MOLE CONCEPT

CONTENTS

JEE (Advanced) Syllabus

Concept of atoms and molecules ; Delton's atomic theory ; Mole concept ; Chemical formulae ; Balanced chemical equations ; Calculations (based on mole concept) involving common oxidation reduction, neutralisation, and displacement reaction ; Concentration in terms of mole fraction, molarity, molality and normality.

JEE (MAIN) Syllabus

Mole concept : Matter and its nature, Dalton's atomic theory ; Concept of atom, molecule, element and compound ; Physical quantities and their measurements in chemistry, precision and accuracy, significant figures, S.I. units, dimensional analysis ; Laws of chemcial combination ; Atomic and moleclar masses, mole concept, molar mass, percentage composition, empirical and molecular formulae ; Chemical equations

Mole Concept

CLASSIFICATION OF MATTER

MATTER : Matter is anything that has mass and occupies space.

Two ways of classifying matter.

I. Physical classification II. Chemical classification

I. Physical classification :

MATTER → SOLID, LIQUID, GAS

	SOLID	LIQUID	GAS
(i)	Particles held very closely packed in ordered manner.	Particles are less closely packed.	Particles are farthest apart
(ii)	No freedom of movement of particles	Particles can move around to some extent	Movement of particles is very easy and fast
(iii)	Definite shape and volume	Definite volume, indefinite shape	indefinite shape and volume
(iv)	Exists at low T and high P	Exists at intermediate P & T	Exists at high T and low P

Note : For same substance :

- Solid and Liquid co-exist at ***MELTING POINT***.
- Liquid and gas co-exist at ***BOILING POINT***.
- Solid and gas co-exist at ***SUBLIMATION POINT***.

II. Chemical classification :

MATTER

- **Pure substances**
  - Have fixed composition
  - Cannot be separated by physical methods
  - **Elements**
    - Made of only one type of atoms
  - **Compounds**
    - Made of two or more types of atoms/ions
    - **Ionic**
    - **Covalent**
- **Mixtures**
  - Variable composition
  - Can be separated by physical methods to pure substances
  - **Homogeneous (solutions)**
    - Have uniform composition and density through out

      Ex : Mixture of gases or NaCl + H_2O or Glucose + H_2O or Alloys
  - **Heterogeneous**
    - Are not uniform in composition and/or density

      Ex. Graphite+Diamond or Fe + FeO or Sand + H_2O

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

On oxygen scale : Relative atomic mass (R.A.M) = $\dfrac{\text{Mass of one atom of an element}}{\frac{1}{16} \times \text{mass of one oxygen atom}}$

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

Atomic mass unit (or amu) :

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

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

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

= 1.66×10^{-24} g or 1.66×10^{-27} kg

- **one amu is also called one Dalton (Da).**
- **Today, amu has been replaced by 'u' which is known as unified mass**

Atomic & molecular mass :

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

- Atomic mass = R.A.M × 1 amu

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

- Molecular mass = Relative molecular mass × 1 amu

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

Solved Examples

Ex. 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 : The Mass / Number Relationship

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 g) of the carbon-12 isotope.

From mass spectrometer we found that there are 6.023×10^{23} atoms present in 12 g 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 ?

Amount of water in world's oceans (litres)
Age of earth (seconds)
Population of earth

Avogadro's number 602,200,000,000,000,000,000,000

Distance from earth to sun (centimeters)

❍ 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

$= 16 \text{ amu} \times 6.02 \times 10^{23}$

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

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

Solved Examples

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

Sol. Let x atoms of oxygen are present

So, $x = \dfrac{16}{32} \times 2N_A$

$\Rightarrow$ $x = N_A$

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}
= $32 \times 1.66 \times 10^{-24}$ g × 6.02×10^{23} = 32 g

Solved Examples

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

Sol. Gram molecular mass of H_2SO_4 = 98 g

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

H_2SO_4	H	S	O
One molecule	2 atom	one atom	4 atom
1 × N_A	2 × N_A atoms	1 × N_A atoms	4 × N_A atoms
∴ one mole	2 mole	one mole	4 mole
∴ **3 mole**	**6 mole**	**3 mole**	**12 mole**

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

S.T.P. (Standard Temperature and Pressure)

At S.T.P. condition : temperature = 0°C or 273 K
pressure = 1 bar

and volume of one mole of gas at STP is found to be experimentally equal to 22.7 litres which is known as molar volume.

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

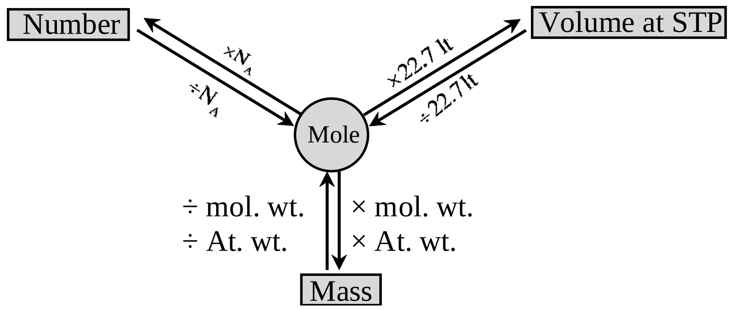
Solved Examples

Ex. Calculate the volume in litres of 20 g hydrogen gas at STP.

Sol. No. of moles of hydrogen gas = $\frac{\text{Mass}}{\text{Molecular mass}} = \frac{20\text{ gm}}{2\text{ gm}}$ = 10 mol

volume of hydrogen gas at STP = 10 × 22.7 lt. = 227 lt.

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



Percentage Composition :

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 Examples

Ex. 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 g of NH_3 always contains 14 g of N and 3 g of H. Now find out % of each element in the compound.

Sol. **Mass % of N in NH_3** $= \dfrac{\text{Mass of N in 1 mol } NH_3}{\text{Mass of 1 mol of } NH_3} \times 100 = \dfrac{14 \text{ gm}}{17} \times 100 = 82.35\ \%$

Mass % of H in NH_3 $= \dfrac{\text{Mass of H is 1 mol } NH_3}{\text{Mass of 1 mole of } NH_3} \times 100 = \dfrac{3}{17} \times 100 = 17.65\ \%$

DENSITY :

It is of two types.

I. Absolute density

II. Relative density

For liquids and solids :

Absolute density $= \dfrac{\text{mass}}{\text{volume}}$

Relative density or specific gravity $= \dfrac{\text{density of the substance}}{\text{density of water at } 4°C\ (1 \text{gm ml}^{-1})}$

For gases :

Absolute density $= \dfrac{\text{mass}}{\text{volume}} = \dfrac{PM}{RT}$

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

Vapour Density :

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

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

$$\text{V.D.} = \frac{M_{gas}}{M_{H_2}} = \frac{M_{gas}}{2} \Rightarrow \boxed{M_{gas} = 2 \times \text{V.D.}}$$

Ex. **A gaseous mixture of H_2 and NH_3 gas contains 68 mass % of NH_3. The vapour density of the mixture is –**

Sol. No. of moles of NH_3 in 100g mixture = $\frac{68}{17} = 4$

No. of moles of H_2 in 100g mixture = $\frac{32}{2} = 16$

$M_{average} = \frac{\text{Total mass}}{\text{Total moles}} = \frac{100}{4+16} = 5$

V.d = $\frac{5}{2}$ = 2.5

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

Solved Examples

Ex. 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 × 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 = $\mathbf{C_6H_6}$

Ex. An organic substance containing carbon, hydrogen and oxygen gave the following percentage composition.
C = 40.684% ; H = 5.085% and O = 54.228%
The molecular weight of the compound is 118 g. Calculate the molecular formula of the compound.

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

$\therefore$ Empirical Formula is $C_2H_3O_2$

Step-2 To calculate the empirical formula mass.
The empirical formula of the compound is $C_2H_3O_2$.
$\therefore$ Empirical formula mass = $(2 \times 12) + (3 \times 1) + (2 \times 16) = 59$.

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 $= n \times (\text{Empirical formula}) = 2 \times C_2H_3O_2 = C_4H_6O_4$
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.

Chemical Equation :

All chemical reaction are represented by chemical equations by using chemical formula of reactants and products. Qualitatively a chemical equation simply describes what the reactants and products are. However, a balanced chemical equation gives us a lot of quantitative information. Mainly the molar ratio in which reactants combine and the molar ratio in which products are formed.

Attributes of a balanced chemical equation:

(a) It contains an equal number of atoms of each element on both sides of equation.(POAC)
(b) It should follow law of charge conservation on either side.
(c) Physical states of all the reagents should be included in brackets.
(d) All reagents should be written in their standard molecular forms (not as atoms)
(e) The coefficients give the relative molar ratios of each reagent.

Solved Examples

Ex. Write a balance chemical equation for following reaction :
When potassium chlorate ($KClO_3$) is heated it gives potassium chloride (KCl) and oxygen (O_2).

Sol. $KClO_3\,(s) \xrightarrow{\Delta} KCl\,(s) + O_2\,(g)$ (unbalanced chemical equation)
$2KClO_3\,(s) \xrightarrow{\Delta} 2\,KCl\,(s) + 3\,O_2\,(g)$ (balanced chemical equation)
Remember a balanced chemical equation is one which contains an equal number of atoms of each element on both sides of equation.

Interpretation of balanced chemical equations :

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

- Mass - mass analysis
- Mass - volume analysis
- Mole - mole analysis
- Vol - Vol analysis (separately discussed as **eudiometry or gas analysis**)
  Now you can understand the above analysis by following example

- **Mass-mass analysis :**
  Consider the reaction

  $2KClO_3 \longrightarrow 2KCl + 3O_2$ According to stoichiometry of the reaction

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

  or $\dfrac{\text{Mass of } KClO_3}{\text{Mass of KCl}} = \dfrac{2\times 122.5}{2\times 74.5}$

  $\dfrac{\text{Mass of } KClO_3}{\text{Mass of } O_2} = \dfrac{2\times 122.5}{3\times 32}$

Solved Examples

Ex. 367.5 gram $KClO_3$ (M = 122.5) when heated. How many gram KCl and oxygen is produced.

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

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

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

$$\frac{\text{mass of } KClO_3}{\text{mass of KCl}} = \frac{2\times 122.5}{2\times 74.5} \Rightarrow \frac{367.5}{W} = \frac{122.5}{74.5}$$

W = 3 × 74.5 = 223.5 g

$$\frac{\text{Mass of } KClO_3}{\text{Mass of } O_2} = \frac{2\times 122.5}{3\times 32} \Rightarrow \frac{367.5}{W} = \frac{2\times 122.5}{3\times 32}$$

W = 144 g

Mass - volume analysis :

Now again consider decomposition of $KClO_3$

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

mass volume ratio : 2 × 122.5 g : 2 × 74.5 g : 3 × 22.7 lt. at STP

we can use two relation for volume of oxygen

$$\frac{\text{Mass of } KClO_3}{\text{volume of } O_2 \text{ at STP}} = \frac{2\times 122.5}{3\times 22.7 \text{ lt}} \quad \text{...(i)}$$

and $$\frac{\text{Mass of KCl}}{\text{volume of } O_2 \text{ at STP}} = \frac{2\times 74.5}{3\times 22.7 \text{ lt}} \quad \text{...(ii)}$$

Solved Examples

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

Sol. $2KClO_3 \longrightarrow 2KCl + 3O_2$

$$\frac{\text{mass of } KClO_3}{\text{volume of } O_2 \text{ at STP}} = \frac{2\times 122.5}{3\times 22.7 \text{ lt}} \Rightarrow \frac{367.5}{V} = \frac{2\times 122.5}{3\times 22.7 \text{ lt}}$$

V = 3 × 3 × 11.35 $\Rightarrow$ **V = 102.15 lt**

Mole-mole analysis :

This analysis is very much important for quantitative analysis point of view. Students are advised to clearly understand this analysis.

Now consider again the decomposition of $KClO_3$.

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

In very first step of mole-mole analysis you should read the balanced chemical equation like

2 moles $KClO_3$ on decomposition gives you 2 moles KCl and 3 moles O_2. and from the stoichiometry of reaction we can write

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

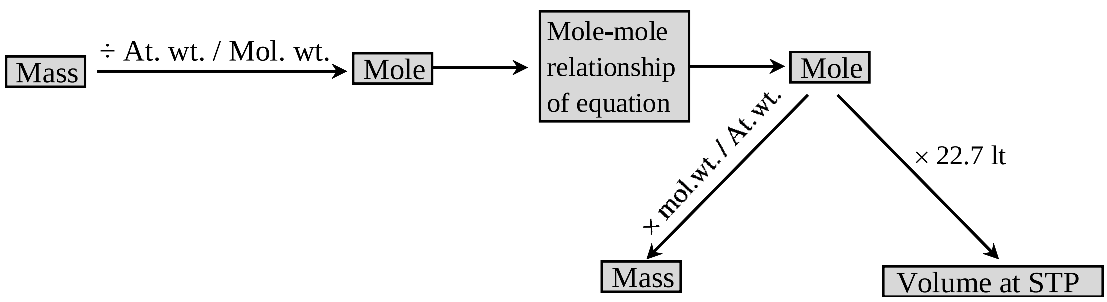
Now for any general balance chemical equation like

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

you can write.

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

Note : In fact mass-mass and mass-vol analysis are also interpreted in terms of mole-mole analysis you can use following chart also.



LIMITING REAGENT (L.R.) :

(i) The reactant which is completely consumed when a reaction goes to completion is called Limiting Reactant or Limiting reagent.

(ii) The reactant whose Stoichiometric amount is least, is limiting reactant.

Where ; Stoichiometric amount = $\dfrac{\text{Given moles of reactant}}{\text{Stoichiometric coefficient of reactant in balance Reaction}}$

(iii) For calculation of moles of product, LR should be used. When amounts of two or more than two reactants are given :

	aA	+	bB	$\longrightarrow$	cC	+	dD
Initial reacting mixture	n_A mol		n_B mol				
Stoichiometric amount	$\dfrac{n_A}{a}$		$\dfrac{n_B}{b}$				

If $\dfrac{n_A}{a} < \dfrac{n_B}{b} \Rightarrow$ A is limiting reagent.

If $\dfrac{n_A}{n_B} = \dfrac{a}{b}$ then reaction occurs to completion & no reactant is left at the end.

If $\dfrac{n_A}{a} > \dfrac{n_B}{b} \Rightarrow$ B is limiting reagent.

Ex. **28 gm Lithium is mixed with 48 gm O_2 to reacts according to the following reaction.**
$4Li + O_2 \longrightarrow 2Li_2O$
The mass of Li_2O formed is

Sol. $4Li + O_2 \longrightarrow 2Li_2O$

moles taken $\frac{28}{7} = 4$ $\quad \frac{48}{32} = 1.5$

$\frac{\text{moles taken}}{\text{stoich.coeff.}}$ $\quad \frac{4}{4} = 1$ (L.R.) $\quad \frac{1.5}{1} = 1.5$

Moles of Li_2O formed $= \frac{2}{4} \times 4 = 2$; Mass of Li_2O formed = 2 × 30 = 60 gm

Ex. **Calculate the mass of sucrose $C_{12}H_{22}O_{11}$ (s) produced by mixing 78 g of C(s), 11 g of H_2(g) & 67.2 litre of O_2 (g) at 0°C and 1 atm according to given reaction (unbalanced) ?**

Sol. $12C(s) + 11\,H_2(g) + \frac{11}{2}O_2 \rightarrow C_{12}H_{22}O_{11}\,(s)$

Moles taken $\frac{78}{12} = 6.5$ $\quad \frac{11}{2} = 5.5$ $\quad \frac{67.2}{22.4} = 3$

$\frac{\text{moles taken}}{\text{stoich.coeff.}}$ $\quad \frac{6.5}{12} = 0.54 = 0.5$ $\quad \frac{5.5}{11}$ (L.R.) $\quad \frac{3}{5.5} = 0.545$

$\therefore$ Moles of $C_{12}H_{22}O_{11}$ formed $= \frac{5.5}{11} = 0.5$

Mass of sucrose obtained = 0.5 × 342 = 171 grams.

PROBLEMS BASED ON MIXTURE :

The composition of any mixture may be determined by reacting the mixture with some substance, by which either one or more component of mixture may react.

Ex. ***1.5 gm mixture of SiO_2 and Fe_2O_3 on very strong heating leave a residue weighting 1.46 gm. The reaction responsible for loss of weight is***

$$Fe_2O_3\,(s) \rightarrow Fe_3O_4(s) + O_2(g)$$

What is the percentage by mass of Fe_2O_3 in original sample.

Sol. $3Fe_2O_3\,(s) \rightarrow 2Fe_3O_4 + \frac{1}{2}O_2$

$3 \times 160 = 480$ gm $\rightarrow$ $\quad \frac{1}{2} \times 32 = 16$ gm

loss of 16 gm $\rightarrow$ 480 gm Fe_2O_3

loss of 0.04 gm $\rightarrow 0.04 \times \frac{480}{16} = 1.2$ gm Fe_2O_3

% by mass $= \frac{1.2}{1.5} \times 100 = 80\%$

In general, when a reaction is carried out in the laboratory we do not obtain actually the theoretical amount of the product. The amount of the product that is actually obtained is called the actual yield. Knowing the actual yield and theorectical yield the percentage yield can be calculate as :

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

The percentage yield of any product is always equal to the percentage extent of that reaction.

Ex. ***Aluminium reacts with sulphur to form aluminium sulphide. If 5.4 gm of Aluminium reacts with 12.8gm sulphure gives 12gm of aluminium sulphides, then the percent yield of the reaction is-***

Sol $2Al + 3S \longrightarrow Al_2S_3$

Mole taken $\frac{5.4}{27}\text{gm} = 0.2$; $\frac{12.8}{32}\text{gm} = 0.4$

$\frac{\text{moles taken}}{\text{stoich. coeff.}}$: $\frac{0.2}{2} = 0.1$ (L.R.) ; $\frac{0.4}{3} = 0.133$

moles of Al_2S_3 formed $= \frac{1}{2} \times 0.2 = 0.1$

mass $= 0.1 \times 150 = 15$ gm

$$\%\text{ yield} = \frac{\text{actual yield}}{\text{theoritical yield}} \times 100 = \frac{12}{15} \times 100 = 80\ \%$$

PERCENTAGE PURITY :

The percentage of a specified compound or element in an impure sample may be given as

$$\boxed{\%\text{ purity} = \frac{\text{Actual mass of compound}}{\text{Total mass of sample}} \times 100}$$

If impurity is unknown, it is always considered as inert (unreactive) material.

Ex. ***A chalk sample exactly requires 17.52 gram HCl for complete reaction with all $CaCO_3$ present in it. If the chalk sample is 72% pure, the mass of sample taken is***

Sol. $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Moles of HCl $= \frac{17.52}{36.5}$

Moles of $CaCO_3 = \frac{1}{2} \times \frac{17.52}{36.5}$

Weight of $CaCO_3$ required $= \frac{1}{2} \times \frac{17.52}{36.5} \times 100$

Mass of sample taken :

$$= \frac{1}{2} \times \frac{17.52}{36.5} \times \frac{100 \times 100}{72} = 33.33 \text{ gm}$$

PROBLEMS RELATED WITH SEQUENTIAL REACTION :

When one of products formed in previous reaction is consumed in the next one.

Ex. $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$
$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$
$3NO_2(g) + H_2O(\ell) \rightarrow 2HNO_3(aq.) + NO(g)$

Ex. ***How many grams H_2SO_4 can be obtained from 1320 gm PbS as per reaction sequence ?***
$2PbS + O_2 \longrightarrow 2PbO + 2SO_2$
$3SO_2 + 2HNO_3 + 2H_2O \longrightarrow 3H_2SO_4 + 2NO$
[At. mass : Pb = 208, S = 32]

Sol. Moles of PbS = $\frac{1320}{240}$ = 5.5 mol
Moles of SO_2 = 5.5 mol = moles of H_2SO_4
Mass of H_2SO_4 = 5.5 × 98 = 539 gm
[When amount of only one reactant is given generally other is assumed in excess.]

PROBLEM RELATED WITH PARALLEL REACTION :
When same two reactants form two or more products by independent reactions.

Ex. $KClO_3 \longrightarrow KCl + O_2$
$KClO_3 \longrightarrow KClO + KClO_4$

Ex. ***Carbon reacts with oxygen forming carbon monoxide and/or carbon dioxide depending an availablity of oxygen. Find moles of each product obtained when 160 gm oxygen reacts with (a) 12 g carbon (b) 120 g carbon (c) 72 g carbon.***

Sol. **(a)** $C + \frac{1}{2}O_2 \longrightarrow CO$ [initially use a reaction using lesser amount of oxygen]

	C	$\frac{1}{2}O_2$	CO
t = 0	1mol	5mol	
t =∞	0 (LR)	5–0.5 = 4.5mol	1mol

Since CO & O_2 are left CO_2 is formed.

$CO + \frac{1}{2}O_2 \longrightarrow CO_2$

	CO	$\frac{1}{2}O_2$	CO_2
t = 0	1mol	4.5mol	0
t = ∞	0	4 mol	1 mol

At end 1 mole CO_2 & no CO present

(b) $C + \frac{1}{2}O_2 \longrightarrow CO$

	C	$\frac{1}{2}O_2$	CO
t = 0	10mol	5mol	0
t =∞	0	0	10mol

At end only 10 mol CO present.

(c) $C + \frac{1}{2}O_2 \longrightarrow CO$

	C	$\frac{1}{2}O_2$	CO
t = 0	6mol	5mol	0
t =∞	0 [LR]	2mol	6mol

$CO + \frac{1}{2}O_2 \longrightarrow CO_2$

	CO	$\frac{1}{2}O_2$	CO_2
t = 0	6mol	2mol	0
t =∞	2mol	0 [LR]	4mol

At end [2mol CO + 4mol CO_2] left.

Ex. ***25.4 gm of iodine and 14.2 gm of chlorine are made to react completely to yield mixture of ICl and ICl_3. Ratio of moles of ICl & ICl_3 formed is (Atomic mass : I = 127, Cl = 35.5)***

Sol.

I_2 +	$Cl_2 \longrightarrow$	ICl +	ICl_3
0.1mol	0.2 mol	x mol	y mol

$\Rightarrow$ 0.2=x+y $\quad\Rightarrow\quad$ x=0.1

0.4=x+3y $\quad\Rightarrow\quad$ y=0.1

Ans. 1 : 1

PRINCIPLE OF ATOM CONSERVATION (POAC)

POAC is nothing but the conservation of atoms of reactants and products involved in a chemical reaction. And if atoms are conserved, moles of atoms shall also be conserved. The principle is fruitful for the students when they don't get the idea of balanced chemical equation in the problem using POAC we do not need to balance a reaction and we can even add two or more reactions. This principle can be understood by the following example.

Consider the decomposition of $KClO_3$ (s) $\rightarrow$ KCl (s) + O_2 (g) (unbalanced chemical reaction)

Apply the principle of atom conservation (POAC) for K atoms.

or moles of K atoms in $KClO_3$ = moles of K atoms in KCl

Now, since 1 molecule of $KClO_3$ contains 1 atom of K

Thus, moles of K atoms in $KClO_3$ = 1 × moles of $KClO_3$

and moles of K atoms in KCl = 1 × moles of KCl

$\therefore$ moles of $KClO_3$ = moles of KCl or $\dfrac{\text{wt. of } KClO_3 \text{ in g}}{\text{mol. wt. of } KClO_3} = \dfrac{\text{wt. of KCl in g}}{\text{mol. wt. of KCl}}$

- The above equation gives the mass-mass relationship between $KClO_3$ and KCl which is important in stoichiometric calculations.Again, applying the principle of atom conservation for O atoms,

moles of O in $KClO_3$ = 3 × moles of $KClO_3$

moles of O in O_2 = 2 × moles of O_2

$\therefore$ 3 × moles of $KClO_3$ = 2 × moles of O_2

or $\quad 3 \times \dfrac{\text{wt. of } KClO_3}{\text{mol. wt. of } KClO_3} = 2 \times \dfrac{\text{vol. of } O_2 \text{ at 1atm and } 0°C}{\text{Molar vol. (22.4 lt)}}$

- The above equations thus gives the mass-volume relationship of reactants and products.

Ex. ***Calcium phosphide Ca_3P_2 formed by reacting magnesium with excess calcium orthophosphate $Ca_3(PO_4)_2$, was hydrolysed by excess water. The evolved phosphine PH_3 was burnt in air to yield phosphrous pentoxide (P_2O_5). How many gram of magnesium metaphosphate would be obtain if 192 gram Mg were used (Atomic weight of Mg = 24, P = 31)***

$$Ca_3(PO_4)_2 + Mg \longrightarrow Ca_3P_2 + MgO$$

$$Ca_3P_2 + H_2O \longrightarrow Ca(OH)_2 + PH_3$$

$$PH_3 + O_2 \longrightarrow P_2O_5 + H_2O$$

$$MgO + P_2O_5 \longrightarrow Mg(PO_3)_2$$

magnesium metaphosphate.

Sol. POAC on Mg

$1 \times n_{Mg} = 1 \times n_{Mg(PO_3)_2} \quad ; \quad \dfrac{192}{24} = n_{Mg(PO_3)_2}$

$W_{Mg(PO_3)_2} = \dfrac{192}{24} \times 182\text{gm}$ = 1456 gm.

Ex. ***27.6 g K_2CO_3 was treated by a series of reagents so as to convert all of its carbon to $K_2Zn_3[Fe(CN)_6]_2$. Calculate the weight of the product. [mol. wt. of K_2CO_3 = 138 and mol. wt. of $K_2Zn_3[Fe(CN)_6]_2$ = 698]***

Sol. Here we have no knowledge about series of chemical reactions but we know about initial reactant and final product, accordingly.

$$K_2CO_3 \xrightarrow[\text{Steps}]{\text{Several}} K_2Zn_3[Fe(CN)_6]_2$$

Since C atoms are conserved, applying POAC for C atoms,

moles of C in K_2CO_3 = moles of C in $K_2Zn_3[Fe(CN)_6]_2$

1 × moles of K_2CO_3 = 12 × moles of $K_2Zn_3[Fe(CN)_6]_2$

($\because$ 1 mole of K_2CO_3 contains 1 moles of C)

$$\frac{\text{wt. of } K_2CO_3}{\text{mol. wt. of } K_2CO_3} = 12 \times \frac{\text{wt. of the product}}{\text{mol. wt. of product}}$$

$$\textbf{wt. of } K_2Zn_3[Fe(CN)_6]_2 = \frac{27.6}{138} \times \frac{698}{12} = \textbf{11.6 g}$$

Oxidation & Reduction

Let us do a comparative study of oxidation and reduction :

Oxidation	**Reduction**
1. Addition of Oxygen e.g. $2Mg + O_2 \rightarrow 2MgO$	1. Removal of Oxygen e.g. $CuO + C \rightarrow Cu + CO$
2. Removal of Hydrogen e.g. $H_2S + Cl_2 \rightarrow 2HCl + S$	2. Addition of Hydrogen e.g. $S + H_2 \rightarrow H_2S$
3. Increase in positive charge e.g. $Fe^{2+} \rightarrow Fe^{3+} + e^-$	3. Decrease in positive charge e.g. $Fe^{3+} + e^- \rightarrow Fe^{2+}$
4. Increase in oxidation number e.g. $\overset{(+2)}{SnCl_2} \rightarrow \overset{(+4)}{SnCl_4}$	4. Decrease in oxidation number e.g. $\overset{(+7)}{MnO_4^-} \rightarrow \overset{(+2)}{Mn^{2+}}$
5. Removal of electron e.g. $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$	5. Addition of electron e.g. $Fe^{3+} + e^- \rightarrow Fe^{2+}$

Oxidation Number

- It is an imaginary or apparent charge developed over atom of an element when it goes from its elemental free state to combined state in molecules.
- It is calculated on basis of an arbitrary set of rules.
- It is a relative charge in a particular bonded state.
- In order to keep track of electron-shifts in chemical reactions involving formation of compounds, a more practical method of using oxidation number has been developed.
- In this method, it is always assumed that there is a complete transfer of electron from a less electronegative atom to a more electronegative atom.

Rules governing oxidation number

The following rules are helpful in calculating oxidation number of the elements in their different compounds. It is to be remembered that the basis of these rule is the electronegativity of the element .

- **Fluorine atom :**
  Fluorine is most electronegative atom (known). It always has oxidation number equal to –1 in all its compounds

- **Oxygen atom :**
  In general and as well as in its oxides , oxygen atom has oxidation number equal to –2.

In case of (i) peroxide (e.g. H_2O_2 , Na_2O_2) is –1,
(ii) super oxide (e.g. KO_2) is –1/2
(iii) ozonide (e.g. KO_3) is –1/3
(iv) in OF_2 is + 2 & in O_2F_2 is +1

- **Hydrogen atom :**
  In general, H atom has oxidation number equal to +1. But in metallic hydrides (e.g. NaH, KH), it is –1.

- **Halogen atom :**
  In general, all halogen atoms (Cl, Br , I) have oxidation number equal to –1.
  But if halogen atom is attached with a more electronegative atom than halogen atom, then it will show positive oxidation numbers.

e.g. $K\overset{+5}{Cl}O_3$, $H\overset{+5}{I}O_3$, $H\overset{+7}{Cl}O_4$, $K\overset{+5}{Br}O_3$

- **Metals :**
  (a) Alkali metal (Li , Na, K, Rb, ...) always have oxidation number +1
  (b) Alkaline earth metal (Be , Mg , Ca ....) always have oxidation number +2.
  (c) Aluminium always has +3 oxidation number

Note : Metal may have negative or zero oxidation number

- Oxidation number of an element in free state or in allotropic forms is always zero

e.g. $\overset{0}{O}_2$, $\overset{0}{S}_8$, $\overset{0}{P}_4$, $\overset{0}{O}_3$

- Sum of the oxidation numbers of atoms of all elements in a molecule is zero.
- Sum of the oxidation numbers of atoms of all elements in an ion is equal to the charge on the ion .
- If the group number of an element in modern periodic table is ***n,*** then its oxidation number may vary from ***(n – 10)*** to ***(n – 18)*** (but it is mainly applicable for p-block elements).

e.g. N- atom belongs to 15th group in the periodic table, therefore as per rule, its oxidation number may vary from

–3 to +5 ($\overset{-3}{N}H_3$, $\overset{+2}{N}O$, $\overset{+3}{N}_2O_3$, $\overset{+4}{N}O_2$, $\overset{+5}{N}_2O_5$)

- The maximum possible oxidation number of any element in a compound is never more than the number of electrons in valence shell.(but it is mainly applicable for p-block elements)

Calculation of average oxidation number :

Solved Examples

Ex. ***Calculate oxidation number of underlined element*** **:**
(a) $Na_2\underline{S}_2O_3$ **(b)** $Na_2\underline{S}_4O_6$

Sol. (a) Let oxidation number of S-atom is x. Now work accordingly with the rules given before .
$(+1) \times 2 + (x) \times 2 + (-2) \times 3 = 0$
$x = + 2$

(b) Let oxidation number of S-atom is x
$\therefore \quad (+1) \times 2 + (x) \times 4 + (-2) \times 6 = 0 \Rightarrow x = + 2.5$

❍ It is important to note here that $Na_2S_2O_3$ have two S-atoms and there are four S-atom in $Na_2S_4O_6$. However none of the sulphur atoms in both the compounds have + 2 or + 2.5 oxidation number, it is the average of oxidation number, which reside on each sulphur atom. Therefore, we should work to calculate the individual oxidation number of each sulphur atom in these compounds.

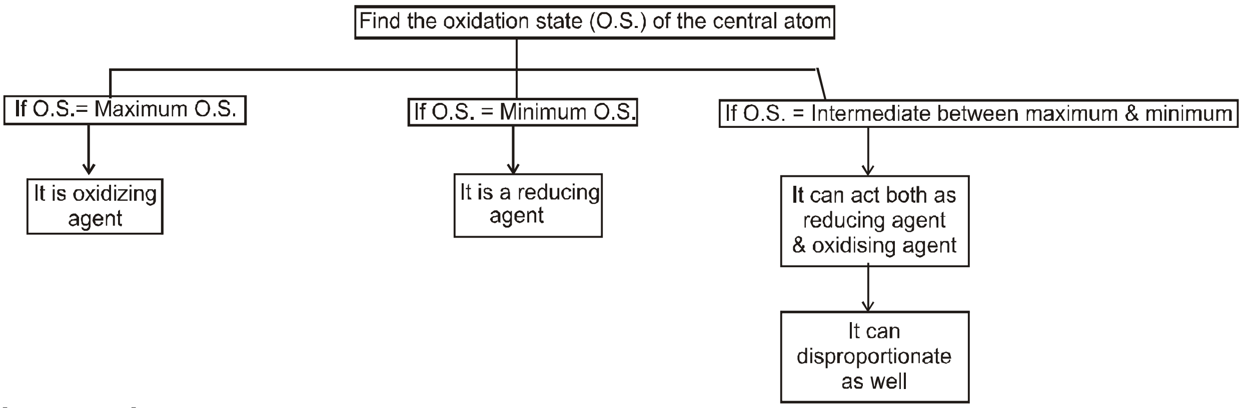
Oxidising and reducing agent

- **Oxidising agent or Oxidant :**
  Oxidising agents are those compounds which can oxidise others and reduce itself during the chemical reaction. Those reagents in which for an element, oxidation number decreases or which undergoes gain of electrons in a redox reaction are termed as oxidants.
  e.g. $KMnO_4$, $K_2Cr_2O_7$, HNO_3, conc.H_2SO_4 etc are powerful oxidising agents .

- **Reducing agent or Reductant :**
  Reducing agents are those compounds which can reduce other and oxidise itself during the chemical reaction. Those reagents in which for an element, oxidation number increases or which undergoes loss of electrons in a redox reaction are termed as reductants.
  e.g. KI , $Na_2S_2O_3$ etc are the powerful reducing agents.

Note : ***There are some compounds also which can work both as oxidising agent and reducing agent***
e.g. H_2O_2, NO_2^-

HOW TO IDENTIFY WHETHER A PARTICULAR SUBSTANCE IS AN OXIDISING OR A REDUCING AGENT



Redox reaction

A reaction in which oxidation and reduction simultaneously take place is called a redox reaction
In all redox reactions, the total increase in oxidation number must be equal to the total decrease in oxidation number.

e.g. $10\overset{+2}{Fe}SO_4 + 2K\overset{+5}{Mn}O_4 + 8H_2SO_4 \longrightarrow 5\overset{+3}{Fe}_2(SO_4)_3 + 2\overset{+2}{Mn}SO_4 + K_2SO_4 + 8H_2O$

Disproportionation Reaction :

A redox reaction in which same element present in a particular compound in a definite oxidation state is oxidized as well as reduced simultaneously is a disproportionation reaction.
Disproportionation reactions are a special type of redox reactions. One of the reactants in a disproportionation reaction always contains **an element that can exist in at least three oxidation states**. The element in the form of reacting substance is in the intermediate oxidation state and both higher and lower oxidation states of that element are formed in the reaction. For example :

$$2H_2\overset{-1}{O}_2(aq) \longrightarrow 2H_2\overset{-2}{O}(\ell) + \overset{0}{O}_2(g)$$

$$\overset{0}{S}_8(s) + 12OH^-(aq) \longrightarrow 4\overset{-2}{S}{}^{2-}(aq) + 2\overset{+2}{S}_2O_3^{2-}(aq) + 6H_2O(\ell)$$

$$\overset{0}{Cl}_2(g) + 2OH^-(aq) \longrightarrow \overset{+1}{Cl}O^-(aq) + \overset{-1}{Cl}{}^-(aq) + H_2O(\ell)$$

Consider the following reactions :

(a) $2KClO_3 \longrightarrow 2KCl + 3O_2$

$KClO_3$ plays a role of oxidant and reductant both. Here, Cl present in $KClO_3$ is reduced and O present in $KClO_3$ is oxidized. Since same element is not oxidized and reduced, so **it is not a disproportionation reaction,** although it looks like one.

(b) $NH_4NO_2 \longrightarrow N_2 + 2H_2O$

Nitrogen in this compound has -3 and +3 oxidation number, which is not a definite value. So it is not a disproportionation reaction. It is an example of comproportionation reaction, which is a class of redox reaction in which an element from two different oxidation state gets converted into a single oxidation state.

(c) $4K\overset{+5}{Cl}O_3 \longrightarrow 3K\overset{+7}{Cl}O_4 + K\overset{-1}{Cl}$

It is a case of disproportionation reaction and Cl atom is disproportionating.

List of some important disproportionation reactions

1. $H_2O_2 \longrightarrow H_2O + O_2$
2. $X_2 + OH^-(\text{dil.}) \longrightarrow X^- + XO^-$ (X = Cl, Br, I)
3. $X_2 + OH^-(\text{conc.}) \longrightarrow X^- + XO_3^-$

F_2 does not undergo disproportionation as it is the most electronegative element.

4. $(CN)_2 + OH^- \longrightarrow CN^- + OCN^-$
5. $P_4 + OH^- \longrightarrow PH_3 + H_2PO_2^-$
6. $S_8 + OH^- \longrightarrow S^{2-} + S_2O_3^{2-}$
7. $MnO_4^{2-} \longrightarrow MnO_4^- + MnO_2$
8. Oxyacids of Phosphorus (+1, +3 oxidation number)
   $H_3PO_2 \longrightarrow PH_3 + H_3PO_3$
   $H_3PO_3 \longrightarrow PH_3 + H_3PO_4$
9. Oxyacids of Chlorine(Halogens)(+1, +3, +5 Oxidation number)
   $ClO^- \longrightarrow Cl^- + ClO_2^-$
   $ClO_2^- \longrightarrow Cl^- + ClO_3^-$
   $ClO_3^- \longrightarrow Cl^- + ClO_4^-$
10. $HNO_2 \longrightarrow NO + HNO_3$

- Reverse of disproportionation is called **Comproportionation.** In some of the disproportionation reactions, by changing the medium (from acidic to basic or reverse), the reaction goes in backward direction and can be taken as an example of **Comproportionation reaction.**

$$I^- + IO_3^- + H^+ \longrightarrow I_2 + H_2O$$

Balancing of redox reactions

All balanced equations must satisfy two criteria.

1. Atom balance (mass balance) :
There should be the same number of atoms of each kind on reactant and product side.

2. Charge balance :
The sum of actual charges on both sides of the equation must be equal.
There are two methods for balancing the redox equations :
1. Oxidation - number change method
2. Ion electron method or half cell method

- Since First method is not very much fruitful for the balancing of redox reactions, students are advised to use second method (Ion electron method) to balance the redox reactions

Ion electron method : By this method redox equations are balanced in two different medium.
(a) Acidic medium (b) Basic medium

- **Balancing in acidic medium**

  Students are adviced to follow the following steps to balance the redox reactions by Ion electron method in acidic medium

Solved Examples

Ex. Balance the following redox reaction :

$FeSO_4 + KMnO_4 + H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + MnSO_4 + H_2O + K_2SO_4$

Sol. **Step–I** Assign the oxidation number to each element present in the reaction.

$$\overset{+2}{Fe}\,\overset{+6}{S}\,\overset{-2}{O_4} + \overset{+1}{K}\,\overset{+7}{Mn}\,\overset{-2}{O_4} + \overset{+1}{H_2}\,\overset{+6}{S}\,\overset{-2}{O_4} \longrightarrow \overset{+3}{Fe_2}(\overset{+6}{S}\,\overset{-2}{O_4})_3 + \overset{+2}{Mn}\,\overset{+6}{S}\,\overset{-2}{O_4} + \overset{+1}{H_2}\overset{-2}{O}$$

Step II :

Now convert the reaction in Ionic form by eliminating the elements or species, which are not undergoing either oxidation or reduction.

$$Fe^{2+} + \overset{+7}{Mn}O_4^- \longrightarrow Fe^{3+} + Mn^{2+}$$

Step III :

Now identify the oxidation / reduction occuring in the reaction

undergoes reduction.

$$Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$$

undergoes oxidation.

Step IV : Spilt the Ionic reaction in two half, one for oxidation and other for reduction.

$$Fe^{2+} \xrightarrow{\text{oxidation}} Fe^{3+} \quad \Big| \quad MnO_4^- \xrightarrow{\text{Reduction}} Mn^{2+}$$

Step V :

Balance the atom other than oxygen and hydrogen atom in both half reactions

$$Fe^{2+} \longrightarrow Fe^{3+} \quad \Big| \quad MnO_4^- \longrightarrow Mn^{2+}$$

Fe & Mn atoms are balanced on both side.

Step VI :

Now balance O & H atom by H_2O & H^+ respectively by the following way : For one excess oxygen atom, add one H_2O on the other side and two H^+ on the same side.

$Fe^{2+} \longrightarrow Fe^{3+}$ (no oxygen atom) ....(i)

$8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ ....(ii)

Step VII :

Equation (i) & (ii) are balanced atomwise. Now balance both equations chargewise. To balance the charge, add electrons to the electrically positive side.

$Fe^{2+} \xrightarrow{\text{oxidation}} Fe^{3+} + e^-$ ....(1)

$5e^- + 8H^+ + MnO_4^- \xrightarrow{\text{Reduction}} Mn^{2+} + 4H_2O$ ....(2)

Step VIII :

The number of electrons gained and lost in each half -reaction are equalised by multiplying both the half reactions with a suitable factor and finally the half reactions are added to give the overall balanced reaction. Here, we multiply equation (1) by 5 and (2) by 1 and add them :

$$Fe^{2+} \longrightarrow Fe^{3+} + e^- \quad ....(1) \times 5$$

$$5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O \quad ....(2)\times 1$$

$$5Fe^{2+} + 8H^+ + MnO_4^- \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

(Here, at his stage, you will get balanced redox reaction in Ionic form)

Step IX :

Now convert the Ionic reaction into molecular form by adding the elements or species, which are removed in step (2).

Now, by some manipulation, you will get :

$$5\,FeSO_4 + KMnO_4 + 4H_2SO_4 \longrightarrow \frac{5}{2}\,Fe_2(SO_4)_3 + MnSO_4 + 4H_2O + \frac{1}{2}\,K_2SO_4$$

or $$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \longrightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + 8H_2O + K_2SO_4.$$

- **Balancing in basic medium :**

  In this case, except step VI, all the steps are same. We can understand it by the following example:

Solved Examples

Ex. Balance the following redox reaction in basic medium :

$$ClO^- + CrO_2^- + OH^- \longrightarrow Cl^- + CrO_4^{2-} + H_2O$$

Sol. By using upto step V, we will get :

$$\overset{+1}{Cl}O^- \xrightarrow{\text{Reduction}} Cl^- \quad \Big| \quad \overset{+3}{Cr}O_2^- \xrightarrow{\text{Oxidation}} \overset{+6}{Cr}O_4^{2-}$$

Now, students are advised to follow step VI to balance 'O' and 'H' atom.

$$2H^+ + ClO^- \longrightarrow Cl^- + H_2O \quad \Big| \quad 2H_2O + CrO_2^- \longrightarrow CrO_4^{2-} + 4H^+$$

- Now, since we are balancing in basic medium, therefore add as many as OH^- on both side of equation as there are H^+ ions in the equation.

$$2OH^- + 2H^+ + ClO^- \longrightarrow Cl^- + H_2O + 2OH^- \quad \Big| \quad 4OH^- + 2H_2O + CrO_2^- \longrightarrow CrO_4^{2-} + 4H^+ + 4OH^-$$

Finally you will get | Finally you will get

$$H_2O + ClO^- \longrightarrow Cl^- + 2OH^- \quad ....(i) \quad \Big| \quad 4OH^- + CrO_2^- \longrightarrow CrO_4^{2-} + 2H_2O \quad .... (ii)$$

Now see equation (i) and (ii) in which O and H atoms are balanced by OH^- and H_2O

Now from step VIII

$$2e^- + H_2O + ClO^- \longrightarrow Cl^- + 2OH^- \quad .... (i)\ \times 3$$

$$4OH^- + CrO_2^- \longrightarrow CrO_4^{2-} + 2H_2O + 3e^- \quad .... (ii)\ \times 2$$

Adding : $3ClO^- + 2CrO_2^- + 2OH^- \longrightarrow 3Cl^- + 2CrO_4^{2-} + H_2O$

SOLUTIONS

A solution is a homogenous mixture of two or more pure substances whose composition may be altered within certain limits. Though the solution is homogenous in nature, yet it retains the properties of its constituents.

Generally solution is composed of two components, solute and solvent. Such type of solution is known as binary solutions.

Solvent is that component in solution whose physical state is the same as that of the resulting solution while other component is called as solute. If the physical state of both component is same, than the component in excess is known as solvent and other one is called as solute. Each component in a binary solution can be in any physical state such as liquid, solid and gaseous state.

CONCENTRATION TERMS :

The concentration of a solution is the amount of solute dissolved in a known amount of the solvent or solution. Solution can be described as dilute or concentrated solution as per their concentration. A dilute solution has a very small quantity of solute while concentrated solution has a large quantity of solute in solution. Various concentration terms are as follows.

Mass percentage :

It may be defined as the number of parts of mass of solute per hundred parts by mass of solution.

$$\textbf{\% by mass} \left(\frac{w}{W}\right) \textbf{:} = \frac{\text{wt. of solute}}{\text{wt. of solution}} \times 100$$

[X % by mass means 100 gm solution contains X gm solute ; $\therefore$ (100 – X) gm solvent]

Mass-volume percentage (W/V %) :

It may be defined as the mass of solute present in 100 cm^3 of solution. For example, If 100 cm^3 of solution contains 5 g of sodium hydroxide, than the mass-volume percentage will be 5% solution.

$$\textbf{\%} \left(\frac{w}{V}\right) = \frac{\text{wt. of solute}}{\text{volume of solution}} \times 100 \text{ [for liq. solution]}$$

[X % $\left(\frac{w}{V}\right)$ means 100 ml solution contains X gm solute]

Volume Percent :

It can be represented as % v/v or % volume and used to prepare such solutions in which both components are in liquids state. It is the number of parts of by volume of solute per hundred parts by volume of solution. Therefore,

$$\textbf{\%} \left(\frac{v}{V}\right) = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100$$

Mole % $= \dfrac{\text{Moles of solute}}{\text{Total moles}} \times 100$

- For gases **% by volume** is same as **mole %**

Mole Fraction (X) :

Mole fraction may be defined as the ratio of number of moles of one component to the total number of moles of all the components (solute and solvent) present in solution. It is denoted by letter X and the sum of all mole fractions in a solution always equals one.

$$\text{Mole fraction (X)} = \frac{\text{Moles of solute}}{\text{Total moles}}$$

Mole fraction does not depend upon temperature and can be extended to solutions having more than two components.

Molarity (M) :

Molarity is most common unit for concentration of solution. It is defined as the number of moles of solute present in one litre or one dm^3 of the solution or millimol of solute present in one mL of solution.

$$\text{Molarity (M)} = \frac{\text{Mole of solute}}{\text{volume of solution in litre}}$$

Molality (m) : The number of gram mole of the solute present in 1000 g of the solvent is known as molality of solution. It represented by letter 'm'.

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$$

The unit of molality is mol/kg and it does not effect by temperature.

Parts per million (ppm) : The very low concentration of solute in solution can be expressed in ppm. It is the numbers of parts by mass of solute per million parts by mass of the solution.

$$\text{Parts per million (ppm)} = \frac{\text{Mass of solute}}{\text{Mass of solvent}} \times 10^6 \cong \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

Get yourselves very much confortable in their inter conversion. It is very handy.

Concentration Type	Mathematical Formula	Concept
Percentage by mass	$\%\left(\frac{w}{w}\right) = \frac{\text{Mass of solute} \times 100}{\text{Mass of solution}}$	Mass of solute present in 100 gm of solution.
Volume percentage	$\%\left(\frac{v}{v}\right) = \frac{\text{Volume of solute} \times 100}{\text{Volume of solution}}$	Volume of solute present in 100 cm^3 of solution.
Mass-volume percentage	$\%\left(\frac{w}{v}\right) = \frac{\text{Mass of solute} \times 100}{\text{Volume of solution}}$	Mass of solute present in 100 cm^3 of solution.
Parts per million	$\text{ppm} = \frac{\text{Mass of solute} \times 10^6}{\text{Mass of solution}}$	Parts by mass of solute per million parts by mass of the solution
Mole fraction	$X_A = \frac{\text{Mole of A}}{\text{Mole of A} + \text{Mole of B} + \text{Mole of C} + ...}$ $X_B = \frac{\text{Mole of B}}{\text{Mole of A} + \text{Mole of B} + \text{Mole of C} + ...}$	Ratio of number of moles of one component to the total number of moles.

Molarity	$M = \dfrac{\text{Mole of solute}}{\text{Volume of solution (in L)}}$	Moles of solute in one litre of solution.
Molality	$m = \dfrac{\text{Mass of solute} \times 1000}{\text{Molar mass of solute} \times \text{Mass of solvent(g)}}$	Moles of solute in one kg of solvent

Ex. ***Calculate the mole fractions of the components of the solution composed by 92 g glycerol and 90 g water ? (M (water) = 18 ; M (glycerol) = 92)***

Sol. Moles of water = 90 g / 18 g = 5 mol water
Moles of glycerol = 92 g / 92 g = 1 mol glycerol
Total moles in solution = 5 + 1 = 6 mol
Mole fraction of water = 5 mol / 6 mol = 0.833
Mole fraction of glycerol = 1 mol / 6 mol = 0.167

Ex. ***What will be the Molarity of solution when water is added to 10 g $CaCO_3$ to make 100 mL of solution?***

Sol. Mol of $CaCO_3$ = 10 / 100 = 0.1
Molarity = Mole of solute / Volume of solution (L) = 0.10 mol / 0.10 L
Therefore ; Molarity of given solution = 1.0 M

Ex. ***Calculate the molality of a solution containing 20 g of sodium hydroxide (NaOH) in 250 g of water?***

Sol. Moles of sodium hydroxide = 20 / 40 = 0.5 mol NaOH
250 gm = 0.25 kg of water
Hence molality of solution = Mole of solute / Mass of solvent (kg)= 0.5 mol / 0.25 kg
or Molality(m) = 2.0 m

Ex. ***Calculate the grams of copper sulphate ($CuSO_4$) needed to prepare 250.0 mL of 1.00 M $CuSO_4$?***

Sol. Moles of $CuSO_4$ = M × V = $1 \times \dfrac{250}{1000}$
Molar mass of copper sulphate = 159.6 g/mol
Hence Mass of copper sulphate (gm) = Moles of $CuSO_4$ × Molar mass of copper sulphate.

$$= 1 \times \frac{250}{1000} \times 159.6 \text{ g/mol}$$

= 39.9 gm of Copper sulphate

Ex. ***How many grams of H_2SO_4 are present in 500 ml of 0.2M H_2SO_4 solution ?***

Sol. $M = \dfrac{\text{moles}}{\text{vol.}} \Rightarrow$ moles of H_2SO_4 = M × V = $0.2 \times \dfrac{500}{1000}$ L = 0.1

Mass of H_2SO_4 = 0.1 × 98 = 9.8 g

Ex. ***Calculate the ppm of mercury in water in given sample contain 30 mg of Hg in 500 ml of solution.***

Sol. Parts per million = $\dfrac{\text{Mass of solute} \times 10^6}{\text{Mass of solution}}$

Mass of Hg = 30 mg

Mass of water = 500/1 = 500g = 50×10^4 mg

(density = mass / volume ; density of water 1 g / ml) $w = \frac{v}{d}$

Therefore, ppm of mercury = $\frac{30 \times 10^6}{50 \times 10^4}$ = 60 ppm of mercury

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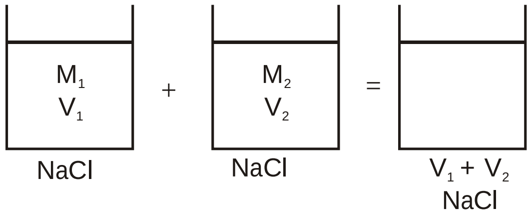
MIXING OF SOLUTIONS :

It is based on law of conservation of moles.

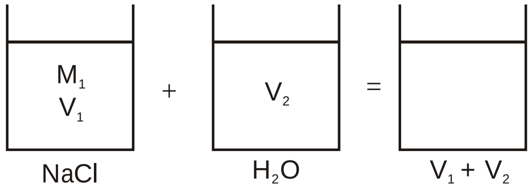
(i) Two solutions having same solute

Final molarity = $\frac{\text{Total moles}}{\text{Total volume}} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$



(ii) Dilution Effect : When a solution is diluted, the moles of solute do not change but molarity changes while on taking out a small volume of solution from a larger volume, the molarity of solution do not change but moles change proportionately.

Final molarity = $\frac{M_1V_1}{V_1 + V_2}$



n-fold or n-times dilution

$\Rightarrow$ **Final volume = $V_1 + V_2 = n(V_1)$**

Ex. ***50 ml 0.2 M H_2SO_4 is mixed with 50 ml 0.3M H_2SO_4. Find molarity of final solution.***

Sol. $M_f = \frac{\text{Total moles of } H_2SO_4}{\text{Total volume}} = \frac{50 \times 0.2 \times 10^{-3} + 50 \times 10^{-3} \times 0.3}{(50+50) \times 10^{-3}} = \boxed{0.25\,M}$

Ex. ***Find final molarity in each case :***

Sol. (i) 500 ml 0.1 M HCl + 500 ml 0.2M HCl

$$M_f = \frac{500 \times 0.1 + 500 \times 0.2}{500 + 500} = \boxed{0.15\,M}$$

(ii) 50 ml 0.1M HCl + 150 ml 0.3MHCl + 300 ml H_2O

$$M_f = \frac{50 \times 0.1 + 150 \times 0.3}{50 + 150 + 300} = \frac{50}{500} = 0.1\ M$$

(iii) 4.9g H_2SO_4 + 250 ml H_2O + 250 ml 0.1 M H_2SO_4

$$M_f = \frac{\frac{4.9}{98} + \frac{250}{1000} \times 0.1}{\left(\frac{250+250}{1000}\right)} = \frac{50+25}{500} = \boxed{0.15\,M}$$

Ex. ***How much water should be added to 2M HCl solution to form 1 litre of 0.5 M HCl ?***

Sol. Let V be initial volume

Then mol of HCl = constant

$2 \times V = 1 \times 0.5 \Rightarrow V = 0.25$ L

Volume of water added = 1 – 0.25 = 0.75 L

Ex. ***Find number of Na^+ & PO_4^{-3} ions in 250 ml of 0.2M Na_3PO_4 solution.***

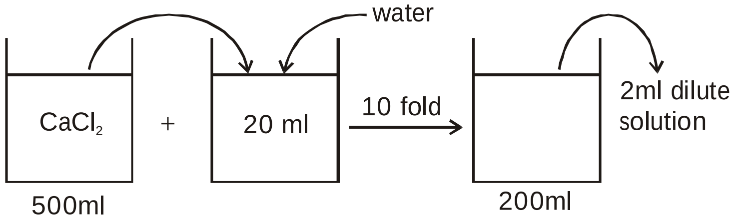
Sol. $Na_3PO_4 + aq. \longrightarrow 3Na^+(aq) + PO_4^{-3}(aq)$ [Ionic compound when added to water ionize completely].

50 millimoles (m.m.) 150 mm 50 mm

No. of Na^+ ions = $150 \times 10^{-3} \times N_A$; No. of PO_4^{-3} ions = $50 \times 10^{-3} \times N_A$

Ex. ***1.11g $CaCl_2$ is added to water forming 500 ml of solution. 20 ml of this solution is taken and diluted 10 folds. Find moles of Cl^- ions in 2 ml of diluted solution.***

Sol. $\frac{1.11}{111} = 0.01$ mol $CaCl_2$



Moles of $CaCl_2$ in 20ml solution = $\frac{0.01}{500} \times 20 = \frac{0.01}{25}$

In 200 ml solution moles of $CaCl_2$ = $\frac{0.01}{25}$ [Note : Dilution does not change moles of solute]

In 2 ml of dilute solution moles of $CaCl_2$ = $\frac{\frac{0.01}{25}}{200} \times 2 = \frac{0.01}{2500} = 8 \times 10^{-6}$

$\therefore$ moles of Cl^- = $2 \times 8 \times 10^{-6} = 1.6 \times 10^{-5}$

Ex. ***What volumes of 1M & 2M H_2SO_4 solution are required to produce 2L of 1.75M H_2SO_4 solution?***

Sol. Let XL be vol. of 1M solution.

$\therefore$ (2 – X)L is vol. of 2M solution.

Moles of H_2SO_4 = $2 \times 1.75 = 1(X) + (2 - X)2$

$3.5 = 4 - X$; $X = 0.5$ L

i.e. 0.5L of 1M & 1.5 L of 2M solution required.

Ex. ***80g NaOH was added to 2L water. Find molality of solution if density of water = 1g/mL***

Sol. $m = \frac{\text{moles of NaOH}}{\text{mass of } H_2O} \times 1000 = \frac{80/40}{2 \times 1000} \times 1000 = \boxed{1 \text{ molal}}$

Ex. ***A 100g NaOH solution has 20g NaOH. Find molality.***

Sol. $m = \frac{20/40}{100 - 20} \times 1000 = \frac{500}{80} = \boxed{6.25 \text{ mol / kg}}$

Ex. ***Find molality of aqueous solution of CH_3COOH whose molarity is 2M and density d = 1.2 g/mL.***

Hint : $\boxed{\frac{1000 \times M}{1000 \times d - MM_s}}$

where d = density in gL^{-1} , M = Molarity, m = molality, M_S = molar mass of solute.

Sol. $m = \frac{2}{1200 - 2 \times 60} \times 1000 = \boxed{1.85 \text{ m}}$

Ex. ***A solution is made by mixing 300 ml 1.5M $Al_2(SO_4)_3$ + 300 ml 2M $CaSO_4$ + 400 ml 3.5M $CaCl_2$ Find final molarity of (1) SO_4^{-2}, (2) Ca^{2+}, (3) Cl^-. [Assume complete dissociation of these compounds].***

Sol. (1) $[SO_4^{-2}]_f = \dfrac{\text{Total moles}}{\text{Total volume}} = \dfrac{300\times1.5\times10^{-3}\times3+300\times2\times10^{-3}}{(300+300+400)\times10^{-3}}$ = 1.95M

(2) $[Ca^{+2}]_f = \dfrac{300\times2+400\times3.5}{1000}$ = 2M

(3) $[Cl^-]_f = \dfrac{400\times3.5\times2}{1000}$ = 2.8M

Ex. ***A solution has 80% $\frac{w}{w}$ NaOH with density $2gL^{-1}$. Find (a) Molarity (b) Molality of solution.***

Sol. Let V_{lit} be vol. of solution

Mass of solute = $(d \times V) \times \dfrac{\left(\%\frac{w}{w}\right)}{100} = 2 \times V \times \dfrac{80}{100} = 1.6V$

(a) $M = \dfrac{1.6V/40}{V} = \boxed{0.04\,M}$ (b) $m = \dfrac{1.6V/40}{2V-1.6V} \times 1000 = \boxed{100\,\text{mol kg}^{-1}}$

Ex. ***4.450 g 100 per cent sulphuric acid was added to 82.20 g water and the density of the solution was found to be 1.029 g/cc at 25°C and 1 atm pressure. Calculate (a) the weight percent, (b) the mole fraction, (c) the mole percent, (d) the molality, (e) the molarity of sulphuric acid in the solution under these conditions.***

Sol. Sulphuric acid = 4.450 g , Water = 82.20 g $\Rightarrow$ Wt. of solution = 86.65 g

$\therefore$ Density of solution = 1.029 g/cc.

(a) Weight percent $= \dfrac{\text{wt. of solute}}{\text{wt. of solution}}\times100 = \dfrac{4.450}{86.65}\times100 = 5.14$

(b) Mole fraction :

Mole of solute $= \dfrac{\text{wt. of solute}}{\text{mol wt. of solute}} = \dfrac{4.45}{98} = 0.0454$

Mole of solvent $= \dfrac{82.20}{18} = 4.566$

Total moles in solution = 0.0454 + 4.566 = 4.6114

Mole fraction of solute $= \dfrac{0.0454}{4.6114} = 0.0098$

(c) Mole percent $= \dfrac{\text{moles of solute}}{\text{Total moles in solution}}\times100$

= mole fraction of solute × 100 = 0.0098 × 100 = 0.98

(d) Molality $= \dfrac{\text{moles of solute}}{\text{mass of solvent (in gm)}}\times1000$

$= \dfrac{0.0454\times1000}{82.2} = 0.552$

(e) Molarity $= \dfrac{\text{moles of solute}}{\text{litre of solution}}$

Volume of solution $= \dfrac{\text{Mass}}{\text{Density}} = \dfrac{86.65}{1.029}\text{ml}$

$= \dfrac{86.65}{1.029 \times 1000}\text{litre}$

Molarity = $\dfrac{0.0454}{\dfrac{86.54}{1.029 \times 1000}} = \dfrac{0.0454 \times 1000 \times 1.029}{86.65} = 0.539$

Ex. ***A solution of KCl has a density of 1.69 g mL^{-1} and is 67% by weight. Find the density of the solution if it is diluted so that the percentage by weight of KCl in the diluted solution is 30%.***

Sol. Let the volume of the KCl solution be 100 mL,

Weight of KCl solution = 100 × 1.69 = 169 g

100 g of solution contains = 67 g of KCl

169 g of solution = $\dfrac{67}{100} \times 169 = 113.23\text{g}$

Lex x mL of H_2O be added.

New volume of solution = (100 + x) mL

New weight of solution = (169 + x) g

(Since x mL of H_2O = x g of H_2O, $d_{H_2O} = 1$)

New percentage of the solution = 30%

% by weight = $\dfrac{\text{weight of solute} \times 100}{\text{weight of solution}}$

30 = $\dfrac{113.23}{(169 + x)} \times 100$

x = 208.43 mL = 208.43 g

New density $= \dfrac{\text{New weight of solution}}{\text{New volume of solution}}$

$= \dfrac{(169 + x)}{(100 + x)}$

$\dfrac{(169 + 208.43)}{(100 + 208.43)} = \dfrac{377.43}{308.43}$

$\therefore$ d = 1.224

Quantitative Estimation of Elements

PERCENTAGE DETERMINATION OF ELEMENTS IN ORGANIC COMPOUNDS :

All these methods are applications of POAC

Do not remember the formulas, derive them using the concept, its easy.

Liebig's method : (*for Carbon and hydrogen*)

$$(w)\,\text{Organic Compound}\xrightarrow[\text{CuO}]{\Delta}(w_1)\,CO_2 + H_2O\,(w_2)$$

% of C = $\dfrac{w_1}{44}\times\dfrac{12}{w}\times 100$

% of H = $\dfrac{w_2}{18}\times\dfrac{2}{w}\times 100$

where w_1 = wt. of CO_2 produced, w_2 = wt. of H_2O produced,
w = wt. of organic compound taken

Estimation of nitrogen : There are two methods for the estimation of nitrogen

(i) Dumas method

(ii) Kjedahl's method.

(i) **Duma's method :**

A known mass of compound is heated with copper oxide (CuO) in an atomsphere of CO_2, which gives free nitrogen along with CO_2 and H_2O.

$C_xH_yN_z$ + (2x + y/2) CuO $\rightarrow$ xCO_2 + y/2 (H_2O) + z/2 (N_2) + (2x + y/2) Cu.

The gaseous mixture is passed over a heated copper gauze which converts traces of nitrogen oxides formed to N_2. The gaseous mixture is collected over an aqueous solution of KOH which absorbs CO_2, and nitrogen is collected in the upper part of the graduated tube.

(w) Organic Compound $\xrightarrow[\text{CuO}]{\Delta}$ $N_2 \rightarrow$ (P, V, T given)

use PV = nRT to calculate moles of N_2, n.

$\therefore$ % of N = $\dfrac{n\times 28}{w}\times 100$

(ii) Kjeldahl's method :

A known mass of organic compound (0.5 gm) is mixed with K_2SO_4 (10 gm) and $CuSO_4$. (1.0 gm) or a drop of mercury (Hg) and conc. H_2SO_4 (25 ml) , and heated in Kjeldahl's flask. $CuSO_4$ or Hg acts as a catalyst, while K_2SO_4 raises the boiling point of H_2SO_4. The nitrogen in the organic compound is quantitatively converted to ammonium sulphate. The resulting mixture is then distilled with excess of NaOH solution and the NH_3 evolved is passed into a known but excess volume of standard HCl or H_2SO_4 . The acid left unused is estimated by titration with some standard alkali. The amount of acid used against NH_3 can thus be known and from this the percentage of nitrogen is calculated.

(a) C + H + S $\xrightarrow[H_2SO_4]{\text{conc.}}$ $CO_2 + H_2O + SO_2$

(b) N $\xrightarrow[H_2SO_4]{\text{conc.}}$ $(NH_4)_2SO_4$

(c) $(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$

(d) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

(w)O.C.+H_2SO_4 $\rightarrow$ $(NH_4)_2SO_4 \xrightarrow{NaOH} NH_3$ + H_2SO_4 $\rightarrow$ (molarity and volume (V litre) consumed given)

$\Rightarrow$ % of N = $\dfrac{MV \times 2 \times 14}{w} \times 100$

where M = molarity of H_2SO_4. Some N containing compounds do not give the above set of reaction as in Kjeldahl's method.

Estimation of sulphur : A known mass of compound is heated with fuming HNO_3 or sodium peroxide (Na_2O_2) in the presence of $BaCl_2$ solution in Carius tube. Sulphur is oxidised to H_2SO_4 and precipitated as $BaSO_4$. It is filerted, dried and weighed.

(w) O.C. + $HNO_3 \rightarrow H_2SO_4 + BaCl_2 \rightarrow (w_1)\ BaSO_4$

$\Rightarrow$ % of S = $\dfrac{w_1}{233} \times \dfrac{1 \times 32}{w} \times 100\%$.

where w_1 = wt. of $BaSO_4$, w = wt. of organic compound

Estimation of phosphorous :

A known mass of compound is heated with fuming HNO_3 or sodium peroxide (Na_2O_2) in Carius tube which converts phosphorous to H_3PO_4. Magnesia mixture ($MgCl_2 + NH_4Cl$) is then added, which gives the precipitate of magnesium ammonium phosphate ($MgNH_4.PO_4$) which on heating gives magnesium pyrophosphate ($Mg_2P_2O_7$), which is weighed. O.C (w) + $HNO_3 \rightarrow H_3PO_4$ + [NH_3 + magnesia mixture ammonium molybdate]

$\rightarrow MgNH_4PO_4 \xrightarrow{\Delta} Mg_2P_2O_7\,(w_1)$

% of P = $\dfrac{w_1}{222} \times \dfrac{2 \times 31}{w} \times 100$

Estimation of halogens :

Carius method : A known mass of compound is heated with conc. HNO_3 in the presence of $AgNO_3$ contained in a hard glass tube known as carius tube in a furnce. C and H are oxidised to CO_2 and H_2O. The halogen forms the corresponding AgX. It is filtered, dried, and weighed.

O.C. + HNO_3 + $AgNO_3 \rightarrow AgX$
If X is Cl then colour = white
If X is Br then colour = dull yellow
If X is I then colour = bright yellow
Flourine can't be estimated by this

% of X = $\dfrac{\text{Atomic mass of X}}{\text{Molecular mass of AgX}} \times \dfrac{\text{Wt. of AgX}}{\text{Wt. of Organic halide}} \times 100$

Ex. ***A sample of 0.5 gm of an organic compound was treated according to Kjeldahl's method. The ammonia evolved was absorbed by 2.45 gm of H_2SO_4. The residual acid required solution containing 0.6 gm. NaOH for neutralisation. Find the percentage composition of nitrogen in the compound ?***

Sol. $2\,NH_3 + H_2SO_4 \rightarrow (NH_4)_2\,SO_4$
$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

m mol of H_2SO_4 used to react with NaOH = $\frac{0.6}{40} = 15\text{mmol}.$

Remaining mmol of H_2SO_4 = $\frac{2.45}{98} \times 10^3 - 15 = 10$

mmol of NH_3 used = 10 × 2 = 20

% N in sample = $\frac{20 \times 10^{-3} \times 14}{0.5} \times 100$ = 56%

Ex. ***Calculate the molar mass of a compound in the Dumas method at 100ºC for which volume of experimental container was 452 ml and the pressure was 745.1 torr. The difference in mass between the empty container and the final measurement was 1.129 gm.***

Sol. $n = \frac{PV}{RT} = \frac{745.1}{760} \times \frac{452 \times 10}{0.0821 \times 373}$ = 0.01448 mol

molar mass (M) = $\frac{1.129}{0.01448}$ = 78.0 gm/mol **.**

MISCELLANEOUS SOLVED PROBLEMS (MSPS)

1. Find the relative atomic mass, atomic mass of the following elements.
(i) Na (ii) F (iii) H (iv) Ca (v) Ag

Sol. (i) 23, 23 amu (ii) 19, 19 amu (iii) 1, 1.008 amu , (iv) 40, 40 amu, (v) 108, 108 amu.

2. A sample of (C_2H_6) ethane has the same mass as 10^7 molecules of methane. How many C_2H_6 molecules does the sample contain ?

Sol. Moles of CH_4 = $\frac{10^7}{N_A}$

Mass of CH_4 = $\frac{10^7}{N_A}$ × 16 = mass of C_2H_6

So Moles of C_2H_6 = $\frac{10^7 \times 16}{N_A \times 30}$

So No. of molecules of C_2H_6 = $\frac{10^7 \times 16}{N_A \times 30}$ × N_A = $\mathbf{5.34 \times 10^6}$**.**

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

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 × 22.7 = 11.35 lit.

4. 14 g of Nitrogen gas and 22 g of CO_2 gas are mixed together. Find the volume of gaseous mixture at STP.

Sol. Moles of $N_2 = \frac{14}{28} = 0.5.$

moles of $CO_2 = \frac{22}{44} = 0.5.$

so total moles = 0.5 + 0.5 = 1.

so vol. at STP = 1 × 22.7 = 22.7 lit.

5. Show that in the reaction $N_2\,(g) + 3H_2(g) \rightarrow 2NH_3\,(g)$, mass is conserved.

Sol.

	N_2 (g)	$3H_2$(g)	$\rightarrow 2NH_3$ (g)
moles before reaction	1	3	0
moles after reaction	0	0	2

Mass before reaction = mass of 1 mole $N_2(g)$ + mass of 3 mole $H_2(g)$

= 14 x 2 + 3 x 2 = 34 g

mass after reaction = mass of 2 mole NH_3

= 2 x 17 = 34 g.

6. When x gram of a certain metal burnt in 1.5 g oxygen to give 3.0 g of its oxide. 1.20 g of the same metal heated in a steam gave 2.40 g of its oxide. shows the these result illustrate the law of constant or definite proportion

Sol. Wt. of metal = 3.0 – 1.5 = 1.5 g

so wt. of metal : wt of oxygen = 1.5 : 1.5 = 1 : 1

similarly in second case, wt. of oxygen = 2.4 – 1.2 = 1.2 g

so wt. of metal : wt of oxygen = 1.2 : 1.2 = 1 : 1

so these results illustrate the law of constant proportion.

7. Find out % of O & H in H_2O compound.

Sol. % of O = $\frac{16}{18} \times 100 = 88.89\%$ and % of H = $\frac{2}{18} \times 100 = 11.11\%$

8. Acetylene & butene have empirical formula CH & CH_2 respectively. The molecular mass of acetylene and butene are 26 & 56 respectively deduce their molecular formula.

Ans. C_2H_2 & C_4H_8

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

For Acetylene : $n = \frac{26}{13} = 2$ $\quad\therefore\quad$ Molecular formula = C_2H_2

For Butene : $n = \frac{56}{14} = 4$ $\quad\therefore\quad$ Molecular formula = C_4H_8.

9. An oxide of nitrogen gave the following percentage composition :

N = 25.94 and O = 74.06

Calculate the empirical formula of the compound.

Ans. N_2O_5

Sol.

Element	% / Atomic mass	Simple ratio	Simple intiger ratio
N	$\frac{25.94}{14} = 1.85$	1	2
O	$\frac{74.06}{16} = 4.63$	2.5	5

So empirical formula is N_2O_5.

10. Find the density of CO_2(g) with respect to N_2O(g).

Sol. R.D. = $\frac{\text{M.wt. of } CO_2}{\text{M.wt. of } N_2O} = \frac{44}{44} = 1.$

11. Find the vapour density of N_2O_5

Sol. V.D. = $\frac{\text{Mol. wt. of } N_2O_5}{2} = 54.$

12. Write a balance chemical equation for following reaction :
When ammonia (NH_3) decompose into nitrogen (N_2) gas & hydrogen (H_2) gas.

Sol. $NH_3 \rightarrow \frac{1}{2} N_2 + \frac{3}{2} H_2$ or $2NH_3 \rightarrow N_2 + 3H_2$.

13. When 170 g NH_3 (M =17) decomposes how many grams of N_2 & H_2 is produced.

Sol. $NH_3 \rightarrow \frac{1}{2} N_2 + \frac{3}{2} H_2$

$$\frac{\text{moles of } NH_3}{1} = \frac{\text{moles of } N_2}{1/2} = \frac{\text{moles of } H_2}{3/2}.$$

So moles of $N_2 = \frac{1}{2} \times \frac{170}{17} = 5.$ So wt. of $N_2 = 5 \times 28 = 140$ g.

Similarly moles of $H_2 = \frac{3}{2} \times \frac{170}{17} = 15.$

So wt. of $H_2 = 15 \times 2 = 30$ g.

14. 340 g NH_3 (M = 17) when decompose how many litres of nitrogen gas is produced at STP.

Sol. $NH_3 \rightarrow \frac{1}{2} N_2 + \frac{3}{2} H_2$

moles of $NH_3 = \frac{340}{17} = 20.$

So moles of $N_2 = \frac{1}{2} \times 20 = 10.$

$\therefore$ vol. of N_2 at STP = 10 × 22.7 = 227 lit.

15. 4 mole of $MgCO_3$ is reacted with 6 moles of HCl solution. Find the volume of CO_2 gas produced at STP, the reaction is

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O.$$

Sol. Here HCl is limiting reagent. So moles of CO_2 formed = 3.
So vol. at STP = 3 × 22.7 = 68.1 lit.

16. 117 g NaCl is dissolved in 500 ml aqueous solution. Find the molarity of the solution.

Sol. Molarity = $\frac{117/58.5}{500/1000}$ = **4M.**

17. 0.32 mole of $LiAlH_4$ in ether solution was placed in a flask and 74 g (1 moles) of t-butyl alcohol was added. The product is $LiAlHC_{12}H_{27}O_3$. Find the weight of the product if lithium atoms are conserved.
[Li = 7, Al = 27, H = 1, C = 12, O = 16]

Sol. Applying POAC on Li
1 × moles of $LiAlH_4$ = 1× moles of LiAlH $C_{12}H_{27}O_3$
254 × 0.32 = 1 × wt. of LiAlH $C_{12}H_{27}O_3$.
wt. of LiAlH $C_{12}H_{27}O_3$ = 81.28 g.

18. Balance the following equations :

(a) $H_2O_2 + MnO_4^- \longrightarrow Mn^{+2} + O_2$ (acidic medium)

(b) $Zn + HNO_3$ (dil) $\longrightarrow Zn(NO_3)_2 + H_2O + NH_4NO_3$

(c) $CrI_3 + KOH + Cl_2 \longrightarrow K_2CrO_4 + KIO_4 + KCl + H_2O$.

(d) $P_2H_4 \longrightarrow PH_3 + P_4$

(e) $Ca_3(PO_4)_2 + SiO_2 + C \longrightarrow CaSiO_3 + P_4 + CO$

Ans. (a) $6H^+ + 5H_2O_2 + 2MnO_4^- \longrightarrow 2Mn^{+2} + 5O_2 + 8H_2O$

(b) $4Zn + 10HNO_3$ (dil) $\longrightarrow 4Zn(NO_3)_2 + 3H_2O + NH_4NO_3$

(c) $2CrI_3 + 64KOH + 27Cl_2 \longrightarrow 2K_2CrO_4 + 6KIO_4 + 54KCl + 32H_2O$.

(d) $6P_2H_4 \longrightarrow 8PH_3 + P_4$

(e) $2Ca_3(PO_4)_2 + 6SiO_2 + 10C \longrightarrow 6CaSiO_3 + P_4 + 10CO$

19. Calculate the resultant molarity of following :

(a) 200 ml 1M HCl + 300 ml water (b) 1500 ml 1M HCl + 18.25 g HCl

(c) 200 ml 1M HCl + 100 ml 0.5 M H_2SO_4 (d) 200 ml 1M HCl + 100 ml 0.5 M HCl

Ans. (a) 0.4 M (b) 1.33 M (c) 1 M (d) 0.83 M.

Sol. (a) Final molarity = $\frac{200 \times 1 + 0}{200 + 300}$ = 0.4 M.

(b) Final molarity = $\frac{1500 \times 1 + \frac{18.25 \times 1000}{36.5}}{1500} = 1.33$ M

(c) Final molarity of H^+ = $\frac{200 \times 1 + 100 \times 0.5 \times 2}{200 + 100}$ = 1 M.

(d) Final molarity = $\frac{200 \times 1 + 100 \times 0.5}{200 + 100}$ = 0.83 M.

20. 518 g of an aqueous solution contains 18 g of glucose (mol.wt. = 180). What is the molality of the solution.

Sol. wt. of solvent = 518 – 18 = 500 g. $\Rightarrow$ so molarity = $\frac{18/180}{500/1000}$ = 0.2.

21. 0.25 of a substance is dissolved in 6.25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Sol. wt. of solution = 0.25 + 6.25 = 6.50.

so % (w/w) = $\frac{0.25}{6.50} \times 100$ = 3.8%.

22. 518 g of an aqueous solution contains 18 g of glucose (mol.wt. = 180). What is the molality of the solution.

Sol. wt. of solvent = 518 – 18 = 500 g. $\Rightarrow$ so molarity = $\frac{18/180}{500/1000}$ = 0.2.

23. 0.25 of a substance is dissolved in 6.25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Sol. wt. of solution = 0.25 + 6.25 = 6.50.

so % (w/w) = $\frac{0.25}{6.50} \times 100$ = 3.8%.

Exercise-1

Marked Questions may have for Revision Questions.

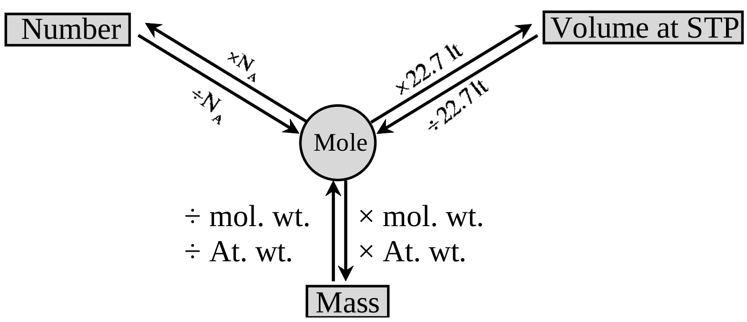
PART - I : SUBJECTIVE QUESTIONS

MOLE-I : Law of Chemical Combination

Section (A) : Molar volume of ideal gases at STP, Average molar mass

Commit to memory :

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



A-1. Calculate volume of H_2 gas kept at STP if it contains as many H atoms as in 98 gm H_3PO_4. [Atomic mass of P = 31]

A-2. 40 mg of gaseous substance (X_2) occupies 4.8 mL of volume at 1 atm and 27°C. Atomic mass of element X is : (R : 0.08 atm L/mole-K)

A-3. A gaseous mixture of H_2 and N_2O gas contains 66 mass % of N_2O. What is the average molecular mass of mixture :

Section (B) : Empirical Formula, % Composition of a given compound by mass, % By mole, Minimum molecular mass determination.

Commit to memory :

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

B-1. Haemoglobin contains 0.25% iron by mass. The molecular mass of of Haemoglobin is 89600 then the number of iron atoms per molecule of Haemoglobin (Atomic mass of Fe = 56) -

B-2. A compound has 52.17 % carbon, 13.05 % hydrogen and 34.78 % oxygen. If molar mass of compound is 46, find number of H-atoms per molecule of the compound.

B-3. The empirical formula of a compounds is CH_2O. 0.25 mole of this compound contains 1 gm hydrogen. The molecular formula of compound is -

B-4. In a gaseous mixture 2mol of CO_2, 1 mol of H_2 and 2 mol of He are present than determine mole percentage of CO_2.

MOLE-II : Basic Stoichiometry

Section (C) : Stoichiometry, Equation based calculations (Elementary level single equation or 2)

Commit to memory :

Now for any general balance chemical equation like

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

you can write.

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

C-1. Calculate the residue obtained on strongly heating 2.76 g Ag_2CO_3.

$$Ag_2CO_{3\,(s)} \xrightarrow{\Delta} 2Ag_{(s)} + CO_{2(g)} + \frac{1}{2}O_{2(g)}$$

C-2. Calculate the weight of iron which will be converted into its oxide by the action of 18g of steam.

Unbalanced reaction : $Fe + H_2O \xrightarrow{\Delta} Fe_3O_4 + H_2$.

C-3. How many gm of HCl is needed for complete reaction with 43.5 gm MnO_2 ? (Mn = 55)
$HCl + MnO_2 \rightarrow MnCl_2 + H_2O + Cl_2$ (unbalance)

C-4. Nitric acid is manufactured by the Ostwald process, in which nitrogen dioxide reacts with water.
$3NO_2\,(g) + H_2O\,(l) \rightarrow 2\,HNO_3\,(aq) + NO\,(g)$
How many grams of nitrogen dioxide are required in this reaction to produce 25.2 gm HNO_3 ?

C-5. What total volume, in litre at 627°C and 0.821 atm, could be formed by the decomposition of 16 gm of NH_4NO_3 ? Reaction : $2\,NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O_{(g)}$.

C-6. Calculate mass of phosphoric acid (H_3PO_4) required to obtain 53.4g pyrophosphoric acid.
$2H_3PO_4 \rightarrow H_4P_2O_7 + H_2O$

Section (D) : Limiting reagent, % Excess, % Yield / Efficiency

D-1. 50 g of $CaCO_3$ is allowed to react with 73.5 g of H_3PO_4. Calculate :
(i) Amount of $Ca_3(PO_4)_2$ formed (in moles)
(ii) Amount of unreacted reagent (in moles)

D-2. Carbon reacts with chlorine to form CCl_4. 36 gm of carbon was mixed with 142 g of Cl_2. Calculate mass of CCl_4 produced and the remaining mass of reactant.

D-3. Potassium superoxide, KO_2, is used in rebreathing gas masks to generate oxygen :
$KO_2(s) + H_2O(l) \rightarrow KOH\,(s) + O_2\,(g)$ (unbalanced)
If a reaction vessel contains 0.158 mol KO_2 and 0.10 mol H_2O, how many moles of O_2 can be produced ?

D-4. A chemist wants to prepare diborane by the reaction
$6\,LiH + 8BF_3 \longrightarrow 6Li\,BF_4 + B_2H_6$
If he starts with 2.0 moles each of LiH & BF_3. How many moles of B_2H_6 can be prepared.

Section (E) : Principle of atom conservation (POAC), Reactions in sequence & parallel, Mixture analysis, % Purity

E-1. What amount of CaO will be produced by 1 g of Calcium ?

E-2. 6 gm nitrogen on successive reaction with different compounds gets finally converted into 30 gm $[Cr(NH_3)_xBr_2]$ Value of x is [Atomic mass of Cr = 52, Br = 80]

E-3. All carbon atom present in 762 gm $KH_3(C_2O_4)_2.2H_2O$ is converted into CO_2. How many gm of CO_2 were obtained.

E-4. $KClO_3$ decomposes by two parallel reaction

(i) $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$ (ii) $4KClO_3 \xrightarrow{\Delta} 3KClO_4 + KCl$

If 3 moles of O_2 and 1 mol of $KClO_4$ is produced along with other products then determine initial moles of $KClO_3$.

E-5. When 4 gm of a mixture of $NaHCO_3$ and NaCl is heated, 0.66 gm CO_2 gas is evolved. Determine the percentage composition (by mass) of the original mixture.

E-6. When 80 gm CH_4 is burnt completely, CO and CO_2 gases are formed in 1 : 4 mole ratio. What is the mass of O_2 gas used in combustion.

MOLE-III : Oxidation Reduction & Balancing Redox Equations

Section (F) : Basics of oxidation number

F-1. Calculate the oxidation number of underlined elements in the following compounds :

(a) $K[\underline{Co}(C_2O_4)_2(NH_3)_2]$ (b) $K_4\underline{P}_2O_7$ (c) $\underline{Cr}O_2Cl_2$
(d) $Na_2[\underline{Fe}(CN)_5(NO^+)]$ (e) $\underline{Mn}_3O_4$ (f) $Ca(\underline{Cl}O_2)_2$
(g) $[\underline{Fe}(NO^+)(H_2O)_5]SO_4$ (h) $\underline{Zn}O_2^{2-}$ (i) $\underline{Fe}_{0.93}O$

F-2. Identify the oxidant and the reductant in the following reactions :

(a) $KMnO_4 + KCl + H_2SO_4 \longrightarrow MnSO_4 + K_2SO_4 + H_2O + Cl_2$
(b) $FeCl_2 + H_2O_2 + HCl \longrightarrow FeCl_3 + H_2O$
(c) $Cu + HNO_3$ (dil) $\longrightarrow Cu(NO_3)_2 + H_2O + NO$
(d) $Na_2HAsO_3 + KBrO_3 + HCl \longrightarrow NaCl + KBr + H_3AsO_4$
(e) $I_2 + Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + NaI$

Section (G) : Balancing redox reactions

G-1. Write balanced net ionic equations for the following reactions in acidic solution :

(a) $S_4O_6^{2-} + Al \longrightarrow H_2S + Al^{3+}$ (b) $Fe^{2+} + Cr_2O_7^{2-} \rightarrow Fe^{3+} + Cr^{3+}$

(c) $IO_4^- + I^- \rightarrow I_2$ (d) $MnO_4^{2-} \rightarrow MnO_4^- + MnO_2$

(e) $HNO_2 \longrightarrow NO_3^- + NO$

G-2. Write balanced net ionic equations for the following reactions in basic solution :

(a) $ClO^- + CrO_2^- \rightarrow Cl^- + CrO_4^{2-}$

(b) $Zn + NO_3^- \rightarrow NH_3 + ZnO_2^{2-}$

(c) $S \rightarrow S^{2-} + S_2O_3^{2-}$

(d) $Mn(OH)_2 + MnO_4^- \longrightarrow MnO_2$

(e) $MnO_4^- + SO_3^{2-} \rightarrow MnO_4^{2-} + SO_4^{2-}$

MOLE-IV : Concentration Measurement

Section (H) : Units of concentration measurement, Interconversion of concentration units

Commit to memory :

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

molality = $\dfrac{\text{number of moles of solute}}{\text{mass of solvent in gram}} \times 1000$

Let number of moles of solute in solution = n

Number of moles of solvent in solution = N

$\therefore$ Mole fraction of solute (x_1) = $\dfrac{n}{n+N}$

$\therefore$ Mole fraction of solvent (x_2) = $\dfrac{N}{n+N}$

% w/w = $\dfrac{\text{mass of solute in gm}}{\text{mass of solution in gm}} \times 100$

% w/v = $\dfrac{\text{mass of solute in gm}}{\text{volume of solution in ml}} \times 100$

% v/v = $\dfrac{\text{volume of solute in ml}}{\text{volume of solution in ml}} \times 100$

$ppm_A = \dfrac{\text{mass of A}}{\text{Total mass}} \times 10^6$ = mass fraction $\times 10^6$

H-1. Find the mass of KOH needed to prepare 100 ml 1 M KOH solution. [At. mass K = 39]

H-2. Calculate the molality of KCl solution prepared by dissolving 7.45 g of KCl to make 500 mL of the solution. (d_{sol} = 1.2 g mL^{-1})

H-3.(i) If you are given a 2M NaOH solution having density 1 g/mL, then find the molality of solution.

(ii) Find the molarity of 5m (molal) NaOH solution having density 1.5 g/ml.

(iii) Find the mole fraction of solute in problem (i)

(iv) Find the mole fraction of solute in problem (ii)

(v) Find the % (w/w) of NaOH in solution in problem (i)

(vi) Find the % (w/w) of NaOH in solution in problem (ii)

(vii) Find the % (w/v) of NaOH in solution in problem (ii)

(viii) A 300 g, 30% (w/w) NaOH solution is mixed with 500 g, 40% (w/w) NaOH solution. Find the mass percentage (w/w) of final solution.

(ix) What is % (w/v) NaOH in problem (viii) if density of final solution is 2 g/ml ?

(x) What is the molality of final solution obtained in problem (viii) ?

H-4. Calculate molarity of all the ions produces by following aq. solution of electrolytes. (Assuming 100% dissociation)

(i) 0.2M NaCl solution

(ii) 1.2M $Al_2(SO_4)_3$ solution

(iii) 1.2M H_2SO_4 solution

(iv) 2.1M $MgCl_2$ solution

Section (I) : Dilution & Mixing of two liquids

I-1. Find the Cl^- concentration in solution which is obtained by mixing one mole each of $BaCl_2$, NaCl and HCl in 500 ml water.

I-2. What maximum volume of 3 M solution of KOH can be prepared from 1 L each of 1 M KOH and 6 M KOH solutions by using water ?

I-3. Find the resultant molarity obtained by mixing the following.
(i) 2 litre, 0.5M HCl + 3 litre, 0.2 M HCl.
(ii) 500 ml, 1M NaCl + 200 ml, 2M NaCl
(iii) 100 ml, 0.1 M NaOH + 400 ml, 0.2 M NaOH
(iv) 2 litre, 0.2M HCl + 500 ml , 0.4 M HCl.

Section (J) : Percentage Determination of Elements in Organic Compounds

J-1. In carius method of estimation of halogen, 0.15g of an organic compound gave 0.12g of AgBr. What is the percentage of bromine in the compound.

J-2. 0.124 gm of an organic compound containing phosphorus gave 0.222 gm of $Mg_2P_2O_7$ by the usual analysis. Calculate the percentage of phosphorous in the compound.(Mg = 24, P = 31)

J-3. 0.28 g of a nitrogenous compound was subjected to Kjeldahl's process to produce 0.17g of NH_3. The percentage of nitrogen in the organic compound is :

J-4. In Dumas' method for estimation of nitrogen, 0.3g of an organic compound give 50 mL of nitrogen collected at 300K temperature and 700 mm pressure. What will be the percentage composition of nitrogen in the compound.

J-5. In sulphur estimation, 0.157 g of an organic compound gave 0.4813 g of barium sulphate. What is the percentage of bromine in the compound.

PART - II : OBJECTIVE QUESTIONS

Single Choice Objective, straight concept/formula oriented

MOLE-I : Law of Chemical Combination

Section (A) : Molar volume of ideal gases at STP, Average molar mass

A-1. Under the same conditions, two gases have the same number of molecules. They must
(A) be noble gases (B) have equal volumes
(C) have a volume of 22.4 dm^3 each (D) have an equal number of atoms

A-2. 80gm of SO_x gas occupies 14 litre at 2atm & 273K. The value of x is :
(A) x = 3 (B) x = 2 (C) x = 4 (D) none

Section (B) : Empirical Formula, % Composition of a given compound by mass, % By mole, Minimum molecular mass determination.

B-1. The empirical formula of a compound of molecular mass 120 is CH_2O. The molecular formula of the compound is :
(A) $C_2H_4O_2$ (B) $C_4H_8O_4$ (C) $C_3H_6O_3$ (D) all of these

B-2. Cortisone is a molecular substance containing 21 atoms of carbon per molecule. The mass percentage of carbon in cortisone is 69.98%. Its molar mass is :
(A) 176.5 (B) 252.2 (C) 287.6 (D) 360.1

B-3. A compound contains 69.5% oxygen and 30.5% nitrogen and its molecular weight is 92. The formula of that compound is :-
(A) N_2O (B) NO_2 (C) N_2O_4 (D) N_2O_5

B-4. A compound of X and Y has equal mass of them. If their atomic weights are 30 and 20 respectively. The molecular formula of compound is -
(A) X_2Y_2 (B) X_3Y_3 (C) X_2Y_3 (D) X_3Y_2

MOLE-II : Basic Stoichiometry

Section (C) : Stoichiometry, Equation based calculations (Elementary level single equation or 2)

C-1. For the reaction $2P + Q \rightarrow R$, 8 mol of P and excess of Q will produce :
(A) 8 mol of R (B) 5 mol of R (C) 4 mol of R (D) 13 mol of R

C-2. If 1.5 moles of oxygen combine with Al to form Al_2O_3, the weight of Al used in the reaction is :
(A) 27 g (B) 40.5 g (C) 54g (D) 81 g

C-3. How many liters of CO_2 at STP will be formed when 0.01 mol of H_2SO_4 reacts with excess of Na_2CO_3 .

$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + H_2O$
(A) 22.4 L (B) 2.24 L (C) 0.227 L (D) 1.12 L

C-4. How many moles of potassium chlorate need to be heated to produce 11.2 litre oxygen at 0°C and 1 atm.

(A) $\frac{1}{2}$ mol (B) $\frac{1}{3}$ mol (C) $\frac{1}{4}$ mol (D) $\frac{2}{3}$ mol

C-5. How many litres of oxygen at 1atm & 273K will be required to burn completely 2.2 g of propane (C_3H_8)
(A) 11.2 L (B) 22.4 L (C) 5.6 L (D) 44.8 L

C-6. Volume of CO_2 obtained at STP by the complete decomposition of 9.85 g $BaCO_3$ is
(At. wt of Ba = 137)
(A) 2.24 lit (B) 1.135 lit (C) 0.135 lit (D) 2.27 lit

Section (D) : Limiting reagent, % Excess, % Yield / Efficiency

D-1. How many mole of $Zn(FeS_2)$ can be made from 2 mole zinc, 3 mole iron and 5 mole sulphur.
(A) 2 mole (B) 3 mole (C) 4 mole (D) 5 mole

D-2. Equal weight of 'X' (At. wt. = 36) and 'Y' (At. wt. = 24) are reacted to form the compound X_2Y_3. Then :
(A) X is the limiting reagent
(B) Y is the limiting reagent
(C) No reactant is left over and mass of X_2Y_3 formed is double the mass of 'X' taken
(D) none of these

D-3. 0.5 mole of H_2SO_4 is mixed with 0.2 mole of $Ca(OH)_2$. The maximum number of moles of $CaSO_4$ formed is
(A) 0.2 (B) 0.5 (C) 0.4 (D) 1.5

D-4. If 1/2 moles of oxygen combine with aluminium to form Al_2O_3 then weight of Aluminium metal used in the reaction is (Al= 27)–
(A) 27 g (B) 18 g (C) 54 g (D) 40.5 g

D-5. The mass of P_4O_{10} produced if 440 gm of P_4S_3 is mixed with 384 gm of O_2 is

$P_4S_3 + O_2 \longrightarrow P_4O_{10} + SO_2$

(A) 568 gm (B) 426 gm (C) 284 gm (D) 396 gm

D-6. The mass of Mg_3N_2 produced if 48 gm of Mg metal is reacted with 34 gm NH_3 gas is

$Mg + NH_3 \longrightarrow Mg_3N_2 + H_2$

(A) $\frac{200}{3}$ gm (B) $\frac{100}{3}$ gm (C) $\frac{400}{3}$ gm (D) $\frac{150}{3}$ gm

Section (E) : Principle of atom conservation (POAC), Reactions in sequence & parallel, Mixture analysis, % Purity

E-1. 25.4 g of iodine and 14.2g of chlorine are made to react completely to yield a mixture of ICl and ICl_3. Calculate the number of moles of ICl and ICl_3 formed.
(A) 0.1 mole, 0.1 mole (B) 0.1 mole, 0.2 mole (C) 0.5 mole, 0.5 mole (D) 0.2 mole, 0.2 mole

E-2. What weight of $CaCO_3$ must be decomposed to produce the sufficient quantity of carbon dioxide to convert 21.2 kg of Na_2CO_3 completely in to $NaHCO_3$. [Atomic mass Na = 23, Ca = 40]

$CaCO_3 \longrightarrow CaO + CO_2$

$Na_2\,CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$

(A) 100 Kg (B) 20 Kg (C) 120 Kg (D) 30 Kg

E-3. NX is produced by the following step of reactions

$M + X_2 \longrightarrow M\,X_2$

$3MX_2 + X_2 \longrightarrow M_3X_8$

$M_3\,X_8 + N_2CO_3 \longrightarrow NX + CO_2 + M_3O_4$

How much M (metal) is consumed to produce 206 g of NX. (Take at wt of M = 56, N=23, X = 80)

(A) 42 g (B) 56 g (C) $\frac{14}{3}$ g (D) $\frac{7}{4}$ g

E-4. The following process has been used to obtain iodine from oil-field brines in California.

$NaI + AgNO_3 \longrightarrow AgI + NaNO_3$; $2AgI + Fe \longrightarrow FeI_2 + 2Ag$

$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$

How many grams of $AgNO_3$ are required in the first step for every 254 kg I_2 produced in the third step.
(A) 340 kg (B) 85 kg (C) 68 kg (D) 380 kg

E-5. Mixture of $MgCO_3$ & $NaHCO_3$ on strong heating gives CO_2 & H_2O in 3 : 1 mole ratio. The weight % of $NaHCO_3$ present in the mixture is:
(A) 30% (B) 80% (C) 40% (D) 50%

E-6. An impure sample of $CaCO_3$ contains 38% of Ca. The percentage of impurity present in the sample is :

(A) 5% (B) 95% (C) 10% (D) 2.5%

MOLE-III : Oxidation Reduction & Balancing Redox Equations

Section (F) : Basics of oxidation number

F-1. The oxidation number of Oxygen in Na_2O_2 is :
(A) + 1 (B) + 2 (C) – 2 (D) – 1

F-2. The oxidation number of Phosphorus in $Mg_2P_2O_7$ is :
(A) + 3 (B) + 2 (C) + 5 (D) – 3

F-3. The oxidation states of Sulphur in the anions SO_3^{2-} , $S_2O_4^{2-}$ and $S_2O_6^{2-}$ follow the order :
(A) $S_2O_6^{2-} < S_2O_4^{2} < SO_3^{2-}$ (B) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-}$
(C) $SO_3^{2-} < S_2O_4^{2-} < S_2O_6^{2-}$ (D) $S_2O_4^{2} < S_2O_6^{2-} < SO_3^{2-}$

F-4. Match List-I (Compounds) with List-II (Oxidation states of Nitrogen) and select answer using the codes given below the lists :

List-I		**List-II**	
(a)	NaN_3	(1)	+5
(b)	N_2H_2	(2)	+2
(c)	NO	(3)	–1/3
(d)	N_2O_5	(4)	–1

Code :

	(a)	(b)	(c)	(d)		(a)	(b)	(c)	(d)
(A)	3	4	2	1	(B)	4	3	2	1
(C)	3	4	1	2	(D)	4	3	1	2

F-5. 1 mole of N_2H_4 loses ten moles of electrons to form a new compound Y. Assuming that all the nitrogen appears in the new compound, what is the oxidation state of nitrogen in Y? (There is no change in the oxidation state of hydrogen).
(A) – 1 (B) – 3 (C) + 3 (D) + 5

F-6. The average oxidation state of Fe in Fe_3O_4 is :
(A) – 8/3 (B) 8/3 (C) 2 (D) 3

Section (G) : Balancing redox reactions

G-1. In the reaction $xHI + yHNO_3 \longrightarrow NO + I_2 + H_2O$, upon balancing with whole number coefficients :
(A) x = 3, y = 2 (B) x= 2, y = 3 (C) x = 6, y = 2 (D) x = 6, y = 1

G-2. For the redox reaction $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$,
the correct whole number stoichiometric coefficients of MnO_4^-, $C_2O_4^{2-}$ and H^+ are respectively:
(A) 2, 5, 16 (B) 16, 5, 2 (C) 5, 16, 2 (D) 2, 16, 5

G-3. For the redox reaction $xP_4 + yHNO_3 \longrightarrow H_3PO_4 + NO_2 + H_2O$, upon balancing with whole number coefficients:
(A) x = 1, y = 5 (B) x = 2, y = 10 (C) x = 1, y = 20 (D) x = 1, y = 15

G-4. In the reaction $X^- + XO_3^- + H^+ \longrightarrow X_2 + H_2O$, the molar ratio in which X^- and XO_3^- react is :
(A) 1 : 5 (B) 5 : 1 (C) 2 : 3 (D) 3 : 2

G-5. CN^- is oxidised by NO_3^- in presence of acid :

$$a\,CN^- + b\,NO_3^- + c\,H^+ \longrightarrow (a + b)\,NO + a\,CO_2 + \frac{c}{2}H_2O$$

What are the whole number values of a, b, c in that order :
(A) 3, 7, 7 (B) 3, 10, 7 (C) 3, 10, 10 (D) 3, 7, 10

MOLE-IV : Concentration Measurement

Section (H) : Units of concentration measurement, Interconversion of concentration units

H-1. 500 mL of a glucose solution contains 6.02×10^{22} molecules. The concentration of the solution is
(A) 0.1 M (B) 1.0 M (C) 0.2 M (D) 2.0 M

H-2. Equal moles of H_2O and NaCl are present in a solution. Hence, molality of NaCl solution is :
(A) 0.55 (B) 55.5 (C) 1.00 (D) 0.18

H-3. What is the molarity of H_2SO_4 solution that has a density of 1.84 g/cc and contains 98% by mass of H_2SO_4? (Given atomic mass of S = 32)
(A) 4.18 M (B) 8.14 M (C) 18.4 M (D) 18 M

H-4. 1000 g aqueous solution of $Ca(NO_3)_2$ contains 10 g of calcium nitrate. Concentration of the solution is :
(A) 10 ppm (B) 100 ppm (C) 1000 ppm (D) 10,000 ppm

H-5. 171 g of cane sugar ($C_{12}H_{22}O_{11}$) is dissolved in 1 litre of water. The molarity of the solution is :
(A) 2.0 M (B) 1.0 M (C) 0.5 M (D) 0.25 M

H-6. Molality of 20% (w/w) aq.glucose solution is :
(A) $\frac{25}{18}$ m (B) $\frac{10}{9}$ m (C) $\frac{25}{9}$ m (D) $\frac{5}{18}$ m

H-7. Molarity of liquid HCl, if density is 1.17 g/cc. :
(A) 36.5 M (B) 18.25 M (C) 32.05 M (D) 42.10 M

Section (I) : Dilution & Mixing of two liquids

I-1. If 500 ml of 1 M solution of glucose is mixed with 500 m l of 1 M solution of glucose final molarity of solution will be :
(A) 1 M (B) 0.5 M (C) 2 M (D) 1.5 M

I-2. 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 :
(A) 750 ml (B) 100 ml (C) 200 mℓ (D) 300 mℓ

I-3. What volume of a 0.8 M solution contains 100 milli moles of the solute?
(A) 100 mL (B) 125 mL (C) 500 mL (D) 62.5 mL

I-4. 2M of 100 ml Na_2SO_4 is mixed with 3M of 100 ml NaCl solution and 1M of 200 ml $CaCl_2$ solution. Then the ratio of the concentration of cation and anion.
(A) 1/2 (B) 2 (C) 1.5 (D) 1

I-5. How much volume of 3.0 M H_2SO_4 is required for the preparation of 1.0 litre of 1.0 M solution?
(A) 300 ml (B) 320 ml (C) 333.3 ml (D) 350.0 ml

I-6. Equal weight of NaCl and KCl are dissolved separately in equal volumes of solutions. Molarity of the solutions will be –
(A) Equal (B) Greater for NaCl
(C) Greater for KCl (D) Uncomparable.

I-7. Equal volumes of 10% (w/v) of HCl is mixed with 10% (w/v) NaOH solution. The resultant solution be.
(A) basic (B) neutral (C) acidic (D) can't be predicted.

Section (J) : Percentage Determination of Elements in Organic Compounds

J-1. In kjeldahl's method, nitogen present in estimated as :
(A) N_2 (B) NH_3 (C) NO_2 (D) None of these

J-2. An organic compound has 6.2 % of phosphorus. On sequence of reaction, the phosphorous present in the 10gm of organic compound is converted to $Mg_2P_2O_7$. Find the weight of $Mg_2P_2O_7$ formed.
(A) 2.22 gm (B) 10.0 gm (C) 4.44 gm (D) 1.11 gm

PART - III : MATCH THE COLUMN

1.

	Column - I		Column - II
(A)	A gaseous organic compound containing C = 52.17%, H = 13.04% & O = 34.78% (by weight) having molar mass 46 g/mol.	(p)	One mole of compound contains $4N_A$ atoms of Hydrogen.
(B)	0.3 g of an organic compound containing C, H and O on combustion yields 0.44 g of CO_2 and 0.18 g of H_2O, with two O atoms per molecule.	(q)	The empirical formula of the compound is same as its molecule formula.
(C)	A hydrocarbon containing C = 42.857% and H = 57.143% (by mole) containing 3C atoms per molecule.	(r)	Combustion products of one mole of compound contains larger number of moles of CO_2 than that of H_2O.
(D)	A hydrocarbon containing 10.5 g carbon per gram of hydrogen having vapour density 46.	(s)	CO_2 gas produced by the combustion of 0.25 mole of compound occupies a volume of 11.2 L at 0°C and 1 atm.

2.

Column I	Column II
(A) $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(s) + H_2(g)$ above reaction is carried out by taking 2 moles each of Zn and HCl	(p) 50% of excess reagent left
(B) $AgNO_3(aq) + HCl(aq) \rightarrow AgCl(s) + HNO_3(g)$ above reaction is carried out by taking 170 g $AgNO_3$ and 18.25 g HCl (Ag = 108)	(q) 22.7 L of gas at STP is liberated
(C) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ 100 g $CaCO_3$ is decomposed	(r) 1 moles of solid (product) obtained.
(D) $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ 2/3 moles of $KClO_3$ decomposed	(s) HCl is the limiting reagent

3.

	Column-I		Column-II
(A)	120 g CH_3COOH in 1 L solution (d_{sol} = 1.2 g/mL)	(p)	M = 2
(B)	120 g glucose dissolved in 1 L solution (d_{sol} = 1.2 g/mL)	(q)	10% w/w solution
(C)	$X_{NH_2CONH_2} = 1/31$ (aqueous solution)	(r)	12% w/v solution
(D)	19.6% (w/v) H_2SO_4 solution $\rightarrow$ ($d_{solution}$ = 1.2 g/mL)	(s)	m = 1.85
		(t)	m = 0.617

Exercise-2

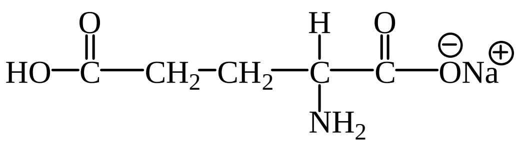
✍ Marked Questions may have for Revision Questions.

PART - I : OBJECTIVE QUESTIONS

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

2. 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 :
(A) CH_4O (B) CH_2O (C) C_2H_4O (D) None

3. Monosodium glutamate (MSG) is salt of one of the most abundant naturally occuring non-essential amino acid which is commonly used in food products like in **"MAGGI"** having structural formula as



Mass % of Na in MSG is-
(A) 14.8 (B) 15.1 (C) 13.6 (D) 16.5

4. The hourly energy requirement of an astronaut can be satisfied by the energy released when 34 g of sucrose ($C_{12}H_{22}O_{11}$) are burnt in his body. How many g of oxygen would be needed to be carried in space capsule to meet his requirement for one day :
(A) 916.2 g (B) 91.62 g (C) 8.162 g (D) 9.162 g.

5.✍ If 10 g of Ag reacts with 1 g of sulphur , the amount of Ag_2S formed will be :
(A) 7.75 g (B) 0.775 g (C) 11 g (D) 10 g

6. 13.4 gm of a sample of unstable hydrated salt : $Na_2SO_4.xH_2O$ was strongly heated. Weight loss on heating is found to be equal to 6.3 gm. Calculate the value of x.
(A) 6 (B) 5 (C) 7 (D) 8

7. When a mixture of 10 mole of SO_2 , 15 mole of O_2 was passed over catalyst , 8 mole of SO_3 was formed. How many mole of SO_2 and O_2 did not enter into combination ?
(A) 2 moles of SO_2, 11 moles of O_2 (B) 3 moles of SO_2, 11.5 moles of O_2
(C) 2 moles of SO_2, 4 moles of O_2 (D) 8 moles of SO_2, 4 moles of O_2

8. When a 12 g mixture of carbon and sulphur is burnt in air, then a mixture of CO_2 and SO_2 is produced, in which the number of moles of SO_2 is half that of CO_2. The mass of the carbon in the mixture is :
(A) 4.08 g (B) 5.14 g (C) 8.74 g (D) 1.54 g

9.✍ 1 mol of iron (Fe) reacts completely with 0.65 mol O_2 to give a mixture of only FeO and Fe_2O_3. Mole ratio of ferrous oxide to ferric oxide is :
(A) 3 : 2 (B) 4 : 3 (C) 20 : 13 (D) none of these

10. When ZnS is boiled with strong nitric acid, the products are zinc nitrate, sulphuric acid and nitrogen dioxide. What are the changes in the oxidation numbers of Zn, S and N :
(A) + 2, + 4, – 1 (B) + 2, + 6, – 2 (C) 0, + 4, – 2 (D) 0, + 8, – 1

11. The following equations are balanced atomwise and chargewise.
(i) $Cr_2O_7^{2-} + 8H^+ + 3H_2O_2 \longrightarrow 2Cr^{3+} + 7H_2O + 3O_2$
(ii) $Cr_2O_7^{2-} + 8H^+ + 5H_2O_2 \longrightarrow 2Cr^{3+} + 9H_2O + 4O_2$
(iii) $Cr_2O_7^{2-} + 8H^+ + 7H_2O_2 \longrightarrow 2Cr^{3+} + 11H_2O + 5O_2$
The precise equation/equations representing the oxidation of H_2O_2 is/are :
(A) (i) only (B) (ii) only (C) (iii) only (D) all the three

12. $xNO_3^- + yI^- + zH^+ \rightarrow 2NO + 3I_2 + 4H_2O$ x , y, z respectively in the above equation are :
(A) 2, 6, 8 (B) 1, 6 , 4 (C) 0, 6 , 8 (D) 2 , 3 , 4

13. A solution of glucose received from some research laboratory has been marked mole fraction x and molality (m) at 10ºC. When you will calculate its molality and mole fraction in your laboratory at 24ºC you will find
(A) mole fraction (x) and molality (m) (B) mole fraction (2x) and molality (2m)
(C) mole fraction (x/2) and molality (m/2) (D) mole fraction (x) and (m ± dm) molality

14. 36.5 % HCl has density equal to 1.20 g mL^{-1}. The molarity (M) and molality (m), respectively, are
(A) 15.7, 15.7 (B) 12, 12 (C) 15.7, 12 (D) 12, 15.7

15. An aqueous solution of ethanol has density 1.025 g/mL and it is 2M. What is the molality of this solution ?
(A) 1.79 (B) 2.143 (C) 1.951 (D) None of these.

16. Mole fraction of ethyl alcohol in aqueous ethyl alcohol (C_2H_5OH) solution is 0.25. Hence percentage of ethyl alcohol by weight is :
(A) 54% (B) 25% (C) 75% (D) 46%

17. Calculate the mass percent (w/w) of sulphuric acid in a solution prepared by dissolving 4 g of sulphur trioxide in a 100 ml sulphuric acid solution containing 80 mass percent (w/w) of H_2SO_4 and having a density of 1.96 g/ml. (molecular weight of H_2SO_4 = 98). Take reaction $SO_3 + H_2O \rightarrow H_2SO_4$
(A) 80.8% (B) 84% (C) 41.65% (D) None of these

18. Molarity and Molality of a solute (M. wt = 50) in aqueous solution is 9 and 18 respectively. What is the density of solution.
(A) 1 g/cc (B) 0.95 g/cc (C) 1.05 g/cc (D) 0.662 g/cc

19. What volume (in ml) of 0.2 M H_2SO_4 solution should be mixed with the 40 ml of 0.1 M NaOH solution such that the resulting solution has the concentration of H_2SO_4 as $\frac{6}{55}$ M.
(A) 70 (B) 45 (C) 30 (D) 58

PART - II : SUBJECTIVE QUESTIONS

1. How many gram ions of SO_4^{-2} are present in 1.25 mole of $K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$:

2. A certain organic substance used as a solvent in many reactions contains carbon, hydrogen, oxygen and sulphur. Weight % of hydrogen in the compound is 7.7. The weight ratio C : O : S = 3 : 2 : 4. What is the least possible molar mass (in g) of the compound ?

3. Calculate maximum mass of $CaCl_2$ produced when 2.4×10^{24} atoms of calcium is taken with 96 litre of Cl_2 gas at 380 mm pressure and at 27ºC.
[R : 0.08 atm L/mole-K & $N_A = 6 \times 10^{23}$]

4. A 2 g sample containing Na_2CO_3 and $NaHCO_3$ losses 0.248 g when heated to 300^0 C , the temperature at which $NaHCO_3$ decomposes to Na_2CO_3 , CO_2 and H_2O. What is the percentage of Na_2CO_3 in the given mixture ?

5. A sample of chalk contains clay as impurity. The clay impurity loses 11% of its weight as moisture on prolong heating. 5 gram sample of chalk on heating shows a loss in weight (due to evolution of CO_2 and water) by 1.1 g. Calculate % of chalk ($CaCO_3$) in the sample. [Hint : Chalk ($CaCO_3$) release CO_2 on heating]

6. A fluorine disposal plant was constructed to carryout the reactions :

$$F_2 + 2NaOH \longrightarrow \frac{1}{2}O_2 + 2NaF + H_2O$$

$$2NaF + CaO + H_2O \longrightarrow CaF_2 + 2NaOH$$

As the plant operated, excess lime was added to bring about complete precipitation of the fluoride as CaF_2. Over a period of operation, 1900 kg of fluorine was fed into a plant and 10,000 kg of lime was required. What was the percentage utilisation of lime ? [Lime : CaO]

7. $Cl_2 + KOH \xrightarrow{60\%} KCl + KClO + H_2O$

$KClO \xrightarrow{50\%} KCl + KClO_3$

$KClO_3 \xrightarrow{80\%} KClO_4 + KCl$

113.5 L Cl_2 gas at STP is passed in 10 L KOH solution, containing 1 mole of potassium hydroxide per liter. Calculate the total moles of KCl produced, rounding it off to nearest whole number. (Yield of chemical reactions are written above the arrow ($\rightarrow$) of respective reaction)

8. If 240 g of carbon is taken in a container to convert it completely to CO_2 but in industry it has been found that 280 g of CO was also formed along with CO_2. Find the mole percentage yield of CO_2. The reactions occurring are $C + O_2 \longrightarrow CO_2$; $C + \frac{1}{2} O_2 \longrightarrow CO$

9. Among the following compounds given below, what is the sum of the oxidation states of all underlined elements ?
$\underline{C}O_2$, $K_2\underline{Mn}O_4$

10. Find the sum of average oxidation number of S in H_2SO_5 (peroxy monosulphuric acid) and $Na_2S_2O_3$ (sodium thiosulphate).

11. The reaction $Cl_2(g) + S_2O_3^{2-} \longrightarrow SO_4^{2-} + Cl^-$ is to be carried out in basic medium. Starting with 1.5 mole of Cl_2, 0.1 mole $S_2O_3^{2-}$ and 3 mole of OH^-. How many moles of OH^- will be left in solution after the reaction is complete. Assume no other reaction occurs.

12. What volume of water should be added to 50 ml of HNO_3 having density 1.5 g ml^{-1} and 63.0% by weight to have one molar solution.

13. What is the quantity of water (in g) that should be added to 16 g. methanol to make the mole fraction of methanol as 0.25 :

14. What volume (in mL) of 90% alcohol by weight (d = 0.8 g mL^{-1}) must be used to prepare 80 mL of 10% alcohol by weight (d = 0.9 g mL^{-1}) ?

15. A solution containing 0.1 mol of a metal chloride MCl_x requires 500 ml of 0.8 M $AgNO_3$ solution for complete reaction $MCl_x + xAgNO_3 \rightarrow xAgCl + M(NO_3)_x$. Then the value of x is :

16. 60 ml of a **"x"** % w/w alcohol (d = 0.6 g/cm^3) must be used to prepare 200 cm^3 of 12% w/w alcohol by weight (d = 0.90 g/cm^3). Calculate the value of **"x"**?

17. During estimation of nitrogen present in an organic compound by Kjeldahl's method, the ammonia evolved from 0.5g of the compound in Kjeldahl's estimation of nitrogen, neutralized 10 mL of 1M H_2SO_4. What is the percentage of nitrogen in the compound :

18. In a gravimetric determination of P , an aqueous solution of dihydrogen phosphate ion $H_2PO_4^-$ is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate, $Mg(NH_4)PO_4.6H_2O$. This is heated and decomposed to magnesium pyrophosphate, $Mg_2P_2O_7$, which is weighed. A solution of $H_2PO_4^-$ yielded 1.054 g of $Mg_2P_2O_7$. What weight of NaH_2PO_4 was present originally ?

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Which is/are correct statements about 1.7 g of NH_3 :

(A) It contain 0.3 mol H – atom
(B) it contain 2.408×10^{23} atoms
(C) Mass % of hydrogen is 17.65%
(D) It contains 0.3 mol N-atom

2. Select the correct statement(s) for $(NH_4)_3PO_4$.

(A) Ratio of number of oxygen atoms to number of hydrogen atoms is 1 : 3

(B) Ratio of number of cations to number of anions is 3 : 1

(C) Ratio of number of gm-atoms of nitrogen to gm-atoms of oxygen is 3 : 2

(D) Total number of atoms in one mole of $(NH_4)_3PO_4$ is 20.

3.✍ If 27 g of Carbon is mixed with 88 g of Oxygen and is allowed to burn to produce CO_2 , then :

(A) Oxygen is the limiting reagent.

(B) Volume of CO_2 gas produced at STP is 51.075 L.

(C) C and O combine in mass ratio 3 : 8.

(D) Volume of unreacted O_2 at STP is 11.35 L.

4. The density of air is 0.001293 g/cm^3 at STP. Identify which of the following statement is correct

(A) Vapour density is 14.67

(B) Molecular weight is 29.35

(C) Vapour density is 0.001293 g/cm^3

(D) Vapour density and molecular weight cannot be determined.

5. 12 g of Mg was burnt in a closed vessel containing 32 g oxygen. Which of the following is /are correct.

(A) 2 gm of Mg will be left unburnt.

(B) 0.75 gm-molecule of O_2 will be left unreacted.

(C) 20 gm of MgO will be formed.

(D) The mixture at the end will weight 44 g.

6. (i) $K_4Fe(CN)_6 + 3H_2SO_4 \longrightarrow 2K_2SO_4 + FeSO_4 + 6HCN$

(ii) $6HCN + 12H_2O \longrightarrow 6HCOOH + 6NH_3$

(iii) (a) $6NH_3 + 3H_2SO_4 \longrightarrow 3(NH_4)_2SO_4$ (b) $6HCOOH \xrightarrow{H_2SO_4} 6CO + 6H_2O$

Above steps of reactions occur in a container starting with one mole of $K_4[Fe(CN)_6]$, 5 mole of H_2SO_4 and enough water. Find out the limiting reagent in step (i) and calculate maximum moles of CO gas and $(NH_4)_2SO_4$ that can be produced.

(A) LR = H_2SO_4 (B) LR = $K_4Fe(CN)_6$,

(C) 6 moles of CO, 2 moles of $(NH_4)_2SO_4$ (D) 5 moles of CO, 2.5 moles of $(NH_4)_2SO_4$

7.✍ A sample of a mixture of $CaCl_2$ and NaCl weighing 4.44 g was treated to precipitate all the Ca as $CaCO_3$, which was then heated and quantitatively converted to 1.12g of CaO. (At . wt. Ca = 40, Na = 23, Cl = 35.5)

(A) Mixture contains 50% NaCl (B) Mixture contains 60% $CaCl_2$

(C) Mass of $CaCl_2$ is 2.22 g (D) Mass of $CaCl_2$ 1.11 g

8. For the following reaction : $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

106.0 g of Na_2CO_3 reacts with 109.5 g of HCl.

Which of the following is/are correct.

(A) The HCl is in excess.

(B) 117.0 g of NaCl is formed.

(C) The volume of CO_2 produced at 0°C and 1 atm is 22.4 L

(D) None of these

9.✍ $A + B \rightarrow A_3B_2$ (unbalanced)

$A_3B_2 + C \rightarrow A_3B_2C_2$ (unbalanced)

Above two reactions are carried out by taking 3 moles each of A and B and one mole of C. Then which option is/are correct ?

(A) 1 mole of $A_3B_2C_2$ is formed (B) $1/2$ mole of $A_3B_2C_2$ is formed

(C) 1/2 mole of A_3B_2 is formed (D) $1/2$ mole of A_3B_2 is left finally

10. 'A' reacts by following two parallel reactions to give B & C If half of 'A' goes into reaction I and other half goes to reaction-II. Then , select the correct statement(s)

$$A + N \xrightarrow{I} B + L$$

$$A + N \xrightarrow{II} \frac{1}{2} B + \frac{1}{2} (C) + L$$

(A) B will be always greater than C
(B) If 2 mole of C are formed then total 2 mole of B are also formed
(C) If 2 mole of C are formed then total 4 mole of B are also formed
(D) If 2 mole of C are formed then total 6 mole of B are also formed

11. Which of the following are examples of disproportionation reaction :
(A) $HgO \longrightarrow Hg + O_2$
(B) $KClO_3 \longrightarrow KCl + O_2$
(C) $KClO_3 \longrightarrow KClO_4 + KCl$
(D) $Cl_2 + OH^- \longrightarrow ClO^- + Cl^- + H_2O$

12. Consider the redox reaction $2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$:
(A) $S_2O_3^{2-}$ gets reduced to $S_4O_6^{2-}$
(B) $S_2O_3^{2-}$ gets oxidised to $S_4O_6^{2-}$
(C) I_2 gets reduced to I^-
(D) I_2 gets oxidised to I^-

13. Which of the following statements is/are correct ?
In the reaction $xCu_3P + yCr_2O_7^{2-} + zH^+ \longrightarrow Cu^{2+} + H_3PO_4 + Cr^{3+}$
(A) Cu in Cu_3P is oxidised to Cu^{2+} whereas P in Cu_3P is also oxidised to PO_4^{3-}
(B) Cu in Cu_3P is oxidised to Cu^{2+} whereas P in Cu_3P is reduced to H_3PO_4
(C) In the conversion of Cu_3P to Cu^{2+} and H_3PO_4, 11 electrons are involved
(D) The value of x is 6.

14. Solutions containing 23 g HCOOH is/are :

(A) 46 g of 70% $\left(\frac{w}{v}\right)$ HCOOH ($d_{solution}$ = 1.40 g/mL)

(B) 50 g of 10 M HCOOH ($d_{solution}$ = 1 g/mL)

(C) 50 g of 25% $\left(\frac{w}{w}\right)$ HCOOH

(D) 46 g of 5 M HCOOH ($d_{solution}$ = 1 g/mL)

15. Which of the following solutions contains same molar concentration ?
(A) 166 g. KI/L solution
(B) 33.0 g $(NH_4)_2SO_4$ in 200 mL solution
(C) 25.0 g $CuSO_4.5H_2O$ in 100mL solution
(D) 27.0 mg Al^{3+} per mL solution

16. If 100 ml of 1M H_2SO_4 solution is mixed with 100 ml of 9.8%(w/w) H_2SO_4 solution (d = 1 g/ml) then :
(A) concentration of solution remains same
(B) volume of solution become 200 ml
(C) mass of H_2SO_4 in the solution is 98 g
(D) mass of H_2SO_4 in the solution is 19.6 g

17. Equal volume of 0.1M NaCl and 0.1M $FeCl_2$ are mixed with no change in volume due to mixing. Which of the following will be true for the final solution. (No precipitation occurs). Assume complete dissociation of salts and neglect any hydrolysis.
(A) $[Na^+]$ = 0.05 M (B) $[Fe^{2+}]$ = 0.05M (C) $[Cl^-]$ = 0.3M (D) $[Cl^-]$ = 0.15M

PART - IV : COMPREHENSION

Read the following comprehension carefully and answer the questions.

Comprehension # 1

A chemist decided to determine the molecular formula of an unknown compound. He collects following informations :

(I) Compounds contains 2 : 1 'H' to 'O' atoms(number of atoms).

(II) Compounds has 40% C by mass

(III) Approximate molecular mass of the compound is 178 g

(IV) Compound contains C, H and O only.

1. What is the % by mass of oxygen in the compound

(A) 53.33% (B) 88.88% (C) 33.33% (D) None of these

2. What is the empirical formula of the compound

(A) CH_3O (B) CH_2O (C) C_2H_2O (D) CH_3O_2

3. Which of the following could be molecular formula of compound

(A) $C_6H_6O_6$ (B) $C_6H_{12}O_6$ (C) $C_6H_{14}O_{12}$ (D) $C_6H_{14}O_6$

Comprehension # 2

According to the Avogadro's law, equal number of moles of gases occupy the same volume at identical condition of temperature and pressure. Even if we have a mixture of non-reacting gases then Avogadro's law is still obeyed by assuming mixture as a new gas.

Now let us assume air to consist of 80% by volume of Nitrogen (N_2) and 20% by volume of oxygen (O_2). If air is taken at STP then its 1 mol would occupy 22.7 L. 1 mol of air would contain 0.8 mol of N_2 and 0.2 mol of O_2 hence the mole fractions of N_2 and O_2 are given by $X_{N_2} = 0.8$, $X_{O_2} = 0.2$

4. Volume occupied by air at STP containing exactly 11.2 g of Nitrogen :

(A) 22.4 L (B) 8.96 L (C) 11.35 L (D) 2.24 L

5. If air is treated as a solution of O_2 and N_2 then % W/W of oxygen is :

(A) $\frac{10}{9}$ (B) $\frac{200}{9}$ (C) $\frac{700}{9}$ (D) $\frac{350}{9}$

6. Density of air at STP is :

(A) 1 g/L (B) 1.26 g/L (C) 2.52 g/L (D) can't be determined

Comprehension # 3

The concentrations of solutions can be expressed in number of ways; viz : mass fraction of solute (or mass percent), Molar concentration (Molarity) and Molal concentration (molality). These terms are known as concentration terms and also they are related with each other i.e. knowing one concentration term for the solution, we can find other concentration terms also. The definition of different concentration terms are given below :

Molarity : It is number of moles of solute present in one litre of the solution.

Molality : It is the number of moles of solute present in one kg of the solvent

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

If molality of the solution is given as 'a' then mole fraction of the solute can be calculated by

$$\text{Mole Fraction} = \frac{a}{a + \frac{1000}{M_{solvent}}} \; ; \; = \frac{a \times M_{solvent}}{(a \times M_{solvent} + 1000)}$$

where a = molality and $M_{solvent}$ = Molar mass of solvent

We can change : Mole fraction $\leftrightarrow$ Molality $\leftrightarrow$ Molarity

7. 60 g of solution containing 40% by mass of NaCl are mixed with 100 g of a solution containing 15% by mass NaCl. Determine the mass percent of sodium chloride in the final solution.

(A) 24.4% (B) 78% (C) 48.8% (D) 19.68%

8. What is the molality of the above solution.

(A) 4.4 m (B) 5.5 m (C) 24.4 m (D) none

9. What is the molarity of solution if density of solution is 1.6 g/ml

(A) 5.5 M (B) 6.67 M (C) 2.59 M (D) none

Comprehension # 4

Column-I		**Column-II**		**Column-III**	
(A)	2 M - aqueous NaOH solution (density = 1.25 gm/ml)	(i)	2 mole solute/litre solution	(I)	6 % (w/v) solution
(B)	1.5 m - aqueous NaOH solution (density = 1.06 gm/ml)	(ii)	1.5 mole solute/litre solution	(II)	8 % (w/v) solution
(C)	0.5 M aqueous Glucose solution (density = 1.09 gm/ml)	(iii)	0.5 mole solute/litre solution	(III)	9 % (w/v) solution
(D)	1.5 M aqueous Urea solution (density = 1.15 gm/ml)	(iv)	1.5 mole solute/kg solvent	(IV)	9 gm solute per 100 gm solvent

10. Which of the following is correct match ?

(A) A – i – II (B) B – ii – I (C) C – iii – IV (D) D – iv – iii

11. Which of the following is correct match ?

(A) A – i – I (B) B – iv – I (C) C – iii – I (D) D – ii – I

12. Which of the following is correct match ?

(A) A – ii – III (B) B – ii – III (C) C – ii – III (D) D – ii – III

Exercise-3

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. Reaction of Br_2 with Na_2CO_3 in aqueous solution gives sodium bromide and sodium bromate with evolution of CO_2 gas. The number of sodium bromide molecules involved in the balanced chemical equation is **[JEE 2011, 4/180]**

2. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is : **[JEE 2011, 3/160]**
(A) 1.78 M (B) 2.00 M (C) 2.05 M (D) 2.22 M

3. 29.2% (w/w) HCl stock solution has a density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5 g mol^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution of 0.4 M HCl is : **[JEE 2012, 4/136]**

4.* For the reaction : $I^- + ClO_3^- + H_2SO_4 \longrightarrow Cl^- + HSO_4^- + I_2$
The correct statement(s) in the balanced equation is/are : **[JEE(Advanced) 2014, 3/120]**
(A) Stoichiometric coefficient of HSO_4^- is 6. (B) Iodide is oxidized.
(C) Sulphur is reduced. (D) H_2O is one of the products.

5. A compound $\mathbf{H_2X}$ with molar weight of 80 g is dissolved in a solvent having density of 0.4 g ml^{-1}. Assuming no change in volume upon dissolution, the **molality** of a 3.2 molar solution is **[JEE(Advanced) 2014, 3/120]**

6. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, $\left(\frac{MW_{solute}}{MW_{solvent}}\right)$, is **[JEE(Advanced) 2016]**

7. The order of the oxidation state of the phosphorus atom in H_3PO_2, H_3PO_4, H_3PO_3 and $H_4P_2O_6$ is **[JEE(Advanced) 2017]**
(A) $H_3PO_4 > H_4P_2O_6 > H_3PO_3 > H_3PO_2$
(B) $H_3PO_3 > H_3PO_2 > H_3PO_4 > H_4P_2O_6$
(C) $H_3PO_2 > H_3PO_3 > H_4P_2O_6 > H_3PO_4$
(D) $H_3PO_4 > H_3PO_2 > H_3PO_3 > H_4P_2O_6$

8. The mole fraction of urea in an aqueous urea solution containing 900 g of water is 0.05. If the density of the solution is 1.2 g cm^{-3}, the molarity of urea solution is ___
(Given data : Molar masses of urea and water are 60 g mol^{-1} and 18 g mol^{-1}, respectively) **[JEE(Advanced) 2019]**

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A 5.2 molal aqueous solution of methyl alcohol, CH_3OH, is supplied. What is the mole fraction of methyl alcohol in the solution? **[AIEEE-2011, 3/120]**
(1) 0.100 (2) 0.190 (3) 0.086 (4) 0.050

2. The molality of a urea solution in which 0.0100 g of urea, $[(NH_2)_2CO]$ is added to 0.3000 dm^3 of water at STP is : **[Re. Paper AIEEE-2011, 3/120]**
(1) 5.55×10^{-4} (2) 33.3 m (3) 3.33×10^{-2} m (4) 0.555 m

3. The density of a solution prepared by dissolving 120 g of urea (mol. mass = 60 u) in 1000 g of water is 1.15 g/mL. The molarity of this solution is : **[AIEEE-2012, 4/120]**

(1) 0.50 M (2) 1.78 M (3) 1.02 M (4) 2.05 M

4. The ratio of number of oxygen atoms (O) in 16.0 g ozone (O_3), 28.0 g carbon monoxide (CO) and 16.0 g oxygen (O_2) is :-

(Atomic mass : C = 12, O = 16 and Avogadro's constant $N_A = 6.0 \times 10^{23}$ mol^{-1})

[AIEEE 2012 (Online)]

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

5. The molarity of a solution obtained by mixing 750 mL of 0.5(M) HCl with 250 mL of 2(M)HCl will be :

[JEE(Main)-2013, 4/120]

(1) 0.875 M (2) 1.00 M (3) 1.75 M (4) 0.975 M

6. Consider the following reaction :

$$xMnO_4^- + yC_2O_4^{2-} + zH^+ \rightarrow xMn^{2+} + 2yCO_2 + \frac{z}{2}H_2O$$

The values of x, y and z in the reaction are, respectively : **[JEE(Main)-2013, 4/120]**

(1) 5, 2 and 16 (2) 2, 5 and 8 (3) 2, 5 and 16 (4) 5, 2 and 8

7. 10 mL of 2(M) NaOH solution is added to 200 mL of 0.5 (M) of NaOH solution. What is the final concentration ? **[JEE(Main-online)-2013]**

(1) 0.57 M (2) 5.7 M (3) 11.4 M (4) 1.14 M

8. The density of 3M solution of sodium chloride is 1.252 g mL^{-1}. The molality of the solution will be(molar mass, NaCl = 58.5 g mol^{-1}) **[JEE(Main-online)-2013]**

(1) 2.18 m (2) 3.00 m (3) 2.60 m (4) 2.79 m

9. In which of the following reactions H_2O_2 acts as a reducing agent ? **[JEE(Main)-2014, 4/120]**

(a) $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$

(b) $H_2O_2 - 2e^- \longrightarrow O_2 + 2H^+$

(c) $H_2O_2 + 2e^- \longrightarrow 2OH^-$

(d) $H_2O_2 + 2OH^- - 2e^- \longrightarrow O_2 + 2H_2O$

(1) (a), (b) (2) (c), (d) (3) (a), (c) (4) (b), (d)

10. The amount of $BaS0_4$ formed upon mixing 100 mL of 20.8% $BaCl_2$ solution with 50 mL of 9.8% H_2SO_4 solution will be : **[JEE(Main-online)-2014]**

(Ba = l37, Cl = 35.5, S=32, H = l and O = 16)

(1) 33.2 g (2) 11.65 g (3) 23.3 g (4) 30.6 g

11. For the estimation of nitrogen, 1.4 g of an organic compound was digested by Kjeldahl method and the evolved ammonia was absorbed in 60 mL of $\frac{M}{10}$ sulphuric acid. The unreacted acid required 20 mL of $\frac{M}{10}$ sodium hydroxide for complete neutralizaton. The percentage of nitrogen in the compound is :

[JEE(Main-online)-2014]

(1) 3% (2) 5% (3) 6% (4) 10%

12. The molecular formula of a commercial resin used for exchanging ions in water softening is $C_8H_7SO_3Na$ (Mol. wt. 206). What would be the maximum uptake of Ca^{2+} ions by the resin when expressed in mole per gram resin ? **[JEE(Main)-2015, 4/120]**

(1) $\frac{1}{103}$ (2) $\frac{1}{206}$ (3) $\frac{2}{309}$ (4) $\frac{1}{412}$

13. A sample of a hydrate of barium chloride weighing 61 g was heated until all the water of hydration is removed. The dried sample weighed 52 g. The formula of the hydrated salt is : (Atomic mass , Ba = 137 amu, Cl = 35.5 amu) **[JEE(Main)-2015 (online)]**

(1) $BaCl_2.H_2O$ (2) $BaCl_2.4H_2O$ (3) $BaCl_2.3H_2O$ (4) $BaCl_2.2H_2O$

14. At 300 K and 1 atm, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O_2 by volume for complete combustion. After combustion the gases occupy 330 mL. Assuming that the water formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is :- **[JEE(Main)-2016]**

(1) C_4H_{10} (2) C_3H_6 (3) C_3H_8 (4) C_4H_8

15. The non-metal that does not exhibit positive oxidation state is : **[JEE(Main)-2016 (online)]**

(1) Fluorine (2) Oxygen (3) Chlorine (4) Iodine

16. 5 L of an alkane requires 25 L of oxygen for its complete combustion. If all volumes are measured at constant temperature and pressure, the alkane is : **[JEE(Main)-2016 (online)]**

(1) Butane (2) Isobutane (3) Ethane (4) Propane

17. The most abundant elements by mass in the body of a healthy human adult are :

Oxygen (61.4%) ; Carbon (22.9%), Hydrogen (10.0%) ; and Nitrogen (2.6%). The weight which a 75 kg person would gain if all ^1H atoms are replaced by ^2H atoms is: **[JEE(Main)-2017]**

(1) 15 kg (2) 37.5 kg (3) 7.5 kg (4) 10 kg

18. 1 gram of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO_2. the molar mass of M_2CO_3 in g mol^{-1} is :- **[JEE(Main)-2017]**

(1) 1186 (2) 84.3 (3) 118.6 (4) 11.86

19. Excess of NaOH (aq) was added to 100 mL of $FeCl_3$(aq) resulting into 2.14 g of $Fe(OH)_3$. The molarity of $FeCl_3$(aq) is : **[JEE(Main)-2017 (online)]**

(Given molar mass of Fe = 56 $gmol^{-1}$ and molar mass of Cl = 35.5 g mol^{-1})

(1) 1.8 M (2) 0.2 M (3) 0.6 M (4) 0.3 M

20. The pair of compounds having metals in their highest oxidation state is : **[JEE(Main)-2017 (online)]**

(1) MnO_2 and CrO_2Cl_2 (2) $[FeCl_4]^-$ and Co_2O_3

(3) $[Fe(CN)_6]^{-3}$ and $[Cu(CN)_4]^{2-}$ (4) $[NiCl_4]^{2-}$ and $[CoCl_4]^{2-}$

21. The ratio of mass percent of C and H of an organic compound ($C_XH_YO_Z$) is 6 : 1. If one molecule of the above compound ($C_XH_YO_Z$) contains half as much oxygen as required to burn one molecule of compound C_XH_Y completely to CO_2 and H_2O. The empirical formula of compound $C_XH_YO_Z$ is : **[JEE(Main)-2018]**

(1) C_2H_4O (2) $C_3H_4O_2$ (3) $C_2H_4O_3$ (4) $C_3H_6O_3$

22. An unknown chlorohydrocarbon has 3.55% of chlorine. If each molecule of the hydrocarbon has one chlorine atom only; chlorine atoms present in 1 g of chlorohydrocarbon are :

(Atomic wt. of Cl = 35.5 u; Avogadro constant = 6.023×10^{23} mol^{-1}) **[JEE(Main)-2018 (online)]**

(1) 6.023×10^{21} (2) 6.023×10^{23} (3) 6.023×10^{20} (4) 6.023×10^{9}

23. For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is :

$2C_{57}H_{110}O_6(s) + 163O_2(g) \rightarrow 114CO_2(g) + 110\ H_2O(l)$ **[JEE(Main)-2019 (Jan.)]**

(1) 495 g (2) 490 g (3) 890 g (4) 445 g

24. The amount of sugar ($C_{12}H_{22}O_{11}$) required to prepare 2 L of its 0.1 M aqueous solution is :

(1) 68.4 g (2) 17.1 g (3) 34.2 g (4)136.8 g

[JEE-Main(Jan.)-2019]

25. A solution of sodium sulfate contains 92 g of Na^+ ions per kilogram of water. The molality of Na^+ ions in that solution in mol kg^{-1} is: **[JEE-Main(Jan.)-2019]**

(1) 16 (2) 8 (3) 4 (4) 12

26. For a reaction, **[JEE(Main)-2019 (-April)]**

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$;

identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures.

(1) 14g of N_2 + 4g of H_2 (2) 28g of N_2 + 6g of H_2

(3) 56g of N_2 + 10g of H_2 (4) 35g of N_2 + 8g of H_2

27. 5 moles of AB_2 weigh 125×10^{-3} kg and 10 moles of A_2B_2 weigh 300×10^{-3} kg. The molar mass of A(M_A) and molar mass of B(M_B) in kg mol^{-1} are : **[JEE(Main)-2019 (-April)]**

(1) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$ (2) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$

(3) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$ (4) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$

28. What would be the molality of 20% (mass/mass) aqueous solution of KI?

(molar mass of KI = 166 g mol^{-1}) **[JEE-Main(April)-2019]**

(1) 1.08 (2) 1.48 (3) 1.51 (4) 1.35

29. Oxidation number of potassium in K_2O, K_2O_2 and KO_2 , respectively, is :

[JEE-Main(Jan)-2020]

(1) +1, +4 and +2 (2) +1, +2 and +4 (3)+1, +1 and +1 (4) +2 , +1 and $+\frac{1}{2}$

30. Ferrous sulphate heptahydrate is used to fortify foods with iron. The amount (in grams) of the salt required to achieve 10 ppm of iron in 100 kg of wheat is _____. **[JEE-Main(Jan)-2020]**

Atomic weight : Fe = 55.85 ; S = 32.0 ;

O = 16.00

31. $NaClO_3$ is used, even in spacecrafts, to produce O_2. The daily consumption of pure O_2 by a person is 492L at 1 atm, 300K. How much amount of $NaClO_3$, in grams, is required to produce O_2 for the daily consumption of a person at 1 atm, 300 K ? **[JEE-Main(Jan)-2020]**

$NaClO_3(s) + Fe(s) \rightarrow O_2(g) + NaCl(s) + FeO(s)$ R = 0.082 L atm mol^{-1} K^{-1}

ANSWER KEY

EXERCISE # 1

PART - I

A-1. (34.05 L) **A-2.** (100) **A-3.** 5.40 **B-1.** (4) **B-2.** (6) **B-3.** ($C_2H_4O_2$)

B-4. $\% \ CO_2 = \frac{2}{2+1+2} \times 100 = 40\%$. **C-1.** 2.16 g **C-2.** 42 g **C-3.** 73 gm **C-4.** 27.6 gm

C-5. 63 L **C-6.** 58.8 gm **D-1.** (i) 1/6 mole (ii) 5/12 mole

D-2. 154 gm , 24 gm **D-3.** 0.1185 **D-4.** 0.25 mole **E-1.** m = 1.4 g

E-2. 4 **E-3.** w_{CO_2} = 528 gm **E-5.** 63%, 37% **E-6.** 304 gm

F-1. (a) +3 (b) +5 (c) +6 (d) +2 (e) +8/3
(f) +3 (g) +1 (h) +2 (i) 200/93 = 2.15

F-2. (a) $K\overset{(+7)}{Mn}O_4 + K\overset{(-1)}{Cl} + H_2SO_4 \longrightarrow \overset{(+2)}{Mn}SO_4 + K_2SO_4 + H_2O + \overset{(0)}{Cl_2}$.

$K\overset{(+7)}{Mn}O_4$ (oxidant) $\longrightarrow \overset{(+2)}{Mn}SO_4$ (reduction half).

$K\overset{(-1)}{Cl}$ (reductant) $\longrightarrow \overset{(0)}{Cl_2}$ (oxidation half).

(b) $\overset{(+2)}{Fe}Cl_2 + H_2\overset{(-1)}{O_2} + HCl \longrightarrow \overset{(+3)}{Fe}Cl_3 + H_2\overset{(-2)}{O}$ (oxidation half)

$\overset{(+2)}{Fe}Cl_2$ (reductant) $\longrightarrow \overset{(+3)}{Fe}Cl_3$ (oxidation half).

$H_2\overset{(-1)}{O_2}$ (oxidant) $\longrightarrow H_2O^{2-}$ (reduction half).

(c) $\overset{(0)}{Cu} + H\overset{(+5)}{N}O_3$ (dil) $\longrightarrow \overset{2+}{Cu}(NO_3)_2 + H_2O + \overset{2+}{N}O$.

$\overset{(0)}{Cu}$ (reductant) $\longrightarrow \overset{2+}{Cu}(NO_3)_2$ (oxidation half).

$H\overset{+5}{N}O_3$ (oxidant) $\longrightarrow \overset{+2}{N}O$ (reduction half).

(d) $Na_2H\overset{+3}{As}O_3 + K\overset{+5}{Br}O_3 + HCl \longrightarrow NaCl + K\overset{-1}{Br} + H_3\overset{+5}{As}O_4$

$Na_2H\overset{+3}{As}O_3$ (reductant) $\longrightarrow H_3\overset{+5}{As}O_4$ (oxidation half).

$K\overset{+5}{Br}O_3$ (oxidant) $\longrightarrow K\overset{-1}{Br}$.

(e) $\overset{0}{I_2} + Na_2\overset{+2}{S_2}O_3 \longrightarrow Na_2\overset{+2.5}{S_4}O_6 + Na\overset{-1}{I}$.

$\overset{0}{I_2}$ (oxidant) $\longrightarrow Na\overset{-1}{I}$ (reduction half).

$Na_2\overset{+2}{S_2}O_3$ (reductant) $\longrightarrow Na_2\overset{+2.5}{S_4}O_6$ (oxidation half).

G-1. (a) $S_4O_6^{2-} + 6Al + 20H^+ \longrightarrow 4H_2S + 6Al^{3+} + 6H_2O$

(b) $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$

(c) $IO_4^- + 7I^- + 8H^+ \rightarrow 4I_2 + 4H_2O$

(d) $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(e) $3HNO_2 \longrightarrow NO_3^- + 2NO + H_2O + H^+$

G-2. (a) $3ClO^- + 2CrO_2^- + 2OH^- \rightarrow 3Cl^- + 2CrO_4^{2-} + H_2O$

(b) $4Zn + NO_3^- + 7OH^- \rightarrow NH_3 + 4ZnO_2^{2-} + 2H_2O$

(c) $4S + 6OH^- \rightarrow 2S^{2-} + S_2O_3^{2-} + 3H_2O$

(d) $3Mn(OH)_2 + 2MnO_4^- \longrightarrow 5MnO_2 + 2H_2O + 2OH^-$

(e) $2MnO_4^- + SO_3^{2-} + 2OH^- \rightarrow 2MnO_4^{2-} + SO_4^{2-} + H_2O$

H-1. 5.6 g **H-2.** 0.168 m

H-3. (i) 2.17 m, (ii) 6.25 M, (iii) 0.0376, (iv) 0.0826, (v) 8% (vi) 16.67%. (vii) 25%, (viii) 36.25%, (ix) 72.5%, (x) 14.2 m.

H-4. **(i)**

$$\boxed{\begin{array}{cccc} NaCl & \rightarrow & Na^+ + & Cl^- \\ 0.2 & & 0.2 & 0.2 \end{array}}$$

(ii)

$$\boxed{\begin{array}{ccccc} Al_2(SO_4) & \rightarrow & 2Al^{3+} & + & 3SO_4^{-2} \\ 1.2 & & 2.4 & & 3.6 \end{array}}$$

(iii)

$$\boxed{\begin{array}{ccccc} H_2SO_4 & \rightarrow & 2H^+ & + & SO_4^{-2} \\ 1.2 & & 2.4 & & 1.2 \end{array}}$$

(iv)

$$\boxed{\begin{array}{ccccc} MgCl_2 & \rightarrow & Mg^{2+} & + & 2Cl^- \\ 2.1 & & 2.1 & & 4.2 \end{array}}$$

I-1. 8 M **I-2.** 2.33 L

I-3. **(i)** 0.32 M

(ii) $\frac{9}{7}$ M

(iii) 0.18 M

(iv) 0.24 M

J-1. 34 **J-2.** 50 **J-3.** 50 **J-4.** 17.46 **J-5.** 42.1

PART - II

A-1.	(B)	**A-2.**	(B)	**B-1.**	(B)	**B-2.**	(D)	**B-3.**	(C)	**B-4.**	(C)	**C-1.**	(C)
C-2.	(C)	**C-3.**	(C)	**C-4.**	(B)	**C-5.**	()	**C-6.**	(B)	**D-1.**	(A)	**D-2.**	(C)
D-3.	(A)	**D-4.**	(B)	**D-5.**	(B)	**D-6.**	(A)	**E-1.**	(A)	**E-2.**	(B)	**E-3.**	(A)
E-4.	(A)	**E-5.**	(D)	**E-6.**	(A)	**F-1.**	(D)	**F-2.**	(C)	**F-3.**	(B)	**F-4.**	(A)
F-5.	(C)	**F-6.**	(B)	**G-1.**	(C)	**G-2.**	(A)	**G-3.**	(C)	**G-4.**	(B)	**G-5.**	(D)
H-1.	(C)	**H-2.**	(B)	**H-3.**	(C)	**H-4.**	(D)	**H-5.**	(C)	**H-6.**	(A)	**H-7.**	(C)
I-1.	(A)	**I-2.**	(C)	**I-3.**	(B)	**I-4.**	(D)	**I-5.**	(C)	**I-6.**	(B)	**I-7.**	(C)
J-1.	(B)	**J-2.**	(A)										

PART - III

1. (A - q,s); (B - p, s); (C - p, q, r); (D - q, r)
2. (A - p,q,r,s; (B - p,s; (C - q,r) ; (D - q)
3. (A)-(P,Q,R,S) ; (B)-(Q,R,T) ; (C)-(Q,S) ; (D)-(P)

EXERCISE # 2

PART - I

1.	(C)	**2.**	(A)	**3.**	(C)	**4.**	(A)	**5.**	(A)	**6.**	(C)	**7.**	(A)
8.	(B)	**9.**	(B)	**10.**	(D)	**11.**	(A)	**12.**	(A)	**13.**	(A)	**14.**	(D)
15.	(B)	**16.**	(D)	**17.**	(A)	**18.**	(B)	**19.**	(A)				

PART - II

1.	5	**2.**	78	**3.**	(222 gm)	**4.**	66.4 %.	**5.**	33.33 %	**6.**	28
7.	4	**8.**	50	**9.**	10	**10.**	8	**11.**	2		
12.	700 ml.	**13.**	27	**14.**	10	**15.**	4	**16.**	**60**	**17.**	56
18.	01.14										

PART - III

1.	(ABC)	**2.**	(AB)	**3.**	(BCD)	**4.**	(AB)	**5.**	(BCD)	**6.**	(BC)
7.	(AC	**8.**	(ABC)	**9.**	(BD)	**10.**	(AD)	**11.**	(CD)	**12.**	(BC)
13.	(ACD)	**14.**	(AB)	**15.**	(ACD)	**16.**	(ABD)	**17.**	(ABD)		

PART - IV

1.	(A)	**2.**	(B)	**3.**	(B)	**4.**	(C)	**5.**	(B)	**6.**	(B)	**7.**	(A)
8.	(B)	**9.**	(B)	**10.**	(A)	**11.**	(B)	**12.**	(D)				

EXERCISE # 3

PART - I

1.	5	**2.**	(C)	**3.**	8 mL.	**4.**	(ABD)	**5.**	**8**	**6.**	**(9)**	**7.**	(A)
8.	2.98												

PART - II

1.	(3)	**2.**	(1)	**3.**	(4)	**4.**	(4)	**5.**	(1)	**6.**	(3)	**7.**	(A)
8.	(D)	**9.**	(4)	**10.**	(B)	**11.**	(D)	**12.**	(4)	**13.**	(4)	**14.**	(3)
15.	(1)	**16.**	(4)	**17.**	(3)	**18.**	(2)	**19.**	(2)	**20.**	(3)	**21.**	(3)
22.	(3)	**23.**	(1)	**24.**	(1)	**25.**	(3)	**26.**	(3)	**27.**	(3)	**28.**	(3)
29.	(3)	**30.**	4.95 to 4.97	**31.**	2120 to 2140								

Reliable Ranker Problems

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

Self Assessment Test

PART- 1 : PAPER JEE (MAIN) PATTERN

SECTION–I : (Maximum Marks : 80)

- This section contains **TWENTY** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :
  Full Marks : +4 If only the bubble corresponding to the correct option is darkened.
  Zero Marks : 0 If none of the bubbles is darkened.
  Negative Marks : –1 In all other cases

1. 112.0 mL of NO_2 at 0ºC and 1 atm was liquefied, the density of the liquid being 1.15 g mL^{-1}. Calculate the volume and the number of molecules in the liquid NO_2.
(A) 0.10 mL and 3.01×10^{22} (B) 0.20 mL and 3.01×10^{21}
(C) 0.20 mL and 6.02×10^{23} (D) 0.40 mL and 6.02×10^{21}

2. Common salt obtained from sea - water contains 96% NaCl by mass. The approximate number of molecules of NaCl present in 10.0 g of the common salt is : (At. wt. Na = 23)
(A) 10^{21} (B) 10^{22} (C) 10^{23} (D) 10^{24}

3. X and Y are two elements which form X_2Y_3 and X_3Y_4. If 0.20 mol of X_2Y_3 weighs 32.0 g and 0.4 mol of X_3Y_4 weighs 92.8 g, the atomic weights of X and Y are respectively
(A) 16.0 and 56.0 (B) 8.0 and 28.0 (C) 56.0 and 16.0 (D) 28.0 and 8.0

4. Consider the following statements :
1. If all the reactants are not taken in their stoichiometric ratio, then at least one reactant will be left behind.
2. 2 moles of H_2(g) and 3 moles of O_2(g) produce 2 moles of water.
3. equal wt. of carbon and oxygen are taken to produce CO_2 then O_2 is limiting reagent.
The above statements 1, 2, 3 respectively are (T = True, F = False)
(A) T T T (B) F T F (C) F F F (D) T F T

5. Which of the following equations is a balanced one :
(A) $5BiO_3^- + 22H^+ + Mn^{2+} \longrightarrow 5Bi^{3+} + 7H_2O + MnO_4^-$
(B) $5BiO_3^- + 14H^+ + 2Mn^{2+} \longrightarrow 5Bi^{3+} + 7H_2O + 2MnO_4^-$
(C) $2BiO_3^- + 4H^+ + Mn^{2+} \longrightarrow 2Bi^{3+} + 2H_2O + MnO_4^-$
(D) $6BiO_3^- + 12H^+ + 3Mn^{2+} \longrightarrow 6Bi^{3+} + 6H_2O + 3MnO_4^-$

6. During the disproportionation of Iodine to iodide and iodate ions, the ratio of iodate and iodide ions formed in alkaline medium is :
(A) 1 : 5 (B) 5 : 1 (C) 3 : 1 (D) 1 : 3

7. How much $NaNO_3$ must be weighed out to make 50 ml of an aqueous solution containing 70 mg of Na^+ per mL ?
(A) 12.394 g (B) 1.29 g (C) 10.934 g (D) 12.934 g

8. The strength of 10^{-2} M Na_2CO_3 solution in terms of molality will be (density of solution = 1.10 g mL^{-1}). (Molecular weight of Na_2CO_3 = 106 g mol^{-1})
(A) 9.00×10^{-3} (B) 1.5×10^{-2} (C) 5.1×10^{-3} (D) 11.2×10^{-3}

9. The temperature at which molarity of pure water is equal to its molality is :
(A) 273 K (B) 298 K (C) 277 K (D) None

10. What is the molarity of H_2SO_4 solution that has a density 1.84 g/cc at 35ºC and contains 98% by weight-
(A) 4.18 M (B) 8.14 M (C) 18.4 M (D) 18 M

11. 5.85 g of NaCl is dissolved in 1 L of pure water. The number of ions in 1 mL of this solution is
(A) 6.02×10^{19} (B) 1.2×10^{22} (C) 1.2×10^{20} (D) 6.02×10^{20}

12. A compound is composed of 74% C, 8.7% H and 17.3% N by mass. If the molecular mass of the compound is 162, what is its molecular formula ?
(A) C_5H_7N (B) $C_{10}H_{16}N_2$ (C) $C_8H_{14}N_3$ (D) $C_{10}H_{14}N_2$

13. Calculate the volume of O_2 needed for combustion of 1 kg of carbon at STP. $C + O_2 \xrightarrow{\Delta} CO_2$.
(A) 1891.67 L O_2 (B) 3733.33 L O_2. (C) 933.33 L O_2. (D) 4666.67 L O_2.

14. Li metal is one of the few substances that reacts directly with molecular nitrogen. The balanced equation for reaction is :

$$6Li(s) + N_2(g) \longrightarrow 2Li_3N(s)$$

How many grams of the product, lithium nitride, can be prepared from 3.5g of lithium metal and 8.4 g of molecular nitrogen ?
(A) 21.00 g of Li_3N. (B) 2.91 g of Li_3N. (C) 5.83 g of Li_3N. (D) 10.50 g of Li_3N.

15. Potassium super oxide, KO_2, is used in rebreathing gas masks to generate O_2. If a reaction vessel contains 0.15 mol KO_2 and 0.10 mol H_2O, what is the limiting reactant ? How many moles of oxygen can be produced?
$2KO_2 + 2H_2O \longrightarrow 2KOH + H_2O_2 + O_2$
(A) H_2O limiting reagent, 0.05 mol of O_2. (B) KO_2 limiting reagent, 0.05 mol of O_2.
(C) H_2O limiting reagent, 0.075 mol of O_2. (D) KO_2 limiting reagent, 0.075 mol of O_2.

16. A 1 g sample of $KClO_3$ was heated under such conditions that a part of it decomposed according to the equation.
(i) $2KClO_3 \longrightarrow 2KCl + 3O_2$
and the remaining underwent change according to the equation
(ii) $4KClO_3 \longrightarrow 3KClO_4 + KCl$
If the amount of O_2 evolved was 146.8 mL at 0ºC and 1 atm, calculate the percentage by weight of $KClO_4$ in the residue.
(A) 29.3 %. (B) 49.8 %. (C) 62.5 %. (D) 87.1 %.

17. A piece of aluminium weighing 2.7 g is heated with 75.0 ml of H_2SO_4 (sp. gr. 1.2 containing 25% H_2SO_4 by mass). After the metal is carefully dissolved the solution is diluted to 400ml. What is the molarity of the free H_2SO_4 in the resulting solution.
(A) 1.056 M (B) 0.560 M (C) 0.312 M (D) 0.198 M

18. 100 ml of 0.15 M solution of $Al_2(SO_4)_3$, the density of the solution is 1.5 g/ml. Report the no. of Al^{3+} ions in this weight.
(A) 1.8×10^{25} ions (B) 6×10^{22} ions (C) 1.8×10^{23} ions (D) 1.8×10^{22} ions

19. 5 g sample of $CuSO_4 . 5H_2O$ was dissolved in water. $BaCl_2$ solution was mixed in excess to this solution. The precipitate ($BaSO_4$) obtained was washed and dried, it weighed 4.66 g. What is the % of SO_4^{2-} by weight in the sample.
(A) 76.8% (B) 38.4% (C) 51% (D) 19.2%

20. At room temperature, the density of water is 1.0 g/ml and the density of ethanol is 0.789 g/ml. What volume of ethanol contains the same number of molecules as are present in 175 ml of water ?
(A) 418.95 ml. (B) 736.33 ml. (C) 566.82 ml. (D) 911.84 ml.

SECTION-II : (Maximum Marks: 20)

- This section contains **FIVE** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.

  For Example : If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +4 If ONLY the correct numerical value is entered as answer.

21. The sodium salt of methyl orange has 7% sodium. What is the minimum molecular weight of the compound?

22. A 10.0 g sample of a mixture of calcium chloride and sodium chloride is treated with Na_2CO_3 solution. This calcium carbonate is heated to convert all the calcium to calcium oxide and the final mass of calcium oxide is 1.62 g. The percentage by mass of calcium chloride in the original mixture is ?

23. $2KI + I_2 + 22\,HNO_3 \longrightarrow 2HIO_3 + 2KIO_3 + 22NO_2 + 10H_2O$
If 3 mole of KI & 2 moles I_2 are reacted with excess of HNO_3. Volume (in lit.) of NO_2 gas evolved at 0ºC and 1 atm is

24. Minimum amount (in gm) of Ag_2CO_3 (s) required to produce sufficient oxygen for the complete combustion of C_2H_2 which produces 11.2 ltr of CO_2 at 0ºC and 1 atm after combustion is: [Ag = 108]

$Ag_2CO_3\,(s) \longrightarrow 2Ag\,(s) + CO_2\,(g) + 1/2\,O_2\,(g)$

$C_2H_2 + 5/2\,O_2 \longrightarrow 2CO_2 + H_2O$

25. In the reaction $4A + 2B + 3C \longrightarrow A_4B_2C_3$ what will be the number of moles of product formed, starting from 2 moles of A, 1.2 moles of B & 1.44 moles of C ?

PART - 2 : PAPER JEE (ADVANCED) PATTERN

SECTION-I : (Maximum Marks : 12)

- This section contains **FOUR** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

  Full Marks : +3 If only the bubble corresponding to the correct option is darkened.
  Zero Marks : 0 If none of the bubbles is darkened.
  Negative Marks : –1 In all other cases

1. Calculate the number of Cl^- and Ca^{2+} ions in 222 g anhydrous $CaCl_2$
(A) $2N_A$ ions of Ca^{+2}, $2N_A$ ions of Cl^- (B) $2N_A$ ions of Ca^{+2}, $4N_A$ ions of Cl^-
(C) $2N_A$ ions of Ca^{+2}, $8N_A$ ions of Cl^- (D) $4N_A$ ions of Ca^{+2}, $4N_A$ ions of Cl^-

2. Equal weight of Zn metal and iodine are mixed together and the iodine is completely converted to ZnI_2. What fraction of weight of the original Zinc remains unreacted. (Atomic wt. Zn = 65)
(A) 0.500 (B) 0.744 (C) 0.488 (D) 0.256

3. One litre of a mixture of CO and CO_2 is passed through red hot charcoal in tube. The new volume becomes 1.4 litre. Find out % composition of mixture by volume. All measurements are made at same P and T.
(A) CO_2 40%, CO 60% (B) CO_2 60%, CO 40% (C) CO_2 25%, CO 75% (D) CO_2 30%, CO 70%

4. Amongst the following, the pair having both the metals in their highest oxidation state is :
(A) $[Fe(CN)_6]^{3-}$ and $[Co(CN)_6]^{3-}$ (B) CrO_2Cl_2 and MnO_4^-
(C) TiO_2 and MnO_2 (D) $[MnCl_4]^{2-}$ and $[NiF_6]^{2-}$

SECTION-II : (Maximum Marks: 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s).
- For each question, choose the correct option(s) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If only (all) the correct option(s) is (are) chosen.
Partial Marks : +3 If all the four options are correct but ONLY three options are chosen.
Partial Marks : +2 If three or more options are correct but ONLY two options are chosen, both of which are correct options.
Partial Marks : +1 If two or more options are correct but ONLY one option is chosen and it is a correct option.
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered).
Negative Marks : –1 In all other cases.

- **For Example :** If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in –1 marks.

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5. 1120 mL of ozonised oxygen at 0ºC and 1 atm weigh 1.76 g. Calculate the volume of oxygen in the ozonised oxygen.

(A) It contain 400 mL O_2 (B) It contain 224 mL O_3
(C) It contain 400 mL O_3 (D) It contain 896 mL O_2

6. A 5L vessel contains 2.8 g of N_2 . When heated to 1800 K , 30% molecules are dissociated into atoms.

(A) Total no. of moles in the container will be 0.13
(B) Total no. of molecules in the container will be close to 0.421×10^{23}.
(C) Total no. of moles in the container will be 0.098.
(D) All of these are correct.

7. Equal masses of SO_2 and O_2 are placed in a flask at 0ºC and 1 atm choose the correct statement.

(A) The number of molecules of O_2 are more than SO_2
(B) Volume occupied at 0ºC and 1 atm is more for O_2 than SO_2
(C) The ratio of number of atoms of SO_2 and O_2 is 3 : 4.
(D) Moles of SO_2 is greater than the moles of O_2 .

8. For the reaction $2P + Q \rightarrow R$, 12 mol of P and 8 mol of Q are taken then

(A) 3 mol of R is produced (B) 6 mol of R is produced
(C) 25% of Q is left behind (D) 25% of Q has reacted

9. $$\left(\begin{array}{l} C_2H_5 \\ | \\ CH\text{–}COOH \\ | \\ C_2H_5 \end{array}\right)_n + AgNO_3\,(\text{Excess}) \longrightarrow \text{Silver salt} \longrightarrow \text{Ag (metal)}$$

If 0.5 mole of silver salt is taken and weight of residue obtained is 216 g. (Ag = 108 g/mol).
Then which the following is correct :

(A) n = 4 (B) n = 2
(C) M.wt. of silver salt is 718 g/mol (D) M.wt. of silver salt is 388 g/mol

10. 21.2 g sample of impure Na_2CO_3 is dissolved and reacted with a solution of $CaCl_2$, the weight of precipitate of $CaCO_3$ is 10.0 g. Which of the following statements is/are correct ?
(A) The % purity of Na_2CO_3 is 50%
(B) The percentage purity of Na_2CO_3 is 60%
(C) The number of moles of Na_2CO_3 = $CaCO_3$ = 0.1 mol.
(D) The number of moles of NaCl formed is 0.1 mol.

11. In the following reaction : $Cr(OH)_3 + OH^- + IO_3^- \rightarrow CrO_4^{2-} + H_2O + I^-$
(A) IO_3^- is oxidising agent
(B) $Cr(OH)_3$ is oxidised
(C) $6e^-$ are being taken per iodine atom
(D) None of these

12. Select dimensionless quantity(ies) :
(A) vapour density (B) molality (C) specific gravity (D) mass fraction

SECTION-III : (Maximum Marks: 18)

- This section contains **SIX** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.
  For Example : If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 If ONLY the correct numerical value is entered as answer.
  Zero Marks : 0 In all other cases.

13. Average atomic mass of magnesium is 24.31 a.m.u. This magnesium is composed of 79 mole % of ^{24}Mg and remaining 21 mole % of ^{25}Mg and ^{26}Mg. Calculate mole % of ^{26}Mg. Report your answer after multiplying by 0.1.

14. 200 g impure $CaCO_3$ on heating gives 5.6 lt. CO_2 gas at STP. Find the percentage of calcium in the lime stone sample.

15. Molarity of H_2SO_4 is 18 M. Its density is 1.8 g/cm^3, hence molality is (If your answer is 'x' then, Report your answer x/500).

16. 1 g of a mixture of equal number of moles of Li_2CO_3 and M_2CO_3 required 44.44 ml of 0.5 M HCl for completion of the reactions.

$$Li_2CO_3 + 2HCl \longrightarrow 2LiCl + H_2O + CO_2$$
$$M_2CO_3 + 2HCl \longrightarrow 2\,MCl + H_2O + CO_2$$

If the atomic mass of Li is 7 , then find the Atomic mass of M.
Report M – 16.

17. A 3 : 2 molar ratio mixture of FeO and Fe_2O_3 react with oxygen to produce a 2 : 3 molar ratio mixture of FeO and Fe_2O_3. Find the mass (in g) of O_2 gas required per mole of the initial mixture.

18. 92 g mixture of $CaCO_3$, and $MgCO_3$ heated strongly in an open vessel. After complete decomposition of the carbonates it was found that the weight of residue left behind is 48 g. Find the mass of $MgCO_3$ in grams in the mixture.

PART - 3 : OLYMPIAD (PREVIOUS YEARS)

1. The volume of 16g of oxygen at S.T.P. is : **[NSEC-2000]**
(A) 2.24 dm^3 (B) 11.2 dm^3 (C) 22.4 dm^3 (D) 8 dm^3

2. When 25 g of Na_2SO_4 is dissolved in 10^3 Kg of solution, its concentration will be **[NSEC-2000]**
(A) 2.5 ppm (B) 25 ppm (C) 250 ppm (D) 100 ppm

3. Consider the following data **[NSEC-2000]**

Element	Atomic weight
A	12.01
B	35.5

A and B combine to form new substance X. If 4 moles of B combines with 1 mole of A to give 1 mole of X, then the weight of one mole of X is **[NSEC-2000]**
(A) 154.0 g (B) 74.0 g (C) 47.5 g (D) 166.0 g

4. Oxidation Number of Mn in $[MnO_4]^-$ is : **[NSEC-2001]**
(A) –7 (B) + 7 (C) + 2 (D) – 2

5. The amount of salt required to prepare 10 dm^3 of decimolar solution is : **[NSEC-2001]**
(A) 0.05 mole (B) 0.02 mole (C) 0.01 mole (D) 1.00 mole

6. If 1 dm^3 of a gas weights 2.5 g at STP, its gram-molecular weight is : **[NSEC-2001]**
(A) 56 g (B) 11.2 g (C) 22.4 g (D) 224 g

7. How many moles of air are there in the lungs of an average adult with a lung capacity of 3.8 L . (Assume that the person is at 1.0 atm pressure and has normal body temperature at 37°C). **[NSEC-2002]**
(A) 0.15 mol (B) 0.25 mol (C) 1.15 mol (D) 2.25 mol.

8. The sterile saline solution used to rinse contact lenses can be made by dissolving 400 mg of NaCl in sterile water and diluting to 100 mL. The molarity of the solution will be of **[NSEC-2002]**
(A) 0.00684 M (B) 0.09564 M (C) 1.0684 M (D) 0.0684 M

9. A molal solution contains one gram mole of solute in : **[NSEC-2002]**
(A) one litre of solution (B) 1000 g of the solvent
(C) one litre of the solvent (D) 22.4 litre of the solution

10. An average cup of coffee contains about 125 mg of caffeine, $C_8H_{10}N_4O_2$. How many moles of caffeine are in a cup ? **[NSEC-2002]**
(A) 8.33×10^{-3} (B) 6.44×10^{-4} (C) 6.234×10^{-23} (D) none of these

11. Cystine has a sulphur content of 26.7%. If its molecule contains two atoms of sulphur, what is its molecular weight ? **[NSEC-2002]**
(A) 240 (B) 24 (C) 2400 (D) 120.

12. Which of the following solutions are unimolar solutions ? **[NSEC-2002]**
(A) 0.46 g of C_2H_5OH in 10 mL of solution (B) 110.98 g of $CaCl_2$ in 1000 mL of solution
(C) 0.23 g of CH_3OH in 100 mL of solution (D) 5.88 g of NaCl in 1000 mL of solution.

13. 1.00 g of a pure element contains 4.39×10^{21} atoms. The element is **[NSEC-2003]**
(A) U (B) Ce (C) Ba (D) Au.

14. The maximum amount of CH_3Cl that can be prepared by reacting 20.0 g of CH_4 with 10.0 g of Cl_2 is **[NSEC-2003]**
(A) 30.0 g (B) 7.1 g (C) 63.1 g (D) 31.6 g

15. Considering air as a 4:1 mixture of nitrogen and oxygen, the mass of air in a hall with dimensions 5 m × 5 m × 5 m at STP is approximately **[NSEC-2003]**
(A) 160 g (B) 160 kg (C) 16 g (D) 1.60 kg.

16. The molar concentration of pure water at 4°C and 1 atm pressure is **[NSEC-2003]**
(A) 1 (B) 5.5 (C) 18 (D) 55.5

17. A mixture of aluminium and zinc weighing 1.67 g was completely dissolved in acid and evolved 1.69 L of hydrogen gas (measured at 273 K and 1 atm pressure). The amount of aluminium in the original mixture is approximately **[NSEC-2004]**
(A) 1.8 g (B) 2.0 g (C) 1.2 g (D) 2.2 g

18. The largest number of molecules is present in 1 g of **[NSEC-2004]**
(A) CO_2 (B) H_2O (C) C_2H_5OH (D) N_2O_5.

19. 20 g of solute X are dissolved in 50 g of water. 15 g of solute Y are dissolved in 70 g of benzene. The molalities of the solutes in these two solutions are the same. Hence, the ratio of the molecular weights of solute X to that of the solute Y is **[NSEC-2004]**
(A) 7:5 (B) 4:3 (C) 15:28 (D) 28:15

20. 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 **[NSEC-2004]**
(A) 0.1 (B) 0.2 (C) 0.5 (D) 0.7

21. The total number of electrons present in 8.0 g of methane is **[NSEC-2004]**
(A) 4.8×10^{24} (B) 3.01×10^{24} (C) 4.8×10^{25} (D) 3.01×10^{23}.

22. The percentage abundances of ^{12}C and ^{13}C are 98.9 and 1.1 respectively. The average mass of carbon (in a.m.u) is **[NSEC-2005]**
(A) 12.111 (B) 12.981 (C) 12.011 (D) 12.891

23. 1000 mL of a gas weighs 1.5 g at NTP. Its gram molecular weight is **[NSEC-2005]**
(A) 22.4 g (B) 33.6 g (C) 11.2 g (D) 15 g.

24. 0.1 g of an element contains 4.39×10^{20} atoms. The element is **[NSEC-2005]**
(A) Ga (B) Ce (C) Pb (D) Ba.

25. The percentages of C, H and N in an organic compound are 40%, 13.3% and 46.7%. The empirical formula of this compound is **[NSEC-2006]**
(A) CH_2N (B) CH_4N (C) CH_5N (D) $C_3H_9N_3$.

26. An element has three isotopes with masses 24 , 25 and 26 with relative abundance of 80%, 15% and 5% respectively. The average mass of the isotope mixture would be **[NSEC-2006]**
(A) 25.25 (B) 25.50 (C) 24.50 (D) 24.25

27. 17.1 grams of aluminum sulfate $Al_2(SO_4)_3$ is dissolved in enough water to prepare 1.00 L of solution .What is the molarity of the sulfate ion the solution? (Neglect any hydrolysis) **[NSEC-2007]**
(A) 1.67×10^{-2} M (B) 5.00×10^{-2} M (C) 1.50×10^{-1} M (D) 2.50×10^{-1} M

28. Chlorine can be prepared by reacting HCl with MnO_2. The reaction is represented by the equation:

$$MnO_2(s) + 4HCL_{(aq)} \longrightarrow Cl_2(g) + MnCl_{2(aq)} + 2H_2O(l)$$

Assuming the reaction goes to completion, what mass of concentrated HCl solution (36.0% HCl by mass) is needed to produce 2.50 g of Cl_2 **[NSEC-2007]**
(A) 5.15 g (B) 14.3 g (C) 19.4 g (D) 26.4 g

29. How many moles of Na^+ ions are there in 20mL of 0.40M solution of Na_3PO_4 ? **[NSEC-2007]**
(A) 0.008 (B) 0.020 (C) 0.024 (D) 0.008

30. Oxalic acid ($H_2C_2O_4$) reacts with permanganate ion according to the balanced equation given below :

$$5H_2C_2O_{4(aq)} + 2MnO_4 (aq) + 6H^+_{(aq)} \rightarrow 2Mn^{2+} (aq) + 10CO_{2(g)} + 8H_2O_{(l)}$$

How many mL of 0.0154 M $KMnO_4$ solution are required to react with 25.0 mL of 0.0208 M $H_2C_2O_4$ solution ? **[NSEC-2008]**
(A) 13.5 mL (B) 18.5 mL (C) 33.8 mL (D) 84.4 mL

31. What is the Na^+ ion concentration in the solution formed by mixing 20 mL of 0.10 M Na_2SO_4 solution with 50 mL of 0.30M Na_3PO_4 solution ? **[NSEC-2008]**
(A) 0.15 M (B) 0.24 M (C) 0.48 (D) 0.70

32. A currency counting machine counts 60 million notes per day. A bank has an many notes as number of oxygen atoms in 24.8 g of $Na_2S_2O_3.5H_2O$ (M.W. = 248) **[NSEC-2008]**
How many days would be required to count these notes ?
(A) 9.33×10^{17} (B) 7.03×10^{10} (C) 8.03×10^{15} (D) 6.66×10^{-12}

33. Which of the following equations represented an oxidation-reduction reaction ? **[NSEC-2008]**

(A) $H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2SO_4$

(B) $H_2SO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + H_2O + CO_2$

(C) $2K_2CrO_4 + H_2SO_4 \longrightarrow K_2Cr_2O_7 + K_2SO_4 + H_2O$

(D) $2H_2SO_4 + Cu \longrightarrow CuSO_4 + 2H_2O + SO_2$

34. Methyl-t-butyl ether, $C_5H_{12}O$, is added to gasoline to promote cleaner burning.How many moles of oxygen gas, O_2 are required to burn 1.0 mol of this compound completely to form carbon dioxide and water ? **[NSEC-2008]**
(A) 4.5 mol (B) 6.0 mol (C) 7.5 mol (D) 8.0 mol

35. The hydrated salt $Na_2SO_4.nH_2O$ loses all water of crystallization on heating and is reduced to 44.1% of its original weight. Therefore, the value n is **[NSEC-2008]**
(A) 5 (B) 10 (C) 6 (D) 7

36. The simplest formula of a compound containing 50% of element ‘A’ (Atomic weight = 10) and 50% of element ‘B’ (Atomic weight = 20) is **[NSEC-2008]**
(A) AB (B) A_2B (C) A_2B_2 (D) A_2B_3

37. 3.7 dm^3 of 1 M NaOH solution is mixed with 5 dm^3 of 0.3 M NaOH solution. The molarity of the resulting solution is : **[NSEC-2009]**
(A) 0.80 M (B) 0.10 M (C) 0.73 M (D) 0.59 M

38. The number of molecules of hydration present in 252 mg of oxalic acid is – **[NSEC-2009]**
(A) 2.68×10^{18} (B) 2.52×10^{21} (C) 1.83×10^{24} (D) 2.4×10^{21}

39. The oxidation-reduction reaction among the following is – **[NSEC-2009]**

(A) $H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2SO_4$

(B) $H_2SO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + H_2O + CO_2$

(C) $2K_2CrO_4 + H_2SO_4 \longrightarrow K_2Cr_2O_7 + K_2SO_4 + H_2O$

(D) $2H_2SO_4 + Cu \longrightarrow CuSO_4 + 2H_2O + SO_2$

40. Silver metal reacts with nitric acid according to the equation **[NSEC-2009]**

$$3Ag\ (s) + 4HNO_3\ (aq) \longrightarrow 3AgNO_3\ (aq) + NO\ (g) + 2H_2O\ (l)$$

The volume of 1.15 M HNO_3 (aq) required to react with 0.784 g of silver is –
(A) 4.74 mL (B) 6.32 mL (C) 8.43 mL (D) 25.3 mL

41. $P_4\ (s) + 3OH^-\ (aq) + 3H_2O\ (l) \longrightarrow PH_3\ (g) + 3H_2PO_2^-\ (aq)$ **[NSEC-2009]**
In the above equation, the species getting oxidized and reduced respectively are :
(A) P_4 and OH^- (B) OH^- and P_4 (C) P_4 and H_2O (D) P_4 and P_4

42. A Compound Containing beryllium has the following composition, Be = 6.1%, N = 37.8% Cl=48%, H = 8.1 %. One mole of the compound has mass of 148g and average atomic mass of beryllium is 9. The molecular formula of the compound is : **[NSEC-2010]**
(A) $BeN_4H_{12}Cl_2$ (B) $BeN_2H_{10}Cl$ (C) $BeN_4H_2Cl_3$ (D) $Be_2N_4H_{10}Cl_2$

43. The molarity of 20% w/w sulphuric acid of density 1.14 g cm^{-3} is **[NSEC-2010]**
(A) 2.32 (B) 2.02 (C) 2.12 (D) 2.22

44. An inorganic bromide impurity in a sample is precipitated as silver bromide. 2.00 g of the sample required 6.4 mL of 0.20 M $AgNO_3$ to completely precipitate the impurity. The mass percentage of the impurity is **[NSEC-2010]**
(A) 5.11 (B) 2.56 (C) 9.15 (D) 1.28

45. The compound which can act as an oxidizing agent as well as reducing agent is **[NSEC-2010]**
(A) HNO_2 (B) HI (C) HCN (D) HCOOH

46. Maximum number of moles of barium phosphate formed when 0.9 mole of barium chloride is mixed with 0.4 mole of sodium phosphate is **[NSEC-2010]**
(A) 0.2 (B) 0.4 (C) 0.9 (D) 1.3

47. The largest number of molecules are present in **[NSEC-2010]**
(A) 70g of Sulphur dioxide (B) 64g of Nitrogen pentoxide
(C) 36g of Water (D) 34g of Carbon dioxide

48. The number of water molecules present in 0.20 g sample of $CuSO_4 . 5H_2O$ (Molar mass = 249.7) is **[NSEC-2011]**
(A) 1.2×10^{21} (B) 2.14×10^{21} (C) 2.14×10^{22} (D) 1.2×10^{23}

49. The compound in which Mn has oxidation state of +3 is **[NSEC-2011]**
(A) $KMnO_4$ (B) $K_2 [Mn(CN)_6]$
(C) $MnSO_4$ (D) $CsMn(SO_4)_2.12H_2O$

50. Excess of silver nitrate is added to a water sample to determine the amount of chloride ion present in the sample. 1.4 g of silver chloride is precipitated. The mass of chloride ion present in the sample is :
Molar masses (g-mol^{-1}) : $AgNO_3$ 169.91, AgCl 143.25 **[NSEC-2011]**
(A) 0.25 g (B) 0.35 g (C) 0.50 g (D) 0.75 g

51. The vapour density of gas A is four times that of B. If the molecular mass of B is M then molecular mass of A is : **[NSEC-2012]**
(A) M (B) 4M (C) M/4 (D) 2M

52. In the reaction, $2KClO_3 \rightarrow 2KCl + 3O_2$ when 36.75 g of $KClO_3$ is heated, the volume of oxygen evolved at N.T.P. will be : **[NSEC-2012]**
(A) 9.74 dm^3 (B) 8.92 dm^3 (C) 10.08 dm^3 (D) 22.4 dm^3

53. A 500 g toothpaste sample has 0.4 g fluoride concentration. The fluoride concentration in terms of ppm will be : **[NSEC-2012]**
(A) 200 (B) 400 (C) 500 (D) 800

54. In a nitration experiment, 10.0g of benzene gas and 13.2 g of nitrobenzene. The percentage yield is : **[NSEC-2012]**
(A) 83.5% (B) 62.7% (C) 88.9% (D) 26.7%

55. In the compound $Na_2S_2O_3$, the oxidation state of sulphur is **[NSEC-2013]**
(A) –2 (B) +2 (C) +4 (D) +6

56. I. $5H_2O_2 + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$ **[NSEC-2014]**

II. $H_2O_2 + Ag_2O \rightarrow 2Ag + H_2O + O_2$
The role of hydrogen peroxide in the above reaction is
(A) oxidising in I and reducing in II (B) reducing in I and oxidising in II
(C) reducing in I as well as in II (D) oxidising in I as well as in II

57. Aluminum carbide (Al_4C_3) liberates methane on treatment with water. The grams of aluminum carbide required to produce 11.2 L of methane under STP conditions is : [Given : Al = 27] **[NSEC-2014]**
(A) 48 (B) 72 (C) 144 (D) 24

58. The specific gravity of a HNO_3 solution is 1.42 and it is 70% w/w. The molar concentration of HNO_3 is : **[NSEC-2014]**

(A) 15.8 (B) 31.6 (C) 11.1 (D) 14.2

PART - 4 : ADDITIONAL PROBLEMS

SUBJECTIVE QUESTIONS

1. Carbon disulphide, CS_2, can be made from by-product SO_2. The overall reaction is

$$5C + 2SO_2 \longrightarrow CS_2 + 4CO$$

How much CS_2 can be produced from 440 kg of waste SO_2 with 60 kg of coke if the SO_2 conversion is 80%?

2.✍ The percent yield for the following reaction carried out in carbon tetrachloride (CCl_4) solution is 80%

$$Br_2 + Cl_2 \longrightarrow 2BrCl$$

(a) What amount of BrCl would be formed from the reaction of 0.025 mol Br_2 and 0.025 mol Cl_2?

(b) What amoumt of Br_2 is left unchanged?

3.✍ Write balanced net ionic equations for the following reactions in acidic solution :

(a) $S_4O_6^{2-}(aq) + Al(s) \longrightarrow H_2S(aq) + Al^{3+}(aq)$

(b) $S_2O_3^{2-}(aq) + Cr_2O_7^{2-}(aq) \longrightarrow S_4O_6^{2-}(aq) + Cr^{3+}(aq)$

(c) $ClO_3^{-}(aq) + As_2S_3(s) \longrightarrow Cl^{-}(aq) + H_2AsO_4^{-}(aq) + HSO_4^{-}(aq)$

(d) $IO_3^{-}(aq) + Re(s) \longrightarrow ReO_4^{-}(aq) + I^{-}(aq)$

(e) $HSO_4^{-}(aq) + As_4(s) + Pb_3O_4(s) \longrightarrow PbSO_4(s) + H_2AsO_4^{-}(aq)$

(f) $HNO_2(aq) \longrightarrow NO_3^{-} + NO(g)$

4. Write balanced net ionic equations for the following reactions in basic solution :

(a) $C_4H_4O_6^{2-}(aq) + ClO_3^{-}(aq) \longrightarrow CO_3^{2-}(aq) + Cl^{-}(aq)$

(b) $Al(s) + BiONO_3(s) \longrightarrow Bi(s) + NH_3(aq) + [Al(OH)_4]^{-}(aq)$

(c) $H_2O_2(aq) + Cl_2O_7(aq) \longrightarrow ClO_2^{-}(aq) + O_2(g)$

(d) $Tl_2O_3(s) + NH_2OH(aq) \longrightarrow TlOH(s) + N_2(g)$

(e) $[Cu(NH_3)_4]^{2+}(aq) + S_2O_4^{2-}(aq) \longrightarrow SO_3^{2-}(aq) + Cu(s) + NH_3(aq)$

(f) $Mn(OH)_2(s) + MnO_4^{-}(aq) \longrightarrow MnO_2(s)$

5. Consider the following reaction involved in the preparation of teflon polymer $\left(CF_2{-}CF_2\right)_n$.

$$XeF_6 + \left(CH_2{-}CH_2\right)_n \longrightarrow \left(CF_2{-}CF_2\right)_n + HF + XeF_4.$$

Determine the moles of XeF_6 required for preparation of 100 g Teflon.

ONLY ONE OPTION CORRECT TYPE

1. In a certain operation 358 g of $TiCl_4$ is reacted with 96 g of Mg. Calculate % yield of Ti if 32 g of Ti is actually obtained [At. wt. Ti = 48, Mg = 24]

(A) 35.38 % (B) 66.6 % (C) 100 % (D) 60 %

2. Phosphoric acid (H_3PO_4) prepared in a two step process.

(A) $P_4 + 5O_2 \longrightarrow P_4O_{10}$

(B) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$.

We allow 62 g of phosphorus to react with excess oxygen which form P_4O_{10} in 85% yield. In the step (B) reaction 90% yield of H_3PO_4 is obtained. Produced mass of H_3PO_4 is :

(A) 37.48 g (B) 149.94 g (C) 125.47 g (D) 564.48 g

3. For the redox reaction, $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$
the correct coefficients of the reactions for the balanced reaction are

	MnO_4^-	$C_2O_4^{2-}$	H^+
(A)	2	5	16
(B)	16	5	2
(C)	5	16	2
(D)	2	16	5

4. A mineral water sample was analysed and found to contain 1×10^{-3} % ammonia (w/w). The mole of dissolved ammonia gas in one litre water bottle is ($d_{water} \approx 1$ g/ml)
(A) 5.8×10^{-4} mol (B) 1×10^{-2} mol (C) 0.58×10^{-2} mol (D) same as w/w
(A) 5.8×10^{-4} mol (B) 1×10^{-2} mol (C) 0.58×10^{-2} mol (D) Hkkj@Hkkj d leku

5. (i) $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
(ii) $AlCl_3 + 3NaOH \rightarrow Al(OH)_3 + 3NaCl$
(iii) $Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$
Above series of reactions are carried out starting with 18 g of Al and 109.5 g of HCl in first step and further 100 g of NaOH is added for step (ii) and (iii). Find out limiting reagent in each step and calculate the maximum amount of $NaAlO_2$ that can be produced in step (iii). (Assume reactions are taken in sequence and also that each reaction goes to 100% completion)

	L.R. in step (I)	L.R. in step (II)	L.R. in step (III)	Moles of $NaAlO_2$
(A)	Al	$AlCl_3$	$Al(OH)_3$	0.66
(B)	Al	Na(OH)	$Al(OH)_3$	0.5
(C)	Al	$AlCl_3$	NaOH	0.5
(D)	HCl	$AlCl_3$	NaOH	0.5

6. 12 g of alkaline earth metal gives 14.8 g of its nitride. Atomic weight of metal is -
(A) 12 (B) 20 (C) 40 (D) 14.8

7. When 100g of ethylene polymerises entirely to polyethene, the weight of polyethene formed as per the equation $n(C_2H_4) \rightarrow (-CH_2-CH_2-)_n$ is :
(A) (n/2)g (B) 100g (C) (100/n)g (D) 100ng

8. Calculate the amount of Ni needed in the Mond's process given below
$$Ni + 4CO \longrightarrow Ni(CO)_4$$
If CO used in this process is obtained through a process, in which 6 g of carbon is mixed with 44 g CO_2. (Ni = 59 u)
(A) 14.675 g (B) 29 g (C) 58 g (D) 28 g

9. The mass of 70% H_2SO_4 required for neutralisation of 1 mol of NaOH.
(A) 49 g (B) 98 g (C) 70 g (D) 34.3 g

10. 0.05 mole of $LiAlH_4$ in ether solution was placed in a flask containing 74g (1 mole) of t-butyl alcohol. The product $LiAlHC_{12}H_{27}O_3$ weighed 12.7 g. If Li atoms are conserved, the percentage yield is : (Li = 7, Al = 27, H = 1, C = 12, O = 16).
(A) 25% (B) 75% (C) 100% (D) 15%

11. What weights of P_4O_6 and P_4O_{10} will be produced by the combustion of 31g of P_4 in 32g of oxygen leaving no P_4 and O_2.
(A) 2.75 g, 219.5 g (B) 27.5 g, 35.5 g (C) 55 g, 71 g (D) 17.5 g, 190.5 g

12. 10 g of a sample of a mixture of $CaCl_2$ and NaCl is treated to precipitate all the calcium as $CaCO_3$. This Ca CO_3 is heated to convert all the Ca to CaO and the final mass of CaO is 1.62 g . The percent by mass of $CaCl_2$ in the original mixture is.
(A) 32.1 % (B) 16.2 % (C) 21.8 % (D) 11.0 %

13. Mole fraction of A in H_2O is 0.2. The molality of A in H_2O is :
(A) 13.9 (B) 15.5 (C) 14.5 (D) 16.8

14. If a piece of iron gains 10% of its weight due to partial rusting into Fe_2O_3 the percentage of total iron that has rusted is :

(A) 23 (B) 13 (C) 23.3 (D) 25.67

15. When x grams of carbon are heated with y grams of oxygen in a closed vessel, no solid residue is left behind. Which of the following statements is correct ?

(A) y/x must lie between 1.33 and 2.67 (B) y/x must be greater than or equal 2.67.

(C) y/x must be less than or equal 1.33 (D) y/x must be greater than or equal 1.33.

16. On mixing 15.0 ml of ethyl alcohol of density 0.792 g ml $^{-1}$ with 15 ml of pure water at 4^0C, the resulting solution is found to have a density of 0.924 g ml $^{-1}$. The percentage contraction in volume is :

(A) 8 % (B) 2 % (C) 3 % (D) 4 %

MATCH THE COLUMN

1.

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

Where M_A, M_B are molar masses, n_A, n_B are no of moles & X_A, X_B are mole fractions of solute and solvent respectively.

2.

Column-I	Column-II
(A) 100 ml of 0.2 M $AlCl_3$ solution + 400 ml of 0.1 M HCl solution	(p) Total concentration of cation(s) = 0.12 M
(B) 50 ml of 0.4 M KCl + 50 ml H_2O	(q) $[SO_4^{2-}]$ = 0.06 M
(C) 30 ml of 0.2 M K_2SO_4 + 70 ml H_2O	(r) $[SO_4^{2-}]$ = 2.5 M
(D) 200 ml 24.5% (w/v) H_2SO_4	(s) $[Cl^-]$ = 0.2 M

SINGLE AND DOUBLE VALUE INTEGER TYPE

1. The measured density at 0ºC and 1 atm of He is 0.1784 g/L. What is the weight (in g) of one mole of He ?

2. The 'roasting' of 100.0 g of a copper ore yielded 71.8 g pure copper. If the ore is composed of Cu_2S and CuS with 4.5 % inert impurity, calculate the percent of Cu_2S in the ore.

The reactions are : $Cu_2S + O_2 \longrightarrow 2Cu + SO_2$ and $CuS + O_2 \longrightarrow Cu + SO_2$

3. A piece of Al weighing 27 g is reacted with 200 ml of H_2SO_4 (specific gravity = 1.8 and 54.5 % by weight) After the metal is completely dissolved 73 g HCl is added and solution is further diluted to 500 ml solution then find the concentration of H^+ ion in mol/litre.

4. 1 g of dry green algae absrobs 4.7×10^{-3} mole of CO_2 per hour by photosynthesis. If the fixed carbon atoms were all stored after photosynthesis as starch $(C_6H_{10}O_5)_n$. Aproximately how long (in hour) would it take for the algae to double their own weight assuming phtosynthesis takes place at a constant rate?

5. CN^- ion is oxidised by a powerful oxidising agent to NO_3^- and CO_2 or CO_3^{2-} depending on the acidity of the reaction mixture.

$$CN^- \longrightarrow CO_2 + NO_3^- + H^+ + ne^-$$

What is the number (n) of electrons per mole of CN^- involved in the process ?

6. To 100 ml of 5 M NaOH solution (density 1.2 g/ml) were added 200 ml of another NaOH solution which has a density of 1.5 g/ml and contains 20 mass percent of NaOH. What will be the volume of the gas (at 0ºC and 1 atm) in litres liberated when aluminium reacts with this (final) solution.
The reaction is $Al + NaOH + H_2O \longrightarrow NaAlO_2 + H_2$

7. A drop (0.05 mL) of 12 M HCl is spread over a thin sheet of aluminium foild (thickness 1 mm and density of Al = 2.7 g/mL). Assuming whole of the HCl is used to dissolve. At what will be the maximum area of hole produced in foild (in cm^2). [Report your answer after multiplying by 10].

8. When 1 mole of A reacts with $\frac{1}{2}$ mole of B_2 ($A + \frac{1}{2}B_2 \rightarrow AB$), 100 Kcal heat is liberated and when 1 mole of A reacted with 2 mole of B_2 ($A + 2B_2 \rightarrow AB_4$), 200 Kcal heat is liberated. When 1 mole of A is completely reacted with excess, of B_2 to form AB as well as AB_4, 140 Kcal heat is liberated calculate the mole of B_2 used. [Write your answer as number of mole of B_2 used × 10]

9. In the reaction : $2Al + Cr_2O_3 \longrightarrow Al_2O_3 + 2Cr$, 49.8 g of Al reacted with 200.0 g Cr_2O_3. How much grams of reactant remains at the completion of the reaction ?

10. In the following reaction

$$xZn + yHNO_3(dil) \longrightarrow aZn(NO_3)_2 + bH_2O + cNH_4NO_3$$

What is the sum of the coefficients (a + b + c) ?

11. H_3PO_4 (98 g mol^{-1}) is 98% by mass of solution. If the density is 1.8 g/ml, calculate the molarity.

12. 3.0 litre of water are added to 2.0 litre of 5 M HCl. What is the molarity of HCl (in M) the resultant solution ?

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. In the reaction $I_2 + C_2H_5OH + OH^- \longrightarrow CHI_3 + HCOO^- + H_2O + I^-$ which of the following statements is/are correct ?
(A) The coefficients of OH^- and I^- in the given in balanced equation are, respectively, 6 and 5.
(B) The coefficients of OH^- and I^- in the given balanced equation are , respectively, 5 and 6.
(C) C_2H_5OH is oxidised to CHI_3 and $HCOO^-$.
(D) The number of electrons in the conversion of C_2H_5OH to CHI_3 and $HCOO^-$ is 8.

2. One mole of a mixture of N_2, NO_2 and N_2O_4 has a mean molar mass of 55.4. On heating to a temperature at which all the N_2O_4 may be presumed to have dissociated : $N_2O_4 \rightleftharpoons 2NO_2$, the mean molar mass tends to the lower value of 39.6. What is the mole ratio of $N_2 : NO_2 : N_2O_4$ in the original mixture ?
(A) 0.5 : 0.1 : 0.4 (B) 0.6 : 0.1 : 0.3 (C) 0.5 : 0.2 : 0.3 (D) 0.6 : 0.2 : 0.2

3. Silver metal in ore is dissolved by potassium cyanide solution in the presence of air by the reaction

$$4\,Ag + 8\,KCN + O_2 + 2H_2O \longrightarrow 4\,K[Ag(CN)_2] + 4\,KOH$$

(A) The amount of KCN required to dissolve 100 g of pure Ag is 120 g.
(B) The amount of oxygen used in this process is 0.742 g (for 100 g pure Ag)
(C) The amount of oxygen used in this process is 7.40 g (for 100 g pure Ag)
(D) The volume of oxygen used at 0ºC and 1 atm is 5.20 litres.

4. Crude calcium carbide, CaC_2, is made in an electric furnace by the following reaction,

$$CaO + 3C \longrightarrow CaC_2 + CO$$

The product contain 85% CaC_2 and 15% unreacted CaO.
(A) 1051.47 kg of CaO is to be added to the furnace charge for each 1000 kg of CaC_2.
(B) 893.8 kg of CaO is to be added to the furnace charge for each 1000 kg of crude product.
(C) 708.2 kg of CaO is to be added to the furnace charge for each 1000 kg of CaC_2.
(D) 910.3 kg of CaO is to be added to the furnace charge for each 1000 kg of crude product.

5. Which of the following statement is/are correct ?
Excess of $H_2S(g)$ is bubbled into 1.0 L of 0.1 M $CuCl_2$ solution.
$Cu^{2+} + H_2S(g) \longrightarrow CuS(s) + 2H^+$
(A) 9.55 g of CuS is produced.
(B) The concentration of H^+ ions is 0.2 M
(C) The concentration of H^+ ions is 0.1 M. (D) 95.5 g CuS is produced.

6. Which of the following statements is/are correct ? 1.0 g mixture of $CaCO_3(s)$ and glass beads liberate 0.22 g of CO_2 upon treatment with excess of HCl. Glass does not react with HCl.
$CaCO_3 + 2HCl \longrightarrow CO_2 + H_2O + CaCl_2$
[M.wt. of $CaCO_3$ = 100, M.wt. of CO_2 = 44, [Atomic weight of Ca = 40]
(A) The weight of $CaCO_3$ in the original mixture is 0.5 g
(B) The weight of calcium in the original mixture is 0.2 g
(C) The weight percent of calcium in the original mixture is 40% Ca.
(D) The weight percent of Ca in the original mixture is 20% Ca.

7. 100 g sample of clay (containing 19% H_2O, 40% silica, and inert impurities as rest) is partially dried so as to contain 10% H_2O
Which of the following is/are correct statements (s) ?
(A) The percentage of silica in paritially dried clay is 44.4%
(B) The mass of paritially dried clay is 90.0 g.
(C) The percentage of inert impurity in paritially dried clay is 45.6%
(D) The mass of water evaporated is 10.0 g

RRP ANSWER KEY

PART - 1

1.	(2)	**2.**	(3)	**3.**	(3)	**4.**	(1)	**5.**	(2)	**6.**	(1)	**7.**	(4)
8.	(1)	**9.**	(3)	**10.**	(3)	**11.**	(3)	**12.**	(4)	**13.**	(1)	**14.**	(3)
15.	(1)	**16.**	(2)	**17.**	(4)	**18.**	(4)	**19.**	(2)	**20.**	(3)		
21.	328.57	22.	32.1	**23.**	739.2	**24.**	**345**	**25.**	0.48				

PART - 2

1.	(B)	**2.**	(B)	**3.**	(A)	**4.**	(B)	**5.**	(BD)	**6.**	(AB)
7.	(ABC)	**8.**	(BC)	**9.**	(AC)	**10.**	(AC)	**11.**	(ABC)	**12.**	(ACD)
13.	1	**14.**	5	**15.**	1	**16.**	7	**17.**	2	**18.**	42

PART - 3

1.	(B)	**2.**	(B)	**3.**	(A)	**4.**	(B)	**5.**	(D)	**6.**	(A)	**7.**	(A)
8.	(D)	**9.**	(B)	**10.**	(B)	**11.**	(A)	**12.**	(B)	**13.**	(C)	**14.**	(B)
15.	(B)	**16.**	(D)	**17.**	(C)	**18.**	(B)	**19.**	(D)	**20.**	(A)	**21.**	(B)
22.	(C)	**23.**	(B)	**24.**	(D)	**25.**	(B)	**26.**	(D)	**27.**	(C)	**28.**	(B)
29.	(C)	**30.**	(A)	**31.**	(D)	**32.**	(C)	**33.**	(D)	**34.**	(C)	**35.**	(B)
36.	(B)	**37.**	(D)	**38.**	(D)	**39.**	(D)	**40.**	(C)	**41.**	(D)	**42.**	(A)
43.	(A)	**44.**	(A)	**45.**	(A)	**46.**	(A)	**47.**	(C)	**48.**	(B)	**49.**	(D)
50.	(B)	**51.**	(B)	**52.**	(C)	**53.**	(D)	**54.**	(A)	**55.**	(B)	**56.**	(C)
57.	(D)	**58.**	(A)										

PART - 4

1. 76 kg of CS_2

2. (a)

$$Br_2 + Cl_2 \longrightarrow 2BrCl$$

1 mol 1mol 2mol

0.025 0.025 0.050 mol

(b) Theoretical yield of BrCl = 0.050 mol

$$\text{actual yield is} = \frac{0.05 \times 80}{100} = 0.04 \text{ mole}$$

Br_2 left unreacted = 0.025 – 0.02 = 0.005 mol.

3. (a) $S_4O_6^{2-}(aq) + 6\,Al(s) + 20\,H^+ \longrightarrow 4H_2S(aq) + 6Al^{3+}(aq) + 6H_2O$

(b) $6S_2O_3^{2-}(aq) + Cr_2O_7^{2-}(aq) + 14\,H^+ \longrightarrow 3S_4O_6^{2-}(aq) + 2Cr^{3+}(aq) + 7H_2O$

(c) $14ClO_3^-(aq) + 3As_2S_3(s) + 18H_2O \longrightarrow 14Cl^-(aq) + 6H_2AsO_4^-(aq) + 9HSO_4^-(aq) + 15H^+$

(d) $7IO_3^-(aq) + 6Re(s) + 3H_2O \longrightarrow 6ReO_4^-(aq) + 7I^-(aq) + 6H^+$

(e) $26H^+ + 30HSO_4^-(aq) + As_4(s) + 10\,Pb_3O_4(s) \longrightarrow 30\,PbSO_4(s) + 4H_2AsO_4^-(aq) + 24H_2O$

(f) $3HNO_2(aq) \longrightarrow NO_3^- + 2NO(g) + H_2O + H^+$

4. (a) $3C_4H_4O_6^{2-}(aq) + 5ClO_3^-(aq) + 18OH^- \longrightarrow 12\,CO_3^{2-}(aq) + 5\,Cl^-(aq) + 15H_2O$

(b) $11Al(s) + 3BiONO_3(s) + 21H_2O + 11OH^- \longrightarrow 3Bi(s) + 3NH_3(aq) + 11Al(OH)_4^-(aq)$

(c) $4H_2O_2(aq) + Cl_2O_7(aq) + 2OH^- \longrightarrow 2ClO_2^-(aq) + 4O_2(g) + 5H_2O$

(d) $Tl_2O_3(s) + 4NH_2OH(aq) \longrightarrow 2TlOH(s) + 2N_2(g) + 5H_2O$

(e) $[Cu(NH_3)_4]^{2+}(aq) + S_2O_4^{2-}(aq) + 4OH^- \longrightarrow 2SO_3^{2-}(aq) + Cu(s) + 4NH_3(aq) + 2H_2O$

(f) $3Mn(OH)_2(s) + 2MnO_4^-(aq) \longrightarrow 5MnO_2(s) + 2H_2O + 2OH^-$

5. 4

ONLY ONE OPTION CORRECT TYPE

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

PART - III

1. (A - p); (B - r,s); (C - r); (D - r,q) **2.** (A - p,s); (B - s); (C - p,q); (D - r)

SINGLE AND DOUBLE VALUE INTEGER TYPE

1.	4	**2.**	62%	**3.**	6	**4.**	8	**5.**	10	**6.**	67	**7.**	2
8.	11	**9.**	60	**10.**	8	**11.**	18	**12.**	2				

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1.	(ACD)	**2.**	(A)	**3.**	(ACD)	**4.**	(AB)	**5.**	(AB)	**6.**	(ABD)
7.	(ABCD)										

Reliable Ranker Problems

PART- 1

1. Mole of $NO_2 = \frac{112}{22400} = 5 \times 10^{-3}$

Mass of $NO_2 = 5 \times 10^{-3} \times 46 = 0.23$ gm

Volume of $NO_2 = \frac{\text{Mass}}{\text{Density}} = \frac{0.23}{1.15} = 0.2$ ml

Number of molecule $= 5 \times 10^{-3} \times 6.023 \times 10^{23} = 3.1 \times 10^{21}$.

2. Mass of NaCl = 10 × 0.96 = 9.6 g

moles of NaCl $= \frac{9.6}{58.5}$

no. of molecules $= \frac{9.6}{58.5} \times 6.023 \times 10^{23} \simeq 10^{23}$

3. $\frac{32}{2x+3y} = 0.2$

$\frac{92.8}{3x+4y} = 0.4$

Hence x = 56 & y = 16.

4. (1) It is a fact.

(2)	$2H_2$	+	O_2	$\longrightarrow$	$2H_2O$
Initial mole	2		3		0
final mole	0		3-1 =2		2

(3) $C + O_2 \longrightarrow CO_2$

$\frac{w}{12}$ $\frac{w}{32}$

Here C is limiting reagent.

5. Reduction

$BiO_3^- + Mn^{2+} \longrightarrow Bi^{3+} + MnO_4^-$

Oxidation

(i) $2e + 6H^+ + BiO_3^- \longrightarrow Bi^{3+} + 3H_2O$

(ii) $4H_2O + Mn^{2+} \longrightarrow MnO_4^- + 8H^+ + 5e$

(i) × 5 + (ii) × 2, we get $14H^+ + 5BiO_3^- + 5Mn^{2+} \longrightarrow 5Bi^{3+} + 2MnO_4^- + 7H_2O$

Hence, (2) is the correct balanced reaction.

6. $3I_2 + OH^- \longrightarrow IO_3^- + 5I^-$ (balance reaction)

So, ratio is 1 : 5.

7. Explanation : M. wt. of $NaNO_3$ = 85
70 mg of Na^+ are present in 1 mL
50 ml of solution contains 50 × 70 = 3500 mg = 3.5 g Na^+ ion
23 g of Na^+ are present in 85 g of $NaNO_3$

3.5 g of Na^+ are present in $\frac{85}{23}$ × 3.5 = 12.934 g of $NaNO_3$

8. Explanation : $m = \frac{M \times 1000}{(1000 \times d - M \times M.Wt.)}$ where 'm' is molality, M is molarity.

$= \frac{10^{-2} \times 1000}{(1000 \times 1.1 - 10^{-2} \times 106)}$

$= \frac{10}{1100 - 1.6} = \frac{10}{1099.4} = 9.00 \times 10^{-3}$ [Take 1099.4 = 1100]

9. At 4ºC i.e. 277 K density of water = 1 g/ml
$\therefore$ 1 kg water $\Rightarrow$ 1000 ml water = 1 lit.
$\therefore$ Molality & molarity remains same.

10. Molarity = $\frac{(\% w/w) \times density \times 10}{Molar\ mass\ of\ solute} = \frac{98 \times 1.84 \times 10}{98}$ = 18.4 M

11. Mole of NaCl = $\frac{5.85}{58.5}$ = 0.1

Molarity = $\frac{0.1}{1}$ = 0.1 M
Moles in 1 ml of solution = MV = $0.1 \times 10^{-3} = 10^{-4}$ mole.
Number of ions in 1 ml = $2 \times 10^{-4} \times 6.023 \times 10^{23} = 1.204 \times 10^{20}$.

12.

Element	Percent	r.a.m.	No. of atoms	atomic ratio
C	74	12	74/12 = 6.16	6.16/1.23 = 5
H	8.7	1	8.7/1 = 8.7	8.7/1.123 = 7
N	17.3	14	17.3/14 = 1.23	1.23/1.23 = 1

The ratio of atoms = C : H : N = 5 : 7 : 1
Empirical formula = C_5H_7N
Empirical formula mass = 5 C + 7H + N = 5 × 12 + 7 × 1 + 14 = 81
Molecular mass = 162 (given)

No. of empirical units per molecule = $n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{162}{81} = 2$

Molecular formula = (Empirical formula) × 2 = $(C_5H_7N) \times 2 = C_{10}H_{14}N_2$

13. $C + O_2 \xrightarrow{\Delta} CO_2$
12g C = 1 mol O_2 = 22.7 L O_2

$\therefore$ 1000 g C = $\frac{22.7}{12} \times 1000$ or 1891.67 L O_2

14.

	$6Li$ +	N_2 $\longrightarrow$	$2Li_3N$
Initial mole	$\frac{3.5}{7} = \frac{1}{2}$	$\frac{8.4}{28} = 0.3$	0
final mole	0	$0.3 - \frac{1}{12}$	$\frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$

mass of Li_3N $= \frac{1}{6} \times 35 = 5.83$ g.

15.

	$2KO_2$ +	$2H_2O$ $\longrightarrow$	$2KOH$ +	H_2O_2 +	O_2
Initial mole	0.15	0.1	0	0	0
final mole	(0.15 – 0.1)	0	0.1	0.05	0.05

$\therefore$ moles of $O_2 = 0.05$

16. $KClO_3 \rightarrow KCl + O_2$

Applying POAC for O atoms in the eqn.(i),

moles of O in $KClO_3$ = moles of O in O_2

$3 \times$ moles of $KClO_3 = 2 \times$ moles of O_2

$$3 \times \frac{wt.of\ \ KClO_3}{mol.wt.of\ KClO_3} = 2 \times \frac{\text{volume at NTP(mL)}}{22400}$$

$$\text{Wt . of } KClO_3 = \frac{2 \times 146.8 \times 122.5}{3 \times 22400} = 0.5358 \text{ g.}$$

In the second reaction :

The amount of $KClO_3$ left = 1 – 0.5358 = 0.4642 g.

We have, $KClO_3 \rightarrow KClO_4 + KCl$

0.4642 g.

Applying POAC for O atoms,

moles of O in $KClO_3$ = moles of $KClO_4$

$3 \times$ moles of $KClO_3 = 4 \times$ moles of $KClO_4$

$$3 \times \frac{\text{wt. of } KClO_3}{\text{mol. wt. of } KClO_3} = 4 \times \frac{\text{wt. of } KClO_4}{\text{mol. wt. of } KClO_4}$$

$$\text{Wt. of } KClO_4 = \frac{3 \times 0.4642 \times 138.5}{122.5 \times 4} = 0.3937 \text{ g.} \qquad \text{......(ii)}$$

Wt. of residue = 1 – wt. of Oxygen

$$= 1 - \frac{146.8}{24400} \times 32 \text{ g} = 0.7902 \text{ g.}$$

$$\therefore \text{ \% of } KClO_4 \text{ in the residue} = \frac{0.3937}{0.7902} \times 100 = 49.8 \text{ \%.}$$

17. $$\text{Molarity of } H_2SO_4 = \frac{\text{sp.gravity} \times \text{\% w/w} \times 10}{\text{Molecular mass}}$$

$$= \frac{1.2 \times 25 \times 10}{98} = \frac{12 \times 25}{98} = 3.06 \text{ M}$$

$3H_2SO_4 + 2Al \longrightarrow Al_2(SO_4)_3 + 3H_2$

$\frac{2.7}{27} = 0.1$

Mole of H_2SO_4 used = $\frac{3}{2} \times 0.1 = 0.15$

Initial mole of $H_2SO_4 = 0.75 \times 3.06 = 0.2295$
Mole of H_2SO_4 remaining = $0.2295 - 0.15$

Molarity of final $H_2SO_4 = \frac{0.0795}{0.4} = 0.198$ M.

18. Moles of $Al_2(SO_4)_3$ = M × V = 0.15 × 0.1 = 0.015
Mass of $Al_2(SO_4)_3$ = Mole × Molar mass = 0.015 × 342 = 5.13 g.
Moles of Al^{3+} = 2 × moles of $Al_2(SO_4)_3$ = 2 × 0.015 = 0.03.
No. of Al^{3+} ions = $0.03 \times 6.023 \times 10^{23} = 1.81 \times 10^{22}$ ions.

19. $$\underset{}{CuSO_4.5H_2O(aq)} + BaCl_2(aq) \longrightarrow \underset{4.66\text{ g}}{BaSO_4(s)} + CaCl_2\,(aq)$$

Mass of $BaSO_4$ = 4.66 g

Mole of $BaSO_4 = \frac{4.66}{233} = \frac{2}{100}$

$\therefore$ Mole of $SO_4^{2-} = \frac{2}{100}$

Mass of $SO_4^{2-} = \frac{2}{100}$ (ionic mass of SO_4^{2-}) = 1.92 g

% $SO_4^{2-} = \frac{1.92}{5} \times 100 = 38.4\%$.

20. Let the volume of ethanol containing the same number of molecules as are present in 175 ml of H_2O be V ml.
As given ,
moles of C_2H_5OH in V ml = moles of H_2O in 175 ml

Now , $$\frac{wt.of\ C_2H_5OH}{mol.wt.of\ C_2H_5OH} = \frac{wt.of\ H_2O}{mol.wt.of\ H_2O}$$

or , $$\frac{0.789 \times V}{46} = \frac{1.0 \times 175}{18} \qquad \therefore \qquad V = 566.82 \text{ ml.}$$

21. % of Na = $\frac{mass\ of\ sodium}{molecular\ mass} \times 100 \qquad \Rightarrow \qquad 7 = \frac{23}{M} \times 100$

$M = \frac{23 \times 100}{7} = 328.6$

22. $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2\,NaCl$

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

Mole of $CaCl_2$ = mole of $CaCO_3$ = mole of CaO = $\left(\frac{1.62}{56}\right)$

Mass of $CaCl_2 = \left(\frac{1.62}{56}\right)$ Molar mass of $CaCl_2$

$= \left(\frac{1.62}{56}\right) \times 111$ g.

% of $CaCl_2 = \frac{3.21}{10} \times 100 = 32.1\,\%$.

23. KI is limiting reagent

$\therefore$ 3 mole of KI will give 33 mole of NO_2 according to stoichiometry.

24. $Ag_2CO_3\,(s) \longrightarrow 2Ag\,(s) + CO_2\,(g) + 1/2\,O_2\,(g)$

$C_2H_2 + 5/2\,O_2 \longrightarrow 2CO_2 + H_2O$

By Stoichiometry of reaction

Moles of CO_2 formed $= \frac{11.2}{22.4} = \frac{1}{2}$

Moles of O_2 required $= \frac{5}{4} \times \frac{1}{2} = \frac{5}{8}$

$\therefore$ Moles of Ag_2CO_3 required $= 2 \times \frac{5}{8} = \frac{5}{4}$; Mass of Ag_2CO_3 required $= \frac{5}{4} \times 276 = 345$ g

25. $4A + 2B + 3C \longrightarrow A_4B_2C_3$

	4A	2B	3C	$A_4B_2C_3$
Initial mole	2	1.2	1.44	0
final mole			0	0.48

C is limiting reagent.

$\therefore$ moles of $A_4B_2C_3$ is 0.48.

PART - 2

1. mol. wt. $CaCl_2 = 111$ g

$\because$ 111 g $CaCl_2$ has N_A ions Ca^{+2} (N_A = Avogadro number)

$\therefore$ 222 g $CaCl_2$ has N_A ions $Ca^{+2} = \frac{N_A \times 222}{111} =$ **2** N_A **ions of Ca^{+2}**

$\because$ 111 g $CaCl_2$ has 2 N_A ions of Cl^-

$\therefore$ 222 g $CaCl_2$ has 2 N_A ions of $Cl^- = \frac{2 \times N_A \times 222}{111}$ ions of $Cl^- =$ **4** N_A **ions of Cl^-**

2. $Zn + I_2 \longrightarrow ZnI_2$

	Zn	I_2	ZnI_2
Mass	x	x	0
Initial mole	$\frac{x}{65}$	$\frac{x}{254}$	0
finally	$\frac{x}{65} - \frac{x}{254}$	0	$\frac{x}{254}$

Fraction of Zn unreacted $= \dfrac{\frac{x}{65} - \frac{x}{254}}{\frac{x}{65}} = 1 - \frac{65}{254} = 0.744$

3. On passing through charcoal only CO_2 reduces to CO.

$CO + C \longrightarrow$ No reaction

Volume a

$CO_2 + C \longrightarrow 2\,CO$

	CO_2	2 CO
Volume before reaction	b	0
Volume after reaction	0	2b

As given $a + b = 1$ and $a + 2b = 1.4$

$\therefore$ b = 0.4 litre $\therefore$ % of b $= \frac{0.4}{1} \times 100 = 40$ %

$\therefore$ a = 0.6 litre $\therefore$ % of a $= \frac{0.6}{1} \times 100 = 60$ %

4. MnO_4^- ; $x + 4(-2) = -1$ or $x = +7$;
CrO_2Cl_2 ; $x + 2(-2) + 2(-1) = 0$ or $x = +6$.

5. Let the volume of oxygen in 1120 mL of ozonised oxygen be x mL at S.T.P.
$\therefore$ Volume of ozone = (1120 - x) mL at S.T.P.
We known that
vol. of mixture × its density = mass
= vol. of oxygen × its density + vol. of ozone × its density

Also, density = $\frac{mass}{volume}$

$\therefore$ density of oxygen = $\frac{32}{22400}$ g/mL (at S.T.P.)

and density of ozone = $\frac{48}{22400}$ g/mL (at S.T.P.)

Hence, $x \times \frac{32}{22400} + (1120 - x) \times \frac{48}{22400} = 1.76$
or, $2x + (1120 - x) \times 3 = 1.76 \times 1400$
or, $x = (3360 - 2464)$ mL = **896 mL O_2.**

6. (A) and (B) Explanation : 30% of molecule dissociated $N_2 \rightarrow 2N$

Amount of N_2 left = $\frac{2.8}{28} \times \frac{70}{100} = 0.1 \times 0.7 = 0.07$
(in moles)

No. of moles of N atoms formed = $2 \times \frac{30}{100} \times 0.1 = 0.06$

(A) Total no . of moles = 0.07 + 0.06 = 0.13
(B) Total number of molecules = $0.07 \times 6.023 \times 10^{23} = 4.2 \times 10^{22}$ molecule = 0.421×10^{23}
$\because$ We have to calculate molecule of nitrogen not atoms.

7. Let W gas of SO_2 and O_2 are taken

moles of $SO_2 = \frac{W}{64}$; moles of $O_2 = \frac{W}{32}$

molecules of $O_2 = \frac{WN_A}{32}$; molecules of $SO_2 = \frac{WN_A}{64}$

hence molecules of O_2 > molecules of SO_2
since moles of O_2 > moles of SO_2 , hence volume of O_2 at 0ºC & 1 atm > volume of SO_2 at 0ºC & 1 atm

8.

	$2P + Q \longrightarrow$		R
initial mole	12	8	0
final mole	0	8 – 6	6

$\therefore$ moles of R formed = 6

% of Q left behind = $\frac{2}{8} \times 100 = 25\%$

9. $0.5 \times n = \frac{216}{108}$ = mol of Ag
n = 4
M.wt = 58 + [165]n g/mol = 718 g/mol

10. Mw of $CaCO_3$ = 100, Mw of Na_2CO_3 = 106
Mw of HNO_3 = 63 g mol^{-1}
$Na_2CO_3 + CaCO_3 \longrightarrow CaCO_3 + 2NaCl$

(a) moles of $CaCO_3 = \frac{10}{100} = 0.1$ mol

moles of Na_2CO_3 = moles of $CaCO_3 \equiv 2 \times$ moles of NaCl
Weight of $Na_2CO_3 = 0.1 \times 106 = 10.6$ g

% purity $Na_2CO_3 = \frac{10.6}{21.2} = 100 = 50\%$

(b) wrong
(c) correct
(d) moles of NaCl = 2 × 0.1 = 0.2 mol

11. Cr oxidises from +3 to +6 while I reduces from +5 to –1. One I atom gain 6 electron.

13. Let mole % of ^{26}Mg be x.

$$\therefore \quad \frac{(21-x)25+x(26)+79(24)}{100} = 24.31$$

x = 10%
Answer = 1

14. $CaCO_3 \longrightarrow CaO + CO_2$

$\frac{5.6}{22.4} = \frac{1}{4}$ mole

mole of CaO = mole of Ca = $\frac{1}{4}$

mass of Ca = $\frac{1}{4} \times 40 = 10$

% of Ca in sample = $\frac{10}{200} \times 100 = 5\%$

15. Let volume of solution is 1000 ml
moles of H_2SO_4 = 18
mass of $H_2SO_4 = 18 \times 98 = 1764$ g
mass of solution = $1000 \times 1.8 = 1800$ g
mass of solvent = 1800 – 1764 = 36 g

molality = $\frac{18}{\left(\frac{36}{1000}\right)} = 500 \quad \Rightarrow \frac{500}{500} = 1$

16. Let each species be a moles, M be molecular mass of metal
a × [2 × 7 + 12 + 48] + a [2 × M + 12 + 48] = 1 ....(1)
and a moles of each carbonate reacts with 2a mole of HCl
hence 4a = $44.44 \times 0.5 \times 10^{-3}$
or a = $11.11 \times 0.5 \times 10^{-3}$ ....(2)
Thus M from solving the equation (1) and (2) is 23 g
M = 23 g
M – 16 = 7

17. From one mole of initial mixture, some FeO must have reacted with oxygen and got converted into Fe_2O_3.

$$4FeO + O_2 \longrightarrow 2Fe_2O_3$$

Initial moles $\frac{3}{5}$ $\frac{2}{5}$

Final moles $\frac{3}{5} - x$ $\frac{2}{5} + \frac{x}{2}$

But, final moles ratio is 2 : 3.

$\therefore$ $$\frac{\left(\frac{3}{5} - x\right)}{\left(\frac{2}{5} + \frac{x}{2}\right)} = \frac{2}{3}$$

$\therefore$ $x = \frac{1}{4}$

$\therefore$ Moles of FeO reacted = x = $\frac{1}{4}$

$\therefore$ Moles of O_2 required = $\frac{1}{4}(x) = \frac{1}{16} = 0.0625$

$\therefore$ Mass of O_2 required = 0.0625 × 32 = 2 g

18. Let x be the mass of $CaCO_3$ hence mass of $MgCO_3$ = 92 – x

$CaCO_3$ + $MgCO_3$

$\frac{x}{100}\downarrow$ $\frac{92-x}{84}\downarrow$

$CaO + CO_2$ $MgO + CO_2$

$\frac{x}{100}$ $\frac{92-x}{84}$

mass of residue = 48 g

$\Rightarrow$ $$\frac{x}{100} \times 56 + \frac{92-x}{84} \times 40 = 48$$

$\Rightarrow$ $$\frac{x}{100} + \frac{92-x}{84} = \frac{6}{7}$$ $\Rightarrow$ x = 50

$\therefore$ mass of $MgCO_3$ = 92 – 50 = 42 g.

PART - 3

18. mole = $\frac{w}{m} = \frac{1}{m}$

for largest no. of molecule m should be lowest.

19. $X = \frac{20}{M_1 \times 50}$

$Y = \frac{15}{70 \times M_2}$

X = Y $\frac{20}{M_1 \times 50} = \frac{15}{70 \times M_2}$; $\frac{28}{15} = \frac{M_1}{M_2}$

20. $3\,BaCl_2 + 2NO_3PO_4 \longrightarrow Ba_3(PO_4)_2 + 6NaCl$

$$\frac{0.5}{3} \qquad \frac{0.2}{2} \qquad\qquad 0.1$$

21. $\frac{1}{2} \times 6.023 \times 10^{23} = 3.0125 \times 10^{23}$

37. $\frac{3.7 \times 1 + 5 \times 0.3}{8.7} = \frac{3.7 + 1.5}{8.7} = \frac{5.2}{8.7} = \frac{52}{87}$

38. $H_2C_2O_4.2H_2O$

$\frac{252 \times 10^{-3}}{126} \times 2 \times N_A = 4 \times N_A \times 10^{-3} = 4 \times 6.02 \times 10^{23} \times 10^{-3} = 24.092 \times 10^{20} = 2.4 \times 10^{21}$.

39.

oxidation

$$\overset{0}{Cu} + 2H_2\underset{6+}{S}O_4 \longrightarrow \overset{2+}{Cu}SO_4 + 2H_2O + \overset{4+}{S}O_2$$

reduction

40. Moles of HNO_3 required = $\frac{0.784}{108} = 0.0072 \times \frac{4}{3} = 0.00968$.

Vol. of HNO_3 = $\frac{0.00963}{1.15} \times 1000 = 8.41$ ml.

41. Disproportionation reaction.

42.

Element	%	%/A	Simplest ratio
Be	6.1	6.1/9 = 0.677	1
N	37.8	37.8/14 = 2.7	4
Cl	48	48/35.5 = 1.35	2
H	8.1	8.1/1 = 8.1	12

Empirical formula = $BeN_4Cl_2H_{12}$
= 9 + 56 + 71 +12
= 148 = n = 1
Molecular formula = $BeN_4Cl_2H_{12}$

43. $M = \frac{10 \times 1.14 \times 20}{98}$

M = 2.32

45. $\overset{+3}{HNO_2}$ can act both as oxiding as well as reducing agent.

46. $BaCl_2 + Na_3PO_4 \longrightarrow Ba_3(PO_4)_2 + NaCl$
nf = 2 nf =3 nf = 6
moles = 0.9 0.4
gram eq. = 1.8 1.2
Hence gram eq. of $Ba_3(PO_4)_2$ formed = 1.2
moles formed = 1.2.

48. Number of water molecules = $\frac{0.2}{249.7} N_A \times 5 = 2.14 \times 10^{21}$

49. $Cs[Mn(SO_4)_2.12H_2O]$

$x - 4 = -1$

$x = +3$

50. $AgNO_3 + Cl^- \longrightarrow AgCl\downarrow + NO_3^-$

1.4 g

$= \frac{1.4}{143.5}$ mol

$= \frac{1.4}{143.25} \times 35.5$ gm Cl = 0.35 gm

51. $VD_A = 4VD_B$ or $\frac{M_A}{2} = 4 \times \frac{M_B}{2}$, or $M_A = 4M_B$

52. $2KClO_3 \longrightarrow 2KCl + 3O_2$

$n_{KClO_3} = \frac{36.75}{122.5} = 0.3$

By mole-mole analysis $\frac{n_{KClO_3}}{2} = \frac{n_{O_2}}{3}$

or $n_{O_2} = \frac{3}{2} \times 0.3 = 0.45$

or volume of O_2 = 0.45 × 22.4

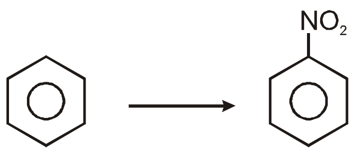
= 10.08 lit.

= 10.08 dm^3

53. 500 gm toothpaste contains 0.4 g fluoride

$\therefore$ 10^6 g toothpaste will contain $\frac{0.4}{500} \times 10^6 = 800$ g fluoride

$\therefore$ ppm of fluoride = 800

54. 

78 gm benzene gives 123 gm nitrobenzene

$\therefore$ 10 gm benzene = $\frac{123}{78} \times 10 = 15.77$ gm(should be)

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

$= \frac{13.2}{15.77} \times 100 \simeq 83.5\%$

56. I. $5H_2O_2 + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$

II. $H_2O_2 + Ag_2O \rightarrow 2Ag + H_2O + O_2$

57. $Al_4C_4 + 12H_2O \longrightarrow 3CH_4 + 4Al(OH)_3$

$$\frac{11.2}{22.4} = \frac{1}{2}\text{mole}$$

Mole of methane = $\frac{11.2}{22.4} = \frac{1}{2}$mole

Wt of $Al_4C_3 = \frac{1}{6} \times 144 = 24\,g$

58. $D = \frac{M}{V} \Rightarrow 1.42 = \frac{100}{V}$

$\Rightarrow V = \frac{100}{1.42}$

Molarity of $HNO_3 = \frac{70 \times 1.42 \times 1000}{63 \times 100} = 15.8$

PART - 4

---

1. SO_2 that converted $= 440 \times \frac{80}{100}$ Kg = 352 kg

	$5C$	+	$2SO_2$	$\longrightarrow$	CS_2	+	$4CO$
Initial mole	5×10^3		$\frac{352}{64} \times 10^3$ $= 5.5 \times 10^3$		0		0
final mole	0		$5.5 \times 10^3 - \frac{2}{5} \times 5 \times 10^3$		1×10^3		4×10^3

mole of CS_2 = 1000
mass = 1000 × 76 g = 76 Kg

2. (a) $Br_2 + Cl_2 \longrightarrow 2BrCl$

1 mol 1mol 2mol
0.025 0.025 0.050 mol

(b) Theoretical yield of BrCl = 0.050 mol actual yield is = $\frac{0.05 \times 80}{100}$ = 0.04 mole

Br_2 left unreacted = 0.025 – 0.02 = 0.005 mol.

5. Balanced chemical equation is

$4nXeF_6 + \left(CH_2–CH_2 \right)_n \longrightarrow \left(CF_2–CF_2 \right)_n + 4nHF + 4nXeF_4$

$n_{teflon} = \frac{100}{100n} = \frac{1}{n}$

$\therefore$ n_{XeF_6} required $= \frac{1}{n} \times 4n = 4$ moles

ONLY ONE OPTION CORRECT TYPE

1.

	$TiCl_4$ +	$2Mg \longrightarrow$	Ti +	$2MgCl_2$
Initial mole	$\frac{358}{190} = 1.88$	$\frac{96}{24} = 4$		
final mole	0	$4 - 2 \times 1.88$	1.88	2×1.88

wt of Ti obtained = $\frac{358}{190} \times 48$

% yield = $\frac{32 \times 100}{\frac{358 \times 48}{190}}$ = 35.38 %

2. Produced mass of H_3PO_4 = $\left(\frac{62}{4 \times 31}\right) \times 0.85 \times 0.9 \times 4 \times 98 = 149.94$ g

3. The balanced equation is

$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

4. 10^{-3} g NH_3 in 100 g solution

one litre water has mass = 1000×1 g

As NH_3 is very less hence we can say

100 g water has 10^{-3} g NH_3

$\therefore$ 1000 g water has = $\frac{10^{-3}}{100} \times 1000$ g = 10^{-2} g NH_3 = $\frac{10^{-2}}{17}$ mole NH_3 = 5.88×10^{-4} mole NH_3.

5. Mole of Al = $\frac{18}{27} = \frac{2}{3}$

Mole of HCl = $\frac{109.5}{36.5} = 3$

Moles of NaOH = $\frac{100}{40} = 2.5$

	$2\,Al + 6\,HCl \longrightarrow 2\,AlCl_3 + 3H_2$			
Initial mole	2/3	3	0	0
final mole	0	1	2/3	

	$AlCl_3 + 3NaOH \longrightarrow Al(OH)_3 + 3NaCl$			
Initial mole	2/3	2.5	0	0
final mole	0	$2.5 - 2/3 \times 3$ = 0.5	2/3	

	$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$			
Initial mole	2/3	0.5	0	0
final mole		0	0.5	

Ans. $NaAlO_2$ = 0.5 moles.

6. $3M + N_2 \longrightarrow M_3N_2$

Let Atomic wt. of metal = a

so (3a + 28) g nitride contains metal = 3a gram

$\therefore$ 14.8 g nitride contains metal = $\frac{3a}{3a+28} \times 14.8 = 12$

so a = 40.

7. By applying POAC for C atoms

moles of ethylene × 2 = mole of polythene × n × 2

$$\frac{100g}{28} \times 2 = \frac{\text{wt. of polethene}}{28 \times n} \times n \times 2$$

wt. of polyethene = 100 g

8. $C + CO_2 \longrightarrow 2CO$

Given moles $\left(\frac{6}{12}\right) = 0.5$ $\quad \left(\frac{44}{44}\right) = 1$

So C is limiting reagent

$\therefore$ CO formed = 1 moles

Now moles of Ni need to react with 1 moles of CO are $\frac{1}{4} \times 58.7 = 14.675$ g.

9. $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

for 1 mole NaOH $\frac{1}{2}$ mole H_2SO_4 required

70 g H_2SO_4 in 100 g solution

$\frac{98}{2}$ g H_2SO_4 in = $\frac{100}{70} \times 49 = 70$ g solution.

10. Li AlH_4 + t-butyl alcohol $\xrightarrow{\text{Ether}}$ $LiAlHC_{12}H_{27}O_3$ (M.W. = 254)

0.05 mole 12.7 gram

$= \frac{12.7}{254} = 0.05$ mole

Li atom remain conserved so
No. of mole of $LiAlH_4$ = No. of mole of $LiAlHC_{12}H_{27}O_3$
So No. of mole of $LiAlHC_{12}H_{27}O_3 = 0.05$

% yield = $\frac{0.05}{0.05} \times 100 = 100\%$

11. $P_4 + O_2 \longrightarrow P_4O_6 + P_4O_{10}$

31 gram 32 gram
According to question weight of P is conserved so
Let Mole of P_4O_6 = a
Mole of P_4O_{10} = b
Initial weight of P = Final weight of P.
$31 = [a \times 4] \times 31 + [b \times 4] \times 31$
$4a + 4b = 1]$ (1) × 3
Initial weight of oxygen = Final weight of oxygen
$32 = [a \times 6] \times 16 + [a \times 10] \times 16$
$3a + 5b = 1]$ (2) × 4

$12a + 20b = 4$

$12a + 12b = 3$ So $b = \frac{1}{8}$

$8b = 1$

Similarly $a = \frac{1}{8}$

So weight of $P_4O_6 = \frac{1}{8} \times 220 = 27.5$ $P_4O_{10} = \frac{284}{8} = 35.5.$

12. $CaCl_2 + NaCl = 10$ g
Let weight of $CaCl_2 = x$ g
$CaCl \rightarrow CaCO_3 \rightarrow CaO$
1 mol 1 mol 1 mol

$\frac{x}{111}$ mol $\frac{x}{111}$ mol $\frac{x}{111}$ mol

Mole of CaO = $\frac{1.62}{56}$

$\therefore \frac{x}{111} = \frac{1.62}{56}$

x = 3.21 g

% of $CaCl_2$ = $\frac{3.21}{10} \times 100 = 32.1$ % $= \frac{3.21}{10} \times 100 = 32.1$ %

13. Mole fraction of A i.e. $X_A = \frac{n_A}{\text{Total moles}}$

So $X_{H_2O} = \frac{n_{H_2O}}{\text{Total moles}}$

Now $\frac{X_A}{X_{H_2O}} = \frac{n_A}{n_{H_2O}}$

and molality = $\frac{n_A \times 1000}{n_{H_2O} \times 18} = \frac{X_A \times 1000}{X_{H_2O} \times 18} = \frac{0.2 \times 1000}{0.8 \times 18}$ = **13.9 Ans.**

14. Let wt. of Fe = 100 g so wt. of O_2 = 10 g

$$2Fe + \frac{3}{2}O_2 \longrightarrow Fe_2O_3$$

by the stoichiometry of the reaction $\frac{10}{32}$ mole of O_2 will combine with $\frac{10}{24}$ mole of Fe

wt. of Fe = $\frac{10}{24} \times 56$ = 23.3 g or 23.3%.

15. $C + \frac{1}{2}O_2 \longrightarrow CO$ .... (1)

Initial mole $\frac{x}{12}$ $\frac{y}{32}$ 0

final mole 0 $\frac{y}{32} - \left(\frac{x}{12}\right)\frac{1}{2}$

$CO + \frac{1}{2}O_2 \longrightarrow CO_2$ .... (2)

For no solid residue C should be zero in eq. (1) For that $\frac{y}{32} - \frac{x}{12} \times \frac{1}{2} > 0$

$$\frac{y}{32} > \frac{x}{24}$$

$$\frac{y}{x} > \frac{32}{24}$$

$$\frac{y}{x} > 1.33$$

16. Mass of ethyl alcohol = 1.5×0.792 g

Mass of water = 15×1

Total mass of solution = $15 + 0.792 \times 15 = 26.88$

Volume of solution = $\frac{\text{mass}}{\text{density}} = \frac{26.88}{0.924} = 29.09$

% decrease in volume = $\left(\frac{30 - 29.09}{30}\right) \times 100 \cong 3\%$.

PART - 3

2. (A) Molarity of cation = $\frac{M_1V_1 + M_2V_2}{V_1 + V_2} = \frac{0.2 \times 100 + 0.1 \times 400}{500} = \frac{0.6}{5} = 0.12$

Molarity of Cl^- = $\frac{3(0.2)100 + 0.1 \times 400}{500} = \frac{0.6 + 0.4}{5} = 0.2$

(B) Molarity of cation = $\frac{50 \times 0.4 + 0}{100} = 0.2$

Molarity of Cl^- = $\frac{0.4 \times 50 + 0}{100} = 0.2$

(C) Molarity of cation = $\frac{2(0.2)30 + 0}{100} = 0.12$

Molarity of SO_4^{2-} = $\frac{30 \times 0.2}{100} = 0.06$

(D) 24.5 g H_2SO_4 in 100 ml solution

$$\text{Molarity} = \frac{\frac{25.4}{98}}{0.1} = 2.5$$

$\therefore$ Concentration of cation = 2 × 2.5 M

Concentration of SO_4^{2-} = 2.5 M.

SINGLE AND DOUBLE VALUE INTEGER TYPE

1. Density of He = 0.1784 g/lit.

1 mole of He will occupy 22.4 lit. at 0ºC and 1 atm

$\therefore$ Mass of 1 mole = V × d = 22.4 × 0.1784 = 3.99 = 4 g.

2. Mass of Cu_2S & CuS = 100 – 4.5 = 95.5 g

Let mass of Cu_2S is x g.

$Cu_2S + O_2 \longrightarrow 2Cu + SO_2$

$CuS + O_2 \longrightarrow Cu + SO_2$

Mass of Cu from Cu_2S + Mass of Cu from CuS = 71.8

$$\frac{x}{159} \times 63.3 \times 2 + \frac{(95.5-x)}{95.5} 63.5 = 71.8$$

$$x\left(\frac{127}{159} - \frac{63.5}{95.5}\right) = 8.3$$

$$x = \frac{8.3}{0.134} = 62.01 \text{ g.}$$

$\therefore$ % of Cu_2S is 62.

3. Molarity of $H_2SO_4 = \dfrac{1.8 \times 54.5 \times 10}{98} = 10$

$2Al \quad + \quad 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$

1 moles 2 moles

(limiting)

Moles of H_2SO_4 left = 2 – 1.5 = 0.5 moles

moles of HCl added = 2 moles

final volume of the solution = 500 ml

moles of H^+ ion = 3

concentration of H^+ ion = 6 M

4. 1 × moles of CO_2 = 6n × moles of starch

$$= 6n \times \frac{1}{162n}$$

So moles of $CO_2 = \frac{6}{162}$

Now 4.7×10^{-3} moles of CO_2 are absorbed in 1 hr

So $\frac{6}{162}$ moles of CO_2 are absorbed in = $\frac{1}{4.7\times10^{-3}} \times \frac{6}{162}$ = 8 hrs.

5. Balanced the equation.

$15H_2O + 3CN^- \longrightarrow 3CO_2 + 3NO_3^- + 30H^+ + 30e^-$

6. Mole of NaOH in 1st solution = 0.5 moles

moles of NaOH addded = $\frac{200\times1.5\times0.2}{40}$ = 1.5

moles of NaOH in the final solution = 1.5 + 0.5 = 2 moles

$Al + NaOH + H_2O \longrightarrow NaAlO_2 + 3/2\ H_2$

moles of H_2 produced from 2 moles of NaOH = 3 moles

volume of H_2 produced at 0ºC and 1 atm = 3 × 22.4 = 67.2 litre

Ans. 67

7. m moles of HCl = 12 × 0.05 = 0.6

Now $Al + 3HCl \rightarrow AlCl_3 + \frac{3}{2} H_2$

so m moles of Al = $\frac{1}{3} \times 0.6$

or weight of Al = $\frac{1}{3} \times \frac{0.6\times27}{1000}$ = 0.0054 gram

∴ Volume of foil = $\frac{0.0054}{2.7}$ mL or cm³ = 0.002 cm³

Now , Area × thickness = Volume

∴ Area = $\frac{0.002}{0.01}$ = 0.2 cm² (thickness = 0.01 cm)

= 0.2 × 10 = **2 Ans.**

Note : The maximum area of hole is possible when 0.01 cm foil of Al is completely attacked.

8. $A + \frac{1}{2} B_2 \longrightarrow AB$, 100 Kcal

x x/2 x

$A + 2B_2 \longrightarrow AB_4$, 200 Kcal

(1–x) 2(1–x) (1–x)

100 x + 200 (1–x) = 140

$200 - 100x = 140$

$x = \frac{60}{100} = 0.6$

n_{B_2} used $= \frac{x}{2} + 2(1-x) = \frac{1}{2} \times 0.6 + 2(1-0.6) = 0.3 + 2 \times 0.4 = 1.1$ mol

Ans $= 1.1 \times 10 = 11$

9. (Atomic weight of Al and Cr = 27 and 52, M.wt. of Cr_2O_3 = 152)

Moles of Al $= \frac{49.8 \text{ g}}{27 \text{ g Al}} = 18.4$ mol

$= \frac{18.4}{2} = 9.2$ mol of Cr_2O_3

Moles of $Cr_2O_3 = \frac{200 \text{ g}}{152 \text{ g } Cr_2O_3} = 1.31$ mol

Since 2 mol Al is required for 1 mol of Cr_2O_3.
So, Al is the limiting reagent and Cr_2O_3 is in excess. Moles of Cr_2O_3 is excess
$= (1.31 - .92) = 0.4$ mol
Weight of excess $Cr_2O_3 = 0.4 \times 152 = 60$ g Cr_2O_3

10. Balance the equation by any method
$4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + 3H_2O + NH_4NO_3$
$\therefore$ a + b + c = 4 + 3 + 1 = 8

11. Molarity $= \frac{10 \times 1.8 \times 98}{98} = 18$ M

12. Molarity of HCl $= \frac{\text{Total moles of HCl}}{\text{Total volume}} = \frac{5 \times 2}{2+3} = 2$ M

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

2. Let mol of N_2 = x, mol of NO_2 = y, mol of N_2O_4 = z

therefore $\frac{28x+46y+92z}{1}$ = 55.4 ....(1)

If $N_2O_4 \longrightarrow 2NO_2$

$\frac{28x+(y+2z)46}{x+y+z+z}$ = 39.6

$\Rightarrow$ $\frac{28x+46y+92z}{1+z}$ = 39.6 ....(2)

By deviding equation (1) by equation (2)

$1 + z = \frac{55.4}{39.6} = 1.4$

z = 0.4 mol

Given x + y + z = 1 ....(3)

Put the value of z in eq. (1)

28x + 46y + 92 + 0.4 = 55.4

28x + 46y = 18.6 ....(4)

By equation (3) & (4)

y = 0.1

$\therefore$ x = 0.5 , y = 0.1 , z = 0.4

3. (A) , (C) and (D) Explanation :

$4\,Ag + 8\,KCN + O_2 + 2\,H_2O \longrightarrow 4\,K[Ag(CN)_2] + 4\,KOH$

$\Rightarrow$ 4 × 108 g of Ag reacts with 8 × 65 g of KCN

100 g of Ag reacts with

$\frac{8\times65}{4\times108} \times 100 = 120$

Hence ,, to dissolve 100 g of Ag , the amount of KCN required = 120 g

Hence , statement (A) is correct.

$\Rightarrow$ 4 × 108 g of Ag require 32 g of O_2

1 g of Ag require $\frac{32}{4\times108}$ = 0.0740 g

$\Rightarrow$ 100 g of Ag require = 7.4 g

Hence, choice (C) is correct.

Hence, volume of O_2 required = $\frac{7.4}{32} \times 22.4 = 5.20$ litre

Hence, (A) , (C) , (D) are correct while (B) is incorrect.

4. $CaO(s) + 3C(s) \longrightarrow CaC_2(s) + CO(g)$

(A) Final product contain 85% CaC_2 & 15% CaO

Let mass of product is 100 g

$\therefore$ Mass of CaC_2 = 85 g

Mass of CaO = 15 g

Used mole of CaO = mole of CaC_2 produced = $\frac{85}{64}$

$\therefore$ mass of CaO for producing 85 g CaC_2 = $\frac{85}{64} \times 56 = 74.375$ g.

$\therefore$ Initial total mass of CaO = 74.375 + 15 = 89.375.

85 g CaC_2 obtained from = 89.38 g CaO

$\therefore$ 1 g CaC_2 obtained from = $\frac{89.38}{85}$ g CaO

10^6 g CaC_2 obtained from = $\frac{89.38}{85} \times 10^6 = 1051470$ g

For 1000 kg CaC_2 requires = 1051.47 kg CaO.

(B) 100 g product requires CaO = 89.38 g

1 g product requires = $\frac{89.38}{100}$

10^6 g product requires = $\frac{89.38}{100} \times 10^6$

For 1000 kg (crude) product = 893.8 kg CaO.

5. Mol of Cu^{2+} = 1.0 L × 0.1 M = 0.1 M Cu^{2+} = 0.1 × 2 mol H^+

(A) Weight of CuS = 0.1 × 95.5 = 9.55 g

(B) Concentration of H^+ = $\frac{0.2 \text{ mol}}{1.0 \text{ L}}$ = 0.2 M

(C) and (D) are wrong.

6. (A) Weight of $CaCO_3$ = (0.22 g CO_2)

$$\left(\frac{1\,\text{mol}\ CO_2}{44\ \text{g}\ CO_2}\right)\left(\frac{1\,\text{mol}\ CaCO_3}{\text{mol}\ CO_2}\right)\left(\frac{100\text{g}\ CaCO_3}{\text{mol}\ CaCO_3}\right) = \frac{0.22\times100}{44} = 0.5\ \text{g}\ CaCO_3$$

(B) Moles of $CaCO_3$ = moles of Ca = $\left(\frac{0.22}{44}\right)$ = 0.005 mol

Weight of Ca = 0.005 × 40 = 0.2 g Ca

(D) % of Ca = $\frac{0.2}{1.0}$ × 100 = 20% Ca

Hence (C) is wrong.

7.

	Silica	H_2O	Impurities
% in original clay ⇒	40	19	100 – (40 + 19) = 41
% after partial drying ⇒	a	10	100 – (a + 10) = 90 – a

On heating, only water evaporates from clay, whereas silica and impurities are left as it is. Therefore, % ratio of silica and impurities remains unchanged, i.e.

$$\frac{40}{a} = \frac{41}{90-a},\ \therefore\ a = 44.4\%$$

% of mipurities after partial drying = (90 – a) = (90 – 44.4) = 45.6%