

## 1. CLASSIFICATION OF MATTER

**1.1 Physical classification:** It is based on physical state under ordinary conditions of temperature and pressure, matter is classified into the following three types:

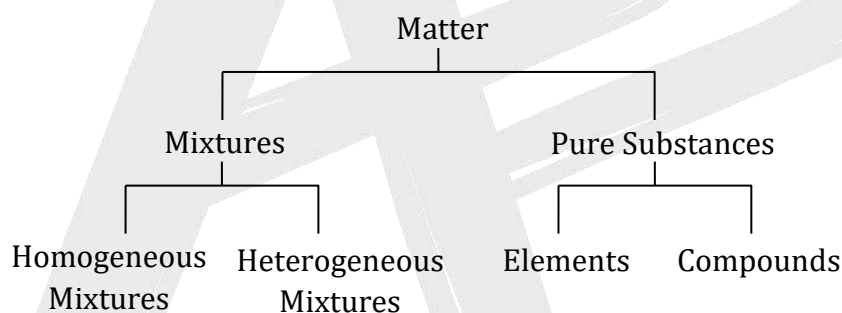
(a) Solid (b) Liquid (c) Gas

**(a) Solid:** A substance is said to be solid if it possesses a definite volume and a definite shape  
E.g. sugar, iron, gold, wood etc.

**(b) Liquid:** A substance is said to be liquid if it possesses a definite volume but not definite shape. They take up the shape of the vessel in which they are put.  
E.g. water, milk, oil, mercury, alcohol etc.

**(c) Gas:** A substance is said to be gas if it neither possesses a definite volume nor a definite shape. This is because they fill up the whole vessel in which they are put.  
E.g. hydrogen( $H_2$ ), oxygen( $O_2$ ), carbon dioxide( $CO_2$ ), etc.

## 1.2 Chemical classification:



On the basis of chemical nature matter is classified into the following two types :

(a) Pure Substance (b) Mixture

**(a) Pure Substance:** When all constituent particles of a substance are same in chemical nature, it is said to be a pure substance. Two type of pure substances:

(i) Element (ii) Compound

**(i) Element:** an element consist of only one type of atoms. These particles may exist as Atoms or molecules. E.g.  $O_2$ ,  $P_4$ ,  $S_8$ , etc.

**(ii) Compound:** When two or more atoms of different elements combine together in a definite ratio.  
E.g. water, ammonia, carbon dioxide, sugar, etc.

**(b) Mixture:** A mixture contains many types of particles. A mixture contains particles of two or more pure substances which may be present in it in any ratio. Hence, their composition is variable. Pure substances forming mixture are called its components. Many of the substances present around you are mixtures. For example, sugar solution in water, air, tea, etc., are all mixtures.  
Two types of mixtures:

(i) Homogeneous mixture

(ii) Heterogeneous mixture

- (i) **Homogeneous mixture:** The components completely mix with each other. This means particles of components of the mixture are uniformly distributed throughout the bulk of the mixture and its composition is uniform throughout. E.g.: Sugar solution, air
- (ii) **Heterogeneous mixture:** In a heterogeneous mixture, the composition is not uniform throughout and sometimes different components are visible. E.g.: mixtures of salt and sugar, grains and pulses along with some dirt (often stone pieces)

## 2. INTRODUCTION:

There are a large number of objects around us which we can see and feel. It was John Dalton who firstly developed a theory on the structure of matter, later on which is known as Dalton's atomic theory.

### 2.1. DALTON'S ATOMIC THEORY:

- (i) Each element is composed of extremely small particles called atoms which can take part in chemical combination.
- (ii) All atoms of a given element are identical i.e., atoms of a particular element are all alike but differ from atoms of other elements.
- (iii) Atoms of different elements possess different properties (including different masses).
- (iv) Atoms are indestructible i.e., atoms are neither created nor destroyed in chemical reactions.
- (v) Atoms of elements combine to form molecules and compounds are formed when atoms of more than one element combine.
- (vi) In a given compound, the relative number and kind of atoms is constant.

**2.2. Atomic mass:** It is the average relative mass of atom of element as compared with times the mass of an atom of carbon-12 isotope.

$$\text{Atomic mass} = \frac{\text{Average mass of an atom}}{1/12 \times \text{Mass of an atom of } C^{12}}$$

$\frac{1}{12}$  of the mass of an atom of carbon-12 equals to  $1.66 \times 10^{-24}$  gm and is also assigned 1amu

**2.3. Gram atomic mass (GAM):** Atomic mass of an element expressed in grams is called Gram atomic mass or gram atom or mole atom.

(i) Number of gram atoms =  $\frac{\text{Mass of an element}}{\text{GAM}}$

(iii) Number of atoms in 1 GAM =  $6.02 \times 10^{23}$

Number of atoms in a given substance = No. of gram atoms  $\times 6.02 \times 10^{23}$

(v) Mass of one atom of the element (in g) =  $\frac{\text{GAM}}{6.02 \times 10^{23}}$

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

**2.4. Molecular mass:** Molecular mass of a molecule, of an element or a compound may be defined as a number which indicates how many times heavier is a molecule of that element or compound as compared with  $\frac{1}{12}$  of the mass of an atom of carbon-12.

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

$$\text{mass of one molecule} = \text{Molecular mass} \times 1.67 \times 10^{-24} \text{ g}$$

Molecular mass of a substance is the additive property and can be calculated by adding the atomic masses of atoms present in one molecule.

**2.5. Gram molecular mass (GMM) :** Molecular mass of an element or compound when expressed in g is called its gram molecular mass, gram molecule or mole molecule.

$$\text{Number of gram molecules} = \frac{\text{Mass of substance}}{\text{GMM}}$$

$$\text{Mass of substance in g} = \text{No. of gram molecules} \times \text{GMM}$$

Element	(Atomic Mass)	(mass of one atom)	Gram Atomic mass
N	14	14 amu	14 gm
He	4	4 amu	4 gm
C	12	12 amu	12 gm

**2.6. Mole**

One mole of any substance contains a fixed number ( $6.023 \times 10^{23}$ ) of any type of particles (atoms or molecules or ions) and has a mass equal to the atomic or molecular weight, in grams. Thus it is correct to refer to a mole of helium, a mole of electrons or a mole of any ion, meaning respectively Avogadro's number of atoms, electrons or ions.

**Methods of Calculations of mole:**

(1) If no. of some species is given, then no. of moles =  $\frac{\text{Given no}}{N_A}$

(2) If weight of a given species is given, then no. of moles =  $\frac{\text{Given wt.}}{\text{Atomic wt.}}$  (for atoms),

or =  $\frac{\text{Given wt.}}{\text{Molecular wt.}}$  (for molecules)

(3) If volume of a gas is given along with its temperature (T) and pressure (P).

$$PV = nRT \quad (n : \text{Number of moles of gas})$$

P (Pressure of gas): Pressure of the gas is the force exerted by the gas per unit area of the walls of the container in all directions.

(PHYSICAL CHEMISTRY)

# MOLE CONCEPT

$$\text{Thus, Pressure (P)} = \frac{\text{Force(F)}}{\text{Area(A)}} = \frac{\text{Mass(m)} \times \text{Acceleration(a)}}{\text{Area(A)}}$$

Name	Symbol	Value
Bar	bar	1 bar = $10^5$ Pa
Atmosphere	atm	1 atm = $1.01325 \times 10^5$ Pa
Torr	Torr	1 Torr = $\frac{101325}{760}$ Pa $\times$ 133.322 Pa
millimeter of mercury	mm Hg	1 mm Hg = 133.322 Pa

V (Volume of gas): Volume is expressed in liters (L), milliliters (mL) or cubic centimeters ( $\text{cm}^3$ ), cubic meters ( $\text{m}^3$ ).

$$1 \text{ m}^3 = 10^3 \text{ dm}^3 = 10^6 \text{ cm}^3 = 10^6 \text{ mL} = 10^3 \text{ L}$$

T (Temperature of gas): S.I. unit of temperature is Kelvin (K).

$$T(\text{K}) = t(^{\circ}\text{C}) + 273.15$$

R (Universal gas constant) : Values of  $R = 0.082 \text{ LatmK}^{-1}\text{mol}^{-1}$

$$= 8.314 \text{ JK}^{-1}\text{mol}^{-1}$$

$$= 1.987 \text{ CalK}^{-1}\text{mol}^{-1}$$

**Note :** 1 mole of atom is also termed as 1 g atom

1 mole of ions is also termed as 1 g ion

1 mole of molecule is also termed as 1 gmolecule

**Ex.1** How much time (in years) would it take to distribute one Avogadro number of wheat grains if  $10^{10}$  grains are distributed each second?

**Ans.**  $1.9 \times 10^6$  years (approx)

**Sol.**  $10^{10}$  grains are distributed in 1 second

$$6.02 \times 10^{23} \text{ grains are distributed in } \frac{6.02 \times 10^{23}}{10^{10}} \text{ sec} = \frac{6.02 \times 10^{23}}{10^{10} \times 60 \times 60 \times 24 \times 365} \text{ years}$$

$$= 1.9 \times 10^6 \text{ years (approx.)}$$

**Ex.2** How many atoms are there in 100 amu of He ?

**Ans.** 25

**Sol.** We know that,  $1 \text{ amu} = \frac{1}{12} \times \text{weight of one } ^{12}\text{C atom}$

or weight of one  $^{12}\text{C atom} = 12 \text{ amu}$  (at. wt. of C = 12 amu).

Similarly, as the atomic weight of He is 4

weight of one He atom = 4 amu.

Thus, the number of atoms in 100 amu of He =  $\frac{100}{4} = 25$ .

**Ex.3** The density of liquid mercury is 13.6 g/cm<sup>3</sup>. How many moles of mercury are there in 1 litre of the metal? (Atomic mass of Hg = 200.)

**Ans.** 68

**Sol.** 1 liter Hg metal

volume = 1000

$$d = \frac{m}{v} \quad \text{mass} = d \times V = 13.6 \times 1000$$

$$\text{No of mole of Hg metal} = \frac{13.6 \times 1000}{200} = 68 \text{ mole}$$

**Ex.4** Calculate the number of molecules in a drop of water weighing 0.09 g.

**Ans.**  $3.01 \times 10^{21}$  molecules of H<sub>2</sub>O

**Sol.** number of mole =  $\frac{0.09}{18}$

$$\text{so number of molecules} = \frac{0.09}{18} \times N_A = 3.01 \times 10^{21}.$$

**Ex.5** A sample of ethane has the same mass as 10.0 million molecules of methane. How many C<sub>2</sub>H<sub>6</sub> molecules does the sample contain?

**Ans.**  $5.34 \times 10^6$

**Sol.** Let the number of C<sub>2</sub>H<sub>6</sub> molecules in the sample be n. As given, mass of C<sub>2</sub>H<sub>6</sub> = mass of 10<sup>7</sup> molecules of CH<sub>4</sub>

$$\frac{n}{N_A} \times \text{mol. wt. of C}_2\text{H}_6 = \frac{10^7}{N_A} \times \text{mol. wt. of CH}_4$$

$$\frac{n}{N_A} \times 30 = \frac{10^7}{N_A} \times 16$$

$$n = 5.34 \times 10^6.$$

**Ex.6** If, from 10 moles NH<sub>3</sub> and 5 moles of H<sub>2</sub>SO<sub>4</sub>, all the H-atoms are removed in order to form H<sub>2</sub> gas, then find the number of H<sub>2</sub> molecules formed.

**Ans.** 20 N<sub>A</sub>

**Sol.** 10 mole NH<sub>3</sub> have mole of 'H' atom = 10 × 3

5 mole of H<sub>2</sub>SO<sub>4</sub> have mole of 'H' atom = 10

Total mole of 'H' atom = 40

mole of H<sub>2</sub> = 20

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

**Ex.7** The weight of 350 mL of a diatomic gas at 0°C and 2 atm pressure is 1 g. The weight of one atom is :

**Ans.** 16 amu

**Sol.**  $PV = nRT$ ;  $n = \frac{PV}{RT}$

$$n = \frac{2 \times 0.350}{0.0821 \times 273} =$$

$$n = \frac{\text{Weight}}{\text{Atomic mass}}$$

Atomic mass = 16 amu

**Ex.8** Oxygen is present in a 1-litre flask at a pressure of  $7.6 \times 10^{-10}$  mm of Hg at 0°C. Calculate the number of oxygen molecules in the flask.

**Ans.**  $0.44 \times 10^{-13}$ .

**Sol.** Pressure =  $7.6 \times 10^{-10}$  mm  
 $= 0.76 \times 10^{-10}$  cm  
 $= \text{atm} (1 \text{ atm} = 76 \text{ cm}) = 10^{-12} \text{ atm}.$

Volume = 1 litre, R = 0.0821 lit. atm/K/mole, temperature = 273 K.

We know that  $PV = nRT$  or  $n = \frac{PV}{RT}$

$$n = \frac{10^{-12} \times 1}{0.082 \times 273} = 0.44 \times 10^{-13}$$

**Ex.9** Equal volumes of oxygen gas and a second gas weigh 1.00 and 2.375 grams respectively under the same experimental conditions. Which of the following is the unknown gas?

(A) NO      (B) SO<sub>2</sub>      (C) CS<sub>2</sub>      (D) CO

**Ans.** (C)

**Sol.** Moles of O<sub>2</sub> = Moles of X(unknown gas)

$$\frac{1}{32} = \frac{2.375}{M_x}$$

$M_x = 76$

## Do yourself-1

1. The number of molecules in 16 g of methane is:
2. A sample of aluminium has a mass of 54.0 g. What is the mass of the same number of magnesium atoms? (At. wt. Al = 27, Mg = 24)  
(A) 12 g (B) 24 g (C) 48 g (D) 96 g
3. Find the total number of H, S and 'O' atoms in the following:  
(i) 196 gm  $\text{H}_2\text{SO}_4$  (ii) 196 amu  $\text{H}_2\text{SO}_4$   
(iii) 5 mole  $\text{H}_2\text{S}_2\text{O}_8$  (iv) 3 molecules  $\text{H}_2\text{S}_2\text{O}_6$ .
4. The volume of a gas at  $0^\circ\text{C}$  and 700 mm pressure is 760 cc. The number of molecules present in this volume is:
5. Four 1-litre flasks are separately filled with the gases  $\text{H}_2$ , He,  $\text{O}_2$  and  $\text{O}_3$  at the same temperature and pressure. The ratio of total number of atoms of these gases present in different flask would be:  
(A) 1 : 1 : 1 : 1 (B) 1 : 2 : 2 : 3 (C) 2 : 1 : 2 : 3 (D) 3 : 2 : 2 : 1
6. The weight of  $2.01 \times 10^{23}$  molecules of CO is—  
(A) 9.3 g (B) 7.2 g (C) 1.2 g (D) 3 g
7. How many moles of e<sup>-</sup> weight one Kg :  
(A)  $6.023 \times 10^{23}$  (B)  $\frac{1}{9.108} \times 10^{31}$  (C)  $\frac{6.023}{9.108} \times 10^{54}$  (D)  $\frac{1}{9.108 \times 6.023} \times 10^8$

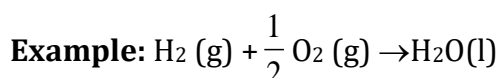
**3. LAWS OF CHEMICAL COMBINATION:**

Antoine Lavoisier, John Dalton and other scientists formulate certain laws concerning the composition of matter and chemical reactions. These laws are known as the law of chemical combination.

**3.1 THE LAW OF CONSERVATION OF MASS:**

It is given by Antoine Lavoisier.

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



Before reaction initially      1 mole     $\frac{1}{2}$  mole

After the reaction              0          0              1 mole

mass before reaction = mass of 1 mole  $\text{H}_2 (\text{g})$  + mass of  $\frac{1}{2}$  mole  $\text{O}_2 (\text{g})$

$$= 2 + 16 = 18 \text{ g}$$

mass after reaction = mass of 1 mole water = 18 g

**3.2 LAW OF CONSTANT OR DEFINITE PROPORTION:**

It is given by Proust. All chemical compounds are found to have constant composition irrespective of their method of preparation or sources.

**Example:** In water ( $\text{H}_2\text{O}$ ), Hydrogen and Oxygen combine in 2 : 1 molar ratio, the ratio remains constant whether it is tap water, river water or sea water or produced by any chemical reaction.

**Ex.10** 1.80 g of a certain metal burnt in oxygen gave 3.0 g of its oxide. 1.50 g of the same metal heated in steam gave 2.50 g of its oxide. Show that these results illustrate the law of constant proportion.

**Sol.** In the first sample of the oxide,

wt. of metal = 1.80 g,

wt. of oxygen = (3.0 – 1.80) g = 1.2 g

$$\frac{\text{wt. of metal}}{\text{wt. of oxygen}} = \frac{1.80\text{g}}{1.2\text{g}} = 1.5$$

In the second sample of the oxide,

$$\frac{\text{wt. of metal}}{\text{wt. of oxygen}} = \frac{1.50\text{g}}{1\text{g}} = 1.5$$

Thus, in both samples of the oxide the proportions of the weights of the metal and oxygen are fixed. Hence, the results follow the law of constant proportion.



## 3.3 THE LAW OF MULTIPLE PROPORTIONS:

It is given by Dalton.

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

**Note:** Simple ratio here means the ratio between small natural numbers, such as 1: 1, 1: 2, 1: 3, Later on this simple ratio becomes the valency and then oxidation state of the element.

**Example:** Carbon and Oxygen when combine, can form two oxides, CO (carbon monoxide), CO<sub>2</sub>(Carbon dioxides)

In CO, 12 g carbon combined with 16 g of oxygen.

In CO<sub>2</sub>, 12 g carbon combined with 32 g of oxygen.

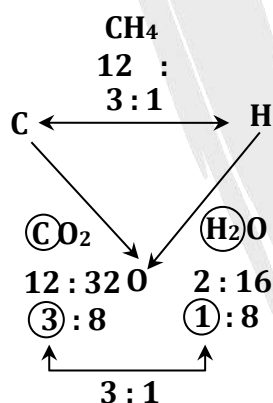
Thus, we can see the mass of oxygen which combine with a constant mass of carbon (12 g) bear simple ratio of 16 : 32 or 1 : 2.

## 3.4 LAW OF RECIPROCAL PROPORTION:

It is given by Richter.

The ratio of the weights of two elements A and B which combine separately with a fixed weight of the third element C is either the same or simple ratio of the weights in which A and B combine directly with each other.

**Example:**



**Ex.11** Ammonia contains 82.35% of nitrogen and 17.65% of hydrogen. Water contains 88.90% of oxygen and 11.10% of hydrogen. Nitrogen trioxide contains 63.15% of oxygen and 36.85% of nitrogen. Show that these data illustrate the law of reciprocal proportions.

**Sol.** In NH<sub>3</sub>, 17.65g of H combine with N = 82.35g

$$1 \text{ g of H combine with N} = \frac{82.35}{17.65} \text{ g} = 4.67 \text{ g}$$

In H<sub>2</sub>O, 11.10 g of H combine with O = 88.90 g

$$1 \text{ g of H combine with O} = \frac{88.90}{11.10} \text{ g} = 8.01 \text{ g}$$

Ratio of the weights of N and O which combine with fixed weight (=1g) of H

$$= 4.67 : 8.01 = 1 : 1.7$$

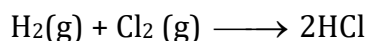
In  $\text{N}_2\text{O}_3$ , ratio of weights of N and O which combine with each other = 36.85 : 63.15

$$= 1 : 1.7$$

Thus the two ratios are the same. Hence it illustrates the law of reciprocal proportions.

### 3.5 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 in the same temperature and pressure



1 vol    1 vol    2 vol

### 3.6 AVOGADRO'S HYPOTHESIS:

Equal volumes of polyatomic all gases have equal number of molecules (not atoms) at same temperature and pressures conditions.

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

At S.T.P. condition:

Temperature =  $0^\circ\text{C}$  or 273 K

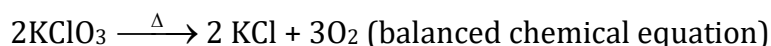
Pressure = 1 bar

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

## 4. STOICHIOMETRY AND STOICHIOMETRIC CALCULATIONS

The word 'stoichiometry' is derived from two Greek words — stoicheion (meaning, element) and metron (meaning, measure). Stoichiometry, thus, deals with the calculation of masses (sometimes volumes also) of the reactants and the products involved in a chemical reaction

**Example:** When potassium chlorate ( $\text{KClO}_3$ ) is heated it gives potassium chloride ( $\text{KCl}$ ) and oxygen ( $\text{O}_2$ ).



- Remember a balanced chemical equation is one which contains an equal number atoms of each element on both sides of equation.

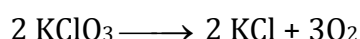
**4.1 Interpretation of balanced chemical equations:**

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

- (a) Mass - mass analysis
- (b) Mass - volume analysis
- (c) Mole - mole analysis
- (a) **Mole - mole analysis:**

This analysis is very much important for quantitative analysis point of view.

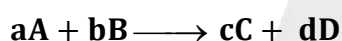
Now consider again the decomposition of  $\text{KClO}_3$ .



In very first step of mole-mole analysis you should read the balanced chemical equation like **2 moles  $\text{KClO}_3$  on decomposition gives you 2 moles  $\text{KCl}$  and 3 moles  $\text{O}_2$**  and from the stoichiometry of reaction we can write

$$\frac{\text{Moles of } \text{KClO}_3}{2} = \frac{\text{Moles of } \text{KCl}}{2} = \frac{\text{Moles of } \text{O}_2}{3}$$

Now for any general balance chemical equation like



you can write.

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

**(b) Mass - mass analysis:**

Consider the reaction  $2 \text{KClO}_3 \longrightarrow 2\text{KCl} + 3\text{O}_2$  According to stoichiometry of the reaction mass-mass ratio :  $2 \times 122.5 : 2 \times 74.5 : 3 \times 32$

$$\text{or } \frac{\text{Mass of } \text{KClO}_3}{\text{Mass of } \text{KCl}} = \frac{2 \times 122.5}{2 \times 74.5} \quad \frac{\text{Mass of } \text{KClO}_3}{\text{Mass of } \text{O}_2} = \frac{2 \times 122.5}{3 \times 32}$$

**Ex.12** Consider the balanced reaction



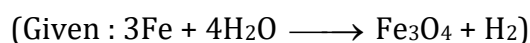
What can be concluded from the coefficients of species in this balanced equation?

- (A) For this reaction, exactly 2 g of  $\text{Cl}_2\text{O}_7$  must be taken to start the reaction
- (B) For this reaction, exactly 2 mol of  $\text{Cl}_2\text{O}_7$  must be taken to start the reaction
- (C) Mole ratio of  $\text{Cl}_2\text{O}_7$ ,  $\text{ClO}_2$  and  $\text{O}_2$  during a chemical reaction at any instant (excluding any negative sign) are 2, 4 and 3 respectively
- (D) The ratio of change in number of moles of  $\text{Cl}_2\text{O}_7$ ,  $\text{ClO}_2$  and  $\text{O}_2$  is 2 : 4 : 3 (excluding any negative sign)

**Ans.** (D)

**Sol.** It follows directly from definition of stoichiometry.

**Ex.13** Calculate the weight of iron which will be converted into its oxide by the action of 36 g of steam.



**Ans.** 84 g

**Sol.** Mole ratio of reaction suggests,

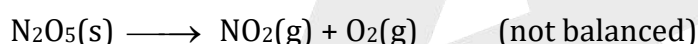
$$\text{Mole of Fe} = \frac{3}{4} \text{ mol of H}_2\text{O}$$

$$= \frac{3}{4} \times \frac{36}{18} = \frac{3}{2}$$

$$\text{wt. of Fe} = \frac{3}{2} \times 56 = 84 \text{ g}$$

**Ex.14** When Dinitrogen pentaoxide ( $\text{N}_2\text{O}_5$ , a white solid) is heated, it decomposes into nitrogen dioxide and oxygen.

If a sample of  $\text{N}_2\text{O}_5$  produces 1.6 g  $\text{O}_2$ , then how many grams of  $\text{NO}_2$  are formed ?



(A) 9.2 g                      (B) 4.6 g                      (C) 2.3 g                      (D) 18.4 g

**Ans.** (A)

**Sol.**  $\text{N}_2\text{O}_5(\text{s}) \longrightarrow 2\text{NO}_2(\text{s}) + \frac{1}{2} \text{O}_2$  (Balanced reaction)

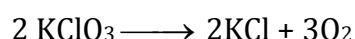
$$\frac{\text{Mole of O}_2}{1/2} = \frac{\text{Mole of NO}_2}{2}$$

$$\frac{1.6}{32} \times 2 \times 2 = \text{Mole of NO}_2 = 0.2$$

$$\text{wt of NO}_2 = 0.2 \times 46 = 9.2 \text{ g.}$$

**(c) Mass - volume analysis :**

Now again consider decomposition of  $\text{KClO}_3$



mass volume ratio :  $2 \times 122.5 \text{ g} : 2 \times 74.5 \text{ g} : 3 \times 22.4 \text{ L at STP}$

we can use two relation for volume of oxygen

$$\frac{\text{Mass of KClO}_3}{\text{volume of O}_2 \text{ at STP}} = \frac{2 \times 122.5 \text{ g}}{3 \times 22.4 \text{ L}} \quad \dots(\text{i})$$

$$\text{and } \frac{\text{Mass of KCl}}{\text{volume of O}_2 \text{ at STP}} = \frac{2 \times 74.5 \text{ g}}{3 \times 22.4 \text{ L}} \quad \dots(\text{ii})$$

**Ex.15** When oxygen gas is passed through Siemen's ozoniser, it completely gets converted into ozone gas. The volume of ozone gas produced at 1 atm and 273K, if initially 96 g of oxygen gas was taken, is :

(A) 44.8 L

(B) 89.6 L

(C) 67.2 L

(D) 22.4 L

**Ans.** (A)

**Sol.**  $3\text{O}_2 \longrightarrow 2\text{O}_3$

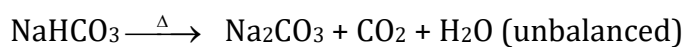
$$\text{Mole} = \frac{96}{32} = 3 \quad \text{mole} = 2$$

Volume of  $\text{O}_3$  gas at 1 atm and 273K =  $2 \times 22.4 = 44.8$  L

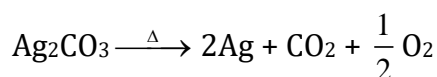


## Do yourself-2

1. Assuming 100% yield of the reaction, how many moles of  $\text{NaHCO}_3$  will produce 448 mL of  $\text{CO}_2$  gas at STP according to the reaction :



- (A) 0.04                      (B) 0.4                      (C) 4                      (D) 40
2. Calculate the residue obtained on strongly heating 2.76 g  $\text{Ag}_2\text{CO}_3$ .



3. For the reaction  $2\text{P} + \text{Q} \longrightarrow \text{R}$ , 4 mol of P and excess of Q will produce :

(A) 8 mol of R              (B) 5 mol of R              (C) 2 mol of R              (D) 1 mol of R

4. If 1.5 moles of oxygen combine with Al to form  $\text{Al}_2\text{O}_3$ , the weight of Al used in the reaction is:

(A) 27 g                      (B) 40.5 g                      (C) 54g                      (D) 81 g

5. How many liters of  $\text{CO}_2$  at STP will be formed when 0.01 mol of  $\text{H}_2\text{SO}_4$  reacts with excess of  $\text{Na}_2\text{CO}_3$ .



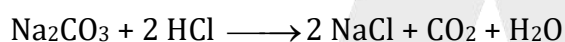
(A) 22.7 L                      (B) 2.27 L                      (C) 0.227 L                      (D) 1.135 L

## 4.2 LIMITING REAGENT:

Many a time, reactions are carried out with the amounts of reactants that are different than the amounts as required by a balanced chemical reaction. In such situations, one reactant is in more amount than the amount required by balanced chemical reaction. The reactant which is present in the least amount gets consumed after sometime and after that further reaction does not take place whatever be the amount of the other reactant. Hence, the reactant, which gets consumed first, limits the amount of product formed and is, therefore, called the limiting reagent.

The reactant which consumed first into the reaction when we 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 should be limiting reactant.

**Ex.16** Six mole of  $\text{Na}_2\text{CO}_3$  is reacted with 4 moles of  $\text{HCl}$  solution. Find the volume of  $\text{CO}_2$  gas produced at STP. The reaction is



**Sol.** From the reaction :



gives moles

3 mol      6 mol

given mole ratio

1 : 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.

**How to find limiting reagent:****Step : I**

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

**Step : II**

See for which reactant this division comes out to be minimum. The reactant having minimum value is limiting reagent.

**Step : III**

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

From

Step I & II

$\text{Na}_2\text{CO}_3$

$\text{HCl}$

$$\frac{6}{1} = 6$$

$$\frac{4}{2} = 2 \text{ (Division in minimum)}$$

- $\text{HCl}$  is limiting reagent

From Step III

$$\text{From } \frac{\text{Mole of HCl}}{2} = \frac{\text{Mole of CO}_2 \text{ produced}}{1}$$

- Mole of CO<sub>2</sub> produced = 2 moles
- Volume of CO<sub>2</sub> produced at S.T.P. = 2 × 22.7 = 45.4 L

**Ex.17** 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 :

- (A) 0.5                      (B) 0.6                      (C) 0.48                      (D) 4.64

**Ans.** (C)

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

Initial mole 2      1.2      1.44      0

final mole                      0      0.48

C is limiting reagent.

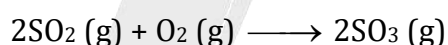
moles of A<sub>4</sub>B<sub>2</sub>C<sub>3</sub> is 0.48.

**Ex.18** A 5 g mixture of SO<sub>2</sub> and O<sub>2</sub> gases is reacted to form SO<sub>3</sub> gas. What should be the mass ratio of SO<sub>2</sub> and O<sub>2</sub> gases in mixture to obtain maximum amount of SO<sub>3</sub> gas :

- (A) 4 : 1                      (B) 3 : 2                      (C) 2 : 3                      (D) 1 : 4

**Ans.** (A)

**Sol.** For maximum amount of product, the reactants should be present in their stoichiometric ratio.



mass    x                      5 - x

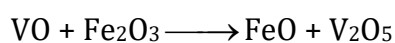
mole     $\frac{x}{64}$                        $\frac{5-x}{32}$

$$\text{So, } \frac{\left(\frac{x}{64}\right)}{\left(\frac{5-x}{32}\right)} = 2 : 1$$

Therefore, x = 4

m<sub>SO2</sub> : m<sub>O2</sub> = 4 : 1.

**Ex.19** Calculate the weight of FeO from 4 g VO and 5.75 g of Fe<sub>2</sub>O<sub>3</sub>. Also report the limiting reactant.



**Ans.** Weight of FeO formed = 5.17 g

**Sol.** Balanced equation                       $2VO + 3Fe_2O_3 \rightarrow 6FeO + V_2O_5$



(PHYSICAL CHEMISTRY)

MOLE CONCEPT

Moles before reaction	$\frac{4}{67}$	$\frac{5.75}{160}$	0	0
=	0.05970	0.03590		
Moles after reaction	$(0.05970 - 0.0359)$	0	$\left(\frac{6}{5} \times 0.0359\right)$	$\left(\frac{1}{3} \times 0.0359\right)$

As 2 moles of VO react with 3 moles of  $\text{Fe}_2\text{O}_3$

- 0.05970 g moles of VO =  $\frac{3}{2} \times 0.05970 = 0.08955$  moles of  $\text{Fe}_2\text{O}_3$

Moles of  $\text{Fe}_2\text{O}_3$  available = 0.0359 only

Hence,  $\text{Fe}_2\text{O}_3$  is the limiting reagent.

Moles of FeO formed =  $\frac{6}{3} \times 0.0359$

- Weight of FeO formed =  $0.0359 \times 2 \times 72 = 5.17$  g

$$\left( \frac{n_{\text{FeO}}}{n_{\text{Fe}_2\text{O}_3}} = \frac{6}{3} \right) = n_{\text{FeO}} = \frac{6}{3} \times n_{\text{Fe}_2\text{O}_3}$$

## Do yourself-3

1. The reaction



is carried out by taking 24 g of carbon and 128 g of  $O_2$ .

Find out :

(i) Which reactant is left in excess?

(ii) How much of it is left?

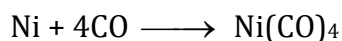
(iii) How many moles of CO are formed?

(iv) How many grams of other reactant should be taken so that nothing is left at the end of reaction?

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

3. Calculate the amount of Ni needed in the Mond's process given below



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

4. 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

5. The mass of  $Na_2SO_4$  produced from 196 gram of  $H_2SO_4$  and 1 mole of NaOH.

(A) 49 g                      (B) 98 g                      (C) 61 g                      (D) 34.3 g

## 4.3 PRINCIPLE OF ATOM CONSERVATION (POAC):

Infect POAC is nothing but the conservation of mass, expressed before in the concepts of atomic theory. And if atoms are conserved, moles of atoms shall also be conserved.

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

This principle can be under stand by the following example.

Consider the decomposition of  $\text{KClO}_3 (\text{s}) \longrightarrow \text{KCl} (\text{s}) + \text{O}_2 (\text{g})$  (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  $\text{KClO}_3$  = moles of K atoms in KCl

Now, since 1 molecule of  $\text{KClO}_3$  contains 1 atom of K

or 1 mole of  $\text{KClO}_3$  contains 1 mole of K, similarly 1 mole of KCl contains 1 mole of K

Thus, moles of K atoms in  $\text{KClO}_3 = 1 \times \text{moles of } \text{KClO}_3$

and moles of K atoms in KCl =  $1 \times \text{moles of KCl}$

- moles of  $\text{KClO}_3$  = moles of KCl

$$\text{or } \frac{\text{wt. of } \text{KClO}_3 \text{ in g}}{\text{mol. wt. of } \text{KClO}_3} = \frac{\text{wt. of KCl in g}}{\text{mol. wt. of KCl}}$$

- \* The above equation gives the mass-mass relationship between  $\text{KClO}_3$  and KCl which is important in stoichiometric calculations.

Again, applying the principle of atom conservation for O atoms,

moles of O in  $\text{KClO}_3 = 3 \times \text{moles of } \text{KClO}_3$

moles of O in  $\text{O}_2 = 2 \times \text{moles of } \text{O}_2$

- $3 \times \text{moles of } \text{KClO}_3 = 2 \times \text{moles of } \text{O}_2$

$$\text{or } \frac{\text{wt. of } \text{KClO}_3}{\text{mol. wt. of } \text{KClO}_3} = 2 \times \frac{\text{vol. of } \text{O}_2 \text{ at NTP}}{\text{standard molar vol. (22.4 lt)}}$$

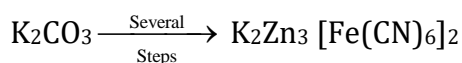
The above equations thus give the mass-volume relationship of reactants and products.

**Ex.20** 27.6g  $\text{K}_2\text{CO}_3$  was treated by a series of reagents so as to convert all of its carbon to  $\text{K}_2\text{Zn}_3 [\text{Fe}(\text{CN})_6]_2$ . Calculate the weight of the product.

[mol. wt. of  $\text{K}_2\text{CO}_3 = 138$  and mol. wt. of  $\text{K}_2\text{Zn}_3 [\text{Fe}(\text{CN})_6]_2 = 698$ ]

**Ans.** 11.6 g

**Sol.** Here we have not knowledge about series of chemical reactions but we known about initial reactant and final product accordingly



## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

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

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

$1 \times \text{moles of } K_2CO_3 = 12 \times \text{moles of } K_2Zn_3 [Fe(CN)_6]_2$

(Q 1 mole of  $K_2CO_3$  contains 1 moles of C)

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

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

**Ex.21** In a gravimetric determination of P of an aqueous solution of dihydrogen phosphate in  $H_2PO_4^-$  is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate,  $Mg(NH_4)PO_4 \cdot 6H_2O$ . This is heated and decomposed to magnesium pyrophosphate,  $Mg_2P_2O_7$ . A solution of  $H_2PO_4^-$  yielded 2.054 g of  $(Mg_2P_2O_7)$ . What weight of  $NaH_2PO_4$  was present originally?

**Ans.** 2.22 g

**Sol.**  $NaH_2PO_4 + Mg^{2+} + NH_4^+ + \frac{3}{4} Mg(NH_4)PO_4 \cdot 6H_2O \xrightarrow{\Delta} Mg_2P_2O_7$

As P atoms are conserved, applying POAC for P atoms, moles of P in  $NaH_2PO_4$  = Moles of P in  $Mg_2P_2O_7$

•  $1 \times \text{Moles of } NaH_2PO_4 = 2 \times \text{Moles of } Mg_2P_2O_7$

$$\bullet \frac{W_{NaH_2PO_4}}{M_{NaH_2PO_4}} = 2 \times \frac{W_{Mg_2P_2O_7}}{M_{Mg_2P_2O_7}} \Rightarrow \frac{W_{NaH_2PO_4}}{120} = 2 \times \frac{2.054}{222}$$

•  $W_{NaH_2PO_4} = 2.22 \text{ g}$

#### 4.4 PERCENTAGE YIELD:

In general, in any chemical reaction, the amount of product formed is always less than the calculated amount due to reversibility in the chemical reaction. Therefore, yield of a chemical reaction (Y) comes into picture and is given by :

$$\text{The percentage yield of product} = \frac{\text{actual yield}}{\text{the theoretical maximum yield}} \times 100$$

**Ex.22** 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 %

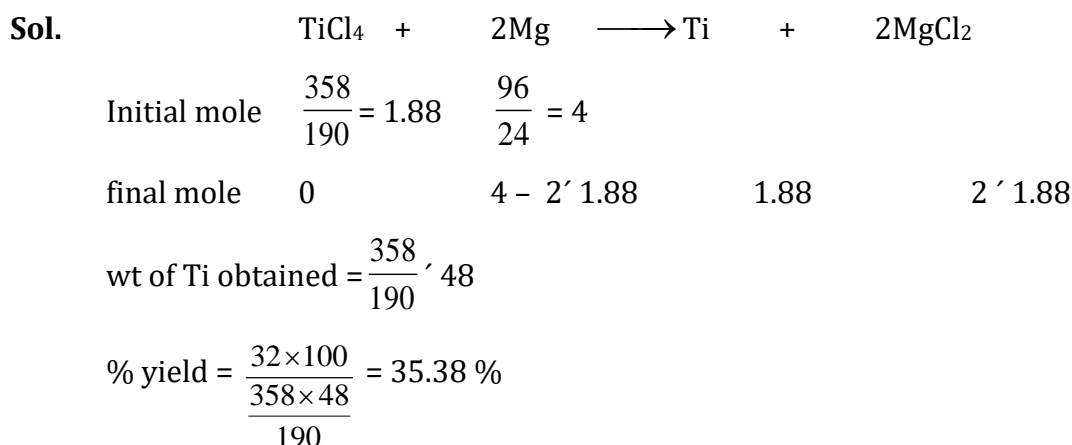
(C) 100 %

(D) 60 %

**Ans.** (A)

## (PHYSICAL CHEMISTRY)

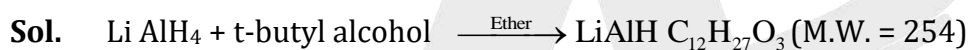
## MOLE CONCEPT



**Ex.23** 0.05 mole of  $\text{LiAlH}_4$  in ether solution was placed in a flask containing 74g (1 mole) of t-butyl alcohol. The product  $\text{LiAlHC}_{12}\text{H}_{27}\text{O}_3$  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%

**Ans.** (C)



0.05 mole 12.7 gram

$$= \frac{12.7}{254} = 0.05 \text{ mole}$$

Li atom remain conserved so

No. of mole of  $\text{LiAlH}_4$  = No. of mole of  $\text{LiAlHC}_{12}\text{H}_{27}\text{O}_3$

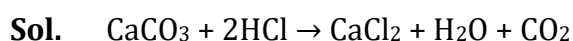
So No. of mole of  $\text{LiAlHC}_{12}\text{H}_{27}\text{O}_3 = 0.05$

$$\% \text{ yield} = \frac{0.05}{0.05} \times 100 = 100\%$$

#### 4.5 PERCENTAGE PURITY:

**Ex.24** How much marble of 90.5 % purity would be required to prepare 10 litres of  $\text{CO}_2$  at 1 atm,  $0^\circ\text{C}$  when the marble is acted upon by dilute HCl ?

**Ans.** 49.326 g



100 g 22.4 litre

22.4 L of  $\text{CO}_2$  at STP will be obtained from 100 g of  $\text{CaCO}_3$

- 10 L of  $\text{CO}_2$  will be obtained from pure  $\text{CaCO}_3 = \frac{100}{22.4} \times 10 = 44.64 \text{ g}$
- Impure marble required =  $\frac{100}{90.5} \times 44.64 = 49.326 \text{ g}$

## (PHYSICAL CHEMISTRY)

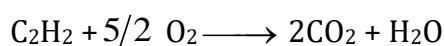
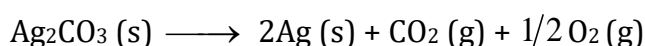
## MOLE CONCEPT

## 4.6 SEQUENTIAL REACTIONS:

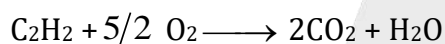
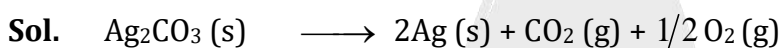
This reaction is defined as that reaction which proceeds from reactants to final products through one or more intermediate stages. The overall reaction is a result of several successive or consecutive steps.

Example:  $A \rightarrow B \rightarrow C$

**Ex.25** Minimum amount of  $\text{Ag}_2\text{CO}_3$  (s) required to produce sufficient oxygen for the complete combustion of  $\text{C}_2\text{H}_2$  which produces 11.2 L of  $\text{CO}_2$  at 1 atm and 273K after combustion is: [Ag = 108]



**Ans.** 345 g



By Stoichiometry of reaction

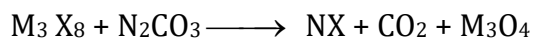
$$\text{Moles of CO}_2 \text{ formed} = \frac{11.2}{22.4} = \frac{1}{2}$$

$$\text{Moles of O}_2 \text{ required} = \frac{5}{4} \times \frac{1}{2} = \frac{5}{8}$$

$$\text{Moles of Ag}_2\text{CO}_3 \text{ required} = 2 \times \frac{5}{8} = \frac{5}{4}$$

$$\text{Mass of Ag}_2\text{CO}_3 \text{ required} = \frac{5}{4} \times 276 = 345 \text{ g}$$

**Ex.26** NX is produced by the following step of reactions

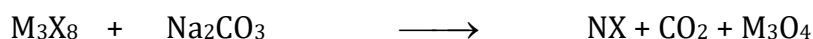
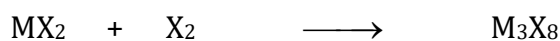


How much M (metal) is consumed to produce 206 g of NX.

(Take at wt of M = 56, N=23, X = 80)

(A) 42 g                      (B) 56 g                      (C) 52g                      (D) 64 g

**Ans.** (A)



$$\text{mole of NX} = \frac{206}{103} = 2$$

POAC for X Atom :

$$\text{No. of X atom in } M_3X_8 = \text{No. of X Atom in NX}$$

$$8 [\text{No. of mole of } M_3X_8] = 1 [\text{No. of mole of NX}]$$

$$\text{No. of mole of } M_3X_8 = \left[ \frac{2}{8} \right] = \frac{1}{4} \text{ mole}$$

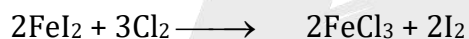
Now POAC for M Atom

$$3 [\text{No. of mole of } M_3X_8] = 1 \times [\text{No. of Mole of M}]$$

$$3 \times \frac{1}{4} = \text{No. of mole of M}$$

$$\text{weight of M atom} = \frac{3}{4} \times 56 = 42 \text{ gram}$$

**Ex.27** The following process has been used to obtain iodine from oil-field brines in California.

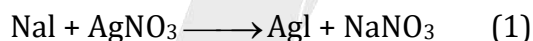


How many grams of  $AgNO_3$  are required in the first step for every 254 kg  $I_2$  produced in the third

- (A) 340 kg                      (B) 85 kg                      (C) 68 kg                      (D) 380 kg

**Ans.** (A)

**Sol.** Balanced equation :



From (3)

$$\frac{\text{mole of } I_2}{2} = \frac{\text{mole of } FeI_2}{2}$$

$$\frac{\text{mole of } FeI_2}{1} = \frac{\text{mole of } AgI}{2}$$

$$\frac{\text{mole of } AgI}{1} = \frac{\text{mole of } AgNO_3}{1}$$

$$\text{mole of } I_2 = (\text{mole of } FeI_2)$$

$$= \left( \frac{\text{mole of } AgI}{2} \right) = \left( \frac{\text{mole of } AgNO_3}{2} \right)$$

$$\frac{254 \times 10^3}{254} = \frac{\text{mole of AgNO}_3}{2}$$

$$2 \times 10^3 = \text{mole of AgNO}_3 = \frac{\text{mass of AgNO}_3}{\text{molar mass of AgNO}_3}$$

$$\text{mass of AgNO}_3 = 170 \times (2 \times 10^3) \text{ g} = 340 \times 10^3 \text{ g} = 340 \text{ kg.}$$

#### 4.7 PARALLEL REACTIONS:

The reactions in which a substance reacts or decomposes in more than one way are called parallel or side reactions.

Example:  $A \longrightarrow B$

$A \longrightarrow C$

**Ex.28** Find out moles of  $\text{CO}_2$  &  $\text{CO}$  produced by combustion of 2 mol carbon with 1.25  $\text{O}_2$  leaving number residue:

**Ans.**  $\text{CO}_2 = 0.5 \text{ mol}, \text{CO}_2 = 1.5 \text{ mol}$

**Sol.**  $\text{C} + \text{O}_2 \longrightarrow \text{CO}_2$

x    x                    x

$\text{C} + \frac{1}{2} \text{O}_2 \longrightarrow \text{CO}$

$2-x \quad \frac{2-x}{2} \quad 2-x$

$$x + 1 - \frac{x}{2} = 1.25$$

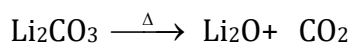
$$\frac{x}{2} = \frac{125}{100}$$

$$x = 0.5 \text{ mol}, \quad \text{CO}_2 = 0.5 \text{ mol}, \text{CO}_2 = 1.5 \text{ mol}$$

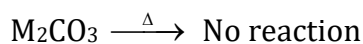
#### 4.8 MIXTURE ANALYSIS:

The analysis of a chemical reaction is generally carried out in the form of mass of reacting species taking part in a given reaction (gravimetric analysis) or in terms of concentrations of reacting species taking part in a given reaction (volumetric analysis). In Gravimetric Analysis, we generally analyse reactions such as : decomposition of compounds under heat to produce a residue and a gas, or displacement reactions, action of acids on metals, or simple balanced chemical equations involving Weight (solid) – Volume (gas) relationships. In Volumetric Analysis, we generally analyse Neutralisation and Redox Titrations involving aqueous solutions in general.

- (i) Except Li carbonates of all the alkali metals are thermally stable and does not decompose on heating.

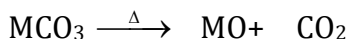




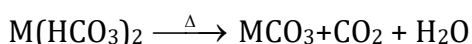


(M = Na, K, Rb, Cs)

- (ii) All the carbonates of alkaline earth metals are thermally unstable and decompose on heating as follow.



- (iii) Bicarbonates of both alkali metals and alkaline earth metals are decomposed at relatively low temperature as follow.



**Ex.29** A sample of 3 g containing  $Na_2CO_3$  and  $NaHCO_3$  loses 0.248 g when heated to  $300^\circ C$ , the temperature at which  $NaHCO_3$  decomposes to  $Na_2CO_3$ ,  $CO_2$  and  $H_2O$ . What is the percentage of  $Na_2CO_3$  in the given mixture?

**Ans.** 77.48%

**Sol.** The loss in weight is due to removal of  $CO_2$  and  $H_2O$  which escape out on heating.

wt. of  $Na_2CO_3$  in the product =  $3.00 - 0.248 = 2.752$  g

Let wt. of  $Na_2CO_3$  in the mixture be x g

wt. of  $NaHCO_3 = (3.00 - x)$  g

Since  $Na_2CO_3$  in the products contains x g of unchanged reactant  $Na_2CO_3$  and rest produced from  $NaHCO_3$ .

The wt. of  $Na_2CO_3$  produced by  $NaHCO_3 = (2.752 - x)$ g



(3.0 - x)            (2.752 - x)

Applying POAC for Na atom

$$1 \times \text{moles of } NaHCO_3 = 2 \times \text{moles of } Na_2CO_3 \Rightarrow \frac{(3-x)}{84} = 2x \frac{(2.752-x)}{106}$$

$$x = 2.3244 \text{ g}$$

$$\% \text{ of } Na_2CO_3 = \frac{2.3244}{3} \times 100 = 77.48\%$$

**Ex.30** 10 g of a sample of a mixture of  $CaCl_2$  and  $NaCl$  is treated to precipitate all the calcium as  $CaCO_3$ . This  $CaCO_3$  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 %

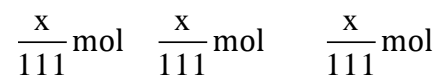
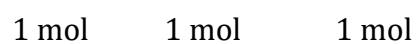
**Ans.** (A)

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

**Sol.**  $\text{CaCl}_2 + \text{NaCl} = 10 \text{ g}$

Let weight of  $\text{CaCl}_2 = x \text{ g}$



$$\text{Mole of CaO} = \frac{1.62}{56}$$

$$\frac{x}{111} = \frac{1.62}{56}$$

$$x = 3.21 \text{ g}$$

$$\% \text{ of CaCl}_2 = \frac{3.21}{10} \times 100 = 32.1 \%$$

## Do yourself-4

- 3.0 g an impure sample of sodium sulphate dissolved in water was treated with excess of barium chloride solution when 1.74 g of  $\text{BaSO}_4$  was obtained as dry precipitate. Calculate the percentage purity of sample.
- If the percentage yield of given reaction is 30%, how many total moles of the gases will be produced, if 8 moles of  $\text{NaNO}_3$  are taken initially :  

$$\text{NaNO}_3 (\text{s}) \rightarrow \text{Na}_2\text{O} (\text{s}) + \text{N}_2 (\text{g}) + \text{O}_2 (\text{g}) \quad (\text{unbalanced})$$

(A) 4.2 mole                      (B) 2.4 mole                      (C) 4.8 mole                      (D) 2.1 mole
- A 5 g mixture of  $\text{SO}_2$  and  $\text{O}_2$  gases is reacted to form  $\text{SO}_3$  gas. What should be the mass ratio of  $\text{SO}_2$  and  $\text{O}_2$  gases in mixture to obtain maximum amount of  $\text{SO}_3$  gas :  

(A) 4 : 1                      (B) 3 : 2                      (C) 2 : 3                      (D) 1 : 4
- 25.4 g of iodine and 14.2g of chlorine are made to react completely to yield a mixture of  $\text{ICl}$  and  $\text{ICl}_3$ . Calculate the number of moles of  $\text{ICl}$  and  $\text{ICl}_3$  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
- When 1 mole of A reacts with  $\frac{1}{2}$  mole of  $\text{B}_2$  ( $\text{A} + \frac{1}{2} \text{B}_2 \rightarrow \text{AB}$ ), 100 Kcal heat is liberated and when 1 mole of A reacted with 2 mole of  $\text{B}_2$  ( $\text{A} + 2\text{B}_2 \rightarrow \text{AB}_4$ ), 200 Kcal heat is liberated. When 1 mole of A is completely reacted with excess, of  $\text{B}_2$  to form AB as well as  $\text{AB}_4$ , 140 Kcal heat is liberated calculate the mole of  $\text{B}_2$  used.  
 [Write your answer as number of mole of  $\text{B}_2$  used  $\times 10$ ]
- A solid mixture weighing 5.00 g containing lead nitrate and sodium nitrate was heated below  $600^\circ\text{C}$  until the mass of the residue was constant. If the loss of mass is 30 %, find the mass of lead nitrate and sodium nitrate in mixture.  

$$2\text{Pb}(\text{NO}_3)_2 \xrightarrow{\Delta} 2\text{PbO} + 4\text{NO}_2 + \text{O}_2$$

$$2\text{NaNO}_3 \xrightarrow{\Delta} 2\text{NaNO}_2 + \text{O}_2$$

(At. wt. of Pb = 207, Na = 23, N = 14, O = 16)

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

## 5. DENSITY:

It is of two type.

1. Absolute density    2. Relative density

## (a) For liquid and solids

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

$$\text{Relative density or specific gravity} = \frac{\text{density of the substance}}{\text{density of water at } 4^{\circ}\text{C}}$$

## (b) For gasses:

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

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

Relative density and Vapour density:

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

$$\text{Vapour density} = \frac{d_{\text{gas}}}{d_{\text{H}_2}} = \frac{PM_{\text{gas}} / RT}{PM_{\text{H}_2} / RT}$$

$$\text{V.D.} = \frac{M_{\text{gas}}}{M_{\text{H}_2}} = \frac{M_{\text{gas}}}{2} \Rightarrow \boxed{M_{\text{gas}} = 2\text{V.D.}}$$

**Ex.31** Find the relative density of  $\text{SO}_3$  gas with respect to methane :

- (A) 8                      (B) 3.5                      (C) 2.5                      (D) 5

**Ans.** (D)

$$\text{Sol. } \text{R.D.} = \frac{M_{\text{SO}_3}}{M_{\text{CH}_4}} = \frac{80}{16} = 5.$$

**Ex.32** The atomic mass of a metal is 27 u. If its valency is 3, the vapour density of the volatile metal chloride will be:

- (A) 66.75                      (B) 321                      (C) 267                      (D) 80.25

**Ans.** (A)

**Sol.** Element must be Al

$$\text{Hence, volatile chloride will be } \text{AlCl}_3 \text{ so } \text{V.D.} = \frac{M_{\text{AlCl}_3}}{2} = \frac{133.5}{2} = 66.75$$

**Ex.33** The density of water at  $4^{\circ}\text{C}$  is  $1 \times 10^3 \text{ kg m}^{-3}$ . Assuming no empty space to be present between water molecules, the volume occupied by one molecule of water is approximately :

- (A)  $3 \times 10^{-23} \text{ mL}$     (B)  $6 \times 10^{-23} \text{ mL}$     (C)  $3 \times 10^{-22} \text{ mL}$     (D)  $6 \times 10^{-22} \text{ mL}$

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

Ans. (A)

Sol.  $1 \times 10^3 \text{ kg/m}^3 = 1 \text{ g/mL}$ . [Since,  $1 \text{ m}^3 = 10^6 \text{ cm}^3 = 10^6 \text{ mL}$ .]  
 $= 1 \text{ gm/cc}$

$6.022 \times 10^{23} \text{ H}_2\text{O}$  molecule weigh ...18 g

1  $\text{H}_2\text{O}$  molecule weigh ..  $\frac{18}{6.022 \times 10^{23}} \text{ g} = 3 \times 10^{-23} \text{ g}$

$d = \frac{\text{mass}}{\text{volume}}$ , So,  $\text{volume} = \frac{3 \times 10^{-23} \text{ g}}{1 (\text{g/mL})} = 3 \times 10^{-23} \text{ mL}$ .

## 6. AVERAGE/ MEAN ATOMIC MASS :

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

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

Where :  $a_1, a_2, a_3 \dots$  atomic mass of isotopes.

and  $x_1, x_2, x_3 \dots$  mole % of isotopes.

**Ex.34** Naturally occurring chlorine is 75.53%  $\text{Cl}^{35}$  which has an atomic mass of 34.969 amu and 24.47%  $\text{Cl}^{37}$  which has a mass of 36.966 amu. Calculate the average atomic mass of chlorine -

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

Sol. (A) Average atomic mass =

$(\% \text{ of I isotope} \times \text{Its atoms mass}) + (\% \text{ II isotope} \times \text{its atomic mass}) / 100$

$$= \frac{75.53 \times 34.969 + 24.47 \times 36.96}{100}$$

= 35.5 amu.

## 6.1 AVERAGE MOLAR MASS OR AVERAGE GRAM MOLECULAR MASS:

The average molar mass of the different substance present in the container

$$= \frac{n_1M_1 + n_2M_2 + \dots + n_nM_n}{n_1 + n_2 + \dots + n_n}$$

Where :  $M_1, M_2, M_3 \dots$  are molar masses.

$n_1, n_2, n_3 \dots$  moles of substances.

Average molecule wt. =  $\frac{\sum n_i M_i}{\sum n_i}$  where  $n_i$  = no. of moles of compound,  $m_i$  = molecular mass of compound

**Ex.35** The molar composition of polluted air is as follows :

Gas	mole percentage composition
Oxygen	16%

Nitrogen	80%
Carbon dioxide	03%
Sulphurdioxide	01%

What is the average molecular weight of the given polluted air ?

**Ans.** 29.48

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

## 6.2 DEGREE OF DISSOCIATION (A):

Degree of dissociation represents the fraction of one mole dissociated into the products.

(Defined for one mole of substance)

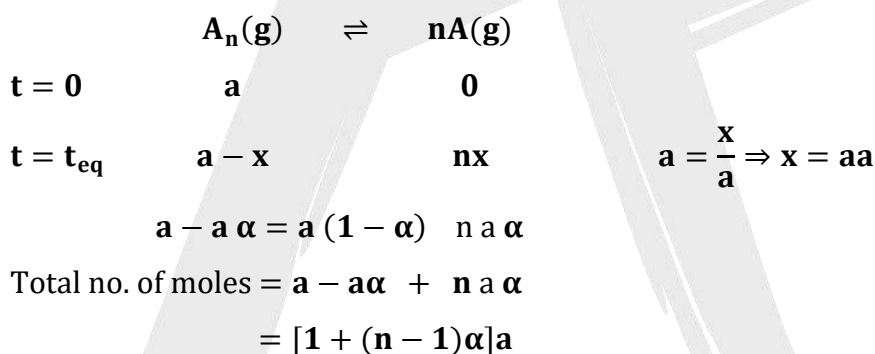
So,  $a = \text{no. of moles dissociated} / \text{initial no. of moles taken}$   
 $= \text{fraction of moles dissociated out of 1 mole.}$

**Note :** % dissociation =  $a \times 100$

Suppose 5 moles of  $\text{PCl}_5$  is taken and if 2 moles of  $\text{PCl}_5$  dissociated then  $a = \frac{2}{5} = 0.4$

## 6.3 RELATIONSHIP BETWEEN AVERAGE MOLAR MASS & DEGREE OF DISSOCIATION (A):

Let a gas  $A_n$  dissociates to give  $n$  moles of  $A$  as follows-



Average molecular weight of mixture(g) =  $\frac{\text{molecular weight of } A_n(g)}{\text{total no. of moles at equilibrium}}$

$$= \frac{a.M_{th}}{a(1 + (n-1)\alpha)}$$

$$M_{avg} = \frac{M_{th}}{[1 + (n-1)\alpha]}$$

where  $M_{th}$  = theoretical molecular weight ( $n$  = atomicity)

$$M_{mixture} = \frac{M_{A_n}}{[1 + (n-1)\alpha]}, M_{A_n} = \text{Molar mass of gas } A_n$$

**Vapour density (V.D).** : Density of the gas divided by density of hydrogen under same temperature & pressure is called vapour density.

$$D = \text{vapour density without dissociation} = \frac{M_{A_n}}{2}$$

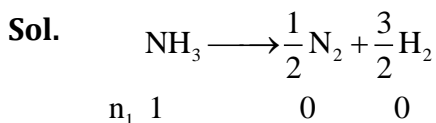
$d = \text{vapour density of mixture} = \text{average vapour density}$

$$\frac{D}{d} = 1 + (n - 1) \alpha$$

$$\alpha = \frac{D - d}{(n - 1) \times d} = \frac{M_T - M_o}{(n - 1) M_o}$$

**Ex.36**  $\text{NH}_3$  decomposes into  $\text{N}_2$  &  $\text{H}_2$ . If average molar mass of reaction mixture is 10 then, find  $\alpha$ ?

**Ans.** 0.7



$$1 - \alpha \quad \frac{\alpha}{2} \quad \frac{3\alpha}{2}$$

$$10 = \frac{17}{1 - \alpha + \frac{\alpha}{2} + \frac{3\alpha}{2}}$$

$$10 = \frac{17}{1 + \alpha}$$

$$1 + \alpha = 1.7$$

$$\alpha = 0.7$$

## 7. PERCENTAGE COMPOSITION AND MOLECULAR FORMULA :

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 proportion any sample of a pure compound always possess constant ratio with their combining elements.

### Example:

Every molecule of ammonia always has formula  $\text{NH}_3$  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  $\text{NH}_3$  always contains 14 g of N and 3 g of H. Now find out % of each element in the compound.

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

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

## 7.1. 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 as the empirical formula of the compound. Further if the molecular mass is known then the molecular formula can be easily determined.

Thus, the empirical formula of a compound is a chemical formula showing the relative number of atoms in the simplest ratio, the molecular formula gives the actual number of atoms of each element in a molecule.

**Empirical formula:** An empirical formula represents the simple whole number ratio of various atoms present in a compound,

**Molecular formula:** whereas, the molecular formula shows the exact number of different types of atoms present in a molecule of a compound

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

That is:

$$\text{molecular formula} = \text{empirical formula} \times n$$

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

**Ex.37** An organic substance containing carbon, hydrogen and oxygen gave the following percentage composition.

C = 40.687 % ; H = 5.085 % and O = 54.228 %

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

**Ans.**  $\text{C}_4\text{H}_6\text{O}_4$

**Sol. Step -1**

To calculate the empirical formula of the compound.

Element	Symbol	Percentage of element	At. mass of element	Relative no. of atoms = $\frac{\text{Percentage}}{\text{At.mass}}$	Simplest Atomic ratio	Simplest whole 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	$\frac{5.085}{1} = 5.035$	$\frac{5.085}{3.389} = 1.5$	3
Oxygen	O	54.228	16	$\frac{54.228}{16} = 3.389$	$\frac{3.389}{3.389} = 1$	2



## Step - 2

To calculate the empirical formula mass.

The empirical formula of the compound is  $C_2H_3O_2$ .

Empirical formula mass

$$= (2 \times 12) + (3 \times 1) + (2 \times 16) = 59.$$

## Step - 3

To calculate the value of 'n'

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

## Step - 4

To calculate the molecular formula of the salt

Molecular formula =  $n \times (\text{Empirical formula})$

$$= 2 \times C_2H_3O_2 = C_4H_6O_4$$

Thus the molecular formula is  $C_4H_6O_4$ .

**Ex.38** Chlorophyll the green colouring material of plants contains 3.68 % of magnesium by mass. Calculate the number of magnesium atom in 5.00 g of the complex.

**Sol.** Mass of magnesium in 5.0 g of complex =  $\frac{3.68}{100} \times 5.00 = 0.184 \text{ g}$

Atomic mass of magnesium = 24

24 g of magnesium contain =  $6.023 \times 10^{23}$  atoms

$$0.184 \text{ g of magnesium would contain} = \frac{6.023 \times 10^{23}}{24} \times 0.184 = 4.617 \times 10^{21} \text{ atom}$$

Therefore, 5.00 g of the given complex would contain  $4.617 \times 10^{21}$  atoms of magnesium.

**Ex.39** A sample of  $CaCO_3$  has Ca = 40%, C = 12% and O = 48% by mass. If the law of constant proportions is true, then the mass of Ca in 5 g of  $CaCO_3$  obtained from another source will be:

- (A) 0.2 g                      (B) 2 g                      (C) 0.6 g                      (D) Cannot be determined

**Ans.** (B)

**Sol.** Mass of Ca =  $5 \times \frac{40}{100} = 2 \text{ g.}$

**8. EXPERIMENTAL METHODS TO DETERMINE ATOMIC & MOLECULAR MASSES****8.1** For determination of atomic mass :**(a)** Dulong's & Pettit's law :

In case of metals, it is observed that product of atomic weight and specific heat capacity is constant.

The equation connecting the two parameters was given by Dulong's and Petit's Law.

Atomic weight of metal  $\times$  specific heat capacity ( $\text{cal/gm}^\circ\text{C}$ ) = 6.4.

It should be remembered that this law is an empirical observation and this gives an approximate value of atomic weight. Also this law can be applied only to metals at high temperature conditions only.

**8.2 Experimental methods for molecular mass determination.****(a)** Victor Meyer's Method**(b)** Silver Salt Method**(c)** Chloroplatinate Salt Method**(a) Victor Meyer's Method:** (Applicable for volatile substance)

A known mass of the volatile substance taken in the Hoffmann's bottle and is vapourised by throwing the Hoffmann's bottle into the Victor Meyer's tube. The vapour displaces an equal volume of the moist air. Which vapours is measured at the room temperature and atmospheric pressure. The barometric pressure and the room temperature is recorded. Following diagram gives the experimental set-up for the Victor-Meyer's process.

Calculation involved

Let the mass of the substance taken by =  $W\text{g}$

Volume of moist vapours collected =  $V\text{cm}^3$

Room temperature =  $T^\circ\text{K}$

Barometric pressure =  $P\text{ mm}$

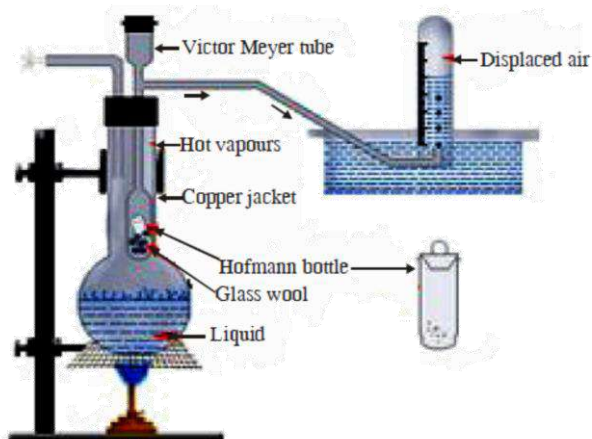
Aqueous tension at  $T^\circ\text{K}$  =  $p\text{ mm}$

Pressure of dry vapour =  $(P - p)\text{ mm}$

Calculation of molecular mass ( $M$ )

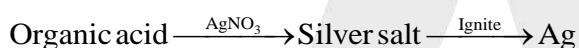
$$\frac{(P-p)}{760} \times \frac{V}{1000} = \frac{w}{M} \times RT$$

$$M = \frac{w \times RT \times 760 \times 1000}{(P-p) \times V}$$



**(b) Silver salt Method:** (A used for organic acids)

A known mass of the acid is dissolved in water followed by the subsequent addition of silver nitrate solution till the precipitation of silver salt is complete. The precipitate is separated, dried, weighed



and ignited till decomposition is complete. The residue of pure silver left behind is weighed. Calculations involved

Let the mass of the silver salt formed =  $W$  g

The mass of Ag formed =  $x$  g

Let us understand to calculations by considering the monobasic acid MX.



Mass of the salt that gives  $x$  gm of Ag =  $W$  g

Mass of the salt gives 108g (1g-atom) of Ag =  $\frac{108W}{x}$  g

Molar mass of salt =  $\frac{108W}{x}$  g

Molar mass of acid = (Molar mass of salt) – (Atomic mass of Ag) + (Atomic mass of H)

$$= \frac{108W}{x} - 108 + 1 = \left( \frac{108W}{x} - 107 \right) \text{g mol}^{-1}$$

For polybasic acid of the type  $H_nX$  ( $n$  is basicity)



Mass of the silver that gives  $x$  g of Ag =  $W$  g

$$\text{Mass of the silver that gives } (108n \text{ g}) \text{ of Ag} = \frac{108nW}{x} \text{ g}$$

$$\text{Molar mass of salt} = \frac{108 \times nW}{x} \text{ g}$$

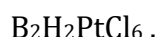
$$\text{Molar mass of acid} = (\text{molar mass of salt}) = \frac{108 \times nW}{x} - n \times 108 - n \times 1$$

$$= n \left( \frac{108W}{x} - 107 \right) \text{ g mol}^{-1}$$

(c) **Platinic chloride Method :** (Applicable for finding the molecular masses of organic bases).

A known mass of organic base is allowed to react with chloroplatinic acid ( $\text{H}_2\text{PtCl}_6$ ) in conc. HCl to form insoluble platinic chloride. The precipitate of platinic chloride is separated, dried, weighed and subsequently ignited till decomposition is complete. The residue left is platinum which is again weighed. The molecular mass is then calculated by knowing the mass of the platinic chloride salt and that of platinum left.

If B represents the molecule of monoacidic organic base, then the formula of platinic chloride salt is



Let the mass of platinic chloride salt = W g, The mass of the platinum residue left = x g

It may be noted that salt formed with diacidic base would be  $\text{B}_2(\text{H}_2\text{PtCl}_6)_2$

With triacidic base it would be  $\text{B}_2(\text{H}_2\text{PtCl}_6)_3$  and with polyacidic base would be  $\text{B}_2(\text{H}_2\text{PtCl}_6)_n$ .

$$\text{Mass of salt which gives 195 g (1 g-atom) of Pt} = \frac{W \times 195}{x} \text{ g}$$

$$\text{Molar mass of salt} = \frac{W \times 195}{x} \text{ g mol}^{-1}$$

Now from the formula  $\text{B}_2(\text{H}_2\text{PtCl}_6)$

$$\text{Molar mass of salt} = (2 \times \text{molar mass of base}) + (\text{Molar mass of } \text{H}_2\text{PtCl}_6)$$

$$\text{Molar mass of base} = \frac{1}{2} (\text{molar mass of salt} - \text{Molar mass of } \text{H}_2\text{PtCl}_6)$$

$$= \frac{1}{2} \left( \frac{W \times 195 \times n}{x} - n \times 410 \right) = \frac{n}{2} \left( \frac{W \times 195}{x} - 410 \right) \text{ g mol}^{-1}$$

## Do yourself-5

- 120 g Mg is burnt in air to give a mixture of MgO and  $\text{Mg}_3\text{N}_2$ . The mixture is now dissolved in HCl to form  $\text{MgCl}_2$  and  $\text{NH}_4\text{Cl}$ . If 107 g  $\text{NH}_4\text{Cl}$  is produced, then determine the moles of  $\text{MgCl}_2$  formed:  
(A) 2.5 (B) 4 (C) 2 (D) 5
- Penicillin V was treated chemically to convert the sulphur present to barium sulphate,  $\text{BaSO}_4$ . A 9.6 mg sample of penicillin V gave 4.66 mg  $\text{BaSO}_4$ . The percentage of sulphur in Penicillin V is x %. If there is one sulphur atom in the molecule, the molecular weight of Pencillin V is y amu. Report your answer as y/x.
- From the following reaction sequence :  

$$\text{Cl}_2 + 2\text{KOH} \longrightarrow \text{KCl} + \text{KClO} + \text{H}_2\text{O}$$

$$3\text{KClO} \longrightarrow 2\text{KCl} + \text{KClO}_3$$

$$4\text{KClO}_3 \longrightarrow 3\text{KClO}_4 + \text{KCl}$$
 Calculate the mass of chlorine needed to produce 138.5 g of  $\text{KClO}_4$  :  
 (A) 142 g (B) 284 g (C) 432 g (D) None of these
- The density of air at STP is  $0.0013 \text{ g mL}^{-1}$ . Its vapour density is :  
 (A) 0.015 (B) 15 (C) 1.5 (D) Data insufficient
- $\text{SO}_3(\text{g}) \rightarrow \text{SO}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$   
 If observed vapour density of mixture at equilibrium is 35 then find out value of a:  
 (A) 0.28 (B) 0.38 (C) 0.48 (D) 0.58
- A sample of a compound contains 9.75 g Zn,  $9 \times 10^{22}$  atoms of Cr and 0.6 gram-atoms of O. What is empirical formula of compound? (Atomic Mass Zn = 65)  
 (A)  $\text{ZnCrO}_4$  (B)  $\text{ZnCr}_2\text{O}_4$  (C)  $\text{Zn}_2\text{CrO}_4$  (D) None of these
- An organic compound on analysis was found to contain 0.032% of sulphur by mass. The molecular mass of the compound, if it's one molecule contains two sulphur atoms, is :  
 (A) 100000 u (B) 10000 u (C) 20000 u (D) 200000 u
- In an organic compound of molar mass  $108 \text{ g mol}^{-1}$  C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be :  
 (A)  $\text{C}_6\text{H}_8\text{N}_2$  (B)  $\text{C}_7\text{H}_{10}\text{N}$  (C)  $\text{C}_5\text{H}_6\text{N}_3$  (D)  $\text{C}_4\text{H}_{18}\text{N}_3$
- At  $100^\circ \text{C}$  and 1 atmp, if the density of liquid water is  $1.0 \text{ g cm}^{-3}$  and that of water vapour is  $0.0006 \text{ g cm}^{-3}$ , then the volume occupied by water molecules in 1 L of steam at that temperature is :  
 (A)  $6 \text{ cm}^3$  (B)  $60 \text{ cm}^3$  (C)  $0.6 \text{ cm}^3$  (D)  $0.06 \text{ cm}^3$

ANSWER KEY

DO YOURSELF

Do yourself-1

1.  $N_A$

2. (C)

**Sol.** Mole of Aluminium =  $\frac{54}{27} = 2$  mole.

Al and Mg have same number of atoms (given). Hence same moles also.

3. (i)  $H = 4N_A$ ,  $S = 2N_A$ ,  $O = 8N_A$  atoms (ii)  $H = 4$  atoms,  $S = 2$  atoms,  $O = 8$  atoms.  
(iii)  $H = 10N_A$ ,  $S = 10N_A$ ,  $O = 40N_A$  atoms (iv)  $H = 6$  atoms,  $S = 6$  atoms,  $O = 18$  atoms.

**Sol.** (A) mole of  $H_2SO_4 = \frac{\text{mass}}{\text{molar mass}} = \frac{196}{98} = 2$ .

1 molecule  $H_2SO_4$  contains 2 atom hydrogen, 1 atom sulphur and 4 atom of oxygen.

Hence :  $H = 4N_A$  atoms,  $S = 2N_A$  atoms,  $O = 8N_A$  atoms

(B) molecule of  $H_2SO_4 = \frac{196}{98} = 2$ .

Hence :  $H = 4$  atoms,  $S = 2$  atoms,  $O = 8$  atoms.

(C) 5 mole  $H_2S_2O_8$  contains

$H = 10N_A$  atoms,  $S = 10N_A$  atoms,  $O = 40N_A$  atoms

(D) 3 molecules  $H_2S_2O_6$  contains

$H = 6$  atoms,  $S = 6$  atoms,  $O = 18$  atoms.

4.  $1.88 \times 10^{22}$

**Sol.**  $PV = nRT$ ,  $N = n \times N_A$

5. (C)

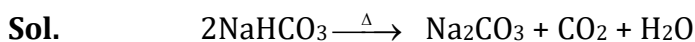
<b>Sol.</b>	$H_2$	:	He	:	$O_2$	:	$O_3$
Ratio of total no. of molecules =	1	:	1	:	1	:	1
So ratio of total no. of atoms =	2	:	1	:	2	:	3

6. (A)

7. (B)

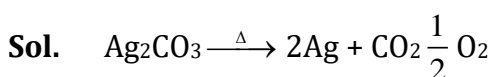
Do yourself-2

1. (A)



$$\begin{aligned} \text{Mole (eksy)} &= \frac{448}{22400} \\ 2 \times 0.02 &= 0.02 \\ &= 0.04 \text{ mole} \end{aligned}$$

2. 2.16 g

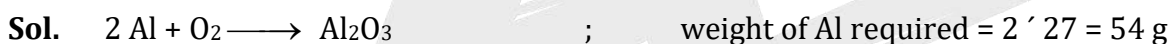


$$276 \text{ g Ag}_2\text{CO}_3 = 216 \text{ g of Ag}$$

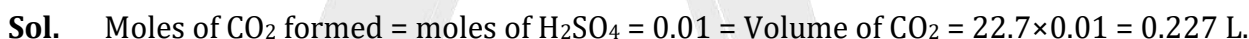
$$2.76 \text{ g of Ag}_2\text{CO}_3 = 2.16 \text{ g of Ag.}$$

3. (C)

4. (C)



5. (C)



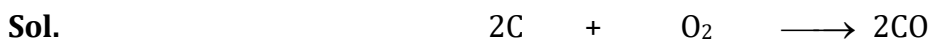
Do yourself-3

1. (i)  $\text{O}_2$  is left in excess.

(ii) 3 moles of  $\text{O}_2$  or 96 g of  $\text{O}_2$  is left.

(iii) 2 moles of CO or 56 g of CO is formed.

(iv) To use  $\text{O}_2$  completely, total 8 moles of carbon or 96 g of carbon is needed.



$$\begin{array}{ccc} \text{Mole before reaction} & \frac{24}{12} & \frac{128}{32} \end{array}$$

$$\begin{array}{ccc} \text{Mole after reaction} & 0 & 3 & 2 \end{array}$$

(i)  $\text{O}_2$  is left in excess.

(ii) 3 moles of  $\text{O}_2$  or 96 g of  $\text{O}_2$  is left.

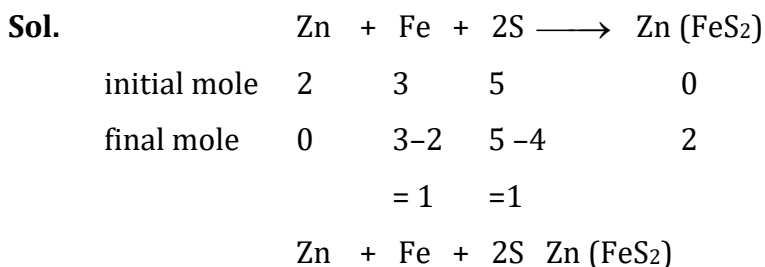
(iii) 2 moles of CO or 56 g of CO is formed.

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

(iv) To use  $O_2$  completely, total 8 moles of carbon or 96 g of carbon is needed.

2. (A)



3. (A)



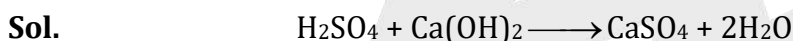
Given moles  $\left(\frac{6}{12}\right) = 0.5$   $\left(\frac{44}{44}\right) = 1$

So C is limiting reagent

CO formed = 1 moles

Now moles of Ni need to react with 1 moles of CO are  $\frac{1}{4} \times 58.7 = 14.675$  g.

4. (A)



Initial mole	0.5	0.2	0	0
finally mole	$0.5 - 0.2$	0	0.2	0.4

5. (C)

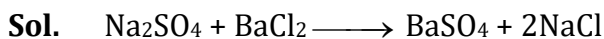


2                      1

So, limiting reagent is NaOH and  $\frac{1}{2}$  mole of  $Na_2SO_4$  is produced

### Do yourself-4

1. 35.33 %



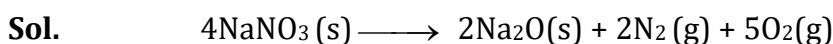
142g                      223g

223 g of  $BaSO_4$  are produced from 142 g of  $Na_2SO_4$

1.74 g of  $BaSO_4$  would be produced by =  $\frac{142}{233} \times 1.74 = 1.06$  g of  $Na_2SO_4$

% purity of  $Na_2SO_4$   $\frac{1.06}{3.0} \times 100 = 35.33$  %

2. (D)





(PHYSICAL CHEMISTRY)

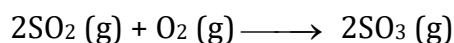
MOLE CONCEPT

Mole 8

$$\text{So, total gas moles produced} = \frac{30}{100} \times 4 \times \frac{7}{4} = 2.1 \text{ mole}$$

3. (A)

**Sol.** For maximum amount of product, the reactants should be present in their stoichiometric ratio.



$$\text{mass } x \quad 5 - x$$

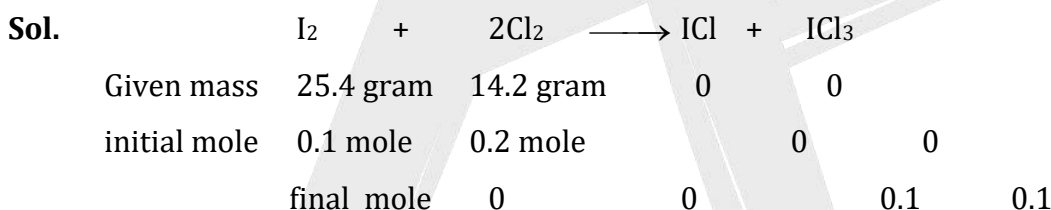
$$\text{mole } \frac{x}{64} \quad \frac{5-x}{32}$$

$$\text{So, } \frac{\left(\frac{x}{64}\right)}{\left(\frac{5-x}{32}\right)} = 2 : 1$$

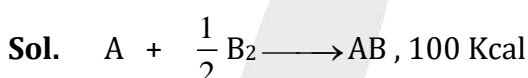
Therefore,  $x = 4$

$$m_{\text{SO}_2} : m_{\text{O}_2} = 4 : 1.$$

4. (A)



5. 11



$$x \quad x/2 \quad x$$



$$(1-x) \quad 2(1-x) \quad (1-x)$$

$$100x + 200(1-x) = 140$$

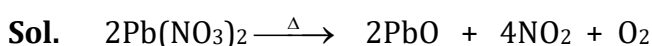
$$200 - 100x = 140$$

$$x = 0.6$$

$$\text{Moles of B}_2 \text{ used} = x/2 + 2(1-x) = \frac{1}{2} \times 0.6 + 2(1-0.6) = 0.3 + 2 \times 0.4 = 1.1 \text{ mol}$$

$$\text{Ans} = 1.1 \times 10 = 11$$

6. 0.95 g



(PHYSICAL CHEMISTRY)

MOLE CONCEPT

$$2 \times 331$$

$$2 \times 223$$



$$2 \times 85$$

$$2 \times 69$$

Let, wt. of  $\text{Pb}(\text{NO}_3)_2$  in mixture = x

wt. of  $\text{NaNO}_3$  =  $(5 - x)$  g

662 g of  $\text{Pb}(\text{NO}_3)_2$  will give residue = 446

$$\text{xg of } \text{Pb}(\text{NO}_3)_2 \text{ will give residue} = \frac{446}{662} \times (x) = 0.674x \text{ g}$$

170 g of  $\text{NaNO}_3$  give residue = 138 g

$$(5 - x), \text{ g } \text{NaNO}_3 \text{ will give residue} = \frac{138}{170} \times (x) = 0.812x \text{ g}$$

170 g of  $\text{NaNO}_3$  give residue = 138 g

$$(5 - x), \text{ g } \text{NaNO}_3 \text{ will give residue} = \frac{138}{170} \times (5 - x) = 0.812(5 - x)$$

$$\text{Actual wt. of residue obtained} = \left( 5 - 5 \times \frac{30}{100} \right) = 3.5 \text{ g}$$

$$0.674x + 0.812 \times (5 - x) = 3.5 \text{ or } 0.138x = 0.56$$

$$x = 4.05 \text{ g} = \text{wt. of } \text{Pb}(\text{NO}_3)_2$$

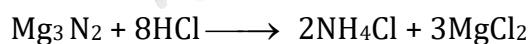
$$\text{wt. of } \text{NaNO}_3 \text{ in the mixture} = (5 - 4.05) = 0.95 \text{ g}$$

Do yourself-5

1. (D)



$$\begin{array}{ccc} a & a & (5 - a) \end{array} \quad \frac{(5 - a)}{3}$$



$$\begin{array}{ccccccc} a & a & \frac{(5 - a)}{3} & \frac{2(5 - a)}{3} & (5 - a) \end{array}$$

$$\text{Total moles of } \text{MgCl}_2 = a + (5 - a) = 5 \text{ moles}$$

2. (72)

**Sol.** Amount of S in  $\text{BaSO}_4 = \frac{32}{233} \times 4.66 = 0.64 \text{ mg}$

$$\% \text{ of S in penicillin V} = \frac{0.64}{9.6} \times 100 = 6.66\%$$

$$\text{molecular wt. of penicillin V} = \frac{9.6}{0.64} \times 32 = 480.$$

3. (B)

**Sol.** 
$$\frac{\text{Mole of KClO}_4}{3} = \frac{\text{Mole of KClO}_3}{4}$$

$$\text{Mole of KClO}_3 = \frac{138.5}{138.5/3} \times 4 = \frac{4}{3}$$

$$\text{Mole of KClO} = \frac{4}{3} \times 3 = 4$$

$$\text{Mole of KClO} = \text{Mole of Cl}_2 = 4$$

$$\text{Mass of Cl}_2 = 4 \times 71 = 284 \text{ g.}$$

4. (B)

**Sol.** 
$$\text{Molar mass of air at STP} = 0.00132 \text{ g mL}^{-1} \times 22700 \text{ mL} = 30 \text{ g}$$

$$\text{so V.D.} = 15$$

5. (A)

**Sol.** 
$$d_0 = \frac{D}{1 + (n-1)\alpha} \quad n = 1 + \frac{1}{2} = 1.5$$

$$35 = \frac{40}{1 + 0.5\alpha}$$

$$1 + 0.5\alpha = \frac{40}{35}$$

$$0.5\alpha = 1.14 - 1$$

$$0.5\alpha = 0.14$$

$$\alpha = 0.28$$

6. (A)

**Sol.** 
$$\text{Mole of Zn} = \frac{9.81}{65} = 0.15 \quad \text{Mole of Cr} = \frac{9 \times 10^{22}}{6.023 \times 10^{23}} = 0.15 \quad \text{Mole of O} = 0.6$$

$$\text{So, Simple ratio Zn} = \frac{0.15}{0.15} = 1 \quad \text{Cr} = \frac{0.15}{0.15} = 1 \quad \text{O} = \frac{0.60}{0.15} = 4$$

So, empirical formula of compound is  $\text{ZnCrO}_4$ .

7. (D)

**Sol.** 
$$\frac{\text{Mass of sulphur}}{\text{Mol. mass of compound}} \times 100 = \% \text{ of sulphur}$$

$$\left( \frac{2 \times 32}{M} \right) \times 100 = 0.032$$

$$M = 2,00,000$$

8. (A)                      9. (C)

A

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

## EXERCISE (O-I)

## PROBLEMS RELATED WITH ATOMIC &amp; MOLECULAR MASS

- The mass of  $3.2 \times 10^5$  atoms of an element is  $8.0 \times 10^{-18}$  g. The atomic mass of the element is about ( $N_A = 6 \times 10^{23}$ )  
(A)  $2.5 \times 10^{-22}$  (B) 15 (C)  $8.0 \times 10^{-18}$  (D) 30
- How many moles of proton weigh 1 gm?  
Given: Mass of 1 proton = 1 a.m.u  
(A)  $10^3$  (B)  $N_A$  (C)  $\frac{1}{N_A}$  (D) 1
- How many moles of proton weigh 1 kg? Given: Mass of 1 proton = 1 a.m.u  
(A)  $10^3$  (B)  $N_A$  (C)  $\frac{1}{N_A} \times 10^3$  (D) 1
- Molar mass of electron is nearly ( $N_A = 6 \times 10^{23}$ )  
Given: Mass of  $1 e^- = 9.1 \times 10^{-31}$  kg  
(A)  $9.1 \times 10^{-31}$  kg mol $^{-1}$  (B)  $9.1 \times 10^{-31}$  gm mol $^{-1}$   
(C)  $54.6 \times 10^{-8}$  gm mol $^{-1}$  (D)  $54.6 \times 10^{-8}$  kg mol $^{-1}$

## PROBLEMS RELATED WITH INTERCONVERSION OF MOLE, MASS AND NUMBER

- The number of molecules of  $\text{CO}_2$  present in 44 g of  $\text{CO}_2$  is :  
(A)  $6.0 \times 10^{23}$  (B)  $3 \times 10^{23}$  (C)  $12 \times 10^{23}$  (D)  $3 \times 10^{10}$
- The number of mole of ammonia in 4.25 g of ammonia is :  
(A) 0.425 (B) 0.25 (C) 0.236 (D) 0.2125
- The weight of a molecule of the compound  $\text{C}_{60}\text{H}_{22}$  is :  
(A)  $1.09 \times 10^{-21}$  g (B)  $1.24 \times 10^{-21}$  g (C)  $5.025 \times 10^{-23}$  g (D)  $16.023 \times 10^{-23}$  g
- The number of electrons in 3.1 mg  $\text{NO}_3^-$  is -  
(A) 32 (B)  $1.6 \times 10^{-3}$  (C)  $9.6 \times 10^{20}$  (D)  $9.6 \times 10^{23}$
- The charge on 1 gram of  $\text{Al}^{3+}$  is : ( $N_A = \text{Avogadro number}$ ,  $e = \text{charge on one electron}$ )  
(A)  $\frac{1}{27} \times N_A \times e$  (B)  $\frac{1}{3} \times N_A \times e$  (C)  $\frac{1}{9} \times N_A \times e$  (D)  $3 \times N_A \times e$
- The weight of  $1 \times 10^{22}$  molecules of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  is :  
(A) 41.59 g (B) 415.9 g (C) 4.159 g (D) 2.38 g
- The number of carbon atoms present in a signature, if a signature written by carbon pencil weights  $1.2 \times 10^{-3}$  gm is  
(A)  $12.04 \times 10^{20}$  (B)  $6.02 \times 10^{19}$  (C)  $3.01 \times 10^{19}$  (D)  $6.02 \times 10^{20}$
- An iodized salt contains 0.5 % of NaI. A person consumes 3 gm of salt every day. The number of iodide ions going into his body every day is

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

- (A)  $10^{-4}$  (B)  $6.02 \times 10^{-4}$  (C)  $6.02 \times 10^{19}$  (D)  $6.02 \times 10^{23}$
13. Which of the following has the Maximum mass ?  
 (A) 1 g-atom of C (B)  $\frac{1}{2}$  mole of  $\text{CH}_4$   
 (C) 10 mL of water (D)  $3.011 \times 10^{23}$  atoms of oxygen
14. Which of the following contain largest number of carbon atoms?  
 (A) 15 gm ethane,  $\text{C}_2\text{H}_6$  (B) 40.2 gm sodium oxalate,  $\text{Na}_2\text{C}_2\text{O}_4$   
 (C) 72 gm glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$  (D) 35 gm pentene,  $\text{C}_5\text{H}_{10}$
15. The number of hydrogen atoms in 0.9 gm glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , is same as  
 (A) 0.048 gm hydrazine,  $\text{N}_2\text{H}_4$  (B) 0.17 gm ammonia,  $\text{NH}_3$   
 (C) 0.30 gm ethane,  $\text{C}_2\text{H}_6$  (D) 0.03 gm hydrogen,  $\text{H}_2$
16. The atomic weights of two elements A and B are 40 and 80 respectively. If x g of A contains y atoms, how many atoms are present in 2x g of B?  
 (A)  $\frac{y}{2}$  (B)  $\frac{y}{4}$  (C) y (D) 2y
17. A sample of aluminium has a mass of 54.0 g. What is the mass of the same number of magnesium atoms? (At. wt. Al = 27, Mg = 24)  
 (A) 12 g (B) 24 g (C) 48 g (D) 96 g.
18. A gaseous mixture contains  $\text{CO}_2$  (g) and  $\text{N}_2\text{O}$  (g) in a 2 : 5 ratio by mass. The ratio of the number of molecules of  $\text{CO}_2$  (g) and  $\text{N}_2\text{O}$  (g) is  
 (A) 5 : 2 (B) 2 : 5 (C) 1 : 2 (D) 5 : 4
19. Ethanol,  $\text{C}_2\text{H}_5\text{OH}$ , is the substance commonly called alcohol. The density of liquid alcohol is 0.8 g/ml at 293 K. If 1.2 mole of ethanol are needed for a particular experiment, what volume of ethanol should be measured out?  
 (A) 55 ml (B) 58 ml (C) 69 ml (D) 79 ml
20. A compound possess 8% sulphur by mass. The least molecular mass is :  
 (A) 200 (B) 400 (C) 155 (D) 355
21. Cortisone is a molecular substance containing 21 atoms of carbon per molecule. The mass percentage of carbon in cortisone is 69.98%. Its molar mass is :  
 (A) 176.5 (B) 252.2 (C) 287.6 (D) 360.1

## PROBLEMS RELATED WITH MOLE AND PV = NRT

22. How many moles are there in  $2.24\text{m}^3$  of any gas at 190 torr and  $273^\circ\text{C}$ .  
 (A) 1.25 moles (B) 12.5 moles  
 (C)  $1.25 \times 10^{-3}$  moles (D)  $1.25 \times 10^3$  mole
23. 80 gm of  $\text{SO}_x$  gas occupies 15 litre at 2 atm & 300 K. The value of x is -

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

(Given :  $R = 0.08 \text{ L-atm/K-Mole}$ )

- (A) 3 (B) 2 (C) 1 (D) None
24. 112.0 ml of  $\text{NO}_2$  at 1atm & 273 K was liquefied, the density of the liquid being 1.15 gm/ml. Calculate the volume of and the number of molecules in the liquid  $\text{NO}_2$ .  
 (A) 0.10 ml and  $3.01 \times 10^{22}$  (B) 0.20 ml and  $3.01 \times 10^{21}$   
 (C) 0.20 ml and  $6.02 \times 10^{23}$  (D) 0.40 ml and  $6.02 \times 10^{21}$
25. While resting, an average 70 kg human male consumes 16.628 L of oxygen per hour at  $27^\circ\text{C}$  and 100 kPa. How many moles of oxygen are consumed by the 70 kg man while resting for 1 hour?  
 (A) 0.67 (B) 66.7 (C) 666.7 (D) 67.5
26. At same temperature and pressure, two gases have the same number of molecules. They must  
 (A) have same mass (B) have equal volumes  
 (C) have a volume of  $22.7 \text{ dm}^3$  each (D) have an equal number of atoms
27. Equal volumes of oxygen gas and a second gas weigh 1.00 and 2.375 grams respectively under the same experimental conditions. Which of the following is the unknown gas?  
 (A) NO (B)  $\text{SO}_2$  (C)  $\text{CS}_2$  (D) CO
28. Four 1-litre flasks are separately filled with the gases  $\text{H}_2$ , He,  $\text{O}_2$  and  $\text{O}_3$  at the same temperature and pressure. The ratio of total number of atoms of these gases present in different flask would be :  
 (A) 1 : 2 : 3 : 4 (B) 2 : 1 : 2 : 4 (C) 2 : 1 : 2 : 3 (D) 2 : 1 : 2 : 3

## PROBLEMS RELATED WITH BALANCING OF REACTION

## PROBLEMS RELATED WITH STOICHIOMETRY AND ONE REACTANT PROBLEM

29. For the reaction  $2\text{P} + \text{Q} \rightarrow \text{R}$ , 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
30. If 1.5 moles of oxygen combine with Al to form  $\text{Al}_2\text{O}_3$ , the weight of Al used in the reaction is:  
 (A) 27 g (B) 40.5 g (C) 54g (D) 81 g
31. Volume of  $\text{O}_2$  obtained at 2 atm & 546K, by the complete decomposition of 8.5 g  $\text{NaNO}_3$  is  
 $2\text{NaNO}_3 \rightarrow 2\text{NaNO}_2 + \text{O}_2$  (Atomic mass of NO. = 23)  
 (A) 2.24 lit (B) 1.12 lit (C) 0.84 lit (D) 0.56 lit
32. Automotive air bags are inflated when a sample of sodium azide ( $\text{NaN}_3$ ) is very rapidly decomposed [ $2\text{NaN}_3(\text{s}) \rightarrow 2\text{Na}(\text{s}) + 3\text{N}_2(\text{g})$ ] then what mass of sodium azide is required to produce 368 litre of  $\text{N}_2(\text{g})$  with density 1.12 g/L  
 (A) 0.638 kg (B) 1.2 kg (C) 1.5 kg (D) 5 kg

## PROBLEMS RELATED WITH LIMITING REACTANT

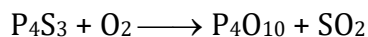
33. The mass of  $\text{Mg}_3\text{N}_2$  produced if 48 gm of Mg metal is reacted with 34 gm  $\text{NH}_3$  gas is  
 $\text{Mg} + \text{NH}_3 \longrightarrow \text{Mg}_3\text{N}_2 + \text{H}_2$

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

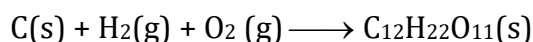
- (A)  $\frac{200}{3}$  gm      (B)  $\frac{100}{3}$  gm      (C)  $\frac{400}{3}$  gm      (D)  $\frac{150}{3}$  gm

34. The mass of  $P_4O_{10}$  produced if 440 gm of  $P_4S_3$  is mixed with 384 gm of  $O_2$  is



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

35. Mass of sucrose  $C_{12}H_{22}O_{11}$  produced by mixing 84 gm of carbon, 12 gm of hydrogen and 56 lit.  $O_2$  at 1 atm & 273 K according to given reaction, is



- (A) 138.5      (B) 155.5      (C) 172.5      (D) 199.5

36. 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

## PROBLEMS RELATED WITH MIXTURE

37. 12.46g of a mixture of  $MgO$  and  $MgCO_3$  on strong heating lost 4.4g in weight what is the %  $MgO$  in the initial mixture.

- (A) 32.58      (B) 64.42      (C) 17.79      (D) 82.21

38. Mixture of  $MgCO_3$  &  $NaHCO_3$  on strong heating give  $CO_2$  &  $H_2O$  in 3 : 1 mole ratio. The weight % of  $NaHCO_3$  present in the mixture is:

- (A) 30%      (B) 80%      (C) 40%      (D) 50%

39. A mixture containing 3 moles each of  $C_4H_8$  and  $C_6H_6$  undergoes complete combustion with  $O_2$  to form  $CO_2$  and  $H_2O$ . Calculate total mass of  $CO_2$  produced

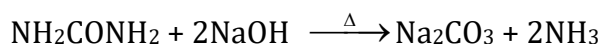
- (A) 1320 gm      (B) 610 gm  
(C) 528 gm      (D) 792 gm

## PROBLEMS RELATED WITH % YIELD AND % PURITY

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

- (A) 100 %      (B) 95 %      (C) 80 %      (D) 75 %

41. Percent yield of  $NH_3$  in the following reaction is 80%:-



How much  $NH_3$  form when 6 g  $NH_2CONH_2$  reacts with 8 g  $NaOH$  ?

- (A) 3.4 g      (B) 2.72 g      (C) 4.25 g      (D) 11.2 g

42. Two successive reactions,  $A \rightarrow B$  and  $B \rightarrow C$ , have yields of 90% and 80%, respectively. What is the overall percentage yield for conversion of A to C?

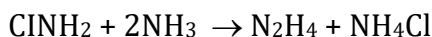
- (A) 90%      (B) 80%      (C) 72%      (D) 85%



## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

43. Hydrazine  $\text{N}_2\text{H}_4$  (used as a fuel in rocket system) can be produced according to the following reaction.



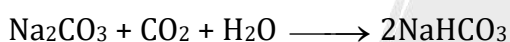
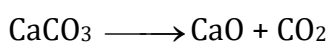
When 1.0 kg  $\text{ClNH}_2$  is reacted with excess of  $\text{NH}_3$ , 473 g of  $\text{N}_2\text{H}_4$  is produced. What is the percentage yield?

- (A) 76.12 (B) 67.21 (C) 26.17 (D) 16.72

## PROBLEMS RELATED WITH SEQUENCE OF REACTION / PARALLEL REACTION

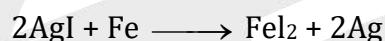
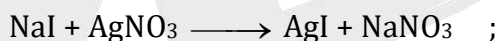
44. What weight of  $\text{CaCO}_3$  must be decomposed to produce the sufficient quantity of carbon dioxide to convert 21.2 kg of  $\text{Na}_2\text{CO}_3$  completely in to  $\text{NaHCO}_3$ .

[Atomic mass Na = 23, Ca = 40]



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

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



How many grams of  $\text{AgNO}_3$  are required in the first step for every 254 kg  $\text{I}_2$  produced in the third step?

- (A) 340 kg (B) 85 kg (C) 68 kg (D) 380 kg

46. 10 g of a sample of a mixture of  $\text{CaCl}_2$  and  $\text{NaCl}$  is treated to precipitate all the calcium as  $\text{CaCO}_3$ . This  $\text{CaCO}_3$  is heated to convert all the Ca to  $\text{CaO}$  and the final mass of  $\text{CaO}$  is 1.62 g. The percent by mass of  $\text{CaCl}_2$  in the original mixture is:

- (A) 32.1 % (B) 16.2 % (C) 21.8 % (D) 11.0 %

47. 25.4 g of iodine and 14.2g of chlorine are made to react completely to yield a mixture of  $\text{ICl}$  and  $\text{ICl}_3$ . Calculate the number of moles of  $\text{ICl}$  and  $\text{ICl}_3$  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

48. What weights of  $\text{P}_4\text{O}_6$  and  $\text{P}_4\text{O}_{10}$  will be produced by the combustion of 31g of  $\text{P}_4$  in 32g of oxygen leaving no  $\text{P}_4$  and  $\text{O}_2$ .

- (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

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

**PROBLEMS RELATED WITH AVERAGE MOLECULAR MASS AND DEGREE OF DISSOCIATION/  
MASS, % BY MASS AND % BY MOLE**

49. In chemical scale, the relative mass of the isotopic mixture of X atoms ( $X^{20}$ ,  $X^{21}$ ,  $X^{22}$ ) is approximately equal to : ( $X^{20}$  and  $X^{21}$  are 99% and 0.5% by mole)  
(A) 20.002 (B) 21.00 (C) 22.00 (D) 20.00
50. The percentage by mole of  $\text{NO}_2$  in a mixture of  $\text{NO}_2(\text{g})$  and  $\text{NO}(\text{g})$  having average molecular mass 34 is :  
(A) 25% (B) 20% (C) 40% (D) 75%
51. Average mol. wt. of a gaseous mixture which contains 80% by mole  $\text{N}_2$  & rest  $\text{O}_2$  gas is-  
(A) 28 (B) 30.6 (C) 28.8 (D) 29.2
52. The vapour density of a sample of  $\text{SO}_3$  gas is 28. Its degree of dissociation into  $\text{SO}_2$  and  $\text{O}_2$  is  
(A)  $1/7$  (B)  $1/6$  (C)  $6/7$  (D)  $2/5$
53. Calculate percentage change in  $M_{\text{avg}}$  of the mixture, if  $\text{PCl}_5$  undergo 50% decomposition in a closed vessel.  $\text{PCl}_5 \longrightarrow \text{PCl}_3 + \text{Cl}_2$   
(A) 50% (B) 66.66 % (C) 33.33 % (D) Zero

**PROBLEMS RELATED WITH EMPIRICAL AND MOLECULAR FORMULA**

54. The empirical formula of a compound of molecular mass 120 is  $\text{CH}_2\text{O}$ . The molecular formula of the compound is :  
(A)  $\text{C}_2\text{H}_4\text{O}_2$  (B)  $\text{C}_4\text{H}_8\text{O}_4$  (C)  $\text{C}_3\text{H}_6\text{O}_3$  (D) all of these
55. An organic compound contain 40% carbon and 6.67% hydrogen by mass. Which of the following represents the empirical formula of the compound?  
(A)  $\text{CH}_2$  (B)  $\text{CH}_2\text{O}$  (C)  $\text{C}_2\text{H}_4\text{O}$  (D)  $\text{CH}_3\text{O}$
56. A compound contains elements X and Y in 1 : 4 mass ratio. If the atomic masses of X and Y are in 1 : 2 ratio, the empirical formula of the compound should be  
(A)  $\text{XY}_2$  (B)  $\text{X}_2\text{Y}$  (C)  $\text{XY}_4$  (D)  $\text{X}_4\text{Y}$
57. A quantity of 1.4 g of a hydrocarbon gives 1.8 g water on complete combustion. The empirical formula of hydrocarbon is  
(A)  $\text{CH}$  (B)  $\text{CH}_2$  (C)  $\text{CH}_3$  (D)  $\text{CH}_4$
58. 74 gm of a sample on complete combustion gives 132 gm  $\text{CO}_2$  and 54 gm of  $\text{H}_2\text{O}$ . The molecular formula of the compound may be  
(A)  $\text{C}_5\text{H}_{12}$  (B)  $\text{C}_4\text{H}_{10}\text{O}$  (C)  $\text{C}_3\text{H}_6\text{O}_2$  (D)  $\text{C}_3\text{H}_7\text{O}_2$
59. Calculate the molecular formula of compound which contains 20% Ca and 80% Br (by wt.) if molecular weight of compound is 200. (Atomic wt. Ca = 40, Br = 80)  
(A)  $\text{Ca}_{1/2}\text{Br}$  (B)  $\text{CaBr}_2$  (C)  $\text{CaBr}$  (D)  $\text{Ca}_2\text{Br}$

## EXERCISE (S-I)

1. Find the molar mass of the following molecules:

**Given :** Atomic mass : O = 16, N = 14, S = 32, C = 12, Cu = 63.5

- |  |  |                       |                                       |
|--|--|-----------------------|---------------------------------------|
| (i) O <sub>2</sub>   | (ii) N <sub>2</sub>  | (iii) NO <sub>2</sub> | (iv) H <sub>2</sub> O                 |
| (v) NH <sub>3</sub>  | (vi) N <sub>2</sub> O <sub>4</sub>                               | (vii) SO <sub>2</sub> | (viii) H <sub>2</sub> SO <sub>4</sub> |
| (ix) CO <sub>2</sub>                                       | (x) Glucose (C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> )     |                       |                                       |
| (xi) Acetic acid (CH <sub>3</sub> COOH)                    | (xii) Sucrose (C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> ) |                       |                                       |
| (xiii) Blue vitriol (CuSO <sub>4</sub> .5H <sub>2</sub> O) |  |                       |                                       |

## PROBLEMS RELATED WITH INTERCONVERSION OF MOLE, MASS AND NUMBER

2. Find the number of moles of the following :

- |                               |                               |                                |                                      |
|-------------------------------|-------------------------------|--------------------------------|--------------------------------------|
| (i) 28 g of N <sub>2</sub>    | (ii) 28 g of N                | (iii) 64 g of O <sub>2</sub>   | (iv) 64 g of O                       |
| (v) 54 mg of H <sub>2</sub> O | (vi) 48 mg of CH <sub>4</sub> | (vii) 23 mg of NO <sub>2</sub> | (viii) 15 mg of CH <sub>3</sub> COOH |

3. Find the following for 180 gm of glucose:

**Give:** Glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)

**Atomic weight :** C = 12, H = 1, O = 16

- |   |                                       |
|---|---------------------------------------|
| (i) Number of mole of glucose                       | (ii) Number of molecules of glucose   |
| (iii) Number of moles of carbon atom                | (iv) Number of moles of hydrogen atom |
| (v) Number of moles of oxygen atom                  |                                       |
| (vi) Number of atoms of carbon, hydrogen and oxygen |                                       |
| (vii) Total number of atoms                         |                                       |

4. For 49 g of H<sub>2</sub>SO<sub>4</sub>, Find the following:

- |   |
|---|
| (i) Number of moles of H <sub>2</sub> SO <sub>4</sub>       |
| (ii) Number of moles of hydrogen, sulphur and oxygen atom   |
| (iii) Number of molecules of H <sub>2</sub> SO <sub>4</sub> |
| (iv) Number of atoms of hydrogen, sulphur and oxygen        |
| (v) Total number of atoms                                   |

5. Find:

- |  |
|--|
| (i) No. of moles of Cu atom in 10 <sup>20</sup> atoms of Cu.   |
| (ii) Mass of 200 atoms of <sup>16</sup> <sub>8</sub> O in amu  |
| (iii) Mass of 100 atoms of <sup>14</sup> <sub>7</sub> N in gm. |
| (iv) No. of molecules & atoms in 54 gm H <sub>2</sub> O.       |
| (v) No. of atoms in 88 gm CO <sub>2</sub> .                    |

6. What is the mass of one <sup>12</sup>C atom in gram?

7. Calculate the weight of 12.046 × 10<sup>23</sup> atoms of carbon.

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

8. Calculate mass of O atoms in 6 gm  $\text{CH}_3\text{COOH}$ ?
9. Calculate mass of water present in 499 gm  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ?  
(Atomic mass – Cu = 63.5, S = 32, O = 16, H = 1)
10. What mass of  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$  contains exactly  $6.023 \times 10^{22}$  atoms of oxygen?
11. Find the total number of nucleons present in 12 gm of  $^{12}\text{C}$  atoms.
12. Calculate the number of electrons, protons and neutrons in 1 mole of  $^{16}\text{O}^{2-}$  ions.
13. The density of liquid mercury is  $13.6 \text{ g/cm}^3$ . How many moles of mercury are there in 1 litre of the metal? (Atomic mass of Hg = 200.)
14. A sample of ethane has the same mass as 10.0 million molecules of methane. How many  $\text{C}_2\text{H}_6$  molecules does the sample contain?
15. How much time (in seconds) would it take to distribute one Avogadro number of wheat grains if  $10^{10}$  grains are distributed each second?
16. Hemoglobin contains 0.25% iron by mass. The molecular mass of Hemoglobin is 89600 then the number of iron atoms per molecule of Hemoglobin (Atomic mass of Fe = 56)

PROBLEMS RELATED WITH  $PV = nRT$ 

17. For the ideal gas, find the missing parameter in each part among P, V, T and n:

(i)	$P = 0.8314 \text{ Pa}$	$V = 6000 \text{ m}^3$	$T = 300 \text{ K}$
(ii)	$P = 5 \text{ atm}$	$V = 8.21 \text{ L}$	$T = 200 \text{ K}$
(iii)	$P = 831.4 \text{ Pa}$	$V = 5000 \text{ L}$	$T = 250 \text{ K}$
(iv)	$V = 8.21 \text{ L}$	$T = 500 \text{ K}$	$n = 10$
(v)	$V = 100 \text{ m}^3$	$T = 300 \text{ K}$	$n = 3$
(vi)	$P = 831.4 \text{ Pa}$	$V = 1000 \text{ L}$	$n = 0.1$
(vii)	$P = 22.4 \text{ atm}$	$T = 273 \text{ K}$	$n = 2$
(viii)	$V = 45.4 \text{ m}^3$	$T = 2730 \text{ K}$	$n = 5$

18. Find the volume of ideal gas at STP:

- (i) 2 moles of  $\text{PCl}_5$   
(ii) 0.25 moles of  $\text{NH}_3$   
(iii) 0.5 moles of  $\text{NO}_2$   
(iv) 4 moles of  $\text{N}_2$

19. Find the moles of ideal gas at STP:

- |   |  |
|---|--|
| (i) 22.7 L of $\text{O}_2$                | (ii) 45.4 L of $\text{N}_2$                |
| (iii) 45.4 mL of $\text{NO}_2$            | (iv) 11.35 mL of $\text{NH}_3$             |
| (v) 2.27 dm <sup>3</sup> of $\text{SO}_3$ | (vi) 113.5 m <sup>3</sup> of $\text{CO}_2$ |

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

## PROBLEMS RELATED WITH BALANCING OF REACTION

20. Balance the following reactions:
- (a)  $\text{C}_3\text{H}_8 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$
- (b)  $\text{C}_2\text{H}_6 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$
- (c)  $\text{CaSiO}_3 + \text{HF} \longrightarrow \text{SiF}_4 + \text{CaF}_2 + \text{H}_2\text{O}$
- (d)  $\text{Cl}_2 + \text{Ca}(\text{OH})_2 \longrightarrow \text{Ca}(\text{ClO}_3)_2 + \text{CaCl}_2 + \text{H}_2\text{O}$
- (e)  $\text{KMnO}_4 + \text{HCl} \longrightarrow \text{KCl} + \text{MnCl}_2 + \text{H}_2\text{O} + \text{Cl}_2$
21. Calculate the volume of  $\text{O}_2$  needed for combustion of 1.2 kg of carbon at STP.  
Reaction:  $\text{C} + \text{O}_2 \xrightarrow{\Delta} \text{CO}_2$ .
22. Methyl-t-butyl ether,  $\text{C}_5\text{H}_{12}\text{O}$ , is added to gasoline to promote cleaner burning. How many moles of oxygen gas,  $\text{O}_2$  are required to burn 1.0 mol of this compound completely to form carbon dioxide and water?
23. Aluminum carbide ( $\text{Al}_4\text{C}_3$ ) liberates methane on treatment with water:  
 $\text{Al}_4\text{C}_3 + 12\text{H}_2\text{O} \longrightarrow 3\text{CH}_4 + 4\text{Al}(\text{OH})_3$ .  
Find mass of aluminum carbide required to produce 11.35 L of methane under STP conditions.
24. Calculate mass of phosphoric acid required to obtain 53.4g pyrophosphoric acid.  
 $2\text{H}_3\text{PO}_4 \longrightarrow \text{H}_4\text{P}_2\text{O}_7 + \text{H}_2\text{O}$
25. Nitric acid is manufactured by the Ostwald process, in which nitrogen dioxide reacts with water.  
 $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{HNO}_3(\text{aq.}) + \text{NO}(\text{g})$   
How many grams of nitrogen dioxide are required in this reaction to produce 25.2 gm  $\text{HNO}_3$ ?
26. Fluorine reacts with uranium to produce uranium hexafluoride,  $\text{UF}_6$ , as represented by this equation  
 $\text{U}(\text{s}) + 3\text{F}_2(\text{g}) \longrightarrow \text{UF}_6(\text{g})$   
How many fluorine molecules are required to produce 2.0 mg of uranium hexafluoride,  $\text{UF}_6$ , from an excess of uranium? The molar mass of  $\text{UF}_6$  is 352 gm/mol.
27. Calculate the percent loss in weight after complete decomposition of a pure sample of potassium chlorate.  
 $\text{KClO}_3(\text{s}) \longrightarrow \text{KCl}(\text{s}) + \text{O}_2(\text{g})$

## PROBLEMS RELATED WITH LIMITING REACTANT

28. 50 g of  $\text{CaCO}_3$  is allowed to react with 73.5 g of  $\text{H}_3\text{PO}_4$ . Calculate:  
(i) Amount of  $\text{Ca}_3(\text{PO}_4)_2$  formed (in moles)  
(ii) Amount of unreacted reagent (in moles)
29. Reaction  $4\text{A} + 2\text{B} + 3\text{C} \longrightarrow \text{A}_4\text{B}_2\text{C}_3$ , is started from 2 moles of A, 1.2 moles of B & 1.44 moles of C. find number of moles of product formed.

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

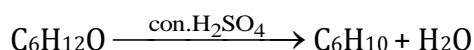
30. Potassium superoxide,  $\text{KO}_2$ , is used in rebreathing gas masks to generate oxygen:  
 $\text{KO}_2(\text{s}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{KOH}(\text{s}) + \text{O}_2(\text{g})$   
 If a reaction vessel contains 0.158 mole  $\text{KO}_2$  and 0.10 mole  $\text{H}_2\text{O}$ , how many moles of  $\text{O}_2$  can be produced?
31. A chemist wants to prepare diborane by the reaction  
 $6 \text{LiH} + 8 \text{BF}_3 \longrightarrow 6 \text{LiBF}_4 + \text{B}_2\text{H}_6$   
 If he starts with 2.0 moles each of  $\text{LiH}$  &  $\text{BF}_3$ . How many moles of  $\text{B}_2\text{H}_6$  can be prepared?
32. Carbon reacts with chlorine to form  $\text{CCl}_4$ . 36 gm of carbon was mixed with 142 g of  $\text{Cl}_2$ . Calculate mass of  $\text{CCl}_4$  produced and the remaining mass of reactant.
33. Sulphuric acid is produced when sulphur dioxide reacts with oxygen and water in the presence of a catalyst:  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l}) \longrightarrow 2 \text{H}_2\text{SO}_4$ . If 5.6 mol of  $\text{SO}_2$  reacts with 4.8 mol of  $\text{O}_2$  and a large excess of water, what is the maximum number of moles of  $\text{H}_2\text{SO}_4$  that can be obtained?

## PROBLEMS RELATED WITH MIXTURE

34. One gram of an alloy of aluminium and magnesium when heated with excess of dil.  $\text{HCl}$  forms magnesium chloride, aluminium chloride and hydrogen. The evolved hydrogen collected at  $0^\circ\text{C}$  has a volume of 1.12 litres at 1 atm pressure. Calculate the composition of (% by mass) of the alloy.
35. 92 g mixture of  $\text{CaCO}_3$  and  $\text{MgCO}_3$  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  $\text{MgCO}_3$  in grams in the mixture.
36. When 4 gm of a mixture of  $\text{NaHCO}_3$  and  $\text{NaCl}$  is heated, 0.66 gm  $\text{CO}_2$  gas is evolved. Determine the percentage composition (by mass) of the original mixture.

## PROBLEMS RELATED WITH PERCENTAGE YIELD AND PERCENTAGE PURITY

37. 200 g impure  $\text{CaCO}_3$  on heating gives 11.35 L  $\text{CO}_2$  gas at STP. Find the percentage of calcium in the lime stone sample.
38. A power company burns approximately 474 tons of coal per day to produce electricity. If the sulphur content of the coal is 1.30 % by weight, how many tons  $\text{SO}_2$  are dumped into the atmosphere each day?
39. A sample of calcium carbonate is 80% pure, 25 gm of this sample is treated with excess of  $\text{HCl}$ . How much volume of  $\text{CO}_2$  will be obtained at 1 atm & 273 K?
40. Cyclohexanol is dehydrated to cyclohexene on heating with conc.  $\text{H}_2\text{SO}_4$ . Find %yield of this reaction, if 61.5 gm cyclohexene is obtained from 100 g of cyclohexanol?

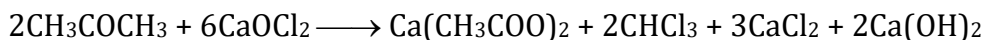




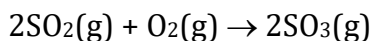
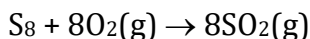
## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

41. If the yield of chloroform obtainable from acetone and bleaching powder is 75%. What is the weight of acetone required for producing 30 gm of chloroform?



42. Sulphur trioxide may be prepared by the following two reactions :



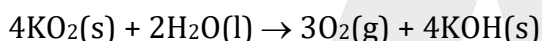
How many grams of  $\text{SO}_3$  will be produced from 1 mol of  $\text{S}_8$ ?

43.  $2\text{PbS} + 3\text{O}_2 \rightarrow 2\text{PbO} + 2\text{SO}_2$

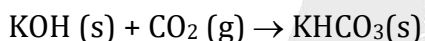


According to the above sequence of reactions, how much  $\text{H}_2\text{SO}_4$  will 1075.5 gm of PbS produce?

44. Potassium superoxide,  $\text{KO}_2$ , is utilized in closed system breathing apparatus. Exhaled air contains  $\text{CO}_2$  and  $\text{H}_2\text{O}$ , both of which are removed and the removal of water generates oxygen for breathing by the reaction



The potassium hydroxide removes  $\text{CO}_2$  from the apparatus by the reaction:



(a) What mass of  $\text{KO}_2$  generates 20 gm of oxygen?

(b) What mass of  $\text{CO}_2$  can be removed from the apparatus by 100 gm of  $\text{KO}_2$  ?

45. Calculate the atomic mass (average) of chlorine using the following data:

	% Natural Abundance	Molar Mass
$^{35}\text{Cl}$	75.77	34.9689
$^{37}\text{Cl}$	24.23	36.9659

46. Average atomic mass of Magnesium is 24.31 amu. This magnesium is composed of 79 mole % of  $^{24}\text{Mg}$  and remaining 21 mole % of  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$ . Calculate mole % of  $^{26}\text{Mg}$ .
47. A gaseous mixture contains 70%  $\text{N}_2$  and 30% unknown gas by volume. If the average molecular mass of gaseous mixture is 37.60, then the molecular mass of unknown gas is
48. A sample of ozone gas is found to be 40% dissociated into oxygen. The average molecular mass of sample should be
49. The vapour density of  $\text{N}_2\text{O}_4$  and  $\text{NO}_2$  mixture at a certain temperature is 30. Calculate the percentage dissociation of  $\text{N}_2\text{O}_4$  at this temperature.  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
50. A moth repellent has the composition 49% C, 2.7% H and 48.3% Cl. Its molecular weight is 147 gm. Determine its molecular formula

51. An organic compound contains carbon, hydrogen and nitrogen. If weight ratio of C, H, N (in same order) is 9 : 1 : 3.5 and molar mass of compound is 216 gm/mole and number of atoms present in 1 molecule of compound are  $x$  then calculate value of  $\frac{x}{4}$ .
52. A compound has carbon, hydrogen and oxygen in 3 : 3 : 1 atomic ratio. If the number of moles in 1 g of the compound is  $6.06 \times 10^{-3}$ , then the molecular formula of the compound will be
53. A 60 gm sample of organic compound having empirical formula  $C_xH_yO$  on complete combustion gives 88 gm of  $CO_2$  & 36 gm of  $H_2O$ . The value of  $(x + y)$  is.

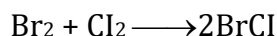




## EXERCISE (S-II)

## PART-I (MOLE CONCEPT)

- What total volume, in litre at  $600^{\circ}\text{C}$  and 1 atm, could be formed by the decomposition of 16 gm of  $\text{NH}_4\text{NO}_3$  ?  
 $2 \text{NH}_4\text{NO}_3 \longrightarrow 2\text{N}_2 + \text{O}_2 + 4\text{H}_2\text{O}_{(\text{g})}$ .
- Calculate maximum mass of  $\text{CaCl}_2$  produced when  $2.4 \times 10^{24}$  atoms of calcium is taken with 96 L of  $\text{Cl}_2$  gas at 380 mm pressure and at  $27^{\circ}\text{C}$ .  
 [R : 0.08 atm L/mole-K &  $N_A = 6 \times 10^{23}$ ]
- Consider the given reaction  
 $\text{H}_4\text{P}_2\text{O}_7 + 2\text{NaOH} \rightarrow \text{Na}_2\text{H}_2\text{P}_2\text{O}_7 + 2\text{H}_2\text{O}$   
 If 534 gm of  $\text{H}_4\text{P}_2\text{O}_7$  is reacted with  $30 \times 10^{23}$  molecules of  $\text{NaOH}$  then total number of molecules produced in the product is
- Titanium, which is used to make air plane engines and frames, can be obtained from titanium tetrachloride, which in turn is obtained from titanium oxide by the following process:  
 $3 \text{TiO}_2(\text{s}) + 4\text{C}(\text{s}) + 6\text{Cl}_2(\text{g}) \longrightarrow 3\text{TiCl}_4(\text{g}) + 2\text{CO}_2(\text{g}) + 2\text{CO}(\text{g})$   
 A vessel contains 4.32 g  $\text{TiO}_2$ , 5.76 g C and; 7.1 g  $\text{Cl}_2$ , suppose the reaction goes to completion as written, how many gram of  $\text{TiCl}_4$  can be produced? (Ti = 48)
- $\text{P}_4\text{S}_3 + 8\text{O}_2 \longrightarrow \text{P}_4\text{O}_{10} + 3\text{SO}_2$   
 Calculate minimum mass of  $\text{P}_4\text{S}_3$  is required to produce at least 1 gm of each product.
- Determine the percentage composition (by mass) of a mixture of anhydrous sodium carbonate and sodium bicarbonate from the following data:  
 wt. of the mixture taken = 2g  
 Loss in weight on heating = 0.11 gm.
- The percent yield for the following reaction carried out in carbon tetrachloride ( $\text{CCl}_4$ ) solution is 80%



- What amount of  $\text{BrCl}$  would be formed from the reaction of 0.025 mole  $\text{Br}_2$  and 0.025 mole  $\text{Cl}_2$ ?
  - What amount of  $\text{Br}_2$  is left unchanged?
- Sodium chlorate,  $\text{NaClO}_3$ , can be prepared by the following series of reactions:  
 $2\text{KMnO}_4 + 16\text{HCl} \rightarrow 2\text{KCl} + 2\text{MnCl}_2 + 8\text{H}_2\text{O} + 5\text{Cl}_2$   
 $6\text{Cl}_2 + 6\text{Ca}(\text{OH})_2 \rightarrow \text{Ca}(\text{ClO}_3)_2 + 5\text{CaCl}_2 + 6\text{H}_2\text{O}$   
 $\text{Ca}(\text{ClO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + 2\text{NaClO}_3$

What mass of  $\text{NaClO}_3$  can be prepared from 100 ml of concentrated  $\text{HCl}$  (density 1.18 gm/ml and 36% by mass)? Assume all other substances are present in excess amounts.

9. By the reaction of carbon and oxygen, a mixture of  $\text{CO}$  and  $\text{CO}_2$  is obtained. What is the composition (% by mass) of the mixture obtained when 20 grams of  $\text{O}_2$  reacts with 12 grams of carbon ?
10. Nitrogen (N), phosphorus (P), and potassium (K) are the main nutrients in plant fertilizers. According to an industry convention, the numbers on the label refer to the mass % of N,  $\text{P}_2\text{O}_5$ , and  $\text{K}_2\text{O}$ , in that order. Calculate the N : P : K ratio of a 30 : 10 : 10 fertilizer in terms of moles of each element, and express it as  $x : y : 1.0$ . Find  $y$ .
11. A mixture of Ferric oxide ( $\text{Fe}_2\text{O}_3$ ) and Al is used as a solid rocket fuel which reacts to give  $\text{Al}_2\text{O}_3$  and Fe. No other reactants and products are involved. On complete reaction of 1 mole of  $\text{Fe}_2\text{O}_3$ , 200 units of energy is released.
- (a) Write a balance reaction representing the above change.
- (b) What should be the ratio of masses of  $\text{Fe}_2\text{O}_3$  and Al taken so that maximum energy per unit mass of fuel is released?
- (c) What would be energy released if 16 kg of  $\text{Fe}_2\text{O}_3$  reacts with 2.7 kg of Al.
12. 5.33 mg of salt  $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\cdot\text{Cl}_2 \cdot \text{H}_2\text{O}$  is treated with excess of  $\text{AgNO}_3(\text{aq.})$  then mass of  $\text{AgCl}$  precipitate obtained will be : Given :  $[\text{Cr} = 52, \text{Cl} = 35.5]$
13. If mass % of oxygen in monovalent metal carbonate is 48%. Then find the number of atoms of metal present in 5mg of this metal carbonate sample is ( $N_A = 6.0 \times 10^{23}$ )
14. To find formula of compound composed of A & B which is given by  $\text{A}_x\text{B}_y$ , it is strongly heated in oxygen as per reaction-
- $$\text{A}_x\text{B}_y + \text{O}_2 \rightarrow \text{AO} + \text{Oxide of B}$$
- If 2.5gm of  $\text{A}_x\text{B}_y$  on oxidation gives 3gm oxide of A, Find empirical formula of  $\text{A}_x\text{B}_y$ ,  
[Take atomic mass of A = 24 & B = 14]
15. In a determination of P an aqueous solution of  $\text{NaH}_2\text{PO}_4$  is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate  $\text{Mg}(\text{NH}_4)\text{PO}_4 \cdot 6\text{H}_2\text{O}$ . This is heated and decomposed to magnesium pyrophosphate,  $\text{Mg}_2\text{P}_2\text{O}_7$  which is weighed. A solution of  $\text{NaH}_2\text{PO}_4$  yielded 1.054 g of  $\text{Mg}_2\text{P}_2\text{O}_7$ . What weight of  $\text{NaH}_2\text{PO}_4$  was present originally?

## EXERCISE (O-II)

## MISCELLANEOUS PROBLEM

- If the mass of neutron is double and that of proton is halved, the molecular mass of  $\text{H}_2\text{O}$  containing only  $\text{H}^1$  and  $\text{O}^{16}$  atoms will
  - increase by about 25%
  - decrease by about 25%
  - increase by about 16.67%
  - decrease by about 16.67%
- The mass of  $\text{CO}_2$  produced from 620 gm mixture of  $\text{C}_2\text{H}_4\text{O}_2$  &  $\text{O}_2$ , prepared to produce maximum energy is (Combustion reaction is exothermic)
 

(A) 413.33 gm      (B) 593.04 gm      (C) 440 gm      (D) 320 gm
- X gm A atoms on combining with Y atoms of B form 5 molecules of a compound containing A & B. Find the molecular weight of compound formed. (Atomic weight of B = M)
 

(A)  $\frac{(\text{XN}_A + \text{MY})}{5}$       (B)  $\frac{\text{X} + \text{M}}{5}$       (C)  $\frac{\text{X} + \text{MY}}{5}$       (D)  $\left(\frac{\text{X} + \text{MYN}_A}{5}\right)$
- The minimum mass of mixture of  $\text{A}_2$  and  $\text{B}_4$  required to produce at least 1 kg of each product is: (Given At. mass of 'A' = 10 ; At. mass of 'B' = 120)
 
$$5\text{A}_2 + 2\text{B}_4 \longrightarrow 2\text{AB}_2 + 4\text{A}_2\text{B}$$

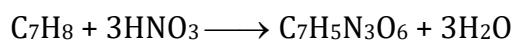
(A) 2120 gm      (B) 1060 gm      (C) 560 gm      (D) 1660 gm
- In the quantitative determination of nitrogen,  $\text{N}_2$  gas liberated from 0.42 gm of a sample of organic compound was collected over water. If the volume of  $\text{N}_2$  gas collected was  $\frac{100}{11}$  mL at total pressure 860 mm Hg at 250 K, % by mass of nitrogen in the organic compound is [Aq. tension at 250 K is 24 mm Hg and  $R = 0.08 \text{ L atm mol}^{-1} \text{ K}^{-1}$ ]
 

(A)  $\frac{10}{3}\%$       (B)  $\frac{5}{3}\%$       (C)  $\frac{20}{3}\%$       (D)  $\frac{100}{3}\%$
- 40 gm of a carbonate of an alkali metal or alkaline earth metal containing some inert impurities was made to react with excess  $\text{HCl}$  solution. The liberated  $\text{CO}_2$  occupied 12.315 lit. at 1 atm & 300 K. The correct option is
  - Mass of impurity is 1 gm and metal is Be
  - Mass of impurity is 3 gm and metal is Li
  - Mass of impurity is 5 gm and metal is Be
  - Mass of impurity is 2 gm and metal is Mg

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

7. Industrially TNT ( $C_7H_5N_3O_6$ , explosive material) is synthesized by reacting toluene ( $C_7H_8$ ) with nitric acid in presence of sulphuric acid. Calculate the maximum weight of  $C_7H_5N_3O_6$  which can be produced by 140.5 gm of a mixture of  $C_7H_8$  and  $HNO_3$ .



- (A) 140.5                      (B) 113.5                      (C)  $\frac{140.5}{2}$                       (D)  $140.5 - (3 \times 18)$

8. One gram of the silver salt of an organic dibasic acid yield, on strong heating, 0.5934 g of silver. If the weight percentage of carbon in it 8 times the weight percentage of hydrogen and one-half the weight percentage of oxygen, determine the molecular formula of the acid. [Atomic weight of Ag = 108]

- (A)  $C_4H_6O_4$                       (B)  $C_4H_6O_6$                       (C)  $C_2H_6O_2$                       (D)  $C_5H_{10}O_5$

## ONE OR MORE THAN ONE MAY BE CORRECT

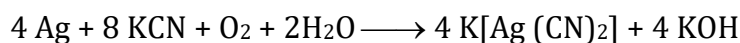
9. Select the correct statement(s) for  $(NH_4)_3PO_4$ .
- (A) Ratio of number of oxygen atom to number of hydrogen atom is 1 : 3  
 (B) Ratio of number of cation to number of anion is 3 : 1  
 (C) Ratio of number of gm-atom of nitrogen to gm-atoms of oxygen is 3 : 2  
 (D) Total number of atoms in one mole of  $(NH_4)_3PO_4$  is 20.
10. 12 g of Mg was burnt in a closed vessel containing 32 g oxygen. Which of the following is not correct?
- (A) 2 gm of Mg will be left unburnt.  
 (B) 0.75 gm-molecule of  $O_2$  will be left unreacted.  
 (C) 20 gm of MgO will be formed.  
 (D) The mixture at the end will weight 44 g.
11. 50 gm of  $CaCO_3$  is allowed to react with 68.6 gm of  $H_3PO_4$  then select the correct option(s)-  
 $3CaCO_3 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3H_2O + 3CO_2$
- (A) 51.67 gm salt is formed                      (B) Amount of unreacted reagent = 35.93 gm  
 (C)  $n_{CO_2} = 0.5$  moles                      (D) 0.7 mole  $CO_2$  is evolved
12. 'A' reacts by following two parallel reaction to give B & C If half of 'A' goes into reaction I and other half goes to reaction-II. Then , select the correct statement(s)
- $A + N \xrightarrow{I} B + L$   
 $A + N \xrightarrow{II} \frac{1}{2} B + \frac{1}{2} C + L$
- (A) B will be always greater than C  
 (B) If 2 mole of C are formed then total 2 mole of B are also formed  
 (C) If 2 mole of C are formed then total 4 mole of B are also formed

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

(D) If 2 mole of C are formed then total 6 mole of B are also formed

13. Silver metal in ore is dissolved by potassium cyanide solution in the presence of air by the reaction



- (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.

14. Given following series of reactions:

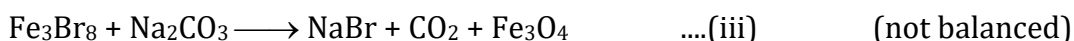
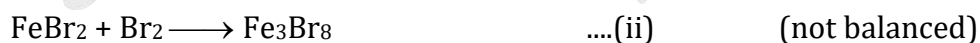
- (I)  $\text{NH}_3 + \text{O}_2 \longrightarrow \text{NO} + \text{H}_2\text{O}$   
 (II)  $\text{NO} + \text{O}_2 \longrightarrow \text{NO}_2$   
 (III)  $\text{NO}_2 + \text{H}_2\text{O} \longrightarrow \text{HNO}_3 + \text{HNO}_2$   
 (IV)  $\text{HNO}_2 \longrightarrow \text{HNO}_3 + \text{NO} + \text{H}_2\text{O}$

Select the correct option(s):

- (A) Moles of  $\text{HNO}_3$  obtained is half of moles of Ammonia used if  $\text{HNO}_2$  is not used to produce  $\text{HNO}_3$  by reaction (IV)  
 (B)  $\frac{100}{6}\%$  more  $\text{HNO}_3$  will be produced if  $\text{HNO}_2$  is used to produce  $\text{HNO}_3$  by reaction (IV) than if  $\text{HNO}_2$  is not used to produce  $\text{HNO}_3$  by reaction (IV)  
 (C) If  $\text{HNO}_2$  is used to produce  $\text{HNO}_3$  then  $\frac{1}{4}$ th of total  $\text{HNO}_3$  is produced by reaction (IV)  
 (D) Moles of NO produced in reaction (IV) is 50% of moles of total  $\text{HNO}_3$  produced.

## COMPREHENSION 15 TO 17

NaBr, used to produce AgBr for use in photography can be self prepared as follows :



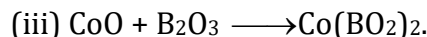
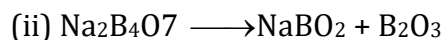
15. Mass of iron required to produce  $2.06 \times 10^3$  kg NaBr  
 (A) 420 gm (B) 420 kg (C)  $4.2 \times 10^5$  kg (D)  $4.2 \times 10^8$  gm
16. If the yield of (ii) is 60% & (iii) reaction is 70% then mass of iron required to produce  $2.06 \times 10^3$  kg NaBr  
 (A)  $10^5$  kg (B)  $10^5$  gm (C)  $10^3$  kg (D) None
17. If yield of (iii) reaction is 90% then mole of  $\text{CO}_2$  formed when  $2.06 \times 10^3$  gm NaBr is formed  
 (A) 20 (B) 10 (C) 40 (D) None

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

## COMPREHENSION 18 TO 19

Preparation of cobalt Metaborate involves the following steps of reactions:



(Atomic weight : B = 11, Co = 59)

18. Mass of  $\text{Ca}_2\text{B}_6\text{O}_{11}$  in kg required to produce 14.5 kg of  $\text{Co}(\text{BO}_2)_2$ , assuming 100% yield of each reaction is

(A) 32.2 (B) 40 (C) 28.2 (D) 30

19. If the yield of reaction (i), (ii) & (iii) is 60%,  $\frac{200}{3}\%$  & 32.2 % respectively, then mass of  $\text{Ca}_2\text{B}_6\text{O}_{11}$  in kg required to produce 14.5 kg of  $\text{Co}(\text{BO}_2)_2$  is

(A) 250 (B) 200 (C) 190 (D) 150

## COMPREHENSION 20 TO 22

Water is added to 3.52 grams of  $\text{UF}_6$ . The products are 3.08 grams of a solid [containing only U, O & F] and 0.8 gram of a gas only. The gas [containing fluorine and hydrogen only], contains 95 % by mass fluorine.

[Assume that the empirical formula is same as molecular formula.]

20. The empirical formula of the gas is  
(A)  $\text{HF}_2$  (B)  $\text{H}_2\text{F}$  (C) HF (D)  $\text{HF}_3$
21. The empirical formula of the solid product is  
(A)  $\text{UF}_2\text{O}_2$  (B)  $\text{UFO}_2$  (C)  $\text{UF}_2\text{O}$  (D) UFO
22. The percentage of fluorine of the original compound which is converted into gaseous compound is  
(A) 66.66 % (B) 33.33 % (C) 50 % (D) 89.9 %

## MATCH THE COLUMN

23. One type of artificial diamond (commonly called YAG for yttrium aluminium garnet) can be represented by the formula  $\text{Y}_3\text{Al}_5\text{O}_{12}$ . [Y = 89, Al = 27]

Column I		Column II	
Element		Weight percentage	
(P)	Y	(1)	22.73%
(Q)	Al	(2)	32.32%
(R)	O	(3)	44.95%

(PHYSICAL CHEMISTRY)

MOLE CONCEPT

24. The recommended daily dose is 17.6 milligrams of vitamin C (ascorbic acid) having formula  $C_6H_8O_6$ . Match the following. Given :  $N_A = 6 \times 10^{23}$

Column I

- (A) O-atoms present  
(B) Moles of vitamin C in 1 gm of vitamin C  
(C) Moles of vitamin C that should be consumed daily

Column II

- (P)  $10^{-4}$  mole  
(Q)  $5.68 \times 10^{-3}$   
(R)  $3.6 \times 10^{20}$

25. Matching list type :

Column-I

- (P)  $2H_2 + O_2 \rightarrow 2H_2O$   
1g 1g  
(Q)  $3H_2 + N_2 \rightarrow 2NH_3$   
1g 1g  
(R)  $H_2 + Cl_2 \rightarrow 2HCl$   
1g 1g  
(S)  $2H_2 + C \rightarrow CH_4$   
1g 1g

Column-II

(mass of product)

- (1) 1.028 g  
(2) 1.333 g  
(3) 1.125 g  
(4) 1.214 g

Code :

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



## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

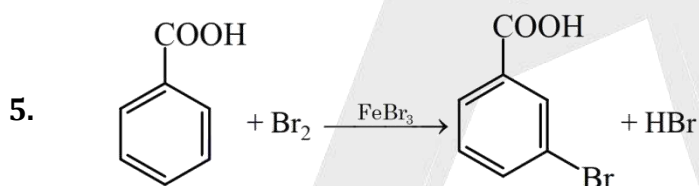
## EXERCISE (JEE MAIN)

1. CNG is an important transportation fuel. When 100 g CNG is mixed with 208 oxygen in vehicles, it leads to the formation of  $\text{CO}_2$  and  $\text{H}_2\text{O}$  and produces large quantity of heat during this combustion, then the amount of carbon dioxide, produced in grams is \_\_\_\_\_. [nearest integer]  
[Assume CNG to be methane] **[JEE Main, June 2022]**

2. 116 g of a substance upon dissociation reaction, yields 7.5 g of hydrogen, 60g of oxygen and 48.5 g of carbon. Given that the atomic masses of H, O and C are 1, 16 and 12 respectively. The data agrees with how many formulae of the following?  
(A)  $\text{CH}_3\text{COOH}$  (B)  $\text{HCHO}$   
(C)  $\text{CH}_3\text{OOCH}_3$  (D)  $\text{CH}_3\text{CHO}$  **[JEE Main, June 2022]**

3. On complete combustion 0.30 g of an organic compound gave 0.20 g of carbon dioxide and 0.10 g of water. The percentage of carbon in the given organic compound is \_\_\_\_\_. (Nearest integer). **[JEE Main, June 2022]**

4. 1 mol of an octahedral metal complex with formula  $\text{MCl}_3 \cdot 2\text{L}$  on reaction with excess of  $\text{AgNO}_3$  gives 1 mol of  $\text{AgCl}$ . The denticity of Ligand L is \_\_\_\_\_. (Integer answer) **[JEE Main, August 2021]**

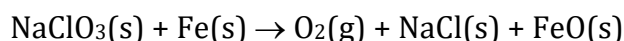


Consider the above reaction where 6.1 g of benzoic acid is used to get 7.8 g of m-bromo benzoic acid. The percentage yield of the product is \_\_\_\_\_.  
(Round off to the Nearest integer)

[Given : Atomic masses : C = 12.0u, H : 1.0u, O : 16.0u, Br = 80.0 u]

**[JEE Main, March 2021]**

6.  $\text{NaClO}_3$  is used, even in space crafts, to produce  $\text{O}_2$ . The daily consumption of pure  $\text{O}_2$  by a person is 492 L at 1 atm, 300 K. How much amount of  $\text{NaClO}_3$ , in grams is required to produce  $\text{O}_2$  for the daily consumption of a person at 1 atm, 300 K ? \_\_\_\_\_.



$$R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

**[JEE Main, 2020]**

7. 5 moles of  $\text{AB}_2$  weigh  $125 \times 10^{-3}$  kg and 10 moles of  $\text{A}_2\text{B}_2$  weigh  $300 \times 10^{-3}$  kg. The molar mass of A ( $M_A$ ) and molar mass of B ( $M_B$ ) in  $\text{kg mol}^{-1}$  are:

- (A)  $M_A = 5 \times 10^{-3}$  and  $M_B = 10 \times 10^{-3}$  (B)  $M_A = 50 \times 10^{-3}$  and  $M_B = 25 \times 10^{-3}$   
(C)  $M_A = 25 \times 10^{-3}$  and  $M_B = 50 \times 10^{-3}$  (D)  $M_A = 10 \times 10^{-3}$  and  $M_B = 5 \times 10^{-3}$

**[Jee Main, April 2019]**



8. For a reaction,  
 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \longrightarrow 2\text{NH}_3(\text{g})$ ; identify dihydrogen ( $\text{H}_2$ ) as a limiting reagent in the following reaction mixtures. **(Mole Concept)**  
(A) 28 g of  $\text{N}_2$  + 6 g of  $\text{H}_2$  (B) 56 g of  $\text{N}_2$  + 10 g of  $\text{H}_2$   
(C) 14 g of  $\text{N}_2$  + 4 g of  $\text{H}_2$  (D) 35 g of  $\text{N}_2$  + 8 g of  $\text{H}_2$   
**[Jee Main, April 2019]**
9. The reaction of mass percent of C and H of an organic compound ( $\text{C}_x\text{H}_y\text{O}_z$ ) is 6 : 1, If one molecule of the above compound ( $\text{C}_x\text{H}_y\text{O}_z$ ) contains half as much oxygen as required to burn on molecule of compound  $\text{C}_x\text{H}_y$  completely to  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . The empirical formula of compound  $\text{C}_x\text{H}_y\text{O}_z$  is: **[JEE(Main)-2018]**  
(A)  $\text{C}_2\text{H}_4\text{O}_3$  (B)  $\text{C}_3\text{H}_6\text{O}_3$  (C)  $\text{C}_2\text{H}_4\text{O}$  (D)  $\text{C}_3\text{H}_4\text{O}_2$
10. 1 gram of a carbonate ( $\text{M}_2\text{CO}_3$ ) on treatment with excess  $\text{HCl}$  produces 0.01186 mole of  $\text{CO}_2$ . the molar mass of  $\text{M}_2\text{CO}_3$  in  $\text{g mol}^{-1}$  is : **[JEE(Main)-2017]**  
(A) 1186 (B) 84.3 (C) 118.6 (D) 11.86
11. 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  $^1\text{H}$  atoms are replaced by  $^2\text{H}$  atoms is **[JEE(Main)-2017]**  
(A) 15 kg (B) 37.5 kg (C) 7.5 kg (D) 10 kg
12. In Carius method of estimation of halogens, 250 mg of an organic compound give 141 mg of  $\text{AgBr}$ . The percentage of bromine in the compound is : (at. mass  $\text{Ag} = 108$ ;  $\text{Br} = 80$ ) **[JEE(Main)-2015]**  
(A) 24 (B) 36 (C) 48 (D) 60
13. The molecular formula of a commercial resin used for exchanging ions in water softening is  $\text{C}_8\text{H}_7\text{SO}_3\text{Na}$  (Mol. Wt. 206) What would be the maximum uptake of  $\text{Ca}^{2+}$  ions by the resin when expressed in mole per gram resin? **[JEE(Main)-2015]**  
(A)  $\frac{1}{103}$  (B)  $\frac{1}{206}$  (C)  $\frac{2}{309}$  (D)  $\frac{1}{412}$

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

14. The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is : [JEE(Main)-2014]  
(A) 1 : 8 (B) 3 : 16 (C) 1 : 4 (D) 7 : 32
15. A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g of CO<sub>2</sub>. The empirical formula of the hydrocarbon is [JEE(Main)-2013]  
(A) C<sub>2</sub>H<sub>4</sub> (B) C<sub>3</sub>H<sub>4</sub> (C) C<sub>6</sub>H<sub>5</sub> (D) C<sub>7</sub>H<sub>8</sub>
16. The ratio of number of oxygen atoms (O) in 16.0 g ozone (O<sub>3</sub>), 28.0 g carbon monoxide (CO) and 16.0 g oxygen (O<sub>2</sub>) is :-  
(Atomic mass : C = 12, O = 16 and Avogadro's constant N<sub>A</sub> = 6.0 × 10<sup>23</sup> mol<sup>-1</sup>) [AIEEE 2012 (Online)]  
(A) 3 : 1 : 1 (B) 1 : 1 : 2 (C) 3 : 1 : 2 (D) 1 : 1 : 1
17. A transition metal M forms a volatile chloride which has a vapour density of 94.8. If it contains 74.75% of chlorine the formula of the metal chloride will be [AIEEE 2012 (Online)]  
(A) MCl<sub>2</sub> (B) MCl<sub>4</sub> (C) MCl<sub>5</sub> (D) MCl<sub>3</sub>
18. How many moles of magnesium phosphate, Mg<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> will contain 0.25 mole of oxygen atoms? [AIEEE 2006]  
(A) 3.125 × 10<sup>-2</sup> (B) 1.25 × 10<sup>-2</sup> (C) 2.5 × 10<sup>-2</sup> (D) 0.02
19. If we consider that 1/6, in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of the substance will : [AIEEE-2005]  
(A) be a function of the molecular mass of the substance  
(B) remain unchanged  
(C) increase two fold  
(D) decrease twice
20. In an organic compound of molar mass 108 g mol<sup>-1</sup> C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be : [AIEEE 2002]  
(A) C<sub>6</sub>H<sub>8</sub>N<sub>2</sub> (B) C<sub>7</sub>H<sub>10</sub>N (C) C<sub>5</sub>H<sub>6</sub>N<sub>3</sub> (D) C<sub>4</sub>H<sub>18</sub>N<sub>3</sub>
21. The weight of 2.01 × 10<sup>23</sup> molecules of CO is- [AIEEE 2002]  
(A) 9.3g (B) 7.2g (C) 1.2g (D) 3g

## EXERCISE (JEE-ADVANCED)

1. Calculate the amount of Calcium oxide required when it reacts with 852 g of  $P_4O_{10}$ .  
 $6CaO + P_4O_{10} \longrightarrow 2 Ca_3 (PO_4)_2$  [JEE 2005]
2. 20% surface sites have adsorbed  $N_2$ . On heating  $N_2$  gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is  $2.46 \text{ cm}^3$ . Density of surface sites is  $6.023 \times 10^{14} / \text{cm}^2$  and surface area is  $1000 \text{ cm}^2$ , find out the no. of surface sites occupied per molecule of  $N_2$ . [JEE 2005]
3. Given that the abundances of isotopes  $^{54}\text{Fe}$ ,  $^{56}\text{Fe}$  and  $^{57}\text{Fe}$  are 5%, 90% and 5%, respectively, the atomic mass of Fe is : [JEE 2009]  
(A) 55.85 (B) 55.95 (C) 55.75 (D) 56.05
4. Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in kg) of Pb produced per kg of  $O_2$  consumed is \_\_\_\_\_.  
(Atomic weights in  $\text{gmol}^{-1}$ : O = 16, S = 32, Pb = 207) (2018)  
Hint:  $PbS + O_2 \rightarrow Pb + SO_2$

ANSWER KEY

Exercise (S-1)

- |         |         |         |         |         |         |         |
|---------|---------|---------|---------|---------|---------|---------|
| 1. (B)  | 2. (D)  | 3. (A)  | 4. (D)  | 5. (A)  | 6. (B)  | 7. (B)  |
| 8. (C)  | 9. (C)  | 10. (C) | 11. (B) | 12. (C) | 13. (A) | 14. (D) |
| 15. (C) | 16. (C) | 17. (C) | 18. (B) | 19. (C) | 20. (B) | 21. (D) |
| 22. (B) | 23. (B) | 24. (B) | 25. (A) | 26. (B) | 27. (C) | 28. (C) |
| 29. (C) | 30. (C) | 31. (B) | 32. (A) | 33. (A) | 34. (B) | 35. (B) |
| 36. (A) | 37. (A) | 38. (D) | 39. (A) | 40. (C) | 41. (B) | 42. (C) |
| 43. (A) | 44. (B) | 45. (A) | 46. (A) | 47. (A) | 48. (B) | 49. (A) |
| 50. (A) | 51. (C) | 52. (C) | 53. (C) | 54. (B) | 55. (B) | 56. (A) |
| 57. (B) | 58. (C) | 59. (B) |         |         |         |         |

Exercise (O-I)

- |  |                            |  |                         |                        |                         |
|--|----------------------------|--|-------------------------|------------------------|-------------------------|
| 1. (i) 32 g  | (ii) 28 g                  | (iii) 46 g                                 | (iv) 18 g               | (v) 17 g               | (vi) 92g                |
| (vii) 64 g   | (viii) 98g                 | (ix) 44 g                                  | (x) 180 g               | (xi) 60 g              | (xii) 342 g             |
| (xiii) 249.5 g   |                            |  |                         |                        |                         |
| 2. (i) 1   | (ii) 2                     | (iii) 2                                    | (iv) 4                  | (v) $3 \times 10^{-3}$ | (vi) $3 \times 10^{-3}$ |
| (vii) $0.5 \times 10^{-3}$   |                            | (viii) $0.25 \times 10^{-3}$               |                         |                        |                         |
| 3. (i) 1   | (ii) $1 \times N_A$        | (iii) 6                                    | (iv) 12                 | (v) 6                  |                         |
| (vi) $6N_A, 12N_A, 6N_A$   | (vii) $24N_A$              |  |                         |                        |                         |
| 4. (i) 0.5   | (ii) 1, 0.5, 2             | (iii) $0.5N_A$                             | (iv) $N_A, N_A/2, 2N_A$ | (v) $3.5N_A$           |                         |
| 5. (i) $\frac{10^{20}}{N_A}$ moles,  | (ii) 3200 amu,             | (iii) $1400 \times 1.66 \times 10^{-24}$ g |                         |                        |                         |
| (iv) $3N_A, 9N_A,$   | (v) $6N_A$                 |  |                         |                        |                         |
| 6. $1.99 \times 10^{-23}$ g  | 7. 24g                     | 8. 3.2 g                                   | 9. 180 g                |                        |                         |
| 10. 2.5 g  | 11. $7.227 \times 10^{24}$ |  |                         |                        |                         |
| 12. $10 \times 6.023 \times 10^{23}, 8 \times 6.023 \times 10^{23}, 8 \times 6.023 \times 10^{23}$ |                            |  |                         |                        |                         |
| 13. 68 mole  | 14. $5.34 \times 10^6$     | 15. $6.023 \times 10^{13}$                 | 16. 4                   |                        |                         |
| 17. (i) $n = 2$  | (ii) $n = 2.5$             | (iii) $n = 2$                              | (iv) $P = 50$ atm       | (v) $P = 74.8$ Pa      |                         |
| (vi) $T = 1000$ K  | (vii) $V = 2$ L            | (viii) $P = 2500$ Pa                       |                         |                        |                         |
| 18. (i) 45.4 L   | (ii) 5.675 L               | (iii) 11.35 L                              | (iv) 90.8 L             |                        |                         |
| 19. (i) 1  | (ii) 2                     | (iii) $2 \times 10^{-3}$                   | (iv) $5 \times 10^{-4}$ | (v) 0.1                |                         |
| (vi) 5000  |                            |  |                         |                        |                         |

20. (a)  $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$   
 (b)  $\text{C}_2\text{H}_6 + \frac{7}{2} \text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$   
 (c)  $\text{CaSiO}_3 + 6\text{HF} \rightarrow \text{SiF}_4 + \text{CaF}_2 + 3\text{H}_2\text{O}$   
 (d)  $6\text{Cl}_2 + 6\text{Ca}(\text{OH})_2 \rightarrow \text{Ca}(\text{ClO}_3)_2 + 5\text{CaCl}_2 + 6\text{H}_2\text{O}$   
 (e)  $2\text{KMnO}_4 + 16\text{HCl} \rightarrow 2\text{KCl} + 2\text{MnCl}_2 + 8\text{H}_2\text{O} + 5\text{Cl}_2$
21. 2270 L      22. 7.5 moles      23. 24      24. 58.8 g  
 25. 27.6 gm      26.  $1.0 \times 10^{19}$       27. 39.18  
 28. (i)  $1/6$  mole (ii)  $5/12$  mole      29. 0.48      30. 0.1185  
 31. 0.25 mole      32.  $w_{\text{C}} = 24 \text{ gm}$  ;  $w_{\text{CCl}_4} = 154 \text{ gm}$       33. 5.6  
 34. Al = 60%; Mg = 40%      35. 42 g      36. 63 % , 37%  
 37. 10 %      38. 12.3      39. 4.48 litre      40. 75  
 41. 19.4 gm      42. 640.0      43. 441 gm  
 44. (a) 59.17 gm (b) 61.97 gm      45. 35.4527      46. 10      47. 60  
 48. 40      50. 53.33 %      51.  $\text{C}_6\text{H}_4\text{Cl}_2$       52. (8)      53.  $\text{C}_9\text{H}_9\text{O}_3$   
 54. (3)

## Exercise (S-II)

1. 50.1 litre  
 2. 222 gm  
 3.  $7.5 \times \text{Na}$   
 4. 9.5  
 5. 1.1458  
 6.  $\text{NaHCO}_3 = 14.9 \%$ ;  $\text{Na}_2\text{CO}_3 = 85.1 \%$   
 7. (a) 0.050 mol ,      (b) 0.050 mol  
 8. 12.9 gm  
 9.  $\% \text{CO} = 65.625$  ;  $\% \text{CO}_2 = 34.375$   
 10. 10 : 0.66 : 1  
 11. (i)  $\text{Fe}_2\text{O}_3 + 2 \text{Al} \longrightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$ ; (ii) 80 : 27; (iii) 10,000 units  
 12. 5.74 gm  
 13.  $6 \times 10^{19}$   
 14.  $(\text{A}_3\text{B}_2)$   
 15. 1.14 gm

Exercise (O-II)

- |                         |           |         |           |          |         |         |
|-------------------------|-----------|---------|-----------|----------|---------|---------|
| 1. (C)                  | 2. (C)    | 3. (A)  | 4. (A)    | 5. (A)   | 6. (B)  | 7. (B)  |
| 8. (B)                  | 9. (AB)   | 10. (A) | 11. (ABC) | 12. (AD) |         |         |
| 13. (ACD)               | 14. (ACD) | 15. (B) | 16. (C)   | 17. (B)  | 18. (A) | 19. (A) |
| 20. (C)                 | 21. (A)   | 22. (A) |           |          |         |         |
| 23. (A)→R, (B)→P, (C)→Q |           |         |           |          |         |         |
| 24. (A)→R; (B)→Q; (C)→P |           |         |           |          |         |         |
| 25. (A)                 |           |         |           |          |         |         |

EXERCISE (JEE MAINS)

- |                   |         |         |         |         |         |
|-------------------|---------|---------|---------|---------|---------|
| 1. (143)          | 2. (2)  | 3. (18) | 4. (2)  | 5. (78) |         |
| 6. (2120 to 2140) |         | 7. (A)  | 8. (B)  | 9. (A)  | 10. (A) |
| 11. (B)           | 12. (A) | 13. (B) | 14. (D) | 15. (D) | 16. (D) |
| 17. (D)           | 18. (A) | 19. (C) | 20. (B) | 21. (A) |         |

EXERCISE (JEE-ADVANCED)

- |        |        |           |           |
|--------|--------|-----------|-----------|
| 1. (B) | 2. (2) | 3. (1008) | 4. (6.47) |
|--------|--------|-----------|-----------|

## Solution

## EXERCISE (S-I)

## TYPE-1: PROBLEMS RELATED WITH ATOMIC &amp; MOLECULAR MASS

1. Atomic mass of element  $= \frac{8.0 \times 10^{-18}}{3.2 \times 10^5} \times 6 \times 10^{23} = 15$

2. Weight of 1 proton = 1 a.m.u or  $\frac{1}{N_A}$  gm

weight of 1 mole proton = 1 gm

3. Weight of 1 proton = 1 a.m.u or  $\frac{1}{N_A}$  gm

weight of 1 mole proton = 1 gm

$\therefore$  1 gm of proton contains = 1 mole

$\therefore$  1000 gm of proton contains =  $10^3$  mole

4. Mass of 1  $e^-$  =  $9.1 \times 10^{-31}$  kg

Mass of 1 mole  $e^-$  =  $9.1 \times 10^{-31} \times 6 \times 10^{23} = 54.6 \times 10^{-8}$  kg/mol

5.  $n_{CO_2} = \frac{44}{44} = 1$  mole

$\Rightarrow$  the molecules of  $CO_2 = N_A$  i.e.  $6 \times 10^{23}$ .

$\Rightarrow$  correct option is (A)

6.  $n_{NH_3} = \frac{4.25}{17}$  i.e. mole

$\Rightarrow$  option (B) is correct.

7. Weight of molecule of compounds  $C_{60}H_{22}$

$= (60 \times 12 + 22 \times 1)$  amu  $= (720 + 22)$  amu

$= 742 \times 1.66 \times 10^{-24}$  g  $= 1.24 \times 10^{-21}$  gm

$\Rightarrow$  Option (B) is correct.

8.  $n_{NO_3^-} = \frac{3.1 \times 10^{-3}}{62 \times 10}$

$= 0.5 \times 10^{-4}$

$= 5 \times 10^{-5}$

Number of electrons in 3.1 mg  $NO_3^\ominus = 5 \times 10^{-5} \times 32 \times 6.022 \times 10^{23} = 9.6 \times 10^{20}$ .

$\Rightarrow$  Correct option is (C)

9. Mole of Al =  $1/27$

(PHYSICAL CHEMISTRY)

MOLE CONCEPT

Charge on 1 gram ions of  $\text{Al}^{+3}$  is  $(1/27) 3 \times N_A e$

$\Rightarrow$  option (C) is correct.

10.  $n_{\text{CuSO}_4 \cdot 5\text{H}_2\text{O}} = \left( \frac{1 \times 10^{22}}{6.022 \times 10^{23}} \right) = 1.66 \times 10^{-2} \text{ mole}$

$\Rightarrow$  weight =  $1.66 \times 10^{-2} \times 249.5 = 4.159 \text{ gm}$

$\Rightarrow$  Correct option is (C)

11.  $n_C \longrightarrow \frac{1.2 \times 10^{-3}}{12} \text{ mole}$

$\Rightarrow$  number of carbon atoms =  $\frac{1.2 \times 10^{-3}}{12} \times N_A$

=  $6.02 \times 10^{19} \text{ atoms}$

$\Rightarrow$  Correct option is (B).



As, 100 g salt contains 0.5 g NaI

$\Rightarrow$  3g salt contains  $\left( \frac{.5}{100} \times 3 \right) \text{ g NaI.}$

= 0.015 g NaI.

$n_{\text{NaI}} \longrightarrow \frac{0.015}{150} \text{ mole}$

$\Rightarrow$  number of  $\text{I}^-$  ions =  $\frac{0.015}{150} \times 6.02 \times 10^{23}$

=  $6.02 \times 10^{19}$ .

$\Rightarrow$  Correct option is (C).

13. (A) 1 of - atom of c = 12 g

(B)  $\frac{1}{2} \text{ mole CH}_4 = 8 \text{ g}$

(C) 10 ml of  $\text{H}_2\text{O} = 10 \text{ g}$

(D)  $3.011 \times 10^{23} \text{ atoms of oxygen} = 8 \text{ g}$

$\Rightarrow$  option (A) is

14. (A)  $n_{\text{C}_2\text{H}_6} = \frac{15}{30} = \frac{1}{2} \text{ mole}$

$\Rightarrow$  number of carbon atoms =  $\frac{N_A}{2} \times 2$  i.e.  $N_A$



$$(B) \quad n_{\text{Na}_2\text{C}_2\text{O}_4} = \frac{40.2}{134} = 0.3 \text{ mole}$$

$$\Rightarrow \text{number of carbon atoms} = 0.3 \times 2N_A = 0.6 N_A$$

$$(C) \quad n_{\text{glucose}} = \frac{72}{180} = 0.4$$

$$\Rightarrow \text{number of carbon atoms} = 0.4 \times 6N_A = 2.4 N_A$$

$$(D) \quad n_{\text{C}_5\text{H}_{10}} = \frac{35}{70} = 0.5$$

$$\Rightarrow \text{number of carbon atoms} = 0.5 \times 5N_A = 2.5 N_A$$

$\Rightarrow$  Correct option is (D)

15. number of H-atom in 0.9 gm glucose =  $\frac{0.9}{180} \times 12N_A = 0.06 N_A$

$$(A) \quad n_{\text{N}_2\text{H}_4} = \frac{0.048}{32}$$

$$\Rightarrow \text{number of H-atoms} = \frac{0.048}{32} \times 4N_A = 0.006 N_A$$

$$(B) \quad n_{\text{NH}_3} = \frac{0.17}{17}$$

$$\Rightarrow \text{number of H-atom} = 0.01 \times 3N_A = 0.03 N_A$$

$$(C) \quad n_{\text{C}_2\text{H}_6} = \frac{0.30}{30} = 0.01$$

$$\Rightarrow \text{number of H-atoms} = 0.06 N_A.$$

$$(D) \quad n_{\text{H}_2} \rightarrow \frac{0.03}{2} = \frac{0.03}{2} \text{ mole}$$

$$\Rightarrow \text{number of H-atoms} = \frac{0.03}{2} \times 2 N_A = 0.03 N_A$$

$\Rightarrow$  Correct option is (C)

16. Atomic weight of A = 40 u

& Atomic weight of B = 80 u

$$\frac{x}{40} \times N_A = y \quad \dots\dots(1)$$

$$\frac{2x}{80} N_A \rightarrow ? \quad \dots\dots(2)$$

Comparing (1) and (2), we get  $2x$  of B = y

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

⇒ option (C) is correct

17.  $n_{\text{Al}} \longrightarrow \frac{54}{27} = 2 \text{ mole.}$

⇒ mass of same number of magnesium atoms = 48 gm

⇒ Correct option is (C).

18. Ratio of number of molecules of  $\text{CO}_2$  &  $\text{N}_2\text{O}$

$$= \frac{2x}{44} \times N_A \times \frac{44}{5x \times N_A} = 2 : 5$$

⇒ correct option is (B)

19. mass of 1.2 mole ethanol =  $(1.2 \times 46) \text{ g}$

$$\Rightarrow \text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{1.2 \times 46}{0.8} = 69 \text{ ml}$$

⇒ Correct option is (C).

20.  $8 = \frac{1 \times 32}{M} \times 100$

$$\Rightarrow M = 400$$

⇒ Correct option is (B).

21.  $69.98 = \frac{21 \times 12}{M} \times 100$

$$\Rightarrow M = \frac{21 \times 12}{69.98} \times 100 \quad \square M = 360.1$$

⇒ Correct option is (D)

22. Pressure =  $\frac{190}{760} \text{ atm}$ , temperature =  $273 + 273.15 \text{ K}$

$$\text{Volume} = 2.24 \text{ m}^3 = 2.24 \times 10^3 \text{ L}$$

$$\text{Moles} = \frac{PV}{RT} = \frac{1}{4} \times 22.4 \times 10^3 \times \frac{1}{0.0821 \times 546}$$

⇒ 12.5 moles

23. Molar mass of  $\text{SO}_x = 32 + 16x$

$$\therefore \text{Number of moles of } \text{SO}_x = \frac{80}{32 + 16x}$$

Putting in equation  $PV = nRT$

$$\Rightarrow 2 \times 15 = \frac{80}{32 + 16x} \times 0.08 \times 300$$

(PHYSICAL CHEMISTRY)

MOLE CONCEPT

$$\Rightarrow 16x + 32 = 64$$

$$\Rightarrow x = 2$$

24.  $n_{\text{NO}_2} = \frac{112}{22.4 \times 10^3}$

$$\Rightarrow \text{number of molecules} = \frac{112}{22.4 \times 10^3} \times 6.02 \times 10^{23} = 3.1 \times 10^{21}$$

$$\text{Now, volume} = \frac{\text{mass}}{\text{density}} = \frac{5 \times 10^{-3} \times 46}{1.15}$$

$$= 200 \times 10^{-3} = 0.20 \text{ ml}$$

$\Rightarrow$  Correct option is (B).

25.  $n = \frac{PV}{RT}$

$$\frac{100 \times 10^3 \times 16.628 \times 10^{-3}}{8.314 \times 300} = 0.67$$

26. By Avogadro's Hypothesis,

for gas A,  $P \cdot V_A = n_A \cdot RT$

for gas B,  $P \cdot V_B = n_B \cdot RT$

If  $n_A = n_B$

$$\Rightarrow V_A = V_B$$

$\Rightarrow$  Correction option is (B).

27. By Avogadro's hypothesis

$$n_{\text{O}_2} = n_{\text{unknown gas}}$$

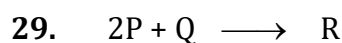
$$\Rightarrow \frac{1}{32} = \frac{2.375}{M} \quad (M \rightarrow \text{molar mass of unknown gas})$$

$$\Rightarrow M = 2.375 \times 32 \quad \Rightarrow \quad M = 76$$

$\Rightarrow$  correct option is (C)

28. Ratio of number of atoms = 2 : 1 : 2 : 3

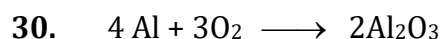
$\Rightarrow$  Correct option is (C).



mole : 8 (Excess)      0

0      4

$\Rightarrow$  Correct option is (C).

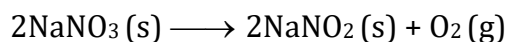


(Excess) 1.5      0

0 1  
 $\Rightarrow$  weight of Al 54 gm.

31. Number of moles of  $\text{NaNO}_3 = \frac{8.5}{85} = 0.1 \text{ mol.}$

For the reaction,



$$0.1 \text{ mol} \qquad 0.1 \times \frac{1}{2} \text{ mol}$$

At 2 atm and 546 K, molar volume = 22.4  $\lambda$

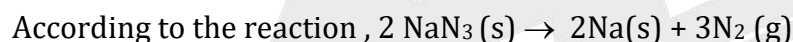
$$\therefore \text{Volume at 2 atm and 546 K} = 22.4 \times \frac{0.1}{2}$$

$$= 1.12 \lambda$$

32. Mass of Nitrogen gas =  $368 \times 1.12$  ( Mass = vol.  $\times$  density )

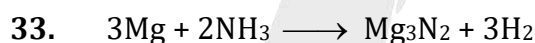
$$\text{Mass of Nitrogen gas} = \frac{368 \times 1.12}{28} \Rightarrow 368 \times 0.04$$

Let mass of  $\text{NaN}_3 = x \text{ gm.}$



$$\text{Number of moles of nitrogen gas produced from } (x) \text{ gm NaN}_3 = \frac{3x}{2 \times 65}$$

$$\text{Given, } \frac{3x}{2 \times 65} = 368 \times 0.04 \Rightarrow x = 637.8 \text{ gm} = 0.638 \text{ kg.}$$



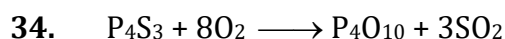
$$\text{Mole : } \frac{48}{24} \quad \frac{34}{17}$$

$$= 2 \quad = 2$$

$\Rightarrow$  Mg is L. R.

$$\Rightarrow \text{mass of Mg}_3\text{N}_2 \text{ produced is } \frac{2}{3} \times (100) \text{ g} = \frac{200}{3} \text{ g}$$

$\Rightarrow$  Correct option is (A)



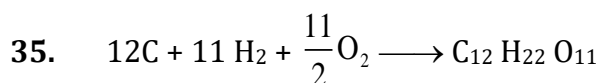
$$\text{Mole : } \frac{440}{220} \quad \frac{384}{32}$$

$$= 2 \quad = 12$$

$\Rightarrow \text{O}_2$  is L.R

$$\Rightarrow \text{mass of } P_4O_{10} \text{ produced} = \frac{(12 \times 284)}{8} \text{ g} = 426 \text{ gm.}$$

$\Rightarrow$  Correct option is (B).



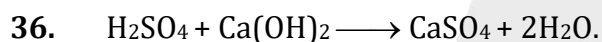
$$\text{Mole : } \frac{84}{12} \quad \frac{12}{2} \quad \frac{56}{22.4}$$

$$= \quad 7 \quad 6 \quad 2.5$$

$\Rightarrow O_2$  is L.R.

$$\Rightarrow \text{Mass of sucrose produced} = \left( \frac{2}{11} \times 2.5 \right) \times 342 \text{ g} = 155.5 \text{ g}$$

$\Rightarrow$  Correct option is (B).



$$\text{Mole} \quad .5 \quad 0.2$$

$Ca(OH)_2$  is L.R.

$\Rightarrow$  number of moles of  $CaSO_4$  formed = 0.2

$\Rightarrow$  Correct option is (A)



On heating due to this reaction



$CO_2(g)$  releases in atmosphere

$\therefore$  Mass of mixture decreases

$$\text{Number of moles of } CO_2 = \frac{4.4}{44} = 0.1 \text{ mol.}$$

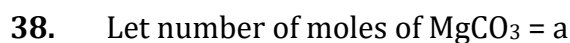
$$\therefore \text{Number of moles of } MgCO_3 = \frac{1}{1} \times 0.1 = 0.1 \text{ mol.}$$

$$\text{Mass of } MgCO_3 = 0.1 \times 84 = 8.4 \text{ gm}$$

$$\text{Mass of } MgO \text{ in initial mixture} = 12.46 - 8.4 = 4.06$$

$$\text{Mass \% of } MgO \text{ in initial mixture} = \frac{4.06}{12.46} \times 100$$

$$= 32.58$$

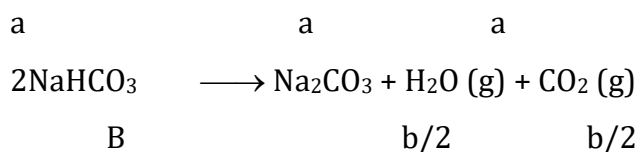


Number of moles of  $NaHCO_3$  = b



## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT



Total number of moles of  $\text{CO}_2 = a + 0.5b$

Total number of moles of  $\text{H}_2\text{O} = 0.5b$

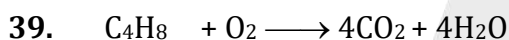
$$\text{According to questions} = \frac{a + 0.5b}{0.5b} = \frac{3}{1}$$

$$\Rightarrow a = b$$

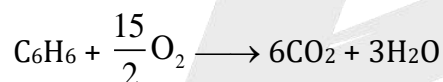
$$\therefore \text{Weight \% of NaHCO}_3 = \frac{\text{Mass of NaHCO}_3 \times 100}{\text{Mass of NaHCO}_3 + \text{Mass of MgCO}_3}$$

$$\Rightarrow \frac{84a}{84a + 84b} \times 100 = \frac{84a}{84a + 84a} \times 100 \quad \{a = b\}$$

$$\Rightarrow \text{Weight \% of NaHCO}_3 = 50\%$$



Given, 3 mol.  $3 \times 4 = 12$  mol produced



Given, 3 mol.  $6 \times 3 = 18$  mol produced

Total moles of  $\text{CO}_2$  produced =  $18 + 12 = 30$

Total mass of  $\text{CO}_2$  produced =  $30 \times 44 = 1320$  gm

40. Moles of Aluminium =  $\frac{5.4}{27} = 0.2$  mole

Moles of Sulphur =  $\frac{12.8}{32} = 0.4$  mole



Moles            0.2            0.4

$\frac{\text{Moles}}{\text{S.Coeff.}}$          $\frac{0.2}{2}$              $\frac{0.4}{3}$

Since, Al is limiting reagent

$$\therefore \text{Number of moles of Al}_2\text{S}_3 \text{ produced theoretically} = \frac{1}{2} \times 0.2$$

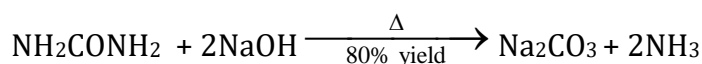
$$\% \text{ yield} = \frac{\text{Actual number of moles}}{\text{Theoretical number of moles}} \times 100$$

$$\text{Actual moles of Al}_2\text{S}_3 \text{ produced} = \frac{12}{150}$$

$$\therefore \% \text{ yield} = \frac{12}{150} \times \frac{1}{0.1} \times 100 = 80\%$$

41. Moles of  $\text{NH}_2\text{CONH}_2 = \frac{6}{60} = 0.1$

$$\text{Moles of NaOH} = \frac{8}{40} = 0.2$$



$$\begin{array}{ccc} \text{Moles} & 0.1 & 0.2 \end{array}$$

$$\begin{array}{ccc} \frac{\text{Moles}}{\text{S.Coeff.}} & \frac{0.1}{1} & \frac{0.2}{2} \end{array}$$

Both reactants are present in stoichiometric coefficient's ratio.

$\therefore$  Moles of  $\text{NH}_3$  can be calculated from any reactant.

$$\text{Number of moles of NH}_3 \text{ produced theoretically} = \frac{2}{1} \times 0.1 = 0.2$$

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

$$80 = \frac{\text{Actual moles of NH}_3}{0.2} \times 100$$

$$\Rightarrow \text{Moles of NH}_3 \text{ produced} = 0.2 \times 0.8 = 0.16$$

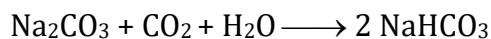
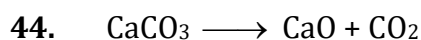
$$\text{Mass of NH}_3 \text{ produced} = 0.16 \times 17 = 2.72 \text{ gm}$$

42. Overall percentage yield =  $90 \times \frac{80}{100} = 72\%$

43. Theoretical yield of  $\text{N}_2\text{H}_4 = \frac{32}{51.5} \times 1000 = 621.36 \text{ g}$

Hence, the percentage yield

$$= \frac{473}{621.36} \times 100 = 76.12\%$$



$$n_{\text{Na}_2\text{CO}_3} = \frac{21.2 \times 10^3}{106} = 2 \times 10^2 \text{ moles.}$$

$$\text{Moles of CaCO}_3 = \text{mole of CO}_2 \quad \dots(1)$$

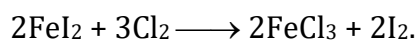
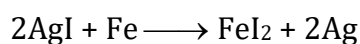
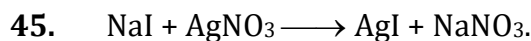
$$\text{Moles of CO}_2 = \text{mole of Na}_2\text{CO}_3 \quad \dots(2)$$

From (1) & (2)

$$\text{Mole of CaCO}_3 = 2 \times 10^2$$

$$\Rightarrow \text{Mass of CaCO}_3 = 2 \times 10^2 \times 100 = 20 \text{ kg}$$

$\Rightarrow$  Correct option is (B).



$$n_{\text{I}_2} = (1 \times 10^3)$$

$$\frac{\text{mole of AgNO}_3}{1} = \frac{\text{mole of AgI}}{1} \quad \dots(1)$$

$$\frac{\text{mole of AgI}}{2} = \frac{\text{mole of FeI}_2}{1} \quad \dots(2)$$

$$\frac{\text{mole of FeI}_2}{2} = \frac{\text{mole of I}_2}{2} \quad \dots(3)$$

From (1), (2) & (3)

$$\begin{aligned} \therefore \text{Mole of I}_2 &= \text{mole of FeI}_2 = \frac{\text{mole of AgI}}{2} \\ &= \frac{\text{mole of AgNO}_3}{2} \end{aligned}$$

$$\Rightarrow 10^3 = \frac{\text{wt of AgNO}_3}{170 \times 2}$$

$$\Rightarrow \text{wt. of AgNO}_3 = 340 \text{ kg}$$

$\Rightarrow$  Correct option is (A)



$$\text{Moles } \frac{x}{111} \quad \frac{x}{111} \quad \frac{x}{111}$$

$$\text{moles of CaO} \longrightarrow \frac{1.62}{56}$$

$$\Rightarrow \text{moles of CaCl}_2 = \frac{1.62}{56}$$

$$\Rightarrow \frac{1.62}{56} = \frac{x}{111}$$

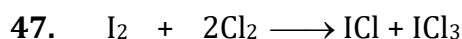


$$\Rightarrow x = \frac{111 \times 1.62}{56}$$

$$\Rightarrow x = 3.21$$

$$\Rightarrow \% \text{ by mass of } \text{CaCl}_2 = \frac{3.21}{10} \times 100 = 32.1 \%$$

$\Rightarrow$  Correct option is (A)



$$\text{Mole: } \frac{25.4}{254} \quad \frac{14.2}{71}$$

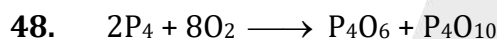
$$= \quad 0.1 \quad 0.2$$

No. L. R

$\Rightarrow$  moles of  $\text{ICl}$  produced = 0.1

& moles of  $\text{ICl}_3$  produced = 0.1

$\Rightarrow$  Correct option is (A)



$$\text{Mole: } \frac{31}{124} \quad \frac{32}{32}$$

$$= \quad \frac{1}{4} \quad 1$$

No. L. R

$$\Rightarrow \text{Weights of } \text{P}_4\text{O}_6 \text{ produced} = \frac{1}{2} \times \frac{1}{4} \times 220 = 27.5 \text{ g}$$

$$\text{& weight of } \text{P}_4\text{O}_{10} \text{ produced} = \frac{1}{8} \times 284 = 35.5 \text{ g}$$

$\Rightarrow$  Correct option is (B)

$$49. \quad M = \frac{99 \times 20 + \frac{1}{2} \times (21 + 22)}{100} = 20.002$$

☑ Correct option is (A)

50. Let % of  $\text{NO}_2$  be x

NO % of number be  $(100 - x)$

$$\Rightarrow 34 = \frac{x \times 46 + (100 - x) \times 30}{100} \quad \text{☑} \quad x = 25 \%$$

$\Rightarrow$  Correct option is (A)

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

51. Average molecular mass =  $\frac{\text{Total mass}}{\text{Total moles}}$

Let total moles of mixture = 100

Moles of  $N_2$  = 80

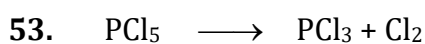
Moles of Oxygen = 20

Total mass of mixture = mass of nitrogen + mass of oxygen

$$\Rightarrow 80 \times 28 + 20 \times 32 = 2880 \text{ gm}$$

$$\text{Avg. molecular mass of mixture} = \frac{2880}{100} = 28.8$$

52.  $\alpha = \frac{80 - 56}{\left(\frac{3}{2} - 1\right)} = \frac{6}{7}$



$$M_{\text{Avg.}} = \frac{M_{\text{Theo.}}}{1 + (n-1)\alpha} = \frac{208.5}{1 + 0.5} = 139$$

$$\Rightarrow \% \text{ change in } M_{\text{Avg.}} \text{ of the mixture} = \left( \frac{208.5 - 139}{208.5} \right) \times 100 = 33.33 \%$$

$\Rightarrow$  Correct option is (C)

54.  $n = \frac{\text{molecular formula mass}}{\text{Empirical formula mass}}$

$$\Rightarrow n = \frac{120}{30} = 4$$

$\Rightarrow$  molecular formula =  $(CH_2O) \times 4$  i.e.  $(C_4H_8O_4)$

$\Rightarrow$  Correct option is (B)

55. Mass per cent of oxygen

$$= 100 - (40 + 6.67) = 53.33$$

Now,

$$N_C : N_H : N_O = \frac{40}{12} : \frac{6.67}{1} : \frac{53.33}{16} = 1 : 2 : 1$$

$\Rightarrow$  Empirical formula =  $CH_2O$

56.  $N_X : N_Y = \frac{1}{1} : \frac{4}{2} = 1 : 2$

$\Rightarrow$  Empirical formula =  $XY_2$

57. Mass per cent of hydrogen

$$= \frac{2}{18} \times \frac{1.8}{1.4} \times 100 = \frac{100}{7}$$

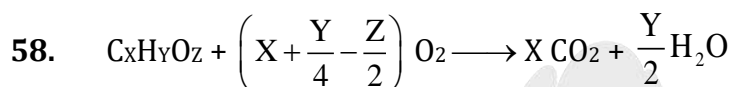
and mass per cent of carbon

$$= 100 - \frac{100}{7} = \frac{600}{7}$$

Now, atomic ratio of C and H

$$= \frac{600/7}{12} : \frac{100/7}{1} = 1:2$$

Hence, the empirical formula =CH<sub>2</sub>



$$n_{CO_2} = \frac{132}{44} = 3$$

$$\Rightarrow X = 3$$

$$n_{H_2O} \longrightarrow \frac{54}{18} = 3$$

$$\Rightarrow Y = 6.$$

$\Rightarrow$  Correct option is (C).

59.

Element	%	Relative number of atoms	Simplest atomic Ratio	Simplest whole Number ratio
Ca	20	$\frac{20}{40} = \frac{1}{2}$	1	1
Br	80	$\frac{80}{80} = 1$	2	2

$\Rightarrow$  Empirical formula is CaBr<sub>2</sub>

$$\text{As, } n = \frac{200}{200} = 1$$

$\Rightarrow$  Molecular formula is CaBr<sub>2</sub>

$\Rightarrow$  correct option is (B).

(PHYSICAL CHEMISTRY)

MOLE CONCEPT

EXERCISE (O-I)

1. (i) 32 g (ii) 28 g (iii) 46 g (iv) 18 g  
(v) 17 g (vi) 92 g (vii) 64 g (viii) 98g  
(ix) 44 g (x) 180 g (xi) 60 g (xii) 342 g  
(xiii) 249.5 g
2. (i) 1 (ii) 2 (iii) 2 (iv) 4  
(v)  $3 \times 10^{-3}$  (vi)  $3 \times 10^{-3}$  (vii)  $0.5 \times 10^{-3}$  (viii)  $0.25 \times 10^{-3}$
3. (i) 1 (ii)  $1 \times N_A$  (iii) 6 (iv) 12  
(v) 6 (vi)  $6N_A$ ,  $12N_A$ ,  $6N_A$  (vii)  $24N_A$
4. (i) 0.5 (ii) 1, 0.5, 2 (iii)  $0.5N_A$  (iv)  $N_A$ ,  $N_A/2$ ,  $2N_A$   
(v)  $3.5N_A$
5. (i)  $\frac{10^{20}}{N_A}$  moles, (ii) 3200 amu,  
(iii)  $1400 \times 1.66 \times 10^{-24}$  g (iv)  $3N_A$ ,  $9N_A$ , (v)  $6N_A$
6. Mass of  $6.023 \times 10^{23}$  atom = 12 gm  
 $\Rightarrow$  Mass of 1 atom =  $\frac{12}{6.023 \times 10^{23}}$  gm  
=  $1.99 \times 10^{-23}$  gm
7. Weight of  $6.023 \times 10^{23}$  atoms = 12 gm  
□ Weight of  $12.046 \times 10^{23}$  atom =  $\frac{12 \times 12.046 \times 10^{23}}{6.023 \times 10^{23}} = 24$  gm
8. Mass of O atoms in 6 gm  $\text{CH}_3\text{COOH}$  =  $n_{\text{CH}_3\text{COOH}} = \frac{6}{60}$  i.e.  $\frac{1}{10}$   
In 1 mole of  $\text{CH}_3\text{COOH}$ , mass of O atom = 32 gm  
□ Mass of O atom in  $\frac{1}{10}$  mole  $\text{CH}_3\text{COOH} = \frac{32}{10}$  i.e. 3.2 gm
9.  $n_{\text{CuSO}_4 \cdot 5\text{H}_2\text{O}} = \frac{499}{249.5} = 2$  mole  
1 mole of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  contains 90 gm  $\text{H}_2\text{O}$   
 $\Rightarrow$  2 mole of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  contains  $(90 \times 2)$  i.e. 180 ;gm  $\text{H}_2\text{O}$ .
10. 1 mole of  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$  contains  $11N_A$  'O' atoms  
 $\Rightarrow 6.023 \times 10^{22}$  atom of 'O' are present in  $\frac{6.023 \times 10^{22}}{11 \times N_A} = \frac{6.023 \times 10^{22}}{11 \times 6.022 \times 10^{23}} = \frac{1}{110}$  mole  
i.e. 2.5 gm
11. Number of Nucleon present in 12 gm of  $^{12}\text{C}$  atoms =  $12 N_A$

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

$$= 12 \times 6.023 \times 10^{23}$$

$$= 7.227 \times 10^{24}$$

12. In 1 mole of  $^{16}\text{O}^{-2}$  ions

$$\text{Number of Electrons} = 10N_A \quad \text{i.e. } 10 \times 6.023 \times 10^{23}$$

$$\text{Number of Protons} = 8N_A \quad \text{i.e. } 8 \times 6.023 \times 10^{23}$$

$$\text{Number of Neutrons} = 8N_A \quad \text{i.e. } 8 \times 6.023 \times 10^{23}$$

13. Mass of liquid mercury = 13.6 gm

$$\text{Moles of liquid mercury} = \frac{13.6}{200} \quad \text{i.e. } 0.068$$

$$\text{Moles of liquid mercury in 1 lit of the metal} = 0.068 \times 1000 = 68 \text{ mole}$$

14. Mass of  $\text{C}_2\text{H}_6$  sample =  $\left(\frac{10^7}{N_A}\right)$  moles of  $\text{CH}_4$  i.e.  $\left(\frac{16 \times 10^7}{N_A}\right)$  g

$$\text{Mole of } \text{C}_2\text{H}_6 \text{ sample} = \left(\frac{16 \times 10^7}{N_A \times 30}\right)$$

$$\text{Number of } \text{C}_2\text{H}_6 \text{ molecules in sample} = \left(\frac{16 \times 10^7}{N_A \times 30}\right) \times N_A \quad \text{i.e. } 5.34 \times 10^6$$

15.  $10^{10}$  grains are distributed in 1 sec

$$\Rightarrow 6.023 \times 10^{23} \text{ grains are distributed in } \frac{6.023 \times 10^{23}}{10^{10}} \text{ sec}$$

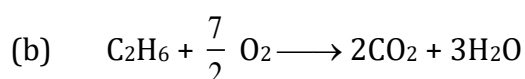
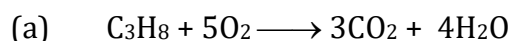
$$= 6.023 \times 10^{13} \text{ seconds.}$$

16.  $25 = \frac{x \times 56}{89600} \times 100$

$$\Rightarrow x = \frac{.25 \times 89600}{56 \times 100} \Rightarrow x = 4$$

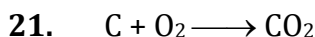
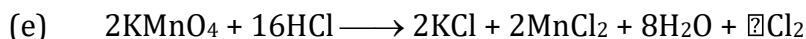
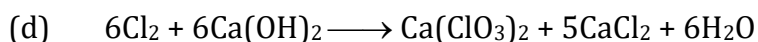
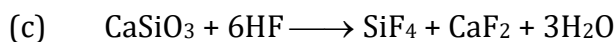
17. (i)  $n = 2$  (ii)  $n = 2.5$  (iii)  $n = 2$  (iv)  $P = 50 \text{ atm}$   
 (v)  $P = 74.8 \text{ Pa}$  (vi)  $T = 1000 \text{ K}$  (vii)  $V = 2 \text{ L}$  (viii)  $P = 2500 \text{ Pa}$
18. (i) 45.4 L (ii) 5.675 L (iii) 11.35 L (iv) 90.8 L
19. (i) 1 (ii) 2 (iii)  $2 \times 10^{-3}$  (iv)  $5 \times 10^{-4}$   
 (v) 0.1 (vi) 5000

20. Balance the following reactions:



## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

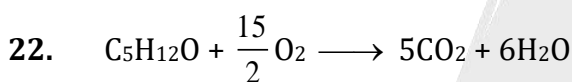


$$n_{\text{C}} \rightarrow \frac{1.2 \times 10^3}{12} \quad \text{i.e. 100 mole.}$$

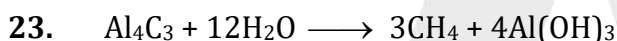
Mole of  $\text{O}_2$  needed for 1 mole C = 1 mole

$\Rightarrow$  Mole of  $\text{O}_2$  needed for 100 mole C = 100 mole

$\Rightarrow$  Volume of  $\text{O}_2$  needed =  $100 \times 22.7 = 2270$  lits.



$\Rightarrow$  Moles of  $\text{O}_2$  required to burn 1 mole of this compound completely is 7.5 moles.



$$n_{\text{CH}_4} = \frac{11.35}{22.70} = \frac{1}{2} \text{ mole}$$

3 mole  $\text{CH}_4$  is produced from 1 mole  $\text{Al}_4\text{C}_3$ .

$\Rightarrow \frac{1}{2}$  mole  $\text{CH}_4$  is produced from 1 mole  $\left(\frac{1}{3} \times \frac{1}{2}\right)$  mole  $\text{Al}_4\text{C}_3$

$$\text{i.e. } \frac{1}{6} \text{ mole } \text{Al}_4\text{C}_3 \quad \text{or} \quad \frac{1}{6} \times 144$$

i.e. 24 gm  $\text{Al}_4\text{C}_3$



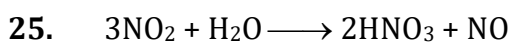
$$n_{\text{H}_4\text{P}_2\text{O}_7} \longrightarrow \frac{53.4}{178} = 0.3 \text{ mole}$$

1 mole  $\text{H}_4\text{P}_2\text{O}_7$  is obtained from 2 mole  $\text{H}_3\text{PO}_4$

$\Rightarrow$  0.3 mole  $\text{H}_4\text{P}_2\text{O}_7$  is obtained from  $(2 \times 0.3)$  mole  $\text{H}_3\text{PO}_4$

= 0.6 mole  $\text{H}_3\text{PO}_4$

i.e.  $(0.6 \times 98) = 58.5$  g  $\text{H}_3\text{PO}_4$



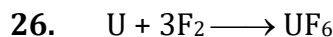
$$n_{\text{HNO}_3} = \frac{25.2}{63} = 0.4$$

2 mole  $\text{HNO}_3$  is produced from 3 mole  $\text{NO}_2$

$$\Rightarrow 0.4 \text{ mole HNO}_3 \text{ is produced from } \left( \frac{3}{2} \times 0.4 \right) = 0.6 \text{ mole NO}_2$$

$$\text{or } (0.6 \times 46) \text{g NO}_2$$

$$\text{i.e. } 27.6 \text{g NO}_2$$

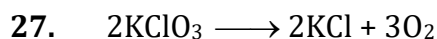


(Excess)

$$n_{\text{UF}_6} = \frac{2 \times 10^{-3}}{352} \Rightarrow n_{\text{UF}_6} = 5.6 \times 10^{-6}$$

1 mole  $\text{UF}_6$  is obtained from 3 mole  $\text{F}_2$

$$\begin{aligned} \Rightarrow 5.6 \times 10^{-6} \text{ mole UF}_6 \text{ is obtained from } & 5.6 \times 10^{-6} \times 3 \times 6.023 \times 10^{23} \\ & = 101.1 \times 10^{17} \\ & = 1 \times 10^{19} \end{aligned}$$

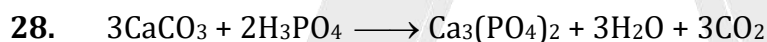


The loss in weight of sample is because of  $\text{O}_2$  gas produced.

$\therefore$  2 mole  $\text{KClO}_3$  is producing 3 mole  $\text{O}_2$

$$\text{i.e. for 1 mole loss is } \left( \frac{3}{2} \times 32 \right) \text{ i.e. } 48 \text{g O}_2.$$

$$\Rightarrow \% \text{ loss in weight} = \left( \frac{48}{122.5} \right) \times 100 = 39.18 \%$$



$$\text{Moles} \rightarrow \frac{50}{100} \quad \frac{73.5}{98}$$

$$= \frac{1}{2} \quad \frac{3}{4}$$

$$\frac{\text{moles}}{\text{S.C}} \rightarrow \frac{1}{6} \quad \frac{3}{8}$$

$\Rightarrow \text{CaCO}_3$  is L. R

(i) Amount of  $\text{Ca}_3(\text{PO}_4)_2$  formed =  $\frac{1}{6}$  mole

(ii) Amount of unreacted reagent =  $\left( \frac{3}{4} - \frac{1}{3} \right) = \frac{9-4}{12} = \left( \frac{5}{12} \right)$  moles.



$$\text{Moles} \quad 2 \quad 1.2 \quad 1.44$$

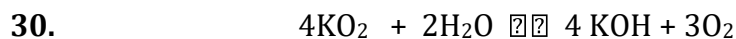
## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

$$\frac{\text{moles}}{\text{S.C}} \rightarrow \frac{2}{4} \quad \frac{1.2}{1} \quad \frac{1.44}{3}$$

$\Rightarrow$  C is L.R

$\Rightarrow$  moles of product formed =  $\frac{1.44}{3} = 0.48$  moles.



$$\text{Moles} \rightarrow 0.158 \quad .10$$

$$\frac{\text{moles}}{\text{S.C}} \rightarrow \frac{0.158}{4} \quad \frac{.10}{2}$$

$\Rightarrow$   $\text{KO}_2$  is L.R.

$\Rightarrow$  Moles of  $\text{O}_2$  produced is  $\frac{3 \times 0.158}{4}$  i.e. 0.1185 mole



$$\text{Moles} : 2 \quad 2$$

$$\frac{\text{moles}}{\text{S.C}} \rightarrow \frac{2}{6} \quad \frac{2}{8}$$

$\Rightarrow$   $\text{BF}_3$  is L.R.

$\Rightarrow$  Moles of  $\text{B}_2\text{H}_6$  prepared =  $\frac{1}{8} \times 2 = \frac{1}{4}$  moles i.e. 0.25 mol



$$\text{moles} \rightarrow \frac{36}{12} \quad \frac{142}{71}$$

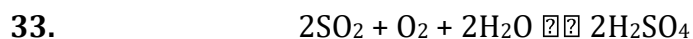
$$\text{i.e.} \quad 3 \quad 2$$

$$\frac{\text{moles}}{\text{S.C}} \rightarrow 3 \quad 1$$

$\Rightarrow$   $\text{Cl}_2$  is L.R.

(i) Mass of  $\text{CCl}_4$  produced =  $1 \times 154$  i.e. 154 gm

(ii) Remaining mass of reactants =  $(3 - 1) \times 12 = 24$  gm

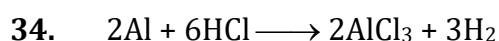


$$\text{moles} \rightarrow 5.6 \quad 4.8 \text{ (excess)}$$

$$\frac{\text{moles}}{\text{S.C}} \rightarrow \frac{5.6}{2} \quad \frac{4.8}{1}$$

$\Rightarrow$   $\text{SO}_2$  is L.R.

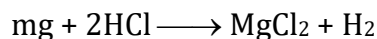
$\Rightarrow$  maximum number of moles of  $\text{H}_2\text{SO}_4$  that can be obtained = 5.6 mole.





Moles  $\frac{x}{27}$  (excess)

$$\Rightarrow \text{moles of H}_2 \text{ obtained} = \left( \frac{3}{2} \times \frac{x}{27} \right) \dots (1)$$



Moles  $\rightarrow \frac{(1-x)}{24}$  (excess)

$$\Rightarrow \text{moles of H}_2 \text{ obtained} = \left( \frac{1-x}{24} \right) \dots (2)$$

$$\Rightarrow \text{Total moles of H}_2 \text{ obtained} = \left( \frac{3x}{54} + \frac{1-x}{24} \right) \dots (3)$$

Now,

$$\Rightarrow n_{\text{H}_2} = \frac{1.12}{22.4} \quad \text{i.e. } 0.05 \dots (4)$$

Now, equation (3) & (4)

$$\frac{3x}{54} + \frac{1-x}{24} = 0.05$$

$$\Rightarrow \frac{12x + 9 - 9x}{216} = 0.05$$

$$m = 10.8 - 9 = \frac{1.8}{3} = 60\%$$

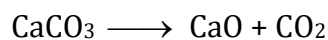
$$3x + 9 = 10.8$$

$$\Rightarrow 3x = 1.8 \quad \Rightarrow \quad x = 0.6$$

$$\Rightarrow \% \text{ by mass Al} \longrightarrow 60\% \quad \& \quad \% \text{ by mass mg} \quad \boxed{40\%}$$

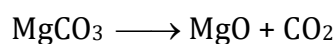
35. let  $\text{CaCO}_3$  be  $x$  gm

2  $\text{MgCO}_3$  be  $(92 - x)$  gm



$$\text{Mole: } \frac{x}{100} \quad 0 \quad 0$$

$$- \quad \frac{x}{100} \quad \frac{x}{100}$$



$$\text{Mole} \quad \left( \frac{92-x}{84} \right) \quad - \quad -$$

$$- \left( \frac{92-x}{84} \right) \left( \frac{92-x}{84} \right)$$

Now, weight of residue = 48

$$\Rightarrow \frac{x}{100} \times 56 + \left( \frac{92-x}{84} \right) \times 40 = 48$$

$\Rightarrow$  on solving we get  $x = 50$

$\Rightarrow$  weight of  $\text{MgCO}_3 = 42 \text{ gm}$ .

36.  $\text{NaCl} \longrightarrow x$  Let  $\text{NaCl}$  be  $x \text{ gm}$  &  $\text{NaHCO}_3$  be  $(4-x) \text{ gm}$



$$\text{Mole} \rightarrow \frac{4-x}{84} \quad 0 \quad 0 \quad 0$$

$$- \quad \frac{(4-x)}{84 \times 2}$$

Now, According to question

$$44 \times \frac{(4-x)}{84 \times 2} = 0.66$$

$$\Rightarrow (4-x) = \frac{0.66 \times 84}{22 \times 100}$$

$\Rightarrow x = 1.48 \text{ gm}$  & Weight of  $\text{NaHCO}_3 = 2.52 \text{ gm}$

$\Rightarrow$  % by mass of  $\text{NaCl} = \frac{1.48}{4} \times 100 = 37 \%$

& % by mass of  $\text{NaHCO}_3$  is 63%

37.  $\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2$

$$n_{\text{CO}_2} = \frac{11.35}{22.70} \rightarrow \frac{1}{2} \text{ mole}$$

$$n_{\text{CaCO}_3} = 2 \text{ mole}$$

$\Rightarrow$  1 mole  $\text{CaCO}_3$  produces 1 mole  $\text{CO}_2$

$\Rightarrow$  2 mole  $\text{CaCO}_3$  produces 2 mole  $\text{CO}_2$

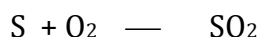
But produced mole is  $\frac{1}{2}$  mole

$\Rightarrow$  % of Ca in lime stone sample =  $\left( \frac{20}{200} \times 100 \right)$  i.e. 10%

38. Sulphur present in 1.30 gm per 100g of coal.

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT



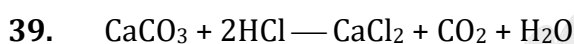
$$\text{Moles } \frac{1.30}{32} \text{ (excess)}$$

$$- \left( \frac{1.30}{32} \right)$$

$$\Rightarrow \text{weight of SO}_2 \text{ produced} = \left( \frac{1.30}{32} \times 64 \right) = 2.60 \text{ gm}$$

100 g coal sample produced 2.60 gm SO<sub>2</sub>

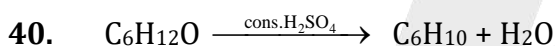
$$\Rightarrow 474 \text{ tons will produced } \frac{2.60}{100} \times 474 \text{ i.e. (12.3 tons)}$$



1 mole CaCO<sub>3</sub> will produce 1 mole CO<sub>2</sub>

$$\text{i.e. } \left( .8 \times \frac{1}{4} \right) \text{ mole will produce } \left( .8 \times \frac{1}{4} \right) \text{ mole CO}_2$$

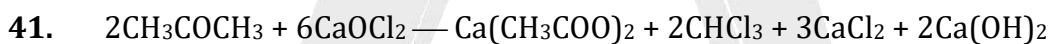
$$\Rightarrow \text{Volume of CO}_2 \text{ produced} = .2 \times 22.4 \text{ litres} = 4.48 \text{ litres.}$$



$$\Rightarrow 1 \text{ mole C}_6\text{H}_{12}\text{O} \text{ will produces 1 mole C}_6\text{H}_{10}. \text{ If yield is 100\%.}$$

$$\Rightarrow \text{moles of C}_6\text{H}_{10} \text{ produced} = 0.75$$

$$\Rightarrow \% \text{ yield} = 75\%$$

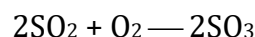
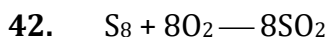


$$x \qquad \qquad \qquad x(0.75)$$

$$\Rightarrow x \times .75 = \frac{30}{119.5}$$

$$\Rightarrow x = \frac{30}{119.5 \times 0.75} \quad \therefore x = 0.334 \text{ mole}$$

$$\Rightarrow \text{Mass of CH}_3\text{COCH}_3 = 0.334 \times 58 \text{ i.e. 19.4 gm}$$



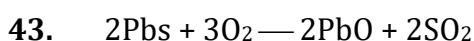
$$1 \text{ mole S}_8 = 8 \text{ mole SO}_2 \qquad \dots(1)$$

$$\Rightarrow 2 \text{ mole SO}_2 = 2 \text{ mole SO}_3$$

$$\text{i.e. } 8 \text{ mole SO}_2 = 8 \text{ mole SO}_3 \qquad \dots(2)$$

From (1) & (2)

$$\text{SO}_3 \text{ obtained from 1 mol of S}_8 = (8 \times 80) \text{g SO}_3 \quad \text{i.e. 640g SO}_3$$





$$n_{\text{Pbs}} = \frac{1075.5}{239.2} = 4.49$$

$$2 \text{ mole Pbs} = 2 \text{ mole SO}_2 \quad \dots(1)$$

$$3 \text{ mole SO}_2 = 3 \text{ mole H}_2\text{SO}_4$$

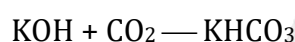
$$\Rightarrow 2 \text{ mole SO}_2 = 2 \text{ mole H}_2\text{SO}_4 \quad \dots(3)$$

From (1) & (3)

$$1 \text{ mole Pbs} = 1 \text{ mole H}_2\text{SO}_4$$

$$\Rightarrow 4.49 \text{ mole Pbs} = 4.49 \text{ mole H}_2\text{SO}_4 \text{ or } 4.50 \text{ mole H}_2\text{SO}_4$$

$$\Rightarrow \text{mass of H}_2\text{SO}_4 = (4.50 \times 98) = 441 \text{ gm}$$



(a) 3 mole O<sub>2</sub> is produced by 4 mole KO<sub>2</sub>

$$\Rightarrow 1 \text{ mole O}_2 \text{ is produced by } \frac{4}{3} \text{ mole KO}_2$$

$$\Rightarrow \left(\frac{20}{32}\right) \text{ mole O}_2 \text{ is produced by } \left(\frac{4}{3} \times \frac{20}{22} \times 71\right) \text{ g KO}_2 = 59.17 \text{ gm.}$$

(b) 1 mole KO<sub>2</sub> = 1 mole KOH  
= 1 mole CO<sub>2</sub>

$$\Rightarrow \left(\frac{100}{71}\right) \text{ mole KO}_2 = \left(\frac{100}{71} \times 44\right) \text{ g CO}_2 = 61.97 \text{ g CO}_2$$

45. mass of chlorine =  $\frac{75.77 \times 34.9689 + 24.23 \times 36.9659}{100}$   
=  $\frac{2649.59355 + 895.683757}{100} = 35.4527$

46.  $24.31 = \frac{79 \times 24 + (21 - x) \times 25 + x \times 26}{100}$

$$\Rightarrow 2431 = 1896 + 525 - 25x + 26x$$

$$\Rightarrow x = 10$$

47.  $37.60 = \frac{70 \times 28 + 30 \times M}{100} \Rightarrow M = 60$

48.  $0.4 = \frac{48 - M}{\left(\frac{3}{2} - 1\right)M} \Rightarrow M = 40$

(PHYSICAL CHEMISTRY)

MOLE CONCEPT

49.  $30 = \frac{46}{1 + \alpha}$

$1 + \alpha = \frac{46}{30}$

$\alpha = 0.53$

50.

%	Atomic mass	Relative number of atom = $\frac{\%}{\text{At mass}}$	Simplest atomic ratio	Simplest whole number ratio
C 49%	12	$\frac{49}{12} = 4.08$	3	3
H 2.7%	1	$\frac{2.7}{1} = 2.70$	1.98 = 2	2
Cl 48.3%	35.5	$\frac{48.3}{35.5} = 1.36$	1	1

⇒ Empirical formula =  $\text{C}_3\text{H}_2\text{Cl}$

⇒  $n = \frac{147}{73.5} = 2$

⇒ molecular formula =  $(\text{C}_6\text{H}_4\text{Cl}_2)$

51. Mass mole simplest ratio

C 9  $\frac{9}{12} = \frac{3}{4}$   $\frac{3}{4} \div \frac{1}{4} = 3$

H 1  $\frac{1}{1} = 1$   $1 \div \frac{1}{4} = 4$

N 3.5  $\frac{3.5}{14} = \frac{1}{4}$   $\frac{1}{4} \div \frac{1}{4} = 1$

∴ Empirical formula is  $\text{C}_3\text{H}_4\text{N}$

Empirical formula mass is 54

Given:

Molecular mass = 216  $n = \frac{216}{54} = 4$

∴ Molecular formula is  $\text{C}_{12}\text{H}_{16}\text{N}_4$

∴ Total number of atoms present in

1 molecule of compound =  $x = (12 + 16 + 4)$

$$\therefore x = 32$$

$$\frac{x}{4} = 8$$

52. Molecular mass of the compound

$$= \frac{1}{6.06 \times 10^{-3}} \approx 165$$

$$\text{Empirical formula mass} = 3 \times 12 + 3 \times 1 + 1 \times 16 = 55$$

$$\text{Now, } n = \frac{165}{55} = 3 \text{ and hence the molecular}$$

$$\text{formula} = (\text{C}_3\text{H}_3\text{O})_3 = \text{C}_9\text{H}_9\text{O}_3$$

53. Number of moles of  $\text{CO}_2 = \frac{88}{44} = 2\text{mol}$

$$\text{Number of moles of } \text{H}_2\text{O} = \frac{36}{18} = 2\text{mol}$$

$$\text{Mass of carbon} = 2 \times 12 = 24 \text{ gm}$$

$$\text{Number of moles of H} = 4 \text{ mol}$$

$$\text{Mass of Hydrogen} = 4 \times 1 = 4$$

$$\text{Mass of oxygen} = 60 - 28 = 32$$

$$\text{Number of moles of oxygen} = \frac{32}{16} = 2$$

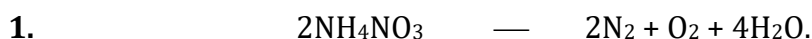
$$\text{Molecular formula} = \text{C}_2\text{H}_4\text{O}_2$$

$$\text{Empirical formula} = \text{CH}_2\text{O}$$

$$\text{The value of } (x + y) \text{ is } = 1 + 2 = 3$$

EXERCISE (S-II)

PART-I (MOLE CONCEPT)



mole initial  $\frac{1}{5}$                       0      0      0

moles final    0                       $\frac{1}{5}$        $\frac{1}{10}$        $\frac{2}{5}$

$$\Rightarrow n_T = \left( \frac{1}{5} + \frac{1}{10} + \frac{2}{5} \right) = \left( \frac{7}{10} \right)$$

Apply =  $Pv = nRT \Rightarrow v = \frac{nRT}{P} = \left( \frac{7}{10} \times 0.0821 \times 873 \right) = 50.14 \text{ litre}$



moles  $\left( \frac{2.4 \times 10^{24}}{6 \times 10^{23}} \right) \left( \frac{380 \times 96}{760 \times 0.08 \times 300} \right)$   
 $\approx 4$                        $\approx 2$

$\Rightarrow \text{Cl}_2$  is L.R.

$\Rightarrow \text{mass of CaCl}_2 = 2 \times 111 = 222 \text{ gm}$



moles: 3                      5

$\Rightarrow \text{NaOH}$  is L.R.

$\Rightarrow \text{number of molecules Na}_2\text{H}_2\text{P}_2\text{O}_7 \text{ formed} = (2.5) N_A$

& number of molecules  $\text{H}_2\text{O}$  formed =  $(5) N_A$

$\Rightarrow \text{Total number of molecules formed in product is } (7.5)N_A.$



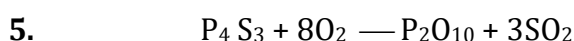
moles  $\frac{4.32}{80}$      $\frac{5.76}{12}$      $\frac{7.1}{71}$

i.e. 0.054    0.48    0.1

$\frac{\text{moles}}{\text{S.C}} \rightarrow \frac{0.054}{3}$      $\frac{0.48}{4}$      $\frac{0.1}{6}$

$\Rightarrow \text{Cl}_2$  is L.R.

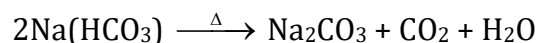
$\Rightarrow \text{Amount of TiCl}_4 \text{ obtained} = \left( \frac{3}{6} \times 0.1 \right) \times 190 = 9.5 \text{ g}$



$$\text{mole: } \left( \frac{1}{64} \times \frac{1}{3} \right) \quad \frac{1}{284} \quad \frac{1}{64}$$

$$\Rightarrow \text{mass of } P_4S_3 \text{ required} = \frac{1}{64 \times 3} \times 220 = 1.1458 \text{ gm}$$

6.  $Na_2CO_3 \xrightarrow{\Delta} x$  Let mass of  $Na_2CO_3$  be x gm 2 mass of  $NaHCO_3$  be (2-x) gm



$$\text{mole } \frac{2-x}{84} \quad \frac{1.89-x}{406}$$

$$\text{Now, } \frac{\text{moles of } NaHCO_3}{2} = \frac{\text{moles of } Na_2CO_3}{1}$$

$$\frac{(2-x)}{84 \times 2} = \frac{1.89-x}{106}$$

$$\Rightarrow 212 - 106x = 84 \times 2 (1.89 - x)$$

$$\Rightarrow 212 - 106x = 317.52 - 168x$$

$$\Rightarrow 168x - 106x = 317.52 - 212$$

$$\Rightarrow 62x = 105.52$$

$$\Rightarrow x = \frac{105.52}{62} = 1.70 \text{ g}$$

$$\% \text{ by mass of } Na_2CO_3 = \frac{1.70}{2} \times 100 = 85.1 \%$$

$$\% \text{ by mass of } NaHCO_3 = 14.9\%$$

7.  $Br_2 + Cl_2 \rightarrow 2BrCl$

$$\text{mole. } 0.025 \quad 0.025$$

$$(0.025 \times 2) \times .8 = 0.04$$

$$(i) \text{ amount of } BrCl \text{ formed} = 0.04$$

$$(ii) \text{ } Br_2 \text{ left unchanged} = 0.025 - 0.02 = 0.005$$

$$8. \quad \frac{\text{mole of } HCl}{16} = \frac{\text{mole of } Cl_2}{5}$$

$$\frac{\text{mole of } Cl_2}{6} = \frac{\text{mole of } Ca(ClO_3)_2}{1}$$

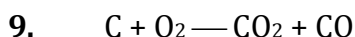
$$\frac{\text{mole of } Ca(ClO_3)_2}{1} = \frac{\text{mole of } NaClO_3}{2}$$

$$\text{Also, moles of } HCl \text{ in } 100 \text{ ml} = 1.164$$

$$\Rightarrow \text{moles of } NaClO_3 = \left( \frac{5 \times 1.164 \times 2}{16 \times 6} \right)$$



$$\Rightarrow \text{mass of NaClO}_3 \text{ produced} = \left( \frac{5 \times 1.164 \times 2}{16 \times 6} \right) \times 106.5 = 12.9 \text{ g}$$



Let moles of CO be x

& moles of  $\text{CO}_2$  be y.

P.O.A.C on C :

$$1 = x + y \quad \dots(1)$$

P.O.A.C on O:

$$2 \times \frac{20}{22} = x + 2y \quad \dots(2)$$

Solving equation (1) & (2), we get

$$x = 0.75 \text{ \& } y = 0.25$$

$$\text{mass \% of CO} = \frac{.75 \times 28}{.75 \times 28 + 0.25 \times 44} \times 100 = \frac{21}{32} \times 100 = 65.625\%$$

$$\text{mass \% of CO}_2 = 34.375 \%$$



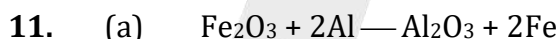
$$\text{mole: } \frac{30}{14} : \frac{10}{142} : \frac{10}{94}$$



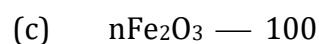
$$\text{mole: } \frac{30}{14} : \frac{10}{71} : \frac{10}{47}$$

$$\text{Simplest: } 10 : 0.66 : 1$$

ratio

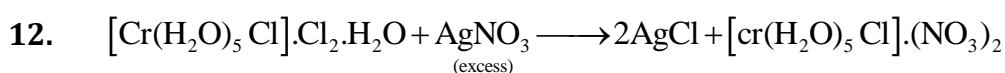


$$\Rightarrow \text{ratio of mass} = \frac{100}{54} \text{ or } 80 : 27$$



moles of  $\text{Fe}_2\text{O}_3$  reacted = 50 moles

$$\Rightarrow \text{energy released} = 50 \times 200 = 10,000 \text{ units}$$



$$\text{moles of } [\text{Cr}(\text{H}_2\text{O})_5 \text{Cl}] \cdot \text{Cl}_2 \cdot \text{H}_2\text{O} \text{ is } \frac{5.33}{266.5} \quad \text{i.e. } 0.02 \text{ moles}$$

$$\Rightarrow \text{moles of AgCl obtained} = 2 \times 0.02 = 0.04 \text{ mole}$$

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

$$\text{mass of AgCl obtained} = 0.04 \times 143.5 = 5.74 \text{ gm}$$

13. Let the metal carbonate be  $M_2CO_3$

$$\text{As, mass \% of O} = 48 = \frac{48}{2x + 60} \times 100$$

$$\Rightarrow x = 20$$

i.e. molar mass of metal = 20gm/mole

$$\Rightarrow \text{moles of } M_2CO_3 = \frac{5 \times 10^{-3}}{(20 \times 2 + 60)} = 5 \times 10^{-5} \text{ mole.}$$

$$\Rightarrow \text{moles of metal is } 10^{-4} \text{ mole}$$

$$\Rightarrow \text{Number of atoms of metal present} = 10^{-4} \times 6 \times 10^{23}$$

i.e.  $6 \times 10^{19}$  atoms

$$\frac{2.5}{24x + 14y} \times x = \frac{3}{40} \times 1$$

14.  $A_x B_y + O_2 \rightarrow AO + \text{oxide of B.}$

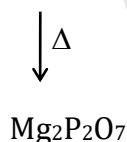
Apply P. O. A. C on A,

$$x \times \frac{2.5}{24x + 14y} = 1 \times \frac{3}{40}$$

$$\Rightarrow x : y = 3 : 2$$

$$\Rightarrow \text{Empirical formula of compound is } 3 : 2$$

15.  $NaH_2PO_4 + NH_4^+ + Mg^{+2} \rightarrow Mg(NH_4) PO_4 \cdot 6H_2O$



Applying P.O.A.C on 'P' atom

$$1 \times n_{NaH_2PO_4} = 2 \times n_{Mg_2P_2O_7}$$

$$1 \times \frac{\text{weight}}{120} = 2 \times \frac{1.054}{222}$$

$$\text{Weight of } NaH_2PO_4 = \frac{2 \times 1.054 \times 120}{222} = 1.14 \text{ gm}$$

1. New molecular mass of
- $\text{H}_2\text{O}$

$$= 2 \times 0.5 + 1 \times 20 = 21$$

Percentage increase in molecular mass of  $\text{H}_2\text{O}$

$$= \frac{21-18}{18} \times 100 = 16.67\%$$

- 2.
- $\text{C}_2\text{H}_4\text{O}_2 + 2\text{O}_2 \longrightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}$
- .

1 mole  $\text{C}_2\text{H}_4\text{O}_2$  & 2 mole  $\text{O}_2$  produces 2 mole  $\text{CO}_2$

i.e. 124 g mixture produces 88 gm  $\text{CO}_2$

$$\Rightarrow 620\text{g mixture will produce } \frac{88}{124} \times 620 = 440\text{ gm}$$

$\Rightarrow$  Correct option is (C)

3. Let the molecule be
- $\text{A}_x\text{B}_y$

$$\text{Molecular weight of compounds formed} = \left( \frac{XN_A + MY}{5} \right)$$

$\Rightarrow$  Correct option is (A).

- 4.
- $5\text{A}_2 + 2\text{B}_4 \longrightarrow 2\text{AB}_2 + 4\text{A}_2\text{B}$
- .

5 mole  $\text{A}_2$  produce 2 mole  $\text{AB}_2$

$\Rightarrow (2 \times 250)\text{g AB}_2$  is produced from 100g  $\text{A}_2$

$$\Rightarrow 1000\text{g AB}_2 \text{ is produced from } \left( \frac{100}{2 \times 250} \right) \times 1000\text{g of A}_2$$

= 200 g of  $\text{A}_2$

Also, 2 mole  $\text{AB}_2$  is produced from 2 mole  $\text{B}_4$

$\Rightarrow (2 \times 250)\text{g AB}_2$  is produced from  $(2 \times 120 \times 4)\text{ g of B}_4$

$$\Rightarrow 1000\text{ g AB}_2 \text{ is produced from } \left( \frac{2 \times 120 \times 4}{2 \times 250} \right) \times 1000 = 1920\text{ gm.}$$

$\Rightarrow$  Minimum mass of mixture of  $\text{A}_2$  &  $\text{B}_2$  is  $(1920 + 200)$

i.e. 2120 gm

$\Rightarrow$  Correct option is (A)

5. mass of substance = 0.42 gm.

$$\text{Volume of N}_2 = \frac{100}{11} \text{ ml}$$

Temperature = 250 K

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

$$\text{Pressure} = 860 - 24 = 836 \text{ mm Hg}$$

Step (1)

$$\text{Volume of N}_2 \text{ at S.T.P.} \quad \text{i.e. } V_2 = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2}$$

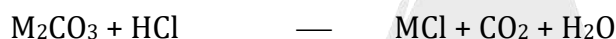
$$\Rightarrow V_2 = \frac{836 \times 100 \times 273}{760 \times 11 \times 250} \quad \Rightarrow V_2 = 10.92 \text{ ml}$$

Step (2)

$$\% \text{ of N}_2 \text{ in organic compound} = \frac{28 \times 10.92}{22700 \times 0.42} \times 100 = \frac{10}{3} \%$$

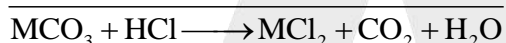
$\Rightarrow$  Correct option is (A)

6. for Alkali metal carbonate

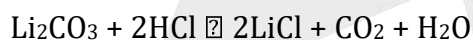


(Excess)

For Alkaline Earth metal carbonate



$$n_{\text{CO}_2} = \frac{1 \times 12.315}{0.0821 \times 300} = 0.5 \text{ mole}$$



1 mole  $\text{CO}_2$  is produced from 1 mole  $\text{Li}_2\text{CO}_3$

$$\Rightarrow 0.5 \text{ mole } \text{CO}_2 \text{ is produced from } .5 \text{ mole } \text{Li}_2\text{CO}_3 \quad \text{OR} \quad = .5 \times (74)$$

$$= 37 \text{ gm. of } \text{Li}_2\text{CO}_3 \quad \& \quad \text{mass of impurity} = 3 \text{ gm}$$

$\Rightarrow$  Correct option is (B)

7.  $\text{C}_7\text{H}_8 + 3\text{HNO}_3 \longrightarrow \text{C}_7\text{H}_5\text{N}_3\text{O}_6 + 3\text{H}_2\text{O}$

As,  $\text{C}_7\text{H}_8$  &  $\text{HNO}_3$  reacts in 1 : 3 ratio

$$\Rightarrow x \times 92 + 3x \times 62 = 140.5 \quad \& \quad x = 0.5$$

$$\Rightarrow \text{Maximum weight of } \text{C}_7\text{H}_5\text{N}_3\text{O}_6 \text{ which can be produced is } 0.5 \times 227 \quad \text{i.e. } 113.5 \text{ gm}$$

Correct option is (B).

8. Method-1

Let the compound be  $\text{C}_x\text{H}_y\text{O}_z$

Now, weight % of C =  $8 \times$  (weight % of H)

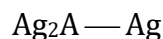
$$\Rightarrow \frac{x}{y} = \frac{2}{3}$$

$$\text{Also, weight \% of C} = \frac{1}{2} \times (\text{weight \% of O})$$

$$\Rightarrow \frac{x}{z} = \frac{2}{3}$$

$\Rightarrow$  The correct option is (B)

Method-2



P.O. A.C. on Ag

$$2 \times \frac{1}{216 + M_A} = \frac{0.5934}{108} \times 1$$

$$\Rightarrow M_A = 148$$

$\Rightarrow$  molar mass of Acid = 150

	C	H	O
weight %	8	1	16
mole %	2	3	3

$\Rightarrow$  Empirical formula =  $\text{C}_2\text{H}_3\text{O}_3$

$\Rightarrow n = 2 \quad \Rightarrow$  molecular formula is  $\text{C}_4\text{H}_6\text{O}_6$

$\Rightarrow$  Correct option is (B)

### ONE OR MORE THAN ONE MAY BE CORRECT

9. For  $(\text{NH}_4)_3\text{PO}_4$ :

Ratio of number of O atoms to number of H atoms =  $\frac{4}{12}$  i.e. (1 : 3)

Ratio of number of cations to number of anions = 3 : 1

Number of gm-atoms of nitrogen to atoms of oxygen =  $\frac{3}{4}$

Total number of atoms in 1 mole of  $(\text{NH}_4)_3\text{PO}_4 = 20N_A$

$\Rightarrow$  Correct options are (A), (B)

10.  $2 \text{Mg} + \text{O}_2 \longrightarrow 2 \text{MgO}$

moles:  $\frac{12}{24} \quad \frac{32}{32}$

$\Rightarrow$  Mg is L.R, So is 100% consumed

i.e. number MgO is left unburnt

Amount of  $\text{O}_2$  left unreacted = 0.75 gm molecule

Amount of MgO formed =  $0.5 \times 40$  i.e. 20 gm

The mixture at the end will weight 44 gm.  $\Rightarrow$  Correct option (A)

(PHYSICAL CHEMISTRY)

MOLE CONCEPT

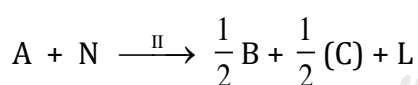
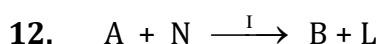


$$\text{moles : } \frac{50}{100} = 0.5 \quad \frac{68.6}{98} = 0.7 \quad \Rightarrow \quad \text{CaCO}_3 \text{ is L.R.}$$

$$\text{Amount of salt formed} = \left( \frac{1}{3} \times 0.5 \times 310 \right) = 35.93 \text{ gm}$$

$$n_{\text{CO}_2} = 0.5$$

$\Rightarrow$  Correct option are (A), (B), (C)



$\Rightarrow$  B will always be greater than C & If 2 moles of C are formed the total 6 mole of B are also formed

$\Rightarrow$  Correct option are (A), (D)



$$\Rightarrow \quad 4 \times 108 \text{g of Ag reacts with } 8 \times 65 \text{g of KCN } 100 \text{g of Ag reacts with } \frac{8 \times 65}{4 \times 108} \times 100$$

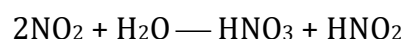
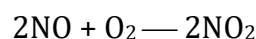
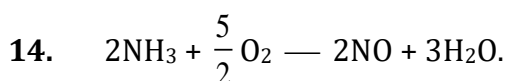
Hence statement A is correct

$$\Rightarrow \quad 4 \times 108 \text{g of Ag require } 32 \text{ gm of O}_2$$

$$\boxed{?} \quad 100 \text{g of Ag require} = \frac{32}{4 \times 108} \times 100 = 7.40 \text{ gm}$$

Hence option (C) is correct.

$$\text{Volume of O}_2 \text{ required} = \frac{7.4}{32} \times 22.4 = 5.20 \text{ liters}$$



(A) Moles of  $\text{HNO}_3$  produced is help of moles of Ammonia used if  $\text{HNO}_2$  is not used to produce  $\text{HNO}_3$  by reaction (IV) .

(B) Incorrect

(C)  $\frac{1}{4}$ th of total  $\text{HNO}_3$  is produced by reaction (IV) if  $\text{HNO}_2$  is used to produce  $\text{HNO}_3$ .

(D) Moles of number produced in reaction (IV) is 50% of moles of total  $\text{HNO}_3$  produced.

COMPREHENSION 14 TO 16

15.  $\text{Fe} + \text{Br}_2 \longrightarrow \text{FeBr}_2$

$\text{Br}_2 + 3\text{FeBr}_2 \longrightarrow \text{Fe}_3\text{Br}_8$

$\text{Fe}_3\text{Br}_8 + 4\text{Na}_2\text{CO}_3 \longrightarrow 8\text{NaBr} + 4\text{CO}_2 + \text{Fe}_3\text{O}_4$ .

(a)  $n_{\text{NaBr}} = \frac{2.06 \times 10^3 \times 10^3}{103} = 2 \times 10^4$

$$\frac{\text{moles of Fe}}{1} = \frac{\text{moles of FeBr}_2}{1}$$

$$\frac{\text{moles of FeBr}_2}{3} = \frac{\text{moles of Fe}_3\text{Br}_8}{1}$$

&  $\frac{\text{moles of Fe}_3\text{Br}_8}{1} = \frac{\text{mole of NaBr}}{8}$

$$\Rightarrow \text{moles of Fe} = \frac{\text{moles of NaBr}}{8} \times 3 = \frac{2 \times 10^4}{8} \times 3$$

$$\Rightarrow \text{mass of Fe required} = \frac{6 \times 10^4 \times 56}{8} = 420 \text{ kg} \quad \square \quad \text{Correct option is (B)}$$

16.  $\text{Fe} + \text{Br}_2 \longrightarrow \text{FeBr}_2$

$\text{Br}_2 + 3\text{FeBr}_2 \longrightarrow \text{Fe}_3\text{Br}_8$

$\text{Fe}_3\text{Br}_8 + 4\text{Na}_2\text{CO}_3 \longrightarrow 8\text{NaBr} + 4\text{CO}_2 + \text{Fe}_3\text{O}_4$ .

(b)  $3\text{FeBr}_2 + \text{Br}_2 \longrightarrow \text{Fe}_3\text{Br}_8$

$$\text{mole} : \frac{3}{8} \times 2 \times 10^4 \times \frac{100}{70} \times \frac{100}{60} \qquad \frac{1}{8} \times 2 \times 10^4 \times \frac{100}{70}$$

$\text{Fe}_3\text{Br}_8 + 4\text{Na}_2\text{CO}_3 \longrightarrow 8\text{NaBr} + 4\text{CO}_2 + \text{Fe}_3\text{O}_4$

$$\text{mole} : \frac{1}{8} \times 2 \times 10^4 \times \frac{100}{70} \qquad 2 \times 10^4$$

$$\Rightarrow \frac{10^6}{8 \times 7} = 0.01786 \times 10^6$$

$$= 1.786 \times 10^4 \text{ moles}$$

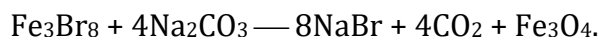
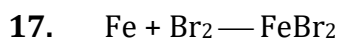
$$\Rightarrow \text{mass of Fe required} = \frac{1.786 \times 10^4 \times 56}{10^2} = 17.86 \times 56$$

$$= 1000 \text{ kg} \quad \text{or} \quad 10^3 \text{ kg}$$

$\Rightarrow$  Correct option is (C)

(PHYSICAL CHEMISTRY)

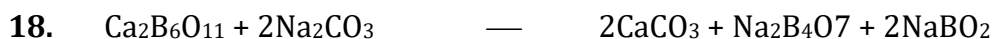
MOLE CONCEPT



(c) moles of  $\text{CO}_2$  formed =  $\frac{1}{2} \times 2 \times 10 = 10$  moles

$\Rightarrow$  Correct option is (B).

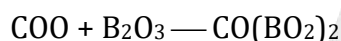
COMPREHENSION 16 TO 17



$\left( \frac{3}{200} \times \frac{10^2}{32.2} \times \frac{100}{60} \right) \times 100 \times 100$   $\left( \frac{3}{200} \times \frac{10^2}{32.2} \times 100 \right) \times 100$



$\left( 100 \times \frac{3}{200} \times \frac{10^2}{32.2} \times 100 \right)$   $\left( \frac{10^2}{32.2} \right) \times 100$



$\left( \frac{10^2}{32.2} \right) \times 100$   $10^2$

$n_{\text{CO}(\text{BO}_2)_2} = \frac{14.5 \times 10^3}{1450} = 10^2$  moles

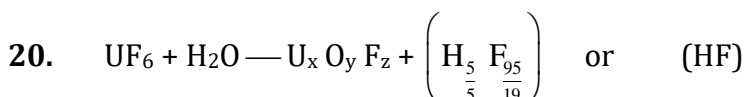
$\Rightarrow$  mass of  $\text{Ca}_2\text{B}_6\text{O}_{11}$  required =  $10^2 \times (80 + 66 + 176) = 322 \times 10^2 \text{g} = 32.2 \text{ kg}$

$\Rightarrow$  correct option is (A)

19. mass of  $\text{Ca}_2\text{B}_6\text{O}_{11}$  obtained =  $\frac{3 \times 10^8}{200 \times 32.2 \times 60} \times 3220 = \frac{10^8}{400} \text{g}$   
 $= \frac{10^6}{4 \times 10^3} \text{kg} = \frac{1000}{4} \text{kg} = 250 \text{ kg}$

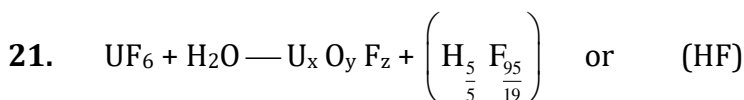
$\Rightarrow$  correct option is (A)

COMPREHENSION 18 TO 20



(a) The empirical formula of gas is HF

$\Rightarrow$  Correct option is (C)



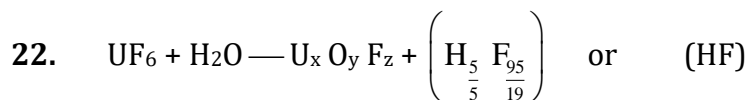
(b) Mass of  $\text{H}_2\text{O} = 3.88 - 3.52 = 0.36 \text{ gm}$



(PHYSICAL CHEMISTRY)

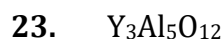
MOLE CONCEPT

- $\Rightarrow$  moles of  $\text{H}_2\text{O} = 0.2$   
 $\Rightarrow \text{UF}_6 + 2\text{H}_2\text{O} \longrightarrow \text{U}_2\text{O}_2\text{F}_2 + 4\text{HF}$   
 $\Rightarrow$  Empirical formula of solid is  $\text{UF}_2\text{O}_2$   
 $\Rightarrow$  Correct option is (A)



- (c) 1 mole  $\text{UF}_6$  gives 4 more HF  
 $\Rightarrow$  % of fluorine converted in gaseous product  
 $= 100 - \left( \frac{114 - 76}{114} \right) \times 100 = 66.66 \%$   
 $\Rightarrow$  Correct option is (C)

MATCH THE COLUMN



weight % of Y  $= \frac{89 \times 3}{594} \times 100 = 44.95 \%$

weight % of Al  $= \frac{27 \times 5}{594} \times 100 = 22.73 \%$

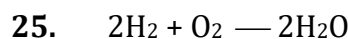
weight % of O  $= \frac{12 \times 6}{594} \times 100 = 32.32 \%$

24.  $n_{\text{C}_6\text{H}_8\text{O}_6} = \frac{17.6 \times 10^{-3}}{176} = 10^{-4}$  moles

O - atoms present  $= 6 \times 6 \times 10^{23} \times 10^{-4} = 3.6 \times 10^{20}$

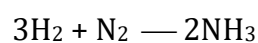
moles of vitamin C in 1 gm of vitamin C  $= 5.68 \times 10^{-3}$ .

moles of vitamin C that should be consumed daily  $= 10^{-4}$



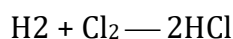
moles:  $\frac{1}{2} \quad \frac{1}{32} \Rightarrow \text{O}_2$  is L.R.

$\Rightarrow$  mass of  $\text{H}_2\text{O}$  produced  $= \frac{1}{32} \times 2 \times 18 = 1.125 \text{ g}$



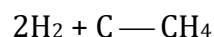
moles:  $\frac{1}{2} \quad \frac{1}{28} \Rightarrow \text{H}_2$  is L.R.

$$\Rightarrow \text{mass of NH}_3 \text{ produced} = \frac{1}{28} \times 2 \times 17 = 1.214 \text{ g}$$



$$\text{moles: } \frac{1}{2} \quad \frac{1}{71} \Rightarrow \text{Cl}_2 \text{ is L.R}$$

$$\Rightarrow \text{mass of HCl produced} = 2 \times 36.5 \times \frac{1}{71} = 1.028 \text{ g}$$

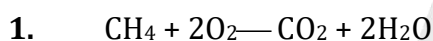


$$\text{moles: } \frac{1}{2} \quad \frac{1}{12} \Rightarrow \text{C is L. R.}$$

$$\Rightarrow \text{Mass of CH}_4 \text{ produced} = \frac{1}{12} \times 16 = 1.333 \text{ g}$$

Correct option is (A)

### EXERCISE (JEE MAINS)



Mole	$\frac{100}{16}$	$\frac{208}{32}$
	$= 6.25$	$= 6.5$
$\frac{\text{Mole}}{\text{Stoi. Coeff}}$	$\frac{6.25}{1}$	$\frac{6.5}{2} = 3.25$

So,  $\text{O}_2$  is limiting reagent

Mole - Mole analysis

$$\frac{n_{\text{O}_2}}{2} = \frac{n_{\text{CO}_2}}{1}$$

$$\frac{6.5}{2} = n_{\text{CO}_2}$$

$$\text{Mass of CO}_2 = \frac{6.5}{2} \times 44 = 143 \text{ gm}$$

2.  $\% \text{H} = \frac{7.5}{116} \times 100 = 6.5$

$$\% \text{O} = \frac{60}{116} \times 100 = 51.7$$

$$\% \text{C} = \frac{48.5}{116} \times 100 = 41.8$$

Relative atomicities = H  $\Rightarrow$  6.5

$$\text{O} \Rightarrow \frac{51.7}{16} = 3.25$$

$$C \Rightarrow \frac{41.8}{12} = 3.5$$

Empirical formula is approx.. CH<sub>2</sub>O

(A) C<sub>2</sub>H<sub>4</sub>O<sub>2</sub> (B) CH<sub>2</sub>O relate to this formula.

$$3. \quad C_xH_yO_z + \left(x + \frac{y}{4} - \frac{z}{2}\right) O_2 \longrightarrow xCO_2 + \frac{y}{2} H_2O$$

$$0.3g \qquad \qquad \qquad 0.2g \qquad \qquad \qquad 0.1g$$

$$\frac{n_{CO_2}}{n_{H_2O}} = \frac{x}{y/2} = \frac{0.2/44}{0.1/18}$$

$$\frac{2x}{y} = \frac{36}{44} = \frac{9}{11}$$

$$x = \frac{9y}{22}$$

$$\frac{n_{C_xH_yO_z}}{n_{CO_2}} = \frac{1}{x}$$

$$\frac{0.3}{12x + y + 16z} \times \frac{44}{0.2} = \frac{1}{x}$$

$$66x = 12x + y + 16z$$

$$54x = y + 16z$$

$$\frac{54 \times 9y}{22} - y = 16z$$

$$\frac{464y}{22} = 16z$$

$$z = \frac{29y}{22}$$

$$C_xH_yO_z = C_xH_yO_z$$

$$C_{\frac{9y}{22}}H_yO_{\frac{29y}{22}}$$

$$C_9H_{22}O_{29}$$

$$\% \text{ of C} = \frac{12 \times 9}{(12 \times 9 + 22 + 29 \times 16)} \times 100 = \frac{108}{594} \times 100$$

$$4. \quad m_{eq} \text{ of NaOH used} = 30 \times 0.25$$

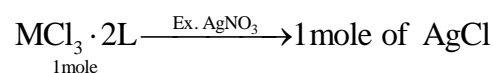
$$m_{eq} \text{ of H}_2\text{SO}_4 \text{ taken} = 50 \times 0.5$$

$$\therefore m_{eq} \text{ of H}_2\text{SO}_4 \text{ used}$$

$$= 50 \times 0.25 \times 30 \times 0.25 = 17.5 \text{ m mol of NH}_3$$

$$\therefore \% N = \frac{17.5 \times 10^{-3} \times 14}{0.166} \times 100 = 147.59\% \text{ (Not Possible)}$$

$$5. \quad MCl_3 \cdot 2L \text{ octahedral}$$



## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

Its means that one  $\text{Cl}^-$  ion present in ionization sphere.

$\therefore$  formula =  $[\text{MCl}_2\text{L}_2]\text{Cl}$

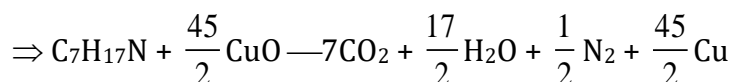
For octahedral complex coordination no. is 6

$\therefore$  L act as bidentate ligand.

6.

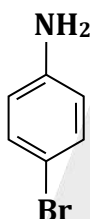
7. Moles of N in N,N – dimethylaminopentane

$$= \left( \frac{57.5}{115} \right) = 0.5 \text{ mol}$$



$$\frac{n_{\text{CuO reacted}}}{\left( \frac{45}{2} \right)} = \frac{n_{\text{C}_7\text{H}_{17}\text{NB reacted}}}{1}$$

$$\Rightarrow n_{\text{CuO reacted}} = \left( \frac{45}{2} \right) \times 0.5 = 11.25$$



8. So compound is

9. (B)

10. Molecular mass of  $\text{BaSO}_4 = 233 \text{ g}$

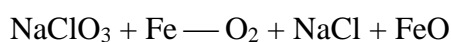
$\therefore 233 \text{ BaSO}_4$  contain — 32 g sulphur

$\therefore 1.44 \text{ g BaSO}_4$  contain  $\frac{32}{233} \times 1.44 \text{ g sulphur given} : 0.471 \text{ g of organic compound}$

$$\% \text{ of S} = \frac{32 \times 1.44}{233 \times 0.471} \times 100 = 41.98\% \approx 42\%$$

11. (12)

$$12. \text{ Mole of } \text{O}_2 = \frac{1 \times 492}{300 \times 0.08} = 20$$



Moles of  $\text{O}_2 = \text{moles of NaClO}_3 = 20$

mass of  $\text{NaClO}_3 = 20 \times 106.5 = 2130 \text{ g}$

13. Let molar mass of A be x

& molar mass of B be y

$$5(x + 2y) = 125 \quad \dots(1)$$

$$10(2x + 2y) = 300 \quad \dots(2)$$

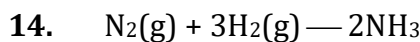
## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

Solving (1) & (2), we get

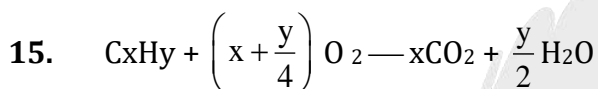
$$x = 5 \text{ \& } y = 10$$

$$\Rightarrow M_A = 5 \times 10^{-3} \text{ kg mol}^{-1} \text{ \& } M_B = 10 \times 10^{-3} \text{ kg mol}^{-1}$$



For completion of reaction  $\text{N}_2$  and  $\text{H}_2$  must be taken in 1 : 3 molar ratio

	$\text{N}_2$	:	$\text{H}_2$		$\text{N}_2$	:	$\text{H}_2$	
(1)	$\frac{28}{12} = 1$		$\frac{6}{2} = 3$		1	:	3	NO LR
(2)	$\frac{56}{28} = 2$		$\frac{10}{2} = 5$		2	:	5	So, $\text{H}_2$ is LR



Vol. of  $\text{CO}_2 = x \times \text{vol. of } \text{C}_x\text{H}_y$

$$4.0 = x \times 10$$

$$x = 4$$

$$\text{Vol. of } \text{O}_2 = \left(x + \frac{y}{4}\right) \times \text{vol. of } \text{C}_x\text{H}_y$$

$$55 = \left(x + \frac{y}{4}\right) \times 10$$

$$y = 6$$

Hence hydrocarbon is  $\text{C}_4\text{H}_6$

16.

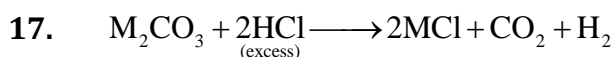
Element	C	:	H
Mass ratio	6	:	1
Mole ratio	1	:	2

So, empirical formula :  $\text{CH}_2$

For burning  $\text{CH}_2$  unit ; oxygen required is  $\frac{3}{2}$  mole

$$\Rightarrow \text{Empirical formula is } (\text{CH}_2\text{O}_{3/2}) \quad \text{i.e. } \text{C}_2\text{H}_4\text{O}_3$$

$$\Rightarrow \text{Correct option is (A)}$$



$$n_{\text{CO}_2} = 0.01186$$

1 mole  $\text{CO}_2$  is produced by 1 mole  $\text{M}_2\text{CO}_3$

$$\Rightarrow 0.01186 \text{ mole } \text{CO}_2 \text{ is produced by } \left(\frac{1 \times 0.01186}{1}\right) \text{ mole } \text{M}_2\text{CO}_3$$

$$\Rightarrow \frac{1}{M_{(\text{M}_2\text{CO}_3)}} = 0.01186$$

$$\Rightarrow M_{M_2CO_3} = \frac{1}{0.01186} = 84.3 \text{ gm}$$

$\Rightarrow$  Correct option is (B)

18.  $100 \text{ kg} \longrightarrow (10\text{kg}^1 \text{ H})$

$\downarrow$

$(20\text{kg}^2 \text{ H})$

$\Delta W = 10 \text{ kg}$

$\Rightarrow$  weight gain is 10% of 75 kg i.e. 7.5 kg

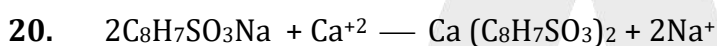
$\Rightarrow$  Correct option is (C)

19. By carius method,

$$\% \text{ Br} = \frac{80 \times \text{weight of AgBr}}{188 \times \text{Weight of organic Halide}} \times 100$$

$$= \frac{80}{188} = \frac{141 \times 10^{-3}}{250 \times 10^{-3}} \times 100 = 24$$

$\Rightarrow$  Correct option is (1)



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

$\Rightarrow$  maximum uptake of  $\text{Ca}^{+2}$  ions =  $\frac{1}{412}$

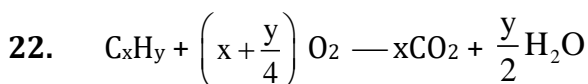
$\Rightarrow$  Correct option is (D).

21.

	0		N
ratio of masses	—	1	: 4
ratio of mole	—	$\frac{1}{16}$	: $\frac{4}{14}$
ratio of molecules	—	$\frac{N_A}{16}$	: $\frac{4N_A}{14}$

$\Rightarrow$  Ratio of number of molecules = 7 : 32

$\Rightarrow$  Correct option is (D)



$n_{\text{CO}_2} \frac{3.08}{44} = 0.07$

$n_{\text{H}_2\text{O}} \frac{.72}{18} = 0.04$

$\therefore \text{C} : \text{H} = 0.07 : 0.04 = 7 : 8$

$\Rightarrow$  The empirical formula of compounds is  $(\text{C}_7\text{H}_8)$

$\Rightarrow$  Correct option is (D)

## (PHYSICAL CHEMISTRY)

## MOLE CONCEPT

23.  $n_{O_3} = \frac{16}{48} = \frac{1}{3}$  mole

$n_{CO} = \frac{28}{28} \sim 1$  mole

$n_{O_2} = \frac{16}{32} = \frac{1}{2}$  mole

$\Rightarrow$  Ratio of oxygen atoms = 1 : 1 : 1

$\Rightarrow$  Correct option is (D)

24.  $V.D = 94.8 \Rightarrow$  molar mass =  $2 \times 94.8 = 189.6$  gm

$\Rightarrow$  mass of chlorine = 74.75% of 189.6 = 141.726 gm

$\Rightarrow$  mole of Cl =  $\frac{141.726}{35.5} = 4$

$\Rightarrow$  Formed of metal chloride will be  $MCl_4$ .

$\Rightarrow$  Correct option is (B)

25. 8 mole oxygen atom is present in 1 mole  $Mg_3(PO_4)_2$

$\Rightarrow$  0.25 mole oxygen atom is present in  $\left(\frac{1}{8} \times .25\right) = 3.125 \times 10^{-2}$  mole.

$\Rightarrow$  Correct option is (A)

26. Remain unchanged

The mass of 1 mole of the substance will remain unchanged.

$\Rightarrow$  Correct option is (B)

27. (B)

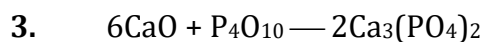
28. (A)

## EXERCISE (JEE-ADVANCED)

1. Atomic mass of Fe =  $\frac{54 \times 5 + 56 \times 90 + 57 \times 5}{100} = 55.95$

$\Rightarrow$  Correct option is (B)

2. (2)

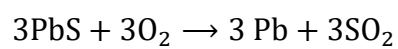
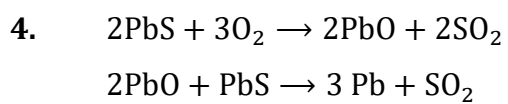


$n_{P_4O_{10}} = \frac{852}{284} = 3$  mole

1 mole  $P_4O_{10}$  reacts with 6 mole CaO

$\Rightarrow$  3 mole  $P_4O_{10}$  reacts with 18 mole CaO or  $18 \times 56$  CaO

i.e. 1008g CaO.



$$32 \text{ kg} \qquad 207 \text{ kg}$$

$$1 \text{ kg} \rightarrow \frac{207}{32} = 6.47 \text{ kg}$$

A