ALLEN CAREER INSTITUTE KOTA (RAJASTHAN)

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NEET SYLLABUS

SOME BASIC CONCEPTS OF CHEMISTRY : *General Introduction: Importance and scope of chemistry. concept of elements, atoms and molecules. Atomic and molecular masses. Mole concept and molar mass; percentage composition and empirical and molecular formula; chemical reactions, stoichiometry and calculations based on stoichiometry. Laws of chemical combination, Dalton's atomic theory: Precision and accuracy, Significant figures*

OBJECTIVES

After studying this unit, we will be able to :

- *understand and appreciate the role of chemistry in different spheres of life;*
- *explain the characteristics of three states of matter;*
- *classify different substances into elements, compounds and mixtures;*
- *explain various laws of chemical combination;*
- *appreciate significance of atomic mass, average atomic mass and molecular mass.*
- *describe the terms – mole and molar mass;*
- *calculate the mass percentage of different elements constituting a compound;*
- *determine empirical formula and molecular formula for a compound from the given experimental data;*
- *perform the stoichiometric calculations.*

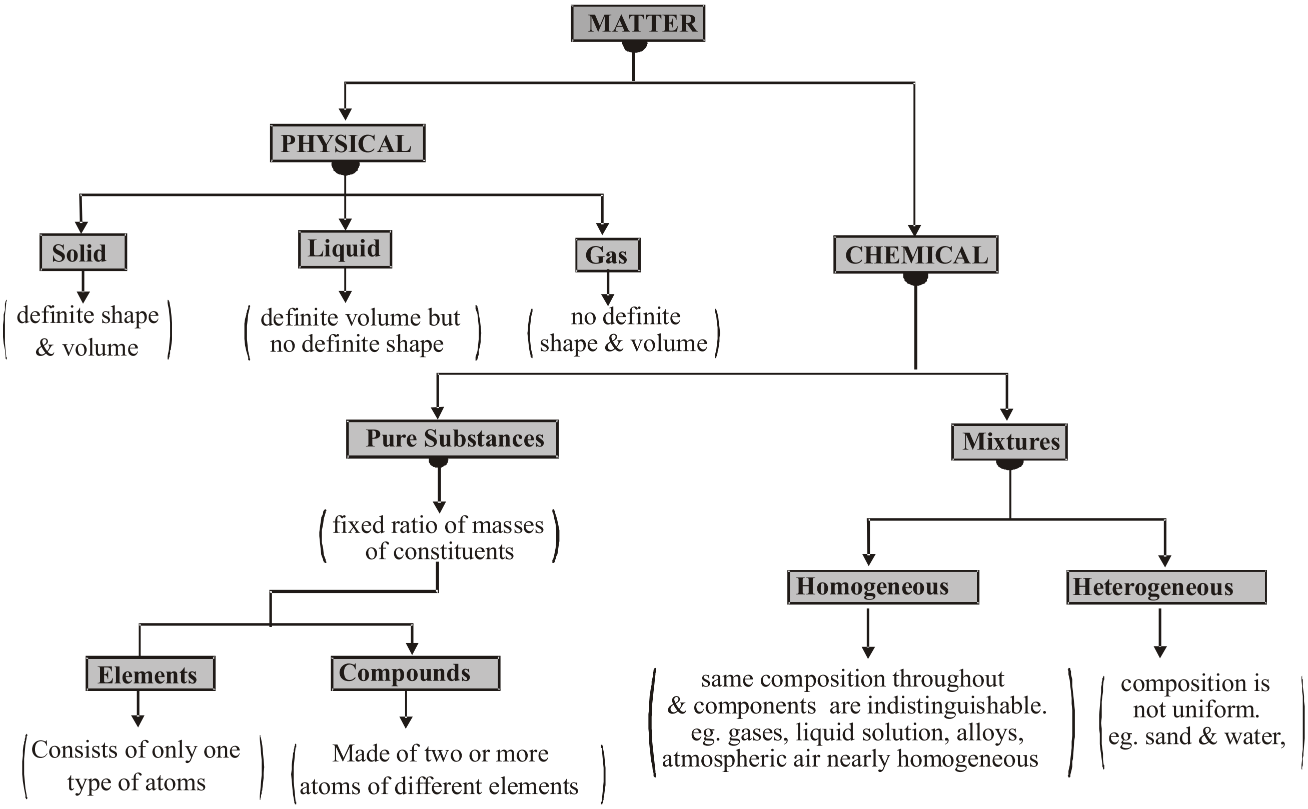
"Chemistry is the melodies you can play on vibrating strings"

Michio Kaku

SOME BASIC CONCEPTS OF CHEMISTRY

1.0 INTRODUCTION

Chemistry deals with the composition, structure and properties of matter. These aspects can be best described and understood in terms of basic constituents of matter: **atoms** and **molecules**. That is why chemistry is called the science of atoms and molecules. Can we see, weight and perceive these entities? Is it possible to count the number of atoms and molecules in a given mass of matter and have a quantitative relationship between the mass and number of these particles (atoms and molecules)? We will like to answer some of these questions in this Unit. We would further describe how physical properties of matter can be quantitatively described using numerical values with suitable units.



Classification of universe

Universe is classified into two types i.e. matter and energy.

(A) **MATTER :** The thing which occupy space and having mass which can be felt by our five senses is called matter.

Matter is further classified into two categories :

(I) Physical classification (II) Chemical classification

PHYSICAL CLASSIFICATION

It is based on physical state under ordinary conditions of temperature and pressure, **so on the basis of two nature of forces matter** can be classified into the following three ways :

(a) Solid (b) Liquid (c) Gas

(a) **Solid :** A substance is said to be solid if it possesses a definite volume and a definite shape.

e.g. Sugar, Iron, Gold, Wood etc.

(b) **Liquid :** A substance is said to be liquid if it possesses a definite volume but not definite shape. They take the shape of the vessel in which they are palced.

e.g. Water, Milk, Oil, Mercury, Alcohol etc.

(c) **Gas :** A substance is said to be gas if it neither possesses a definite volume nor a definite shape. This is because they completely occupy the whole vessel in which they are placed.

e.g. Hydrogen(H_2), Oxygen(O_2), Carbon dioxide(CO_2) etc.

Chemical Classification

It may be classified into two types :

(a) Pure Substances (b) Mixtures

(a) Pure Substance : A material containing only one type of substance. Pure Substance can not be separated into simpler substance by physical method.

e.g. : Elements = Na, Mg, Ca .... etc.

Compounds = HCl, H_2O, CO_2, HNO_3 .... etc.

Pure substances are classified into two types :

(a) Elements (b) Compounds

(i) Elements : The pure substances containing only one kind of atoms.

It is classified into 3 types (depend on physical and chemical property)

(i) Metal → Zn, Cu, Hg, Ac, Sn, Pb etc.

(ii) Non-metal → N_2, O_2, Cl_2, Br_2, F_2, P_4, S_8 etc.

(iii) Metalloids → B, Si, As, Te etc.

(ii) Compounds : It is defined as pure substances containing more than one kind of elements or atoms which are combined together in a fixed proportion by weight and which can be decomposed into simpler substances by the suitable chemical methods. The properties of a compound are completely different from those of its constituent elements.

e.g. HCl, H_2O , H_2SO_4 , $HClO_4$, HNO_3 etc.

(b) Mixtures : A material which contains more than one type of substance and which are mixed in any ratio by weight are known as mixtures. The properties of a mixture are same as the property individual components. The components of a mixture can be separated by simple physical methods.

Mixtures are classified into two types :

(i) Homogeneous mixtures : The mixtures in which all the components are present **uniformly** are called as homogeneous mixtures. Components of a mixture are present in single phase.

e.g. Water + Salt, Water + Sugar, Water + alcohol,

(ii) Heterogenous mixtures : The mixtures in which all the components are present **non-uniformly** are called as Heterogenous mixture.

e.g. Water + Sand, Water + Oil, blood, petrol etc.

Illustrations

Illustration 1. Which is an example of matter according to physical state at room temperature and pressure.

(1) solid (2) liquid (3) gas (4) all of these

Solution **Ans. (4)** According to the physical state at room temperature and pressure, the matter is present in 3 state solid, liquid & gas

Illustration 2. Which of the following are the types of the compound.

(1) Organic compound (2) Inorganic compound

(3) Both (1) and (2) (4) None of these

Solution **Ans. (3)** Compound is divided into 2 types. Inorganic compound & Organic compound

Illustration 3. Which of the following is an example of a homogeneous mixture.

(1) Water + Alcohol (2) Water + Sand (3) Water + Oil (4) None of these

Solution **Ans. (1)** Water and alcohol are completely mixed and form uniform solution.

Illustration 4. Which of the following is a solution.

(1) Heterogeneous mixture (2) Homogeneous mixture

(3) Both (1) and (2) (4) None of these

Solution **Ans. (2)** Homogeneous mixture is a solution.

Illustration 5. Which of the following is a compound

(1) graphite (2) producer gas (3) cement (4) marble

Solution **Ans. (4)** Marble = $CaCO_3$ = compound.

Illustration 6. Which of the following statements is/are true :

(1) An element of a substance contains only one kind of atoms.

(2) A compound can be decomposed into its components.

(3) All homogeneous mixtures are solutions.

(4) All of these

Solution **Ans. (4)**

Illustration 7. A pure substance can only be :-

(1) A compound (2) An element

(3) An element or a compound (4) A heterogenous mixture

Solution **Ans. (3)**

Illustration 8. Which one of the following is not a mixture :

(1) Tap water (2) Distilled water (3) Salt in water (4) Oil in water

Solution **Ans. (2)**

1.1 S.I. UNITS (INTERNATIONAL SYSTEM OF UNITS)

Different types of units of measurements have been in use in different parts of the world e.g. kilograms, pounds etc. for mass ; miles, furlongs, yards etc. for distance.

To have a common system of units throughout the world. French Academy of Science, in 1791, introduced a new system of measurements called metric system in which the different units of a physical quantity are related to each other as multiples of powers of 10, e.g. 1 km = 10^3 m, 1cm = 10^{-2} m etc. This system of units was found to be so convenient that scientists all over the world adopted this system for scientific data.

(A) Seven Basic Units

The seven basic physical quantities in the International System of Units, their symbols, the names of their units (called the base units) and the symbols of these units are given in Table.

TABLE : SEVEN BASIC PHYSICAL QUANTITIES AND THEIR S.I. UNITS

Physical Quantity	Symbol	S.I. Unit	Symbol
Length	ℓ	metre	m
Mass	m	kilogram	kg
Time	t	second	s
Electric current	I	ampere	A
Temperature	T	kelvin	K
Luminous intensity	I_u	candela	cd
Amount of the substance	n	mole	mol

(B) Prefixes Used With Units

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

TABLE : SOME COMMONLY USED PREFIXES WITH THE BASE UNITS.

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

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

and **1 millilitre (1mL) = 1 cm^3 = 1cc**

(C) SOME IMPORTANT UNIT CONVERSIONS

1. Length :
- 1 mile = 1760 yards
- 1 yard = 3 feet
- 1 foot = 12 inches
- 1 inch = 2.54 cm
- 1Å = 10^{-10}m or 10^{-8} cm

2. Mass :
- 1 Ton = 1000 kg
- 1 Quintal = 100 kg
- 1 kg = 2.205 Pounds (lb)
- 1 kg = 1000 g
- 1 gram = 1000 milli gram
- 1 amu = 1.67×10^{-24} g

3. Volume :
- 1 L = 1 dm^3 = 10^{-3} m^3 = 10^3 cm^3 = 10^3 mL = 10^3 cc
- 1 mL = 1 cm^3 = 10^{-6} m^3 = 1 cc

4. Energy :
- 1 calorie = 4.184 joules $\simeq$ 4.2 joules
- 1 joule = 10^7 ergs
- 1 litre atmosphere (L-atm) = 101.3 joule
- 1 electron volt (eV) = 1.602×10^{-19} joule

5. Pressure :
- 1 atmosphere (atm) = 760 torr
  = 760 mm of Hg
  = 76 cm of Hg
  = 1.01325×10^5 pascal (Pa)
  = 1.01325×10^5 N/m^2

6. Temperature : °C + 273.15 = K ; $\frac{5}{9}$(°F – 32) = °C

Some More Prefixes :

Semi	=	$\frac{1}{2}$	Mono	=	1
Sesqui	=	$\frac{3}{2}$ = 1.5	Di or Bi	=	2
Tri	=	3	Tetra	=	4
Penta	=	5	Hexa	=	6
Hepta	=	7	Octa	=	8
Nona	=	9	Deca	=	10
Undeca	=	11	Do deca	=	12
Trideca	=	13	Tetra deca	=	14
Pentadeca	=	15	Hexa deca	=	16
Hepta deca	=	17	Octa deca	=	18
Nonadeca	=	19	Eicoso/Icoso	=	20

GOLDEN KEY POINTS

- The unit named after a scientist is started with a small letter and not with a capital letter e.g. unit of force is written as newton and not as Newton.

  Likewise unit of heat and work is written as joule and not as Joule.
- Symbols of the units do not have a plural ending like 's'. For example we have 10 cm and not 10 cms.
- Words and symbols should not be mixed e.g. we should write either joules per mole or J mol^{-1} and not joules mol^{-1}
- Prefixes are used with the basic units e.g. kilometer means 1000 m (because meter is the basic unit).

  Exception. Though kilogram is the basic unit of mass, yet prefixes are used with gram because in kilogram, kilo is already a prefix.
- A unit written with a prefix and a power is a power for the complete unit e.g. cm^3 means $(centimeter)^3$ and not centi $(meter)^3$.

Illustrations

Illustration 9. Which one of the following forms part of seven basic SI units :

(1) Joule (2) Candela (3) Newton (4) Pascal

Solution **Ans. (2)**

Illustration 10 Convert 2 litre atmosphere into erg.

Solution 2 litre atmosphere = 2×101.3 joule = $2\times101.3\times10^7$ erg. = 202.6×10^7 erg.

{1 litre atmosphere = 101.3J}

Illustration 11 Convert 2 atm into cm of Hg.

Solution 2 atm = 2 × 76 cm of Hg = 152 cm of Hg

{1 atmosphere = 76 cm of Hg}

Illustration 12 Convert 20 dm^3 into mL.

Solution 20 dm^3 = 20 L = 20 × 1000 mL = 2×10^4 mL

1 dm^3 = 1 L = 1000 mL

Illustration 13 Convert 59 F into °C.

Solution $°C = \frac{5}{9}(F - 32) = \frac{5}{9}(59 - 32) = \frac{5}{9} \times 27 = 15°C$

1.2 MOLE CONCEPT

In SI Units we represent mole by the symbol 'mol'. It is defined as follows :

(i) A mole is the amount of a substance that contains as many entities (atoms, molecules or other particles) as there are atoms in exactly 12g of the carbon - 12 isotope.

It may be emphasised that the mole of a substance always contains the same number of entities, no matter what the substance may be. In order to determine this number precisely, the mass of a carbon-12 atom was determined by a mass spectrometer and found to be equal to 1.992648×10^{-23}g Knowing that 1 mole of carbon weighs 12g, the number of atoms in it is equal to :

$$\frac{12\text{g/mol } C^{12}}{1.992648\times10^{-23}\text{g/ } C^{12}\text{ atom}} = 6.0221367 \times 10^{23} \text{ atoms/mol}$$

(ii) In a simple way, we can say that mole has 6.0221367×10^{23} entities (atoms, molecules or ions etc.)

The number of entities in 1 mole is so important that it is given a separate name and symbol, known as '**Avogadro constant**' denoted by N_A .

Here entities may represent atoms, ions, molecules or other subatomic entities. Chemists count the number of atoms and molecules by weighing. In a reaction we require these particles (atoms, molecules and ions) in a definite ratio. We make use of this relationship between numbers and masses of the particles for determining the stoichiometry of reactions .

Formula to get moles are following :

(i) $\text{Number of moles (n)} = \frac{\text{weight (g)}}{\text{molar mass}}$

Where molar mass = gram atomic mass or gram molecular mass or gram ionic mass

(ii) $\text{Number of moles (n)} = \frac{V_{(L)}}{22.4}$ (Where V = Volume of gas in L at NTP or STP)

(iv) $\text{Number of moles (n)} = \frac{N}{N_A}$ (Where N = Number of particles)

$$\text{No. of moles of atoms} = \frac{\text{number of atoms}}{N_A} \text{ and No. of moles of molecules} = \frac{\text{number of molecules}}{N_A}$$

SOME RELATED DEFINITIONS :

Atomic Mass (Relative Atomic Mass)

It is defined as the number which indicates how many times the mass of one atom of an element is heavier in comparison to $1/12^{th}$ part of the mass of one atom of C^{12}.

Atomic mass unit (amu) : The quantity $1/12^{th}$ mass of an atom of C^{12} is known as atomic mass unit.

Since mass of 1 atom of $C^{12} = 1.9924 \times 10^{-23}$ g

$$\therefore 1/12^{th} \text{ part of the mass of 1 atom} = \frac{1.9924\times10^{-23}\text{g}}{12} = 1.67 \times 10^{-24} \text{ g} = 1 \text{ a.m.u.} = \frac{1}{6.023\times10^{23}}$$

It may be noted that the atomic masses as obtained above are the relative atomic masses and not the actual masses of the atoms. These masses on the atomic mass scale are expressed in terms of atomic mass units (abbreviated as amu). Today, 'amu' has been replaced by 'u' which is known as unified mass.

One atomic mass unit (amu) is equal to $1/12^{th}$ of the mass of an atom of C^{12} isotope.

Thus the atomic mass of hydrogen is 1.008 amu while that of oxygen is 15.9994 amu (or taken as 16 amu).

Gram Atomic Mass (or Mass of 1 Gram Atom)

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

gram atomic mass = mass of 1 **gram atom** = mass of 1 **mole atom**

= mass of N_A atoms = mass of 6.023×10^{23} atoms.

Ex. gram atomic mass of oxygen = mass of 1 **g atom** of oxygen = mass of 1 **mol atom** of oxygen.

= mass of N_A atoms of oxygen. $= \left(\frac{16}{N_A} g\right) \times N_A = 16$ g

Molecular Mass (Relative Molecular Mass)

The number which indicates how many times the mass of one molecule of a substance is heavier in comparison to 1/12th part of the mass of an atom of C^{12}.

Gram Molecular Mass (Mass of 1 Gram Molecule)

When numerical value of molecular mass of the substance is expressed in grams then the value becomes gram molecular mass.

gram molecular mass = mass of 1 **gram molecule** = mass of 1 **mole molecule**

= mass of N_A molecules = mass of 6.023×10^{23} molecules

Ex. gram molecular mass of H_2SO_4 = mass of 1 **gram molecule** of H_2SO_4

= mass of 1 **mole molecule** of H_2SO_4

= mass of N_A molecules of H_2SO_4

$= \left(\frac{98}{N_A} g\right) \times N_A = 98$ g

Actual Mass

The mass of one atom or one molecule of a substance is called as actual mass.

Ex. (i) Actual mass of O_2 = 32 amu = $32 \times 1.67 \times 10^{-24}$ g → Actual mass

(ii) Actual mass of H_2O = (2 + 16) amu = $18 \times 1.67 \times 10^{-24}$g = 2.99×10^{-23} g

Atomicity – Total number of atoms in **a molecule** of elementary substance is called as atomicity.

Ex.

Molecule	Atomicity
H_2	2
O_2	2
O_3	3
NH_3	4

Illustrations

Illustration 14. Find out the volume and mole in 56 g nitrogen at STP

Solution Molecular weight of N_2 is 28 g

(a) Calculation of volume : $\because$ 28 g of N_2 occupies = 22.4 L at STP

$\therefore$ 56 g of N_2 occupies $= \frac{22.4}{28} \times 56$ L = 44.8 L at STP

(b) Calculation of mole : $\because$ 28 g of N_2 = 1 mol of N_2

$\therefore$ 56 g of N_2 $= \frac{1}{28} \times 56$ = 2 mol of N_2

Illustration 15. Calculate the volume and mass of 0.2 mol of O_3 at STP.

Solution (a) Calculation of volume : $\because$ volume of 1 mole of O_3 at STP = 22.4 L

$\therefore$ volume of 0.2 mole of O_3 at STP = 22.4 × 0.2

= 4.48 L

(b) Calculation of mass : $\because$ mass of 1 mol of O_3 = 48 g

$\therefore$ mass of 0.2 mol of O_3 = 48 × 0.2 g = 9.6 g

Illustration 16. Find out the moles & mass in 1.12 L O_3 at STP.

Solution (a) Calculation of mole: $\because$ at STP 22.4 L of O_3 contain = 1 mol of O_3

$\therefore$ at STP 1.12 L of O_3 contain $= \frac{1}{22.4} \times 1.12$

= 0.05 mol of O_3

(b) Calculation of mass : Molecular weight of O_3 = 48 g

$\because$ weight of 22.4 L of O_3 at STP is = 48 g

$\therefore$ weight of 1.12 L of O_3 at STP is $= \frac{48}{22.4} \times 1.12$ = 2.4 g

Illustration 17. Find out the mass of 10^{21} molecules of Cu.

Solution For Cu (i.e. mono atomic substance) number of atoms = number of molecules

$$\text{Number of moles of Cu} = \frac{N}{N_A} = \frac{10^{21}}{6.023 \times 10^{23}} = \frac{\text{weight}}{\text{Atomic weight}} = \frac{\text{weight}}{63.5}$$

$$\text{weight of Cu} = \frac{10^{21}}{6.023 \times 10^{23}} \times 63.5 = 0.106 \text{ g}$$

Illustration 18. Calculate the number of molecules and number of atoms present in 1 g of nitrogen ?

Solution Number of moles $(n) = \frac{\text{weight}}{M_w} = \frac{1}{28}$ $\Rightarrow$ Number of molecules $(N) = \frac{N_A}{28}$

$\because$ 1 molecule of N_2 gas contain = 2 atoms

$\therefore$ $\frac{N_A}{28}$ molecules of N_2 gas contain $= 2 \times \frac{N_A}{28} = \frac{N_A}{14}$ atoms

Illustration 19. Calculate the number of moles in 11.2 L at STP of oxygen.

Solution Number of moles of O_2 $(n) = \frac{V}{22.4} = \frac{11.2}{22.4} = 0.5$ mol

Illustration 20. $\frac{1}{2}$ **g molecule** of oxygen. Find (i) mass, (ii) number of molecules, (iii) volume at STP. (iv) No. of oxygen atoms.

Solution

(i) $n = \frac{1}{2}\ \text{mol} = \frac{\text{weight}}{M_w} = \frac{\text{weight}}{32}$ $\Rightarrow$ weight of oxygen = 16 g

(ii) $n = \frac{1}{2}\ \text{mol} = \frac{N}{N_A}$ $\Rightarrow$ Number of molecules of oxygen (N) = $\frac{N_A}{2}$

(iii) $n = \frac{1}{2}\ \text{mol} = \frac{V}{22.4}$ $\Rightarrow$ V = 11.2 L

(iv) 1 molecule of O_2 contain = 2 oxygen atoms.

$\frac{N_A}{2}$ molecules of O_2 contain = $\frac{N_A}{2} \times 2 = N_A$ oxygen atoms.

BEGINNER'S BOX-1

1. The modern atomic weight scale is based on.
(1) C^{12} (2) O^{16} (3) H^1 (4) C^{13}

2. Gram atomic weight of oxygen is
(1) 16 amu (2) 16 g (3) 32 amu (4) 32 g

3. Molecular weight of SO_2 is :
(1) 64 g (2) 64 amu (3) 32 g (4) 32 amu

4. 1 amu is equal to :-
(1) $\frac{1}{12}$ of C^{12} (2) $\frac{1}{14}$ of O^{16} (3) 1 g of H_2 (4) 1.66×10^{-24} kg

5. The actual molecular mass of chlorine is :
(1) 58.93×10^{-24} g (2) 117.86×10^{-24} g (3) 58.93×10^{-24} kg (4) 117.86×10^{-24} kg

RELATION BETWEEN MOLECULAR WEIGHT AND VAPOUR DENSITY :

Vapour density (V.D) : Vapour density of a gas is the ratio of densities of gas & hydrogen at the same temperature & pressure.

$$\text{Vapour Density (V.D)} = \frac{\text{Density of gas}}{\text{Density of hydrogen}} = \frac{d_{gas}}{d_{H_2}} \qquad \left\{ d = \frac{m(\text{mass})(g)}{V(\text{Volume})(mL)} \right.$$

$$\text{V.D} = \frac{(m_{gas})\text{for certain V litre volume}}{(m_{H_2})\text{for certain V litre volume}}$$

If N molecules are present in the given volume of a gas and hydrogen under similar condition of temperature and pressure.

$$\text{V.D.} = \frac{(m_{gas})\text{ of N molecules}}{(m_{H_2})\text{of N molecules}} = \frac{(m_{gas})\text{ of 1 molecule}}{(m_{H_2})\text{of 1 molecule}} = \frac{\text{Molecular mass of gas}}{2}$$

$\therefore$ **Molecular mass of gas (M_w) = 2 × V.D**

RELATION BETWEEN MOLAR MASS (M_w) & VOLUME :

At STP. $M_{W.} = 2 \times V.D = 2\times\frac{d_{gas}}{d_{H_2}} = 2 \times \frac{(m_{gas})\text{for certain V litre volume}}{(m_{H_2})\text{for certain V litre volume}}$

or $M_W = 2\times\frac{\text{mass of 1 litre gas}}{\text{mass of 1 litre }H_2}$

$d_{H_2} = 0.000089\frac{g}{mL} = \frac{m}{V} = \frac{m}{1000mL}$

or $M_W = 2\times\frac{\text{Mass of 1 litre gas}}{0.089g}$

$V = 1\ L = 1000\ mL$

$M_W\ (g) = 22.4 \times \text{mass of 1 litre gas}$

then $m_{H_2} = 0.089g$

M_W(g) = Mass of 22.4 litre gas or **M_w(g) ≡ 22.4 litre (at STP)**

GRAM MOLECULAR VOLUME (GMV)

At NTP, the volume of 1 mole of gaseous substance is 22.4 litre is called as gram molecular volume.

At NTP, d_{H_2} = 0.000089 g/mL = mass/volume = mass/1000 mL

If volume = 1 L = 1000 mL then mass = 0.089 g

∵ 0.089g H_2 occupies = 1 L at STP

∴ 1 g H_2 occupies = $\frac{1\text{litre}}{0.089}$ at STP

∴ 2 g or 1 mol H_2 occupies = $\frac{1\text{litre}}{0.089} \times 2$ = 22.4 L at STP

1 mole of any gaseous substance occupy 22.4 litre of volume at NTP or STP

1 mol ≡ 22.4 L (at STP)

Illustrations

Illustration 21. Calculate the number of atoms of chlorine in 2.08 g of $BaCl_2$.(Atomic weight of Ba = 137, Cl = 35.5)

Solution Number of moles of $BaCl_2$ (n) = $\frac{\text{weight}}{M_w} = \frac{2.08}{208} = 0.01\text{ mol} = \frac{N}{N_A}$

Number of molecules of $BaCl_2$ (N) = 0.01 N_A

1 molecule of $BaCl_2$ contain = 2 chlorine atoms.

0.01 N_A molecules $BaCl_2$ contain = 2 × 0.01 N_A Chlorine atoms. = 2×10^{-2} N_A Chlorine atoms.

Illustration 22. Calculate the number of molecules and number of atoms present in 1.2 g of ozone.

Solution Number of moles of O_3 (n) = $\frac{\text{weight}}{M_w} = \frac{1.2}{48} = \frac{1}{40}$ mol

⇒ number of molecules of O_3 (N) = $\frac{N_A}{40}$

∵ 1 molecule of O_3 contain = 3 atoms, ∴ $\frac{N_A}{40}$ molecules O_3 contain = $\frac{3N_A}{40}$ atoms.

Illustration 23. Calculate the number of atoms present in one drop of water having mass 1.8 g.

Solution Number of moles of H_2O (n) = $\frac{\text{weight}}{M_w} = \frac{1.8}{18} = 0.1$ mol

Number of molecules of H_2O (N) = 0.1 N_A

$\because$ 1 molecule of H_2O contain = 3 atoms

$\therefore$ 0.1 N_A molecules of H_2O contain = 3 × (0.1 N_A) = 0.3 N_A atoms.

Illustration 24. Calculate the number of atoms present in one litre of water (density of water is 1 g/mL).

Solution 1 litre = 1000 mL = 1000 g

Moles of H_2O (n) = $\frac{\text{weight}}{M_w} = \frac{1000}{18} = 55.5 \text{ mol} = \frac{N}{N_A}$

$\Rightarrow$ number of molecules of H_2O (N) = 55.5 N_A

$\because$ 1 molecule of H_2O contain = 3 atoms

$\therefore$ 55.5 N_A molecules H_2O contain = 3 × (55.5 N_A) atoms = 166.5 N_A atoms

Illustration 25. At NTP the density of a gas is 0.00445 g/mL then find out its V.D. and molecular mass.

Solution V.D. $= \frac{\text{Density of gas}}{\text{Density of } H_2} = \frac{0.004450}{0.000089} = 50$

Molecular mass = 2 × V.D.= 2 ×50 = 100

Illustration 26. Weight of 1 L gas is 2 g then find out its V.D. and molecular mass

Solution Density of gas = $\frac{\text{Mass}}{\text{Volume}} = \frac{2}{1000} = 0.002$ g/mL

V.D. $= \frac{\text{Density of gas}}{\text{Density of } H_2} = \frac{0.002000}{0.000089} = 22.4$

Molecular mass = 2 × V.D. = 44.8

GOLDEN KEY POINTS

- Term molar mass means mass of 1 mol particles.
- Vapour density is calculated with respect to H_2 gas under similar conditions of temperature and pressure.
- Relative density = $\frac{\text{Density of gas A}}{\text{Density of gas B}}$
- Specific gravity : It is density of material with respect to water.
- Vapour density, relative density and specific gravity are ratios so they are unitless.
- The term STP means 273.15 K (0°C) and 1 bar pressure. The term NTP means 273.15 K (0°C) and 1 atm.

BEGINNER'S BOX-2

1. Calculate the number of atoms in 11.2 L of SO_2 gas at STP :

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

2. Which of the following has maximum mass :

(1) 0.1 gram atom of carbon (2) 0.1 mol of ammonia

(3) 6.02×10^{22} molecules of hydrogen (4) 1120 cc of carbon dioxide at STP

3. The total number of electrons present in 18 mL of water :-

(1) 6.02×10^{22} (2) 6.02×10^{23} (3) 6.02×10^{24} (4) 6.02×10^{25}

4. The volume of 1.0 g of hydrogen at NTP is :

(1) 2.24 L (2) 22.4 L (3) 1.12 L (4) 11.2 L

5. 11 grams of a gas occupy 5.6 litres of volume at STP. The gas is :-

(1) NO (2) N_2O_4 (3) CO (4) CO_2

6. At NTP, 5.6 L of a gas weight 8 grams. The vapour density of gas is :-

(1) 32 (2) 40 (3) 16 (4) 8

7. The vapour densities of two gases are in the ratio of 1 : 3. Their molecular masses are in the ratio of :-

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

1.3 PERCENTAGE COMPOSITION, EMPIRICAL FORMULA & MOLECULAR FORMULA

Percentage formula (% by mass)

(In a molecule or compound) Mass $\%$ of an element $= \frac{\text{Number of atom (Atomicity)} \times \text{atomic mass}}{\text{molecular mass}} \times 100$

If number of atom =1 : Molecular mass = **minimum molecular mass**

Empirical Formula

The empirical formula of a compound express the *simplest whole number ratio of atoms* of various elements present in 1 molecule of the compound.

Ex.

	H_2O_2	CH_4	C_2H_6	$C_2H_4O_2$
Molecular Formula →	2:2	1:4	2:6	2:4:2
	1:1	1:4	1:3	1:2:1
Empirical Formula →	HO	CH_4	CH_3	CH_2O

Molecular Formula

The molecular formula of a compound represents the **actual number of atoms** present in 1 molecule of the compound i.e. it shows the real formula of its 1 molecule.

Relationship between Empirical & Molecular Formula

Molecular Formula = n × Empirical Formula

[Where n = natural no. (1, 2, 3,.........)]

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

Determination of Empirical Formula

Following steps are involved to determine the empirical formula of the compounds –

(1) First of all find the % by weight of each element present in 1 molecule of the compound

(2) The % by weight of each element is divided by its atomic weight. It gives atomic ratio of elements present in the compounds.

(3) Atomic ratio of each element is divided by the minimum value of atomic ratio as to get simplest ratio of atoms.

(4) If the value of simplest atomic ratio is fractional then raise the value to the nearest whole number.

or Multiply with suitable coefficient to convert it into nearest whole number.

(5) Write the Empirical formula as we get the simplest ratio of atoms.

Illustrations

Illustration 28. Find out percentage composition of each element present in glucose ?

Solution

% of C = $\frac{12\times6}{180}\times100=40\%$

% of H = $\frac{12\times1}{180}\times100=6.67\%$

% of O = $\frac{16\times6}{180}\times100=53.33\%$

Illustration 29. In a compound x is 75.8% and y is 24.2% by weight present. If atomic weight of x and y are 24 and 16 respectively. Then calculate the empirical formula of the compound.

Solution

Elements	%	Atomic weight	$\frac{\%}{\text{Atomic weight}}$	Simplest ratio	Ratio
x	75.8%	24	$\frac{75.8}{24}=3.1$	$\frac{3.1}{1.5}=2$	2
y	24.2%	16	$\frac{24.2}{16}=1.5$	$\frac{1.5}{1.5}=1$	1

Empirical formula = x_2y

Illustration 30. In a compound Carbon is 52.2%, Hydrogen is 13%, Oxygen is 34.8% are present and molecular mass of the compound is 92. Calculate molecular formula of the compound ?

Solution

Elements	%	Atomic weight	$\frac{\%}{\text{Atomic weight}}$	Simplest ratio	Ratio
C	52.2	12	$\frac{52.2}{12}$=4.35 = 4.4	$\frac{4.4}{2.2}=2$	2
H	13	1	$\frac{13}{1}=13$	$\frac{13}{22}$=5.9	6
O	34.8	16	$\frac{34.8}{16}=2.2$	$\frac{2.2}{2.2}=1$	1

Empirical formula = C_2H_6O

Empirical formula mass = 12 ×2 + 16 + 6 = 46

$$n=\frac{\text{Molecular formula mass}}{\text{Empirical formula mass}}=\frac{92}{46}=2$$

molecular formula = $2\times(C_2H_6O)=C_4H_{12}O_2$

BEGINNER'S BOX-3

1. A hydrocarbon contain 80% C. The vapour density of compound is 30. Empirical formula of compound is :-

(1) CH_3 (2) C_2H_6 (3) C_4H_{12} (4) C_4H_8

2. Two elements X (Atomic weight = 75) and Y (Atomic weight = 16) combine to give a compound having 75.8% of X. The empirical formula of compound is :

(1) XY (2) X_2Y (3) X_2Y_2 (4) X_2Y_3

3. In a compound element A (Atomic weight = 12.5) is 25% and element B (Atomic weight = 37.5) is 75% by weight. The Empirical formula of the compound is :

(1) AB (2) A_2B (3) A_2B_2 (4) A_2B_3

1.4 STOICHIOMETRY BASED CONCEPT (PROBLEMS BASED ON CHEMICAL REACTION)

One of the most important aspects of a chemical equation is that when it is written in the balanced form, it gives quantitative relationships between the various reactants and products in terms of moles, masses, molecules and volumes. This is called stoichiometry (Greek word, meaning 'to measure an element'). For example, a balanced chemical equation along with the quantitative information conveyed by it is given below:

Ex.1

$CaCO_{3(s)}$	+	$2HCl_{(aq)}$	$\longrightarrow$	$CaCl_{2(aq)}$	+	$H_2O_{(l)}$	+	$CO_{2(s)}$
1 Mol		2 Mol		1 Mol		1 Mol		1 Mol
$40 + 12 + 3 \times 16$		$2(1 + 35.5)$		$40 + 2 \times 35.5$		$2 \times 1 + 16$		$12 + 2 \times 16$
= 100 g		= 73 g		= 111 g		= 18 g		= 44 g or 22.4 L at STP

Thus,

(i) 1 mole of calcium carbonate reacts with 2 moles of hydrochloric acid to give 1 mole of calcium chloride, 1 mole of water and 1 mole of carbon dioxide.

(ii) 100 g of calcium carbonate react with 73 g hydrochloric acid to give 111 g of calcium chloride, 18 g of water and 44 g (or 22.4 litres at STP) of carbon dioxide.

Ex.2

1		3		2	Stoichiometric coefficient
$N_{2(g)}$	+	$3H_{2(g)}$	$\rightarrow$	$2NH_{3(g)}$	
1 mol	+	3 mol	$\rightarrow$	2 mol	
22.4 L	+	3×22.4 L	$\rightarrow$	2×22.4 L (at STP)	
1 L	+	3 L	$\rightarrow$	2 L	
1000 mL	+	3000 mL	$\rightarrow$	2000 mL	
1 mL	+	3 mL	$\rightarrow$	2 mL	
28 g	+	6 g	$\rightarrow$	34 g (According to the law of conservation of mass)	

- Gram can not be represented according to stoichiometry.

The quantitative information conveyed by a chemical equation helps in a number of calculations. The problems involving these calculations may be classified into the following two different types :

(a) Single reactant based (b) More than one reactant based

(A) SINGLE REACTANT BASED :

(1) Mass - Mass Relationships i.e. mass of one of the reactants or products is given and the mass of some other reactant or product is to be calculated.

(2) Mass - Volume Relationships i.e. mass/volume of one of the reactants or products is given and the volume/mass of the other is to be calculated.

(3) Volume - Volume Relationships i.e.volume of one of the reactants or the products is given and the volume of the other is to be calculated.

General method : Calculations for all the problems of the above types consists of the following steps :-

(i) Write down the balanced chemical equation.

(ii) Write the relative number of moles or the relative masses (gram atomic or molecular masses) of the reactants and the products below their formula.

(iii) In case of a gaseous substance, write down 22.4 litres at STP below the formula in place of 1 mole

(iv) Apply unitary method to make the required calculations.

Quite often one of the reactants is present in larger amount than the other as required according to the balanced equation. The amount of the product formed then depends upon the reactant which has reacted completely. This reactant is called the limiting reactant. The excess of the other is left unreacted.

Combustion reaction : (Problem based on combustion reactions) :

For balancing the combustion reaction: First of all balance C atoms, Then balance H atom, Finally balance Oxygen atom.

For Example : Combustion reaction of C_2H_6 : $C_2H_6 + O_2 \longrightarrow CO_2 + H_2O$ (skeleton equation)

First balance C atoms $C_2H_6 + O_2 \longrightarrow 2CO_2 + H_2O$

Now balance H atoms $C_2H_6 + O_2 \longrightarrow 2CO_2 + 3H_2O$

Now balance Oxygen atoms $C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$

Illustrations

TYPE-I (INVOLVING MASS-MASS RELATIONSHIP)

Illustration 31. How much iron can be theoretically obtained in the reduction of 1 kg of Fe_2O_3

Solution

1	3	2	3

$Fe_2O_3 + 3H_2 \longrightarrow 2Fe + 3H_2O$

$$n = \frac{\text{weight}}{M_w} = \frac{1000}{160}\text{mol}$$

The equation shows that 2 mol of iron are obtained from 1 mol of ferric oxide.

Hence, the obtained no. of moles of Fe = $\frac{2\times1000}{160}$ =12.5 mol = $\frac{\text{weight}}{\text{Atomic weight}} = \frac{\text{weight}}{56}$

Weight of iron obtained = 12.5 × 56 g = 700 g

Illustration 32. What amount of silver chloride is formed by the action of 5.850 g of sodium chloride on an excess of silver nitrate?

Solution

1	1	1	1

$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

$$n = \frac{\text{weight}}{M_w} = \frac{5.85}{58.5} = 0.1 \text{ mol}$$

1 mol of AgCl is obtained from 1 mol of NaCl

Hence, the number of moles of AgCl obtained with 0.1 mol of NaCl = 0.1 mol

$$\because \quad n = \frac{\text{weight}}{M_W} \Rightarrow 0.1 \text{ mol} = \frac{\text{weight}}{M_w} = \frac{\text{weight}}{143.5} \Rightarrow \text{weight} = 0.1 \times 143.5 \text{ g} = 14.35 \text{ g.}$$

TYPE-II (MASS - VOLUME RELATIONSHIP)

Illustration 33. For complete combustion of 3g ethane the required volume of O_2 & produced volume of CO_2 at STP will be.

Solution

2	7	4	6

$$2C_2H_{6(g)} + 7O_{2(g)} \longrightarrow 4CO_{2(g)} + 6H_2O_{(g)}$$

$$n = \frac{\text{weight}}{M_w} = \frac{3}{30} = \frac{1}{10} = 0.1 \text{ mol}$$

(a) Required moles of $O_2 = \frac{7}{2} \times 0.1 = 0.35$ mol

volume of O_2 at STP = 0.35 × 22.4 = 7.84 L

(b) Produced moles of $CO_2 = \frac{4}{2} \times 0.1 = 0.2$ mol

volume of CO_2 at STP = 0.2 ×22.4 = 4.48 L

Illustration 34. In the following reaction, if 10 g of H_2 reacts with N_2. What will be the volume of NH_3 at STP.

$N_2 + 3H_2 \longrightarrow 2NH_3$

Solution

1	3	2

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

10g

$$n = \frac{\text{weight}}{M_w} = \frac{10}{2} = 5 \text{ mol.}$$

Produced moles of $NH_3 = \frac{2}{3} \times 5 = \frac{10}{3}$, Volume of NH_3 at STP = $\frac{10}{3} \times 22.4$ = 74.67 litre

TYPE-III (VOLUME-VOLUME RELATIONSHIP)

Illustration 35. For complete combustion of 1.12 L of butane (C_4H_{10}), the produced volume of $H_2O_{(g)}$ & $CO_{2(g)}$ at STP will be.

Solution

1	13/2	4	5

$$C_4H_{10(g)} + 13/2\,O_{2(g)} \longrightarrow 4CO_{2(g)} + 5H_2O_{(g)}$$

1.12L

Volume of $H_2O_{(g)}$ at STP = 5 × 1.12 = 5.6 L

Volume of $CO_{2(g)}$ at STP = 4 × 1.12 = 4.48 L

Illustration 36. For complete combustion of 5 mol propane (C_3H_8). The required volume of O_2 at STP will be.

Solution For C_3H_8, the combustion reaction is

1	5	3	4

$$C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(l)}$$

5 mol

Required moles of O_2 = 5 × 5 = 25 mol = $\frac{V}{22.4}$

volume of O_2 gas at STP = 25 × 22.4 = 560 L

(B) MORE THAN ONE REACTANT BASED :

Limiting reagent (L.R.) concept

Limiting Reagent (L.R.) : The reactant which is completely consumed in a reaction is called as limiting reagent.

Ex.	1	2	1	2	⟵ Stoichiometry
	A +	2B ⟶	C +	2D	
given	3 mol	9mol			
	3 – 3 = 0 mol	9 – 6 = 3 mol	3 mol	6 mol	

L.R. = A

$$X = \frac{\text{given value (may moles, volume, or molecules)}}{\text{Stoichiometry Co-efficient}}$$

Reactants having least value of x are limiting reagents.

Ex. A + 2B → P

$3/1 = 3$ $\qquad$ $9/2 = 4.5$

$3 < 4.5$ So A is L.R.

Illustrations

Illustration 37. A + 5B ⟶ C + 3D In this reaction which is a L.R.

Solution A + 5B ⟶ C + 3D Given 10 mol of A and 10 mol of B.

10 mol $\qquad$ 10 mol

$x = \frac{10}{1} = 10$ $\qquad$ $x = \frac{10}{5} = 2$

$2 < 10$ So B is L.R.

Illustration 38. $H_{2(g)} + \frac{1}{2} O_{2(g)} \longrightarrow H_2O_{(g)}$; In the above reaction what is the volume of water vapour at STP.

Given 4 g of H_2 and 32 g of O_2

Solution

1	$1/2$	1		
$H_{2(g)}$ +	$\frac{1}{2} O_{2(g)}$ ⟶	$H_2O_{(g)}$		
4 g	32 g		For H_2	For O_2
$n = \frac{4}{2} = 2$ mol	$n = \frac{32}{32} = 1$ mol		$\frac{2}{1} = 2$	$\frac{1}{\frac{1}{2}} = 2$ mol

Moles of $H_2O_{(g)}$ = 2 mol = $\frac{V}{22.4}$ $\qquad$ 2 = 2 So Both H_2 & O_2 are L.R.

Volume of $H_2O_{(g)}$ at STP = $22.4 \times 2 = 44.8$ litre

Illustration 39. At NTP, In a container 100 mL N_2 and 100 mL of H_2 are mixed together. Then find out the produced volume of NH_3.

Solution Balanced equation will be $N_2 + 3H_2 \longrightarrow 2NH_3$.

Given 100mL 100mL

For determination of Limiting reagent. Now divide the given quantities by stoichiometry coefficients

$$\frac{100}{1} = 100 \qquad \frac{100}{3} = 33.3 \text{ (Limiting reagent)}$$

In this reaction H_2 is limiting reagent so reaction will proceed according to H_2.

As per stoichiometry from 3 mL of H_2 produces ; volume of NH_3 = 2 mL

That is from 100 mL of H_2 produced volume of $NH_3 = \frac{2}{3} \times 100 = 66.6$ mL

BEGINNER'S BOX-4

1. 1.5 mol of O_2 combine with Mg to form oxide MgO. The mass of Mg (At. mass 24) that has combined is :

(1) 72 g (2) 36 g (3) 24 g (4) 94 g

2. What quantity of lime stone on heating will give 56 kg of CaO :-

(1) 1000 kg (2) 56 kg (3) 44 kg (4) 100 kg

3. For reaction $A + 2B \rightarrow C$. The amount of product formed by starting the reaction with 5 mol of A and 8 mol of B is :

(1) 5 mol (2) 8 mol (3) 16 mol (4) 4 mol

1.5 EQUIVALENT WEIGHT

The equivalent weight of a substance is the number of parts by mass of the substance that combine with or displaces directly or indirectly 1.008 parts by mass of hydrogen or 8 parts by mass of oxygen or 35.5 parts by mass of chlorine or 108 parts by weight of Ag.

(a) Calculation of Equivalent Weight

(i) $\text{Equivalent weight} = \frac{\text{Atomic weight}}{\text{Valency factor}}$

(ii) $\text{Equivalent weight of ions} = \frac{\text{formula weight of ion}}{\text{Valency}}$

(iii) Equivalent weight of ionic compound = equivalent weight of cation + equivalent weight of anion

Ex. Equivalent weight of H_2SO_4 = Equivalent weight of H^++Equivalent weight of Anion(SO_4^{-2})

= 1 + 48 = 49

(iv) $\text{Equivalent weight of acid / base} = \frac{\text{Molecular weight}}{\text{Basicity/Acidity}}$

(v) Equivalent weight of salt $= \dfrac{\text{Molecular weight}}{\text{Total charge on cation or anion}}$

Ex. Na_2SO_4 (salt) $\rightarrow 2Na^+ + SO_4^{-2}$

Total charge on cation or anion is 2

molecular weight of Na_2SO_4 is = $(2 \times 23 + 32 + 16 \times 4) = 142$

Equivalent weight of $Na_2SO_4 = \dfrac{142}{2} = 71$

(vi) Equivalent weight of an oxidizing or reducing agent

$$= \frac{\text{Molecular weight of the substance}}{\text{Number of electrons gain/lost by one molecule}}$$

(b) Concept of gram equivalent and law of chemical equivalence :

Number of gram equivalent $= \dfrac{W_{(gram)}}{E}$

$$= \frac{W_{(gram)} \times \text{Valence factor}}{M}$$

$= n \times$ valence factor

According to it, in a reaction equal number of gram equivalents of reactants react to give equal number of gram equivalents of products.

For a reaction

$$aA + bB \longrightarrow cC + dD$$

Number of gram equivalents of A = Number of gram equivalents of B = Number of gram equivalents of C = Number of gram equivalents of D

(c) METHODS FOR DETERMINATION OF EQUIVALENT WEIGHT

(i) **Hydrogen displacement method :** This method is used for those elements which can evolve hydrogen from acids i.e. active metals.

equivalent weight of metal $= \dfrac{\text{weight of metal}}{\text{weight of } H_2 \text{ gas (displaced)}} \times 1.008$

(ii) **Oxide formation method :** A known mass of the element is changed into oxide directly or indirectly. The mass of oxide is noted.

Mass of oxygen = (Mass of oxide – Mass of element)

equivalent weight of element $= \dfrac{\text{weight of element}}{\text{weight of oxygen}} \times 8$

(iii) **Chloride formation method :** A known mass of the element is changed into chloride directly or indirectly. The mass of the chloride is determined.

equivalent weight of element $= \dfrac{\text{weight of element}}{\text{weight of chlorine}} \times 35.5$

(iv) Metal to metal displacement method : More active metal can displace less active metal from its salt's solution. The mass of the displaced metal bear the same ratio as their equivalent weights.

$$\frac{m_1}{m_2} = \frac{E_1}{E_2}$$

(v) Double decomposition method : This method is based on the following points -

(a) The mass of the compound reacted and the mass of product formed are in the ratio of their equivalent masses.

(b) The equivalent mass of the compound (electrovalent) is the sum of equivalent masses of its radicals.

(c) The equivalent mass of a radical is equal to the formula mass of the radical divided by its charge.

$$AB + CD \longrightarrow AD \text{ (ppt.)} + CB$$

$$\frac{\text{Mass of AB}}{\text{Mass of AD}} = \frac{\text{Equivalent mass of AB}}{\text{Equivalent mass of AD}} = \frac{\text{Equivalent mass of A} + \text{Equivalent mass of B}}{\text{Equivalent mass of A} + \text{Equivalent mass of D}}$$

(vi) Silver salt method : This method is used for finding the equivalent weight of carbonic (organic) acids. A known mass of the RCOOAg is changed into Ag through combustion. The mass of Ag is determined.

$$\frac{\text{Equivalent weight of RCOOAg}}{\text{Equivalent weight of Ag}} = \frac{\text{weight of RCOOAg}}{\text{weight of Ag}}$$

$$\text{equivalent weight of RCOOAg} = \frac{\text{weight of RCOOAg}}{\text{weight of Ag}} \times 108$$

(vii) By electrolysis : $\frac{w_1}{w_2} = \frac{E_1}{E_2}$

Where w_1 & w_2 are deposited weight of metals at electrodes and E_1 and E_2 are equivalent weight respectively.

1.6 METHODS FOR CALCULATION OF ATOMIC WEIGHT AND MOLECULAR WEIGHT

(a) Methods for Determination of Atomic Weight

(i) Atomic weight = equivalent weight × valency

(ii) Dulong and Petit's law - This law is applicable only for solids (except Be, B, Si, C)

Atomic mass × specific heat (Cal g^{-1} °C) ≈ 6.4

or atomic mass (approximate) = $\frac{6.4}{\text{specific heat}}$

(iii) Law of isomorphism : Isomorphous substances form crystals which have same shape and size and can grow in the saturated solution of each other.

Examples of isomorphous compounds -

(1) H_2SO_4 and K_2CrO_4

(2) $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$ and $MgSO_4.7H_2O$

(3) $KClO_4$ and $KMnO_4$

(4) $K_2SO_4.Al_2(SO_4)_3.24H_2O$ and $K_2SO_4.Cr_2(SO_4)_3.24H_2O$

Conclusions -

- Masses of two elements that combine with same mass of other elements in their respective compounds are in the ratio of their atomic masses.

$$\frac{\text{Mass of one elements (A) that combines with a certain mass of other element}}{\text{Mass of other element (B) that combines with the same mass of other element}} = \frac{\text{Atomic mass of A}}{\text{Atomic mass of B}}$$

- The valencies of the elements forming isomorphous compounds are the same.

(iv) Volatile chloride method

Required condition – chloride of element should be vapour.
Required data - (i) Vapour density of chloride. (ii) Equivalent weight of element.
Let the valency of the element be x. The formula of its chloride will be MCl_x.
Molecular weight = Atomic weight of M + 35.5 x
∵ Atomic weight = Equivalent weight × valency or A = E × x

∴ Molecular weight = E x + 35.5 x or 2 × V.D. = x(E + 35.5) or $x = \frac{2 \times \text{V.D.}}{E + 35.5}$

(v) Specific heat method : If $\frac{C_P}{C_V} = \gamma$ is given, then

Case I.	If $\gamma = 5/3 = 1.66$	Atomicity will be one
Case II.	If $\gamma = 7/5 = 1.4$	Atomicity will be two
Case III.	If $\gamma = 4/3 = 1.33$	Atomicity will be three

$$\text{Atomic weight} = \frac{\text{Molecular weight}}{\text{Atomicity}}$$

(b) Method for Determination of Molecular Weight :

(i) Molecular weight = 2 × V.D.

(ii) Victor Mayer's method is used to determine molecular weight of volatile compound.

Illustrations

Illustration 40. Specific heat of a metal is $0.031 \frac{°C \times Cal}{g}$, and its equivalent weight is 103.6. Calculate the exact atomic weight of the metal.

Solution According to Dulong and Petit's law - approximate atomic weight = $\frac{6.4}{0.031}$ = 206.45

$$\text{Valency of metal} = \frac{\text{Approximate atomic weight}}{\text{Equivalent weight}} = \frac{206.45}{103.6} = 1.99 \simeq 2$$

So, the exact atomic weight of the element = Equivalent weight × valency
= 103.6 × 2 = 207.2

Illustration 41. A chloride of an element contains 49.5% chlorine. The specific heat of the element is 0.064 °C cal g^{-1}. Calculate the equivalent mass, valency and atomic mass of the element.

Solution Mass of chlorine in the metal chloride = 49.5
Mass of metal = (100 – 49.5) = 50.5

$$\text{Equivalent weight of metal} = \frac{\text{weight of metal}}{\text{weight of chlorine}} \times 35.5 = \frac{50.5}{49.50} \times 35.5 = 36.21$$

Now according to Dulong and Petit's law,

$$\text{Approximate at. wt. of the metal} = \frac{6.4}{\text{specific heat}} = \frac{6.4}{0.064} = 100$$

$$\text{Valency} = \frac{\text{Approximate atomic weight}}{\text{Equivalent weight}} = \frac{100}{36.21} = 2.7 \simeq 3$$

Hence, exact atomic weight = 36.21 × 3 = 108.63

Illustration 42. The oxide of an element contains 67.67% of oxygen and the vapour density of its volatile chloride is 79. Calculate the atomic weight of the element.

Solution Calculation of equivalent weight : weight of oxygen = 67.67 g

weight of element = 100 – 67.67 = 32.33 g

$\because$ 67.67 g of oxygen combines with 32.33 g of element

$\therefore$ 8 g of oxygen combines with = $\frac{32.33 \times 8}{67.67}$ = 3.82 g of element

$\therefore$ Equivalent weight of the element = 3.82

Suppose M represents one atom of the element and x is its valency. The molecular formula of the volatile chloride would be MCl_x.

Formula weight of chloride = 3.82 × x + 35.5 x = 39.32 x

But molecular weight of Chloride = 2 ×V.D. $\Rightarrow$ 39.32 x = 2 ×79$\Rightarrow$ x = $\frac{2 \times 79}{39.32}$ = 4

Now atomic weight = Equivalent weight ×valency of element = 3.82 ×4 = 15.28

Illustration 43. Vapour density of a gas is 16. If the ratio of specific heat at constant pressure and specific heat at constant volume is 1.4. Then find out its atomic weight.

Solution Given : $\frac{C_P}{C_V} = 1.4 = \gamma$ and vapour density = 16

We know that Molecular weight = 2 ×vapour density

$\therefore$ Molecular weight = 2 × 16 = 32

Here γ = 1.4 so atomicity will be 2.

$$\text{Atomic weight} = \frac{\text{Molecular weight}}{\text{Atomicity}} = \frac{32}{2} = 16$$

GOLDEN KEY POINTS

- Equivalent weight of a species changes with reaction in which it gets involved.
- Amount of substance which loses or gains 1 mole electrons or 96500 coulomb electricity will always be its equivalent weight.

BEGINNER'S BOX-5

1. Molecular weight of dibasic acid is W. Its equivalent weight will be :

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

2. 0.126 g of an acid requires 20 ml of 0.1 N NaOH for complete neutralization. Eq. wt. of the acid is:

(1) 45 (2) 53 (3) 40 (4) 63

3. In a metal oxide 32% oxygen is present what will be equivalent mass of metal ?

(1) 17 (2) 34 (3) 32 (4) 52

4. 1 mol O_2 will be equal to :

(1) 4 g equivalent oxygen (2) 2 g equivalent oxygen

(3) 32 g equivalent oxygen (4) 8 g equivalent oxygen

5. Volume of one gram equivalent of H_2 at NTP is :

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

1.7 LAWS OF CHEMICAL COMBINATION

(a) Law of Mass Conservation (Law of Indestructibility of Matter)

"It was given by **Lavoisier** and tested by **Landolt"**

According to this law, the mass can neither be created nor be destroyed in a balanced chemical reaction or physical reaction. But one form is changed into another form is called as law of mass conservation.

If the reactants are completely converted into products, then the sum of the mass of reactants is equal to the sum of the mass of products.

Total mass of reactants = Total mass of products.

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

Total mass of reactants = Total mass of products + Mass of unreacted reactants

Ex.

$$H_2 + Cl_2 \longrightarrow 2HCl$$

Mass in (g) 2 71 → 2(1 + 35.5)

2 + 71 = 73 g → 73 g

Illustrations

Illustration 44. What weight of $BaCl_2$ would react with 24.4 g of sodium sulphate to produce 46.6 g of barium sulphate and 23.4 g of sodium chloride ?

Solution Barium chloride and sodium sulphate react to produce barium sulphate and sodium chloride according to the equation : $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$

x g 24.4 g 46.6 g 23.4 g

Let the weight of $BaCl_2$ be x g. According to law of conservation of mass :

Total mass of reactants = Total mass of products

Total mass of reactants = (x + 24.4) g

Total mass of products = (46.6 + 23.4) g

Equating the two masses ⇒ x + 24.4 = 46.6 + 23.4

x = 46.6 + 23.4 – 24.4 or x = 45.6 g

Hence, the weight of $BaCl_2$ is 45.6 g

Illustration 45. 10g of $CaCO_3$ on heating gives 4.4 g of CO_2 then determine weight of produced CaO in quintal.

Solution $CaCO_3 \longrightarrow CaO + CO_2$

10 g x g 4.4 g

According to law of conservation of mass

$$\begin{cases} 1\text{quintal} = 100\text{kg} \\ 1\text{kg} = 1000\text{g} \end{cases}$$

10 = 4.4 + x

10 - 4.4 = x

x = 5.6 g

weight of CaO(x) $= 5.6 \times \frac{kg}{1000} = 5.6 \times 10^{-3}\ kg = 5.6 \times 10^{-3} \times \frac{1}{100}$ quintal $= 5.6 \times 10^{-5}$ quintal

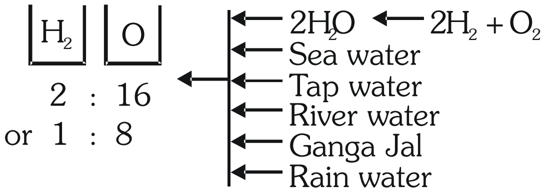
(b) Law of Definite Proportion / Law of Constant Composition

"It was given by **Proust**."

According to this law, a compound can be obtained from different sources. But the ratio of each component (by weight) remain same.i.e. it does not depend on the method of its preparation or the source from which it has been obtained.

For example :- molecule of ammonia always has the formula NH_3. That is one molecule of ammonia always contains, one atom of nitrogen and three atoms of hydrogen or 17 g of NH_3 always contains 14 g of nitrogen and 3 g of hydrogen.

Ex. Water can be obtained from different sources but the ratio of weight of H and O remains same.



Illustrations

Illustration 46. Weight of copper oxide obtained by treating 2.16 g of metallic copper with nitric acid and subsequent ignition was 2.70 g. In another experiment, 1.15 g of copper oxide on reduction yielded 0.92 g of copper. Show that the results illustrate the law of constant composition.

Solution

In I experiment

weight of Cu = 2.16 g

weight of CuO = 2.7 g

weight of Oxygen = 2.7 – 2.16 = 0.54 g

Cu : O

2.16 : 0.54

$$\frac{2.16}{0.54} : \frac{0.54}{0.54}$$

4 : 1

In II experiment

weight of CuO = 1.15 g

weight of Cu = 0.92 g

weight of Oxygen = 1.15 – 0.92 = 0.23 g

Cu : O

0.92 : 0.23

$$\frac{0.92}{0.23} : \frac{0.23}{0.23}$$

4 : 1

Thus the ratio of the masses of copper and oxygen in the two experiment are same. Hence the given data illustrate the law of constant proportion.

Illustration 47. In an experiment 2.4 g of FeO on reduction with hydrogen gives 1.68 g of Fe. In another experiment 2.9 g of FeO gives 2.03 g of Fe on reduction with hydrogen. Show that the above data illustrate the law of constant proportion.

Solution

In I experiment

Weight of FeO = 2.4 g

Weight of Fe = 1.68 g

Weight of Oxygen = 2.4 – 1.68 = 0.72 g

Fe : O

1.68 : 0.72

$$\frac{1.68}{0.72} : \frac{0.72}{0.72}$$

2.33 : 1

In II experiment

Weight of FeO = 2.9 g

Weight of Fe = 2.03 g

Weight of Oxygen = 2.9 – 2.03 = 0.87 g

Fe : O

2.03 : 0.87

$$\frac{2.03}{0.87} : \frac{0.87}{0.87}$$

2.33 : 1

Thus the ratio of the masses of iron and oxygen in the two experiment are same. Hence the given data illustrate the law of constant proportion.

(c) Law of Multiple Proportion

"It was given by **John Dalton**"

According to law of Multiple proportion if two elements combine to form more than one compound then the different mass of one element which combine with a fixed mass of other element bear a simple ratio to one another.

The following examples illustrate this law.

(i) **Nitrogen and oxygen combine to form five oxides, which are :** Nitrous oxide (N_2O), nitric oxide (NO), nitrogen trioxide (N_2O_3), nitrogen tetraoxide (N_2O_4) and nitrogen pentaoxide (N_2O_5).

Weight of oxygen which combine with the fixed weight of nitrogen in these oxides are calculated as under:

Oxide Ratio of weight of nitrogen and oxygen in each compound

N_2O 28 : 16 NO 14 : 16 N_2O_3 28 : 48

N_2O_4 28 : 64 N_2O_5 28 : 80

Number of parts by weight of oxygen which combine with 14 parts by weight of nitrogen from the above are 8,16,24,32 and 40 respectively. Their ratio is 1 : 2 : 3 : 4 : 5, which is a simple ratio. Hence, the law is illustrated.

(ii) Sulphur combines with oxygen to from two oxides SO_2 and SO_3, the weights of oxygen which combine with a fixed weight of sulphur, i.e. 32 parts by weight of sulphur in two oxides are in the ratio of 32 : 48 or 2 : 3 which is a simple ratio. Hence the law of multiple proportions is illustrated.

Illustrations

Illustration 48. Hydrogen peroxide and water contain 5.93% and 11.2% of hydrogen respectively. Show that the data illustrate the law of multiple proportions.

Solution

Compound H_2O_2	Compound H_2O
H : O	H : O
5.93 : 94.07	11.2 : 88.8
$\frac{5.93}{5.93} : \frac{94.07}{5.93}$	$\frac{11.2}{11.2} : \frac{88.8}{11.2}$
① : 15.86	① : 7.92

Thus the ratio of weighs of oxygen which combine with the fixed weight (1.0 gram) of hydrogen in H_2O_2 and H_2O is 15.86 : 7.92 = 2 : 1 (Which is simple ratio). So the law of multiple proportion is illustrated.

Illustration 49. Carbon combines with hydrogen in P, Q and R. The % of hydrogen in P, Q and R are 25, 14.3, and 7.7 respectively. Which law of chemical combination is illustrated ?

Solution

P	Q	R
H : C	H : C	H : C
25 : 75	14.3 : 85.7	7.7 : 92.3
$1 : \frac{75}{25}$	$1 : \frac{85.7}{14.3}$	$1 : \frac{92.3}{7.7}$
① : 3	① : 6	① : 12

Ratio of C in compounds P, Q and R is = 3 : 6 : 12 = 1 : 2 : 4

Which is a simple ratio so the data illustrate the law of multiple proportion.

(d) Law of Gaseous Volume

"It was given by **Gay Lussac**"

According to this law, in the gaseous reaction, the reactants are always combined in a simple ratio by volume and form products, which is **simple ratio by volume** at same temperature and pressure.

Ex.1 One volume of hydrogen combines with one volume of chlorine to produce 2 volumes of hydrogen chloride.

Simple ratio = 1 : 1 : 2.

1		1		2	⟵ Stoichiometry
$H_{2(g)}$	+	$Cl_{2(g)}$	⟶	$2HCl_{(g)}$	
1 Volume		1 Volume		2 Volume	

Ex.2 One volume of nitrogen combines with 3 volumes of hydrogen to from 2 volumes of ammonia.

Simple ratio 1 : 3 : 2

1		3		2
$N_{2(g)}$	+	$3H_{2(g)}$	⟶	$2NH_{3(g)}$
1 Volume		3 Volume		2 Volume

Special Note : This law is used only for gaseous reaction. It relate volume to mole or molecules. But not relate with mass.

Illustrations

Illustration 50. For the gaseous reaction : $H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$. If 40 mL of hydrogen completely reacts with chlorine then find out the required volume of Chlorine & volume of produced $HCl_{(g)}$?

Solution According to Gay Lussac's Law :

1		1		2
$H_{2(g)}$	+	$Cl_{2(g)}$	⟶	$2HCl_{(g)}$

∵ 1 mL of $H_{2(g)}$ will react with 1 mL of $Cl_{2(g)}$ and 2 mL of $HCl_{(g)}$ will produce

∴ 40 mL of $H_{2(g)}$ will react with 40 mL of $Cl_{2(g)}$ and 80 mL of $HCl_{(g)}$ will produce

required volume of $Cl_{2(g)}$ = 40 mL

produced volume of $HCl_{(g)}$ = 80 mL

Illustration 51. For the gaseous reaction : $H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$. If initially 20 mL of $H_{2(g)}$ and 30 mL of $Cl_{2(g)}$ are present then find out the volume of $HCl_{(g)}$ and unreacted part of $Cl_{2(g)}$.

Solution According to Gay-Lussac's Law

1		1		2
$H_{2(g)}$	+	$Cl_{2(g)}$	⟶	$2HCl_{(g)}$

∵ 1 mL of $H_{2(g)}$ will react with 1 mL of $Cl_{2(g)}$ and 2 mL of $HCl_{(g)}$ will produce

∴ 20 mL of $H_{2(g)}$ will react with 20 mL of $Cl_{2(g)}$ and 40 mL of $HCl_{(g)}$ will produce

Given volume of $Cl_{2(g)}$ is 30 mL but its 20 mL reacts with $H_{2(g)}$. So 10 mL of $Cl_{2(g)}$ remains unreacted.

(e) Avogadro's law

"Equal volume of all gases contain equal number of molecules at same temperature and pressure."

Ex.

1	1	2	⟵ Stoichiometry
$H_{2(g)}$ +	$Cl_{2(g)}$ ⟶	$2HCl_{(g)}$	
1 Volume	1 Volume	2 Volume	
N molecules	N molecules	2N molecules	
$\frac{1}{2}$ molecule (1 atom)	$\frac{1}{2}$ molecule (1 atom)	1 molecule	

It is correct due to molecule is divisible.

ANSWER KEY

BEGINNER'S BOX-1	**Que.**	1	2	3	4	5					
	Ans.	**1**	**2**	**2**	**1**	**2**					
BEGINNER'S BOX-2	**Que.**	1	2	3	4	5	6	7			
	Ans.	**2**	**4**	**3**	**4**	**4**	**3**	**1**			
BEGINNER'S BOX-3	**Que.**	1	2	3							
	Ans.	**1**	**4**	**1**							
BEGINNER'S BOX-4	**Que.**	1	2	3							
	Ans.	**1**	**4**	**4**							
BEGINNER'S BOX-5	**Que.**	1	2	3	4	5					
	Ans.	**1**	**4**	**1**	**1**	**2**					

EXERCISE-I (Conceptual Questions) — Build Up Your Understanding

QUESTIONS BASED ON MOLES

1. The number of atoms present in 16 g of oxygen is

(1) $6.02 \times 10^{11.5}$ (2) 3.01×10^{23}

(3) $3.01 \times 10^{11.5}$ (4) 6.02×10^{23}

2. The number of atoms in 4.25 g of NH_3 is approx:-

(1) 1×10^{23} (2) 1.5×10^{23}

(3) 2×10^{23} (4) 6×10^{23}

3. Which of the following contains maximum number of oxygen atoms ?

(1) 1 g of O

(2) 1 g of O_2

(3) 1 g of O_3

(4) all have the same number of atoms

4. The number of atoms present in 0.5 g atom of nitrogen is same as the atoms in –

(1) 12 g of C (2) 32 g of S

(3) 8 g of oxygen (4) 24 g of Mg

5. Which of the following contains maximum number of atoms ?

(1) 4 g of H_2 (2) 16 g of O_2

(3) 28 g of N_2 (4) 18 g of H_2O

6. Number of neutrons present in 1.7 g of ammonia is -

(1) N_A (2) $N_A/10 \times 4$

(3) $(N_A/10) \times 7$ (4) $N_A \times 10 \times 7$

7. 5.6 L 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

8. Number of oxygen atoms in 8 g of ozone is -

(1) 6.02×10^{23} (2) $\frac{6.02 \times 10^{23}}{2}$

(3) $\frac{6.02 \times 10^{23}}{3}$ (4) $\frac{6.02 \times 10^{23}}{6}$

9. The number of atoms in "n" mole of gas can be given by :-

(1) n ×Av. No. ×atomicity (2) $\frac{n \times \text{Av.No.}}{\text{Atomicity}}$

(3) $\frac{\text{Av.No.} \times \text{Atomicity}}{n}$ (4) None

10. Sum of number of protons, electrons and neutrons in 12g of ${}^{12}_{6}C$ is :-

(1) 1.8 (2) 12.044×10^{23}

(3) 1.084×10^{25} (4) 10.84×10^{23}

11. The weight of one atom of Uranium is 238 amu. Its actual weight is .... g.

(1) 1.43×10^{26} (2) 3.94×10^{-22}

(3) 6.99×10^{-23} (4) 1.53×10^{-22}

12. The actual weight of a molecule of water is -

(1) 18 g

(2) 2.99×10^{-23} g

(3) both (1) & (2) are correct

(4) 1.66×10^{-24} g

13. What is the mass of a molecule of CH_4 :–

(1) 16 g (2) 26.6×10^{22} g

(3) 2.66×10^{-23} g (4) 16 N_A g

14. Which of the following has the highest mass ?

(1) 1 g atom of C

(2) 1/2 mole of CH_4

(3) 10 mL of water

(4) 3.011×10^{23} atoms of oxygen

15. Which of the following contains the least number of molecules ?

(1) 4.4 g CO_2 (2) 3.4 g NH_3

(3) 1.6 g CH_4 (4) 3.2 g SO_2

16. The number of molecule in 4.25 g of NH_3 is -

(1) 1.505×10^{23} (2) 3.01×10^{23}

(3) 6.02×10^{23} (4) None of these

17. Elements A and B form two compounds B_2A_3 and B_2A. 0.05 moles of B_2A_3 weight 9.0 g and 0.10 mole of B_2A weight 10 g. Calculate the atomic weight of A and B :-

(1) 20 and 30 (2) 30 and 40

(3) 40 and 30 (4) 30 and 20

18. 5.6 L of oxygen at NTP is equivalent to –

(1) 1 mol (2) 1/2 mol

(3) 1/4 mol (4) 1/8 mol

19. 4.4 g of an unknown gas occupies 2.24 L of volume at STP. The gas may be :-

(1) N_2O (2) CO

(3) CO_2 (4) 1 & 3 both

20. Which contains least number of molecules :–

(1) 1 g CO_2 (2) 1 g N_2

(3) 1 g O_2 (4) 1 g H_2

21. If V mL of the vapours of substance at NTP weight W g. Then molecular weight of substance is:-

(1) (W/V) × 22400 (2) $\frac{V}{W} \times 22.4$

(3) (W - V) × 22400 (4) $\frac{W \times 1}{V \times 22400}$

22. If 3.01 × 10^{20} molecules are removed from 98 mg of H_2SO_4, then the number of moles of H_2SO_4 left are :–

(1) 0.1 × 10^{-3} (2) 0.5 × 10^{-3}

(3) 1.66 × 10^{-3} (4) 9.95 × 10^{-2}

23. A gas is found to have the formula $(CO)_x$. It's VD is 70. The value of x must be:-

(1) 7 (2) 4 (3) 5 (4) 6

24. Vapour density of gas is 11.2. Volume occupied by 2.4 g of this at STP will be -

(1) 11.2 L (2) 2.24 L

(3) 22.4 L (4) 2.4 L

25. The volume of a gas in discharge tube is 1.12 × 10^{-7} mL at STP. Then the number of molecule of gas in the tube is -

(1) 3.01 ×10^{4} (2) 3.01 ×10^{15}

(3) 3.01 ×10^{12} (4) 3.01 ×10^{16}

26. 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}

27. The total number of ions persent in 1 mL of 0.1 M barium nitrate $Ba(NO_3)_2$ solution is -

(1) 6.02 ×10^{18} (2) 6.02 ×10^{19}

(3) 3.0 ×6.02 ×10^{19} (4) 3.0 ×6.02 ×10^{18}

28. The weight of 1 mole of a gas of density 0.1784 g L^{-1} at NTP is -

(1) 0.1784 g (2) 1 g

(3) 4 g (4) 4 amu

29. Given that one mole of N_2 at NTP occupies 22.4 L the density of N_2 is -

(1) 1.25 g L^{-1} (2) 0.80 g L^{-1}

(3) 2.5 g L^{-1} (4) 1.60 g L^{-1}

30. The number of gram molecules of oxygen in 6.02 ×10^{24} CO molecules is –

(1) 10 g molecules (2) 5 g molecules

(3) 1 g molecules (4) 0.5 g molecules

QUESTIONS BASED ON PERCENTAGE, EMPIRICAL FORMULA & MOLECUALR FORMULA

31. A compound of X and Y has equal mass of them. If their atomic weights are 30 and 20 respectively. Molecular formula of the compound is :-

(1) X_2Y_2 (2) X_3Y_3

(3) X_2Y_3 (4) X_3Y_2

32. An oxide of sulphur contains 50% of sulphur in it. Its emperial formula is -

(1) SO_2 (2) SO_3

(3) SO (4) S_2O

33. A hydrocarbon contains 80% of carbon, then the hydrocarbon is -

(1) CH_4 (2) C_2H_4

(3) C_2H_6 (4) C_2H_2

34. Emperical formula of glucose is -

(1) $C_6H_{12}O_6$ (2) $C_3H_6O_3$

(3) $C_2H_4O_2$ (4) CH_2O

35. An oxide of metal M has 40% by mass of oxygen. Metal M has atomic mass of 24. The emperical formula of the oxide is :-

(1) M_2O (2) M_2O_3 (3) MO (4) M_3O_4

36. A compound contains 38.8% C, 16.0% H and 45.2% N. The formula of the compound would be

(1) CH_3NH_2 (2) CH_3CN

(3) C_2H_5CN (4) $CH_2(NH)_2$

37. The simplest formula of a compound containing 50% of element X(at wt. = 10) and 50% of element Y(at wt. = 20) is:-

(1) XY (2) X_2Y (3) XY_2 (4) X_3Y

38. Which of the following compounds has same empirical formula as that of glucose:-

(1) CH_3CHO (2) CH_3COOH

(3) CH_3OH (4) C_2H_6

39. A gas is found to contain 2.34 g of Nitrogen and 5.34 g of oxygen. Simplest formula of the compound is -

(1) N_2O (2) NO (3) N_2O_3 (4) NO_2

40. 2.2 g of a compound of phosphorous and sulphur has 1.24 g of 'P' in it. Its emperial formula is -

(1) P_2S_3 (2) P_3S_2

(3) P_3S_4 (4) P_4S_3

41. On analysis, a certain compound was found to contain iodine and oxygen in the ratio of 254:80. The formula of the compound is :
(At mass I = 127, O = 16)
(1) IO (2) I_2O (3) I_5O_2 (4) I_2O_5

42. The number of atoms of Cr and O are 4.8×10^{10} and 9.6×10^{10} respectively. Its empirical formula is –
(1) Cr_2O_3 (2) CrO_2
(3) Cr_2O_4 (4) CrO_5

43. Insulin contains 3.4% sulphur ; the minimum molecular weight of insulin is :
(1) 941.176 (2) 944
(3) 945.27 (4) None

44. A giant molecule contains 0.25% of a metal whose atomic weight is 59. Its molecule contains one atom of that metal. Its minimum molecular weight is -
(1) 5900 (2) 23600
(3) 11800 (4) $\frac{100 \times 59}{0.4}$

45. Caffine has a molecular weight of 194. It contains 28.9% by mass of nitrogen Number of atoms of nitrogen in one molecule of it is :-
(1) 2 (2) 3
(3) 4 (4) 5

QUESTIONS BASED ON STOICHIOMETRY

46. 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 g of A combines with b g of B to give C and D
(4) a molecules of A combines with b molecules of B to give C and D

47. Assuming that petrol is octane (C_8H_{18}) and has density 0.8 g mL^{-1}. 1.425 L of petrol on complete combustion will consume.
(1) 50 mole of O_2 (2) 100 mole of O_2
(3) 125 mole of O_2 (4) 200 mole ofO_2

48. In a given reaction, 9 g of Al will react with
$$2Al + \frac{3}{2}O_2 \rightarrow Al_2O_3$$
(1) 6 g O_2 (2) 8 g O_2
(3) 9 g O_2 (4) 4 g O_2

49. The equation :
$2Al_{(s)} + \frac{3}{2} O_2(g) \rightarrow Al_2O_{3(s)}$ shows that :-
(1) 2 mol of Al reacts with $\frac{3}{2}$ mol of O_2 to produce $\frac{7}{2}$ mol of Al_2O_3
(2) 2 g of Al reacts with $\frac{3}{2}$ g of O_2 to produce one mol of Al_2O_3
(3) 2 g of Al reacts with $\frac{3}{2}$ L of O_2 to produce 1 mol of Al_2O_3
(4) 2 mol of Al reacts with $\frac{3}{2}$ mol of O_2 to produce 1 mol of Al_2O_3

50. 1 L of CO_2 is passed over hot coke. When the volume of reaction mixture becomes 1.4 L, the composition of reaction mixture is–
(1) 0.6 L CO
(2) 0.8 L CO_2
(3) 0.6 L CO_2 and 0.8 L CO
(4) None

51. 26 cc of CO_2 are passed over red hot coke. The volume of CO evolved is :–
(1) 15 cc (2) 10 cc
(3) 32 cc (4) 52 cc

52. If 1/2 mol of oxygen combine with Aluminium to form Al_2O_3 then weight of Aluminium metal used in the reaction is (Al= 27) –
(1) 27 g (2) 18 g
(3) 54 g (4) 40.5 g

53. The number of litres of air required to burn 8 litres of C_2H_2 is approximately-
(1) 40 (2) 60 (3) 80 (4) 100

54. If 0.5 mol of $BaCl_2$ is mixed with 0.2 mol of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is -
$$3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$$
(1) 0.7 (2) 0.5
(3) 0.3 (4) 0.1

55. If 8 mL of uncombined O_2 remain after exploding O_2 with 4 mL of hydrogen, the number of mL of O_2 originally were -

(1) 12 (2) 2
(3) 10 (4) 4

56. 4 g of hydrogen are ignited with 4 g of oxygen. The weight of water formed is -

(1) 0.5 g (2) 3.5 g
(3) 4.5 g (4) 2.5 g

57. For the reaction $A + 2B \longrightarrow C$,
5 mol of A and 8 mol of B will produce

(1) 5 mole of C
(2) 4 mole of C
(3) 8 mole of C
(4) 13 mole of C

58. If 1.6 g of SO_2 and 1.5×10^{22} molecules of H_2S are mixed and allowed to remain in contact in a closed vessel until the reaction

$2H_2S + SO_2 \longrightarrow 3S + 2H_2O$,

proceeds to completion. Which of the following statement is true ?

(1) Only 'S' and 'H_2O' remain in the reaction vessel.
(2) 'H_2S' will remain in excess
(3) 'SO_2' will remain in excess
(4) None

59. 12 L of H_2 and 11.2 L of Cl_2 are mixed and exploded. The composition by volume of mixture is–

(1) 24 L of HCl (g)
(2) 0.8 L Cl_2 and 20.8 L HCl (g)
(3) 0.8 L H_2 and 22.4 L HCl (g)
(4) 22.4 L HCl (g)

60. 10 mL of gaseous hydrocarbon on combustion give 40 mL of CO_2(g) and 50 mL of H_2O (vap.). The hydrocarbon is -

(1) C_4H_5 (2) C_8H_{10}
(3) C_4H_8 (4) C_4H_{10}

61. 500 mL of a gaseous hydrocarbon when burnt in excess of O_2 gave 2.5 L of CO_2 and 3.0 L of water vapours under same conditions. Molecular formula of the hydrocarbon is -

(1) C_4H_8 (2) C_4H_{10}
(3) C_5H_{10} (4) C_5H_{12}

QUESTIONS BASED ON EQUIIVALENT WEIGHTS

62. Molecular weight of tribasic acid is W. Its equivalent weight will be :

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

63. A, E, M and n are the atomic weight, equivalent weight, molecular weight and valency of an element. The correct relation is :

(1) $A = E \times n$ (2) $A = \frac{M}{E}$
(3) $A = \frac{M}{n}$ (4) $M = A \times n$

64. Sulphur forms two chlorides S_2Cl_2 and SCl_2. The equivalent mass of sulphur in SCl_2 is 16. The equivalent weight of sulphur in S_2Cl_2 is -

(1) 8 (2) 16
(3) 32 (4) 64

65. If equivalent weight of S in SO_2 is 8 then equivalent weight of S in SO_3 is -

(1) $\frac{8\times2}{3}$ (2) $\frac{8\times3}{2}$
(3) $8 \times 2 \times 3$ (4) $\frac{2\times3}{8}$

66. Which property of an element is not variable :

(1) Valency (2) Atomic weight
(3) Equivalent weight (4) None

67. One g equivalent of a substance is present in -

(1) 0.25 mol of O_2 (2) 0.5 mol of O_2
(3) 1.00 mol of O_2 (4) 8.00 mol of O_2

68. In a compound AxBy ,

(1) Mole of A = mole of B = mole of Ax By
(2) eq. of A = eq of B = eq. of AxBy
(3) yx mole of A = yx mole of B = (x + y) × mole of AxBy
(4) y × mole of A = y × mole of B

69. 0.45 g of acid (molecular wt. = 90) was exactly neutralised by 20 mL of 0.5 N NaOH. Basicity of the acid is -

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

70. 0.5 g of a base was completely neutralised by 100 mL of 0.2 N acid. Equivalent weight of the base is

(1) 50 (2) 100
(3) 25 (4) 125

71. 0.126 g of an acid requires 20 mL of 0.1 N NaOH for complete neutralisation. Equivalent weight of the acid is –

(1) 45 (2) 53 (3) 40 (4) 63

72. 2g of a base whose equivalent weight is 40 reacts with 3 g of an acid. The equivalent weight of the acid is :

(1) 40 (2) 60
(3) 10 (4) 80

73. Equivalent weight of a divalent metal is 24. The volume of hydrogen liberated at STP by 12 g of the same metal when added to excess of an acid solution is -

(1) 2.8 litres (2) 5.6 litres
(3) 11.2 litres (4) 22.4 litres

74. 0.84 g of a metal carbonate reacts exactly with 40 mL of N/2 H_2SO_4. The equivalent weight of the metal carbonate is -

(1) 84 (2) 64
(3) 42 (4) 32

75. 1.0 g of a metal combines with 8.89 g of Bromine. Equivalent weight of the metal is nearly :

(at.wt. of Br = 80)

(1) 8 (2) 9 (3) 10 (4) 7

76. H_3PO_4 is a tribasic acid and one of its salt is NaH_2PO_4. What volume of 1M NaOH solution should be added to 12 g NaH_2PO_4 to convert it into Na_3PO_4 ? (at.wt of P=31)

(1) 100 mL (2) 200 mL
(3) 80 mL (4) 300 mL

77. 0.84 g of metal hydride contains 0.04 g of hydrogen. The equivalent wt. of the metal is .....

(1) 80 (2) 40 (3) 20 (4) 60

78. A_1 g of an element give A_2 g of its oxide. The equivalent mass of the element is –

(1) $\frac{A_2 - A_1}{A_1} \times 8$ (2) $\frac{A_2 - A_1}{A_2} \times 8$

(3) $\frac{A_1}{A_2 - A_1} \times 8$ (4) $(A_2 - A_1) \times 8$

79. When an element forms an oxide in which oxygen is 20% of the oxide by mass, the equivalent mass of the element will be –

(1) 32 (2) 40 (3) 60 (4) 128

80. If 1.2 g of a metal displaces 1.12 L of hydrogen at NTP, equivalent mass of the metal would be –

(1) 1.2×11.2 (2) 12
(3) 24 (4) 1.2 + 11.2

81. 1 g of hydrogen is found to combine with 80 g of bromine. 1 g of calcium (valency = 2) combines with 4 g of bromine. The equivalent weight of calcium is –

(1) 10 (2) 20
(3) 40 (4) 80

82. 2.8 g of iron displaces 3.2 g of copper from a solution of copper suphate. If the equivalent mass of iron is 28, then equivalent mass of copper will be –

(1) 16 (2) 32
(3) 48 (4) 64

83. A metal oxide is reduced by heating it in a stream of hydrogen. It is found that after complete reduction 3.15 g of the oxide have yielded 1.05 g of the metal. We may conclude that.

(1) Atomic weight of the metal is 4
(2) Equivalent weight of the metal is 8
(3) Equivalent weight of the metal is 4
(4) Atomic weight of the metal is 8

84. If m_1 g of a metal A displaces m_2 g of another metal B from its salt solution and if their equivalent weight are E_2 and E_1 respectively then the equivalent weight of A can be expressed by:-

(1) $\frac{m_1}{m_2} \times E_2$ (2) $\frac{m_2}{m_1} \times E_2$

(3) $\frac{m_1}{m_2} \times E_1$ (4) $\frac{m_2}{m_1} \times E_1$

85. 14 g of element X combines with 16 g 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 is XO
(2) The element X could have an atomic weight of 14 and its oxide is 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

86. If 2.4 g of a metal displaces 1.12 L hydrogen at normal temperature and pressure equivalent weight of metal would be:-

(1) 12 (2) 24
(3) 1.2×11.2 (4) $1.2 \div 11.2$

87. 45 g of acid of molecular weight 90 neutralised by 200 mL of 5 N caustic potash. The basicity of the acid is :-

(1) 1 (2) 2
(3) 3 (4) None

88. The weights of two elements which combine with one another are in the ratio of their :–

(1) Atomic weight (2) Molecular weight
(3) Equivalent weight (4) None

89. The oxide of a metal has 32% oxygen. It's equivalent weight would be:-

(1) 34 (2) 32
(3) 17 (4) 16

90. 1.6 g of Ca and 2.60 g of Zn when treated with an acid in excess separately, produced the same amount of hydrogen. If the equivalent weight of Zn is 32.6, what is the equivalent weight of Ca:-

(1) 10 (2) 20 (3) 40 (4) 5

91. 74.5 g of a metallic chloride contains 35.5 g of chlorine. The equivalent mass of the metal is –

(1) 19.5 (2) 35.5
(3) 39.0 (4) 78.0

QUESTIONS BASED ON CALCULATION OF ATOMIC WEIGHTS AND MOLECULAR WEIGHTS

92. The equivalent weight of an element is 4. It's chloride has a V.D. 59.25. Then the valency of the element is –

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

93. Vapour density of metal chloride is 77. Equivalent weight of metal is 3, then its atomic weight will be-

(1) 3 (2) 6 (3) 9 (4) 12

94. Specific heat of a solid element is 0.1 Cal g^{-1} °C and its equivalent weight is 31.8. Its exact atomic weight is -

(1) 31.8 (2) 63.6 (3) 318 (4) 95.4

95. The specific heat of an element is 0.214 Cal g^{-1} °C. The approximate atomic weight is -

(1) 0.6 (2) 12 (3) 30 (4) 65

96. A metal M forms a sulphate which is isomorphous with $MgSO_4.7H_2O$. If 0.6538 g of metals M displaced 2.16 g of silver from silver nitrate solution, then the atomic weight of the metal M is

(1) 32.61 (2) 56.82 (3) 65.38 (4) 74.58

97. The carbonate of a metal is isomorphous with $MgCO_3$ and contains 6.091% of carbon. Atomic weight of the metal is nearly -

(1) 48 (2) 68.5
(3) 137 (4) 120

98. 71 g of chlorine combines with a metal giving 111 g of its chloride. The chloride is isomorphous with $MgCl_2.6H_2O$. The atomic mass of the metal is:-

(1) 20 (2) 30 (3) 40 (4) 69

99. The atomic weight of a metal (M) is 27 and its equivalent weight is 9, the formula of its chloride will be:-

(1) MCl (2) MCl_2
(3) M_3Cl (4) MCl_3

100. 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

101. The specific heat of a metal M is 0.25. Its equivalent weight is 12. What is it's correct atomic weight :–

(1) 25.6 (2) 36 (3) 24 (4) 12

102. The density of air is 0.001293 g ml^{-1}. It's vapour density is –

(1) 143 (2) 14.3 (3) 1.43 (4) 0.143

103. Relative density of a volatile substance with respect to CH_4 is 4. Its molecular weight would be –

(1) 8 (2) 32 (3) 64 (4) 128

104. Vapour density of a gas is 16. The ratio of specific heat at constant pressure to specific heat at constant volume is 1.4, then its atomic weight is -

(1) 8 (2) 16 (3) 24 (4) 32

105. The weight of substance that displaces 22.4 L air at NTP is :

(1) Mol. wt. (2) At. wt.
(3) Eq. wt. (4) All

106. 0.39 g of a liquid on vapourisation gave 112 mL of vapour at STP. Its molecular weight is -

(1) 39 (2) 18.5 (3) 78 (4) 112

107. In victor Mayer's method 0.2 g of a volatile compound on volatilisation gave 56 mL of vapour at STP. Its molecular weight is -

(1) 40 (2) 60 (3) 80 (4) 120

108. 510 mg of a liquid on vapourisation in Victor Mayer's apparatus displaces 67.2 cc of dry air (at NTP). The molecular weight of liquid is -

(1) 130 (2) 17 (3) 1700 (4) 170

109. 5 L of gas at STP weighs 6.25 g. What is its gram molecular weight ?

(1) 1.25 (2) 14 (3) 28 (4) 56

110. 0.44 g of a colourless oxide of nitrogen occupies 224 mL at STP. The compound is -

(1) N_2O (2) NO (3) N_2O_4 (4) NO_2

111. One litre of a certain gas weighs 1.16 g at STP. The gas may possibly be -

(1) C_2H_2 (2) CO (3) O_2 (4) NH_3

112. Equivalent weight of bivalent metal is 32.7. Molecular weight of its chloride is :–

(1) 68.2 (2) 103.7 (3) 136.4 (4) 166.3

113. The oxide of an element possess the molecular formula M_2O_3. If the equivalent mass of the metal is 9, the molecular mass of the oxide will be –

(1) 27 (2) 75 (3) 102 (4) 18

QUESTIONS BASED ON LAWS OF CHEMICAL COMBINATION

114. The law of multiple proportion was proposed by :

(1) Lavoisier (2) Dalton
(3) Proust (4) Gaylussac

115. Which one of the following pairs of compound illustrate the law of multiple proportions ?

(1) H_2O, Na_2O (2) MgO, Na_2O
(3) Na_2O, BaO (4) $SnCl_2$, $SnCl_4$

116. In the reaction $N_2 + 3H_2 \longrightarrow 2\,NH_3$, ratio by volume of N_2, H_2 and NH_3 is 1 : 3 : 2. This illustrates law of -

(1) Difinite proportion
(2) Multiple proportion
(3) Law of conservation of mass
(4) Gaseous volumes

117. Different proportions of oxygen in the various oxides of nitrogen prove the law of -

(1) Equivalent proportion
(2) Multiple proportion
(3) Constant proportion
(4) Conservation of matter

118. Oxygen combines with two isotopes of carbon ^{12}C and ^{14}C to form two sample of carbon dioxide. The data illustrates -

(1) Law of conservation of mass
(2) Law of multiple proportions
(3) Law of gaseous volume
(4) None of these

119. The law of conservation of mass holds good for all of the following except -

(1) All chemical reactions
(2) Nuclear reactions
(3) Endothermic reactions
(4) Exothermic reactions

120. Number of molecules in 100 mL of each of O_2, NH_3 and CO_2 at STP are –

(1) in the order $CO_2 < O_2 < NH_3$
(2) in the order $NH_3 < O_2 < CO_2$
(3) the same
(4) $NH_3 = CO_2 < O_2$

121. The empirical formula of an organic compound containing carbon and hydrogen is CH_2. The mass of one litre of this organic gas is exactly equal to that of one litre of N_2 at same temperature and pressure. Therefore, the molecular formula of the organic gas is –

(1) C_2H_4 (2) C_3H_6
(3) C_6H_{12} (4) C_4H_8

122. Four one litre flasks are seperately filled with the gases hydrogen, helium, oxygen and ozone at same room temperature and pressure. The ratio of total number of atoms of these gases present in the different flasks would be -

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

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

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

124. A and B are two identical vessels. A contains 15 g ethane at 1 atm and 298 K. The vessel B contains 75 g of a gas X_2 at same tamperature and pressure. The vapour density of X_2 is –

(1) 75 (2) 150
(3) 37.5 (4) 45

125. When 100 g of ethylene polymerizes to polyethylene according to equation

$nCH_2 = CH_2 \rightarrow$ -(- CH_2 - CH_2 -$)_n$-. The weight of polyethylene produced will be:-

(1) $\frac{n}{2}$ g (2) 100 g (3) $\frac{100}{n}$ g (4) 100n g

126. 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. Determine the weight of $BaSO_4$ produced ?

(1) 11.65 g (2) 23.3 g

(3) 25.5 g (4) 30.6 g

127. A chemical equation is balanced according to the law of –

(1) Multiple proportion

(2) Constant comosition

(3) Gaseous volume

(4) Conservation of mass

128. Two flasks A & B of equal capacity of volume contain NH_3 and SO_2 gas respectively under similar conditions. Which flask has more number of moles:-

(1) A

(2) B

(3) Both have same moles

(4) None

EXERCISE-I (Conceptual Questions) **ANSWER KEY**

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	4	4	4	3	1	3	2	2	1	3	2	2	3	1	4
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	1	3	3	4	1	1	2	3	4	3	1	3	3	1	2
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	3	1	3	4	3	1	2	2	4	4	4	2	1	2	3
Que.	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	3	2	4	3	4	2	4	4	3	3	2	3	3	4
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Ans.	4	2	1	3	1	2	1	2	2	3	4	2	2	3	2
Que.	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Ans.	2	3	3	1	2	2	2	3	3	3	2	2	3	3	2
Que.	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
Ans.	3	2	4	2	3	3	3	3	4	1	3	2	3	2	1
Que.	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	3	3	4	3	1	1	3	3	2	4	4	2	4	2	3
Que.	121	122	123	124	125	126	127	128							
Ans.	1	3	2	1	2	2	4	3							

EXERCISE-II (Previous Year Questions) AIPMT/NEET & AIIMS (2006-2018)

AIPMT 2008

1. What volume of oxygen gas (O_2) measured at 0°C and 1 atm, is needed to burn completely 1L of propane gas (C_3H_8) measured under the same conditions:-

(1) 5 L (2) 10 L
(3) 7 L (4) 6 L

2. Volume occupied by one molecule of water (density =1 gcm^{-3}) is :-

(1) 3.0×10^{-23} cm^3 (2) 5.5×10^{-23} cm^3
(3 9.0×10^{-23} cm^3 (4) 6.023×10^{-23} cm^3

3. How many moles of lead (II) chloride will be formed from a reaction between 6.5 g of PbO and 3.2 g of HCl ? (Atomic wt. of Pb=207)

(1) 0.011 (2) 0.029
(3) 0.044 (4) 0.333

4. An organic compound contains carbon, hydrogen and oxygen. Its elemental analysis gives 38.71% of C and 9.67% of H. The empirical formula of the compound would be :-

(1) CHO (2) CH_4O
(3) CH_3O (4) CH_2O

AIPMT 2009

5. 10 g of hydrogen and 64 g of oxygen were filled in a steel vessel and exploded. Amount of water produced in this reaction will be :-

(1) 1 mol (2) 2 mol
(3) 3 mol (4) 4 mol

AIPMT 2010

6. The number of atoms in 0.1 mol of a triatomic gas is :- ($N_A = 6.02 \times 10^{23}$ mol^{-1})

(1) 1.800×10^{22} (2) 6.026×10^{22}
(3) 1.806×10^{23} (4) 3.600×10^{23}

AIPMT Mains 2011

7. Which has the maximum number of molecules among the following ?

(1) 64 g SO_2 (2) 44 g CO_2
(3) 48 g O_3 (4) 8 g H_2

NEET UG 2013

8. An excess of $AgNO_3$ is added to 100 mL of a 0.01 M solution of dichlorotetraaquachromium(III) chloride. The number of moles of AgCl precipitated would be :-

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

AIPMT 2014

9. Equal masses of H_2,O_2 and methane have been taken in a container of volume V at temeprature 27°C at identical conditions. The ratio of the volumes of gases $H_2 : O_2 : CH_4$ would be :

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

10. When 22.4 L of H_2(g) is mixed with 11.2 L of Cl_2(g) at S.T.P., the moles of HCl (g) formed is equal to:-

(1) 1 mol of HCl (g)

(2) 2 mol of HCl (g)

(3) 0.5 mol of HCl (g)

(4) 1.5 mol of HCl (g)

11. 1.0 g of magnesium is burnt with 0.56 g O_2 in a closed vessel. Which reactant is left in excess and by how much ?
(At. wt. Mg = 24 ; O = 16)

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

AIPMT 2015

12. A mixture of gases contains H_2 and O_2 gases in the ratio of 1 : 4 (w/w). What is the molar ratio of the two gases in the mixture ?

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

Re-AIPMT 2015

13. The number of water molecules is maximum in :-

(1) 18 g of water

(2) 18 mol of water

(3) 18 molecules of water

(4) 1.8 g of water

14. If avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change :

(1) the ratio of chemical species to each other in a balanced equation

(2) the ratio of elements to each other in a compound

(3) the definition of mass in units of grams

(4) the mass of one mole of carbon

15. 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)

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

NEET-II 2016

16. 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

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

AIIMS 2016

17. An organic compound, on analysis, was found to contain 71.7% of chlorine, 4.04% of hydrogen and rest is carbon. If its molecular weight is 99. Then calculate molecular formula :-

(1) $CHCl_3$ (2) $C_2H_4Cl_2$
(3) $C_2H_2Cl_2$ (4) CH_3Cl

NEET(UG) 2018

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

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

19. In which case is the number of molecules of water maximum?

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

AIIMS 2018

20. Initially in a container 1 g of gas A has 4 atm pressure at constant temperature. If 2 g of gas B is added in same container at same temperature then pressure becomes 6 atm what will be the ratio of molecular weight of A and B :-

(1) $M_A = 4M_B$ (2) $M_A = 2M_B$
(3) $M_B = 2M_A$ (4) $M_B = 4M_A$

21. 2 g mixture of two divalent metals A (at wt = 30) and B (at wt = 15) on reacting with dilute HCl solution gives 2.24 L H_2 gas at NTP then composition of A (in g) :-

(1) 1 (2) 0.5 (3) 1.5 (4) 1.2

EXERCISE-II (Previous Year Questions) **ANSWER KEY**

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	1	1	2	3	4	3	4	2	3	1	1	1	2	4	2
Que.	16	17	18	19	20	21									
Ans.	3	2	3	1	4	1									

EXERCISE-III (Analytical Questions) — Check Your Understanding

1. Number of HCl molecules present in 10 mL of 0.1 M solution is :
(1) 6.022×10^{23} (2) 6.023×10^{22}
(3) 6.022×10^{21} (4) 6.022×10^{20}

2. The volume of a gas at 0°C and 700 mm pressure is 760 cc. The no. of molecules present in this volume is
(1) 1.88×10^{22} (2) 6.022×10^{23}
(3) 18.8×10^{23} (4) 18.8×10^{22}

3. Rearrange the following (I to IV) in the order of increasing masses and choose the correct answer. (Atomic masses : N = 14, O = 16, Cu = 63)
I 1 molecule of oxygen
II 1 atom of Nitrogen
III $1 \times 10^{-10} \times$(g molecular weight of oxygen)
IV $1 \times 10^{-10} \times$(g atomic weight of copper)
(1) II < I < III < IV (2) IV < III < II < I
(3) II < III < I < IV (4) III < IV < I < II

4. The number of moles of carbon dioxide which contain 8 g of oxygen is –
(1) 0.5 mole (2) 0.20 mole
(3) 0.40 mole (4) 0.25 mole

5. 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) 2.08×10^{-23} g
(3) 5.53×10^{-23} g (4) 6.24×10^{-23} g

6. The maximum number of molecules are present in
(1) 5 L of N_2 gas at STP
(2) 0·5 g of H_2 gas
(3) 10 g of O_2 gas
(4) 15 L of H_2 gas at STP

7. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mol of oxygen atoms?
(1) 2.5×10^{-2} (2) 0.02
(3) 3.125×10^{-2} (4) 1.25×10^{-2}

8. The mass of carbon anode consumed (giving only carbondioxide) in the production of 270 Kg of aluminium metal from bauxite by the Hall's process is : $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$
(1) 180 kg (2) 270 kg
(3) 240 kg (4) 90 kg

9. 22.4 L of water vapour at NTP, When condensed to water occupies an approximate volume of -
(1) 18 L (2) 1 L
(3) 1 mL (4) 18 mL

10. 0.01 mol of iodoform (CHI_3) reacts with Ag to produce a gas whose volume at NTP is

$$2CHI_3 + 6Ag \rightarrow C_2H_2 + 6AgI(s)$$

(1) 224 mL (2) 112 mL
(3) 336 mL (4) None of these

11. The minimum quantity in grams of H_2S needed to precipitate 63.5 g of Cu^{2+} will be nearly :

$$Cu^{+2} + H_2S \rightarrow CuS + H_2$$

(1) 63.5 g (2) 31.75 g
(3) 34 g (4) 20 g

12. 2.76 g of silver carbonate on being strongly heated yields a residue weighing –

$$Ag_2CO_3 \rightarrow 2Ag + CO_2 + \tfrac{1}{2} O_2$$

(1) 2.16 g (2) 2.48 g
(3) 2.32 g (4) 2.64 g

13. The volume of gas at NTP produced by 100 g of CaC_2 with water is :-

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

(1) 70 L (2) 35 L
(3) 17.5 L (4) 22.4 L

14. 90 mL of pure dry O_2 is subjected to silent electric discharge. If only 10% of it is converted to O_3, volume of the mixture of gases (O_2 and O_3) after the reaction will be ------ and after passing through turpentine oil will be ....
(1) 84 mL and 78 mL (2) 81 mL and 87 mL
(3) 78 mL and 84 mL (4) 87 mL and 81 mL

15. Element 'A' reacts with oxygen to form a compound A_2O_3. If 0.359 g of 'A' reacts to give 0.559 g of the compound, then atomic weight of 'A' will be :–
(1) 51 (2) 43.08
(3) 49.7 (4) 47.9

16. 1.12 mL of a gas is produced at STP by the action of 4.12 mg of alcohol ROH with methyl magnesium iodide. The molecular mass of alcohol is –

$$R-OH + CH_3MgI \rightarrow CH_4 + Mg(OR)I$$

(1) 16 (2) 41.2
(3) 82.4 (4) 156.0

17. $CaCO_3$ is 90% pure. Volume of CO_2 collected at STP when 10 g of $CaCO_3$ is decomposed is -
(1) 2.016 L (2) 1.008 L
(3) 10.08 L (4) 20.16 L

18. 50 g $CaCO_3$ will react with ...... g of 20% HCl by weight .
(1) 36.5 g (2) 73 g
(3) 109.5 g (4) 182.5 g

19. Two oxides of a metal contains 50% and 40% of the metal respectively. The formula of the first oxide is MO.Then the formula of the second oxide is
(1) MO_2 (2) M_2O_3
(3) M_2O (4) M_2O_5

20. A gas mixture of 3 L of propane and butane on complete combustion at 25°C produces 10 L of CO_2. Initial composition of the propane & butane in the gas mixture is –
(1) 66.67%, 33.33% (2) 33.33%, 66.67%
(3) 50%, 50% (4) 60%, 40%

21. The atomic mass of an element is 27. If valency is 3, the vapour density of the volatile chloride will be:-
(1) 66.75 (2) 6.675 (3) 667.5 (4) 81

22. 1 L of a hydrocarbon weighs as much as 1 Lof CO_2 under similar conditions. Then the molecular formula of the hydrocarbon is -
(1) C_3H_8 (2) C_2H_6
(3) C_2H_4 (4) C_3H_6

23. There are two oxides of sulphur. They contain 50% and 60% of oxygen respectively by weight. The weight of sulphur which combine with 1 g of oxygen is in the ratio of -
(1) 1 : 1 (2) 2 : 1
(3) 2 : 3 (4) 3 : 2

24. A litre of air containing 1% Ar is repeatedly passed over hot Cu and hot Mg till no reduction of volume takes place. The final volume of Ar shall be :
(1) 0 mL (2) 230 mL
(3) 770 mL (4) 10 mL

25. An organic compound having molecular mass 60 is found to contain 20% of C, 6.67% of H and 46.67% of H while rest is oxygen. On heating it gives NH_3 along with a solid residue. The solid residue gives violet colour with alkaline copper sulphate solution. The compound is -
(1) $(NH_2)_2CO$ (2) $CH_3CH_2CONH_2$
(3) CH_3NCO (4) CH_3CONH_2

26. Perecentage composition of an organic compound is as follows :
C=10.06, H=0.84 , Cl=89.10
Which of the following corresponds to its molecular formula if the vapour density is 60.0
(1) $CH_2\ Cl_2$ (2) $CHCl_3$
(3) CH_3Cl (4) None

27. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of molecules is :
(1) 1 : 8 (2) 3 : 16
(3) 1 : 4 (4) 7 : 32

28. A gaseous hydrocarbon on combustion gives 0.72 g of water and 3.08 g of CO_2. The empirical formula of the hydrocarbon is
(1) C_2H_4 (2) C_3H_4
(3) C_6H_6 (4) C_7H_8

EXERCISE-III (Analytical Questions) **ANSWER KEY**

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	4	1	1	4	3	4	3	4	4	2	3	1	2	4	2
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28		
Ans.	3	1	4	2	1	1	1	4	4	1	2	4	4		

EXERCISE-IV (Assertion & Reason) Target AIIMS

Directions for Assertion & Reason questions

These questions consist of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.

(B) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(C) If Assertion is True but the Reason is False.

(D) If both Assertion & Reason are false.

1. ***Assertion :–*** 16 g each of O_2 and O_3 contains $\frac{N_A}{2}$ and $\frac{N_A}{3}$ atoms respectively
Reason :– 16 g O_2 and O_3 contains same no. of molecules.
(1) A (2) B (3) C (4) D

2. ***Assertion :–*** Volume occupied by 1 mol $H_2O_{(l)}$ is equal to 22400 cc at NTP.
Reason :– 1 mol of any substance occupies 22.4 L volume at N.T.P.
(1) A (2) B (3) C (4) D

3. ***Assertion :–*** 44 g of CO_2 28 g of CO have same volume at STP.
Reason :– Both CO_2 and CO are formed by C and oxygen.
(1) A (2) B (3) C (4) D

4. ***Assertion :–*** Equivalent wt. of Cu in both CuO and Cu_2O is different.
Reason :– Equavalent wt. of an element is constant.
(1) A (2) B (3) C (4) D

5. ***Assertion :–*** On compressing a gas to half the volume, the number of moles is halved.
Reason :– Number of moles decreases with decrease in volume.
(1) A (2) B (3) C (4) D

6. ***Assertion :–*** The amount of the products formed in a reaction depends upon the limiting reactant.
Reason :– Limiting reactant reacts completely in the reaction.
(1) A (2) B (3) C (4) D

7. ***Assertion :–*** Carbon and oxygen combined together only in one fixed ratio.
Reason :– In a chemical compound the elements are combined together in a fixed ratio.
(1) A (2) B (3) C (4) D

8. ***Assertion :–*** At same temp & pressure 1 L O_2 and 1 L SO_2 contains equal no. of molecules.
Reason :– According to Avogadro's hypothesis equal volume of all gases under similar condition of temperature and pressure contains equal number of molecules.
(1) A (2) B (3) C (4) D

9. ***Assertion :–*** Law of conservation of mass holds good for nuclear reaction.
Reason :– Law states that mass can be neither created nor destroyed in a chemical reaction.
(1) A (2) B (3) C (4) D

10. ***Assertion :–*** The balancing of chemical equations is based on law of conservation of mass.
Reason :– Total mass of reactants is equal to total mass of products in a chemical reaction.
(1) A (2) B (3) C (4) D

11. ***Assertion :–*** Pure water obtained from different sources such as river, well, spring, sea etc. always contains hydrogen and oxygen combined in the ratio of 1 : 8 by mass
Reason :– A chemical compound always contains elements combined together in same proportion by mass.
(1) A (2) B (3) C (4) D

EXERCISE-IV (Assertion & Reason) ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11
Ans.	4	4	2	3	4	1	4	1	4	1	1