment, 40.0g of $KClO_3$ is heated until it completely decomposes and the collected oxygen gas actual yield is found to be 14.9g.

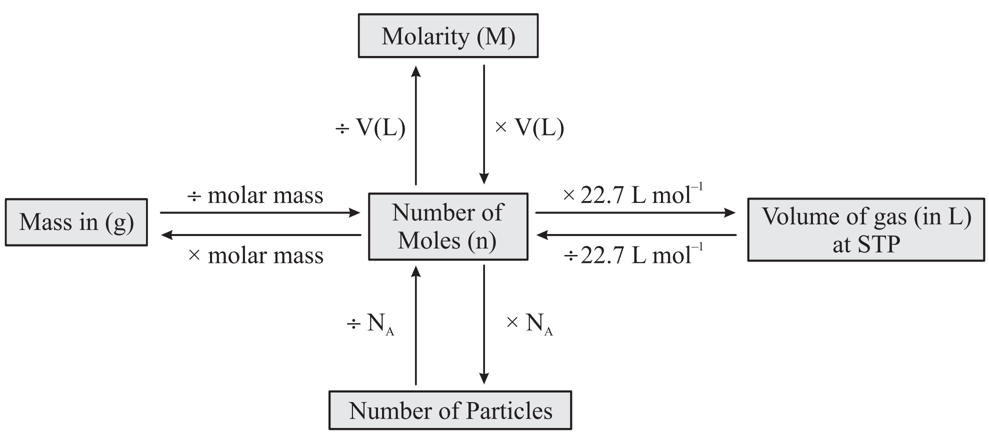
What is the theoretical yield of oxygen gas and percent yield of the reaction respectively?

(1) 15.7; 94.9 (2) 13.6; 74.5

(3) 12.5; 87.6 (4) 17.4; 68.4

Short Notes

Various Relations of Moles



Important Formulae of Concentration Terms

1. $w/w\ \% = \frac{w_2}{w_1 + w_2} \times 100$

2. $w/v\ \% = \frac{w_2}{V_{sol}} \times 100$

3. $v/v\ \% = \frac{v_2}{v_1 + v_2} \times 100$

4. $ppm = \frac{w_2}{w_1 + w_2} \times 10^6$

5. $ppb = \frac{w_2}{w_1 + w_2} \times 10^9$

6. $X_2 = \frac{n_2}{n_1 + n_2}; X_1 = \frac{n_1}{n_1 + n_2}$

7. $M = \frac{W_2 \times 1000}{M_2 \times V(ml)}$

8. $M = \frac{\frac{w}{w}\% \times d \times 10}{\text{Molar mass of solute}}$

9. $m = \frac{\text{Moles of the solute}}{\text{mass of solvent(kg)}} = \frac{W_2 \times 1000}{M_2 \times W_1(g)}$

10. $m = \frac{x_2 \times 1000}{x_1 \times Mw_1(g)}$

11. $d = M\left(\frac{1}{m} + \frac{M_2(g)}{1000}\right)$

12. $M = M\frac{1000dX_2}{x_1M_1 + x_2M_2(g)}$

Conc. Terms	Formula
Mole Fraction	Mole fraction = $\frac{\text{Moles of component}}{\text{Total number of moles present in solution}}$ $x_A = \frac{n_A}{n_A + n_B + n_C.....}$
Parts per million	ppm of a solute in solution = $\frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$
Degree of hardness of water	Hardness of water = $\frac{\text{mass of } CaCO_3}{\text{Total mass of water}} \times 10^6$
Mass Percentage	$\%w/w = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$
Mass by volume Percentage	$\%w/v = \frac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$
Volume by volume percentage	$\%v/v = \frac{\text{Volume of solute}(cm^3)}{\text{Volume of solution}(cm^3)} \times 100$
Molarity	Molarity, (M) = $\frac{\text{Moles of solute}}{\text{Volume of solution (L)}}$
Molality	Molality, (m) = $\frac{\text{Moles of solute}}{\text{Mass of solvent (Kg)}}$

Some Important Relations

$M = \frac{10 \times \%w/v}{M_{solute}}$

$M = \frac{10 \times \%w/w \times d}{M_{solute}}$

$\%w/v = \% \; w/w \times d$

$m = \frac{X_{solute}}{X_{solvent}} \times \frac{1000}{M_{solvent}}$

$m = \frac{1000 \times M}{1000d - M \times M_{solute}}$

Where,

M = Molarity,

m = Molality

d = Density

$M_1/M_{solvent}$ = Molar mass of solvent

M_2/M_{solute} = Molar mass of solute

X_{solute} = Mole fraction of solute

$X_{solvent}$ = Mole fraction of solvent

Solved Examples

1. It takes 2.56×10^{-3} equivalent of KOH to neutralize 0.1254g H_2XO_4. The number of neutrons in X is

(1) 16 (2) 8

(3) 7 (4) 32

Sol. (4) Mole of $H_2XO_4 = \dfrac{0.1254}{M_x + 66}$[$M_x$ = Atomic mass of x]

'n' factor of H_2XO_4 = 2 [H_2XO_4 is dibasic acid]

$\therefore 2.56 \times 10^{-3} = \dfrac{0.1254}{M_X + 66} \times 2$

M_x= 31.96 g/mol = 32 g/mol

2. How many grams of sodium bicarbonate are required to neutralize 10.0 ml of 0.902 M vinegar?

(1) 8.4g (2) 1.5g

(3) 0.75g (4) 1.07g

Sol. (3) $NaHCO_3 + \underset{\text{Vinegar}}{CH_3COOH} \rightleftharpoons CH_3COONa + CO_2 + H_2O$

Equivalent of acid = $\dfrac{10 \times 0.902}{1000}$

Equivalent of $NaHCO_3$ = 9.02×10^{-3}

Amount of $NaHCO_3$

= $9.02 \times 10^{-3} \times 84$

= 0.758

3. A sample of hard water contains 244 ppm of HCO_3^- ions. What is the minimum mass of CaO required to remove HCO_3^- ions completely from 1 kg of such water sample

(1) 56 mg

(2) 112 mg

(3) 168 mg

(4) 244 mg

Sol. (2) Mass of HCO_3^- in 1 kg or 10^6 mg water = 244 mg

Millimoles of $HCO_3^- = \dfrac{244}{61} = 4$

$Ca(HCO_3) + CaO \longrightarrow CaCO_3 + H_2O + CO_2 + 2e^-$

millimoles of CaO = 2

mass of CaO = 56 × 2 = 112 mg

4. 100 ml of each of 0.5 N NaOH, N/5 HCl and N/10 H_2SO_4 are mixed together. The resulting solution will be

(1) Acidic

(2) Neutral

(3) Alkaline

(4) None

Sol. (3) Meq. of NaOH = 100 × 0.5 = 50

Meq. of HCl = $\dfrac{1}{5} \times 100 = 20$ = 20

Meq. of H_2SO_4 = $\dfrac{1}{10} \times 100 = 10$

Total meq. of acid = 20 + 10 = 30

Total meq. of NaOH = 50

meq. of NaOH left = 50 – 30 = 20

Thus, solution will be alkaline.

5. The chloride of a metal (M) contains 65.5% of chlorine. 100 ml of the vapour of the chloride of the metal at STP weight 0.72g. the molecular formula of the metal chloride is

(1) MCl_3

(2) MCl

(3) MCl_2

(4) MCl_4

Sol. (1) Molecular mass of chloride of metal = weight of 22,400 ml vapour of metal at STP

$= \dfrac{0.72 \times 22,400}{100} = 161.28\text{g}$

100g of metal chloride contains = 65.5 g chloride

161.28g metal chloride contains = $\dfrac{65.5 \times 161.28}{100}$

= 105.6g

Therefore, the number of mole of chlorine atoms per mole of metal chloride

= 105.6/35.5 = 3

Hence the molecular formula of metal chloride is MCl_3

6. Gaseous mixture of propane and butane of volume 3 litre on complete combustion produces 11.0 litre CO_2 under standard conditions of temperature and pressure. The ratio of volume of butane to propane is

(1) 1 : 2 (2) 2 : 1

(3) 3 : 2 (4) 3 : 1

Sol. (2) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

x litres of propane produce 3x litre of CO_2

$C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$

(3 – x) litres of butane produce 4(3 – x) lit of CO_2

3x + 4(3 – x) = 11

3x + 12 – 4x = 11

12 – x = 11

x = 1 litre

Volume of butane : propane = 2 : 1

7. The percent loss in weight after heating a pure sample of potassium chlorate (Molecular weight = 122.5) will be

(1) 12.25

(2) 24.50

(3) 39.18

(4) 49

Sol. (3) $2KClO_3 \longrightarrow 2KCl + 3O_2\uparrow$

By Stoichiometry,

245 g $KClO_3$ on heating shows a weight loss of 96 gm

$\therefore$ % loss = $\frac{96}{245}\times100 = 39.18\%$

8. In an experiment, 50 ml of 0.1 M solution of a salt reacted with 25 ml of 0.1 M solution of sodium sulphite. The half equation for the oxidation of sulphite ion:

$$SO^{2-}_{3(aq)} + H_2O \longrightarrow SO^{2-}_{4(aq)} + 2H^{+}_{(aq)} + 2e^{\ominus}$$

If the oxidation number of the metal in the salt was 3, what would be the new oxidation number of the metal?

(1) 0 (2) 1

(3) 2 (4) 4

Sol. (3) SO_3^{2-} get oxidised and its 'n' factor is 2

The metal must have been reduced

Applying the law of equivalence

$50 \times 0.1 \times (3 - n) = 25 \times 0.1 \times 2$

9. The chloride of a metal contains 71% chlorine by weight and the vapour density of it is 50. The atomic weight of the metal will be

(1) 29

(2) 58

(3) 35.5

(4) 71

Sol. (1) Molecular weight of metal chloride = 50 × 2 = 100

Let metal chloride be MCl_n then

Eq. of metal = eq. of chloride, or $\frac{29}{E} = \frac{71}{35.5}$

$\therefore$ E $\frac{29}{2}$

Now a + 35.5n = 100

or n.E + 35.5n = 100

n = 2

Therefore a = 2 × E = 2 × 29/2 = 29

10. How many moles of hydrogen present in 34 gm of NH_3

(1) 6 (2) 5

(3) 4 (4) 7

Sol. (1) No. of moles of $NH_3 = \frac{34}{17} = 2$

No. of moles of hydrogen = 2 × 3 = 6

Exercise-1 (Topicwise)

MEASUREMENT AND SIGNIFICANT FIGURES

1. The number of significant figures in 0.0045 are
   (1) Two (2) Three
   (3) Four (4) Five
2. Light travels with a speed of 3×10^8 m/sec. The distance travelled by light in 1 Femto sec is
   (1) 0.03 mm (2) 0.003 mm
   (3) 3 mm (4) 0.0003 mm
3. Area of nuclear cross-section is measured in "Barn". It is equal to
   (1) 10^{-20} m^2 (2) 10^{-30} m^2
   (3) 10^{-28} m^2 (4) 10^{-14} m^2
4. Two students X and Y report the mass of the same substance as 7.0 g and 7.00 g respectively, which of the following statement is correct?
   (1) Both are equally accurate
   (2) X is more accurate than Y
   (3) Y is more accurate than X
   (4) Both are inaccurate scientifically
5. The number of significant figures in value of π are
   (1) 1 (2) 2
   (3) 3 (4) ∞
6. 5.041 has how many significant figures.
   (1) 1 (2) 2
   (3) 3 (4) 4
7. The correctly reported answer of the addition of 29.4406, 3.2 and 2.25 will have significant figures
   (1) 3 (2) 4
   (3) 2 (4) 5
8. What is the area of rectangle which is 12.34 cm wide and 1.23 cm long? Report the answer to correct significant figures
   (1) 15.2 m^2 (2) 15.2 cm^2
   (3) 16.2 cm^2 (4) 16.2 m^2
9. If an object has a mass of 0.2876 g, then find the mass of nine such objects. Report the answer to correct significant figures
   (1) 2.5884 g (2) 2.5886 g
   (3) 2.588 g (4) 2.5 g
10. The value of Plank's constant is 6.62618×10^{-34} Js. The number of significant figures in it is
    (1) Six
    (2) Five
    (3) Three
    (4) Thirty four

LAW OF CHEMICAL COMBINATIONS

11. In Habers process, the volume at S.T.P of ammonia relative to the total volume of reactants at STP is
    (1) One fourth (2) One half
    (3) Same (4) Three fourth
12. 6 g of carbon combines with 32 g of sulphur to form CS_2, 12 g of C also combine with 32 g oxygen to form CO_2. 10 g of sulphur combines with 10 g of oxygen to form Sulphur dioxide. Which law is illustrated by this?
    (1) Law of multiple proportions
    (2) Law of constant composition
    (3) Law of reciprocal proportions
    (4) Gay Lussac's law
13. Which of the following data illustrates the law of conservation of mass?
    (1) 56 g of C reacts with 32 g of Oxygen to produce 44 g of CO_2
    (2) 1.70 g of $AgNO_3$ reacts with 100 ml of 0.1M HCl to produce 1.435 g of AgCl and 0.63 g of HNO_3
    (3) 12 g of C is heated in vacuum and on cooling, there is no change in mass
    (4) 36 g of S reacts with 16 g of O_2 to produce 48 g of SO_2
14. One part of an element A combines with two parts of another element B, 6 parts of element C combines with 4 parts of (B) If A and C combine together the ratio of their weights, will be governed by
    (1) law of definite proportion
    (2) law of multiple proportion
    (3) law of reciprocal proportion
    (4) law of conservation of mass
15. The law of conservation of mass holds good for all of the following except.
    (1) All chemical reactions (2) Nuclear reaction
    (3) Endothermic reactions (4) Exothermic reactions
16. The % of copper and oxygen in samples of CuO obtained by different methods were found to be same. This proves the law of
    (1) Constant Proportion
    (2) Reciprocal Proportion
    (3) Multiple Proportion
    (4) Conservation of mass.
17. Two elements X and Y combine in gaseous state to form XY in the ratio 1 : 35.5 by mass. The mass of Y that will be required to react with 2 g of X is
    (1) 7.1 g (2) 3.55 g
    (3) 71 g (4) 35.5 g

18. 4.4 g of an oxide of nitrogen gives 2.24 L of nitrogen and 60 g of another oxide of nitrogen gives 22.4 L of nitrogen at S.T.P. The data illustrates

(1) Law of conservation of mass
(2) Law of constant proportions
(3) Law of multiple proportions
(4) Law of reciprocal proportions

19. "The total mass of reactants is always equal to the total mass of products in a chemical reaction". This statement is konwn as

(1) Law of conservation of mass
(2) Law of definite proportions
(3) Law of equivalent weights
(4) Law of combining masses

20. The law of multiple proportions is illustrated by the two compounds

(1) Sodium chloride and sodium bromide
(2) Ordinary water and heavy water
(3) Caustic soda and caustic potash
(4) Sulphur dioxide and sulphur trioxide

21. If law of conservation of mass was to hold true, then 20.8 g of $BaCl_2$ on reaction with 9.8 g of H_2SO_4 will produce 7.3 g of HCl and $BaSO_4$ equal to

(1) 11.65 g (2) 23.3 g
(3) 25.5 g (4) 30.6 g

22. One of the following combinations which illustrates the law of reciprocal proportions is

(1) N_2O_3, N_2O_4, N_2O_5
(2) NaCl, NaBr, NaI
(3) CS_2, CO_2, SO_2
(4) PH_3, P_2O_3, P_2O_5

23. Hydrogen and oxygen combine to form H_2O_2 and H_2O containing 5.93% and 11.2% hydrogen respectively, the data illustrates

(1) Law of conservation of mass
(2) Law of Constant proportions
(3) Law of reciprocal proportions
(4) Law of multiple proportions

24. Two elements X (of mass 16) and Y (of mass 14) combine to form compounds A, B and C. The ratio of different masses of Y which combine with a fixed mass of X in A, B and C is 1 : 3 : 5, if 32 parts by mass of X combines with 84 parts by mass of Y in B, then in C, 16 parts by mass of X will combine with;

(1) 14 parts by mass of Y (2) 42 parts by mass of Y
(3) 70 parts by mass of Y (4) 84 parts by mass of Y

ATOMIC AND MOLECULAR MASSES

25. Insulin contains 3.4% sulphur by mass. What will be the minimum molecular weight of insulin?

(1) 94.117 u (2) 1884 u
(3) 941 u (4) 976 u

26. Boron has two isotopes 10B and 11B whose relative abundances are 20% and 80% respectively. Atomic weight of Boron is

(1) 10 (2) 11
(3) 10.5 (4) 10.8

27. Avogadro's number is the number of molecules present in

(1) 1 g of molecule (2) 1 atom of molecule
(3) gram molecular mass (4) 1 litre of molecule

28. One amu is equal to

(1) 1.66×10^{-8} g (2) 1.66×10^{-4} g
(3) 1.66×10^{-16} g (4) 1.66×10^{-24} g

29. The number of molecules present in one milli litre of a gas at STP is known as

(1) Avogadro number (2) Boltzman number
(3) Loschmidt number (4) Universal gas constant

30. If the atomic mass unit 'u' were defined to be $\frac{1}{5}^{th}$ of the mass of an atom of C-12, what would be the atomic weight of nitrogen in amu or 'u' in this state? Atomic weight of N on conventional scale is 14

(1) 6.77 u (2) 5.834 u
(3) 14 u (4) 23 u

31. A 100 g sample of Haemoglobin on analysis was found to contain 0.34% Fe by mass. If each haemoglobin molecule has four Fe^{2+} ions, the molecular mass of haemoglobin is (Fe = 56 amu)

(1) 77099.9 g (2) 12735 g
(3) 65882 g (4) 96359.9 g

MOLE CONCEPT AND MOLAR MASSES

32. 1 g-atom of nitrogen represents

(1) 6.02×10^{23} N_2 molecules
(2) 22.4 L of N_2 at S.T.P
(3) 11.2 L of N_2 at S.T.P
(4) 28 g of nitrogen

33. Which is correct for 10 g of $CaCO_3$?

(1) It contains 1 g atom of carbon
(2) It contains 0.3 g atoms of oxygen
(3) It contains 12 g of calcium
(4) It refers to 0.1 g equivalent of $CaCO_3$

34. The number of oxygen atoms present in 14.6 g of magnesium bicarbonate is

(1) 6 N_A (2) 0.6 N_A
(3) N_A (4) $\frac{N_A}{2}$

35. Which of the following has the highest mass?

(1) 20 g of sulphur
(2) 4 mol of carbon dioxide
(3) 12×10^{24} atoms of hydrogen
(4) 11.2 L of helium at N.T.P.

36. If isotopic distribution of C-12 and C-14 is 98% and 2% respectively, then the number of C-14 atoms in 12 g of carbon is
(1) 1.032×10^{22} (2) 3.01×10^{22}
(3) 5.88×10^{23} (4) 6.02×10^{23}

37. 5.6 L of a gas at S.T.P. weights equal to 8 g. The vapour density of gas is
(1) 32 (2) 16 (3) 8 (4) 40

38. One atom of an element weighs 1.8×10^{-22} g, its atomic mass is
(1) 29.9 g (2) 18 g
(3) 108.36 g (4) 154 g

39. If H_2SO_4 ionises as $H_2SO_4 + 2H_2O \rightarrow 2H_3O^+ + SO_4^{2-}$. Then total number of ions produced by 0.1 mol H_2SO_4 will be
(1) 9.03×10^{21} (2) 3.01×10^{22}
(3) 6.02×10^{22} (4) 1.8×10^{23}

40. Which of the following will not have a mass of 10 g?
(1) 0.1 mol $CaCO_3$ (2) 1.51×10^{23} Ca^{2+} ions
(3) 0.16 mol of CO_3^{2-} ions (4) 7.525×10^{22} Br atom

41. x L of N_2 at S.T.P. contains 3×10^{22} molecules. The number of molecules in x/2 L of ozone at S.T.P. will be
(1) 3×10^{22} (2) 1.5×10^{22}
(3) 1.5×10^{21} (4) 1.5×10^{11}

42. A person adds 1.71 gram of sugar ($C_{12}H_{22}O_{11}$) in order to sweeten his tea. The number of carbon atoms added are: (mol mass of sugar = 342)
(1) 3.6×10^{22} (2) 7.2×10^{21}
(3) 0.05 (4) 6.6×10^{22}

43. The number of atoms present in 0.1 mole of P_4 (at. mass = 31) are
(1) 2.4×10^{24} atoms
(2) Same as in 0.05 mol of S_8
(3) 6.02×10^{22} atoms
(4) Same as in 3.1g of phosphorus

44. Which one contains maximum number of molecules?
(1) 2.5 g molecule of N_2
(2) 4 g atom of nitrogen
(3) 3.01×10^{24} atoms of H_2
(4) 82 g of dinitrogen

45. Out of 1.0 g dioxygen, 1.0 g (atomic) oxygen and 1.0 g ozone, the maximum number of oxygen atoms are contained in
(1) 1.0 g of atomic oxygen
(2) 1.0 g of ozone
(3) 1.0 g of oxygen gas
(4) All contain same number of atoms

46. The maximum volume at S.T.P. is occupied by
(1) 12.8 g of SO_2
(2) 6.02×10^{22} molecules of CH_4
(3) 0.5 mol of NO_2
(4) 1g molecule of CO_2

47. If N_A is Avogadro's number, then the number of oxygen atoms in one g-equivalent of oxygen is $[O_2 + 4e \rightarrow 2O^{2-}]$
(1) N_A (2) $N_A/2$
(3) $N_A/4$ (4) $2N_A$

48. If 224 ml. of a triatomic gas has a mass of 1g at 273 K and 1 atm pressure, then the mass of one atom is
(1) 8.30×10^{-23} g (2) 6.24×10^{-23}
(3) 2.08×10^{-23} g (4) 5.54×10^{-23} g

49. The rest mass of an electron is 9.11×10^{-31} kg. Molar mass of the electron is
(1) 1.5×10^{-31} kg mol^{-1} (2) 9.11×10^{-31} kg mol^{-1}
(3) 5.5×10^{-7} kg mol^{-1} (4) 6.02×10^{23} kg mol^{-1}

50. A sample of ammonium phosphate, $(NH_4)_3PO_4$, contains 3.18 moles of hydrogen atoms. The number of moles of oxygen atoms in the sample is
(1) 0.265 (2) 0.795
(3) 1.06 (4) 3.18

51. What is the total number of atoms present in 25.0 mg of camphor, $C_{10}H_{16}O$?
(1) 9.89×10^{19} (2) 6.02×10^{20}
(3) 9.89×10^{20} (4) 2.67×10^{21}

52. Which of the following samples contains the largest number of atoms?
(1) 1 g of CO_2 (2) 1 g of C_8H_{18}
(3) 1 g of C_2H_6 (g) (4) 1 g of LiF (s)

53. 4.0 g of caustic soda (NaOH) (mol mass 40) contains same number of sodium ions as are present in
(1) 10.6 g of Na_2CO_3 (mol. mass 106)
(2) 58.5 g of NaCl (Formula mass 58.5)
(3) 100 ml of 0.5 M Na_2SO_4 (Formula mass 142)
(4) 1 mol of $NaNO_3$ (mol. mass 85)

54. Total number of atoms present in 64 gm of SO_2 is
(1) $2 \times 6.02 \times 10^{23}$
(2) 6.02×10^{23}
(3) $4 \times 6.02 \times 10^{23}$
(4) $3 \times 6.02 \times 10^{23}$

55. The total number of protons, electrons and neutrons in 12 gm of ${}_6C^{12}$ is
(1) 1.084×10^{25} (2) 6.022×10^{23}
(3) 6.022×10^{22} (4) 18

56. Number of Ca^{+2} and Cl^- ions in 111 g of anhydrous $CaCl_2$ respectively are
(1) N_A, $2N_A$ (2) $2N_A$, N_A
(3) N_A, N_A (4) None

57. The maximum volume at N.T.P. is occupied by
(1) 12.8 gm of SO_2
(2) 6.02×10^{22} molecules of CH_4
(3) 0.5 mol of NO_2
(4) 1 gm-molecule of CO_2

58. Number of moles of water in 488 g of $BaCl_2.2H_2O$ are - (Ba = 137)

(1) 2 moles (2) 4 moles
(3) 3 moles (4) 5 moles

59. 4.4 g of CO_2 and 2.24 litre of H_2 at STP are mixed in a container. The total number of molecules present in the container will be

(1) 6.022×10^{23} (2) 1.2044×10^{23}
(3) 2 moles (4) 6.023×10^{24}

60. One mole of nitrogen gas has volume equal to

(1) 1 litre of nitrogen at S.T.P.
(2) 32 litre of nitrogen at S.T.P.
(3) 22.4 litre of nitrogen at S.T.P.
(4) 11.2 litre of nitrogen at S.T.P.

61. The number of atoms present in 0.1 mole of P_4.

(1) 2.4×10^{23} atom (approx)
(2) Same as in 0.05 mole of S_8
(3) Same as in 124 g of P_4
(4) 2.4×10^{24} atom (approx)

62. 23g of sodium will react with ethyl alcohol to give

(1) 1 mole of H_2
(2) 1/2 mole of H_2
(3) 1 mole of O
(4) 1 mole of NaOH

63. If we assume 1/24 th part of mass of carbon instead of 1/12 th part of it as 1 amu., mass of 1 mole of a substance will

(1) Remain unchanged (2) get doubled
(3) Get halved (4) can't be predicted

64. 10 grams of each O_2, N_2 and Cl_2 are kept in three bottles. The correct order of arrangement of bottles containing decreasing number of molecules.

(1) O_2, N_2, Cl_2 (2) Cl_2, N_2, O_2
(3) Cl_2, O_2, N_2 (4) N_2, O_2, Cl_2

65. Maximum number of atoms are present in

(1) 14 gms. of carbon monoxide
(2) 2 gms. of hydrogen
(3) 11.2 lit. of nitrogen at STP
(4) 1.5 gms atoms of helium

66. Which of the following gases contain the same number of molecules as that of 16 grams of oxygen?

(1) 16 gm of O_3 (2) 32 grams of SO_2
(3) 16 gm of SO_2 (4) All of these

PERCENTAGE COMPOSITION AND EMPIRICAL & MOLECULAR FORMULA

67. The percentage of C, H and N in an organic compound are 40%, 13.3% and 46.7% respectively then empirical formula is

(1) $C_3H_{13}N_3$ (2) CH_2N
(3) CH_4N (4) CH_6N

68. B_1 g of an element gives B_2 g of its chloride, the equivalent mass of the element is

(1) $\frac{B_1}{B_2 - B_1} \times 35.5$ (2) $\frac{B_2}{B_2 - B_1} \times 35.5$
(3) $\frac{B_2 - B_1}{B_1} \times 35.5$ (4) $\frac{B_2 - B_1}{B_2} \times 35.5$

69. 60 g of a compound on analysis gave 24 g C, 4 g H and 32 g O. The empirical formula of the compound is

(1) $C_2H_4O_2$ (2) $C_2H_2O_2$
(3) CH_2O_2 (4) CH_2O

70. A compound made of two elements A and B are found to contain 25% A (at mass 12.5) and 75% B (at mass 37.5). The simplest formula of the compound is

(1) AB (2) AB_2
(3) AB_3 (4) A_3B

71. 400 mg of capsule contains 100 mg of ferrous fumarate. The percentage of Fe present in the capsule is approximately: (formula of ferrous fumarate is $(CHCOO)_2$ Fe).

(1) 8.2% (2) 25%
(3) 16% (4) Unpredictable

72. Simplest formula of compound containing 50% of element X (at mass 10) and 50% of element Y (at mass 20) is

(1) XY (2) X_2Y
(3) XY_2 (4) X_2Y_3

73. A compound having the empirical formula (C_3H_4O) has a molecular mass of 170 ± 5. The molecular formula of it's compound is

(1) C_3H_4O (2) $C_6H_8O_2$
(3) $C_6H_{12}O_3$ (4) $C_9H_{12}O_3$

74. Two oxides of a metal contains 50% and 40% metal (M) respectively. If the formula of first oxide is MO_2, the formula of second oxide will be

(1) MO_2 (2) MO_3
(3) M_2O (4) M_2O_5

75. The vapour density of gas A is four times that of B. If molecular mass of B is M, then molecular mass of A is

(1) M (2) 4 M
(3) $\frac{M}{4}$ (4) 2 M

76. A metal nitride M_3N_2 contains 28% of nitrogen. The atomic mass of metal M is

(1) 24 (2) 54
(3) 9 (4) 87.62

77. A container of volume V, contains 0.28 g of N_2 gas. If same volume of an unknown gas under similar conditions of temperature and pressure weights 0.44 g, the molecular mass of gas is

(1) 22 (2) 44
(3) 66 (4) 88

78. A gaseous hydrocarbon on complete combustion gives 3.38 g of CO_2 and 0.690 g of H_2O and no other products. The empirical formula of hydrocarbon is

(1) CH (2) CH_2
(3) CH_3 (4) The data is not complete

79. The percentage of Carbon in CO_2 is

(1) 27.27% (2) 29.27%
(3) 30.27% (4) 26.97%

80. The haemoglobin from red blood corpuscles of most mammals contain approximately 0.33% of iron by mass. The molecular mass of haemoglobin is 67200. The number of iron atoms in each molecule of haemoglobin is

(1) 3 (2) 4
(3) 2 (4) 6

81. On analysis a certain compound was found to contain iodine and oxygen in the ratio of 254 g of iodine (at mass 127) and 80 g oxygen (at mass 16). What is the formula of compound?

(1) IO (2) I_2O
(3) I_5O_3 (4) I_2O_5

82. 0.5 mol of potassium ferrocyanide contains carbon equal to: (Formula of potassium ferrocyanide is $K_4[Fe(CN)_6]$.

(1) 1.5 mol (2) 36 g
(3) 18 g (4) 3.6 g

83. 14 g of element X combine with 16g of oxygen. On the basis of this information, which of the following is a correct statement

(1) The element X could have an atomic weight of 7 and its oxide formula XO
(2) The element X could have an atomic weight of 14 and its oxide formula X_2O
(3) The element X could have an atomic weight of 7 and its oxide is X_2O
(4) The element X could have an atomic weight of 14 and its oxide is XO_2

84. A compound has 20% of nitrogen by weight. If one molecule of the compound contains two nitrogen atoms, the molecular weight of the compound is

(1) 35 (2) 70
(3) 140 (4) 280

85. A sample of pure compound contains 1.15 g of sodium, 3.01×10^{22} atoms of carbon and 0.1 mol of oxygen atom. Its empirical formula is

(1) Na_2CO_3 (2) $NaCO_2$
(3) Na_2CO (4) Na_2CO_2

STOICHIOMETRY & CONCENTRATION TERMS

86. 'X' litres of carbon monoxide is present at STP. It is completely oxidized to CO_2. The volume of CO_2 formed is 11.207 litres at STP. What is the value of 'X' in litres?

(1) 22.414 (2) 11.207
(3) 5.6035 (4) 44.828

87. The volume of phosgene formed at STP when 11.2 lit of chlorine reacts with carbon monoxide is

(1) 11.2 lit (2) 22.4 lit
(3) 5.6 lit (4) 44.8 lit

88. What mass of $CaCl_2$ in grams would be enough to produce 14.35 gm of AgCl?

$CaCl_2 + 2AgNO_3 \rightarrow Ca\ (NO_3)_2 + 2\ AgCl$

(1) 5.55 g (2) 8.29 g
(3) 16.59 g (4) 10 g

89. What weight of sodium hydroxide is required to neutralise 100 mL of 0.1N HCl?

(1) 4 g (2) 0.4 g
(3) 0.04 g (4) 40 g

90. H_2O_2 is sold as a solution of approximately 5.0 g H_2O_2 per 100 mL of the solution. The molarity of this solution is approximately

(1) 0.15 M (2) 1.5 M
(3) 3.0 M (4) 3.4 M

91. The amount of oxalic acid (eq.wt.63) required to prepare 500 ml of its 0.10 N solution is

(1) 0.315 g (2) 3.150 g
(3) 6.300 g (4) 63.00 g

92. The molarity of pure water is

(1) 100 M (2) 55.6M
(3) 50 M (4) 18 M

93. The mass of 70% H_2SO_4 by mass is required for neutralisation of 1 mole of NaOH is

(1) 65 (2) 98 (3) 70 (4) 54

94. If potassium chlorate is 80% pure then 48 g of oxygen would be produced from

(1) 153.12 g of $KClO_3$ (2) 120 g of $KClO_3$
(3) 20 g of $KClO_3$ (4) 90 g of $KClO_3$

95. Density of a solution containing x% by mass of H_2SO_4 is y. The normality is

(1) $\frac{xy \times 10}{98}$ (2) $\frac{xy \times 10}{98y} \times 2$
(3) $\frac{xy \times 10}{98} \times 2$ (4) $\frac{x \times 10}{98y}$

96. Mass percentage (w/w) of ethylene glycol ($HOCH_2$ - CH_2OH) in a aqueous solution is 20, then mole fraction of solute is

(1) 0.5 (2) 0.067
(3) 0.1 (4) 0.4

97. Number of gram equivalents of solute in 100 ml of 5 N HCl solution is

(1) 50 (2) 500 (3) 5 (4) 0.5

98. If 1.26 grams of oxalic acid is dissolved in 250 ml of solution then its normality is

(1) 0.05 (2) 0.04 (3) 0.02 (4) 0.08

99. 100 ml of ethylalcohol is made upto a litre with distilled water. If the density of C_2H_5OH is 0.46 gm/ml. Then its molality is
(1) 0.55 m (2) 1.11m
(3) 2.22 m (4) 3.33m

100. A solution of 0.1 mole of a metal chloride MCl_x required 500 mL of 0.6 M $AgNO_3$ solution for complete ppt. The value of x is
(1) 5 (2) 4
(3) 3 (4) 1

101. If 20 g of $CaCO_3$ is treated with 100 mL 20% HCl solution. The amount of CO_2 produced is
(1) 22.4l g (2) 8.8 g
(3) 2.2 g (4) 8 l

102. The mass of $CaCO_3$ required to react with 25 mL of 0.75 molar HCl is
(1) 0.94 g (2) 0.68 g
(3) 0.76 g (4) 0.52 g

103. 2 moles of H_2S and 11.2 L of SO_2 at S.T.P. reacts to form x moles of sulphur. The value of x is
(1) 1.5 (2) 3.5
(3) 7.8 (4) 12.7

104. Sulphuryl chloride (SO_2Cl_2) reacts with H_2O to give a mixture of H_2SO_4 & HCl. Aqueous solution of 1 mole SO_2Cl_2 will be neutralised by
(1) 3 moles of NaOH (2) 2 moles of $Ca(OH)_2$
(3) Both (1) and (2) (4) None of these

105. If 0.30 mol of zinc are added to 0.52 mol of HCl, the moles of H_2 formed are
(1) 0.52 (2) 0.30
(3) 0.26 (4) 0.60

106. The specific gravity of 98% H_2SO_4 is 1.8 g/cc. 50 ml of this solution is mixed with 1750 ml of pure water. Molarity of resulting solution is
(1) 0.2 M (2) 0.5 M
(3) 0.1 M (4) 1 M

107. How many grams of H_3PO_4 is required to completely neutralize 120g of NaOH
(1) 49 (2) 98
(3) 196 (4) 9.8

108. The weight of oxygen required to completely react with 27 gms of 'Al' is
(1) 8 gm (2) 16 gm
(3) 32 gm (4) 24 gm

Exercise-2 (Learning Plus)

1. Which of the following is/are not affected by temperature?
(1) Molarity (2) Molality
(3) Normality (4) None of these

2. Ferric sulphate on heating gives sulphur trioxide. The ratio between the weights of oxygen and sulphur present in SO_3 obtained by heating 1 kg of ferric sulphate is
(1) 2 : 3 (2) 1 : 3
(3) 3 : 1 (4) 3 : 2

3. The number of atoms present in 4.25 grams of NH_3 is approximately
(1) 1×10^{23} (2) 8×10^{20}
(3) 2×10^{23} (4) 6.02×10^{23}

4. Two students performed the same experiment separately and each one of them recorded two readings of mass which are given below. Correct reading of mass is 3.0 g. On the basis of given data, mark the correct option out of the following statements

Students	Readings	
	(i)	(ii)
A	3.01	2.99
B	3.05	2.95

(1) Results of both the students are neither accurate nor precise
(2) Results of student A are both precise and accurate
(3) Results of student B are neither precise nor accurate
(4) Results of student B are both precise and accurate

5. What will be the molarity of a solution, which contains 5.85 g of NaCl (s) per 500 mL?
(1) 4 mol L^{-1} (2) 20 mol L^{-1}
(3) 0.2 mol L^{-1} (4) 2 mol L^{-1}

6. Number of atoms in 558.5 gram Fe (at. wt. of Fe = 55.85 g mol^{-1} is
(1) Twice that 60 g carbon (2) 6.023×10^{22}
(3) Half that in 8g He (4) $5558.5 \times 6.023 \times 10^{23}$

7. Neon has two isotpoes Ne^{20} and Ne^{22}. If atomic weight of Neon is 20.2, the ratio of the relative abundances of the isotopes is
(1) 1 : 9 (2) 9 : 1
(3) 70 % (4) 80 %

8. The total weight of 10^{22} molecular units of $CuSO_4 . 5H_2O$ is nearly
(1) 4.144 g (2) 5.5 g
(3) 24.95 g (4) 41.45 g

9. The number of Cl^- and Ca^{+2} ions in 222g. of $CaCl_2$ are

(1) $4N_A, 2N_A$ (2) $2N_A, 4N_A$

(3) $1N_A, 2N_A$ (4) $2N_A, 1N_A$

10. The empirical formula of a gaseous compound is 'CH_2'. The density of the compound is 1.25 gm/lit. at S.T.P. The molecular formula of the compound is 'X'

(1) C_2H_4 (2) C_3H_6

(3) C_6H_{12} (4) C_4H_8

11. If 500 mL of a 5 M solution is diluted to 1500 mL, what will be the molarity of the solution obtained?

(1) 1.5 M (2) 1.66 M

(3) 0.017 M (4) 1.59 M

12. The number of atoms present in one mole of an element is equal to Avogadro number. Which of the following element contains the greatest number of atoms?

(1) 4 g He (2) 46 g Na

(3) 0.40 g Ca (4) 12 g He

13. The empirical formula of an organic compound is CH_2O. Its vapour density is 45. The molecular formula of the compound is

(1) CH_2O (2) $C_2H_4O_2$

(3) $C_3H_6O_3$ (4) $C_6H_{12}O_6$

14. 0.132 g of an organic compound gave 50 ml of N_2 at STP. The weight percentage of nitrogen in the compound is close to

(1) 15 (2) 20

(3) 48.9 (4) 47.34

15. 0.7 moles of potassium sulphate is allowed to react with 0.9 moles of barium chloride in aqueous solutions. The number of moles of the substance precipitated in the reaction is

(1) 1.4 moles of potassium chloride

(2) 0.7 moles of barium sulphate

(3) 1.6 moles of potassium chloride

(4) 1.6 moles of barium sulphate

16. The number of moles of Fe_2O_3 formed when 0.5 moles of O_2 and 0.5 moles of Fe are allowed to react are

(1) 0.25 (2) 0.5

(3) 1/3 (4) 0.125

17. Amount of oxalic acid required to prepare 250ml of N/10 solution (MW of oxalic acid = 126) is

(1) 1.5759 g (2) 3.15 g

(3) 15.75 g (4) 63.0 g

18. The composition of compound A is 40% X and 60% Y. The composition of compound B is 25% X and 75% Y. According to the law of multiple Proportions the ratio of the weight of element Y in compounds A and B is

(1) 1:2 (2) 2 : 1 (3) 2 : 3 (4) 3 :4

19. If the concentration of glucose ($C_6H_{12}O_6$) in blood is 0.9 g L^{-1}, what will be the molarity of glucose in blood?

(1) 5 M (2) 50 M

(3) 0.005 M (4) 0.5 M

20. What will be the molality of the solution containing 18.25 g of HCl gas in 500 g of water?

(1) 0.1 m (2) 10 m

(3) 0.5 m (4) 1 m

21. Increasing order of number of moles of the species

(*i*) 3 grams of NO

(*ii*) 8.5 grams of PH_3 and

(*iii*) 8 grams of methane is

(1) (*i*) < (*ii*) < (*iii*) (2) (*iii*) < (*ii*) < (*i*)

(3) (*i*) < (*iii*) < (*ii*) (4) (*ii*) < (*iii*) < (*i*)

22. The number of molecules present in 1.12×10^{-7} cc of a gas at STP is

(1) 6.02×10^{23} (2) 3.01×10^{12}

(3) 6.02×10^{12} (4) 3.01×10^{23}

23. From 320 mg. of O_2, 6.023×10^{20} molecules are removed, the no. of moles remained are

(1) 9×10^{-3} moles

(2) 9×10^{-2} moles

(3) Zero

(4) 3×10^{-3} moles

24. An oxide of nitrogen has a molecular weight 92. Find the total number of electrons in one gram mole of that oxide.

(1) 4.6 N (2) 46 N

(3) 23 N (4) 2.3 N

25. No. of moles of water in 488.6 gms of $BaCl_2.2H_2O$ are (molecular weight of $BaCl_2.2H_2O$ = 244.33)

(1) 2 moles (2) 4 moles

(3) 3 moles (4) 5 moles

26. One mole of any substance contains 6.022×10^{23} atoms/molecules. Number of molecules of H_2SO_4 present in 100 mL of 0.02 M H_2SO_4 solution is

(1) 12.044×10^{20} molecules

(2) 6.022×10^{23} molecules

(3) 1×10^{23} molecules

(4) 12.044×10^{23} molecules

27. Given the numbers, 161 cm, 0.161 cm, 0.0161 cm. The number of significant figures for the three numbers is

(1) 3, 4 and 5, respectively

(2) 3, 4 and 4, respectively

(3) 3, 3 and 4, respectively

(4) 3, 3 and 3, respectively

28. A certain compound contains magnesium, carbon and Nitrogen in the mass ratio 12 : 12 : 14. The formula of the compound is

(1) MgCN (2) Mg_2CN

(3) $MgCN_2$ (4) $Mg(CN)_2$

29. An oxide of nitrogen contains 36.8% by weight of nitrogen. The formula of the compound is

(1) N_2O (2) N_2O_3

(3) NO (4) NO_2

30. 40 ml. of a hydrocarbon undergoes combustion in 260 ml of oxygen and gives 160 ml of carbon dioxide. If all gases are measured under similar conditions of temperature and pressure, the formula of hydrocarbon is

(1) C_3H_8 (2) C_4H_8
(3) C_6H_{14} (4) C_4H_{10}

31. The mass of Hydrogen at S.T.P. that is present in a vessel which can hold 4 grams of oxygen under similar conditions is

(1) 1 gram (2) 0.5 grams
(3) 0.25 gms. (4) 0.125 gm

32. Which of the following solutions has the highest normality?

(1) 172 milli equivalents in 200 ml
(2) 84 milli equivalents in 100 ml
(3) 275 milli equivalents in 250 ml
(4) 43 milli equivalents in 60 ml

33. What volume of 75 % H_2SO_4 by mass is required to prepare 1.5 litres of 0.2 M H_2SO_4? (Density of the sample is 1.8 g/cc)

(1) 14.2cc (2) 28.4cc
(3) 21.7cc (4) 7.1 cc

34. The empirical formula and molecular mass of a compound are CH_2O and 180 g respectively. What will be the molecular formula of the compound?

(1) $C_9H_{18}O_9$ (2) CH_2O
(3) $C_6H_{12}O_6$ (4) $C_2H_4O_2$

35. If the density of a solution is 3.12 g mL^{-1}, the mass of 1.5 mL solution in significant figures is

(1) 4.7 g (2) 4680×10^{-3} g
(3) 4.680 g (4) 46.80 g

36. 4.9 grams of H_2SO_4 is present is 100 ml of the solution, then its molarity and normality are

(1) 1, 0.5 (2) 1, 1
(3) 0.5, 1 (4) 0.5, 2

37. In order to prepare one litre normal solution of $KMnO_4$, how many grams of $KMnO_4$ required if the solution is to be used in acidic medium for oxidation

(1) 158 (2) 79
(3) 31.6 (4) 790

38. 50 gm of sample of sodium hydroxide required for complete neutralisation, 1L of 1N HCl. What is the percentage purity of NaOH is

(1) 50 (2) 60
(3) 70 (4) 80

39. Which of the following statements is correct about the reaction given below?

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(g)$$

(1) Total mass of iron and oxygen in reactants = total mass of iron and oxygen in product therefore it follows law of conservation of mass
(2) Total mass of reactants = total mass of product, therefore, law of multiple proportions is followed
(3) Amount of Fe_2O_3 can be increased by taking any one of the reactants (iron or oxygen) in excess
(4) Amount of Fe_2O_3 produced will decrease if the amount of any one of the reactants (iron or oxygen) is taken in excess

40. Which of the following statements indicates that law of multiple proportion is being followed?

(1) Sample of carbon dioxide taken from any source will always have carbon and oxygen in the ratio 1 : 2
(2) Carbon forms two oxides namely CO_2 and CO, where masses of oxygen which combine with fixed mass of carbon are in the simple ratio 2 : 1
(3) When magnesium burns in oxygen, the amount of magnesium taken for the reaction is equal to the amount of magnesium in magnesium oxide formed
(4) At constant temperature and pressure, 200 mL of hydrogen will combine with 100 mL oxygen to produce 200 mL of water vapour

Exercise-3 (Multiconcept)

MATCH THE COLUMN MCQs

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

	Column-I		Column-II
A.	1 mole of Na	p.	6.02×10^{23}
B.	1 mole of H_2O	q.	Atomic weight in gram
C.	1 mole of NH_3	r.	Molecular weight in gram
D.	No. of molecules in 16 g CH_4	s.	Avogadro's number

(1) A-(p,q,s); B-(p,r,s); C-(p,r,s); D-(p,s)
(2) A-(p,s); B-(q,r,s); C-(p,s); D-(p,s)
(3) A-(p,s); B-(q,s); C-(p,s); D-(p,s)
(4) A-(q,s); B-(q,r,s); C-(p,s); D-(p,s)

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

Column-I		Column-II	
A.	$2H_2 + O_2 \rightarrow 2H_2O$ 1g 1g	p.	1.028 g
B.	$3H_2 + N_2 \rightarrow 2NH_3$ 1g 1g	q.	1.333 g
C.	$H_2 + Cl_2 \rightarrow 2HCl$ 1g 1g	r.	1.125 g
D.	$2H_2 + C \rightarrow CH_4$ 1g 1g	s.	1.214 g

(1) A-(q); B-(r); C-(p); D-(s)
(2) A-(p); B-(q); C-(s); D-(r)
(3) A-(r); B-(s); C-(p); D-(q)
(4) A-(s); B-(q); C-(p); D-(r)

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

Column-I (Amount of substance)		Column-II (No. of moles of particular atoms in the given substance)	
A.	6.022×10^{24} formula units of $Al_2(SO_4)_3.3H_2O$	p.	15-mole O-atoms
B.	90 gm $C_6H_{12}O_6$	q.	3-mole O-atoms
C.	112 litre $SO_3(g)$ at 1 atm and 0°C	r.	2.5 mole O-atoms
D.	54 gram N_2O_5 (g)	s.	150-mole O-atoms

(1) A-(s); B-(q); C-(p); D-(r)
(2) A-(q); B-(r); C-(p); D-(s)
(3) A-(s); B-(p); C-(r); D-(q)
(4) A-(p); B-(r); C-(s); D-(q)

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

Column-I (Reaction)		Column-II (At the end)	
A.	$\underset{4\text{ mol}}{2A} + \underset{6\text{ mol}}{2B} \xrightarrow{50\%\text{ yield}} 3C$	p.	3 moles C formed
B.	$\underset{4\text{ mol}}{\frac{1}{2}A} + \underset{8\text{ mol}}{2B} \xrightarrow{80\%\text{ yield}} C$	q.	3.2 moles C formed
C.	$\underset{15\text{ mol}}{3A} + \underset{20\text{ mol}}{2B} \xrightarrow{60\%\text{ yield}} C$	r.	A is limiting reagent
D.	$\underset{5\text{ mol}}{A} + \underset{12\text{ mol}}{3B} \xrightarrow{20\%\text{ yield}} 2C$	s.	B is limiting reagent
		t.	1.6 moles C formed

(1) A-(s,r); B-(q,s); C-(p,r); D-(r,t)
(2) A-(s,t); B-(p,r); C-(q,s); D-(p,r)
(3) A-(s,r); B-(p,s); C-(r,p); D-(q,t)
(4) A-(p,r); B-(q,s); C-(p,r); D-(s,t)

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

Column-I (Compound)		Column-II (Relative amounts of products on complete combustion)	
A.	CH_4	p.	Moles of CO_2 < Moles of H_2O
B.	C_2H_4	q.	Moles of CO_2 = Moles of H_2O
C.	C_2H_2	r.	Moles of CO_2 > Moles of H_2O
D.	C_3H_8	s.	Moles of CO_2 < Moles of O_2

(1) A-(s,r); B-(q,s); C-(p,r); D-(r,t)
(2) A-(s,t); B-(p,r); C-(q,s); D-(p,r)
(3) A-(s,r); B-(p,s); C-(r,p); D-(q,t)
(4) A-(p,s); B-(q,s); C-(r,s); D-(p,s)

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

Column-I		Column-II	
A.	20% (w/w) solution of KOH (density of solution = 1.02 gm/mL)	p.	8.6 M
B.	Solution containing 954.6 gm of $CaCl_2$ in 1 L	q.	3.64 M
C.	Volume of 1.204×10^{24} molecules of water at 4°C	r.	5 mL
D.	Volume of 0.2 M NaOH solution containing 40 mg of NaOH	s.	36 mL

(1) A-(q); B-(p); C-(s); D-(r)
(2) A-(q); B-(r); C-(p); D-(s)
(3) A-(s); B-(p); C-(r); D-(q)
(4) A-(p); B-(r); C-(s); D-(q)

7. Where M_A, M_B are molar masses, n_A, n_B are no of moles & X_A, X_B is mole fractions of solute and solvent respectively. Match the column-I with column-II.

Column-I		Column-II	
A.	Molarity	p.	Dependent on temperature
B.	Molality	q.	$\frac{M_A \times n_A}{n_A M_A + n_B M_B} \times 100$
C.	Mole fraction	r.	Independent of temperature
D.	Mass %	s.	$\frac{X_A}{X_B M_B} \times 1000$

(1) A-(q); B-(p,r); C-(s); D-(r,s)
(2) A-(q,s); B-(r); C-(p,r); D-(s)
(3) A-(p); B-(r,s); C-(r); D-(q,r)
(4) A-(p,r); B-(r); C-(s); D-(q,s)

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

Column-I		Column-II	
A.	88g of CO_2	p.	0.25 mol
B.	6.022×10^{23} molecules of H_2O	q.	2 mol
C.	5.6 litres of O_2 at STP	r.	1 mol

Column-I		Column-II	
D.	96 g of O_2	s.	6.022×10^{23} Molecules
E.	1 mol of any gas	t.	3 mol

(1) A-(t); B-(q); C-(p); D-(r); E-(s)
(2) A-(q); B-(r); C-(p); D-(t); E-(s)
(3) A-(s); B-(p); C-(r); D-(q); E-(t)
(4) A-(p); B-(t); C-(s); D-(q); E-(r)

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

Column-I		Column-II	
A.	32 gm each of O_2 and S	p.	2 moles of Fe
B.	2 gram molecule of $K_3[Fe(CN)_6]$	q.	3 moles of ozone molecule
C.	144 gm of oxygen atom	r.	1 mole
D.	From 168 g of iron 6.023×10^{23} atoms of iron are removed the iron left	s.	12 moles of carbon atoms

(1) A-(r); B-(p,s); C-(q); D-(p)
(2) A-(q); B-(r); C-(p,s); D-(s)
(3) A-(s); B-(p); C-(r); D-(q,r)
(4) A-(p,q); B-(r); C-(s); D-(q)

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

Column-I		Column-II	
A.	49 g H_2SO_4	p.	0.5 mole
B.	20 g NaOH	q.	1.5 N_A atoms
C.	11.2 L of CO_2 at STP	r.	0.5 N_A molecules
D.	6.023×10^{23} atoms of Oxygen	s.	2 mole of 'O' atom

(1) A-(p,q,r); B-(p,s,r); C-(p,r); D-(p,q,r)
(2) A-(p,r); B-(p,q,r); C-(p,s); D-(p,q,r)
(3) A-(p,q,r); B-(p,q,s); C-(p,s,r); D-(q,r)
(4) A-(p,s,r); B-(p,r); C-(p,q,r); D-(p,r)

CORRECT-INCORRECT STATEMENT MCQs

11. Which of the following is correct?
(1) The sum of mole fractions of all the components in a solution is always unity
(2) Mole fraction depends upon temperature
(3) Mole fraction is always negative
(4) Mole fraction is independent of the content of solute in the solution

12. Equal masses of SO_2 and O_2 are placed in a flask at STP choose the incorrect statement
(1) The number of molecules of O_2 is more than SO_2
(2) Volume occupied at STP is more for O_2 than SO_2
(3) The ratio of the number of atoms of SO_2 and O_2 is 3 : 4
(4) Moles of SO_2 is greater than the moles of O_2

13. For the reaction:
$2Fe_2S_3 + 6H_2O + 3O_2 \longrightarrow 4Fe(OH)_3 + 6S$
If 4 moles of Fe_2S_3 are combined with 2 mole of H_2O and 3 moles of O_2, then which of the following statements incorrect:
(1) H_2O limiting reagent
(2) Moles of $Fe(OH)_3$ formed is 4/3
(3) Moles of Fe_2S_3 remaining is 10/3
(4) Mass of O_2 remaining is 32 gm

14. Select the incorrect statements
(1) Ratio of gm/litre & % w/v of a solution is independent of solute substance.
(2) Ratio of % w/v and molarity of a solution depends on the solute substance.
(3) Ratio of % w/v and molarity of a solution depends on the solvent substance.
(4) Ratio of % w/v & ppm for any solution is same

15. Identify the incorrect statement from the following.
(1) The multiple of prefix femto is 10^{-15}
(2) The multiple of prefix pico is 10^{-12}
(3) The multiple of prefix nano is 10^{-18}
(4) The multiple of prefix micro is 10^{-6}

16. In a gaseous reaction of the type
$aA + bB \longrightarrow cC + dD$
Which statement is wrong ?
(1) a litre of A combines with b litre of B to give C and D
(2) a mole of A combines with b moles of B to give C and D
(3) a gram of A combines with b gram of B to give C and D
(4) a molecules of A combines with b molecules of B to give C and D

17. Which statement is false for the balanced equation given below ?
$CS_2 + 3O_2 \rightarrow 2SO_2 + CO_2$
(1) One mole of CS_2 will produce one mole of CO_2
(2) The reaction of 16 g of oxygen produces 7.33 g of CO_2
(3) The reaction of one mole of O_2 will produce 2/3 mole of SO_2
(4) Six molecules of oxygen require three molecules of CS_2

18. 8 g H_2 and 32 g O_2 is allowed to react to form water then which of the following statement is correct?
(1) O_2 is a limiting reagent (2) O_2 is reagent in excess
(3) H_2 is limiting reagent (4) 40 g of water is formed

19. In an ionic compound, molar ratio of cation to anion is 1 : 2. If atomic masses of metal and non-metal respectively are 138 and 19, then the correct statement is
(1) The molecular mass of the compound is 176
(2) Formula mass of the compound is 176
(3) Formula mass of the compound is 157
(4) The molecular mass of the compound is 157

20. Which of the following is correct?
(1) The sum of mole fractions of all the components in a solution is always unity
(2) Mole fraction depends upon temperature
(3) Mole fraction is always negative
(4) Mole fraction is independent of the content of solute in the solution

STATEMENT BASED MCQs

(1) Both Statement-I and Statement-II are correct.
(2) Both Statement-I and Statement-II are incorrect.
(3) Statement-I is correct and Statement-II is incorrect.
(4) Statement-I is incorrect and Statement-II is correct.

21. **Statement-I:** 10,000 molecules of CO_2 have the same volume at STP as 10,000 molecules of CO at STP.
Statement-II: Both CO and CO_2 are formed by combustion of carbon in presence of oxygen.

22. **Statement-I:** Molality and mole fraction are not affected by temperature.
Statement-II: Molality (m) = $\frac{W}{GMM} \times \frac{1}{b(Kg)}$ (where, b = mass of solvent).

23. **Statement-I:** The percentage of nitrogen in urea is 46.6%.
Statement-II: Urea is an ionic compound.

24. **Statement-I:** Equal moles of different substances contain same number of constituent particles.
Statement-II: Equal weights of different substances contain the same number of constituent particles.

25. **Statement-I:** Equivalent of $K_2Cr_2O_7$ has 1 equivalent of K, Cr and O each.
Statement-II: A species contains same number of equivalents of its components.

26. **Statement-I:** The molality of the solution does not change with change in temperature.
Statement-II: The molality of the solution is expressed in units of moles per 1000 g of solvent.

27. **Statement-I:** Equivalent weight of ozone in the change $O_3 \rightarrow O_2$ is 8.
Statement-II: 1 mole of O_3 on decomposition gives $\frac{3}{2}$ moles of O_2.

28. **Statement-I:** A solution which contains one gram equivalent of solute per litre of solutions is known as molar solution.
Statement-II: Molarity = $\text{normality} \times \frac{\text{mol. wt. of solute}}{\text{eq. wt. of solute}}$

29. **Statement-I:** Weight of 1 molecule of O_2 = 32 u
Statement-II: 1 g molecule = 6.023×10^{23} molecules.

30. **Statement-I:** Normality and molarity can be calculated from each other.
Statement-II: Normality is equal to the product of molarity and n.

ASSERTION & REASON MCQs

(1) If both Assertion (A) and Reason (R) are True and the Reason (R) is a correct explanation of the Assertion (A).
(2) If both Assertion (A) and Reason (R) are True but Reason (R) is not a correct explanation of the Assertion (A).
(3) If Assertion (A) is True but the Reason (R) is False.
(4) Assertion (A) is False but Reason (R) is True.

31. **Assertion (A):** 1 mole of any gas occupies 22.4 lit at NTP.
Reason (R): In 1502 cm, zero is significant.

32. **Assertion (A):** One molal aqueous solution of glucose contains 180 g of glucose in 1 kg of water.
Reason (R): A solution containing one mole of solute in 1000 g of solvent is called one molal solution.

33. **Assertion (A):** The weight percentage of compound A in a solution is given by

$$\% \text{ of A} = \frac{\text{Mass A}}{\text{Total mass of solution}} \times 100$$

Reason (R): The mole fraction of component A is given by,

$$\text{Mole fraction of A} = \frac{\text{No. of moles of A}}{\text{Total no. of moles of all components}}$$

34. **Assertion (A):** One molal solution prepared at 20°C will retain the same molality at 100°C, provided there is no loss of solute or solvent on heating.
Reason (R): Molality is independent of temperature.

35. **Assertion (A):** Laboratory reagents are usually made up to a specific molarity rather than a given molality.
Reason (R): The volume of a liquid is more easily measured than its mass.

36. **Assertion (A):** Molality and mole fraction concentration units do not change with temperature.
Reason (R): These units are not defined in terms of any volume.

37. **Assertion (A):** The molality and molarity of very dilute aqueous solutions differ very little.
Reason (R): The density of water is about 1.0 g cm^{-3} at room temperature.

38. **Assertion (A):** For calculating the molality or the mole fraction of solute, if the molarity is known, it is necessary to know the density of the solution.
Reason (R): Molality, molarity and the mole fraction of solute can be calculated from the weight percentage and the density of the solution.

39. **Assertion (A):** The ratio of the mass of 100 billion atoms of magnesium to the mass of 100 billion atoms of lead can be expressed as $\frac{24}{207}$.
Reason (R): Atomic weights are relative masses.

40. **Assertion (A):** A molecule of butane, C_4H_{10} has a mass of 58.12 amu.
Reason (R): One mole of butane contains 6.022×10^{23} molecules and has a mass of 58.12 g.

Exercise-4 (Past 10 Years Questions)

1. What mass of 95% pure $CaCO_3$ will be required to neutralise 50 mL of 0.5 M HCl solution according to the following reaction? **(2022)**

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + 2H_2O_{(l)}$

[Calculate upto second place of decimal point]

(1) 9.50 g (2) 1.25 g (3) 1.32 g (4) 3.66 g

2. An organic compound contains 78% (by wt.) carbon and remaining percentage of hydrogen. The right option for the empirical formula of this compound is: [Atomic wt. of C is 12, H is 1] **(2021)**

(1) CH_2 (2) CH_3 (3) CH_4 (4) CH

3. Which one of the followings has maximum number of atoms? **(2020)**

(1) 1 g of Mg(s) [Atomic mass of Mg = 24]
(2) 1 g of O_2(g) [Atomic mass of O = 16]
(3) 1 g of Li(s) [Atomic mass of Li = 7]
(4) 1 g of Ag(s) [Atomic mass of Ag = 108]

4. One mole of carbon atom weighs 12g, the number of atoms in it is equal to. **(2020 Covid)**

(Mass of carbon- 12 is 1.9926×10^{-23} g)

(1) 6.022×10^{22} (2) 12×10^{22}
(3) 6.022×10^{23} (4) 12×10^{23}

5. The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is **(2019)**

(1) 10 (2) 20 (3) 30 (4) 40

6. A mixture of 2.3 g formic acid and 4.5 g oxalic acid is treated with concentration H_2SO_4. The evolved gaseous mixture is passed through KOH pellets. Weight (in g) of the remaining product at STP will be **(2018)**

(1) 1.4 (2) 3.0 (3) 4.4 (4) 2.8

7. In which case is number of molecules of water maximum? **(2018)**

(1) 18 mL of water
(2) 0.18 g of water
(3) 10^{-3} mol of water
(4) 0.00224 L of water vapours at 1 atm and 273 K

8. A hydrocarbon contains 85.7% of Carbon and 14.3% of Hydrogen. If 42 mg of the compound contains 3.01×10^{20} molecules, the molecular formula of the compound will be **(2017-Gujarat)**

(1) C_2H_4 (2) C_3H_6 (4) C_6H_{12} (4) $C_{12}H_{24}$

9. Suppose the elements X and Y combine to form two compounds XY_2 and X_3Y_2. When 0.1 mole of XY_2 weighs 10 g and 0.05 mole of X_3Y_2 weighs 9 g, the atomic weights of X and Y are **(2016-II)**

(1) 20, 30 (2) 30, 20 (3) 40, 30 (4) 60, 40

10. The number of water molecules is maximum in **(2015 Re)**

(1) 18 moles of water (2) 18 molecules of water
(3) 1.8 gram of water (4) 18 gram of water

11. If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change **(2015 Re)**

(1) The ratio of elements to each other in a compound
(2) The definition of mass in units of grams
(3) The mass of one mole of carbon
(4) The ratio of chemical species to each other in a balanced equation

12. What is the mass of the precipitate formed when 50 mL of 16.9% solution of $AgNO_3$ is mixed with 50 mL of 5.8% NaCl solution?

(Ag = 107.8, N = 14, O = 16, Na = 23, Cl = 35.5) **(2015 Re)**

(1) 3.5 g (2) 7 g (3) 14 g (4) 28 g

13. 20.0 g of a magnesium carbonate sample decomposes on heating to give carbon dioxide and 8.0 g magnesium oxide. What will be the percentage purity of magnesium carbonate in the sample?

(Atomic weight of Mg = 24) **(2015 Re)**

(1) 96 (2) 60 (3) 84 (4) 75

14. When 22.4 litres of H_2(g) is mixed with 11.2 litres of Cl_2(g), each at STP, the moles of HCl(g) formed is equal to **(2014)**

(1) 2 mol of HCl(g) (2) 0.5 mol of HCl(g)
(3) 1.5 mol of HCl(g) (4) 1 mol of HCl(g)

15. 1.0 g of magnesium is burnt with 0.56 g O_2 in a closed vessel. Which reactant is left in excess and how much? **(2014)**

(Atomic weight Mg = 24; O = 16)

(1) O_2, 0.16 g (2) Mg, 0.44 g
(3) O_2, 0.28 g (4) Mg, 0.16 g

16. Equal masses of H_2, O_2 and methane have been taken in a container of volume V at temperature 27°C in identical conditions. The ratio of the volumes of gases $H_2 : O_2$: methane would be **(2014)**

(1) 8 : 16 : 1 (2) 16 : 8 : 1
(3) 16 : 1 : 2 (4) 8 : 1 : 2

17. 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of solution is **(2013)**

(1) 0.02 M (2) 0.01 M
(3) 0.001 M (4) 0.1 M

18. An excess of $AgNO_3$ is added to 100 mL of a 0.01 M solution of dichlorotetraaquachrominum(III) chloride. The number of moles of AgCl precipitated would be **(2013)**

(1) 0.001 (2) 0.002
(3) 0.003 (4) 0.01

ANSWER KEY

CONCEPT APPLICATION

1. (1)	**2.** (2)	**3.** (3)	**4.** (4)	**5.** (2)	**6.** (3)	**7.** (2)	**8.** (4)	**9.** (1)	**10.** (1)
11. (2)	**12.** (2)	**13.** (1)	**14.** (3)	**15.** (4)	**16.** (4)	**17.** (3)	**18.** (1)	**19.** (1)	**20.** (2)
21. (4)	**22.** (1)								

EXERCISE-1 (TOPICWISE)

1. (1)	**2.** (4)	**3.** (3)	**4.** (3)	**5.** (4)	**6.** (4)	**7.** (1)	**8.** (2)	**9.** (3)	**10.** (1)
11. (2)	**12.** (3)	**13.** (2)	**14.** (3)	**15.** (2)	**16.** (1)	**17.** (3)	**18.** (3)	**19.** (1)	**20.** (4)
21. (2)	**22.** (3)	**23.** (4)	**24.** (3)	**25.** (3)	**26.** (4)	**27.** (3)	**28.** (4)	**29.** (3)	**30.** (2)
31. (3)	**32.** (3)	**33.** (2)	**34.** (2)	**35.** (2)	**36.** (1)	**37.** (2)	**38.** (3)	**39.** (4)	**40.** (3)
41. (2)	**42.** (1)	**43.** (2)	**44.** (4)	**45.** (4)	**46.** (4)	**47.** (3)	**48.** (4)	**49.** (3)	**50.** (3)
51. (4)	**52.** (3)	**53.** (3)	**54.** (4)	**55.** (1)	**56.** (1)	**57.** (4)	**58.** (2)	**59.** (2)	**60.** (3)
61. (1)	**62.** (2)	**63.** (1)	**64.** (4)	**65.** (2)	**66.** (2)	**67.** (3)	**68.** (1)	**69.** (4)	**70.** (1)
71. (1)	**72.** (2)	**73.** (4)	**74.** (2)	**75.** (2)	**76.** (1)	**77.** (2)	**78.** (1)	**79.** (1)	**80.** (2)
81. (4)	**82.** (2)	**83.** (3)	**84.** (3)	**85.** (2)	**86.** (2)	**87.** (1)	**88.** (1)	**89.** (2)	**90.** (2)
91. (2)	**92.** (2)	**93.** (3)	**94.** (1)	**95.** (3)	**96.** (2)	**97.** (4)	**98.** (4)	**99.** (2)	**100.** (3)
101. (2)	**102.** (1)	**103.** (1)	**104.** (2)	**105.** (3)	**106.** (2)	**107.** (2)	**108.** (4)		

EXERCISE-2 (LEARNING PLUS)

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

EXERCISE-3 (MULTICONCEPT)

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

EXERCISE-4 (PAST 10 YEARS QUESTIONS)

1. (3)	**2.** (2)	**3.** (3)	**4.** (3)	**5.** (3)	**6.** (4)	**7.** (1)	**8.** (3)	**9.** (3)	**10.** (1)
11. (3)	**12.** (2)	**13.** (3)	**14.** (4)	**15.** (4)	**16.** (3)	**17.** (2)	**18.** (1)		