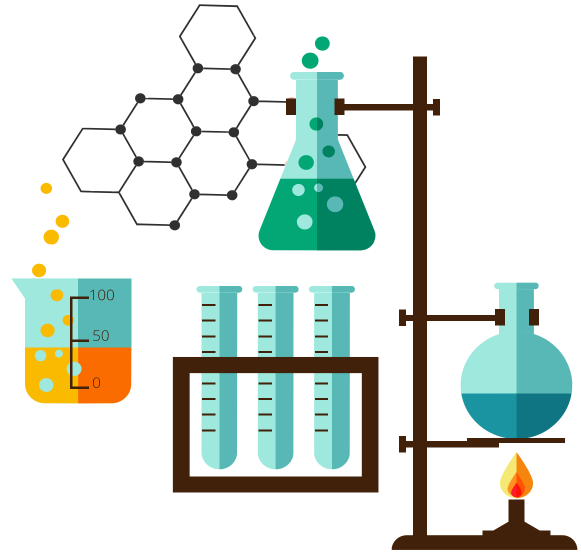
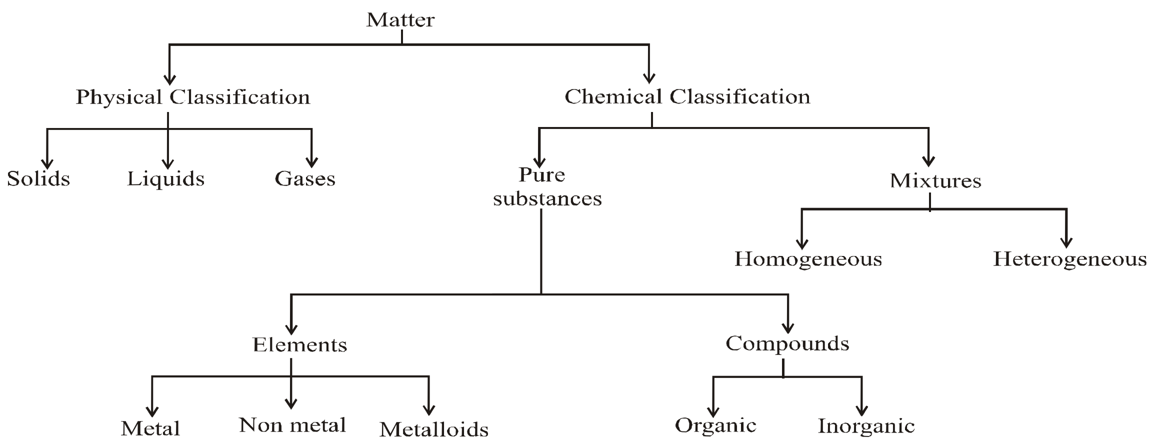
01



Some Basic Concepts of Chemistry

Classification of Matter



Laws of Chemical Combination

Law of conservation of mass [Lavoisier]

In a chemical change total mass remains conserved i.e. mass before the reaction is always equal to mass after the reaction.

H_2 (g) + 1/2 O_2 (g) $\rightarrow$ $H_2O\,(\ell)$

1 mole   1/2 mole   1 mole

mass before the reaction = 1 × 2 + 1/2 × 32 = 18 gm

mass after the reaction = 1 × 18 = 18 gm

SOLVED EXAMPLE

EXAMPLE 1

A 15.9g sample of sodium carbonate is added to a solution of acetic acid weighing 20.0g. The two substances react, releasing carbon dioxide gas to the atmosphere. After reaction, the contents of the reaction vessel weigh 29.3g. What is the mass of carbon dioxide given off during the reaction?

Sol. The total mass of reactants taken = 15.9 + 20.0 = 35.9 gm. From the conservation of mass, the final mass of the contents of the vessel should also be 35.9 gm. But it is only 29.3 gm. The difference is due to the mass of released carbon dioxide gas.

Hence, the mass of carbon dioxide gas released

= 35.9 – 29.3 = **6.6 gm**

Law of constant composition [Proust]

All chemical compounds are found to have constant composition irrespective of their method of prepration or sources.

In H_2O, Hydrogen & oxygen combine in 2 : 1 molar ratio, this ratio remains constant whether it is Tap water, river water or seawater or produced by any chemical reaction.

EXAMPLE 2

The following are results of analysis of two samples of the same or two different compounds of phosphorus and chlorine. From these results, decide whether the two samples are from the same or different compounds. Also state the law, which will be obeyed by the given samples.

	Compound A	Compound B
Amount P →	1.542 gm	1.156 gm
Amount Cl →	5.297 gm	3.971 gm

Sol. The mass ratio of phosphorus and chlorine in compound A, $m_P : m_{Cl} = 1.156 : 3.971 = 0.2911 : 1.000$

The mass ratio of phosphorus and chlorine in compound B, $m_P : m_{Cl} = 1.542 : 5.297 = 0.2911 : 1.000$

As the mass ratio is same, both the compounds are **same** and the samples obey the **law of definite proportion.**

Law of multiple proportions [Dalton]

When one element combines with the other element to form two or more different compounds, the mass of one element, which combines with a constant mass of the other bear a simple ratio to one another.

⇒ Carbon is found to form two oxides which contain 42.9% & 27.3% of carbon respectively show that these figures shows the law of multiple proportion.

	First oxide	Second oxide
Carbon	42.9 %	27.3 %
Oxygen	57.1 %	72.7%

Given

In th first oxide, 57.1 parts by mass of oxygen combine with 42.9 parts of carbon.

1 part of oxygen will combine with $\frac{42.9}{57.1}$ part of carbon $= 0.751$

Similarly in 2nd oxide

1 part of oxygen will combine with $\frac{27.3}{72.7}$ part of carbon $= 0.376$

The ratio of carbon that combine with the same mass of oxygen $= 0.751 : 0.376 = 2 : 1$

This is a simple whole no ratio this means above data shows the law of multiple proportion.

EXAMPLE 3

2.5 ml of a gaseous hydrocarbon exactly requires 12.5 ml oxygen for complete combustion and produces 7.5 ml carbon dioxide and 10.0 ml water vapour. All the volumes are measured at the same pressure and temperature. Show that the data illustrates Gay Lussac's law of volume combination.

Sol. $V_{\text{hydrocarbon}} : V_{\text{oxygen}} : V_{\text{carbon dioxide}} : V_{\text{water vapour}}$

$= 2.5 : 12.5 : 7.5 : 10.0 =$ **1 : 5 : 3 : 4 (simple ratio)**

Hence, the data is according to the **law of volume combination.**

Gay-Lussac's Law of Combining Volume :

According to him elements combine in a simple ratio of atoms, gases combine in a simple ratio of their volumes provided all measurements should be done at the same temperature and pressure

$$\underset{1\text{ vol}}{H_2(g)} + \underset{1\text{ vol}}{Cl_2(g)} \longrightarrow \underset{2\text{ vol}}{2HCl}$$

Avogadro's Hypothesis :

Equal volume of all gases have equal number of molecules (not atoms) at same temperature and pressure condition.

S.T.P.
P - 1 bar
T - 273.15 K
V - 22.7 L mol^{-1}

N.T.P. (Normal Temperature and Pressure)

At N.T.P. condition :

temperature = 0°C or 273 K, pressure = 1 atm = 760 mm of Hg and volume of one mole of gas at NTP is found to be experimentally equal to 22.4 litres which is known as molar volume.

Note :

Measuring the volume is equivalent to counting the number of molecules of the gas.

Basic Definitions :

Relative atomic mass :

One of the most important concept come out from Dalton's atomic theory was that of relative atomic mass or relative atomic weight. This is done by expressing mass of one atom with respect to a fixed standard. Dalton used hydrogen as the standard (H = 1). Later on oxygen (O = 16) replaced hydrogen as the reference. Therefore relative atomic mass is given as

On hydrogen scale :

Relative atomic mass (R.A.M)

$$= \frac{\text{Mass of one atom of an element}}{\text{mass of one hydrogen atom}}$$

On oxygen scale :

Relative atomic mass (R.A.M)

$$= \frac{\text{Mass of one atom of an element}}{\frac{1}{16} \times \text{mass of one oxygen atom}}$$

- The present standard unit which was adopted internationally in 1961, is based on the mass of one carbon-12 atom.

Relative atomic mass (R.A.M)

$$= \frac{\text{Mass of one atom of an element}}{\frac{1}{12} \times \text{mass of one C} - 12 \text{ atom}}$$

Atomic mass unit (or amu) :

The atomic mass unit (amu) is equal to $\left(\frac{1}{12}\right)^{th}$ mass of one atom of carbon-12 isotope.

$\therefore$ 1 amu = $\frac{1}{12}$ × mass of one C-12 atom

$\simeq$ mass of one nucleon in C-12 atom.

= 1.66×10^{-24} gm or 1.66×10^{-27} kg

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

Atomic & molecular mass :

It is the mass of 1 atom of a substance it is expressed in amu.

- Atomic mass = R.A.M × 1 amu

Relative molecular mass

$$= \frac{\text{mass of one molecule of the substance}}{\frac{1}{12} \times \text{mass of one} - \text{C-12 atom}}$$

- Molecular mass = Relative molecular mass × 1 amu

> **Note :**
> Relative atomic mass is nothing but the number of nucleons present in the atom.

SOLVED EXAMPLE

EXAMPLE 4

Calculate mass of one atom of nitrogen in gram.

Sol. Mass of 6.022×10^{23} atoms of nitrogen = gram atomic mass of nitrogen = 14 g

Mass of 1 atom = GAM/N_A

Mass of 1 atom of nitrogen = $\frac{14g}{6.022 \times 10^{23}}$

$= 2.32 \times 10^{-23}$ g

EXAMPLE 5

Find the relative atomic mass of 'O' atom and its atomic mass.

Sol. The number of nucleons present in 'O' atom is 16.

$\therefore$ relative atomic mass of 'O' atom = 16.

Atomic mass = R.A.M × 1 amu = 16 × 1 amu = 16 amu

MOLE CONCEPT

Mole

Mole is a chemical counting SI unit and defined as follows :

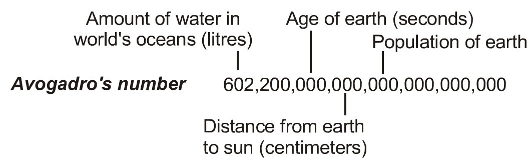
A mole is the amount of a substance that contains as many entities (atoms, molecules or other particles) as there are atoms in exactly 0.012 kg (or 12 gm) of the carbon-12 isotope.

From mass spectrometer we found that there are 6.023×10^{23} atoms present in 12 gm of C-12 isotope.

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

i.e. on the whole we can say that 1 mole is the collection of 6.02×10^{23} entities. Here entities may represent atoms, ions, molecules or even pens, chair, paper etc also include in this but as this number (N_A) is very large therefore it is used only for very small things.

How big is a mole ?



> **Note :**
> **In modern practice gram-atom and gram-molecule are termed as mole.**

Gram Atomic Mass :

The atomic mass of an element expressed in gram is called gram atomic mass of the element.

or

It is also defined as mass of 6.02×10^{23} atoms.

or

It is also defined as the mass of one mole atoms.

For example for oxygen atom :

Atomic mass of 'O' atom = mass of one 'O' atom = 16 amu

gram atomic mass = mass of 6.02×10^{23} 'O' atoms = 16 amu × 6.02×10^{23}

= $16 \times 1.66 \times 10^{-24}$ g × 6.02×10^{23} = 16 g

($\because 1.66 \times 10^{-24} \times 6.02 \times 10^{23} \simeq 1$)

SOLVED EXAMPLE

EXAMPLE 6

(a) What is the mass of one atom of Cl?

(b) What is the atomic mass of Cl?

(c) What is the gram atomic mass of Cl?

Sol. (a) Mass of one atom of Cl = 17 amu.

(b) Atomic mass of Cl = $\frac{\text{Mass of an atom in amu}}{1\text{amu}}$

$= \frac{17\text{amu}}{1\text{amu}} = 17.$

(c) Gram atomic mass of Cl

= [Mass of 1 Cl atom × N_A]

= 17 amu × N_A = $\frac{17}{N_A} \times N_A$ gram = 17 gram

EXAMPLE 7

(a) What is the mass of one atom of He ?
(b) What is the atomic mass of He ?
(c) What is the gram atomic mass of He ?

Sol. (a) Mass of one atom of He = 4 amu.
(b) Atomic mass of He

$$= \frac{\text{Mass of an atom in amu}}{1\text{amu}} = \frac{4\text{amu}}{1\text{amu}} = 4.$$

(c) Gram atomic mass of He
= [Mass of 1 He atom × N_A]

$$= 4 \text{ amu} \times N_A = \frac{4}{N_A} \times N_A \text{ gram} = 4 \text{ gram}$$

EXAMPLE 8

Total number of atoms of all elements present in 1 mole of ammonium dichromate is ?

(1) 14 (2) 19
(3) 6×10^{23} (4) 114×10^{23}

Ans. **(4)**

Sol. $(NH_4)_2Cr_2O_7 = 19 \times 6.02 \times 10^{23} = 114 \times 10^{23}$ atoms

EXAMPLE 9

Calculate the actual mass of a water molecule in gram.

Sol. Molecular mass of H_2O = 18 amu
Weight of 6.022×10^{23} molecules of water = 18 g

$$\text{Weight of one molecule} = \frac{18}{6.022 \times 10^{23}}$$

$= 2.99 \times 10^{-23}$ g

EXAMPLE 10

How many atoms of oxygen are their in 16 g oxygen.

Sol. Let x atoms of oxygen are present
So, $16 \times 1.66 \times 10^{-24} \times x = 16$ g

$$x = \frac{1}{1.66 \times 10^{-24}} = N_A$$

Gram molecular mass :
The molecular mass of a substance expressed in gram is called the gram-molecular mass of the substance.

or

It is also defined as mass of 6.02×10^{23} molecules

or

It is also defined as the mass of one mole molecules.

For example for 'O_2' molecule :
Molecular mass of 'O_2' molecule
= mass of one 'O_2' molecule
= 2 × mass of one 'O' atom
= 2 × 16 amu
= 32 amu
gram molecular mass = mass of 6.02×10^{23} 'O_2' molecules
= 32 amu × 6.02×10^{23}
= $32 \times 1.66 \times 10^{-24}$ gm × 6.02×10^{23} = 32 gm

Methods of Calculations of Mole

(a) If no. of some species is given, then no. of moles

$$= \frac{\text{Given no.}}{N_A}$$

(b) If weight of a given species is given, then no of

$$\text{moles} = \frac{\text{Given wt}}{\text{Atomic wt.}} \text{(for atoms)},$$

$$\text{or} = \frac{\text{Given wt.}}{\text{Molecular wt.}} \text{(for molecules)}$$ Total number of atoms of all elements present in 1

(c) If volume of a gas is given along with its temperature (T) and pressure (P) use $n = \frac{PV}{RT}$

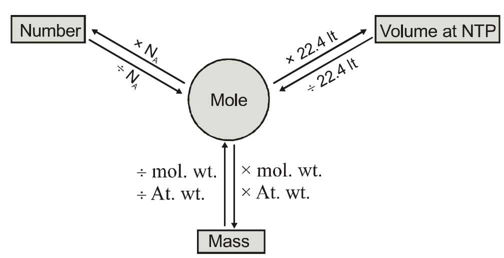
where R = 0.0821 lit-atm/mol–K (when P is in atmosphere and V is in litre.)

1 mole of any gas at NTP (0°C & 1 bar) occupies 22.7 litre.

1 mole of any gas at NTP (0°C & 1 atm) occupies 22.4 litre.

Atom : Atom is smallest particle which can not be divided into its constituents.

Y-map : Interconversion of mole - volume, mass and number of particles :



Note : Measuring the volume is equivalent to counting the number of molecules of the gas.

EXAMPLE 11

The number of atoms contained in 11.2 L of SO_2 at N.T.P. are -

(1) $3/2 \times 6.02 \times 10^{23}$ (2) $2 \times 6.02 \times 10^{23}$
(3) 6.02×10^{23} (4) $4 \times 6.02 \times 10^{23}$

Ans. **(1)**

Sol. 22.4 litre gas has = 1 mole

$$1 \text{ litre gas has} = \frac{1}{22.4} \times 11.2 = \frac{1}{2} \text{ mole}$$

= S + 2O = 3

$$= \frac{3}{2} \times 6.02 \times 10^{23}$$

Elemental Analysis

For n mole of a compound ($C_3H_7O_2$)

Moles of C = 3n

Moles of H = 7n

Moles of O = 2n

SOLVED EXAMPLE

EXAMPLE 12

How many molecules of water are present in 9 gram of water?

Sol. $\frac{9}{18}\times 6.023\times 10^{23}$

$=3.011\times 10^{23}$

Percentage Formula Composition :

% of element in compound

$$=\frac{\text{atomic weight of element}\times\text{number of atom}\times 100}{\text{total molecular weight of compound}}$$

Here we are going to find out the percentage of each element in the compound by knowing the molecular formula of compound.

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

SOLVED EXAMPLE

EXAMPLE 13

Every molecule of ammonia always has formula NH_3 irrespective of method of preparation or sources. i.e. 1 mole of ammonia always contains 1 mol of N and 3 mole of H. In other words 17 gm of NH_3 always contains 14 gm of N and 3 gm of H. Now find out % of each element in the compound.

Sol **Mass % of N in NH_3** =

$$\frac{\text{Mass of N in 1 mol } NH_3}{\text{Mass of 1 mol of } NH_3}\times 100=\frac{14\text{ gm}}{17}\times 100$$

$$= 82.35\ \%$$

Mass % of H in NH_3

$$=\frac{\text{Mass of H is 1 mol } NH_3}{\text{Mass of 1 mole of } NH_3}\times 100$$

$$=\frac{3}{17}\times 100=17.65\ \%$$

Density :

(a) Absolute density

(b) Relative density

$$\text{Absolute density}=\frac{\text{Mass}}{\text{volume}}$$

$$\text{Relative density}=\frac{\text{density of substance}}{\text{density of standard substance}}$$

$$\text{Specific gravity}=\frac{\text{density of substance}}{\text{density of } H_2O \text{ at } 4°C}$$

Vapour density : It is defined only for gas.

It is a density of gas with respect to H_2 gas at same temperature & pressure

$$V.D=\frac{d\text{ gas}}{d_{H_2}}=\frac{PM_{gas}/RT}{PM_{H_2}/RT}$$

$$=\frac{M_{gas}}{M_{H_2}}=\frac{M}{2}$$

$$V.D=\frac{M}{2}$$

SOLVED EXAMPLE

EXAMPLE 14

What is the V.D. of SO_2 with respect to CH_4

Sol $V.D.=\frac{M.W.\ SO_2}{M.W.\ CH_4}$

$=\frac{64}{16}=4$ **Ans.**

EXAMPLE 15

7.5 litre of the particular gas at S.T.P. weighs 16 gram. What is the V.D. of gas

Sol 7.5 litre = 16 gram

$$\text{moles}=\frac{7.5}{22.4}=\frac{16}{M}$$

M = 48 gram

$$V.D=\frac{48}{2}=24$$

DPP-1

Q.1 Which one of the following pairs of compounds illustrate the law of multiple proportions ?

(1) H_2O, Na_2O (2) MgO, Na_2O

(3) Na_2O, BaO (4) $SnCl_2, SnCl_4$

Q.2 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 reciprocal proportions

(4) None of these

Q.3 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

Q.4 A container of volume V, contains 0.28 gm of N_2 gas. If same volume of an unknown gas under similar condition of temperature and pressure weighs, 0.44 gm, the molecular mass of the gas is

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

Q.5 A sample of pure carbon dioxide, irrespective of its source contains 27.27% carbon and 72.73% oxygen. The data support

(1) Law of constant composition

(2) Law of conservation of mass

(3) Law of reciprocal proportions

(4) Law of multiple proportions

Q.6 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) $\frac{n}{2}$ gm (2) 100 gm

(3) $\frac{100}{n}$ gm (4) 100ngm

Q.7 The law of definite proportions is not applicable to nitrogen oxide because

(1) Nitrogen atomic weight is not constant

(2) Nitrogen molecular weight is variable

(3) Nitrogen equivalent weight is variable

(4) Oxygen atomic weight is variable

Q.8 The actual weight of a molecule of water is -

(1) 18 gm

(2) 2.99×10^{-23} gm

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

(4) None of these

Q.9 Sum of number of protons, electrons and neutrons in 12gm of $^{12}_{6}C$ is :-

(1) 1.8 (2) 12.044×10^{23}

(3) 1.084×10^{25} (4) 10.84×10^{23}

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

(1) 10 gm molecules

(2) 5 gm molecules

(3) 1 gm molecules

(4) 0.5 gm molecules

Q.11 Two flask A & B of equal capacity of volume contain NH_3 and SO_2 gas respectively under similar conditions which flask has more no. of moles –

(1) A

(2) b

(3) Both have same moles

(4) None

Q.12 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}

Q.13 22.4 litre of water vapour at NTP, When condensed to water occupies an approximate volume of -

(1) 18 litre (2) 1 litre

(3) 1 ml (4) 18 ml

Q.14 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) $3.0 \times 6.02 \times 10^{19}$

(4) $3.0 \times 6.02 \times 10^{18}$

Q.15 One gm equivalent of a substance is present in -

(1) 0.25 mole of O_2

(2) 0.5 mole of O_2

(3) 1.00 mole of O_2

(4) 8.00 mole of O_2

Empirical and Molecular Formula :

We have just seen that knowing the molecular formula of the compound we can calculate percentage composition of the elements. Conversely if we know the percentage composition of the elements initially, we can calculate the relative number of atoms of each element in the molecules of the compound. This gives us the empirical formula of the compound. Further if the molecular mass is known then the molecular formula can easily be determined.

The empirical formula of a compound is a chemical formula showing the relative number of atoms in the simplest ratio. An empirical formula represents the simplest whole number ratio of various atoms present in a compound.

The molecular formula gives the actual number of atoms of each element in a molecule. The molecular formula shows the exact number of different types of atoms present in a molecule of a compound.

The molecular formula is an integral multiple of the empirical formula.

i.e. molecular formula = empirical formula × n

$$\text{where } n = \frac{\text{molecular formula mass}}{\text{empirical formula mass}}$$

SOLVED EXAMPLE

EXAMPLE 16

Acetylene and benzene both have the empirical formula CH. The molecular masses of acetylene and benzene are 26 and 78 respectively. Deduce their molecular formulae.

Sol. ∵ Empirical Formula is CH

Step-1 The empirical formula of the compound is CH

∴ Empirical formula mass = (1 × 12) + 1 = 13.

Molecular mass = 26

Step-2 To calculate the value of 'n'

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{26}{13} = 2$$

Step-3 To calculate the molecular formula of the Compound.

Molecular formula = n × (Empirical formula of the compound)

$= 2 \times CH = C_2H_2$

Thus the molecular formula is $\mathbf{C_2H_2}$

Similarly for benzene

To calculate the value of 'n'

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{78}{13} = 6$$

thus the molecular formula is 6 × CH = $\mathbf{C_6H_6}$

EXAMPLE 17

An organic substance containing carbon, hydrogen and oxygen gave the following percentage composition.

C = 40.684% ; H = 5.085% and O = 54.228%

The molecular weight of the compound is 118. Calculate the molecular formula of the compound.

Sol. **Step-1**

To calculate the empirical formula of the compound.

Element	Symbol	Percentage of element	At. mass of element	Relative no. of atoms = $\frac{\text{Percentage}}{\text{At. mass}}$	Simplest atomic ratio	Simplest whole no. atomic ratio
Carbon	C	40.687	12	$\frac{40.687}{12} = 3.390$	$\frac{3.390}{3.389} = 1$	2
Hydrogen	H	5.085	1	$\frac{5.085}{1} = 5.085$	$\frac{5.085}{3.389} = 1.5$	3
Oxygen	O	54.228	16	$\frac{54.228}{16} = 3.389$	$\frac{3.389}{3.389} = 1$	2

∴ Empirical Formula is $C_2H_3O_2$

Step-2 To calculate the empirical formula mass.

The empirical formula of the compound is $C_2H_3O_2$.

Step-3 To calculate the value of 'n'

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{118}{59} = 2$$

Step-4 To calculate the molecular formula of the salt.

Molecular formula = n × (Empirical formula)

$= 2 \times C_2H_3O_2 = C_4H_6O_4$

Thus the molecular formula is $C_4H_6O_4$.

Chemical Reaction :

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

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 alongwith the quantitative information conveyed by it is given below:

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

1Mole 2Mole 1Mole 1Mole 1Mole

40 + 12 + 3 × 16 2(1 + 35.5) 40 + 2 × 35.5

2 × 1 + 16 12 + 2 × 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.

Stoichiometry

$N_2 + 3H_2 \rightarrow 2NH_3$

1 mole + 3 mole $\rightarrow$ 2 mole

22.4 litre + 3 × 22.4 litre $\rightarrow$ 2 × 22.4 litre (at STP)

1 litre + 3 litre $\rightarrow$ 2 litre

1000 mL + 3000 mL $\rightarrow$ 2000 mL

1 mL + 3 mL $\rightarrow$ 2 mL

28 gm + 6 gm $\rightarrow$ 34 g

(According to the law of conservation of mass)

Gram can not be represented by 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 different types :-

(a) 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.

(b) 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.

(c) 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.

The general method of 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)

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

$C_2H_6 + \frac{7}{2} O_2 \longrightarrow 2CO_2 + 3H_2O$

Type I : Involving Mass-Mass Relationship

SOLVED EXAMPLE

EXAMPLE 18

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

Sol. Writing the equation for the reaction

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 with 1 mol of NaCl

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

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

$\Rightarrow$ Weight = 0.1 × 143.5 g = 14.35 g.

Type II : Mass - Volume Relationship

EXAMPLE 19

At 25°C for complete combustion of 5 mol propane (C_3H_8). The required volume of O_2 at STP will be.

Sol. For C_3H_8, the combustion reaction is

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

5 mol

Required moles of O_2 = 5 × 5 = 25 mol

volume of O_2 gas at STP (V) = 25 × 22.4 = 560 litre

Limiting Reagent (L.R.) Concept

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

Ex 1 2 1 2 ← Stoichiometry

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

given 3 mol 9mol

3 – 3 = 0 mol 9 – 6 = 3 mol 3 mol 6 mol

L.R. = A

Formula for checking L.R. =

$$\frac{\text{given value (may moles, volume, or molecules)}}{\text{Stoichiometry Coefficient}}$$

Least value indicate the L.R.

Ex. A B

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

3 < 4.5 So A is L.R.

Identification : More than 1 initial quantites of reactants are given

SOLVED EXAMPLE

EXAMPLE 20

$A + 5B \rightarrow C + 3D$ In this reaction which is a L.R.

Given 10 mol 10 mol

Sol. For A For B

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

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

EXAMPLE 21

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

Given 4 g 32 g

Sol. 1 $\frac{1}{2}$ 1

$H_{2(g)} + \frac{1}{2} O_{2(g)} \longrightarrow H_2O_{(g)}$

4 g 32 g

For H_2 For O_2

$n = \frac{4}{2} = 2\text{mol}$ $n = \frac{32}{32} = 1\text{mol}$

$\frac{2}{1} = 2$ $\frac{1}{\frac{1}{2}} = 2\text{ mol}$

Moles of $H_2O_{(g)}$ = 2 mol

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

EXAMPLE 22

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.

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

Given 100mL 100mL

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

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

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

According to stoichiometry from 3 mL of H_2 produced 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

Percentage Yield :

The percentage yield of product =

$$\frac{\text{actual yield}}{\text{the theoretical maximum yield}} \times 100$$

- The actual amount of any limiting reagent consumed in such incomplete reactions is given by [% yield × given moles of limiting reagent] [For reversible reactions]
- For irreversible reaction with % yield less than 100, the reactants is converted to product (desired and waste.)

SOLVED EXAMPLE

EXAMPLE 23

For the reaction

$CaO + 2HCl \rightarrow CaCl_2 + H_2O$

1.23 gram of CaO is reacted with excess of hydrochloric acid and 1.85 gm $CaCl_2$ is formed. What is the % yield of the reaction?

Sol. $CaO + 2HCl \rightarrow CaCl_2 + H_2O$

56 gm CaO will produce 111 gm $CaCl_2$

$\Rightarrow$ 1.23 gram of CaO will produce :

$\frac{111}{56} \times 1.23 = 2.43$ gm $CaCl_2$

Thus Theoretical yield = 2.43 gm

Actual yield = 1.85 gm

$\% \text{ yield} = \frac{1.85}{2.43} \times 100 = 76\%$

Percent Purity

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

% purity =

$$\left[\frac{\text{Amount of reactant calculated from the chemical equation}}{\text{Actual amount of reactant taken}}\right] \times 100$$

DPP-2

Q.1 Emperical formula of glucose is -
(1) $C_6H_{12}O_6$ (2) $C_3H_6O_3$
(3) $C_2H_4O_2$ (4) CH_2O

Q.2 A compound is found to contain 80% of carbon and 20% of hydrogen, then the molecular formula of the compound is-
(1) C_6H_6 (2) C_2H_5OH
(3) C_2H_6 (4) C_2H_4

Q.3 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) None of these

Q.4 Assuming that petrol is octane (C_8H_{18}) and has density 0.8 g/ml, 1.425 litre 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 of O_2

Q.5 A compound (60 *g*) on analysis gave $C = 24$ g, $H = 4$ *g*, $O = 32$ *g*. Its empirical formula is
(1) $C_2H_2O_2$ (2) C_2H_2O
(3) CH_2O_2 (4) CH_2O

Q.6 The simplest formula of a compound containing 50% of element X (atomic mass 10) and 50% of element *Y* (atomic mass 20) is
(1) XY (2) X_2Y (3) XY_3 (4) X_2Y_3

Q.7 What is the concentration of nitrate ions if equal volumes of 0.1 *M* $AgNO_3$ and 0.1 *M NaCl* are mixed together
(1) 0.1 *N* (2) 0.2 *M* (3) 0.05 *M* (4) 0.25 *M*

Q.8 The pair of species having same percentage (mass) of carbon is :
(1) CH_3COOH and $C_6H_{12}O_6$
(2) CH_3COOH and C_2H_5OH
(3) $HCOOCH_3$ and $C_{12}H_{22}O_{11}$
(4) $C_6H_{12}O_6$ and $C_{12}H_{22}O_{11}$

Q.9 Weight of oxygen in Fe_2O_3 and FeO is in the simple ratio for the same amount of iron is :
(1) 3 : 2 (2) 1 : 2 (3) 2 : 1 (4) 3 : 1

Q.10 For the reaction
$2x + 3y + 4z \rightarrow 5w$
Initially if 1 mol of x, 3 mol of y and 4 mol of z is taken. If 1.25 mol of w is obtained then % yield of this reaction is
(1) 50% (2) 60% (3) 70% (4) 40%

Equivalent Weight

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

Calculation of equivalent weight :

- $\text{Equivalent weight} = \dfrac{\text{Atomic weight}}{\text{Valency Factor}}$
- $\text{Equivalent weight of ions} = \dfrac{\text{Formula weight of ion}}{\text{Valency}}$
- 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
- $\text{Equivalent weight of acid / base} = \dfrac{\text{Molecular weight}}{\text{Basicity / Acidicity}}$
- $\text{Equivalent weight of salt} = \dfrac{\text{Molecular weight}}{\text{Total charge on cation or anion}}$

Ex. Na_2SO_4 (salt) i.e. $2Na^+$ & 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 $Na_2SO_4 = \dfrac{142}{2} = 71$

- Equivalent weight of an oxidizing or reducing agent

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

Concept of gram equivalent and law of chemical equivalence:

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

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

= n × valence factor; where

According to it in a reaction equal gram equivalent of reactant are reacts to give same number of gram equivalent of products.

For a reaction
$aA + bB \rightarrow cC + dD$

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

Methods for determination of the equivalent weight :

- **Hydrogen displacement method :** This method is used for those elements which can evolve hydrogen from acids, i.e., active metals.
  equivalent weight of metal =
  $$\frac{\text{weight of metal}}{\text{weight of } H_2 \text{ gas (displaced)}} \times 1.008$$
- **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
  $$= \frac{\text{weight of element}}{\text{weight of oxygen}} \times 8$$
- **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
  $$= \frac{\text{weight of element}}{\text{weight of chlorine}} \times 35.5$$
- **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.
  $$\frac{m_1}{m_2} = \frac{E_1}{E_2}$$
- **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.
  $$AB + CD \longrightarrow AD\text{ (ppt.)} + CB$$
  $$\frac{\text{Mass of AB}}{\text{Mass of AD}} = \frac{\text{Equivalent mass of AB}}{\text{Equivalent mass of AD}}$$
  $$= \frac{\text{Equivalent mass of A} + \text{Equivalent mass of B}}{\text{Equivalent mass of A} + \text{Equivalent mass of D}}$$

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 combusion. The mass of Ag is determined.

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

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

equivalent weight of RCOOAg

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

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.

Methods for determination of Atomic weight -

- **Atomic weight = equivalent weight × n**
  where n = valency
- **Dulong and Petit's law -** This law is applicable only for solids (except Be, B, Si, C)
  Atomic mass × specific heat (in calory/gram) ≈ 6.4
  OR
  Atomic mass (approximate) = $\frac{6.4}{\text{specific heat}}$

SOLVED EXAMPLE

EXAMPLE 24

Specific heat of a metal is 0.031 cal per degree per gram, and its equivalent weight is 103.6. Calculate the exact atomic weight of the metal.

Sol. According to Dulong and Petit's law -

approximate atomic weight = $\frac{6.4}{0.031} = 206.45$

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

EXAMPLE 25

A chloride of an element contains 49.5% chlorine. The specific heat of the element is 0.064. Calculate the equivalent mass, valency and atomic mass of the element.

Sol. Mass of chlorine in the metal chloride = 49.5
Mass of metal = (100 – 49.5) = 50.5
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, Approximate Atomic weight 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 $= 36.21 \times 3 = 108.63$

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.

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

$$= \frac{\text{Atomic mass of A}}{\text{Atomic mass of B}}$$

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

Atomic mass from vapour density of a chloride -

Required condition $\rightarrow$ 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 + 35.5x

$\because$ Atomic weight = Equivalent weight × valency

or $A = E \times x$

$\therefore$ Molecular weight $= E \times x + 35.5\,x$

or $2 \times V.D. = x(E + 35.5)$ or $x = \frac{2 \times V.D.}{E + 35.5}$

SOLVED EXAMPLE

EXAMPLE 26

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.

Sol. 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 $= 3.82 \times x + 35.5\,x = 39.32\,x$

But molecular weight of Chloride = 2 × V.D.

$\Rightarrow 39.32\,x = 2 \times 79$ $\Rightarrow x = \frac{2 \times 79}{39.32} = 4$

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

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

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

EXAMPLE 27

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.

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

We know that Molecular weight = 2 × vapour density

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

Here $\gamma = 1.4$ so atomicity will be 2.

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

Methods for determination of Molecular weight :

Molecular weight = 2 × vapour density

Diffusion method (only for gases) :- According to Graham's diffusion law

$$\text{rate of diffusion of a gas} \propto \frac{1}{\sqrt{\text{Molecular weight or density}}}$$

$$\therefore \quad \frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

Concentration of Solution

Concentration of solution can be expressed in any of the following ways.

(a) % by wt ⇒ amount of solute dissolved in 100 gm of solution

4.9% H_2SO_4 by wt.

⇒ 100 gm of solution contains 4.9 gm of H_2SO_4

(b) % by volume ⇒ volume of solute dissolved in 100 ml of solution

x% H_2SO_4 by volume

⇒ 100 ml of solution contains x ml H_2SO_4

(c) % wt by volume ⇒ wt. of solute present in 100 ml of solution

(d) % volume by wt. ⇒ volume of solute present in 100 gm of solution.

Concentration Terms

Molarity (M) : No. of moles of solute present in 1000 ml of solution.

$$\text{molarity (M)} = \frac{\text{moles of solute}}{\text{volume of solution (lit)}}$$

$$M = \frac{\text{m.moles of solute}}{\text{volume of solution(ml)}}$$

Molality (m)

No. of moles of solute present in 1000 gm of solvent

$$m = \frac{\text{moles of solute}}{\text{wt.of solvent in kg}},$$

$$m = \frac{\text{m.moles of solute}}{\text{wt.of solvent in gm}}$$

Normality (N)

No of gm equivalents of solute present in 1000 ml of solution

$$N = \frac{\text{gm equivalents of solute}}{\text{volume of solution(lit)}}$$

$$= \frac{\text{m. equivalent of solute}}{\text{volume of solution in (ml)}}$$

Formality (F)

The formality is the no. of gm formula weights of the ionic solute present in 1000 ml of solution.

$$F = \frac{\text{wt in gm}}{\text{formula wt} \times \text{volume of solution (lit)}}$$

Mole fraction

The mole fraction of a particular component in a solution is defined as the number of moles of that component per mole of solution.

If a solution has nA mole A & n_B mole of B.

$$\text{mole fraction of A } (X_A) = \frac{n_A}{n_A + n_B}$$

$$\text{mole fraction of B } (X_B) = \frac{n_B}{n_A + n_B}$$

$$X_A + X_B = 1$$

Parts per million (ppm) :

$$\frac{\text{Mass of solute}}{\text{Mass of solvent}} \times 10^6 \cong \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

SOLVED EXAMPLE

EXAMPLE 28

0.2 mole of HCl and 0.1 mole of barium chloride were dissolved in water to produce a 500-mL solution. The molarity of the Cl^- ions is -

(A) 0.06 M (B) 0.09 M

(C) 0.12 M (D) 0.80 M

Ans. **(D)**

Sol. $HCl \longrightarrow Cl^-$

0.2 mole

$BaCl_2 \longrightarrow 2Cl^-$

$2 \times 0.1 = 0.2$

Total moles of $Cl^- = 0.4$

$$M = \frac{w \times 1000}{m \times v}$$

$$\text{Molarity} = \frac{0.4 \times 1000}{500} = 0.8 \quad \because \frac{w}{m} = 0.4$$

Relationship Between Molarity, Molality & Density of Solution

Let the molarity of solution be 'M', molality be 'm' and the density of solution be d gm/mℓ.

Molarity implies that there are M moles of solute in 1000 ml of solution wt of solution = density × volume = 1000 d gm wt of solute = MM_1

where M_1 is the molecular wt of solute

wt of solvent = $(1000d - MM_1)$ gm

$(1000d - MM_1)$ gm of solvent contains M moles of solute

1000 gm of solvent have

$$= \frac{M}{1000d - MM_1} \times 1000 \text{ mole} = \text{Molality}$$

no. of moles of solute present in 1000 gm of solvent =

$$\frac{1000 \times M}{1000d - MM_1} = \text{Molality}$$

$$\text{on simplifying } d = M\left[\frac{1}{m} + \frac{M_1}{1000}\right]$$

Relationship between molality & mole fraction

Consider a binary solution consisting of two components A (Solute) and B (Solvent).

Let x_A & x_B are the mole fraction of A & B respectively.

$$x_A = \frac{n_A}{n_A + n_B}, \quad x_b = \frac{n_B}{n_A + n_B}$$

If molality of solution be m then

$$m = \frac{n_A}{\text{mass of solvent}} \times 1000 = \frac{n_A}{n_B \times M_B} \times 1000$$

where M_B is the molecular wt of the solvent B

$$m = \frac{x_A}{x_B} \times \frac{1000}{M_B}$$

$$\text{molality} = \frac{\text{mole fraction of A}}{\text{mole fraction of B}} \times \frac{1000}{M_B}$$

$$m = \frac{\text{mole fraction of solute}}{\text{mole fraction of solvent}} \times \frac{1000}{\text{molecular wt. of solvent}}$$

DPP-3

Q.1 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) $\frac{100 \times 59}{0.4}$

Q.2 How many moles of potassium chlorate need to be heated to produce 11.2 litre oxygen at N.T.P.

(1) $\frac{1}{2}$ mol (2) $\frac{1}{3}$ mol

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

Q.3 If 1.6 gms of SO_2 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

Q.4 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) $(A_2 - A_1) \times 8$

Q.5 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

Q.6 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) None

Q.7 Specific heat of a solid element is 0.1Cal/gm °C and its equivalent weight is 31.8. Its exact atomic weight is -

(1) 31.8 (2) 63.6

(3) 318 (4) 95.4

Q.8 A solution of A (MM = 20) and B (MM = 10), [Mole fraction $X_B = 0.6$] having density 0.7 gm/ml then molarity and molality of B in this solution will be ________________ and ______________ respectively.

(1) 30M,75m

(2) 40M,75m

(3) 30M,65m

(4) 50M,55m

Q.9 125 ml of 8% w/w NaOH solution sp. gravity = 1 is added to 125 ml of 10 % w/v HCl solution. The nature of resultant solution would be _________

(1) Acidic (2) Basic

(3) Neutral (4) None

Q.10 Equal moles of H_2O and NaCl are present in a solution. Hence, molality of NaCl solution is :

(1) 0.55 (2) 55.5

(3) 1.00 (4) 0.18

SOLVED EXAMPLE

EXAMPLE 29

An aqueous solution is 1.33 molal in methanol. Determine the mole fraction of methanol & H_2O

Sol. molality

$$= \frac{\text{mole fraction of solute}}{\text{mole fraction of solvent} \times \text{mol.wt of solvent}} \times 1000$$

$$1.33 = \frac{x_A}{x_B \times M_B} \times 1000,$$

$$\frac{1.33 \times 18}{1000} = \frac{x_A}{x_B}, \frac{23.94}{1000} = \frac{x_A}{x_B}$$

$\Rightarrow x_A = 0.02394\, x_B, x_A + x_B = 1$

$\Rightarrow 1.02394\, x_B = 1$

$$x_B = \frac{1}{1.02394} = 0.98, x_A = 0.02 \textbf{ Ans.}$$

2nd Method : 1.33 molal $\rightarrow$ 1.3 moles of solute in 1 kg of solvent.

mole fraction of solute

$$= \frac{\text{moles of solute}}{\text{moles of solute} + \text{moles of solvent}},$$

$$= \frac{n}{n + \frac{1000}{18}} = \frac{1.33}{1.33 + 1000/18}$$

mole fraction of solute = 0.02

mole fraction of solvent = 1 – 0.02 = 0.98

EXAMPLE 30

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

Sol. Mass of substance = 0.5 g

Mass of solvent = 25 g

$\therefore$ Percentage of the substance (w/w)

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

EXAMPLE 31

From 160 g of SO_2 (g) sample, 1.2046×10^{24} molecules of SO_2 are removed then find out the volume of left over SO_2 (g) at NTP.

Sol. Given moles $= \frac{160}{64} = 2.5.$

Removed moles $= \frac{1.2046 \times 10^{24}}{6.023 \times 10^{23}} = 2.$

so left moles = 0.5.

volume left at STP = 0.5 × 22.4 = 11.2 lit.

EXAMPLE 32

Calculate the mass in gm of $2N_A$ molecules of CO_2 -

(1) 22 gm (2) 44 gm

(3) 88 gm (4) None of these.

Sol. **(3)**

$\because$ N_A molecules of CO_2 has molecular mass = 44.

$\therefore$ $2N_A$ molecules of CO_2 has molecular mass

$= 44 \times 2 = 88$ gm.

EXAMPLE 33

How many molecules are in 5.23 gm of glucose ($C_6H_{12}O_6$) -

(1) 1.65×10^{22} (2) 1.75×10^{22}

(3) 1.75×10^{21} (4) None of these

Sol. **(2)**

$\because$ 180 gm glucose has = N_A molecules

$\therefore$ 5.23 gm glucose has $= \frac{5.23 \times 6.023 \times 10^{23}}{180}$

$= 1.75 \times 10^{22}$ molecules

EXAMPLE 34

How many molecules are present in one mℓ of water vapours at NTP -

(1) 1.69×10^{19} (2) 2.69×10^{-19}

(3) 1.69×10^{-19} (4) 2.69×10^{19}

Sol. (4)

$\because$ 22.4 litre water vapour at NTP has

$= 6.023 \times 10^{23}$ molecules

$\therefore$ 1×10^{-3} litre water vapours at NTP has

$$= \frac{6.023 \times 10^{23}}{22.4} \times 10^{-3} = 2.69 \times 10^{+19}$$

EXAMPLE 35

How many years it would take to spend Avogadro's number of rupees at the rate of 1 million rupees in one second -

(1) 19.098×10^{19} years (2) 19.098 years

(3) 19.098×10^{9} years (4) None of these

Sol. (3)

$\because$ 10^6 rupees are spent in 1sec.

$\therefore$ 6.023×10^{23} rupees are spent in

$$= \frac{1 \times 6.023 \times 10^{23}}{10^6} \text{ sec}$$

$$= \frac{1 \times 6.023 \times 10^{23}}{10^6 \times 60 \times 60 \times 24 \times 365} \text{ years}, = 19.098 \times 10^9 \text{ year}$$

EXAMPLE 36

An atom of an element weighs 6.644×10^{-23} g. Calculate g atoms of element in 40 kg-

(1) 10 gm atom (2) 100 gm atom

(3) 1000 gm atom (4) 10^4 gm atom

Sol. (3)

$\because$ weight of 1 atom of element

$= 6.644 \times 10^{-23}$ gm

$\therefore$ weight of 'N' atoms of element

$= 6.644 \times 10^{-23} \times 6.023 \times 10^{23} = 40$ gm

$\because$ 40 gm of element has 1 gm atom.

$\therefore$ 40 x 10^3 gm of element has $\dfrac{40 \times 10^3}{40}$,

$= 10^3$ gm atom.

EXAMPLE 37

The density of O_2 at NTP is 1.429g / litre. Calculate the standard molar volume of gas-

(1) 22.4 lit. (2) 11.2 lit
(3) 33.6 lit (4) 5.6 lit.

Sol. (1)

$\because$ 1.429 gm of O_2 gas occupies volume = 1 litre.

$\therefore$ 32 gm of O_2 gas occupies = $\dfrac{32}{1.429}$,

= 22.4 litre/mol.

EXAMPLE 38

Calculate the weight of lime (CaO) obtained by heating 200 kg of 95% pure lime stone ($CaCO_3$).

(1) 104.4 kg (2) 105.4 kg
(3) 212.8 kg (4) 106.4 kg

Sol. **(4)**

$\because$ 100 kg impure sample has pure $CaCO_3 = 95$ kg

$\therefore$ 200 kg impure sample has pure $CaCO_3$

$= \dfrac{95 \times 200}{100} = 190$ kg. $CaCO_3 \rightarrow CaO + CO_2$

$\because$ 100 kg $CaCO_3$ gives CaO = 56 kg.

$\therefore$ 190 kg $CaCO_3$ gives CaO = $\dfrac{56 \times 190}{100} = 106.4$ kg.

EXAMPLE 39

Calculate the weight of one atom of Ag –

(At. wt. of Ag = 108)

(1) 17.93×10^{-23}gm (2) 16.93×10^{-23} gm
(3) 17.93×10^{23} gm (4) 36×10^{-23} gm

Sol. **(1)**

$\because$ N_A atoms of Ag weigh 108 gm

$\therefore$ 1 atom of Ag weigh = $\dfrac{108}{N_A}$

$= \dfrac{108}{6.023 \times 10^{23}} = 17.93 \times 10^{-23}$ gm.

EXAMPLE 40

In 5g atom of Ag (at. wt. = 108), calculate the no. of atoms of Ag ($N = N_A$) -

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

Sol. (3)

$\because$ 1 gm atom of Ag has atoms = N

$\therefore$ 5 gm atom of Ag has atoms = 5N.

EXAMPLE 41

Calculate the number of atoms of each element present in 122.5 g of $KClO_3$.

Sol. No. of moles of $KClO_3 = \dfrac{122.5}{122.5} = 1.$

(mol. wt. of $KClO_3$ = 122.5)

From the formula $KClO_3$, we know that 1 mole of $KClO_3$ contains 1 mole of K atoms, 1 mole of Cl atoms and 3 moles of O atoms.

$$\left.\begin{array}{l} \therefore \text{no. of atoms of K} = 1 \times 6.022 \times 10^{23} \\ \text{no. of atoms of Cl} = 1 \times 6.022 \times 10^{23} \\ \text{no. of atoms of O} = 3 \times 6.022 \times 10^{23} \end{array}\right\}$$

EXAMPLE 42

The vapour density (hydrogen = 1) of a mixture consisting of NO_2 and N_2O_4 is 38.3 at 26.7ºC. Calculate the number of moles of NO_2 in 100 g of the mixture.

Sol. Wt. of NO_2 = x g.

obs. mol. wt. (wt./mole) = $\dfrac{\text{wt. in g}}{\text{total moles}}$

$$= \frac{100}{\left(\dfrac{x}{46} + \dfrac{100 - x}{92}\right)} = 2 \times 38.3.$$

moles of NO_2 = 0.437 mole

EXAMPLE 43

Calculate the total ions & charge present in 4.2 gm of N^{-3}

Sol. mole = $\dfrac{\text{wt in gm}}{\text{Ionic wt}} = \dfrac{4.2}{14} = 0.3$

total no of ions = $0.3 \times N_A$ ions

total charge = $0.3\, N_A \times 3 \times 1.6 \times 10^{-19}$

$= 0.3 \times 6.023 \times 10^{23} \times 3 \times 1.6 \times 10^{-19}$,

$= 8.67 \times 10^4$ C **Ans.**

EXAMPLE 44

Find the total number of iron atom present in 224 amu iron.

Sol. Since 56 amu = 1 atom

Therefore 224 amu = $\dfrac{1}{56} \times 224 = 4$ atom **Ans.**

CLASS ASSIGNMENT

Q.1 One fermi is
(1) 10^{-13} *cm* (2) 10^{-15} *cm*
(3) 10^{-10} *cm* (4) 10^{-12} *cm*

Q.2 Which of the following pairs of substances illustrate the law of multiple proportions
(1) CO and CO_2 (2) H_2O and D_2O
(3) NaCl and NaBr (4) MgO and $Mg(OH)_2$

Q.3 Chemical equation is balanced according to the law of
(1) Multiple proportion
(2) Reciprocal proportion
(3) Conservation of mass
(4) Definite proportions

Q.4 The law of multiple proportions is illustrated by the two compounds
(1) Sodium chloride and sodium bromide
(2) Ordinary water and heavy water
(3) Caustic soda and caustic potash
(4) Sulphur dioxide and sulphur trioxide

Q.5 1 *amu* is equal to
(1) $\frac{1}{12}$ of C – 12 (2) $\frac{1}{14}$ of O - 16
(3) 1g of H_2 (4) 1.66×10^{-23} kg

Q.6 1 mol of CH_4 contains
(1) 6.02×10^{23} atoms of *H*
(2) 4 *g* atom of Hydrogen
(3) 1.81×10^{23} molecules of CH_4
(4) 3.0 *g* of carbon

Q.7 7.5 grams of a gas occupy 5.8 litres of volume at STP the gas is
(1) NO (2) N_2O (3) CO (4) CO_2

Q.8 The number of atoms in 4.25 *g* of NH_3 is approximately
(1) 1×10^{23} (2) 2×10^{23} (3) 4×10^{23} (4) 6×10^{23}

Q.9 One litre of a gas at STP weight 1.16 *g* it can possible be
(1) C_2H_2 (2) CO (3) O_2 (4) CH_4

Q.10 The mass of a molecule of water is
(1) 3×10^{-26} *kg* (2) 3×10^{-25} *kg*
(3) 1.5×10^{-26} *kg* (4) 2.5×10^{-26} *kg*

Q.11 If N_A is Avogadro's number then number of valence electrons in 4.2 *g* of nitride ions (N^{3-})
(1) 2.4 N_A (2) 4.2 N_A
(3) 1.6 N_A (4) 3.2 N_A

Q.12 The number of molecule at NTP in 1 *ml* of an ideal gas will be
(1) 6×10^{23} (2) 2.69×10^{19}
(3) 2.69×10^{23} (4) None of these

Q.13 Volume of a gas at STP is 1.12×10^{-7} cc. Calculate the number of molecules in it
(1) 3.01×10^{20} (2) 3.01×10^{12}
(3) 3.01×10^{23} (4) 3.01×10^{24}

Q.14 4.4 g of an unknown gas occupies 2.24L of volume at standard temperature and pressure. The gas may be
(1) Carbon dioxide (2) Carbon monoxide
(3) Oxygen (4) Sulphur dioxide

Q.15 The number of oxygen atoms in 4.4 *g* of CO_2 is approx.
(1) 1.2×10^{23} (2) 6×10^{22}
(3) 6×10^{23} (4) 12×10^{23}

Q.16 The total number of protons in 10 *g* of calcium carbonate is ($N_0 = 6.023 \times 10^{23}$)
(1) 1.5057×10^{24} (2) 2.0478×10^{24}
(3) 3.0115×10^{24} (4) 4.0956×10^{24}

Q.17 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) $NH_3 = CO_2 < O_2$

Q.18 Caffeine has a molecular weight of 194. If it contains 28.9% by mass of nitrogen, number of atoms of nitrogen in one molecule of caffeine is
(1) 4 (2) 6 (3) 2 (4) 3

Q.19 The percentage of oxygen in NaOH is
(1) 40 (2) 60 (3) 8 (4) 10

Q.20 What is the % of H_2O in $Fe(CNS)_3.3H_2O$
(1) 45 (2) 30
(3) 19 (4) 25

Q.21 A hydrocarbon contains 86% carbon, 488ml of the hydrocarbon weight 1.68 *g* at STP. Then the hydrocarbon is an
(1) Alkane (2) Alkene
(3) Alkyne (4) Arene

Q.22 In the reaction,
$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$, When 1 mole of ammonia and 1 mole of O_2 are made to react to completion
(1) 1.0 mole of H_2O is produced
(2) 1.0 mole of NO will be produced
(3) All the oxygen will be consumed
(4) All the ammonia will be consumed

Q.23 If isobutane and n-butane are present in a gas, then how much oxygen should be required for complete combustion of 5 *kg* of this gas
(1) 17.9 *kg* (2) 9 *kg*
(3) 27 *kg* (4) 1.8 *kg*

Q.24 12g of Mg (at. mass 24) will react completely with acid to give
(1) One mole of H_2
(2) 1/2 mole of H_2
(3) 2/3 mole of O_2
(4) Both 1/2 mol of H_2 and 1/2 mol of O_2

Q.25 100 *g* $CaCO_3$ reacts with 1 *litre* 1 *N HCl*. On completion of reaction how much weight of CO_2 will be obtain
(1) 5.5 g (2) 11 g
(3) 22 g (4) 33 g

Q.26 Calculate volume of carbon dioxide produced on heating 10 g of limestone at S.T.P.
(1) 2.24 L (2) 22.4 L
(3) .224 L (4) 2.24 ml

Q.27 Find the volume of CO required to reduce 0.25 mole ferric oxide as per the given equation
$Fe_2O_3 + 3\,CO \rightarrow 2Fe + 3CO_2$
(1) 16.8 dm^3 (2) 67.2 dm^3
(3) 22.4 dm^3 (4) 44.8 dm^3

Q.28 How many litre of oxygen at STP is required to burn 60 g C_2H_6 ?
(1) 24.4 L (2) 11.2 L
(3) 22.4 × 7 L (4) 8.5 L

Q.29 A solution is prepared by adding 2g of a substance A to 18 g of water. Calculate the mass per cent of the solute.
(1) 8% (2) 9%
(3) 10% (4) 11%

Q.30 What will be the molality of the solution made by dissolving 10 g of NaOH in 100 g of water?
(1) 2.5 m (2) 5 m
(3) 10 m (4) 1.25 m

Q.31 A given solution of NaOH contains 4.00 g of NaOH per litre of solution. Calculate the molarity of this solution. Molar mass of NaOH = 40.00 g
(1) 0.1 M (2) 0.5
(3) 0.7 (4) 0.8

Q.32 Which has maximum number of atoms of oxygen
(1) 10 ml $H_2O(l)$
(2) 0.1 mole of V_2O_5
(3) 12 gm $O_3(g)$
(4) 12.044×10^{22} molecules of CO_2

Q.33 Mass of one atom of the element A is 3.9854×10^{-23}. How many atoms are contained in 1g of the element A?
(1) 2.509×10^{22}
(2) 6.022×10^{23}
(3) 12.044×10^{23}
(4) None

Q.34 The number of atoms present in 0.5 g-atoms of nitrogen is same as the atoms in
(1) 12 g of C
(2) 32 g of S
(3) 8 g of oxygen
(4) 24g of Mg

Q.35 How many moles of magnesium phosphate $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms:
(1) 0.02
(2) 3.125×10^{-2}
(3) 1.25×10^{-2}
(4) 2.5×10^{-2}

HOME ASSIGNMENT

Q.1 The number of water molecules in 1 litre of water is
(1) 18 (2) 18×1000
(3) N_A (4) $55.55\ N_A$

Q.2 2g of oxygen contains number of atoms equal to that in
(1) 0.5g of hydrogen (2) 4g of sulphur
(3) 7g of nitrogen (4) 2.3g of sodium

Q.3 Haemoglobin contains 0.33% of iron by weight. The molecular weight of haemoglobin is approximately 67200. The number of iron atoms (At. wt. of *Fe* = 56) present in one molecule of haemoglobin is
(1) 6 (2) 1 (3) 4 (4) 2

Q.4 How many moles of lead nitrate is needed to produce 224 litre of oxygen at NTP ?
$2Pb(NO_3) \rightarrow 2Pb + 4NO_2 + O_2$
(1) 10 (2) 20 (3) 30 (4) 40

Q.5 A gaseous mixture of propane and butane of volume 3 litre on combustion produces 11 litre CO_2 under standard conditions of temperature and pressure. The ratio of volume of butane to propane is :
(1) 1 : 2 (2) 2 : 1 (3) 3 : 2 (4) 3 : 1

Q.6 A sample of Calcium phosphate $Ca_3(PO_4)_2$ contains 8 mol of O atoms. The number of mole of Ca atoms in the sample is :
(1) 4 (2) 1.5 (3) 3 (4) 8

Q.7 An iodized salt contains 0.5% of NaI. A person consumes 3 gm of salt everyday. The number of iodide ions going into his body everyday is
(1) 10^{-4} (2) 6.02×10^{-4}
(3) 6.02×10^{19} (4) 6.02×10^{23}

Q.8 64 g of an organic compound has 24 g carbon and 8 g hydrogen and the rest is oxygen. The empirical formula of the compound is :
(1) CH_4O (2) CH_2O (3) C_2H_4O (4) None

Q.9 Two elements X (atomic mass=75) and Y (atomic mass=16) combine to give a compound having 75.8% of X. The formula of the compound is:
(1) X_2Y_3 (2) X_2Y (3) X_2Y_2 (4) XY

Q.10 Mole fraction of ethyl alcohol in aqueous ethyl alcohol (C_2H_5OH) solution is 0.25. Hence percentage of ethyl alcohol by weight is :
(1) 54% (2) 25%
(3) 75% (4) 46%

Q.11 74 gm of sample on complete combustion gives 132 gm CO_2 and 54 gm of H_2O. The molecular formula of the compound may be
(1) C_5H_{12} (2) $C_4H_{10}O$ (3) $C_3H_6O_2$ (4) $C_3H_7O_2$

Q.12 The oxide of a metal contains 30% oxygen by weight. If the atomic ratio of metal and oxygen is 2 : 3, determine the atomic weight of metal.
(1) 12 (2) 56 (3) 27 (4) 52

Q.13 10 ml of a compound containing 'N' and 'O' is mixed with 30 ml of H_2 to produce H_2O (*l*) and 10 ml of N_2(g). Molecular formula of compound if both reactants reacts completely, is
(1) N_2O (2) NO_2
(3) N_2O_3 (4) N_2O_5

Q.14 36.5 % (w/w) HCl has density equal to 1.20 g mL^{-1}. The molarity (M) and molality (m), respectively, are
(1) 15.7, 15.7 (2) 12, 12
(3) 15.7, 12 (4) 12, 15.7

Q.15 Decreasing order of mass of pure NaOH in each of the aqueous solution.
(I) 50 g of 40% (W/W) NaOH
(II) 50 ml of 50% (W/V) NaOH (d_{sol} = 1.2 g/ml).
(III) 50 g of 15 M NaOH (d_{sol} = 1 g/ml).
(1) I, II, III (2) III, II, I
(3) II, III, I (4) III = II = I.

Q.16 Mole fraction of A in H_2O is 0.2. The molality of A in H_2O is :
(1) 13.9 (2) 15.5
(3) 14.5 (4) 16.8

Q.17 The molarity of the solution containing 2.8% (W/V) solution of KOH is : (Given atomic mass of K = 39) is :
(1) 0.1 M (2) 0.5 M
(3) 0.2 M (4) 1 M

Q.18 If 500 ml of 1 M solution of glucose is mixed with 500 ml of 1 M solution of glucose final molarity of solution will be:
(1) 1 M (2) 0.5 M
(3) 2 M (4) 1.5 M

Q.19 The volume of water that must be added to a mixture of 250 mL of 0.6 M HCl and 750 mL of 0.2 M HCl to obtain 0.25 M solution of HCl is :
(1) 750 mL (2) 100 mL
(3) 200 mL (4) 300 mL

Q.20 What volume of a 0.8 M solution contains 100 milli moles of the solute?

(1) 100 mL (2) 125 mL
(3) 500 mL (4) 62.5 mL

Q.21 The molarity of Cl^- in an aqueous solution which was (w/V) 2% NaCl, 4% $CaCl_2$ and 6% NH_4Cl will be

(1) 0.342 (2) 0.721
(3) 1.12 (4) 2.18

Statement Type Question (22 to 24)

Read the Statement-I and Statement-II carefully to mark the correct option out of the options given below:

(1) Both the statement are correct
(2) Both the statement are incorrect
(3) Statement -I is correct but statement II is incorrect
(4) Statement - I are incorrect but statement II is correct

Q.22 **Statement-I :** For calculating the molality or the mole fraction of solute, if the molarity is known, it is necessary to know the density of the solution.

Statement-II : Molality, molarity and the mole fraction of solute can be calculated from the weight percentage and the density of the solution

Q.23 **Statement-I :** 16 gm each of O_2 and O_3 contains $\frac{N_A}{2}$ and $\frac{N_A}{3}$ atomes respectively

Statement-II : 16 gm O_2 and O_3 contains same no. of molecules.

Q.24 **Statement-I :** Pure water obtained from different sources such as, river, well, spring, sea etc. always contains hydrogen and oxygen combined in the ratio 1 : 8 by mass

Statement-II : A chemical compound always contains elements combined together in same proportion by mass, it was discovered by French chemist, Joseph Proust (1799).

Q.25 **Statement-I :** A one molal solution prepared at 20°C will retain the same molality at 100°C, provided there is no loss of solute or solvent on heating.

Statement-II : Molality is independent of temperature.

Assertion and Reason

Read the assertion and reason carefully to mark the correct option out of the options given below:

(1) If both Assertion and Reason are correct, and Reason is the correct explanation of Assertion.
(2) If both Assertion and Reason are correct, and Reason is not the correct explanation of Assertion.
(3) If Assertion is correct and Reason is incorrect.
(4) If Assertion is incorrect but Reason is correct.

Q.26 **Assertion (A):** Approximate mass of 1 atom of O^{16} in gms is $(16 / N_A)$

Reason (R): 1 atom of O^{16} weighs 16 a.m.u & 1 a.m.u = $(1 / N_A)$ g.

Q.27 **Assertion (A):–** At same temp and pressure 1lit O_2 and 1lit SO_2 contains equal no. of molecules.

Reason (R):– Accourding to avogadros hypothesis equal volume of all gases under similar condition of temp and pressure contains equal no. of molecules.

Q.28 **Assertion (A) :** Molality of pure ethanol is lesser than pure water.

Reason (R) : As density of ethanol is lesser than density of water.

[Given : dethanol = 0.789 gm/ml; dwater = 1 gm/ml]

Q.29 **Assertion (A):–** A reactant that is entirely consumed when a reaction goes to completion is known as limiting reactant.

Reason (R):– The amount of reactant limits the amount of product formed.

Match The Column

Q.30 Match the columns

Column-I		Column-II	
(P)	52 amu of He	(i)	11.2L at NTP
(Q)	$2N_A$ atoms in a sample of NH_3	(ii)	13 atoms of He
(R)	1 gm molecule of Nitrogen	(iii)	0.1 mole
(S)	1.8 g of H_2O	(iv)	28 g

(1) (P) – (ii); (Q) – (i); (R) – (iv); (S) – (iii)
(2) (Q) – (iv); (P) – (ii); (R) – (i); (S) – (iii)
(3) (Q) – (ii); (P) – (iii); (R) –(iv); (S) – (i)
(4) (Q) – (i); (P) – (iv); (R) –(ii); (S) – (iii)

NEET PREVIOUS YEAR'S

Q.1 Equal masses of H_2, O_2 and methane have been taken in a container of volume V at temperature 27°C in identical conditions. The ratio of the volumes of gases $H_2 : O_2$: methane would be : **[AIPMT-2014]**

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

Q.2 When 22.4 litres of $H_{2(g)}$ is mixed with 11.2 litres of $Cl_{2(g)}$, each at S.T.P., the moles of $HCl_{(g)}$ formed is equal to : **[AIPMT-2014]**

(1) 1 mol of $HCl_{(g)}$ (2) 2 mol of $HCl_{(g)}$
(3) 0.5 mol of $HCl_{(g)}$ (4) 1.5 mol of $HCl_{(g)}$

Q.3 1.0 g of magnesium is burnt with 0.56 g O_2 in a closed vessel. Which reactant is left in excess and how much? (At. wt. Mg = 24, O = 16) **[AIPMT-2014]**

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

Q.4 If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change **[AIPMT-2015]**

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

Q.5 The number of water molecules is maximum in **[AIPMT-2015]**

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

Q.6 What is the mass of the precipitate formed when 50 mL of 16.9% solution of $AgNO_3$ is mixed with 50 mL of 5.8 % NaCl solution ? **[AIPMT-2015]**

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

Q.7 Suppose the elements X and Y combine to from two compounds XY_2 and X_3Y_2. When 0.2 mole of XY_2 weighs 10g and 0.05 moles of X_3Y_2 weighs 9g, the atomic weights of X and Y are : **[NEET Phase II-2016]**

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

Q.8 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 **[NEET - 2018]**

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

Q.9 In which case is number of molecules of water maximum? **[NEET - 2018]**

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

Q.10 The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is :- **[NEET-2019]**

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

Q.11 Which one of the following has maximum number of atoms ? **[NEET-2020]**

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

Q.12 What mass of 95% pure $CaCO_3$ will be required to neutralise 50 mL of 0.5 M HCl solution according to the following reaction ?

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(q)} + H_2O(\ell)$ **[NEET-2022]**

[Calculate upto second place of decimal point]

(1) 1.32 g (2) 3.65 g
(3) 9.50 g (4) 1.25 g

Q.13 The **right** options for the mass of CO_2 produced by heating 20 g of 20 % pure limestone is (Atomic mass of Ca = 40) **[NEET-2023]**

$[CaCO_3 \xrightarrow{1200K} CaO + CO_2]$

(1) 1.76 g (2) 2.64 g
(3) 1.32 g (4) 1.12 g

Q.14 A compound X contains 32% of A, 20% of B and remaining percentage of C. Then, the empirical formula of X is : **[NEET-2024]**

(Given atomic masses of A = 64; B = 40; C = 32 u)

(1) ABC_4 (2) A_2BC_2
(3) ABC_3 (4) AB_2C_2

Q.15 The highest number of helium atoms is in **[NEET-2024]**

(1) 2.271098 L of helium at STP
(2) 4 mol of helium
(3) 4 u of helium
(4) 4 g of helium

Q.16 1 gram of sodium hydroxide was treated with 25 mL of 0. M HCl solution, the mass of sodium hydroxide left unreacted is equal to **[NEET-2024]**

(1) 200 mg (2) 0 mg (3) 250 mg (4) Zero

ANSWER KEY

DPP-1

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

DPP-2

Q.1 (4) **Q.2** (3) **Q.3** (4) **Q.4** (3) **Q.5** (4) **Q.6** (2) **Q.7** (3) **Q.8** (1) **Q.9** (1) **Q.10** (1)

DPP-3

Q.1 (2) **Q.2** (2) **Q.3** (3) **Q.4** (3) **Q.5** (1) **Q.6** (4) **Q.7** (2) **Q.8** (1) **Q.9** (1) **Q.10** (2)

CLASS ASSIGNMENT

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

HOME ASSIGNMENT

Q.1 (4) **Q.2** (2) **Q.3** (3) **Q.4** (2) **Q.5** (1) **Q.6** (3) **Q.7** (3) **Q.8** (1) **Q.9** (1) **Q.10** (4)
Q.11 (3) **Q.12** (2) **Q.13** (3) **Q.14** (4) **Q.15** (2) **Q.16** (1) **Q.17** (2) **Q.18** (1) **Q.19** (3) **Q.20** (2)
Q.21 (4) **Q.22** (1) **Q.23** (2) **Q.24** (1) **Q.25** (1) **Q.26** (1) **Q.27** (1) **Q.28** (2) **Q.29** (1) **Q.30** (1)

NEET PREVIOUS YEAR'S

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