MOLE CONCEPT

CONTENTS

JEE(Advanced) Syllabus

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

JEE(Main) Syllabus

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 chemical combination; Atomic and molecular masses, mole concept, molar mass, percentage composition, empirical and molecular formulae; Chemical equations and stoichiometry.

MOLE CONCEPT

1. SECTION (A) : MOLAR VOLUME OF IDEAL GASES AT STP, AVERAGE MOLAR MASS

2. INTRODUCTION :

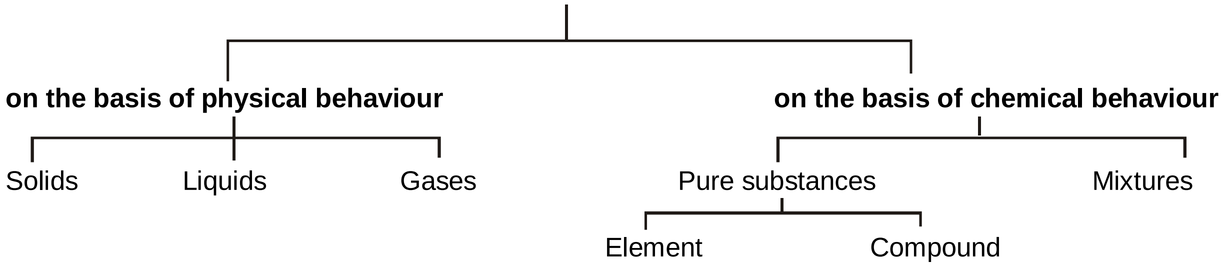
There are a large number of objects around us which we can see and feel.
Anything that occupies space and has mass is called matter.

Ancient Indian and Greek Philosopher's beleived that the wide variety of object around us are made from combination of five basic elements : Earth, Fire, Water, Air and Sky.
The Indian Philosopher Kanad (600 BC) was of the view that matter was composed of very small, indivisible particle called *"parmanus"*.
Ancient Greek Philosophers also believed that all matter was composed of tiny building blocks which were hard and indivisible.
The Greek philosopher Democritus named these building blocks as atoms, meaning indivisible.
All these people have their philosophical view about matter, they were never put to experimental tests, nor ever explain any scientific truth.
It was ***John Dalton*** who firstly developed a theory on the structure of matter, later on which is known as ***Dalton's atomic theory.***

Th1: DALTON'S ATOMIC THEORY :

- Matter is made up of very small indivisible particles called atoms.
- All the atoms of a given element are identical in all respect i.e. mass, shape, size, etc.
- Atoms cannot be created or destroyed by any chemical process.
- Atoms of different elements are different in nature.

Classification of matter



Basic Definitions :

D1: 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) = $\dfrac{\text{Mass of one atom of an element}}{\frac{1}{12}\times\text{mass of one C}-12\text{ atom}}$

D2: **Atomic mass unit (or amu) :**

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

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

$\approx$ 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

Example 1. Find the relative atomic mass of 'O' atom and its atomic mass.

Solution 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:

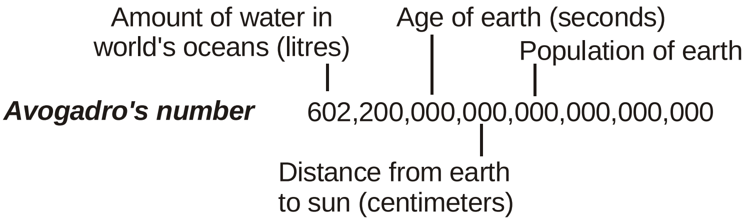
D3: ***A mole is the amount of a substance that contains as many entities (atoms, molecules or other particles) as there are atoms in exactly 0.012 kg (or 12 g) of the carbon-12 isotope.***

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 ?



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

Gram Atomic Mass :

D4: 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

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

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

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

Solved Examples

Example 1. How many atoms of oxygen are their in 16 g oxygen.

Solution Let x atoms of oxygen are present

So, $16 \times 1.66 \times 10^{-24} \times x = 16 \text{ g}$

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

Gram molecular mass :

D5: 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 = $32 \text{ amu} \times 6.02 \times 10^{23}$

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

Solved Examples

Example 1. 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.

Solution 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
$1 \times N_A$	$2 \times N_A$ atoms	$1 \times N_A$ atoms	$4 \times N_A$ atoms
∴ one mole	2 mole	one mole	4 mole
∴ 3 mole	**6 mole**	**3 mole**	**12 mole**

D6:

- **AVERAGE/ MEAN ATOMIC MASS :**

The weighted average of the isotopic masses of the element's naturally occuring isotopes.

Mathematically, average atomic mass of X (A_x) = $\frac{a_1x_1 + a_2x_2 + ... + a_nx_n}{100}$

Where : a_1, a_2, a_3 .... atomic mass of isotopes and x_1, x_2, x_3 .... mole % of isotopes.

Solved Examples

Example 1. Naturally occuring chlorine is 75% Cl^{35} which has an atomic mass of 35 amu and 25% Cl^{37} which has a mass of 37 amu. Calculate the average atomic mass of chlorine -

(A) 35.5 amu (B) 36.5 amu (C) 71 amu (D) 72 amu

Solution (A) Average atomic mass = $\frac{\% \text{ of I isotope} \times \text{its atoms mass} + \% \text{ of II isotope} \times \text{its atomic mass}}{100}$

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

Note :

(a) In all calculations we use this mass.

(b) In periodic table we report this mass only.

D7:

- **MEAN MOLAR MASS OR MOLECULAR MASS:**

The average molar mass of the different substance present in the container = $\frac{n_1M_1 + n_2M_2 + ...n_nM_n}{n_1 + n_2 + ...n_n}$.

Where : M_1, M_2, M_3 .... are molar masses and n_1, n_2, n_3 .... moles of substances.

Solved Examples

Example 1. The molar composition of polluted air is as follows :

Gas	At. wt.	mole percentage composition
Oxygen	16	16%
Nitrogen	14	80%
Carbon dioxide	-	03%
Sulphurdioxide	-	01%

What is the average molecular weight of the given polluted air ? (Given, atomic weights of C and S are 12 and 32 respectively.

Solution $M_{avg} = \frac{\sum_{j=1}^{j=n} n_jM_j}{\sum_{j=1}^{j=n} n_j}$ Here $\sum_{j=1}^{j=n} n_j = 100$

$$\therefore M_{avg} = \frac{16 \times 32 + 80 \times 28 + 44 \times 3 + 64 \times 1}{100} = \frac{512 + 2240 + 132 + 64}{100} = \frac{2948}{100} = \textbf{29.48 Ans.}$$

D8: **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

$$\begin{array}{llll} H_2(g) & + \; Cl_2(g) & \longrightarrow & 2HCl \\ 1 \text{ vol} & \;\; 1 \text{ vol} & & 2 \text{ vol} \end{array}$$

D9: **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 atm = 760 mm of Hg

and volume of one mole of gas at STP is found to be experimentally equal to 22.4 litres which is known as molar volume.

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

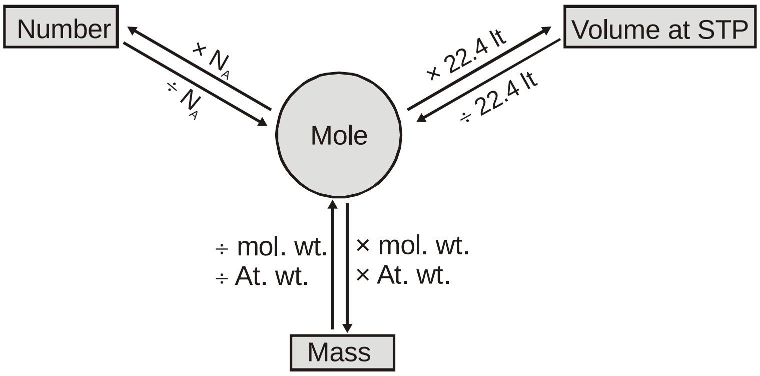
Solved Examples

Example 1. Calculate the volume in litres of 20 g hydrogen gas at STP.

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

volume of hydrogen gas at STP = 10 × 22.4 lt.

App-1: Y-map : Interconversion of mole-volume, mass and number of particles :



3. SECTION (B) : EMPIRICAL FORMULA, % COMPOSITION OF A GIVEN COMPOUND BY MASS, % BY MOLE, MINIMUM MOLECULAR MASS DETERMINATION.

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

Example 1. 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.

Solution **Mass % of N in NH_3** = $\frac{\text{Mass of N in 1 mol NH}_3}{\text{Mass of 1 mol of NH}_3} = \frac{14\text{ g}}{17} \times 100 = 82.35\ \%$

Mass % of H in NH_3 = $\frac{\text{Mass of H in 1 mol NH}_3}{\text{Mass of 1 mol of NH}_3} \times 100 = \frac{3}{17} \times 100 = 17.65\ \%$

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.

D10: 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.

D11: 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

Example 1. 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.

Solution $\because$ Empirical Formula is CH

Step 1. The empirical formula of the compound is CH

$\therefore$ Empirical formula mass = (1 × 12) + 1 = 13.

Molecular mass = 26

Step 2. To calculate the value of ‘n’

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

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’

$$n = \frac{\text{Molecular formula mass}}{\text{Empirical formula mass}} = \frac{78}{13} = 6$$ thus the molecular formula is 6 × CH = $\mathbf{C_6H_6}$

Example 2. 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.

Solution

Step 1. To calculate the empirical formula of the compound.

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

∴ Empirical Formula is $C_2H_3O_2$

Step 2. To calculate the empirical formula mass.

The empirical formula of the compound is $C_2H_3O_2$.

∴ Empirical formula mass = (2 × 12) + (3 × 1) + (2 × 16) = 59.

Step 3. To calculate the value of 'n'

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

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

Molecular formula = n × (Empirical formula) $= 2 \times C_2H_3O_2 = C_4H_6O_4$

Thus the molecular formula is $C_4H_6O_4$.

4. SECTION (C) : STOICHIOMETRY, EQUATION BASED CALCULATIONS (ELEMENTARY LEVEL SINGLE EQUATION OR 2)

Th2: 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

Example 1. Write a balance chemical equation for following reaction :

When potassium chlorate ($KClO_3$) is heated it gives potassium chloride (KCl) and oxygen (O_2).

Solution $KClO_3(s) \xrightarrow{\Delta} KCl(s) + O_2(g)$ (unbalanced chemical equation)

$2KClO_3(s) \xrightarrow{\Delta} 2KCl(s) + 3O_2(g)$ (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

Th3:

- **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 $\frac{\text{Mass of } KClO_3}{\text{Mass of KCl}} = \frac{2 \times 122.5}{2 \times 74.5}$ $\frac{\text{Mass of } KClO_3}{\text{Mass of } O_2} = \frac{2 \times 122.5}{3 \times 32}$

Solved Examples

Example 1. 367.5 gram $KClO_3$ (M = 122.5) when heated. How many gram KCl and oxygen is produced.

Solution 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

Th4: ● **Mass - volume analysis :**

Now again consider decomposition of $KClO_3$

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

mass volume ratio : 2 × 122.5 g : 2 × 74.5 g : 3 × 22.4 lt. at STP

we can use two relation for volume of oxygen

$$\frac{\text{Mass of } KClO_3}{\text{volume of } O_2 \text{ at STP}} = \frac{2 \times 122.5}{3 \times 22.4 \ \text{lt}} \qquad \text{...(i)}$$

and $$\frac{\text{Mass of KCl}}{\text{volume of } O_2 \text{ at STP}} = \frac{2 \times 74.5}{3 \times 22.4 \ \text{lt}} \qquad \text{...(ii)}$$

Solved Examples

Example 1. 367.5 g $KClO_3$ (M = 122.5) when heated, how many litre of oxygen gas is produced at STP.

Solution You can use here equation (1)

$$\frac{\text{Mass of } KClO_3}{\text{volume of } O_2 \text{ at STP}} = \frac{2 \times 122.5}{3 \times 22.4 \ \text{lt}} \quad \Rightarrow \quad \frac{367.5}{V} = \frac{2 \times 122.5}{3 \times 22.4 \ \text{lt}}$$

V = 3 × 3 × 11.2 ⇒ **V = 100.8 lt**

Th5: ● **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

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

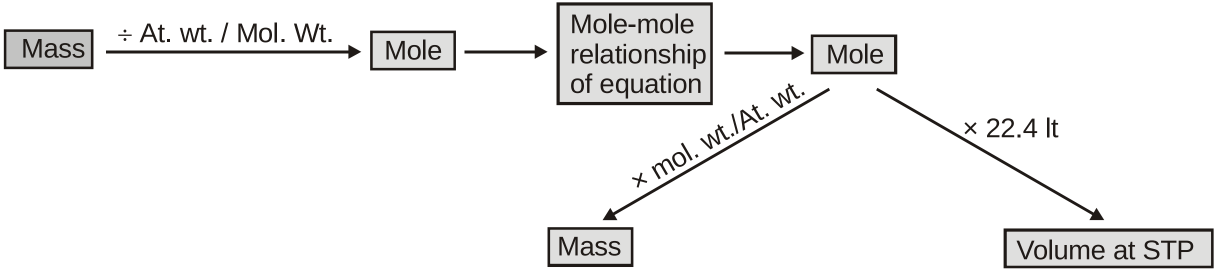
Now for any general balance chemical equation like

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

you can write.

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

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



5. SECTION (D) : LIMITING REAGENT, % EXCESS, % YIELD / EFFICIENCY

Limiting reagent :

D12: The reactant which is consumed first and limits the amount of product formed in the reaction, is called limiting reagent.

Limiting reagent is present in least stoichiometric amount and therefore, controls amount of product.

The remaining or left out reactant is called the excess reagent.

When you are dealing with balance chemical equation then if number of moles of reactants are not in the ratio of stoichiometric coefficient of balanced chemical equation, then there should be one reactant which is limiting reactant.

Solved Examples

Example 1. Three mole of Na_2CO_3 is reacted with 6 moles of HCl solution. Find the volume of CO_2 gas produced at STP. The reaction is :

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

Solution From the reaction : $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

given moles	3 mol		6 mol
given mole ratio	1	:	2
Stoichiometric coefficient ratio	1	:	2

See here given moles of reactant are in stoichiometric coefficient ratio therefore none reactant left over.

Now use Mole-mole analysis to calculate volume of CO_2 produced at STP

$$\frac{\text{Moles of } Na_2CO_3}{1} = \frac{\text{Mole of } CO_2 \text{ Produced}}{1}$$

Moles of CO_2 produced = 3

volume of CO_2 produced at STP = 3 × 22.4 L = 67.2 L

Example 2. 6 moles of Na_2CO_3 is reacted with 4 moles of HCl solution. Find the volume of CO_2 gas produced at STP. The reaction is :

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$.

Solution From the reaction : $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

given mole of reactant	6	:	4
given molar ratio	3	:	2
Stoichiometric coefficient ratio	1	:	2

See here given number of moles of reactants are not in stoichiometric coefficient ratio. Therefore there should be one reactant which consumed first and becomes limiting reagent.

But the question is how to find which reactant is limiting, it is not very difficult you can easily find it. According to the following method.

Th6: How to find limiting reagent :

Step 1. Divide the given moles of reactant by the respective stoichiometric coefficient of that reactant.

Step 2. See for which reactant this division come out to be minimum. The reactant having minimum value is limiting reagent for you.

Step 3. Now once you find limiting reagent then your focus should be on limiting reagent

From Step 1 & 2	**Na_2CO_3**	**HCl**
	$\frac{6}{1} = 6$	$\frac{4}{2} = 2$ (division is minimum)

∴ **HCl is limiting reagent**

From Step 3

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

∴ mole of CO_2 produced = 2 moles

∴ volume of CO_2 produced at S.T.P. = 2 × 22.4 = 44.8 lt.

6. SECTION (E) : PRINCIPLE OF ATOM CONSERVATION (POAC), REACTIONS IN SEQUENCE & PARALLEL, MIXTURE ANALYSIS, % PURITY

Th7: Principle of Atom Conservation (POAC) :

POAC is conservation of mass. Atoms are conserved, moles of atoms shall also be conserved in a chemical reaction (but not in nuclear reactions.)

This principle is fruitful for the students when they don't get the idea of balanced chemical equation in the problem.

The strategy here will be around a particular atom. We focus on a atom and conserve it in that reaction. This principle can be understand 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.

Moles of K atoms in reactant = moles of K atoms in products

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

or 1 mole of $KClO_3$ contains 1 mole of K, similarly,1 mole of KCl contains 1 mole 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 $$\frac{\text{wt. of } KClO_3 \text{ in g}}{\text{mol. wt. of } KClO_3} = \frac{\text{wt. of KCl in g}}{\text{mol. wt. of KCl}}$$

- 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 $$3 \times \frac{\text{wt. of } KClO_3}{\text{mol. wt. of } KClO_3} = 2 \times \frac{\text{vol. of } O_2 \text{ at NTP}}{\text{standard molar vol. (22.4 lt.)}}$$

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

Solved Examples

Example 1. 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]

Solution Here we do not have 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)

$$\frac{\text{wt. of } KClO_3}{\text{mol. wt. of } KClO_3} = 12 \times \frac{\text{wt. of the product}}{\text{mol. wt. of product}}$$

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

7. SECTION (F) : BASICS OF OXIDATION NUMBER

Th8: 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. $Fe^{3+} + e^- \rightarrow Fe^{2+}$

Th9: 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 ($\overset{-3}{N}H_3$, $\overset{+2}{NO}$, $\overset{+3}{N}_2O_3$, $\overset{+4}{N}O_2$, $\overset{+5}{N}_2O_5$)

- 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

Example 1. **Calculate oxidation number of underlined element :**

(a) $Na_2\underline{S}_2O_3$

(b) $Na_2\underline{S}_4O_6$

Solution.

(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

$\therefore$ $(+1) \times 2 + (x) \times 4 + (-2) \times 6 = 0 \Rightarrow x = +2.5$

❍ 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.

Th10: 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^-

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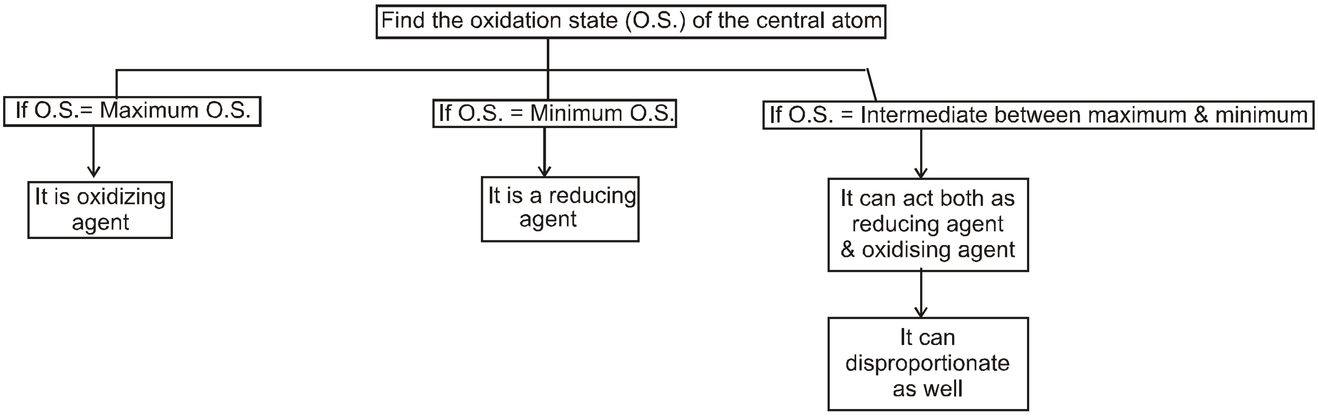
HOW TO IDENTIFY WHETHER A PARTICULAR SUBSTANCE IS AN OXIDISING OR A REDUCING AGENT



Redox reaction

D13 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) $2KClO_3 \longrightarrow 2KCl + 3O_2$

KClO₃ 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.**

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

8. SECTION (G) : BALANCING REDOX REACTIONS

Th11: 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

Example 1. Balance the following redox reaction :

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

Solution.

Step 1. 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 2. 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 3. Now identify the oxidation / reduction occuring in the reaction

undergoes reduction.

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

undergoes oxidation.

Step 4. Spilt the Ionic reaction in two half, one for oxidation and other for reduction.

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

Step 5. Balance the atom other than oxygen and hydrogen atom in both half reactions

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

Fe & Mn atoms are balanced on both side.

Step 6. 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 7. 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 8. 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 :

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

$5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ ....(2) ×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 9. 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 :

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

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

Example 1. Balance the following redox reaction in basic medium :

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

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

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

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

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

❍ 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.

$2OH^- + 2H^+ + ClO^- \longrightarrow Cl^- + H_2O + 2OH^-$ Finally you will get $H_2O + ClO^- \longrightarrow Cl^- + 2OH^-$ ....(i)	$4OH^- + 2H_2O + CrO_2^- \longrightarrow CrO_4^{2-} + 4H^+ + 4OH^-$ Finally you will get $4OH^- + CrO_2^- \longrightarrow CrO_4^{2-} + 2H_2O$ .... (ii)

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

Now from step VIII

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

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

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

9. SECTION (H) : UNITS OF CONCENTRATION MEASUREMENT, INTERCONVERSION OF CONCENTRATION UNITS

Solutions :

D14: A mixture of two or more substances can be a solution. We can also say that "a solution is a homogeneous mixture of two or more substances,'' 'Homogeneous' means 'uniform throughout'. Thus a homogeneous mixture, i.e., a solution, will have uniform composition throughout.

Properties of a solution :

- A solution is clear and transparent. For example, a solution of sodium chloride in water is clear and tranparent.
- The solute in a solution does not settle down even after the solution is kept undisturbed for some time.
- In a solution, the solute particle cannot be distinguished from the solvent particles or molecules even under a microscope. In a true solution, the particles of the solute disappear into the space between the solvent molecules.
- The components of a solution cannot be separated by filtration.

Concentration terms :

The following concentration terms are used to expressed the concentration of a solution. These are

- Molarity (M)
- Molality (m)
- Mole fraction (x)
- % calculation
- ppm

❍ Remember that all of these concentration terms are related to one another. By knowing one concentration term you can also find the other concentration terms. Let us discuss all of them one by one.

Molarity (M) :

D15: The number of moles of a solute dissolved in 1 L (1000 ml) of the solution is known as the molarity of the solution.

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

Let a solution is prepared by dissolving w g of solute of mol.wt. M in V ml water.

$\therefore$ Number of moles of solute dissolved = $\dfrac{w}{M}$

$\therefore$ V ml water have $\dfrac{w}{M}$ mole of solute

$\therefore$ 1000 ml water have $\dfrac{w \times 1000}{M \times V_{ml}}$ $\therefore$ Molarity (M) = $\dfrac{w \times 1000}{(\text{Mol. wt of solute}) \times V_{ml}}$

Some other relations may also useful.

Number of millimoles = $\dfrac{\text{mass of solute}}{(\text{Mol. wt. of solute})} \times 1000$ = (Molarity of solution × V_{ml})

❍ Molarity of solution may also given as :

$\dfrac{\text{Number of millimole of solute}}{\text{Total volume of solution in ml}}$

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

Mathematically : Molarity decreases as temperature increases.

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

Solved Examples

Example 1. 149 g of potassium chloride (KCl) is dissolved in 10 Lt of an aqueous solution. Determine the molarity of the solution (K = 39, Cl = 35.5)

Solution Molecular mass of KCl = 39 + 35.5 = 74.5 g

$\therefore$ Moles of KCl = $\frac{149\text{ g}}{74.5\text{ g}}$ = 2

$\therefore$ Molarity of the solution = $\frac{2}{10}$ = 0.2 M

D16: Molality (m) :

The number of moles of solute dissolved in1000 g (1 kg) of a solvent is known as the molality of the solution.

i.e., molality = $\frac{\text{number of moles of solute}}{\text{mass of solvent in gram}} \times 1000$

Let Y g of a solute is dissolved in X g of a solvent. The molecular mass of the solute is M_0. Then Y/M_0 mole of the solute are dissolved in X g of the solvent. Hence

Molality = $\frac{Y}{M_0 \times X} \times 1000$

❍ ***Molality is independent of temperature changes.***

Solved Examples

Example 1. 225 g of an aqueous solution contains 5 g of urea. What is the concentration of the solution in terms of molality. (Mol. wt. of urea = 60)

Solution Mass of urea = 5 g

Molecular mass of urea = 60

Number of moles of urea = $\frac{5}{60}$ = 0.083

Mass of solvent = (255 – 5) = 250 g

$\therefore$ Molality of the solution = $\frac{\text{Number of moles of solute}}{\text{Mass of solvent in gram}} \times 1000 = \frac{0.083}{250} \times 1000$= 0.332.

Mole fraction (x) :

D17: The ratio of number of moles of the solute or solvent present in the solution and the total number of moles present in the solution is known as the mole fraction of substances concerned.

Let number of moles of solute in solution = n

Number of moles of solvent in solution = N

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

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

also $x_1 + x_2 = 1$

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

% calculation :

The concentration of a solution may also expressed in terms of percentage in the following way.

D18:

- **% weight by weight (w/w) :** It is given as mass of solute present in per 100 g of solution.

i.e. $$\% \text{ w/w} = \frac{\text{mass of solute in g}}{\text{mass of solution in g}} \times 100$$

D19:

- **% weight by volume (w/v) :** It is given as mass of solute present in per 100 ml of solution.

i.e., $$\% \text{ w/v} = \frac{\text{mass of solute in g}}{\text{volume of solution in ml}} \times 100$$

D20:

- **% volume by volume (v/v) :** It is given as volume of solute present in per 100 ml solution.

i.e., $$\% \text{ v/v} = \frac{\text{volume of solute in ml}}{\text{volume of solution in ml}} \times 100$$

Solved Examples

Example 1. 0.5 g of a substance is dissolved in 25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Solution Mass of substance = 0.5 g

Mass of solvent = 25 g

∴ Percentage of the substance (w/w) = $\frac{0.5}{0.5+25} \times 100 = 1.96$

Example 2. 20 cm^3 of an alcohol is dissolved in80 cm^3 of water. Calculate the percentage of alcohol in solution.

Solution Volume of alcohol = 20 cm^3

Volume of water = 80 cm^3

∴ Percentage of alcohol = $\frac{20}{20+80} \times 100 = 20.$

Parts Per Million (ppm)

D21: When the solute is present in very less amount, then this concentration term is used. It is defined as the number of parts of the solute present in every 1 million parts of the solution. ppm can both be in terms of mass or in terms of moles. If nothing has been specified, we take ppm to be in terms of mass. Hence, a 100 ppm solution means that 100 g of solute is present in every 1000000 g of solution.

$$\text{ppm}_A = \frac{\text{mass of A}}{\text{Total mass}} \times 10^6 = \text{mass fraction} \times 10^6$$

10. SECTION (I) : DILUTION & MIXING OF TWO LIQUIDS

❍ If a particular solution having volume V_1 and molarity = M_1 is diluted upto volume V_2 mL than

$M_1V_1 = M_2V_2$

M_2 : Resultant molarity

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

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

MISCELLANEOUS SOLVED PROBLEMS (MSPS)

Problem 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.

Problem 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 = **5.34×10^6.**

Problem 3. From 160 g of SO_2 (g) sample, 1.2046×10^{24} molecules of SO_2 are removed then find out the volume of left over SO_2 (g) at 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 × 22.4 = 11.2 lit.

Problem 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 × 22.4 = 22.4 lit.

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

Sol.

	N_2 (g)	+ $3H_2$(g) ⟶	$2NH_3$ (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 × 2 + 3 × 2 = 34 g

mass after reaction = mass of 2 mole NH_3 = 2 × 17 = 34 g.

Problem 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.

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

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

Problem 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.

Problem 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.

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

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

Problem 11. Find the vapour density of N_2O_5

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

Problem 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 $2NH_3 \rightarrow N_2 + 3H_2$.

Problem 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.

Problem 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 $= 10 \times 22.4 = 224$ lit.

Problem 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 $= 3 \times 22.4 = 67.2$ lit.

Problem 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.**

Problem 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

$1 \times$ moles of $LiAlH_4 = 1\times$ moles of $LiAlH\ C_{12}H_{27}O_3$

$254 \times 0.32 = 1 \times$ wt. of $LiAlH\ C_{12}H_{27}O_3$.

wt. of $LiAlH\ C_{12}H_{27}O_3 = 81.28$ g.

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

Problem 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 = $\frac{1500 \times 1 + \frac{18.25 \times 1000}{36.5}}{1500}$ = 133 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.

Problem 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. ⇒ so molarity = $\frac{18/180}{500/1000}$ = 0.2.

Problem 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) = $\frac{0.25}{6.50}$ × 100 = 3.8%.

CHECK LIST

Theories (Th)

Th-1 : Dalton's Atomic Theory ☐

Th-2 : Chemical Equation ☐

Th-3 : Mass-Mass Analysis ☐

Th-4 : Mass-volume Analysis ☐

Th-5 : Mole-mole Analysis ☐

Th-6 : How to Find Limiting Reagent ☐

Th-7 : Principle of Atom Conservation (POAC) ☐

Th-8 : Oxidation & Reduction ☐

Th-9 : Oxidation Number ☐

Th10 : Oxidising and reducing agent ☐

Th11 : Balancing of redox reactions ☐

Definitions (D)

D1 : Relative atomic mass ☐

D2 : Atomic mass unit (or amu) ☐

D3 : Mole ☐

D4 : Gram Atomic Mass ☐

D5 : Gram molecular mass ☐

D6 : Average/Mean Atomic Mass ☐

D7 : Mean molar mass or molecular mass ☐

D8 : Gay-Lussac's Law of Combining Volume ☐

D9 : Avogadro's hypothesis ☐

D10 : Empirical formula ☐

D11 : Molecular formula ☐

D12 : Limiting reagent ☐

D13 : Redox reaction ☐

D14 : Solutions ☐

D15 : Molarity (M) ☐

D16 : Molality (m) ☐

D17 : Mole fraction (x) ☐

D18 : % weight by weight (w/w) ☐

D19 : % weight by volume (w/v) ☐

D20 : % volume by volume (v/v) ☐

D21 : Parts Per Million (ppm) ☐

Exercise-1

✍ **Marked questions are recommended for Revision.**

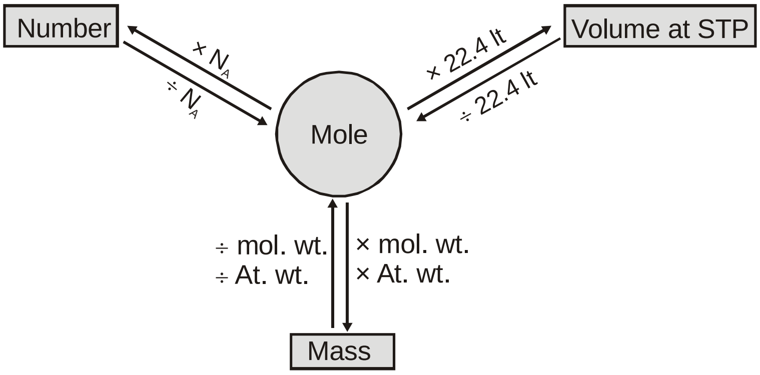
PART - I : SUBJECTIVE QUESTIONS

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. What is the volume of following at STP (i) 2 g of H_2 (ii) 16 g of O_3.

A-2.✍ 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. 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.

B-2.✍ A compound has haemoglobin like structure. It has one Fe. It contain 4.6% of Fe. Determine its molecular mass.

B-3. A compound contains 25% hydrogen and 75% carbon by mass. Determine the empirical formula of the compound.

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.

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

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

$$Ag_2CO_3 \xrightarrow{\Delta} 2Ag + CO_2 + \frac{1}{2}O_2$$

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. A sample of $KClO_3$ on decomposition yielded 448 mL of oxygen gas at NTP.
Calculate (i) Weight of oxygen product, (ii) Weight of $KClO_3$ originally taken, and (iii) Weight of KCl produced.
(K = 39 , Cl = 35.5 and O = 16)

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.

$CaCO_3 + H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + H_2O + CO_2$

Calculate :
(i) Amount of $Ca_3(PO_4)_2$ formed (in moles)
(ii) Amount of unreacted reagent (in moles)

D-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) How many moles of BrCl is formed from the reaction of 0.025 mol Br_2 and 0.025 mol Cl_2?
(b) How many moles of Br_2 is left unreacted?

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

E-1. $KClO_3$ 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-2.^✍ What mass of CaO will be produced by 1 g of Calcium ?

E-3.✍ A 2 g sample containing Na_2CO_3 and $NaHCO_3$ loses 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 mass percentage of Na_2CO_3 in the given mixture ?

E-4.✍ 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 ($CaCO_3$) releases CO_2 on heating]

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) IO_3^- (aq) + Re(s) $\longrightarrow$ ReO_4^- (aq) + I^- (aq)
(b) $S_4O_6^{2-}$(aq) + Al(s) $\longrightarrow$ H_2S(aq) + Al^{3+}(aq)
(c) $S_2O_3^{2-}$(aq) + $Cr_2O_7^{2-}$(aq) $\longrightarrow$ $S_4O_6^{2-}$(aq) + Cr^{3+}(aq)
(d) ClO_3^- (aq) + As_2S_3(s) $\longrightarrow$ Cl^- (aq) + $H_2AsO_4^-$ (aq) + HSO_4^- (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)

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

(a) Tl_2O_3(s) + NH_2OH(aq) $\longrightarrow$ TlOH(s) + N_2(g)
(b) $C_4H_4O_6^{2-}$(aq) + ClO_3^- (aq) $\longrightarrow$ CO_3^{2-}(aq) + Cl^- (aq)
(c) H_2O_2(aq) + Cl_2O_7(aq) $\longrightarrow$ ClO_2^- (aq) + O_2(g)
(d) Al(s) + $BiONO_3$(s) $\longrightarrow$ Bi(s) + NH_3(aq) + $[Al(OH)_4]^-$ (aq)
(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)

MOLE-IV : Concentration Measurement

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

Commit to memory :

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

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

Let number of moles of solute in solution = n

Number of moles of solvent in solution = N

$$\therefore \quad \text{Mole fraction of solute } (x_1) = \frac{n}{n+N} \qquad \therefore \quad \text{Mole fraction of solvent } (x_2) = \frac{N}{n+N}$$

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

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

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

$$\text{ppm}_A = \frac{\text{mass of A}}{\text{Total mass}} \times 10^6 = \text{mass fraction} \times 10^6$$

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)

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 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.

I-3. 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-4.^✍

(i) 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.

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

(iii) What is the molality of final solution obtained in problem (i) ?

PART - II : ONLY ONE OPTION CORRECT TYPE

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. 16 g of an ideal gas SO_x occupies 5.6 L. at STP. 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 u 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. Calculate the molecular formula of compound which contains 20% Ca and 80% Br (by wt.) if molecular weight of compound is 200 u. (Atomic wt. Ca = 40, Br = 80)
(A) $Ca_{1/2}Br$ (B) $CaBr_2$ (C) CaBr (D) Ca_2Br

B-3.✍ A compound possess 8% sulphur by mass. The least molecular mass is :
(A) 200 u (B) 400 u (C) 155 u (D) 355 u

B-4. 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 g (B) 252.2 g (C) 287.6 g (D) 360.1 g

MOLE-II : Basic Stoichiometry

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

C-1.✍ How many moles of potassium chlorate need to be heated to produce 11.2 litre oxygen at N.T.P.

$$KClO_3 \longrightarrow KCl + \frac{3}{2}O_2$$

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

C-2.✍ For the reaction 2P + Q → 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-3. 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) 54 g (D) 81 g

C-4. 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) 0.224 L (D) 1.12 L

C-5.✍ When 100 g 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

C-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

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

D-1. 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-2. 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-3.✍ 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-4.✍ 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

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

E-1. 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-2.✍ 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-3.✍ The following process has been used to obtain iodine from oil-field brines in California.

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

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

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-4.✍ 25.4 g of iodine and 14.2 g 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-5. 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

E-6. 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%

E-7. 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 ?
(A) 1.14 g (B) 1.62 g (C) 2.34 g (D) 1.33 g

E-8. 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 %

E-9.✍ The mass of 70% pure H_2SO_4 required for neutralisation of 1 mol of NaOH is
(A) 49 g (B) 98 g (C) 70 g (D) 34.3 g

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

F-6.✍ 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

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 :

$$aCN^- + bNO_3^- + cH^+ \longrightarrow (a + b)\ NO + aCO_2 + \frac{c}{2} H_2O$$

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. 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

H-3. A solution of $FeCl_3$ is $\frac{M}{30}$ its molarity for Cl^- ion will be :
(A) $\frac{M}{90}$ (B) $\frac{M}{30}$ (C) $\frac{M}{10}$ (D) $\frac{M}{5}$

H-4. 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-5. 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

H-6.✍ 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-7.✍ The molarity of the solution containing 2.8%(mass / volume) solution of KOH is :
(Given atomic mass of K = 39) is :
(A) 0.1 M (B) 0.5 M (C) 0.2 M (D) 1 M

H-8.✍ Decreasing order of mass of pure NaOH in each of the aqueous solution.
(i) 50 g of 40% (W/W) NaOH
(ii) 50 ml of 50% (W/V) NaOH (d_{sol} = 1.2 g/ml).
(iii) 50 g of 15 M NaOH (d_{sol} = 1 g/ml).
(A) i, ii, iii (B) iii, ii, i (C) ii, iii, i (D) iii = ii = i

Section (I) : Dilution & Mixing of two liquids

I-1. If 500 ml of 1 M solution of glucose is mixed with 500 ml of 1 M solution of glucose final molarity of solution will be :
(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 $m\ell$ (D) 300 $m\ell$

I-3.✍ The molarity of Cl^{-} in an aqueous solution which was (w/V) 2% NaCl, 4% $CaCl_2$ and 6% NH_4Cl will be
(A) 0.342 (B) 0.721 (C) 1.12 (D) 2.18

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.✍ 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 - 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)	A hydrocarbon containing 10.5 g carbon per gram of hydrogen having vapour density 46.	(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)	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.	(s)	CO_2 gas produced by the combustion of 0.25 mole of compound occupies a volume of 11.2 L at NTP.

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)	22.4 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)	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

Exercise-2

✍ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

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. 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 gram 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.

4.✍ 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

5.^ 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

6.✍ 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

7. Formation of polyethene from calcium carbide takes place as follows :

$$CaC_2 + H_2O \rightarrow Ca(OH)_2 + C_2H_2 \ ; \ C_2H_2 + H_2 \rightarrow C_2H_4$$

$$n(C_2H_4) \rightarrow (-CH_2-CH_2-)_n.$$

The amount of polyethylene possibly obtainable from 64.0 kg CaC_2 can be
(A) 28 kg (B) 14 kg (C) 21 kg (D) 42 kg

8.✍ 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

9.✍ 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.

10. 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

11. 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

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. When arsenic sulphide is boiled with NaOH, sodium arsenite and sodium thioarsenite are formed according to reaction :

$x\,As_2S_3 + y\,NaOH \longrightarrow xNa_3AsO_3 + xNa_3AsS_3 + \frac{y}{2}H_2O$. What are the values of x and y?

(A) 1, 6 (B) 2, 8 (C) 2, 6 (D) 1, 4

14.✍ Balance the following equation and choose the quantity which is the sum of the coefficients of reactants and products :

.... $KMnO_4$ +....... H_2O_2 +....... H_2SO_4 .... $\longrightarrow$ $MnSO_4$ +....... O_2 +....... H_2O +....... K_2SO_4

(A) 26 (B) 23 (C) 28 (D) 22

15.^ 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

16.✍ 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

17. 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

18. 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.

19.✍ 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%

20. 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

21. On mixing 15.0 ml of ethyl alcohol of density 0.792 g ml^{-1} with 15 ml of pure water at 4^0 C, 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 %

PART - II : NUMERICAL VALUE 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. Consider the following reaction involved in the preparation of teflon polymer $-\!\left(CF_2\text{–}CF_2\right)\!-_n$.

$$XeF_6 + -\!\left(CH_2\text{–}CH_2\right)\!-_n \longrightarrow -\!\left(CF_2\text{–}CF_2\right)\!-_n + HF + XeF_4.$$

Determine the moles of XeF_6 required for preparation of 100 g Teflon.

4. 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 ?

5.✍ 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.

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

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

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

112 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.✍ 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]

10. 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.

11. Among the following compounds given below, what is the sum of the oxidation states of all underlined elements ?

$\underline{C}O_2$, $K_2\underline{Mn}O_4$

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

13. 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.

14.✍ 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) ?

15.✍ 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 ?

16.✍ H_3PO_4 (98 g mol^{-1}) is 98% by mass of solution. If the density is 1.8 g/ml, calculate the molarity.

17.✍ 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}) ?

18. 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 ?

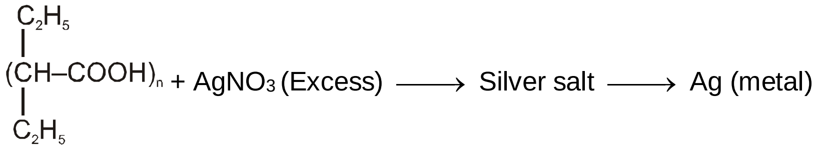
19.✍ A solution containing 0.1 mol of a metal chloride MCl_x requires 500 ml of 0.8 M $AgNO_3$ solution for complete reaction $MCl_x + xAgNO_3 \rightarrow xAgCl + M(NO_3)_x$. Then the value of x is :

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. The density of air is 0.001293 g/cm^3 at STP. Identify which of the following statement is correct
(A) Vapour density is 14.48
(B) Molecular weight is 28.96
(C) Vapour density is 0.001293 g/cm^3
(D) Vapour density and molecular weight cannot be determined.

3.



$$\left(\underset{C_2H_5}{\overset{C_2H_5}{\overset{|}{\underset{|}{C}}}}H\text{–}COOH\right)_n + AgNO_3\,(\text{Excess}) \longrightarrow \text{Silver salt} \longrightarrow \text{Ag (metal)}$$

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

4.✍ 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 NTP is 50.4 L.
(C) C and O combine in mass ratio 3 : 8.
(D) Volume of unreacted O_2 at STP is 11.2 L.

5. 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 NTP is 22.4 L.
(D) None of these

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.✍ $A + B \rightarrow A_3B_2$ (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

8.✍ 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

9. 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.

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.✍ 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 statement(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

12. Which of the following reactions is not a redox reaction ?

(A) $H_2O_2 + KOH \longrightarrow KHO_2 + H_2O$ (B) $Cr_2O_7^{2-} + 2OH^- \longrightarrow 2CrO_4^{2-} + H_2O$

(C) $Ca(HCO_3)^2 \xrightarrow{\Delta} CaCO_3 + CO_2 + H_2O$ (D) $H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$

13.✍ Consider the redox reaction $2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2\,I^-$:

(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^-

14. 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) $Cl_2 + OH^- \longrightarrow ClO^- + Cl^- + H_2O$

15.✍ 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

16. 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.

17. Select dimensionless quantity(ies) :

(A) vapour density (B) molality (C) specific gravity (D) mass fraction

18. Which of the following solutions contains same molar concentration ?

(A) 166 g. KI/L solution (B) 33.0 g $(NH_4)_2\,SO_4$ in 200 mL solution

(C) 25.0 g $CuSO_4.5H_2O$ in 100mL solution (D) 27.0 mg Al^{3+} per mL solution

19. 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)

20. 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

21.✍ 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 information :
(I) Compounds contains 2 : 1 'H' to 'O' atoms(number of atoms).
(II) Compounds has 40% C by mass
(III) Molecular mass of the compound is 180 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 22.4 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 NTP containing exactly 11.2 g of Nitrogen :
(A) 22.4 L (B) 8.96 L (C) 11.2 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 NTP is :
(A) 1 g/L (B) $\frac{9}{7}$ g/L (C) $\frac{2}{7}$ g/L (D) can't be determined

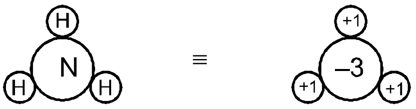
Comprehension # 3

In chemistry, oxidation and reduction are taken as two mutually exclusive events. For example, if life is oxidation then death is taken as reduction, taking off a flight is oxidation then standing would be reduction and so many other. In brief it is used as redox in chemical science.

There are so many conceptual facts regarding redox such as adding oxygen or oxygenation, removing hydrogen or dehydrogenation, removing electron or dielectronation are fixed for oxidation and their corresponding antonyms would be reduction processes. Simple way of judging whether a monatomic species has under gone oxidation or reduction is to note if the charge number of species has changed. It is possible to assign to an atom in polyatomic species an operative charge number called their oxidation number or state. (O.N. or O.S.). There is no standard symbol for this quantity so we say it is ϕ. An O.N. is assigned to an element in a compound by assuming that it is present as ion with a characteristic charge for instance oxygen is present as O(–II) and fluorine as F(–I) and some time it may be hypothetical also. For example

For ZnO

For NH$_3$



In continuation to our study, species promoting oxidation are named as oxidant and those promoting reduction are termed as reductant. At the same time their equivalent weights is the ratio of their molecular weight and change is O. N. ($\Delta\phi$) involving one molecule/formula unit of the reactant i.e., molecular weight divided by number of electrons lost or gained by one molecule/formula during their respective action.

Based on the above discussion answer the following objective question having one best answer.

7. Which corresponds to oxidation action

(A) $\phi = 0$ (B) $\Delta\phi = 0$ (C) $\Delta\phi > 0$ (D) $\Delta\phi < 0$

8. A compound contain P(II), Q(V) R(-II). The possible formula of the compound is

(A) PQR_2 (B) $Q_2(PR_3)_2$ (C) $P_3[QR_4]_2$ (D) $P_3(Q_4R)_2$

9. A compound has θ number of carbon, ϕ number of hydrogen and ψ number of oxygen their equation of finding oxidation number (x) of carbon will be

(A) $\psi^3 + 4x\theta^2 + \phi = 0$ (B) $x\theta + \phi - 2\psi = 0$ (C) $\theta x + \frac{\phi}{x} - \frac{2\psi}{3} = 0$ (D) none of these

Comprehension # 4

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 givenas 'a' then mole fraction of the solute can be calculated by

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

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

We can change : Mole fraction ↔ Molality ↔ Molarity

10. 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%

11. What is the molality of the above solution.
(A) 4.4 m (B) 5.5 m (C) 24.4 m (D) none

12. 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 # 5

Answer Q.13, Q.14 and Q.15 by appropriately matching the information given in the three columns of the following table.

Salt and water is formed by acid-base neutralisation reaction. If ratio of moles of acid & base taken is not similar to the ratio of their stoichiometric coefficient, then one of the component is limiting reagent. Assume no dissociation of water in following reactions. (Base is 80% pure only, take impurity present as inert & non electrolytic) (Molecular mass of Cs = 133, I = 127, Rb = 85.5, Sr = 88)

Column-1		**Column-2**			**Column-3**
(I)	$CsOH + HI \longrightarrow CsI + H_2O$ 37.5 g in 500mL 500 mL of 0.8M	(i)	Acid is limiting reagent	(P)	Molarity of H^+ in resulting solution = 0.2M
(II)	$RbOH + HNO_3 \longrightarrow RbNO_3 + H_2O$ 51.25 g in 500 mL 500 mL of 0.2M	(ii)	Base is limiting reagent	(Q)	Molarity of cation in resulting solution = 0.4M
(III)	$Sr(OH)_2 + H_2SO_4 \longrightarrow SrSO_4 + 2H_2O$ 61 g in 500 mL 500 mL of 0.8M	(iii)	Molarity of cation in resulting solution = 0.8M	(R)	Molarity of cation in resulting solution = 1.6M
(IV)	$Ba(OH)_2 + 2HBr \longrightarrow BaBr_2 + 2H_2O$ 342 g in 500 mL 500 mL of 6.4M	(iv)	Molarity of anion in resulting solution = 3.2M	(S)	Molarity of anion in resulting solution = 0.4 M

13. Select correct combination for the resulting basic solution.
(A) (I) (iii) (S) (B) (I) (iv) (R) (C) (II) (i) (Q) (D) (III) (ii) (S)

14. Select correct combination for the resulting acidic solution.
(A) (I) (iii) (S) (B) (I) (iv) (S) (C) (I) (ii) (P) (D) (II) (i) (R)

15*. Select incorrect combination(s)
(A) (I) (ii) (P) (B) (II) (i) (R) (C) (IV) (iv) (R) (D) (III) (ii) (S)

Exercise-3

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

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

1. Amongst the following, the pair having both the metals in their highest oxidation state is :
[JEE 2004, 3/84]
(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 $[NiF_6]^{2-}$

2. **Paragraph for Question Nos. (i) to (iii)**

Chemical reactions involve interaction of atoms and molecules. A large number of atoms/molecules (approximately 6.023 × 10^{23}) are present in a few grams of any chemical compound varying with their atomic/molecular masses. To handle such large numbers conveniently, the mole concept was introduced. This concept has implications in diverse areas such as analytical chemistry, biochemistry, electrochemistry and radiochemistry. The following example illustrates a typical case, involving chemical / electrochemical reaction, which requires a clear understanding of the mole concept.

A 4.0 molar aqueous solution of NaCl is prepared and 500 mL of this solution is electrolysed. This leads to the evolution of chlorine gas at one of the electrodes (atomic mass : Na = 23, Hg = 200 ; 1 Faraday = 96500 coulombs).

**[At the anode : $2Cl^- \rightarrow Cl_2 + 2e^-$

At the cathode : $Na^+ + e^- \rightarrow Na$

$Na + Hg \rightarrow NaHg$ (sodium amalgam)]

** (These reactions were not present in IIT-JEE paper)

(i) The total number of moles of chlorine gas evolved is : **[JEE-2007, 4/162]**

(A) 0.5 (B) 1.0 (C) 2.0 (D) 3.0

(ii) If the cathode is a Hg electrode, the maximum weight (g) of amalgam formed from this solution is : **[JEE-2007, 4/162]**

(A) 200 (B) 225 (C) 400 (D) 446

(iii) The total charge (coulombs) required for complete electrolysis is : **[JEE-2007, 4/162]**

(A) 24125 (B) 48250 (C) 96500 (D) 193000

3. A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL, and 25.0 mL. The number of significant figures in the average titre value is : **[JEE 2010, 3/163]**

4. The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is **[JEE 2011, 4/180]**

5. 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]**

6. 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

7. 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]**

8.* 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.

9. 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]**

10. 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, 3/124]**

11. 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, 3/122]**

(A) $H_3PO_4 > H_3PO_2 > H_3PO_3 > H_4P_2O_6$ (B) $H_3PO_4 > H_4P_2O_6 > H_3PO_3 > H_3PO_2$

(C) $H_3PO_2 > H_3PO_3 > H_4P_2O_6 > H_3PO_4$ (D) $H_3PO_3 > H_3PO_2 > H_3PO_4 > H_4P_2O_6$

12. 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_____`. **[JEE(Advanced) 2019, 3/124]**

(**Given data :** Molar masses of urea and water are 60 g mol^{-1} and 18 g mol^{-1}, respectively)

PART - II : JEE (MAIN) ONLINE PROBLEMS (PREVIOUS YEARS)

1. Dissolving 120 g of a compound of (mol. wt. 60) in 1000 g of water gave a solution of density 1.12 g/mL. The molarity of the solution is : **[JEE(Main) 2014 Online (09-04-14), 4/120]**
(1) 1.00 M (2) 2.00 M (3) 2.50 M (4) 4.00 M

2. The amount of oxygen in 3.6 moles of water is : **[JEE(Main) 2014 Online (09-04-14), 4/120]**
(1) 115.2 g (2) 57.6 g (3) 28.8 g (4) 18.4 g

3. A gaseous compound of nitrogen and hydrogen contains 12.5% (by mass) of hydrogen. The density of the compound relative to hydrogen is 16. The molecular formula of the compound is :
[JEE(Main) 2014 Online (11-04-14), 4/120]
(1) NH_2 (2) N_3H (3) NH_3 (4) N_2H_4

4. The amout of $BaSO_4$ formed upon mixing 100 mL of 20.8% $BaCl_2$ solution with 50 mL of 9.8% H_2SO_4 solution will be : (Ba = 137, Cl = 35.5, S = 32, H = 1 and O = 16) :
[JEE(Main) 2014 Online (12-04-14), 4/120]
(1) 23.3 g (2) 11.65 g (3) 30.6 g (4) 33.2 g

5. Amongst the following, identify the species with an atom in +6 oxidation state :
[JEE(Main) 2014 Online (19-04-14), 4/120]
(1) $[MnO_4]^-$ (2) $[Cr(CN)_6]^{3-}$ (3) Cr_2O_3 (4) CrO_2Cl_2

6. Consider the reaction :

$$H_2SO_{3(aq.)} + Sn^{4+}_{(aq)} + H_2O_{(l)} \rightarrow Sn^{2+}_{(aq)} + HsO^-_{4(aq)} + 3H^+_{(aq)}$$

Which of the following statements is correct ? **[JEE(Main) 2014 Online (19-04-14), 4/120]**
(1) Sn^{4+} is the oxidizing agent because it undergoes oxidation
(2) Sn^{4+} is the reducing agent because it undergoes oxidation
(3) H_2SO_3 is the reducing agent because it undergoes oxidation
(4) H_2SO_3 is the reducing agent because it undergoes reduction

7. How many electrons are involved in the following redox reaction ?
[JEE(Main) 2014 Online (19-04-14), 4/120]

$$Cr_2O_7^{2-} + Fe^{2+} + C_2O_4^{2-} \rightarrow Cr^{3+} + Fe^{3+} + CO_2 \text{ (unblanced)}$$

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

8. 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 (10-04-15), 4/120]**
(1) $BaCl_2 + H_2O$ (2) $BaCl_2 + 4H_2O$ (3) $BaCl_2 + 3H_2O$ (4) $BaCl_2 + 2H_2O$

9. $A + 2B + 3C \rightleftharpoons AB_2C_3$
Reaction of 6.0 g of A, 6.0×10^{23} atoms of B, and 0.036 mol of C yields 4.8 g of compound AB_2C_3. If the atomic mass of A and C are 60 and 80 amu, respectively, the atomic mass of B is (Avogadro no. = 6×10^{23}) : **[JEE(Main) 2015 Online (11-04-15), 4/120]**
(1) 50 amu (2) 60 amu (3) 70 amu (4) 40 amu

10. The non-metal that does not exhibit positive oxidation state is :
[JEE(Main) 2016 Online (09-04-16), 4/120]
(1) Fluorine (2) Oxygen (3) Chlorine (4) Iodine

11. 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 (09-04-16), 4/120]**
(1) Butane (2) Isobutane (3) Ethane (4) Propane

12. An organic compound contains C, H and S. The minimum molecular weight of the compound containing 8% sulphur is: (atomic weight of S = 32 amu) **[JEE(Main) 2016 Online (09-04-16), 4/120]**
(1) 300 g mol^{-1} (2) 400 g mol^{-1} (3) 200 g mol^{-1} (4) 600 g mol^{-1}

13. The amount of arsenic pentasulphide that can be obtained when 35.5 g arsenic acid is treated with excess H_2S in the presence of conc. HCl (assuming 100% conversion)
[JEE(Main) 2016 Online (09-04-16), 4/120]
(1) 0.25 mol (2) 0.125 mol (3) 0.333 mol (4) 0.50 mol

14. 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 (08-04-17), 4/120]**

(Given molar mass of Fe = 56 g mol^{-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

15. The pair of compounds having metals in their highest oxidation state is :

[JEE(Main) 2017 Online (08-04-17), 4/120]

(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 $[CoCl_4]^{2-}$

16. A sample of $NaClO_3$ is converted by heat to NaCl with a loss of 0.16 g of oxygen. The residue is dissolved in water and precipitated as AgCl. The mass of AgCl (in g) obtained will be : (Given: Molar mass of AgCl = 143.5 g mol^{-1}) **[JEE(Main) 2018 Online (15-04-18), 4/120]**

(1) 0.35 (2) 0.54 (3) 0.41 (4) 0.48

17. 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 (16-04-18), 4/120]

(1) 6.023×10^9 (2) 6.023×10^{23} (3) 6.023×10^{21} (4) 6.023×10^{20}

18. 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) 2019 Online (09-01-19)S1, 4/120]**

(1) 16 (2) 12 (3) 8 (4) 4

19. For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is :

$$2C_{57}H_{110}O_6(s) + 163O_2(g) \longrightarrow 114CO_2(g) + 110H_2O(l)$$

[JEE(Main) 2019 Online (09-01-19), 4/120]

(1) 490 g (2) 445 g (3) 495 g (4) 890 g

20. The amount of sugar ($C_{12}H_{22}O_{11}$) required to prepare 2 L of its 0.1 M aqueous solutions is:

[JEE(Main) 2019 Online (10-01-19)S2, 4/120]

(1) 68.4 g (2) 34.2 g (3) 17.1 g (4) 136.8 g

21. An organic compound is estimated through Dumas method and was found to evolve 6 moles of CO_2, 4 moles of H_2O and 1 mole of nitrogen gas. The formula of the compound is:

[JEE(Main) 2019 Online (11-01-19)S1, 4/120]

(1) C_6H_8N (2) $C_6H_8N_2$ (3) $C_{12}H_8N_2$ (4) $C_{12}H_8N$

22. A 10 mg effervescent tablet containing sodium bicarbonate and oxalic acid releases 0.25 ml of CO_2 at T = 298.15 K and p = 1 bar. If molar volume of CO_2 is 25.0 L under such condition, what is the percentage of sodium bicarbonate in each tablet ? [Molar mass of $NaHCO_3$ = 84 g mol^{-1}]

[JEE(Main) 2019 Online (11-01-19)S1, 4/120]

(1) 0.84 (2) 33.6 (3) 8.4 (4) 16.8

23. 50 mL of 0.5 M oxalic acid is needed to neutralize 25 mL of sodium hydroxide solution. The amount of NaOH in 50 mL of the given sodium hydroxide solution is: **[JEE(Main) 2019 Online (12-01-19)S1, 4/120]**

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

24. 8 g of NaOH is dissolved in 18 g of H_2O. Mole fraction of NaOH in solution and molality (in mol kg^{-1}) of the solution respectively are : **[JEE(Main) 2019 Online (12-01-19)S2, 4/120]**

(1) 0.2, 11.11 (2) 0.167, 11.11 (3) 0.167, 22.20 (4) 0.2, 22.20

25. The percentage composition of carbon by mole in methane is :

[JEE(Main) 2019 Online (08-04-19)S2, 4/120]

(1) 80% (2) 20% (3) 75% (4) 25%

26. For a reaction, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$; identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures. **[JEE(Main) 2019 Online (09-04-19)S1, 4/120]**

(1) 14g of N_2 + 4g of H_2 (2) 35g of N_2 + 8g of H_2 (3) 28 g of N_2 + 6g of H_2 (4) 56g of N_2 + 10g of H_2

27. What would be the molality of 20% (mass/mass) aqueous solution of KI? (molar mass of KI = 166 g mol^{-1}) **[JEE(Main) 2019 Online (09-04-19)S2, 4/120]**
(1) 1.35 (2) 1.08 (3) 1.48 (4) 1.51

28. At 300 K and 1 atmospheric pressure, 10 mL of a hydrocarbon required 55 mL of O_2 for complete combustion, and 40 mL of CO_2 is formed. The formula of the hydrocarbon is :
[JEE(Main) 2019 Online (10-04-19)S1, 4/120]
(1) C_4H_7Cl (2) C_4H_6 (3) C_4H_{10} (4) C_4H_8

29. The minimum amount of $O_2(g)$ consumed per gram of reactant is for the reaction :
(Given atomic mass : Fe = 56, O = 16, Mg = 24, P = 31, C= 12, H = 1)
[JEE(Main) 2019 Online (10-04-19)S2, 4/120]
(1) $4\ Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ (2) $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$
(3) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ (4) $P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$

30. An example of a disproportionation reaction is : **[JEE(Main) 2019 Online (12-04-19)S1, 4/120]**
(1) $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$ (2) $2CuBr \rightarrow CuBr_2 + Cu$
(3) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$ (4) $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$

31. 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 Online (12-04-19)S1, 4/120]**
(1) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$ (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) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$

32. The mole fraction of a solvent in aqueous solution of a solute is 0.8. The molality (in mol kg^{-1}) of the aqueous solution is **[JEE(Main) 2019 Online (12-04-19)S1, 4/120]**
(1) 13.88×10^{-3} (2) 13.88 (3) 13.88×10^{-2} (4)13.88×10^{-1}

33. 25 g of an unknown hydrocarbon upon burning produces 88g of CO_2 and 9 g of H_2O. This unknown hydrocarbon contains : **[JEE(Main) 2019 Online (12-04-19)S2, 4/120]**
(1) 22 g of carbon and 3g of hydrogen (2) 24 g of carbon and 1g of hydrogen
(3) 20 g of carbon and 5g of hydrogen (4) 18 g of carbon and 7g of hydrogen

34. Oxidation number of potassium in K_2O, K_2O_2 and KO_2, respectively, is:
[JEE(Main) 2020 Online (07-01-20)S1, 4/120]
(1) +1, +2 and +4 (2) +1, +4 and +2 (3) +1, +1 and +1 (4) +2, +1 and $+\frac{1}{2}$

35. The ammonia (NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide (NaOH) can be neutralized by : **[JEE(Main) 2020 Online (07-01-20)S2, 4/120]**
(1) 200 ml of 0.4 N HCl (2) 200 ml of 0.2 N HCl (3) 100 ml of 0.1 N HCl (4) 100 ml of 0.2 N HCl

36. The redox reaction among the following is : **[JEE(Main) 2020 Online (07-01-20)S2, 4/120]**
(1) reaction of $[Co(H_2O)_6]Cl_3$ with $AgNO_3$
(2) formation of ozone from atmospheric oxygen in the presence of sunlight
(3) combination of dinitrogen with dioxygen at 2000 K (4) reaction of H_2SO_4 with NaOH

37. 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) 2020 Online (08-01-20)S1, 4/120]
Atomic weight : Fe = 55.85 ; S = 32.00 ; O = 16.00

38. $NaClO_3$ is used, even in spacecrafts, to produces O_2.The daily consumption of pure O_2 by a person is 492L at 1 atm, 300 K. 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) 2020 Online (08-01-20)S2, 4/120]**
$NaClO_3(s) + Fe(s) \rightarrow O_2(g) + NaCl(s) + FeO(s)$; R = 0.082 L atm $mol^{-1}K^{-1}$

39. The compound that cannot act both as oxidising and reducing agent is :
[JEE(Main) 2020 Online (09-01-20)S1, 4/120]
(1) HNO_2 (2) H_3PO_4 (3) H_2SO_3 (4) H_2O_2

40. The molarity of HNO_3 in a sample which has density 1.4 g/mL and mass percentage of 63% is __________. (Molecular Weight of HNO_3 = 63) **[JEE(Main) 2020 Online (09-01-20)S1, 4/120]**

41. 10.30 mg of O_2 dissolved into a liter of sea water of density 1.03 g/mL. The concentration of O_2 in ppm is_____________. **[JEE(Main) 2020 Online (09-01-20)S2, 4/120]**

Answers

EXERCISE – 1

PART – I

A-1. (i) 22.4 L (ii) 7.466 L **A-2.** 5.40 **B-1.** % CO_2 = 40%.

B-2. 1217 g $mole^{-1}$ **B-3.** CH_4 **C-1.** 2.16 g **C-2.** 42 g

C-3. (i) 0.64 g, (ii) 1.64 g, (iii) 0.993 g. **D-1.** (i) 1/6 mole (ii) 5/12 mole

D-2. (a) 0.04 mole (b) 0.005 mole **E-1.** $\frac{10}{3}$ mole **E-2.** m = 1.4 g

E-3. 66.4 %. **E-4.** 33.33 %

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) $7IO_3^-$ (aq) + 6Re(s) + $3H_2O \longrightarrow 6ReO_4^-$ (aq) + $7I^-$ (aq) + $6H^+$
(b) $S_4O_6^{2-}$(aq) + 6 Al(s) + 20 $H^+ \longrightarrow 4H_2S$(aq) + $6Al^{3+}$(aq) + $6H_2O$
(c) $6S_2O_3^{2-}$(aq) + $Cr_2O_7^{2-}$(aq) + 14 $H^+ \longrightarrow 3S_4O_6^{2-}$(aq) + $2Cr^{3+}$(aq) + $7H_2O$
(d) $14ClO_3^-$ (aq) + $3As_2S_3$(s) + $18H_2O \longrightarrow 14Cl^-$ (aq) + $6H_2AsO_4^-$ (aq) + $9HSO_4^-$ (aq) + $15H^+$
(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^+

G-2. (a) $Tl_2O_3(s) + 4NH_2OH(aq) \longrightarrow 2TlOH(s) + 2N_2(g) + 5H_2O$
(b) $3C_4H_4O_6^{2-}(aq) + 5ClO_3^-(aq) + 18OH^- \longrightarrow 12\ CO_3^{2-}(aq) + 5\ Cl^-(aq) + 15H_2O$
(c) $4H_2O_2(aq) + Cl_2O_7(aq) + 2OH^- \longrightarrow 2ClO_2^-(aq) + 4O_2(g) + 5H_2O$
(d) $11Al(s) + 3BiONO_3(s) + 21H_2O + 11OH^- \longrightarrow 3Bi(s) + 3NH_3(aq) + 11Al(OH)_4^-(aq)$
(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) $3Mn(OH)_2(s) + 2MnO_4^-(aq) \longrightarrow 5MnO_2(s) + 2H_2O + 2OH^-$

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%

I-1. 8 M **I-2.** 700 ml. **I-3.** 2.33 L

I-4. (i) 36.25%, (ii) 72.5%, (iii) 14.2 m.

PART - II

A-1.	(B)	**A-2.**	(B)	**B-1.**	(B)	**B-2.**	(B)	**B-3.**	(B)
B-4.	(D)	**C-1.**	(B)	**C-2.**	(C)	**C-3.**	(C)	**C-4.**	(C)
C-5.	(B)	**C-6.**	(C)	**D-1.**	(A)	**D-2.**	(A)	**D-3.**	(C)
D-4.	(A)	**E-1.**	(B)	**E-2.**	(A)	**E-3.**	(A)	**E-4.**	(A)
E-5.	(B)	**E-6.**	(C)	**E-7.**	(A)	**E-8.**	(A)	**E-9.**	(C)
F-1.	(D)	**F-2.**	(C)	**F-3.**	(B)	**F-4.**	(A)	**F-5.**	(B)
F-6.	(C)	**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.**	(B)
H-5.	(A)	**H-6.**	(C)	**H-7.**	(B)	**H-8.**	(B)	**I-1.**	(A)
I-2.	(C)	**I-3.**	(D)	**I-4.**	(D)	**I-5.**	(A)		

PART - III

1. (A - q,s); (B - q, r); (C - p, q, r); (D - p, s) **2.** (A - p,q,r,s; (B - p,s; (C - q,r) ; (D - q)

3. (A - p,s); (B - s); (C - p,q); (D - r)

EXERCISE - 2

PART - I

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

PART - II

1.	5	**2.**	78	**3.**	4	**4.**	60	**5.**	2
6.	28	**7.**	4	**8.**	50	**9.**	11	**10.**	42
11.	10	**12.**	8	**13.**	2	**14.**	8	**15.**	27
16.	18	**17.**	10	**18.**	2	**19.**	4		

PART - III

1.	(ABC)	**2.**	(AB)	**3.**	(AC)	**4.**	(BCD)	**5.**	(ABC)
6.	(BC)	**7.**	(BD)	**8.**	(AC)	**9.**	(ABD)	**10.**	(AC)
11.	(ABCD)	**12.**	(ABC)	**13.**	(BC)	**14.**	(CD)	**15.**	(ABC)
16.	(ACD)	**17.**	(ACD)	**18.**	(ACD)	**19.**	(AB)	**20.**	(ABD)
21.	(ABD)								

PART - IV

1.	(A)	**2.**	(B)	**3.**	(B)	**4.**	(C)	**5.**	(B)
6.	(B)	**7.**	(C)	**8.**	(C)	**9.**	(B)	**10.**	(A)
11.	(B)	**12.**	(B)	**13.**	(C)	**14.**	(C)	**15.**	(BD)

EXERCISE - 3

PART - I

1.	(B)	**2.**	**(i)** (B)	**(ii)**	(D)	**(iii)**	(D)	**3.**	3
4.	5	**5.**	5	**6.**	(C)	**7.**	8 mL.	**8.**	(ABD)
9.	8	**10.**	(9)	**11.**	(B)	**12.**	(2.98)		

PART - II

1.	(2)	**2.**	(2)	**3.**	(4)	**4.**	(2)	**5.**	(4)
6.	(3)	**7.**	(3)	**8.**	(4)	**9.**	(1)	**10.**	(1)
11.	(4)	**12.**	(2)	**13.**	(2)	**14.**	(2)	**15.**	(3)
16.	(4)	**17.**	(4)	**18.**	(4)	**19.**	(3)	**20.**	(1)
21.	(2)	**22.**	(3)	**23.**	BONUS	**24.**	(2)	**25.**	(2)
26.	(4)	**27.**	(3)	**28.**	(2)	**29.**	(1)	**30.**	(2)
31.	(3)	**32.**	(2)	**33.**	(2)	**34.**	(3)	**35.**	(4)
36.	(3)	**37.**	4.95 to 4.97	**38.**	2120.00 to 2140.00			**39.**	(2)
40.	14.00 to 14.00	**41.**	10.00 to 10.00						

Additional Problems for Self Practice (APSP)

✍ **Marked questions are recommended for Revision.**

This Section is not meant for classroom discussion. It is being given to promote self study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Marks: 100 **Max. Time : 1 Hour**

Important Instructions:

A. General :

1. The test paper is of **1** hour duration.
2. The Test Paper consists of **25** questions and each questions carries **4** Marks. Test Paper consists of **Two** Sections.

B. Test Paper Format and its Marking Scheme:

1. Section-1 contains **20** multiple choice questions. Each question has four choices (1), (2), (3) and (4) out of which **ONE** is correct. For each question in Section-1, you will be awarded 4 marks if you give the corresponding to the correct answer and zero mark if no given answers. In all other cases, minus one **(–1)** mark will be awarded.
2. Section-2 contains **5** questions. The answer to each of the question is a **Numerical Value**. For each question in Section-2, you will be awarded 4 marks if you give the corresponding to the correct answer and zero mark if no given answers. No negative marks will be answered for incorrect answer in this section. In this section answer to each question is **NUMERICAL VALUE** with two digit integer and decimal upto two digit. If the numerical value has more than two decimal places **truncate/round-off** the value to **TWO** decimal placed.

SECTION-1

This section contains **20** multiple choice questions. Each questions has four choices (1), (2), (3) and (4) out of which Only **ONE** option is correct.

1. 112.0 mL of NO_2 at STP 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.

(1) 0.10 mL and 3.01×10^{22} (2) 0.20 mL and 3.01×10^{21}

(3) 0.20 mL and 6.02×10^{23} (4) 0.40 mL and 6.02×10^{21}

2. 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

(1) 16.0 and 56.0 (2) 8.0 and 28.0 (3) 56.0 and 16.0 (4) 28.0 and 8.0

3. $2KI + I_2 + 22\,HNO_3 \longrightarrow 2HIO_3 + 2KIO_3 + 22NO_2 + 10H_2O$

If 3 mole of KI & 2 moles I_2 are reacted with excess of HNO_3. Volume of NO_2 gas evolved at NTP is

(1) 739.2 Lt (2) 1075.2 Lt (3) 44.8 Lt (4) 67.2 Lt

4. 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 :

(1) 0.5 (2) 0.6 (3) 0.48 (4) 4.64

5. Which of the following equations is a balanced one :

(1) $5BiO_3^- + 22H^+ + Mn^{2+} \longrightarrow 5Bi^{3+} + 7H_2O + MnO_4^-$

(2) $5BiO_3^- + 14H^+ + 2Mn^{2+} \longrightarrow 5Bi^{3+} + 7H_2O + 2MnO_4^-$

(3) $2BiO_3^- + 4H^+ + Mn^{2+} \longrightarrow 2Bi^{3+} + 2H_2O + MnO_4^-$

(4) $6BiO_3^- + 12H^+ + 3Mn^{2+} \longrightarrow 6Bi^{3+} + 6H_2O + 3MnO_4^-$

6. During the disproportionation of Iodine to iodide and iodate ions, the ratio of iodate and iodide ions formed in alkaline medium is :

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

7. 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})

(1) 9.00×10^{-3} (2) 1.5×10^{-2} (3) 5.1×10^{-3} (4) 11.2×10^{-3}

8. The temperature at which molarity of pure water is equal to its molality is :

(1) 273 K (2) 298 K (3) 277 K (4) None

9. 5.85 g of NaCl is dissolved in 1 L of pure water. The number of ions in 1 mL of this solution is

(1) 6.02×10^{19} (2) 1.2×10^{22} (3) 1.2×10^{20} (4) 6.02×10^{20}

10. The correct expression relating molality (m), molarity (M), density of solution (d) and molar mass (M_2) of solute is :

(1) $m = \frac{M}{d + MM_2} \times 1000$ (2) $m = \frac{M}{1000d - MM_2} \times 1000$

(3) $m = \frac{d + MM_2}{M} \times 1000$ (4) $m = \frac{1000d - MM_2}{M} \times 1000$

11. 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 ?

(1) C_5H_7N (2) $C_{10}H_{16}N_2$ (3) $C_8H_{14}N_3$ (4) $C_{10}H_{14}N_2$

12. Calculate the volume of O_2 needed for combustion of 1 kg of carbon at STP. $C + O_2 \xrightarrow{\Delta} CO_2$.

(1) 1866.67 L O_2. (2) 3733.33 L O_2. (3) 933.33 L O_2. (4) 4666.67 L O_2.

13. 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 ?

(1) 21.00 g of Li_3N. (2) 2.91 g of Li_3N. (3) 5.83 g of Li_3N. (4) 10.50 g of Li_3N.

14. 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?

$$2KO_2 + 2H_2O \longrightarrow 2KOH + H_2O_2 + O_2$$

(1) H_2O limiting reagent, 0.05 mol of O_2. (2) KO_2 limiting reagent, 0.05 mol of O_2.

(3) H_2O limiting reagent, 0.075 mol of O_2. (4) KO_2 limiting reagent, 0.075 mol of O_2.

15. 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 NTP, calculate the percentage by weight of $KClO_4$ in the residue.

(1) 29.3 %. (2) 49.8 %. (3) 62.5 %. (1) 87.1 %.

16. Equal weights of mercury and I_2 are allowed to react completely to form a mixture of mercurous and mercuric iodide leaving none of the reactants. Calculate the ratio of the weights of Hg_2I_2 and HgI_2 formed.

(1) 1 : 0.653 (2) 0.732 : 1 (3) 1 : 0.523 (4) 0.523 : 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.

(1) 1.056 M (2) 0.560 M (3) 0.312 M (4) 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.

(1) 1.8×10^{25} ions (2) 6×10^{22} ions (3) 1.8×10^{23} ions (4) 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.

(1) 76.8% (2) 38.4% (3) 51% (4) 19.2%

20. Calcium phosphide (Ca_3P_2) formed by reacting calcium orthophosphate ($Ca_3(PO_4)_2$) with magnesium was hydrolysed by water. The evolved phosphine (PH_3) was burnt in air to yield phosphorus pentoxide (P_2O_5). How many grams of magnesium metaphosphate would be obtained, if 19.2 g of magnesium were used for reducing calcium phosphate.

$$Ca_3(PO_4)_2 + Mg \longrightarrow Ca_3P_2 + MgO$$
$$Ca_3P_2 + H_2O \longrightarrow Ca(OH)_2 + PH_3$$
$$PH_3 + O_2 \longrightarrow P_2O_5 + H_2O$$
$$MgO + P_2O_5 \longrightarrow \underset{\text{magnesium metaphosphate}}{Mg(PO_3)_2}$$

(1) 145.8 gram (2) 32 gram (3) 50.4 gram (4) 18.2 gram

SECTION-2

This section contains **5** questions. Each question, when worked out will result in **Numerical Value**.

---

21. 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 :

22. Minimum amount of $Ag_2CO_3(s)$ (in gram) required to produce sufficient oxygen for the complete combustion of C_2H_2 which produces 1.12 ltr of CO_2 at S.T.P after combustion is: [Ag = 108]

$$Ag_2CO_3\,(s) \longrightarrow 2Ag\,(s) + CO_2\,(g) + \frac{1}{2}O_2\,(g)$$
$$C_2H_2 + \frac{5}{2}O_2 \longrightarrow 2CO_2 + H_2O$$

23. How much $NaNO_3$ must be weighed (in gram) out to make 50 ml of an aqueous solution containing 70 mg of Na^+ per mL ?

24. What is the molarity of H_2SO_4 solution that has a density 1.84 g/cc at 35ºC and contains 98% by weight-

25. 64 g of a mixture of NaCl and KCl were treated with concentrated sulphuric acid. The total mass of metal sulphates obtained was found to be 76 g. What are the mass percents of NaCl in the mixture. The reactions are,

$2\,NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2\,HCl$; $2\,KCl + H_2SO_4 \longrightarrow K_2SO_4 + 2\,HCl$

Practice Test-1 (IIT-JEE (Main Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

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

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

1. In an organic compound of molar mass 108 g mol^{-1} C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be : **[AIEEE 2002, 3/225]**

(1) $C_6H_8N_2$ (2) $C_7H_{10}N$ (3) $C_5H_6N_3$ (4) $C_4H_{18}N_3$

2. When $KMnO_4$ acts as an oxidising agent and ultimately forms MnO_4^{2-}, MnO_2, Mn_2O_3 and Mn^{2+}, then the number of electrons transferred in each case is : **[AIEEE 2002, 3/225]**

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

3. Which of the following is a redox reaction? **[AIEEE 2002, 3/225]**

(1) $NaCl + KNO_3 \longrightarrow NaNO_3 + KCl$ (2) $CaC_2O_4 + 2\ HCl \longrightarrow CaCl_2 + H_2C_2O_4$

(3) $Mg(OH)_2 + 2\ NH_4Cl \longrightarrow MgCl_2 + 2NH_4OH$ (4) $Zn + 2AgCN \longrightarrow 2\ Ag + Zn(CN)_2$

4. Which of the following concentration factor is affected by change in temperature? **[AIEEE 2002, 3/225]**

(1) Molarity (2) Molality (3) Mole fraction (4) Weight fraction

5. What volume of hydrogen gas at 273 K and 1 atm pressure will be consumed in obtaining 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen- **[AIEEE 2003, 3/225]**

(1) 44.8 lit. (2) 22.4 lit. (3) 89.6 lit. (4) 67.2 lit.

6. 6.02×10^{20} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is **[AIEEE 2004, 3/225]**

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

7. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is : **[AIEEE 2005, 1½/225]**

(1) + 3 (2) + 2 (3) + 1 (4) 0

8. Two solution of a substance (non electrolyte) are mixed in the following manner. 480 ml of 1.5M first solution + 520 ml of 1.2M second solution. What is the molarity of the final mixture ? **[AIEEE 2005, 3/225]**

(1) 2.70M (2) 1.344M (3) 1.50M (4) 1.20M

9. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms? **[AIEEE-2006, 3/165]**

(1) 0.02 (2) 3.125×10^{-2} (3) 1.25×10^{-2} (4) 2.5×10^{-2}

10. Density of a 2.05M solution of acetic acid in water is 1.02 g/ml. The molality of the solution is : **[AIEEE-2006, 3/165]**

(1) 1.14 mol kg^{-1} (2) 3.28 mol kg^{-1} (3) 2.28 mol kg^{-1} (4) 0.44 mol kg^{-1}

11. In the reaction $2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2Al^{3+}_{(aq)} + 6Cl^{-}_{(aq)} + 3H_2(g)$ **[AIEEE-2007, 3/120]**

(1) 6L $HCl_{(aq)}$ is consumed for every 3L H_2 produced.
(2) 33.6 L $H_{2(g)}$ is produced regardless temperature and pressure for every moles that reacts.
(3) 67.2 L $H_{2(g)}$ at STP is produced for every mole of Al that reacts .
(4) 11.2 L $H_{2(g)}$ at STP is produced for every mole of $HCl_{(aq)}$ consumed.

12. The density (in g mL^{-1}) of a 3.60 M sulphuric acid solution that is 29% (H_2SO_4 molar mass = 98 g mol^{-1}) by mass will be : **[AIEEE-2007, 3/120]**

(1) 1.22 (2) 1.45 (3) 1.64 (4) 1.88

13. 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

14. 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 : **[AIEEE-2011, 3/120]**

(1) 5.55×10^{-4} (2) 33.3 m (3) 3.33×10^{-2} m (4) 0.555 m

15. 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

16. 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

17. 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

18. 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)

19. 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) $\frac{1}{412}$

20.^ 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, 4/120]**

(1) C_3H_8 (2) C_4H_8 (3) C_4H_{10} (4) C_3H_6

21. 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, 4/120]**

(1) 84.3 (2) 118.6 (3) 11.86 (4) 1186

22. 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, 4/120]**

(1) 37.5 kg (2) 7.5 kg (3) 10 kg (4) 15 kg

23. Which of the following reactions is an example of a redox reaction ? **[JEE(Main)-2017, 4/120]**

(1) $XeF_2 + PF_5 \longrightarrow [XeF]^+ PF_6^-$ (2) $XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$

(3) $XeF_6 + 2H_2O \longrightarrow XeO_2F_2 + 4HF$ (4) $XeF_4 + O_2F_2 \longrightarrow XeF_6 + O_2$

PART - III : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. The vapour density of carbon dioxide is **[NSEC-2000]**

(A) 44 (B) 32 (C) 22 (D) 12

2. The volume of 16 g 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

3. Molality of a solution is the number of : **[NSEC-2000]**

(A) moles of the solute per 1000g of the solvent.

(B) gram equivalent of the solute per kilogram of the solvent

(C) gram moles of the solute per 1000 cm^3 of solution.

(D) moles of the solute per 100g of the solvent

4. 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

(A) 154.0 g (B) 74.0 g (C) 47.5 g (D) 166.0 g

5. In the following reaction, $SO_2 + 2H_2S \rightarrow 3S + 2H_2O$ **[NSEC-2000]**

(A) sulphur is oxidised and reduced (B) sulphur is oxidised and hydrogen is reduced
(C) sulphur is reduced and there is no oxidation (D) hydrogen is oxidised and sulphur is reduced

6. 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

7. 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

8. If two compounds have the same empirical formula but differnet molecular formula, they must have : **[NSEC-2001]**

(A) same viscosity (B) different molecular weight
(C) different percentage composition (D) same vapour density

9. 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.

10. 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

11. 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

12. 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

13. 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.

14. 1 gram mole of CO_2 contains : **[NSEC-2002]**

(A) 3 gram atoms of CO_2 (B) 6.022×10^{23} atoms of carbon
(C) 6.022×10^{23} atoms of oxygen (D) 3.011×10^{23} molecules of CO_2.

15. 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.

16. 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.

17. 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

(A) 30.0 g (B) 7.1 g (C) 63.1 g (D) 31.6 g

18. 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

19. 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.

20. 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

21. An ammonia bottle in the laboratory is labelled density 0.91 g cm^{-3} 25% w/w. The molarity of this solution is **[NSEC-2004]**
(A) 11.5 M (B) 15 M (C) 13.4 M (D) 17 M.

22. 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

23. 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}.

24. 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

25. The strength of 10^{-2} molar Na_2CO_3 solution in terms of molality will be (density of the solution = 1.10 g mL^{-1}) **[NSEC-2005]**
(A) 9.00×10^{-3} (B) 1.5×10^{-2} (C) 5.1×10^{-3} (D) 11.2×10^{-3}.

26. 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.

27. 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.

28. 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) $C_3H_9N_3$.

29. The ideal mass (in kg) of aluminium metal produced after processing of 1 metric ton of Al_2O_3 ore is **[NSEC-2006]**
(A) 1000 (B) 530 (C) 795 (D) 265

30. 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

31. A qualitative analysis of papavering, an opium alkaloid showed carbon, hydrogen and nitrogen. A quantitative Analysis gave 70.8% carbon, 6.2% hydrogen and 4.1% nitrogen. The empirical formula of papavering is: **[NSEC-2007]**
(A) $C_{20}H_{20}N_2$ (B) $C_{20}H_{21}O_4N$ (C) $C_{10}H_{11}O_3N$ (D) $C_{21}H_{20}N$

32. Ethyl propanoate has a pineapple like odour and is used as a flavoring agent in fruit syrups. It is prepared as follows:

$$C_2H_5OH_{(aq)} + C_2H_5COOH_{(aq)} \longrightarrow C_2H_5COOC_2H_{5(aq)} + H_2O(\ell)$$

In an experiment, 349 grams of ethyl propanoate was obtained from 250 grams of ethanol, with propanoic acid in excess:
(M.W.of ethyl proanoate: 102, M.W.of ethanol : 46)
The percentage yield of the above reaction is : **[NSEC-2007]**
(A) 48.2 (B) 62.9 (C) 54.6 (D) 32.7

33. Which of the following molecules contains the maximum % of sulfur by mass ? **[NSEC-2007]**
(A) Na_2SO_4 (B) H_2SO_4 (C) Li_2SO_4 (D) $PbSO_4$

34. 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

35. 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

36. 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

37. 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

38. 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}

39. 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) $2H_2SO_4 + Cu \longrightarrow CuSO_4 + 2H_2O + SO_2$

40. 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

41. 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

42. 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

43. 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

44. 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

45. Heating of a solution does not change : **[NSEC-2009]**
(A) the normality of the solution (B) the molarity of the solution
(C) the molality of the solution (D) the density of the solution

46. 0.14 g of a substance when burnt in oxygen yields 0.28 g of oxide. The substance is – **[NSEC-2009]**
(A) nitrogen (B) carbon (C) sulphur (D) phosphorous

47.^ The number of molecules of hydration present in 252 mg of hydrated oxalic acid ($H_2C_2O_4.2H_2O$) is – **[NSEC-2009]**
(A) 2.68×10^{18} (B) 2.52×10^{21} (C) 1.83×10^{24} (D) 2.4×10^{21}

48. 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) $2H_2SO_4 + Cu \longrightarrow CuSO_4 + 2H_2O + SO_2$

49. Silver metal reacts with nitric acid according to the equation.

$$3Ag\ (s) + 4HNO_3\ (aq) \longrightarrow 3AgNO_3\ (aq) + NO\ (g) + 2H_2O\ (l)$$

The volume of 1.15 M HNO_3 (aq) required to react with 0.784 g of silver is : **[NSEC-2009]**

(A) 4.74 mL (B) 6.32 mL (C) 8.43 mL (D) 25.3 mL

50. The conversion which represents oxidation is : **[NSEC-2010]**

(A) $NO_2^- \rightarrow N_2$ (B) $VO_2^+ \rightarrow VO_3^-$ (C) $ClO^- \rightarrow Cl^-$ (D) $CrO_4^{2-} \rightarrow Cr_2O_7^{2-}$

51. 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 148 g 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) $Be_2N_4H_{10}Cl_2$

52. 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

53. 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

54. 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

55. The largest number of molecules are present in **[NSEC-2010]**

(A) 70 g of Sulphur dioxide (B) 64 g of Nitrogen pentoxide

(C) 36 g of Water (D) 34 g of Carbon dioxide

56. 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}

57. An element X is found to combine with oxygen to form X_4O_6. If 8.40 g of this element combine with 6.50 g of oxygen, the atomic weight of the element in u is **[NSEC-2011]**

(A) 24.0 (B) 31.0 (C) 50.4 (D) 118.7

58. 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

59. The maximum amount of CH_3Cl that can be prepared from 20g of CH_4 and 10g of Cl_2 by the following reaction, is :

$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$, (presume that no other reaction is taking place) **[NSEC-2012]**

(A) 3.625 mole (B) 0.141 mole (C) 1.41 mole (D) 0.365 mole

60. 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

61. The mode of expression in which the concentration remains independent of temperature is: **[NSEC-2012]**

(A) Molarity (B) Normality (C) Formality (D) Molality

62. In a nitration experiment, 10.0 g 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%

63. Approximate numbers of moles of hydrogen atoms in 1.006×10^{23} molecules of diethyl ether are : **[NSEC-2014]**

(A) 0.16 (B) 6 (C) 1.67 (D) 3

64. 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

65. 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

66. The ratio of the masses of methane and ethane In a gas mixture is 4 : 5. The ratio of number of their molecules in the mixture is: **[NSEC-2015]**

(A) 4 : 5 (B) 3 : 2 (C) 2 : 3 (D) 5 : 4

67. At constant T and P, 5.0 L of SO_2 are reacted with 3.0 L of O_2 according to the following equation

$$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g)$$

The volume of the reaction mixture at the completion of the reaction is **[NSEC-2017]**

(A) 0.5 L (B) 8.0 L (C) 5.5 L (D) 5 L

68. Lithium oxide (Li_2O; molar mass = 30 g mol^{-1}) is used in space shuttles to remove water vapour according to the following reaction

$Li_2O_{(s)} + H_2O(g) \rightarrow 2LiOH_{(s)}$

If 60 kg of water and 45 kg of Li_2O are present in a shuttle
I. water will be removed completely
II. Li_2O will be the limiting reagent
III. 100 kg of Li_2O will be required to completely remove the water present
IV. 27 kg of water will remain in the shuttle at the end of the reaction **[NSEC-2017]**

(A) II only (B) II and IV (C) III and IV (D) II and III

69. Which of the following mixtures of water and H_2SO_4 would have mass percentage of H_2SO_4 close to 30? **[NSEC-2017]**

(A) 30 g H_2SO_4 + 100 g H_2O (B) 1 mol of H_2SO_4 + 2 mol of H_2O
(C) 1 mol of H_2SO_4 + 200g of H_2O (D) 0.30 mol H_2SO_4 + 0.70 mol H_2O

70. A fuel/ oxidant system consisting of N,N-dimethylhydrazine $(CH_3)_2NNH_2$ and N_2O_4 (both liquids) is used in space vehicle propulsion. The liquid components are mixed stichiometrically so that N_2, CO_2 and H_2O are the only products. If all gases are under the same reaction conditions, number of moles of gases produced from 1 mole of $(CH_3)_2NNH_2$ is **[NSEC-2017]**

(A) 3 (B) 6 (C) 9 (D) 4.5

71. Number of moles of $KClO_3$ that have to be heated to produce 1.0 L of O_2 (g) at STP can be expressed as **[NSEC-2018]**

(A) 1/3 (1/22.4) (B) ½(1/22.4) (C) 2/3 (1/22.4) (D) 3/2 (22.4)

72. Among the following, number of oxygen atoms present in the maximum in **[NSEC-2018]**

(A) 1.0 g of O_2 molecules (B) 4.0 g of O atoms
(C) 1.0 g of O_3 (D) 1.7 g of H_2O

73. Among the following, the reaction/s that can be classified as oxidation-reduction is/are. **[NSEC-2018]**

I. $Cr_2O_7^{2-}(aq) + 2OH^-(aq) \rightarrow 2CrO_4^{2-} + H_2O(l)$
II. $SiCl_4(l) + 2Mg(s) \rightarrow 2MgCl_2(l) + Si(s)$
III. $6Cl_2(l) + 12KOH(l) \rightarrow 2KClO_3(g) + 10\ KCl + 6H_2O(l)$
IV. $2H_2O_2 \rightarrow 2H_2O(l) + O_2(g)$

(A) I and IV (B) I, II and III (C) II, III and IV (D) IV only

74. In the following reaction, the values of a, b and c, respectively are **[NSEC-2018]**

$a\,F_2(g) + b\,OH^-(aq) \longrightarrow c\,F^-(aq) + d\,OF_2(g) + e\,H_2O(l)$

(A) 3, 2, 4 (B) 3, 4, 2 (C) 2, 2, 4 (D) 2, 2, 2

75. In $YBa_2Cu_3O_{7-x}$, a superconducting oxide that got George Bednorz and Karl Muller the Noble prize in 1986, Cu can exist in both +2 and +3 oxidation states and their proportion depends on the value of 'x'. In $YBa_2Cu_3O_{7-0.5}$ **[NSEC-2018]**

(A) 0.5 moles of Cu are in +3 oxidation state (B) 5% of Cu is in +3 oxidation sate

(C) All the Cu is in +3 oxidation state (D) All Cu is in +2 oxidation state

76. A common method to clean spills is to use to Na_2CO_3(Molar mass 106 g.) If 50.0 mL of 0.75 M HCl is split on a wooden surface, the amount of Na_2CO_3 required is **[NSEC-2018]**

(A) 3.75 g (B) 7.5 g (C) 2.0 g (D) 4.0 g

77. Penicillamine is used in the treatment of arthritis. One molecule of penicillamine contains a single sulphur atom and the weight percentage of sulphur in penicillamine is 21.49%. Molecular weight of penicillamine in g mol^{-1} is **[NSEC-2018]**

(A) 85.40 (B) 68.76 (C) 125.2 (D) 149.2

78. The analysis of three different binary oxides of bromine (Br) and oxygen (O) gives the following results :

Compound	Mass of O combined with 1.0 g of Br
X	0.101 g
Y	0.303 g
Z	0.503 g

Which of the following statements is not correct ? **[NSEC-2018]**

I Compound Y is Br_2O_3 II Compound Z is Br_2O_5

III Compound Z is Br_2O_7 IV Compound Y is Br_2O_5

(A) I and III (B) II and IV (C) III and IV (D) I and II

79. Which of the following statements is/are correct ? **[NSEC-2018]**

I. Number of significant figure in 2345.100 is three

II. 0.00787 rounded to two significant figures is written as 0.787×10^{-2}

III. 340 rounded to two significant figures is written as 0.34×10^{3}

IV. The number of significant figures in 0.020 is two

(A) II and III (B) III and IV (C) I, II and IV (D) III only

80. Myoglobin, (Mb), an oxygen storage protein, contains 0.34% Fe by mass and in each molecule of myoglobin one ion of Fe is present. Molar mass of Mb (g mol^{-1}) is (Molar mass of Fe = 5.845 g mol^{-1}) **[NSEC-2019]**

(A) 16407 (B) 164206 (C) 16425 (D) 164250

81. A balance having a precision of 0.0001 g was used to measure a mass of a sample of about 15 g. The number of significant figures to be reported in this measurement is **[NSEC-2019]**

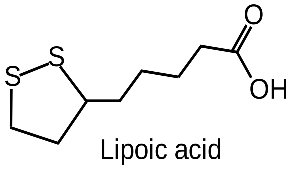
(A) 2 (B) 3 (C) 5 (D) 1

82. Mercury is highly hazardous and hence its concentration is expressed in the units of ppb (micrograms of Hg present in 1 L of water). Permissible level of Hg in drinking water is 0.0335 ppb. Which of the following is an alternate representation of this concentration? **[NSEC-2019]**

(A) 3.35×10^{-2} mg dm^{-3} (B) 3.35×10^{-5} mg dm^{-3}

(C) 3.35×10^{-5} mg m^{-3} (D) 3.35×10^{-4} g L^{-1}

83. Lipoic acid with the following structure is a growth factor required by many organisms. Percentages of 'S' and 'O' in lipoic acid respectively are (atomic masses of 'S' and 'O' are 32.065 g mol^{-1} and 15.999 g mol^{-1} respectively) **[NSEC-2019]**



Lipoic acid

(A) 33.03, 16.48 (B) 31.11, 18.24 (C) 31.11, 15.52 (D) 31.42, 15.68

PART - IV : 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%?

ONLY ONE OPTION CORRECT TYPE

2. 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 %

3. Phosphoric acid (H_3PO_4) prepared in a two step process.

(1) $P_4 + 5O_2 \longrightarrow P_4O_{10}$

(2) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$.

We allow 62 g of phosphorus to react with excess oxygen which form P_4O_{10} in 85% yield. In the step (2) 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

4. 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

5. 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

6. (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

MATCH THE COLUMN

7.

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

NUMERICAL VALUE QUESTIONS

8. The measured density at NTP of He is 0.1784 g/L. What is the weight (in g) of one mole of He ?

9. 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 $CuS + O_2 \longrightarrow Cu + SO_2$

10. 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.

11. 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?

12. 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 ?

13. 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 STP) in litres liberated when aluminium reacts with this (final) solution.
The reaction is
$Al + NaOH + H_2O \longrightarrow NaAlO_2 + H_2$

14. 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 foil (in cm^2). [Report your answer after multiplying by 100].

ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

15. 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.

16. 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

17. 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 STP is 5.20 litres.

18. 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.

19. 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.

PART - V : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr. **Max. Marks : 66**

Important Instructions

A. General :

1. The test is of 1 hour duration.
2. The Test Booklet consists of 22 questions. The maximum marks are 66.

B. Question Paper Format

3. Each part consists of five sections.
4. Section 1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
5. Section 2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
6. Section 3 contains 6 questions. The answer to each of the questions is a numerical value, ranging from 0 to 9 (both inclusive).
7. Section 4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a partcular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
8. Section 5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

C. Marking Scheme

9. For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (–1) mark will be awarded.
10. For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
11. For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

SECTION-1 : (Only One option correct Type)

This section contains 7 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

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 masses of oxygen, hydrogen and methane are taken in a container in identical condition. Find the ratio of the volumes of the gases.
(A) $O_2 : H_2 : CH_4$ 1 : 16 : 2 (B) $O_2 : H_2 : CH_4$ 1 : 8 : 1
(C) $O_2 : H_2 : CH_4$ 16 : 1 : 8 (D) $O_2 : H_2 : CH_4$ 8 : 1 : 8

3. The elements A and B form a compound that contains 60% A and 40% B by mass. The atomic mass of B is twice that of A. Find the empirical formula of the compound.
(A) A_3B_2 (B) A_3B (C) A_2B_3 (D) AB_3

4. 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

5. 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%

6. The molality of a sulphuric acid solution is 0.2. Calculate the total weight of the solution having 1000 g of solvent.
(A) 1000 g (B) 1098.6 g (C) 980.4 g (D) 1019.6g

7. Generally commercial hydrochloric acid is prepared by heating NaCl with concentrated H_2SO_4. How much H_2SO_4 solution containing 93.0% H_2SO_4 by mass is required for the production of 1000 kg of concentrated hydrochloric acid containing 43% HCl by weight.
(A) 590.0 kg solution of H_2SO_4. (B) 310.3 kg solution of H_2SO_4.
(C) 620.7 kg solution of H_2SO_4. (D) 708.2 kg solution of H_2SO_4.

Section-2 : (One or More than one options correct Type)

This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

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8. If H_2SO_4 is formed from it's elements by taking 6.023×10^{23} atom of 'O' 5.6 litre of H_2 gas at STP and 8 g S then
(A) 0.125 moles of H_2SO_4 are formed (B) 0.25 moles of H_2SO_4 are formed
(C) no moles of 'S' are left (D) 1/4 mole of O_2 is left

9. 1120 mL of ozonised oxygen at S.T.P. weigh 1.76 g. Report the composition of 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

10. 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.

11. Equal masses of SO_2 and O_2 are placed in a flask at STP choose the correct statement.
(A) The number of molecules of O_2 are more than SO_2
(B) Volume occupied at STP 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 .

12. 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

Section-3 : (Numerical Value Questions)

This section contains 6 questions. Each question, when worked out will result in a numerical value from 0 to 9 (both inclusive)

---

13. XeF_6 fluorinates I_2 to IF_7 and liberates Xenon(g). 3.5 mmol of XeF_6 can yield a maximum of_____ mmol of IF_7.

14. Balance the following equation and choose the quantity which is the sum of the coefficients of all species:

$$\ldots\ldots\ldots\ CS_2 + \ldots\ldots\ldots\ Cl_2 \longrightarrow CCl_4 + \ldots\ldots\ldots\ S_2Cl_2$$

15. 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.

16. 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.

17. 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).

18. 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.

SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

Comprehension #

Cis-platin is used as an anticancer agent for the treatment of solid tumors, and its prepared as follows :

$K_2[PtCl_4] + 2NH_3 \longrightarrow [Pt(NH_3)_2Cl_2] + 2KCl$

Potassium tetra chloro platinate (II)   Cis-platin

Given 83.0 g of $K_2[PtCl_4]$ is reacted with 83.0 g of NH_3.

[Atomic weights : K = 39, Pt = 195, Cl = 35.5, N = 14]

19. Which reactant is the limiting reagent and which is in excess ?

	Limiting	**Excess**
(A)	$K_2[PtCl_4]$	NH_3
(B)	NH_3	$K_2[PtCl_4]$
(C)	None	None
(D)	Both	Both

20. The number of mol of $K_2[PtCl_4]$ and NH_3 used, respectively, are

(A) 0.1, 0.2 (B) 0.2, 0.4 (C) 0.3, 0.6 (D) 0.03, 0.06

21. The number of mol of excess reactant is

(A) 4.68 (B) 4.78 (C) 4.58 (D) 4.48

SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct

---

22. Match the reactions given in List I with the number of electrons lost or gained in List II

	Column – I		**Column – II**
	Reaction		**Number of electrons lost or gained**
(P)	$Mn(OH)_2 + H_2O_2 \longrightarrow MnO_2 + 2H_2O$	(1)	8
(Q)	$AlCl_3 + 3K \longrightarrow Al + 3KCl$	(2)	2
(R)	$3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$	(3)	3
(S)	$3H_2S + 2HNO_3 \longrightarrow 3S + 2NO + 4H_2O$	(4)	6

Code :

	P	Q	R	S		P	Q	R	S
(A)	2	3	1	4	(B)	3	2	1	4
(C)	2	1	3	4	(D)	1	4	3	2

Practice Test-2 (IIT-JEE (ADVANCED Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

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

APSP Answers

PART - I

1.	(2)	**2.**	(3)	**3.**	(1)	**4.**	(3)	**5.**	(2)
6.	(1)	**7.**	(1)	**8.**	(3)	**9.**	(3)	**10.**	(2)
11.	(4)	**12.**	(1)	**13.**	(3)	**14.**	(1)	**15.**	(2)
16.	(4)	**17.**	(4)	**18.**	(4)	**19.**	(2)	**20.**	(4)
21.	32.10	**22.**	34.50	**23.**	12.934	**24.**	18.40	**25.**	42.89

PART - II

1.	(1)	**2.**	(3)	**3.**	(4)	**4.**	(1)	**5.**	(4)
6.	(2)	**7.**	(1)	**8.**	(2)	**9.**	(2)	**10.**	(3)
11.	(4)	**12.**	(1)	**13.**	(3)	**14.**	(1)	**15.**	(4)
16.	(1)	**17.**	(3)	**18.**	(4)	**19.**	(4)	**20.**	**(Bonus)**
21.	(1)	**22.**	(2)	**23.**	(4)				

PART - III

1.	(C)	**2.**	(B)	**3.**	(A)	**4.**	(A)	**5.**	(A)
6.	(D)	**7.**	(A)	**8.**	(B)	**9.**	(A)	**10.**	(D)
11.	(B)	**12.**	(B)	**13.**	(A)	**14.**	(B)	**15.**	(B)
16.	(C)	**17.**	(B)	**18.**	(C)	**19.**	(B)	**20.**	(D)
21.	(C)	**22.**	(A)	**23.**	(B)	**24.**	(C)	**25.**	(A)
26.	(B)	**27.**	(D)	**28.**	(B)	**29.**	(B)	**30.**	(D)
31.	(B)	**32.**	(B)	**33.**	(B)	**34.**	(C)	**35.**	(B)
36.	(C)	**37.**	(D)	**38.**	(C)	**39.**	(D)	**40.**	(C)
41.	(B)	**42.**	(B)	**43.**	(B)	**44.**	(D)	**45.**	(C)
46.	(C)	**47.^**	(D)	**48.**	(D)	**49.**	(C)	**50.**	(B)
51.	(A)	**52.**	(A)	**53.**	(A)	**54.**	(A)	**55.**	(C)
56.	(B)	**57.**	(B)	**58.**	(B)	**59.**	(B)	**60.**	(C)
61.	(D)	**62.**	(A)	**63.**	(C)	**64.**	(D)	**65.**	(A)
66.	(B)	**67.**	(C)	**68.**	(D)	**69.**	(C)	**70.**	(C)
71.	(C)	**72.**	(B)	**73.**	(C)	**74.**	(D)	**75.**	(D)
76.	(C)	**77.**	(D)	**78.**	(C)	**79.**	(B)	**80.**	(C)
81.	(C)	**82.**	(B)	**83.**	(C)				

PART – IV

1.	76 kg of CS_2	**2.**	(A)	**3.**	(B)	**4.**	(A)	**5.**	(A)
6.	(C)	**7.**	(A - p); (B - r,s); (C - r); (D - r,q)			**8.**	4	**9.**	62%
10.	6	**11.**	8	**12.**	10	**13.**	67	**14.**	2
15.	(ACD)	**16.**	(A)	**17.**	(ACD)	**18.**	(AB)	**19.**	(AB)

PART – V

1.	(B)	**2.**	(A)	**3.**	(B)	**4.**	(B)	**5.**	(A)
6.	(D)	**7.**	(C)	**8.**	(BC)	**9.**	(BD)	**10.**	(AB)
11.	(ABC)	**12.**	(BC)	**13.**	3	**14.**	6	**15.**	1
16.	5	**17.**	1	**18.**	7	**19.**	(A)	**20.**	(B)
21.	(D)	**22.**	(A)						

APSP Solutions

PART – I

1. Mole of NO_2= $\frac{112}{22400}$ = 5×10^{-3}

Mass of NO_2 = $5 \times 10^{-3} \times 46 = 0.23$ g

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. $\frac{32}{2x+3y} = 0.2$

$\frac{92.8}{3x+4y} = 0.4$

Hence x = 56 & y = 16.

3. KI is limiting reagent

$\therefore$ 3 mole of KI will give 33 mole of NO_2 according to stoichiometry.

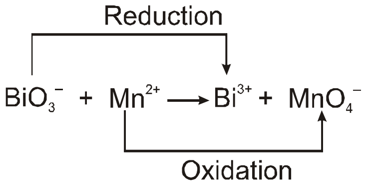
4.

	4A	+	2B	+	3C	$\longrightarrow$	$A_4B_2C_3$
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.

5.



(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 $14\,H^+ + 5\,BiO_3^- + 5Mn^{2+} \longrightarrow 5Bi^{3+} + 2MnO_4^- + 7\,H_2O$

Hence, (2) is the correct balanced reaction.

6. $3I_2 + OH^- \longrightarrow IO_3^- + 5I^-$ (balance reaction) So, ratio is 1 : 5.

7. Explanation : $m = \frac{M \times 1000}{(1000 \times d - M \times M.Wt.)}$ 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]

8. 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.

9. 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 × 10^{-3} = 10^{-4} mole.

Number of ions in 1 ml = 2 × 10^{-4} × 6.023 × 10^{23} = 1.204 × 10^{20}.

10. Molarity = M

Let volume of be 1 ltr.

$\therefore$ mass of solvent = 1000 d – M × M_2

Molality = m = $\frac{M}{1000\,d - MM_2}$ × 1000

11.

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) × 2 = $C_{10}H_{14}N_2$

12. $C + O_2 \xrightarrow{\Delta} CO_2$

12g C = 1 mol O_2 = 22.4 L O_2

$\therefore$ 1000 g C = $\frac{22.4}{12}$ × 1000 or 1866.67 L O_2.

13.

	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.

14.

	$2KO_2$	+	$2H_2O$	$\longrightarrow$	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

15. $KClO_3 \rightarrow KCl + O_2$

Applying POAC for O atoms in the eqn.(i),

moles of O in $KClO_3$ = moles of O in O_2

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

$$3 \times \frac{\text{wt.of } KClO_3}{\text{mol.wt. of } KClO_3} = 2 \times \frac{\text{volume at NTP(mL)}}{22400}$$

$$\text{Wt . of } KClO_3 = \frac{2\times146.8\times122.5}{3\times22400} = 0.5358 \text{ g.}$$

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 × moles of $KClO_3$ = 4 × 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

$$= 1 - \frac{146.8}{24400} \times 32 \text{ g} = 0.7902 \text{ g.}$$

$$\therefore \% \text{ of } KClO_4 \text{ in the residue} = \frac{0.3937}{0.7902} \times 100 = 49.8 \%.$$

16. Let mass of Hg is w g

	$2Hg$	$+ I_2$	$\longrightarrow$	Hg_2I_2
Initial mole	2a	a		
fianl mole	0	0		a

	Hg	$+ I_2$	$\longrightarrow$	Hg_2I_2
Initial mole	b	b		
fianl mole	0	0		b

$$\therefore \text{ mole of Hg} = 2a + b = \frac{w}{200.6} \qquad \text{........... (1)}$$

$$\therefore \text{ mole of } I_2 = a + b = \frac{w}{254} \qquad \text{........... (2)}$$

eqution (1) – (2)

$$a = \frac{w}{200.6} - \frac{w}{254}$$

$$\therefore \quad b = \frac{w}{254} - \left(\frac{w}{200.6} - \frac{w}{254}\right) = \frac{w}{127} - \frac{w}{200.6}$$

$$\therefore \quad \frac{\text{Mass of } Hg_2I_2}{\text{Mass of } HgI_2} = \frac{a \times 655.2}{b \times 454.6} = \frac{\left(\frac{w}{200.6} - \frac{w}{254}\right)655.2}{\left(\frac{w}{127} - \frac{w}{200.6}\right)454.6} = \frac{0.523}{1}.$$

17.
$$\text{Molarity of } H_2SO_4 = \frac{\text{sp. gravity} \times \% \text{ w/w} \times 10}{\text{Molecular mass}}$$

$$= \frac{1.2 \times 25 \times 10}{98} = \frac{12 \times 25}{98} = 3.06 \text{ M}$$

$$3H_2SO_4 + 2Al \longrightarrow Al_2(SO_4)_3 + 3H_2$$

$$\frac{2.7}{27} = 0.1$$

$$\text{Mole of } H_2SO_4 \text{ used} = \frac{3}{2} \times 0.1 = 0.15$$

Initial mole of H_2SO_4 = 0.75 × 3.06 = 0.2295

Mole of H_2SO_4 remaining = 0.2295 – 0.15

$$\text{Molarity of final } H_2SO_4 = \frac{0.0795}{0.4} = 0.198 \text{ M.}$$

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 × 6.023 × 10^{23} = 1.81 × 10^{22} ions.

19. $CuSO_4.5H_2O(aq) + BaCl_2(aq) \longrightarrow \underset{4.66\text{ g}}{BaSO_4(s)} + CaCl_2\ (aq)$

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. Balance chemical equations are :

$$Ca_3(PO_4)_2 + 8Mg \longrightarrow Ca_3P_2 + 8MgO$$
$$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$$
$$2PH_3 + 4O_2 \longrightarrow P_2O_5 + 3H_2O$$
$$MgO + P_2O_5 \longrightarrow Mg(PO_3)_2$$

moles of magnesium used = 0.8 moles
moles of MgO formed = 0.8 moles
moles of Ca_3P_2 formed 0.1 moles
moles of PH_3 formed = 0.2 moles
moles of P_2O_5 formed = 0.1 mole (limiting reagent)
moles of $Mg(PO_3)_2$ = 0.1 moles
mass of $Mg(PO_3)_2$ = 18.2 gram **Ans. 18 gram**

21. $CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2\ NaCl$

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

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 $CaCl_2 = \frac{3.21}{10} \times 100 = 32.10$ %.

22. $Ag_2CO_3\ (s) \longrightarrow 2Ag\ (s) + CO_2\ (g) + \frac{1}{2}O_2\ (g)$

$C_2H_2 + \frac{5}{2}O_2 \longrightarrow 2CO_2 + H_2O$

By Stoichiometry of reaction

Moles of CO_2 formed = $\frac{1.12}{22.4} = \frac{1}{20}$

Moles of O_2 required = $\frac{5}{4} \times \frac{1}{20} = \frac{5}{80}$

Moles of Ag_2CO_3 required $= 2 \times \frac{5}{80} = \frac{5}{40}$

Mass of Ag_2CO_3 required = $\frac{5}{40} \times 276 = 34.50$ g

23. 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 $\frac{85}{23} \times 3.5 = 12.934$ g of $NaNO_3$

24. Molarity = $\frac{(\%w/w)\times\text{density}\times 10}{\text{Molar mass of solute}} = \frac{98\times 1.84\times 10}{98}$ = 18.4 M

25. Consider that mass of NaCl = xg

$\therefore$ Moles of NaCl will be = $\frac{x}{58.5}$ and moles of KCl will be = $\frac{64-x}{74.5}$

By using POAC for Na and K

$\because$ Moles of NaCl × 1 = Moles of Na_2SO_4 × 2

or Moles of Na_2SO_4 = Moles of NaCl × $\frac{1}{2}$

$\because$ Moles of KCl × 1 = Moles of K_2SO_4 × 2

or Moles of K_2SO_4 = Moles of KCl × $\frac{1}{2}$

Total weight of Na_2SO_4 and K_2SO_4 is 76 g

Hence $\frac{1}{2}\times\frac{x}{58.5}\times 142+\frac{1}{2}\times\frac{64-x}{74.5}\times 174 = 76$

$\Rightarrow$ $1.2137 \times 74.74 - 1.1678\,x = 76$

$\Rightarrow$ $0.0459\,x = 1.26$

$\Rightarrow$ x = 27.45 g

% mass of NaCl = $\frac{27.45}{64}\times 100$ = 42.89%

% mass of KCl = 100 – 42.89 = 57.11%.

PART - II

1. Molar mass = 108 g/mole

Element	**Wt. Ratio**	**Wt. ratio/Atomic mass**	**Simple Ratio**	**Simple Integer ratio**
C	9 x	$\frac{9x}{12}=\frac{3x}{4}$	3	3
H	1 x	x	4	4
N	3.5 x	$\frac{3.5x}{14}=\frac{x}{4}$	1	1

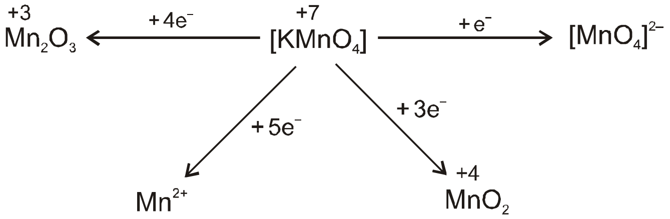
$\therefore$ C_3H_4N

Empirical mass = 12 × 3 + 4 + 14 = 54

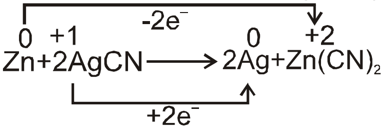
n = $\frac{108}{54}$ = 2

$\therefore$ Molecular Formula = $C_6H_8N_2$

2.



3. The oxidation states show a change only in reaction



$$\overset{0}{Zn}+2\overset{+1}{Ag}CN \longrightarrow 2\overset{0}{Ag}+\overset{+2}{Zn}(CN)_2$$

4. Molarity depends on volume (volume changes with changes in temperature).

5. $2BCl_3 + 3H_2 \longrightarrow 2B + 6HCl$

moles of B = $\frac{21.6}{10.8}$ = 2

So moles of H_2 = 3

Now vol at STP = 3 × 22.4 = 67.2 lt.

6. Molarity = $\frac{\text{Moles of solute}}{V_{lt}} = \frac{6.02\times11^{20}/6.02\times10^{23}}{100/1000}$ = 0.01 M

7. Let the oxidation state of Cr is x.

x + 4(0) + 2 (–1) = + 1

x – 2 = + 1 or, x = + 1 + 2 = + 3.

8. Final molarity = $\frac{M_1V_1+M_2V_2}{V_1+V_2} = \frac{1.5\times480+1.2\times520}{480+520}$ = 1.344M

9. 1 mole of $Mg_3(PO_4)_2$

⇒ 3 mole of Mg atom + 2 mole of P atom + 8 mole of O atom. 8 mole of oxygen atoms are present in = 1 mole of $Mg_3(PO_4)_2$, 0.25 mole of oxygen atoms are present in $\frac{1\times0.25}{8}$ = 3.125×10^{-2} moles of $Mg_3(PO_4)_2$.

10. molality (m) = $\frac{M}{1000d-MM_1} \times 1000 = \frac{2.05}{(1000\times1.02)\ -\ (2.05\ \times\ 60)} \times 1000$ = 2.28 mol kg^{-1}

M = Molarity, M_1 = Molecular mass of solute, d = density

11. $2Al(s) + 6HCl(aq) \longrightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$

3 mole H_2 from 6 mole HCl consumed.

∴ 1 mole H_2 from 2 mole HCl consumed.

1/2 mole(11.2 Lit) H_2 from 1 mole HCl consumed.

12. 3.6 M solution means 3.6 mole of H_2SO_4 is present in 1000 ml of solution

∴ Mass of 3.6 moles of H_2SO_4 is = 3.6 × 98 g = 352.8 g

∴ Mass of H_2SO_4 in 1000 ml of solution = 352.8 g

Given, 29g of H_2SO_4 is present in 100 g of solution

∴ 352.8 g of H_2SO_4 is present in $\frac{100}{29}$ × 352.8 = 1216 g of solution

Now density = $\frac{\text{Mass}}{\text{Volume}} = \frac{1216}{1000}$ = 1.216 g/mL = 1.22 g/mL

13. $X_{\text{ethyl alcohol}} = \frac{5.2}{5.2+\frac{1000}{18}}$ = 0.086

14. Molality = $\frac{0.01/60}{0.3} = \frac{0.01}{60\times0.3}$; d = 1 g/ml = 5.55×10^{-4} m.

15. Molarity = $\frac{\text{mols of solute}}{\text{volume of sol. }(\ell)} = \frac{120\times1.15}{60\times1120}$ = 2.05 M

16. $M_f = \frac{M_1V_1+M_2V_2}{V_1+V_2} = \frac{0.5\times\frac{3}{4}+2\times\frac{1}{4}}{1}$ = 0.875 M

17. $MnO_4^- \quad + \quad C_2O_4^{2-} + H^+ \longrightarrow Mn^2 + CO_2 + H_2O$

vf = 1(7 –2)   vf = 2(3–2)

= 5   = 2

Balanced Equation :

$2MnO_4^- + 5C_2O_4^{2-} + 16\,H^+ \longrightarrow 2Mn^{2+} + 10\,CO_2 + 8H_2O$

So, x = 2, y = 5 & z = 16.

18. H_2O_2 acts as reducing agent when it releases electrons. i.e. (b) & (d)

19. 1 g of $C_8H_7SO_3Na = \frac{1}{206}$ mole

$2C_8H_7SO_3Na \quad + \quad Ca^{2+} \longrightarrow (C_8H_7SO_3)_2Ca \quad + \quad 2Na^+$

$\frac{1}{206}$ mole $\frac{1}{412}$ mole

20. $C_xH_y\,(g) + \left(x+\frac{y}{4}\right) O_2\,(g) \rightarrow xCO_2\,(g) + \frac{y}{2} H_2O\,(\ell)$

15ml

Volume of O_2 used $= \frac{20}{100} \times 375 = 75$ ml.

Volume of air remaining = 300 ml

Total volume of gas left after combustion = 330 ml

Volume of CO_2 gases after combustion = 330 – 300 = 30 ml.

$C_xH_y\,(g) + \left(x+\frac{y}{4}\right) O_2\,(g) \rightarrow xCO_2\,(g) + \frac{y}{2} H_2O\,(\ell)$

15 ml   75 ml   30 ml

$\frac{x}{1} = \frac{30}{15} \quad \Rightarrow \quad x = 2$

$\frac{x+\frac{y}{4}}{1} = \frac{75}{15} \quad \Rightarrow \quad x + \frac{y}{4} = 5$

$\Rightarrow \quad y = 12$

$\Rightarrow \quad C_2H_{12}$

Confirmed :

Such compound is impossible and also not in option. So it should be bonus.

However if we seriously wish to give an answer then by looking at options, we can see that only C_3H_8 is able to consume 75 ml O_2. So (1) can also be given as answer.

21. $M_2CO_3 + 2HCl \longrightarrow MCl_2 + H_2O + CO_2$

$\frac{1}{M_0}$Mole   0.01186 mol.

M_0 = Molar mass of M_2CO_3

$\frac{1}{M_0} = 0.01186$

$M_0 = 84.3\ g/mol$

22. 75 kg person contain 10% hydrogen i.e. 7.5 kg Hydrogen.

If all H atom are replaced by ^2H, the weight of Hydrogen become twice i.e. it increases by 7.5 kg.

23. 1, 2, 3 are non redox

In 4, O_2F_2 is oxidising agent & XeF_4 is reducing agent.

PART - IV

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.

	$TiCl_4$	+	$2Mg \longrightarrow$	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 $= \dfrac{32 \times 100}{\frac{358 \times 48}{190}} = 35.38$ %

3. 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

4. The balanced equation is
$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

5. 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 $NH_3 = 5.88 \times 10^{-4}$ mole NH_3.

6. 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 × 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.

8. Density of He = 0.1784 g/lit.
1 mole of He will occupy 22.4 lit. at NTP
$\therefore$ Mass of 1 mole = V × d = 22.4 × 0.1784 = 3.99 = 4 g.

9. 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.

10. Molarity of $H_2SO_4 = \frac{1.8 \times 54.5 \times 10}{98} = 10$

$2Al \quad + \quad 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$
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

11. 1 × moles of CO_2 = 6n × moles of starch

$$= 6n \times \frac{1}{162\,n}$$

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 $= \frac{1}{4.7 \times 10^{-3}} \times \frac{6}{162} = 8$ hrs.

12. Balanced the equation.

$15H_2O + 3CN^- \longrightarrow 3CO_2 + 3NO_3^- + 30H^+ + 30e^-$

13. Mole of NaOH in 1st solution = 0.5 moles

moles of NaOH addded $= \frac{200 \times 1.5 \times 0.2}{40} = 1.5$

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 STP = 3 × 22.4 = 67.2 litre **Ans. 67**

14. 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 $= \frac{1}{3} \times \frac{0.6 \times 27}{1000} = 0.0054$ gram

$\therefore$ Volume of foil $= \frac{0.0054}{2.7}$ mL or $cm^3 = 0.002\ cm^3$

Now , Area × thickness = Volume

∴ Area = $\frac{0.002}{0.01}$ = 0.2 cm^2 (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.

16. 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

⇒ $\frac{28x+46y+92z}{1+z}$ = 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

∴ x = 0.5 ,y = 0.1 ,z = 0.4

17. (A) , (C) and (D) Explanation :

$4 Ag + 8 KCN + O_2 + 2 H_2O \longrightarrow 4 K[Ag(CN)_2] + 4 KOH$

⇒ 4 × 108 g of Ag reacts with 8 × 65 g of KCN

100 g of Ag reacts with

$\frac{8\times65}{4\times108}$ × 100 = 120

Hence ,, to dissolve 100 g of Ag , the amount of KCN required = 120 g

Hence , statement (A) is correct.

⇒ 4 × 108 g of Ag require 32 g of O_2

1 g of Ag require $\frac{32}{4\times108}$ = 0.0740 g

⇒ 100 g of Ag require = 7.4 g

Hence, choice (C) is correct.

Hence, volume of O_2 required = $\frac{7.4}{32}$ × 22.4 = 5.20 litre

Hence, (A) , (C) , (D) are correct while (B) is incorrect.

18. $CaO(s) + 3C(s) \longrightarrow CaC_2(s) + CO(g)$

(A) Final product contain 85% CaC_2 & 15% CaO

Let mass of product is 100 g

∴ Mass of CaC_2 = 85 g

Mass of CaO = 15 g

Used mole of CaO = mole of CaC_2 produced = $\frac{85}{64}$

∴ mass of CaO for producing 85 g CaC_2 = $\frac{85}{64}$ × 56 = 74.375 g.

∴ Initial total mass of CaO = 74.375 + 15 = 89.375.

85 g CaC_2 obtained from = 89.38 g CaO

∴ 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.

19. 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.

PART - V

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. Suppose each gas has a mass of X g.

Therefore , $O_2 : H_2 : CH_4$

Weight – X X X

No. of moles – $\frac{X}{32}$ $\frac{X}{2}$ $\frac{X}{16}$

Volume of ratio – $\frac{X}{32} : \frac{X}{2} : \frac{X}{16}$

Hence , $O_2 : H_2 : CH_4$ 1 : 16 : 2

3.

Elements	Atomic mass	%	Relative No. of atoms	Simple ratio	Simplest whole no.
A	x	60	60/x	3	3
B	2x	40	40/2x = 20/x	1	1

$\therefore$ Empirical formula A_3B

4.

$$Zn + I_2 \longrightarrow ZnI_2$$

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 = $\frac{\frac{x}{65} - \frac{x}{254}}{\frac{x}{65}} = 1 - \frac{65}{254} = 0.744$

5. On passing through charcoal only CO_2 reduces to CO.

$CO + C \xrightarrow{\quad} \text{No reaction}$

Volume a

$CO_2 + C \xrightarrow{\quad} 2\,CO$

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 = $\frac{0.6}{1} \times 100 = 60\ \%$

6. m = 0.2 mole / kg

weight of solvent = 1000 gram

weight of solute = 0.2 × 98 = 19.6 gram

Total weight of solution = 1000 + 19.6 = 1019.6 ml.

7. Mass of HCl = $1000 \times \left(\frac{43}{100}\right) = 430$ kg.

$2NaCl + H_2SO_4 \xrightarrow{\quad} Na_2SO_4 + 2HCl$

$$\frac{\text{Mole of HCl}}{2} = \frac{\text{Mole of } H_2SO_4}{1}$$

$$\frac{430 \times 10^3}{36.5 \times 2} = \text{mole of } H_2SO_4$$

$$\text{Mass of } H_2SO_4 = \frac{98 \times 430 \times 10^3}{36.5 \times 2} = 577.26 \times 10^3 \text{ g}$$

$$\text{Mass of 93\% } H_2SO_4 = 577.26 \times \frac{100}{93} = 620.71 \text{ kg.}$$

8. $H_2 + S + 2O_2 \rightarrow H_2SO_4$

$n_{H_2} = \frac{5.6}{22.4} = \frac{1}{4}$ $n_S = \frac{8}{32} = \frac{1}{4}$ $n_{O_2} = \frac{1}{2}$

As all reactants are in stoichiometric ratios, none will be left behind.

Hence $\frac{1}{4}$ mole of H_2SO_4 is formed.

9. 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 = $\frac{\text{mass}}{\text{volume}}$

$\therefore$ 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) × 3 = 1.76 × 1400

or, x = (3360 – 2464) mL = **896 mL O_2.**

10. (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 × 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.

11. 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 STP > volume of SO_2 at STP.

12.

	$2P + Q \longrightarrow R$		
initial mole	12	8	0
final mole	0	8 – 6	6

$\therefore$ moles of R formed = 6

% of Q left behind = $\frac{2}{8} \times 100 = 25\%$

13. $XeF_6 + I_2 \longrightarrow IF_7 + Xe$

POAC on 'F' :

6 (m.mole of XeF_6) = 7 (m.mole of IF_7)

$\frac{3.5 \times 6}{7}$ = 3 m.moles of IF_7

14. $CS_2 + 3Cl_2 \longrightarrow CCl_4 + S_2Cl_2$

1 + 3 + 1 + 1 = 6

15. Let mole % of ^{26}Mg be x.

$$\therefore \quad \frac{(21 - x)\ 25 + x\ (26) + 79\ (24)}{100} = 24.31$$

x = 10%

Answer = 1

16. $CaCO_3 \longrightarrow CaO + CO_2$

$\frac{5.6}{22.4} = \frac{1}{4}$mole

mole of CaO = mole of Ca = $\frac{1}{4}$

mass of Ca = $\frac{1}{4} \times 40 = 10$

% of Ca in sample = $\frac{10}{200} \times 100 = 5\%$

17. Let volume of solution is 1000 ml

moles of H_2SO_4 = 18

mass of H_2SO_4 = 18 × 98 = 1764 g

mass of solution = 1000 × 1.8 = 1800 g

mass of solvent = 1800 – 1764 = 36 g

molality = $\frac{18}{\left(\frac{36}{1000}\right)} = 500 \quad \Rightarrow \quad \frac{500}{500} = 1$

18. Let each species be a moles, M be molecular mass of metal
$a \times [2 \times 7 + 12 + 48] + a [2 \times M + 12 + 48] = 1$ ....(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
$M - 16 = 7$

19. Mw of $K_2[PtCl_4] = 2 \times 39 + 195 + 4 \times 35.5 = 415$ g
Mw of $NH_3 = 17$ g
Mol of $K_2[PtCl_4] = \frac{83.0}{415} = 0.2$ mol (limiting reagent)
Mol of $NH_3 = \frac{83}{17} = 4.88$ mol (excess)

20. Mol of $K_2[PtCl_4]$ consumed = 0.2 mol = mol of cisplatin
NH_3 consumed = 2 × 0.2 0.4 mol

21. Excess of NH_3 unreacted = 4.88 – 0.4 = 4.48 mol

22. (P) $Mn^{2+} \longrightarrow Mn^{4+} + 2e^-$ (Oxidation)
$2e^- + H_2O_2 \longrightarrow 2H_2O$ (Reduction)
(Q) $3K \longrightarrow 3K^+ + 3e^-$ (Oxidation)
$3e^- + Al^{3+} \longrightarrow Al$ (Reduction)
(R) $3Fe \longrightarrow Fe_3O_4 + 8e^-$ (Oxidation)
$3x = 0$ $3x - 8 = 0$
$3x = 8$
$8e^- + 4H_2O \longrightarrow 4H_2$ (Reduction)
$8x - 8 = 0$ $8x = 0$
$8x = 8$
(S) $3H_2S \longrightarrow 3S + 6e^-$ (Oxidation)
$2 + x = 0$ $x = 0$
$x = -2$
$6e^- + 2NO_3^- \longrightarrow 2NO$ (Reduction)
$x - 6 = -1$ $x - 2 = 0$
$x = 5$ $x = 2$