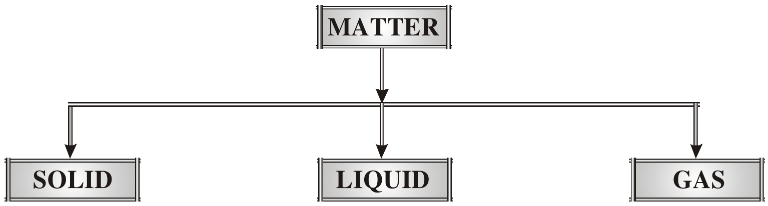
MOLE CONCEPT

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

Two ways of classifying matter :

I. Physical classification II. Chemical classification

1.1 Physical classification :

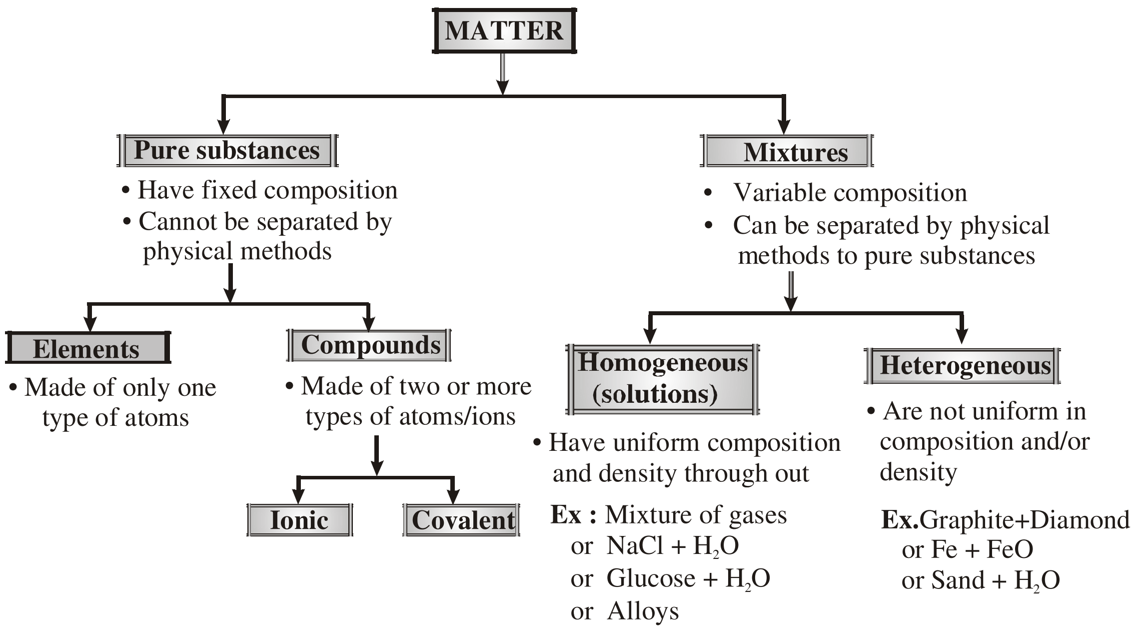


	SOLID	LIQUID	GAS
(i)	Particles held very closely packed in ordered manner.	Particles are less closely packed.	Particles are farthest apart
(ii)	No freedom of movement of particles	Particles can move around to some extent	Movement of particles is very easy and fast
(iii)	Definite shape and volume	Definite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

Note : For same substance :

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

1.2 Chemical classification :



Note • **PHASE :** It is the state of matter uniform in density and composition.

• Homogeneous mixtures have single phase while heterogeneous mixtures are multi-phase.

Ex : NaCl + H_2O mixture has one phase

Ex : Graphite + Diamond mixture has 2 phases.

2 SOME SPECIFIC PROPERTIES OF SUBSTANCES

2.1 Deliquescence :

The property of certain compounds of taking up the moisture present in atmosphere and becoming wet when exposed, is known as deliquescence. These compounds are known as deliquescent. Sodium hydroxide, potassium hydroxide, anhydrous calcium chloride, anhydrous magnesium chloride, anhydrous feric chloride, etc., are the examples of deliquescent compounds.

2.2 Hygroscopicity :

Certain compounds combine with the moisture of atmosphere and are converted into hydroxides or hydrates. Such substances are called hygroscopic. Anhydrous copper sulphate, quick lime (CaO), anhydrous sodium carbonate, etc., are of hygroscopic nature.

2.3 Efflorescence :

The property of some crystalline substances of losing their water of crystallisation on exposure and becoming powdery on the surface is called efflorescence and such salts are know as efflorescent. The examples are : Ferrous sulphate ($FeSO_4.7H_2O$), sodium carbonate ($Na_2CO_3.10H_2O$), sodium sulphate ($Na_2SO_4.10H_2O$), potash alum [$K_2SO_4.Al_2(SO_4)_3.24H_2O$], etc.

2.4 Malleability :

This property is shown by metals. When metallic solid is being beaten, it does not break but is converted into thin sheet. It is said to possess the property of malleability. Copper, gold, silver, aluminium, lead, etc., can be easily hammered into sheets. Gold is the most malleable metal.

2.5 Ductility :

The property of metal to be drawn into wires is termed ductility. Copper, silver, gold, aluminium, iron, etc., are ductile in nature. Platinum is the most ductile metal.

2.6 Brittleness :

The solid materials which break into small pieces on hammering are called brittle. The solids of non-metals and ionic solid are generally brittle in nature.

Ex: Ice, Diamond etc.

3. THE LAW OF CHEMICAL COMBINATION

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

3.1 Law of indestructibility of matter or conservation of Mass :

Antoine Lavosier
(1743-1794)

Antoine-Laurent de Lavosier, the "father of modern chemistry," wasa French nobleman prominent in the histories of chemistry and biology. He named both oxygen and hydrogen and predicted silicon.

- This law was proposed by ***Lavoisier in 1789.***
- According to this law, in all physical or chemical changes the total mass of the system remains constant or in a physical or chemical change, mass is neither created nor destroyed. Thus, in a physical or chemical change.

Total mass of reactant reacted = Total mass of products formed

Ex. $H_2O(s) \longrightarrow H_2O(\ell)$

Above reaction shows the physical change and the wt. of H_2O (s) = wt. of $(H_2O)(\ell)$

In case the reacting materials are not completely consumed, the relationship will be.

Total masses of reactants = Total masses of product + masses of unreacted reactants

- In nuclear reactions (Mass + energy) is conserved, not the mass seperately.

Ex.1 ***When 4.2 g $NaHCO_3$ is added to a solution of CH_3COOH weighing 10.0 g, it is observed that 2.2 g CO_2 is released into atmosphere. The residue is found to weigh 12.0 g. Show that these observations are in agreement with the law of conservation of mass.***

Sol. $NaHCO_3 + CH_3COOH \longrightarrow CH_3COONa + H_2O + CO_2$

Initial mass = 4.2 + 10 = 14.2

Final mass = 12 + 2.2 = 14.2

Thus, during the course of reaction law of conservation of mass is obeyed.

DO YOUR SELF-01

1. 100 gm $CaCO_3$(s) on heating decompose completely and gives 44 gm CO_2(g). The residue is found to weight 56 gms. show that these observations proof the law of conservation of mass.

2. 12 gm C(s) react with 32 gm O_2(g) to form CO_2(g). Find amount of CO_2(g) obtained if no reactant left at end of reaction .

Answers :

1. Initial mass = final mass **2.** 44 gm

3.2. Law of constant or definite proportion :

- This law was given by ***Joseph Louis Proust. in 1799***.
- Chemical compostion of a compound remains constant whether it is obtained by any method or any source.

◆ **Example :**

In water (H_2O), Hydrogen and Oxygen combine in 1 : 8 mass ratio, the ratio remains constant whether it is tap water, river water or sea water or produced by any chemical reaction.

Joseph Proust
(1754 - 1826)

Proust was born the son of anapothecary at Angers in north-west France. He studied in Paris.He lived in poverty for some years before being awarded a pension by Louis XVIII.

Ex.2 ***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

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

In the second sample of the oxide,

wt. of metal = 1.50 g , wt. of oxygen = (2.50 – 1.50) g = 1 g

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

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

Note: This law is not applicable in case of isotopes.

DO YOUR SELF-02

1. 12 gm C(s) burnt in oxygen gave 28 gm CO(g). 36 gm C(s) reduce Al_2O_3(s) to gave 84 gm CO(g). Show that these results illustrate the law of constant proportion.
2. Is proportion of hydrogen and oxygen in H_2O different if source of H_2O changed?

Answers :

1. In both sample of CO the proportions of C and O are fixed 2. No

3.3. The law of multiple proportion :

- This law was given by Dalton in 1803.
- If two elements combine to form more than one compound, then the different masses of one element which combine with a fixed mass of the other element, bear a simple ratio to one another.

Ex. Nitrogen and oxygen combine to form five stable oxides –

N_2O	Nitrogen 28 parts	Oxygen 16 parts
N_2O_2	Nitrogen 28 parts	Oxygen 32 parts
N_2O_3	Nitrogen 28 parts	Oxygen 48 parts
N_2O_4	Nitrogen 28 parts	Oxygen 64 parts
N_2O_5	Nitrogen 28 parts	Oxygen 80 parts

The masses of oxygen which combine with same mass of nitrogen in the five compounds bear a ratio 16 : 32 : 48 : 64 : 80 or 1 : 2 : 3 : 4 : 5.

Note: This law is not applicable in case of isotopes.

Ex.3 ***Carbon forms two oxides. One contains 27.27 % carbon & another contains 42.86% carbon. Show that the data illustrate the law of multiple proportion.***

Sol. The mass ratio of C : O in first oxide = 27.27 : 72.73 = 3 : 8

The mass ratio of C : O in second oxide = 42.86 : 57.14 = 3 : 4

Hence for each 3 gm of carbon the masses of oxygen combined is in 2 : 1 ratio.

Hence the data is according the law of multiple proportion.

Joseph Louis
Gay Lussac
(1778 - 1850)

Joseph Louis Gay-Lussac also ; 6 December 1778 – 9 May1850)was a French chemist and physicist. He is known mostly for two laws related to gases, and for his work on alcohol-water mixtures , which led to the degrees Gay-Lussac used to measure alcoholic beverages in many countries.

3.4 Law of Gaseous volumes :

- This law was given by ***Gay-Lussac.*** in 1808.
- According to this law, gases react with each other in the simple ratio of their volumes and if products are also gases then they are also in simple ratio of volume provided that all volumes are measure at same temp. & pressure.

eg. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

1 vol. 3vol. 2vol.

Ex.4 ***For the gaseous reaction , $H_2 + Cl_2 \longrightarrow 2HCl$. If 40 ml of hydrogen completely reacts with chlorine then find out the required volume of chlorine and volume of produced HCl ?***

Sol. According to Gay Lussac's Law :

$H_2 + Cl_2 \longrightarrow 2HCl$

$\because$ 1 ml of H_2 will react will 1 ml of Cl_2 and 2 ml of HCl will produce.

$\therefore$ 40 ml of H_2 will react with 40 ml of Cl_2 and 80 ml of HCl will produce.

required vol. of Cl_2 = 40 ml, produced vol. of HCl = 80 ml

DO YOUR SELF-03

1. 2ml $SO_2(g)$ react with 1 ml of $O_2(g)$ completely to form $SO_3(g)$

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

Is it true that 3ml of $SO_3(g)$ obtained at end of reaction.

Answer

1. No.

3.5. Avogadro's law (1811) : Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.

4. DALTON'S ATOMIC THEORY

Ancient Indian and Greek philosophers have always wondered about the unknown and unseen form of matter. The idea of divisibility of matter was considered long back in India, around 500 BC. An Indian philosopher ***Maharishi Kanad***, postulated that if we go on dividing matter (padarth), we shall get smaller and smaller particles. Ultimately, a time will come when we shall come across the smallest particle beyond which further division will not be possible. He named these particles **Parmanu**. Another Indian philosopher, Pakudha Katyayama, elaborated this doctrine and said that these particles normally exist in a combined form which gives us various forms of matter. Around the same era, the Greek philosopher Democritus expressed the belief that all matter consists of very small, indivisible particles, which he named ***atomos*** (meaning uncuttable or indivisible).

John Dalton (1766 - 1844) , an Englishman, began teaching at a Quaker school when he was 12. His fascination with science included an intense interest in meterology (he kept careful daily weather records for 46 years), which led to an interest in the gases of the air and their ultimate components, atom. Dalton is best known for his atomic theory, in which he postulated that the fundamental differences among atoms are their masses. He was the first to prepare a table of relative atomicweight.

Although Democritus' ideal was not accepted by many of his contemporaries (notably Plato and Aristotle), some how it endured. Experimental evidence from early scientific investigations provided support for the notion of "atomism" and gradually gave rise to the modern definitions of elements and compounds. It was in ***1808, John Dalton***, formulated a precise definition of the indivisible building blocks of matter that we call atoms. Dalton's work marked the beginning of the modern era of chemistry. The hypotheses about the nature of matter on which Dalton's atomic theory is based can be summarized as follows :

(i) Matter consists of indivisible atoms.

(ii) All atoms of a given element are identical, having the same size, mass and chemical properties. The atoms of one element are different from the atoms of all other elements.

(iii) Compounds are formed when atoms of different elements combine in a fixed ratio.

(iv) A chemical reaction involves only the separation, combination or rearrangement of atoms. It does not result in their creation or destruction.

5. ATOMIC AND MOELCULAR MASSES :

The mass of an atom depends on the number of electrons, protons, and neutrons it contains. Knowledge of an atom's mass is important in laboratory work. But atoms are extremely small particles - even the smallest speck of dust that our unaided eyes can detect contains as many as 1×10^{16} atoms ! Clearly we cannot weigh a single atom, but it is possible to determine the mass of one atom relative to another experimentally. The first step is to assign a value to the mass of one atom of a given element so that it can be used as a standard.

5.1 RELATIVE ATOMIC MASS :

Hydrogen, being lightest atom was arbitrarily assigned a mass of 1 (without any units) and other elements were assigned masses relative to it. However, the present system of atomic masses is based on carbon - 12 as the standard and has been agreed upon in 1961. Here, Carbon - 12 is one of the isotopes of carbon and can be represented as ^{12}C. In this system, ^{12}C is assigned a mass of exactly 12 atomic mass unit **(amu)** and masses of all other atoms are given relative to this standard.

Relative Atomic Mass is defined as the number which indicates how many times the mass of one atom of an element is heavier in comparison to 1/12th part of the mass of one atom of C-12.

$$\text{Relative atomic mass of an element} = \frac{\text{mass of one atom of an element}}{\frac{1}{12}[\text{mass of one C - 12 atom}]}$$

$$= \frac{\text{Mass of one atom of an element}}{1\,\text{amu}}$$

5.1.1 ATOMIC MASS UNIT (a.m.u. or u) : The quantity $1/12^{th}$ mass of an atom of C^{12} is known as atomic mass unit.

Since mass of 1 atom of C - 12 $= 1.992648 \times 10^{-23}$ g

$\therefore$ $1/12^{th}$ part of the mass of 1 atom $= \dfrac{1.992648 \times 10^{-23}\,\text{g}}{12} = 1.67 \times 10^{-24}$ g $= \dfrac{1}{6.022 \times 10^{23}}$ g

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

5.1.2 GRAM ATOMIC MASS OR MASS OF 1 G ATOM :

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

gram atomic mass (GAM) = mass of 1 **g atom** = mass of 1 **mole atoms**

= mass of N_A atoms = mass of 6.022×10^{23} atoms.

Ex. GAM of oxygen= mass of 1 **g atom** of oxygen = mass of 1 **mol atoms** of oxygen.

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

Ex. Mass of one atom of Oxygen = 16 amu or $16 \times 1.66 \times 10^{-24}$ g

Mass of N_A atoms of Oxygen = $16 \times 1.66 \times 10^{-24} \times 6.022 \times 10^{-23}$ g = 16 g

Now see the table given below and understand the definition given before.

Element	R.A.M. (Relative Atomic Mass)	Atomic mass (mass of one atom)	Gram Atomic mass or weight
N	14	14 amu	14 gm
He	4	4 amu	4 gm
C	12	12 amu	12 gm

5.1.3 AVERAGE ATOMIC MASS :

If an element exists in different isotopic forms having relative abundance $X_1\%$, $X_2\%$ ..... $X_n\%$, with relative atomic masses M_1, M_2 ..... M_n respectively then ,

$$\text{Avg. Atomic mass of element} = \frac{X_1}{100}(M_1) + \frac{X_2}{100}(M_2) + ... + \frac{X_n}{100}(M_n) = \sum_{i=1 \text{ to } n} \frac{X_i}{100}(M_i)$$

Ex.5 ***The atomic mass of an element is 50***
(i) Calculate the mass of one atom, in amu
(ii) Calculate the mass of 6.022×10^{23} atoms, in gm
(iii) Calculate the number of atoms in its 10 gm
(iv) What mass of the element contains 3.011×10^{20} atoms

Sol. (i) 50 amu
(ii) 50 gm
(iii) $\because$ 50 gm of element contains 6.022×10^{23} atoms

$\therefore$ 10 gm of element will contain $\frac{6.022 \times 10^{23}}{50} \times 10 = 1.2044 \times 10^{22}$ atoms

(iv) $\because$ 6.022×10^{23} atoms weighs 50 gm

$\therefore$ 3.011×10^{20} atoms weighs $\frac{50}{6.022 \times 10^{23}} \times 3.011 \times 10^{20} = 0.025$ gm

Ex.6 ***An element exist in nature in two isotopic forms : X^{30} (90%) and X^{32}(10%). What is the average atomic mass of element ?***

Sol. Av. atomic mass = $\frac{\Sigma(\%\text{abundance} \times \text{atomic mass})}{100} = \frac{90 \times 30 + 10 \times 32}{100} = 30.2$

DO YOUR SELF-04

1. Calculate mass of 1 atom of ${}^{16}_{8}O$ in gram.
2. Calculate mass of 6.022×10^{20} atoms of ${}^{14}_{7}N$ in gm.
3. Find no. of ${}^{4}_{2}He$ atoms present in 52 amu He sample ?
4. Element B exist in nature in two isotopic form B-10 (20%) and B -11 (80%). What is average atomic mass of B ?

Answers :

1. 2.66×10^{-23} gm **2.** 1.4×10^{-2} gm. **3.** 13 **4.** 10.8

5.2 RELATIVE MOLECULAR MASS :

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

OR

The molecular mass of a substance is the sum of atomic masses of all the atoms present in a molecule. It is obtained by multiplying the atomic mass of each element by the number of its atoms and adding them together.

Ex. molecular mass of oxygen (O_2) = 32

molecular mass of (O_3) = 48

molecular mass of HCl = 1 + 35.5 = 36.5

molecular mass of H_2SO_4 = 2 + 32 + 64 = 98

5.2.1 GRAM MOLECULAR MASS (MASS OF 1 G MOLECULE) :

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

gram molecular mass (GMM) = mass of 1 **g molecule** = mass of 1 **mole molecules**

= mass of N_A molecules = mass of 6.022×10^{23} molecules

Ex. GMM of H_2SO_4 = mass of 1 **g molecule** of H_2SO_4

= mass of 1 **mole molecules** of H_2SO_4

= mass of N_A molecules of H_2SO_4

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

Ex. Molecular Mass of N_2 = 28 amu = $28 \times 1.66 \times 10^{-28}$ g

Mass of N_A molecules of N_2 = $28 \times 1.66 \times 10^{-24} \times 6.022 \times 10^{23}$ g = 28 g

5.2.2 AVERAGE MOLECULAR MASS OF NON-REACTING GAS MIXTURE :

$$M_{avg.} = \frac{\text{Total mass of mixture}}{\text{Total mole}} = \frac{\Sigma(\%\text{vol} \times \text{molecular mass})}{100} = \frac{100}{\Sigma\left(\frac{\%\text{mass}}{\text{molecular mass}}\right)}$$

Ex.7 ***The molecular mass of a compound is 75***

(i) Calculate the mass of 100 molecules, in amu.

(ii) Calculate the mass of 5000 molecules, in gm.

(iii) What is the mass of 6.022×10^{20} molecules, in gm

(iv) How many molecules are in its 2.5 mg

Sol. (i) mass of 1 molecules = 75 amu

$\therefore$ mass of 100 molecules = 7500 amu

(ii) Mass of 5000 molecules = 5000×75 amu

$= 5000 \times 75 \times 1.66 \times 10^{-24} = 6.225 \times 10^{-19}$ gm

(iii) $\therefore$ 6.022×10^{23} molecules weighs 75 gm

$\because$ 6.022×10^{20} molecules weighs $\frac{75}{6.022\times10^{23}}\times6.022\times10^{20} = 0.075$ gm

(iv) $\therefore$ 75 gm compound contains 6.022×10^{23} molecules

$\because$ 2.5×10^{-3} gm will contain $\frac{6.022\times10^{23}}{75}\times2.5\times10^{-3} = 2.007 \times 10^{19}$ molecules.

Ex.8 ***A gaseous mixture contains 40% H_2 and 60% He, by volume. What is the average molecular mass of mixture ?***

Sol. $M_{av} = \frac{\Sigma(\%\,\text{by vol.}\times\text{molecular mass})}{100} = \frac{40\times2+60\times4}{100} = 3.20$

DO YOUR SELF-05

1. What is the molar mass of CO_2, SO_2, SO_3, urea (NH_2CONH_2) , glucose ($C_6H_{12}O_6$), sucrose (cane sugar) ($C_{12}H_{22}O_{11}$), PCl_5, PCl_3, Cl_2, $KClO_3$, Na_2CO_3, $NaHCO_3$, $CaCO_3$ and $CaCl_2$.

2. What is the mass of one CO_2 molecule in gm?

3. Calculate mass of 50 molecules of CO_2 in gm.

4. Calculate mass of 5 molecule of CO_2 in amu.

5. A gaseous mixture contains 2 moles of He and 6 moles H_2 gas. What is the average molecular mass of mixtrue ?

6. A gases mixture contains 40% H_2 and 60% He, by moles. What is the average molecular mass of mixture?

Answers :

1. 44 gm, 64 gm, 80 gm, 60 gm, 180 gm, 342 gm, 208.5 gm, 137.5 gm, 71 gm, 122.5 gm, 106 gm, 84 gm, 100 gm and 111 gm.

2. 7.3×10^{-23} gm **3.** 3.67×10^{-21} gm **4.** 220 amu

5. 2.50 **6.** 3.20

6 INTRODUCTION TO MOLE

Atoms and molecules are extremely small in size and their numbers in even a small amount of any substance is really very large. To handle such large numbers, a unit of similar magnitude is required. The 14th Geneva conference on weight and measures adopted **mole** as a ***seventh basic SI unit of the amount of a substance.*** Mole concept is essential tool for the fundamental study of chemical calculations. This concept is simple but its application requires a thorough practice. There are many ways of measuring the amount of substance, weight and volume being the most common, but basic unit of chemistry is the atom or a molecule and measuring the number of molecule is more important.

6.1 DEFINITION OF MOLE AND MOLAR MASS :

- A mole is the amount of a substance that contains as many entities (Atoms, Molecules, Ions or any other particles) as there are atoms in exactly 12 g of C-12 isotope.
- A mole of a substance contains Avogadro's number (6.022×10^{23}) of particles.
  The term mole, like a dozen or a gross, thus refers to a particular number of things. A dozen eggs equals 12 eggs, a gross of pencils equals 144 pencils, and a mole of ethanol equal 6.022×10^{23} ethanol molecules.
- The ***molar mass*** of a substance is the mass of one mole of the substance. Carbon-12 has a molar mass of exactly 12 g/mol , by definition.
- 1 g-atom = 1 mole atoms = N_A atoms
- 1 g-molecule = 1 mole molecules = N_A molecules
- 1 g-ion = 1 mole ions = N_A ions

6.2 Methods to calculate moles :

(i) If number of particles (molecules or atoms) is given then,

$$\text{mole} = \frac{\text{Given number of molecule / atom}}{N_A}$$

(ii) If mass is given then, number of mole = $\dfrac{\text{Given mass of substance (in gm)}}{\text{GAM / GMM}}$

(iii) If volume of gas is given then, mole

$$= \frac{\text{Volume of gas at STP}}{22.7\text{ L}} = \frac{\text{Volume of gas at }0^\circ\text{C and 1 atm}}{22.4\text{L}}$$

(Standard molar volume is the volume occupied by 1 mole of an ideal gas gas at STP (Standard temperature and pressure which is 273.15 K & 1 bar respectively) , which is equal to 22.7 L).

1 mole of an ideal gas occupy 22.4 L at 0ºC and 1 atm.

(iv) Under any condition of temperature and pressure, moles of gases may be calculated using IDEAL GAS EQUATION : PV = nRT,

where, R = Universal Gas Constant
= 0.082 L-atm/K-mol
= 8.314 J/K-mol
$\approx$ 2 cal/K-mol

<u>Units of pressure and their relation:</u>

1 atm = 76 cm Hg
= 760 mm Hg
= 760 torr (1 torr = 1 mm Hg)
= 1.01325×10^6 dyne/cm^2
= 1.01325×10^5 N/m^2 or Pa
= 1.01325 bar (1 bar = 10^5 Pa)

1 bar = 75 cm Hg

Units of Volume and their relation:

1 ml = 1 cm^3 = 1 c.c.

1 Litre = 1000 ml = 1 dm^3

1 m^3 = 1000 L

Units of Temperature and their relation:

T = 273.15 + t

where, T = Absolute temperature (in Kelvin) and t = temperature in °C

(Normally , we take 273K in calculation)

(v) Sometimes gas is collected over water. In this case, the measured pressure is sum of pressure of gas and the vapour pressure of water (also called Aqueous Tension). In order to calculate moles of gas, the vapour pressure of water should be deducted from the measured pressure.

Ex.9 ***Calculate the number of g-molecules (mole of molecules) in the following :***

(i) 3.2 gm CH_4

(ii) 70 gm nitrogen

(iii) 4.5 × 10^{24} molecules of ozone

(iv) 2.4 × 10^{21} atoms of hydrogen

(v) 11.2 L ideal gas at 0°C and 1 atm

(vi) 4.54 ml SO_3 gas at STP

(vii) 8.21 L C_2H_6 gas at 400K and 2atm

(viii) 164.2 ml He gas at 27°C and 570 torr [$N_A = 6 \times 10^{23}$]

Sol. (i) 3.2 gram CH_4

number of moles (CH_4) = $\frac{w}{M} = \frac{3.2}{16}$ = 0.2 moles

(ii) 70 gram N_2

Number of moles = $\frac{w}{M} = \frac{70}{28} = 2.5$

(iii) 4.5 × 10^{24} molecules of O_3

Number of moles $= \frac{\text{no. of molecules}}{N_A} = \frac{4.5 \times 10^{24}}{6 \times 10^{23}} = 7.5$

(iv) 2.4 × 10^{21} atoms of hydrogen

Number of gram molecules of H_2 = $\frac{\text{no. of molecules}}{N_A} = \frac{2.4 \times 10^{21}}{2 \times 6 \times 10^{23}} = 0.002$

(v) 11.2 litre ideal gas at 0°C and 1 atm

Number of moles = $\frac{\text{Volume at } 0^\circ C \,\&\, 1\,\text{atm}}{22.4\,\text{litre}} = \frac{11.2}{22.4} = 0.5$

(vi) 4.54 ml SO_3 gas at STP

Number of moles $= \dfrac{V_{STP}(ml)}{22700 ml} = \dfrac{4.54}{22700} = 2 \times 10^{-4}$

(vii) 8.21 litre C_2H_6 at 400 K and 2 litre

$$n = \frac{PV}{R.T} = \frac{2 \times 8.21}{0.0821 \times 400} = 0.5$$

(viii) 164.2 ml He gas at 27ºC and 570 torr

$$n = \frac{PV}{RT} = \left(\frac{570}{760} atm\right) \times \frac{164.2 \times 10^{-3} litre}{0.0821 \times 300} = 0.005$$

Ex.10 ***Find no. of protons in 180 ml H_2O. Density of water = 1 gm/ml.***

Sol. Mass of water = density × volume = 180 g

Moles of water $= \dfrac{180}{18} = 10$

1 mol water has 10 mol protons

$\therefore$ 10 mol water has 100 mol protons $= 100 \times 6.022 \times 10^{23}$ protons

$= 6.022 \times 10^{25}$ protons.

Ex.11 ***What mass of $Na_2SO_4.7H_2O$ contains exactly 6.022×10^{22} atoms of oxygen ?***

Sol. Molar mass of $Na_2SO_4.7H_2O$ = 275 gm.

1 mole $Na_2SO_4.7H_2O$ has 11 mol O-atoms.

$\Rightarrow$ 11 N_A O – atoms are in 275 g $Na_2SO_4 . 7H_2O$

$\Rightarrow 6.022 \times 10^{22}$ O – atoms are in $= \dfrac{275}{11 \times 6.022 \times 10^{23}} \times 6.022 \times 10^{22}$ g = 2.5 g

Ex.12 ***What is number of atoms and molecules in 112 L of $O_3(g)$ at 0ºC and 1atm ?***

Sol. Moles of molecules $= \dfrac{112}{22.4} = 5$

Moles of atoms = 5 × 3 = 15

No. of molecules = 5 N_A

No. of atoms = 15N_A.

DO YOUR SELF-06

1. A box contains 12×10^{22} number of oxygen atoms. Find moles of O-atoms? ($N_A = 6 \times 10^{23}$)

2. If a closed container contain 5 moles of CO_2 gas, then find total number of CO_2 molecules in the container ($N_A = 6 \times 10^{23}$)

3. A flask of 8.2 *L* contains CH_4 gas at a pressure of 2 atm. Find moles of CH_4 gas at 400K?

4. Find moles of O-atom in 5.6 litres of SO_3 at 0°C, 1 atm?

5. How many atoms are there in 5 moles of silver ($N_A = 6 \times 10^{23}$)

6. How many moles of O-atom are there in 1 mole $CaCO_3$

7. How many moles of O-atom are in 2.7×10^{25} molecules of CO_2 ($N_A = 6 \times 10^{23}$)

8. Find number of O-atoms in 1 mole O_2

9. Find moles of Cu atom and number of Cu atoms in it's 0.635 gm (Cu = 63.5)

10. Find number of molecules in 11.35 litre SO_2 gas at STP.

11. 2 moles of H_2SO_4 is kept in a beaker. Find

(i) Moles of H-atom (ii) Moles of S-atom

(iii) Moles of O-atom (iv) Number of O-atoms

12. A flask contains 16 gm helium $\left({}_{2}^{4}\text{He}\right)$ gas (Gram atomic mass of He = 4). Find

(i) Moles of He (ii) Moles of proton

(iii) Total number of neutrons

13. 6.4 gm of SO_2 will contain how many

(i) Moles of SO_2 molecule

(ii) Number of SO_2 molecules

Answers :

1.	0.2	2.	3×10^{24}	3.	0.5 mole		
4.	0.75 moles	5.	3×10^{24}	6.	3 mole		
7.	90	8.	$2N_A$	9.	0.01 mole, $(0.01 \times N_A)$		
10.	$(0.5 \times N_A)$	11.	(i) 4	(ii) 2	(iii) 8	(iv) $8N_A$	
12.	(i) 4 (ii) 8	(iii) $8N_A$					
13.	(i) 0.1 mole	(ii) $(0.1 \times N_A)$					

7 DENSITY :

It is of two types.

I. Absolute density

II. Relative density

7.1 For liquids and solids :

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

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

7.2 For gases :

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

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

Vapour Density :

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

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

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

Ex.13 ***A gaseous mixture of H_2 and NH_3 gas contains 68 mass % of NH_3. The vapour density of the mixture is –***

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

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

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

V D $=\frac{5}{2}=2.5$

DO YOUR SELF-07

1. Find V.D. of SO_3
2. A glass contains 36 ml of liquid water (density = 1 gm/ml). Find
   (i) Moles of H_2O
   (ii) Number of H_2O molecules
   (iii) Number of H-atoms

Answers :

1. 40 2. (i) 2 mole (ii) $2\times N_A$ (iii) $4\times N_A$

8. STOICHIOMETRY

Stoichiometry is the calculation of amounts of reactants and products involved in a reaction. Stoichiometric calculations require a balanced chemical equation of the reaction.

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

8.1 SIGNIFICANCE OF STOICHIOMETRIC COEFFICIENTS :

Stoichiometric coefficients of chemical equation tells us about the ratio in which moles of reactants react and moles of products form.

Ex.	$2H_2(g)$	+	$O_2(g)$	$\longrightarrow$	$2\,H_2O\,(g)$
1st interpretation	2 moles		1 mole		2 moles
2nd interpretation	$2\,N_A$ molecules		N_A molecules		$2\,N_A$ molecules
3rd interpretation	2 molecules		1 molecules		2 molecules

Ex.14 ***What mass of CaO is formed by heating 50 g $CaCO_3$ in air ?***

Sol. $CaCO_3\,(s) \longrightarrow CaO\,(s) + CO_2\,(g)$

50 gm

$=\frac{50}{100}$ mol

$=\frac{1}{2}$ mol $\qquad \frac{1}{2}$ mol $= \frac{1}{2}\times 56 =$ 28 gm

Ex.15 ***If 1 mole of ethanol (C_2H_5OH) completely burns to form carbon dioxide and water, mass of carbon dioxide formed is about***

Sol. $C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$

1 mole $\qquad$ 2 mole

$\therefore$ mass of CO_2 formed $= 2 \times 44 = 88$ gm

Ex.16. ***What volume of CO_2 at 0ºC and 1 atm is formed by heating 200 g $CaCO_3$?***

Sol. $CaCO_3\,(s) \longrightarrow CaO(s) + CO_2\,(g)$

200 gm

$= \frac{200}{100}$ mol $=$ 2 mol $\qquad$ 2 mol

Volume of gas at 0ºC and 1 atm = No. of moles × 22.4 L = 2 × 22.4 = 44.8 L.

DO YOUR SELF-08

1. $2NH_3 \longrightarrow N_2 + 3H_2$

   Find moles of H_2 produced from 4 moles of NH_3

2. $NH_2COONH_4 \xrightarrow{\Delta} 2NH_3 + CO_2$

   If 6 moles of NH_3 is produced then find moles of NH_2COONH_4 intially taken.

3. $KClO_3 \rightarrow KCl + O_2$ (unbalanced) ,

   If in above reaction 5 moles of $KClO_3$ was heated, then find moles of O_2 produced on completion of reaction

4. $2NH_3 \rightarrow N_2 + 3H_2$

   If at the end of reaction , 18 mole of H_2 is produced then find moles of NH_3 initially taken

Answers :

1. **6** **2.** **(3)** **3.** **(7.5)** **4.** **(12)**

LIMITING REAGENT (L.R.) :

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

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

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

(iii) When amounts of two or more than two reactants are given :

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

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

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

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

For calculation of moles of product, LR should be used.

Ex.17. ***28 gm Lithium is mixed with 48 gm O_2 to reacts according to the following reaction.***

$4Li + O_2 \longrightarrow 2Li_2O$ (Li = 7)

The mass of Li_2O formed is

Sol.

	4Li	+	O_2	$\longrightarrow$	$2Li_2O$
moles taken	$\dfrac{28}{7}$ =4		$\dfrac{48}{32}$ = 1.5		
$\dfrac{\text{moles taken}}{\text{stoich. coeff.}}$	$\dfrac{4}{4} = 1$ (L.R.)		$\dfrac{1.5}{1} = 1.5$		

Moles of Li_2O formed = $\dfrac{2}{4} \times 4 = 2$

Mass of Li_2O formed = 2 × 30 = 60 gm

Ex.18 ***Calculate the mass of sucrose $C_{12}H_{22}O_{11}$ (s) produced by mixing 78 g of C(s), 11 g of H_2(g) & 67.2 litre of O_2 (g) at 0ºC and 1 atm according to given reaction (unbalanced) ?***

$C(s) + H_2(g) + O_2(g) \rightarrow C_{12}H_{22}O_{11}(s)$

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

	12C(s)	11 H_2(g)	$\frac{11}{2}O_2$
Moles taken	$\dfrac{78}{12}$ = 6.5	$\dfrac{11}{2}$ = 5.5	$\dfrac{67.2}{22.4}$ = 3
$\dfrac{\text{moles taken}}{\text{stoich. coeff.}}$	$\dfrac{6.5}{12}$ = 0.54	$\dfrac{5.5}{11}$ = 0.5 (L.R.)	$\dfrac{3}{5.5}$ = 0.545

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

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

DO YOUR SELF-9

1. 3 moles $N_2(g)$ is allowed to react with 6 moles of $H_2(g)$ to form $NH_3(g)$ in a close container. Find limiting reagent.
2. $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$
   0.2 mole $CaCO_3$ is reacted with 0.5 moles HCl. Find mass of CO_2 produced?
3. Maximum 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 is
   $C(s) + H_2(g) + O_2(g) \longrightarrow C_{12}H_{22}O_{11}(s)$
   (A) 138.5 (B) 155.5 (C) 186.5 (D) 199.5

Answers:

1. (H_2) 2. 8.80 gm 3. (B)

8.3 PROBLEMS BASED ON MIXTURE :

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

Ex.19 ***1.5 gm mixture of SiO_2 and Fe_2O_3 on very strong heating leave a residue weighing 1.46 gm. The reaction responsible for loss of weight is***

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

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

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

3×160 $\qquad\qquad$ $\frac{1}{2}\times 32$

$= 480$ gm $\qquad\qquad$ $=16$ gm

loss of 16 gm $\rightarrow$ 480 gm Fe_2O_3

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

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

DO YOUR SELF-10

1. 19 gm mixture of $Na_2CO_3(s)$ and $NaHCO_3(s)$ on heating gives 2.2 gm CO_2 gas.
   Find % $NaHCO_3$ (by mass) in mixture.
2. Write decomposition reaction of $CaCO_3(s)$ and Na_2CO_3 (s) on heating.

Answers :

1. 44.21 %
2. $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$

   $NaCO_3(s) \xrightarrow{\Delta}$ (No decomposition)

8.4 PERCENTAGE YIELD :

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

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

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

Ex.20 ***Aluminium reacts with sulphur to form aluminium sulphide. If 5.4 gm of Aluminium reacts with 12.8gm sulphure gives 12gm of aluminium sulphides, then the percent yield of the reaction is. (Al = 27, S = 32)***

Sol $2Al + 3S \longrightarrow Al_2S_3$

	$2Al$	$3S$
Mole taken	$\frac{5.4}{27}$ gm $= 0.2$	$\frac{12.8}{32}$ gm $= 0.4$
$\frac{\text{moles taken}}{\text{stoich. coeff.}}$	$\frac{0.2}{2} = 0.1$ (L.R.)	$\frac{0.4}{3} = 0.133$

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

mass of Al_2S_3 formed $= 0.1 \times 150 = 15$ gm

But, from equation, only 12 gm Al_2S_3 is formed.

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

DO YOUR SELF-11

1. 5 moles of $CaCO_3$ on heating yielded 2 moles of CO_2. Find % yield of reaction
2. 245 gm of $KClO_3$ on heating yielded 64 gm O_2. Find % yield of reaction. (K = 39, Cl = 35.5)

Answers :

1. 40% 2. 66.67

8.5 DEGREE OF DISSOCIATION, α :

It represents the mole of substance dissociated per mole of the substance taken.

$$A \rightarrow n \text{ particles}; \quad \alpha = \frac{M_o - M}{(n-1).M}$$

where, n = number of product particles per particle of reactant

M_o = Molar mass of 'A'

M = Molar mass of final mixture

Dissociation decreases the average molar mass of system while association increases it.

Same formula is applicable for association, taking the correct value of 'n'.

Ex.21 ***For the reaction $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$***

Calculate degree of dissociation (α) if observed molar mass of mixture is 13.6

Sol. $M_0 = M_{NH_3} = 17$, $M = 13.6$ (given) , $n = \frac{4}{2} = 2$

$$\alpha = \frac{M_o - M}{(n-1).M} = \frac{17-13.6}{(2-1)\times 13.6} = 0.25$$

DO YOUR SELF-12

1. Find value of α if % dissociation is 25%
2. 'A' dissociate into 'B' and 'C' according reaction.

   $A \rightarrow 2B + C$

   If 5 moles of 'A' is 40% dissociated, then find moles of 'A' left.

Answers :

1. 0.25 2. 3 mol

8.6 PERCENTAGE PURITY :

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

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

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

Ex.22 ***A chalk sample exactly requires 17.52 gram HCl for complete reaction with all $CaCO_3$ present in it. If the chalk sample is 72% pure, the mass of sample taken is***

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

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

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

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

Mass of sample taken :

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

DO YOUR SELF-13

1. A 2000 gm sample of $CaCO_3$ is 80% pure. Find weight (in gm) of pure $CaCO_3$
2. An impure sample (having 60% purity) of $KClO_3$ contains 30 gm of pure $KClO_3$. Find weight of impure sample.
3. A 200 gm sample of $CaCO_3$ having 40% purity is heated. Find moles of CO_2 obtained.

Answers :

1. 1600 gm 2. 50 gm 3. 0.8 moles

8.7 PROBLEMS RELATED WITH SEQUENTIAL REACTION :

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

Ex.23 ***How many grams H_2SO_4 can be obtained from 1320 gm PbS as per reaction sequence ?***

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$$

$$3SO_2 + 2HNO_3 + 2H_2O \longrightarrow 3H_2SO_4 + 2NO$$

[At. mass : Pb = 208, S = 32]

Sol. Moles of PbS = $\frac{1320}{240}$ = 5.5 mol

Moles of SO_2 = 5.5 mol = moles of H_2SO_4

Mass of H_2SO_4 = 5.5 × 98 = 539 gm

[When amount of only one reactant is given generally other is assumed in excess.]

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

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

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

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

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

magnesium metaphosphate.

Sol. Balanced chemical reaction :

$$Ca_3(PO_4)_2 + 8Mg \longrightarrow Ca_3P_2 + 8MgO$$

excess $\quad \frac{192}{24} = 8\text{mole} \quad \frac{1}{8}\text{mole} \quad$ 8mole

$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$

$\frac{1}{8}$mole $\frac{1}{4}$mole

$2PH_3 + 4O_2 \longrightarrow P_2O_5 + 3H_2O$

$\frac{1}{4}$mole $\frac{1}{8}$mole

MgO +	P_2O_5	$\longrightarrow$	$Mg(PO_3)_2$
8mole	1/8mole (LR)		1/8 mole obtained

$W_{Mg(PO_3)_2}$ = 1/8 × 182 = 22.75 Mg

DO YOUR SELF-14

1. $A \longrightarrow 2B + C$

$3B \longrightarrow 2D$

Find moles of D produced if initially 3 moles of A are taken -

2. $2A + 3B \longrightarrow 4C + D$
(excess)

$3C \longrightarrow 2E$

If in the above reaction 6 moles of E are produced, find moles of 'A' initially taken.

Answers :

1. (4) **2. (4.5 mole)**

8.8 PROBLEM RELATED WITH PARALLEL REACTION :

When same two reactants form two or more products by independent reactions.

Ex.25 ***Carbon reacts with oxygen forming carbon monoxide and/or carbon dioxide depending an availablity of oxygen. Find moles of each product obtained when 160 gm oxygen reacts with (a) 12 g carbon (b) 120 g carbon (c) 72 g carbon.***

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

	C	O_2		CO
t = 0	1mol	5mol		
t =∞	0 (LR)	5–0.5 4.5mol	=	1mol

Since CO & O_2 are left, CO_2 will also formed.

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

	CO	O_2	CO_2
t = 0	1mol	4.5mol	0
t = ∞	0	4 mol	1 mol

At end, 1 mole CO_2 & no CO present

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

	C	O_2	CO
t = 0	10mol	5mol	0
t =∞	0	0	10mol

At end only 10 mol CO present.

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

t = 0	6mol	5mol	0
t = ∞	0 [LR]	2mol	6mol

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

t = 0	6mol	2mol	0
t = ∞	2mol	0 [LR]	4mol

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

Ex.26 ***25.4 gm of iodine and 14.2 gm of chlorine are made to react completely to yield mixture of ICl and ICl_3. Ratio of moles of ICl & ICl_3 formed is (Atomic mass : I = 127, Cl = 35.5)***

Sol.

I_2	+	Cl_2 ⟶	ICl	+ ICl_3
0.1mol		0.2 mol	x mol	y mol

Applying conservations of I and Cl -atom

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

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

$\therefore\ n_{ICl} : n_{ICl_3} = x : y = 1 : 1$

DO YOUR SELF-15

1. 2 moles carbon and 1.5 moles of oxygen gas are reacted in a container to produce CO or CO_2 or both. Find moles of CO, CO_2 produced.

Answer :

1. CO = 1 mole, CO_2 = 1 mole

8.9 PRINCIPLE OF ATOM CONSERVATION (POAC)

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

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

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

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

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

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

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

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

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

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

  moles of O in O_2 = 2 × moles of O_2

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

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

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

Ex.27 ***27.6 g K_2CO_3 was treated by a series of reagents so as to convert all of its carbon to $K_2Zn_3[Fe(CN)_6]_2$. Calculate the weight of the product. [mol. wt. of K_2CO_3 = 138 and mol. wt. of $K_2Zn_3[Fe(CN)_6]_2$ = 698]***

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

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

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

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

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

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

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

DO YOUR SELF-16

1. 3 moles of S_8 was treated by a series of reagents so as to convert all of its S to H_2SO_4. Calculate weight of product.

Answsers :

1. 2352 gm.

9. PERCENTAGE COMPOSITION OF ANY ELEMENT IN ANY COMPOUND :

Percentage of perticular element present in a compound given as ,

Mass % of an element

$$= \frac{\text{mass of that element in the compound}}{\text{molar mass of the compound}} \times 100$$

$$= \frac{\text{no. of atoms of that element} \times \text{Atomic mass}}{\text{molar mass of the compound}} \times 100$$

Let us understand it by taking the example of water (H_2O). Since water contains hydrogen and oxygen, the percentage composition of both these elements can be calculated as follows :

Mass % of an element $= \frac{\text{mass of that element in the compound} \times 100}{\text{molar mass of the compound}}$

Molar mass of water = 18 g

Mass % of hydrogen $= \frac{2 \times 1}{18} \times 100 = 11.11$

Mass % of oxygen $= \frac{16}{18} \times 100 = 88.89$

9.1 PERCENTAGE DETERMINATION OF ELEMENTS IN ORGANIC COMPOUNDS :

All these methods are applications of POAC

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

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

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

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

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

(b) **Duma's method :** (*for nitrogen*)

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

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

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

(c) Kjeldahl's method : (for nitrogen)

$$\text{O.C.(w)} \xrightarrow[\text{conc. }\Delta]{H_2SO_4} (NH_4)_2SO_4 \xrightarrow[\Delta]{\text{NaOH}} NH_3(w_1)$$

$$\% \text{ of N} = \frac{14}{17} \times \frac{w_1}{w} \times 100$$

(d) **Sulphur :**

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

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

(e) **Phosphorus :**

O.C. (w) + $HNO_3 \rightarrow H_3PO_4$ + [NH_3 + magnesia mixture ammonium molybdate] $\rightarrow$

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

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

(f) **Carius method :** (*Halogens*)

O.C. (w) + HNO_3 + $AgNO_3 \rightarrow AgX\ (w_1)$

If X is Cl then colour = curdy white

If X is Br then colour = dull yellow

If X is I then colour = bright yellow

Flourine can't be estimated by this

$$\% \text{ of X} = \frac{w_1}{\text{(M. weight of AgX)}} \times \frac{1 \times (\text{At.wt.of X})}{w} \times 100$$

Ex.28 In which of the following has same % composition of C,

$HCHO$, CH_3COOH, $C_6H_{12}O_6$, CH_3COCH_3

Sol. $HCHO$, CH_3COOH, $C_6H_{12}O_6$

$$\% \ C(HCHO) = \frac{1\times 12}{30}\times 100 = 40\%$$

$$\% \ C(CH_3COOH) = \frac{2\times 12}{60}\times 100 = 40\%$$

$$\% \ C(C_6H_{12}O_6) = \frac{6\times 12}{180}\times 100 = 40\%$$

$$\% \ C(CH_3COCH_3) = \frac{3\times 12}{58}\times 100 = 62.07\%$$

Ex.29 ***A sample of 0.5 gm of an organic compound was treated according to Kjeldahl's method. The ammonia evolved was absorbed by 2.45 gm of H_2SO_4. The residual acid required solution containing 1.2 gm. NaOH for neutralisation. Find the percentage composition of nitrogen in the compound ?***

Sol. $2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2\ SO_4$

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Moles of H_2SO_4 taken $= \frac{2.45}{98} = 0.025$

Moles of NaOH $= \frac{1.2}{40} = 0.03$

$\therefore$ Moles of H_2SO_4 reacted with NaOH $= \frac{0.03}{2} = 0.015$

Remaining mol of $H_2SO_4 = 0.025 - 0.05 = 0.01$

mol of NH_3 evolved $= 0.01 \times 2 = 0.02$

% N in sample $= \frac{0.02\times 14}{0.5}\times 100 = 56\%$

DO YOUR SELF-17

1. Find % oxygen in C_2H_5OH

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

Answers :

1. 34.78% **2** 78.0 gm/mol .

10. EMPIRICAL AND MOLECULAR FORMULA

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

i.e. **Empirical formula :** Formula depicting constituent atoms in their simplest ratio.

Molecular formula : Formula depicting actual number of atoms in one molecule of the compound.

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

i.e. molecular formula = empirical formula × n

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

Example :

Molecular Formula	H_2O_2	C_6H_6	C_2H_6	$C_2H_4O_2$
	2 : 2	6 : 6	2 : 6	2 : 4 : 2
Simplest ratio	1 : 1	1 : 1	1 : 3	1 : 2 : 1
Empirical Formula	H O	C H	CH_3	CH_2O

10.1 DETERMINATION OF EMPIRICAL FORMULA :

Following steps are involved in determining the empirical formula of the compounds –

(i) First of all find the % by wt. of each element present in the compound.

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

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

(iv) If the value of simplest atomic ratio is fractional then raise the value to the nearest whole number or multiply with suitable coefficient to convert it into nearest whole number

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

10.2 DETERMINATION OF MOLECULAR FORMULA :

(i) Find out the empirical formula mass by adding the atomic masses of all the atoms present in the empirical formula of compound.

(ii) Divide the molecular mass (determined experimentally by some suitable method) by the empirical formula mass and find out the value of n.

(iii) Multiply the empirical formula of the compound with 'n' so as to find out the molecular formula of the compound.

Ex.30. ***An organic compound contains 49.3% carbon, 6.84% hydrogen and its vapour density is 73. Molecular formula of compound is :-***

Sol. V.D. = 73 $\Rightarrow$ M = 2 × 73 = 146

$$C = 146 \times \frac{49.3}{100} = 71.978 \text{ g} = \frac{71.978}{12} \simeq 6 \text{ mole}$$

$$H = 146 \times \frac{6.84}{100} = 9.9864 \text{ g} = \frac{71.978}{12} \simeq 10 \text{ mole}$$

$$O = 146 \times \frac{100-(49.3+6.84)}{100} = \frac{64.86}{16} = 64.86 \text{ g} \approx 4 \text{ mol}$$

M.F. = $C_6H_{10}O_4$

Ex.31 ***The empirical formula of an organic compound containing carbon & hydrogen is CH_2. The mass of 1 litre of organic gas is exactly equal to mass of 1 litre N_2 therefore molecular formula of organic gas is.***

Sol. Empirical Mass of CH_2 = 12 + 2 = 14

$\because$ Mass of 1 litre of organic gas = Mass of 1 litre of N_2

Since V, P, T, n are same.

Therefore from $PV = \frac{m}{M}RT$ implies that molar mass should also be same.

$\therefore$ Molecular mass of organic compound will be 28 g

$$n = \frac{\text{Molecular mass}}{\text{Empirical mass}} = \frac{28}{14} = 2$$

So molecular formula = 2 × CH_2 = C_2H_4

DO YOUR SELF-18

1. In which of following has same emperical formula -

C_2H_2, C_2H_4, C_2H_6, C_6H_6

2. Determine the empirical formula of an oxide of iron, which has 70% Fe and 30% 'O' by mass. (Fe = 56)

Answers :

1. C_2H_2, C_6H_6, **2.** Fe_2O_3

11. EUDIOMETRY :

Eudiometry or gas analysis involves the calculations based on gaseous reactions or the reactions in which at least two components are gaseous, in which the amounts of gases are represented by their volumes, measured at the same pressure and temperature. Some basic assumptions related with calculations are:

(i) Gay-Lussac's law of volume combination holds good. According to this law, the volumes of gaseous reactants reacted and the volumes of gaseous products formed, all measured at the same temperature and pressure, bear a simple ratio.

$$\underset{\text{1 vol.}}{N_2\,(g)} + \underset{\text{3 vol.}}{3H_2\,(g)} \longrightarrow \underset{\text{2 vol.}}{2NH_3\,(g)}$$

Problem may be solved directly is terms of volume, in place of mole. The stoichiometric coefficients of a balanced chemical reactions gives the ratio of volumes in which gaseous substances are reacting and products are formed, at same temperature and pressure.

(ii) The volumes of solids or liquids is considered to be negligible in comparison to the volume of gas. It is due to the fact that the volume occupied by any substance in gaseous state is even more than thousand times the volume occupied by the same substance in solid or liquid states.

$$\underset{\substack{\text{2 mole}\\ \text{2 vol.}}}{2H_2\,(g)} + \underset{\substack{\text{1 mole}\\ \text{1 vol.}}}{O_2\,(g)} \longrightarrow \underset{\substack{\text{2 mole}\\ \text{0 vol.}}}{2H_2O\,(l)}$$

(iii) Air is considered as a mixture of oxygen and nitrogen gases only. It is due to the fact that about 99% volume of air is composed of oxygen and nitrogen gases only.

(iv) Nitrogen gas is considered as a non- reactive gas. It is due to the fact that nitrogen gas reacts only at very high temperature due to its very high thermal stability. Eudiometry is performed in an eudiometer tube and the tube can not withstand very high temperature. This is why, nitrogen gas can not participate in the reactions occurring in the eudiometer tube.

(v) The total volume of non-reacting gaseous mixture is equal to sum of partial volumes of the component gases **(Amagat's law)**.

$V = V_1 + V_2 + \ldots\ldots\ldots\ldots$

Partial volume of gas in a non-reacting gasesous mixture is its volume when the entire pressure of the mixture is supposed to be exerted only by that gas.

(vi) The volume of gases produced is often given by certain solvent which absorb contain gases.

Solvent	**Gases absorb**
KOH	CO_2, SO_2, Cl_2
Ammonical Cu_2Cl_2	CO
Turpentine oil	O_3
Alkaline pyrogallol	O_2
water	NH_3, HCl
$CuSO_4/CaCl_2$	H_2O

(vii) EUDIOMETER

An eudiometer is a laboratory device that measures the change in volume of a gas mixture following a physical or chemical change.

Ex.32 10 ml of CO is mixed with 25 ml air (20% O_2 by volume). Find final volume (in ml) after complete combustion.

Sol. $$\overset{10\,ml}{CO} + \overset{5ml}{\frac{1}{2}O_2} \longrightarrow \underset{10\,ml}{CO_2}$$

$V_f = V_{CO_2}$ + Volume of remaining air = 10 + 20 = 30 ml

Ex.33 A 3 L gas mixture of propane (C_3H_8) and butane (C_4H_{10}) on complete combustion at 25°C produced 10 L CO_2. Assuming constant P and T conditions what was volume of butane present in initial mixture ?

Sol. $C_3H_8(g) + 5O_2 \longrightarrow 3CO_2(g) + 4H_2O(l)$

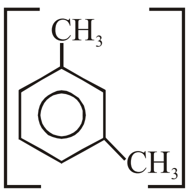
x L 3x L

$C_4H_{10}(g) + \frac{13}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$

(3-x) L 4(3 – x) L

from question 3x + 4 (3 –x) = 10 ⇒ x = 2

∴ Volume of butane , C_4H_{10} = (3 – x) = 1 L

Ex.34 100 ml gaseous meta Xylene 

undergoes combustion with excess of oxygen at room temperature and pressure. Volume contraction / expansion (in ml) during reaction is

Sol.. $C_4H_{10}(g) + \frac{21}{2}O_2(g) \longrightarrow 8CO_2(g) + 5H_2O(l)$

100 ml $\frac{21}{2}\times 100 = 1050ml$ 800 ml 0

∴ Conctraction in volume = (100 + 1050) – 800 = 350 ml

Ex.35 An alkene upon combustion produces CO_2(g) and H_2O(g). In this combustion process if there is no volume change occurs then the no. of C atoms per molecule of alkene will be :

Ans.(2)

$C_nH_{2n}(g) + \frac{3n}{2}\ O_2(g) \rightarrow nCO_2(g) + nH_2O(g)$

if there no volume changes i.e. $\Delta_{ng} = 0$

$$(n + n) - \left(1+\frac{3n}{2}\right) = 0 \ \Rightarrow\ n = 2$$

Ex.36 A gaseous hydrocarbon (C_xH_y) requires 6 times of its own volume of O_2 for complete oxidation and produces 4 times of its volume of CO_2. Find out the volume of x + y.

Ans. (012)

$$C_xH_y + \quad (x + \frac{y}{4})\, O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O(l)$$

$$a \qquad a\left(x+\frac{y}{4}\right) \qquad ax$$

Given that : a(x + y/4) = 6a

and ax = 4 (a)

x = 4 and y = 8 ...(2)

$\therefore$ x + y = 4 + 8 = 12

Ex.37 On heating 60 ml mixture containing equal volume of chlorine gas and it's gaseous oxide, volume becomes 75 ml due complete decomposition of oxide. On treatment with KOH volume becomes 15 ml. What is the formula of oxide of chlorine ?

Ans. Cl_2O

Sol. Let oxide of Cl is Cl_xO_y

So in 60 mL $\Rightarrow$ 30 mL Cl_xO_y and 30 mL Cl_2.

Now,

$$Cl_xO_y \longrightarrow \frac{x}{2}Cl_2 + \frac{y}{2}O_2$$

30mL

$$\frac{30.x}{2}\text{mL} \qquad \frac{30.y}{2}\text{mL}$$

Given :

$$75 = 30+\frac{30x}{2}+\frac{30y}{2} \Rightarrow x + y = 3 \text{ ....(i)}$$

KOH absorbs Cl_2 and volume becomes 15 mL so,

$$(75 - 15) = V_{Cl_2} = 30+\frac{30x}{2} \Rightarrow x = 2 \text{ and } y = 1$$

So the oxide : Cl_2O

Ex.38 5 L of A (g) & 3 L of B(g) measured at same T & P are mixed together which react as follows

$$\mathbf{2A(g) + B(g) \rightarrow C (g)}$$

What will be the total volume (in litre) after the completion of the reaction at same T & P.

Ans. (3)

Sol. $2A(g) + B(g) \longrightarrow C(g)$

5L 3L

L.R. is A

So, volume of C produced = $\frac{1}{2}\times 5$ = 2.5 L

and, volume of B reacted = $\frac{1}{2}\times 5$ = 2.5 L

So, volume fo B remained = 3 – 2.5 = 0.5 L

Hence, $V_{total} = V_C + V_B$ = 2.5 + 0.5 = 3 L

DO YOUR SELF-19

1. KOH solvent can absorb in which of following gas.

(A) Cl_2 (B) SO_2 (C) CO_2 (D) H_2

2. O_2 gas can be absorb by

(A) Turpentine oil (B) Alkaline pyragallol solution

(C) KOH solvent (D) Ammonical $Cu_2\ Cl_2$ solution

3. How much volume in ml of CO_2 gas obtain at root temperature after complete combustion of 16 ml CH_4 gas.

4. Write and balance the combustion reactions of following hydrocarbons.

(i) CH_4 (ii) C_2H_4 (iii) C_3H_8 (iv) C_4H_8

(iv) C_2H_2 (iv) $C_2H_5\ OH$

5. Complete the following table related to combustion of hydrocarbon in Eudiometer tube. (All volume measurements are done at room temperature and pressure.)

Volume of hydrocarbon	Volume of oxygen (O_2)	Initial volume(V_i) of gases	Final volume(V_f) of gases	Volume contraction
10 ml CH_4	20 ml O_2			
30 ml C_2H_4	90 ml O_2			
30 ml C_2H_4	100 ml O_2			
50 ml C_3H_8	300 ml O_2			
20 ml C_2H_5OH	80 ml O_2			

Answers :

1. **(A,B,C)**

2. **(B)**

3. **(16 ml)**

4. **(i)** $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

(ii) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

(iii) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

(iv) $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

(iv) $C_2H_2 + \frac{5}{2}O_2 \rightarrow 2CO_2 + H_2O$

(iv) $C_2H_5\ OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

5. **Ans.**

Volume of hydrocarbon	Volume of oxygen (O_2)	Initial volume(V_i) of gases	Final volume(V_f) of gases	Volume contraction
10 ml CH_4	20 ml O_2	30 ml	10 ml	20 ml
30 ml C_2H_4	90 ml O_2	120 ml	60 ml	60 ml
30 ml C_2H_4	100 ml O_2	130 ml	70 ml	60 ml
50 ml C_3H_8	300 ml O_2	350 ml	200 ml	150 ml
20 ml C_2H_5OH	80 ml O_2	100 ml	60 ml	40 ml

SOLVED EXAMPLES

Ex.1 When the same amount of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volume of hydrogen evolved is. **[JEE-1979]**

(A) 1 : 1 (B) 1 : 2 (C) 2 : 1 (D) 9 : 4

Ans. **(A)**

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$

$Zn + NaOH \rightarrow Na_2ZnO_2 + H_2\uparrow$

Ex.2 If 0.50 mole of $BaCl_2$ is mixed with 0.20 mol of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is - **[JEE-1981]**

(A) 0.70 (B) 0.50 (C) 0.20 (D) 0.10

Ans.(D)

Ex.3 What weight of AgCl will be precipitated when a solution containing 4.77 g of NaCl is added to a solution of 5.77 g of $AgNO_3$. (Ag = 108)

Ans. **(4.879 gm)**

$AgNO_3 + NaCl \rightarrow NaNO_3 + AgNCl$

5.77 gm 4.77 gm

0.034 mole (LR) 0.082 mole

wt. of AgCl = 0.034 × 143.5 = 4.879 gm

Ex.4 n-butane is product by the monobromination of ethane followed by the Wurtz reaction. Calculate the volume of ethane at NTP required to produce 55g n-butane, if the bromination takes place with 90% yield and the Wurtz reaction with 85% yield. **JEE-1984]**

Ans. **(55.50 litre)**

(i) Monobromination of ethane

$$\underset{\text{Ethane}}{C_2H_6} \xrightarrow{Br_2} C_2H_5Br$$

(ii) Wurtz reaction :

$$2C_2H_5Br + 2Na + \xrightarrow[\text{ether}]{\text{Dry}} C_4H_{10} + 2NaBr$$

Molecular weight of

$C_4H_{10} = (12 \times 4) + (10 + 1) = 58$

$\therefore$ Amount of n-butane to be produced $= \frac{55}{58}$ mol = 0.948 mol

$\therefore$ Amount of C_2H_5Br required to obtain 0.948 mol

But the conversion is only 85%

Hence, the amount of C_2H_5Br required $= \frac{1.896}{85} \times 100 = 2.23$ mol

To obtain C_2H_5Br from C_2H_6, the same amount of C_2H_6 would be required. But the percent conversion of C_2H_6 to required $= \frac{2.23}{90} \times 100 = 2.478$mol.

Thus , required volume of ethane of NTP = 22400 × 2.478 = 55507.2 ml = 55.50 L.

Ex.5 A solid mixture (5.0 g) consisting of lead nitrate and sodium nitrate was heated below 600ºC unitll the weight of the residue was constant. If the loss in weight is 20% find the amount of lead nitrate and sodium nitrate in the mixture. **[JEE-1990]**

Ans. **$Pb(NO_3)_2$ = 3.32 gm, $NaNO_3$ = 1.68 gm**

Sol. $\underset{\text{a gm}}{Pb(NO_3)_2} \longrightarrow PbO + 2NO_2\uparrow + \frac{1}{2}O_2\uparrow$

$\underset{\text{b gm}}{NaNO_3} \longrightarrow NaNO_2 + \frac{1}{2}O_2\uparrow$

$\therefore$ a + b = 5 ..... (1)

The loss in weight for 5 g mixture = $5 \times \frac{28}{100} = 1.4g$

$\therefore$ Residue left = 5 – 1.4 = 3.6 g

The residue contain PbO + $NaNO_2$

$\because$ 331 g $Pb(NO_3)_2$ gives = 223g PbO

$\therefore$ ag $Pb(NO_3)_2$ gives = $\frac{223 \times a}{332}$ g PbO

Similarly ,

$\therefore$ 85 g $NaNO_3$ gives = 69 $NaNO_3$

$\therefore$ bg $NaNO_3$ gives = $\frac{69 \times b}{85}$ g $NaNO_3$

Solving equation, (1) and (2)

a = 3.32 g and b = 1.68 g

Ex.6 The weight of 2.01×10^{23} molecules of CO is- **[AIEEE 2002]**

(1) 9.3 g (2) 7.2 g (3) 1.2 g (4) 3 g

Ans. **(1)**

Sol. Mass = $\frac{2.01 \times 10^{23}}{6.02 \times 10^{23}} \times 28$ = 9.3 gm

Ex.7 In an organic compound of molar mass 108 g mol^{-1} C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be : **[AIEEE 2002]**

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

Ans. **(1)**

Sol.

	C		H		N
	9	:	1	:	3.5
Mole	$\frac{9}{12}$	:	$\frac{1}{1}$	:	$\frac{3.5}{14}$
	0.75	:	1	:	0.25

C_3H_4N = emp. formula

mol. formula = $C_6H_8N_2$

Ex.8 How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms? **[AIEEE 2006]**

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

Ans. (1)

Sol. $x \times 8 = 0.25 \Rightarrow x = 3.125 \times 10^{-2}$

Ex.9 In the reaction **[AIEEE-2007]**

$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2Al^{3+}{}_{(aq)} + 6Cl^{-}{}_{(aq)} + 3H_2(g)$.

Select the correct information(s)

(1) 6L $HCl_{(aq)}$ is consumed for every 3L $H_2(g)$ produced

(2) 33.6 L $H_{2(g)}$ is produced regardless of temperature and pressure for every mole of Al that reacts

(3) 67.2 L $H_{2(g)}$ at STP is produced for every mole of Al that reacts

(4) 11.2 L $H_{2(g)}$ at STP is produced for every mole of of $HCl_{(aq)}$ consumed

Ans.(4)

Ex.10 30 ml gaseous mixture of methane and ethylene in volume ratio X : Y requires 350 ml air containing 20% of O_2 by volume for complete combustion. If ratio of methane and ethylene changed to Y : X. What will be volume of air (in ml) required for complete reaction under similar condition of temperature and pressure.

$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O\ (l)$

V_1ml $2V_1$ml V_1ml 0

$C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O\ (l)$

V_2ml $3V_2$ml $2V_2$ml 0

For given data : $V_1 + V_2 = 30$

and $2V_1 + 3V_2 = 350 \times \frac{20}{100} = 70$

$\therefore V_1 = 20\ ,\ V_2 = 10$

For required data : $V_1 = 10$ and $V_2 = 20$

$\therefore$ Volume of O_2 required $= 2V_1 + 3V_2 = 80$ ml and volume of air required $= 80 = \frac{100}{20} = 400$ml

Ex.11 5 ml of gas containing only carbon and hydrogen was mixed with an excess of oxygen (30 ml) and the mixture exploded by means of an electric spark. After the explosion , the volume of the mixed gases remaining was 25 ml. On adding a concentrated solution of potassium hydroxide, the volume further diminished to 15 ml the residual gas being pure oxygen. All volumes have been reduced to NTP. Calculate the molecular formula of the hydrocarbon. **[JEE-1979]**

Ans. (C_2H_4)

Sol. Volume of oxygen taken = 30 ml

Volume of unused oxygen = 15 ml

Volume of O_2 used = Volume of O_2 added - volume of O_2 left = 30 – 15 = 15 ml.

and volume of CO_2 produced = 25 – 15 = 10 ml

General equation of the combustion of a hydrocarbon is as following lows.

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

$$5\text{ ml} \quad 5\left(x+\frac{y}{2}\right)\text{ml} \quad 5x$$

$\therefore$ 5x = 10 $\Rightarrow$ x = 2

and $5\left(x+\frac{y}{2}\right) = 15$

$\therefore$ Molecular formula of hydrocarbon = C_2H_4

Ex.12 A 20.0 ml mixture of CO , CH_4 and He gases is exploded by an electric discharge at room temperature wth excess of oxygen. The volume contraction is found to be 13.0 cm^3. A further contraction of 14.0 cm^3 occurs when the residual gas is treated with KOH solution. Find out the composition of the gaseous mixture in terms of volume percentage. **[JEE-1995]**

Ans. (% CH_4 = 20, % CO = 50, % He = 30)

Sol. $CO(g) + \frac{1}{2} O_2(g) \longrightarrow CO_2(g)$

$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(l)$

'x' is the volume of CO and y is the volume of CH_4

Thus, $\frac{1}{2}x + 2y = 13$ (1)

x + y = 14 (2)

x = 10 and y = 4

Thus, % CH_4 = 20, % CO = 50, % He = 30

EXERCISE S-I

PROBLEMS RELATED WITH DIFFERENT TYPES OF ATOMIC MASSES & BASIC CONCEPT OF MOLE

1. Find :

(i) No. of moles of Cu atom in 10^{23} atoms of Cu.

MC0001

(ii) Mass of 200 $^{16}_{8}O$ atoms in amu

MC0001

(iii) Mass of 100 atoms of $^{14}_{7}N$ is y × 10^{-22} in gm ,then value of y is (1 amu = 1.67 × 10^{-24} gm)

MC0001

(iv) No. of molecules & atoms in 54 gm H_2O is y × 10^{23} and z × 10^{23} respectively then value of y & z is (N_A = 6.022 × 10^{23})

MC0002

(v) No. of molecules in 88 gm CO_2 is y × 10^{23} , then value of y is (N_A = 6.022 × 10^{23})

MC0002

2. If mass of one ^{12}C atom is y × 10^{-23} gm, then value of y is ?

MC0003

3. Calculate mass (in gm) of O atoms in 6 gm CH_3COOH ?

MC0004

4. Calculate mass of water (in gm) present in 499 gm $CuSO_4.5H_2O$?
(Atomic mass : Cu = 63.5, S = 32, O = 16, H = 1)

MC0005

5. What mass (in gm) of $Na_2SO_4.7H_2O$ contains exactly 6.022 × 10^{22} atoms of oxygen ?
(N_A = 6.022 × 10^{23})

MC0006

6. The weight (in gram) of pure potash Alum ($K_2SO_4.Al_2(SO_4)_3.24H_2O$) which contains 6.4 gm oxygen is. (Atomic weight of K = 39, S = 32, Al = 27)

MC0007

7. The Kohinoor diamond was the largest diamond ever found. How many moles of carbon atom were peresent in it, if it is weigh 3300 carat. [Given: 1 carat = 200 mg]

MC0008

8. Calculate volume (in litre) of H_2 gas kept at STP if it contains as many H atoms as in 98 gm H_3PO_4. [Atomic mass of P = 31]

MC0009

9. 80gm of SO_x gas occupies 14 litre at 2atm & 273K. The value of x is :

MC0010

10. 40 mg of gaseous substance (X_2) occupies 4.8 mL of volume at 1 atm and 27°C. Atomic mass of element X is : (R : 0.082 atm L/mole-K)

MC0011

STOICHIOMETRY

11. How many gm of HCl is needed for complete reaction with 21.75 gm MnO_2 ?
(Mn = 55, Cl = 35.5)

$$HCl + MnO_2 \longrightarrow MnCl_2 + H_2O + Cl_2$$

MC0012

12. Nitric acid is manufactured by the Ostwald process, in which nitrogen dioxide reacts with water.

$$3\ NO_2\ (g) + H_2O\ (l) \rightarrow 2\ HNO_3\ (aq) + NO\ (g)$$

How many grams of nitrogen dioxide are required in this reaction to produce 25.2 gm HNO_3 ?

MC0013

13. Flourine reacts with uranium to produce uranium hexafluoride, UF_6, as represented by this equation

$$U(s) + 3F_2(g) \rightarrow UF_6(g)$$

If no. of fluorine molecules are required to produce 7.04 mg of uranium hexafluoride, UF_6, from an excess of uranium is $y \times 10^{19}$ then value of y is ? The molar mass of UF_6 is 352 gm/mol.
($N_A = 6.022 \times 10^{23}$)

MC0014

14. What total volume, in litre at 627°C and 82.1 atm, could be formed by the decomposition of 16 gm of NH_4NO_3 ? Reaction : $2\ NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O_{(g)}$. (R : 0.0821 atm L/mole-K)

MC0015

15. Calculate mass of phosphoric acid (in gm) required to obtain 53.4g pyrophosphoric acid.

$$2H_3PO_4 \rightarrow H_4P_2O_7 + H_2O$$

MC0016

LIMITING REACTANT

16 Carbon reacts with chlorine to form CCl_4. 36 gm of carbon was mixed with 142 g of Cl_2. If ratio of mass of CCl_4 produced and the remaining mass of excess reactant is y : 1, then value of y is

MC0017

17. Potassium superoxide, KO_2, is used in rebreathing gas masks to generate oxygen :

$$KO_2(s) + H_2O(l) \rightarrow KOH\ (s) + O_2\ (g)$$

If a reaction vessel contains 0.158 mol KO_2 and 0.10 mol H_2O, how many moles of O_2 can be produced ?

MC0018

18. A chemist wants to prepare diborane (B_2H_6) by the reaction

$$6\ LiH + 8BF_3 \longrightarrow 6Li\ BF_4 + B_2H_6$$

If he starts with 2.0 moles each of LiH & BF_3. How many moles of B_2H_6 can be prepared.

MC0019

19. Sulphuric acid is produced when sulphur dioxide reacts with oxygen and water in the presence of a catalyst : $2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4$. If 5.6 mol of SO_2 reacts with 4.8 mol of O_2 and a large excess of water, what is the maximum number of moles of H_2SO_4 that can be obtained ?

MC0020

PROBLEMS RELATED WITH MIXTURE

20. One gram of an alloy of aluminium and magnesium when heated with excess of dil. HCl forms magnesium chloride, aluminium chloride and hydrogen. The evolved hydrogen collected at 0°C has a volume of 1.12 litres at 1 atm pressure. Calculate the composition of (% by mass) of the alloy.
(Al = 27, Mg = 24)

MC0021

21. A sample containing only $CaCO_3$ and $MgCO_3$ is ignited to CaO and MgO. The mixture of oxides produced weight exactly half as much as the original sample. Calculate the percentages of $CaCO_3$ and $MgCO_3$ (by mass) in the sample.

MC0022

22. 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 = 0.124 gm.

MC0023

23. A sample of mixture of $CaCl_2$ and NaCl weighing 2.22 gm was treated to precipitate all the Ca as $CaCO_3$ which was then heated and quantitatively converted to 0.84 gm of CaO. Calculate mass fraction of $CaCl_2$ in the mixture.

MC0024

24. When 4 gm of a mixture of $NaHCO_3$ and NaCl is heated, 0.66 gm CO_2 gas is evolved. If ratio of the percentage composition (by mass) of the $NaHCO_3$ and NaCl is y : 1 then value of y is.

MC0025

25 A power company burns approximately 500 tons of coal per day to produce electricity. If the sulphur content of the coal is 1.20 % by weight, how many tons SO_2 are dumped into the atmosphere per hour ?

MC0026

26. Calculate the percent loss in weight after complete decomposition of a pure sample of potassium chlorate. (K = 39, Cl = 35.5)

$$KClO_3(s) \longrightarrow KCl(s) + O_2(g)$$

MC0027

27 A sample of calcium carbonate is 80% pure, 25 gm of this sample is treated with excess of HCl.How much volume (in litre) of CO_2 will be obtained at 1 atm & 273 K?

MC0028

28 Cyclohexanol is dehydrated to cyclohexene on heating with conc. H_2SO_4. If the yield of this reaction is 75%, how much cyclohexene (in gm) will be obtained from 100 g of cyclohexanol ?

$$C_6H_{12}O \xrightarrow{\text{con. } H_2SO_4} C_6H_{10}$$

MC0029

29 If the yield of chloroform obtainable from acetone and bleaching powder is 58%. What is the weight of acetone (in gm) required for producing 239 mg of chloroform ?

$$2CH_3COCH_3 + 6CaOCl_2 \rightarrow Ca(CH_3COO)_2 + 2CHCl_3 + 3CaCl_2 + 2Ca(OH)_2$$

MC0030

30. Calculate % yield of the reaction if 200g $KHCO_3$ produces 22g of CO_2 upon strong heating. (K = 39)

MC0031

31. The vapour density of a sample of N_2O_4 gas is 35. What percent of N_2O_4 molecules are dissociated into NO_2 ? .

MC0032

32. If a sample of pure SO_3 gas is heated to 600ºC, it dissociates into SO_2 and O_2 gases upto 50%. If the average molar mass of the final sample is M_{avg} find value of $\left(\frac{M_{av}}{100}\right)$.

MC0033

33. When silent electric discharge is passed through O_2 gas, it converts into O_3. If the density of final sample is 20 times the density of hydrogen gas under similar conditions, calculate the mass percent of O_2 in the final sample.

MC0034

34. When acetylene (C_2H_2) gas is passed through red hot iron tube, it trimerises into benzene (C_6H_6) vapours. If the average molar mass of vapours coming out through the tube is 50, calculate the degree of trimerisation of acetylene.

MC0035

SEQUENTIAL & PARALLEL REACTIONS

35. $Br_2(l)$ reacts with $Cl_2(g)$ to form BrCl and $BrCl_3$, simultaneously. How many moles of $Cl_2(g)$ reacts completely with 0.03 moles of $Br_2(l)$ to form BrCl and $BrCl_3$ in 5 : 1 molar ratio

MC0036

36. When 80 gm CH_4 is burnt , CO and CO_2 gases are formed in 1 : 4 mole ratio. If the mass of O_2 gas used in combustion is w gm then find value of (w/100).

MC0037

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

$$S_8 + 8O_2(g) \rightarrow 8SO_2(g)$$

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

If amount of SO_3 will be produced from 1 mol of S_8 is w gm, then value of w/100 is.

MC0038

38. Potassium superoxide, KO_2, is utilised in closed system breathing apparatus. Exhaled air contains CO_2 and H_2O, both of which are removed and the removal of water generates oxygen for breathing by the reaction

$4KO_2(s) + 2H_2O(l) \rightarrow 3O_2(g) + 4KOH(s)$

The potassium hydroxide removes CO_2 from the apparatus by the reaction :

$KOH(s) + CO_2(g) \rightarrow KHCO_3(s)$

(a) What mass of KO_2 (in gm) generates 0.24 gm of oxygen ?

(b) What mass of CO_2 (in gm) can be removed from the apparatus by 100 gm of KO_2 ? (K = 39)

MC0039

PRINCIPLE OF ATOM CONSERVATION

39. In a determination of P, an aqueous solution of NaH_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, $Mg_2P_2O_7$ which is weighed. A solution of NaH_2PO_4 yielded 1.11 g of $Mg_2P_2O_7$. What weight of NaH_2PO_4 (in gm) was present originally ? (P = 31)

MC0040

40. 6 gm nitrogen on successive reaction with different compounds gets finally converted into 30 gm $[Cr(NH_3)_xBr_2]$ Value of x is [Atomic mass : Cr = 52, Br = 80]

MC0041

41. A 5.00 gm sample of a natural gas, consisting of methane (CH_4), and ethylene, (C_2H_4) was burned in excess oxygen, yielding $\frac{44}{3}$ gm of CO_2 and some H_2O as products. What mole percent of the sample was ethylene?

MC0042

42. All carbon atom present in $KH_3(C_2O_4)_2.2H_2O$ weighing 7.62 gm is converted to CO_2. How many gm of CO_2 were obtained. (K = 39)

MC0043

PERCENTAGE COMPOSITION, EMPERICAL AND MOLECULAR FORMULA

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

MC0044

44. 1.6 g of an organic compound containing sulphur, when treated with series of reagents, produces H_2SO_4 which on reaction with $BaCl_2$ produces 0.233 g of $BaSO_4$. Calculate % by mass of S in the organic compound. **(Given : Atomic weight of Ba = 137)**

MC0045

45. When 2.0 gm of an organic compound is burnt completely, 150 ml N_2 gas at 27°C and 0.821 atm is obtained. The mass fraction of nitrogen in the compound is.

(R = 0.0821 atm L/mole - K)

MC0046

46. A polystyrene of formula $Br_3C_6H_2(C_8H_8)_n$ was prepared by heating styrene with tribromobenzyl peroxide in the absence of air. It was found to contain 10.48% bromine by weight. Find the value of n. (Br = 80).

MC0047

47. 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

MC0048

48. 0.5 g of NaOH is required by 0.4 gm of a polybasic acid H_nA (Molecular weight = 96gm) for complete neutralization. Value of 'n' would be : (Assume all H atom are replaced)–

MC0049

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

MC0050

50. A compound has 62 % carbon, 10.4 % hydrogen and 27.6 % oxygen. If molar mass of compound is 58, if ratio of no. of C atom to H-atom is y : 1 then value of y is.

MC0051

EUDIOMETRY

51. What volume (in ml) of O_2(g) is needed for complete combustion of 40 ml ethane gas (C_2H_6) ?

MC0052

52. 10 ml of CO is mixed with 25 ml air having 20% O_2 by volume. What would be the final volume (in ml) if none of CO and O_2 is left after the reaction?

MC0053

53. Calculate the volume (in ml) of CO_2 evolved by the combustion of 50 ml of a mixture containing 40% C_2H_4 and 60% CH_4 (by volume)

MC0054

54. 10 moles of a mixture of CO (g) and CH_4(g) was mixed with 22 moles of O_2 gas and subjected to sparking. Find the moles of gas absorbed when the residual gases are passed through alc. KOH.

MC0055

55. 60 ml of a mixture of nitrous oxide and nitric oxide was exploded with excess of hydrogen. If 38 ml of N_2 was formed, calculate % volume of NO gas in the mixture.

MC0056

56. When 100 ml of a $O_2 - O_3$ mixture was passed through turpentine, there was reduction of volume by 20 ml. If 100 ml of such a mixture is heated, what will be the increase in volume (in ml)?

MC0057

57. 10 ml of an oxide of nitrogen produce 20 ml NO_2 and 5 ml O_2 on complete decomposition. The oxide of nitrogen is-

MC0058

58. A gaseous alkane is exploded with O_2. The volume of O_2 required for complete combustion and the volume of CO_2 formed after combustion are in 7 : 4 ratio. What is the molecular formula of alkane ?

MC0059

59. When a certain quantity of oxygen was ozonised in a suitable apparatus, the volume decreased by 4 ml. On addition of turpentine the volume further decreased by 8 ml. All volumes were measured at the same temperature and pressure. From these data, if formula of ozone is O_x then find x.

MC0060

60. A 20 ml mixture of C_2H_4 and C_2H_2 undergoes sparking in gas eudiometer with just sufficient amount of O_2 and shows contraction of 37.5 ml. The volume (in ml) of C_2H_2 in the mixture is.

MC0061

EXERCISE S-II

MOLE

1. Two substance P_4 & O_2 are allowed to react completely to form mixture of P_4O_6 & P_4O_{10} leaving none of the reactants. Using this information calculate the moles of P_4O_6 and P_4O_{10} in the final mixture when the following amounts of P_4 & O_2 are taken.

$P_4 + 3O_2 \longrightarrow P_4O_6$

$P_4 + 5O_2 \longrightarrow P_4O_{10}$

(i) If 1 mole P_4 & 4 mole of O_2

(ii) If 3 mole P_4 & 11 mole of O_2

(iii) If 3 mole P_4 & 13 mole of O_2

MC0062

2. By the reaction of carbon and oxygen, a mixture of CO and CO_2 is obtained. What is the mass percent of CO in of the mixture obtained when 20 grams of O_2 reacts with 12 grams of carbon ?

MC0063

3. Nitrogen (N), phosporus (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, P_2O_5, and K_2O, in that order. If the N : P : K ratio of a 28: 11.75 : 11.75 fertilizer in terms of moles of each elements, and express it as x : y : 1. Find value of y (P = 31, K = 39)

MC0064

4 A 10 g sample of a mixture of calcium chloride and sodium chloride is treated with Na_2CO_3 to precipitate calcium as calcium carbonate. This $CaCO_3$ is heated to convert all the calcium to CaO and the final mass of CaO is 1.12gm. Calculate % by mass of NaCl in the original mixture.

MC0065

5. A mixture of Ferric oxide **(Fe_2O_3)** and **Al** is used as a solid rocket fuel which reacts to give **Al_2O_3** and **Fe**. No other reactants and products are involved. On complete reaction of 1 mole of **Fe_2O_3**, 200 units of energy is released.

(a) Write a balance reaction representing the above change.

(b) If the ratio of masses of Fe_2O_3 and Al taken so that maximum energy per unit mass of fuel is released is y : 1 then value of y is

(c) What would be energy released if 16 kg of Fe_2O_3 reacts with 2.7 kg of Al.

MC0066

6. 5.33 mg of salt $[Cr(H_2O)_5Cl].Cl_2.\ H_2O$ is treated with excess of $AgNO_3$(aq.), then mass (in mg) of AgCl precipitate obtained will be :

Given : [Cr = 52, Cl = 35.5, Ag = 108]

MC0067

7. If mass % of oxygen in monovalent metal carbonate is 48%, If the number of atoms of metal present in 5mg of this metal carbonate sample is $y \times 10^{19}$ then value of y is ($N_A = 6.022 \times 10^{23}$).

MC0068

8. The formula of compound composed of A & B which is given by A_xB_y, it is strongly heated in oxygen as per reaction-

$A_xB_y + O_2 \rightarrow AO$ + Oxide of B

If 2.5gm of A_xB_y on oxidation gives 3gm oxide of A, If ratio of x : y is z : 1 then value of z is.

[Atomic mass of A = 24 & B = 14]

MC0069

9. Calculate the maximum mass of $CaCl_2$ produced when 2.4×10^{24} atoms of calcium is taken with 96 litre of Cl_2 gas at 380 mm pressure and at 27ºC.

[R = 0.08 atm L/mole-K & $N_A = 6 \times 10^{23}$]

MC0070

10. $P_4S_3 + 8O_2 \longrightarrow P_4O_{10} + 3SO_2$

Calculate mass in gm of P_4S_3 is required to produce at least 9.6 gm of each product. (P = 31, S =32)

MC0071

11. Consider the given reaction

$H_4P_2O_7 + 2NaOH \rightarrow Na_2H_2P_2O_7 + 2H_2O$

If 534 gm of $H_4P_2O_7$ is reacted with 3.0×10^{24} formula units of NaOH, then the total number of moles of H_2O produced is ($N_A = 6 \times 10^{23}$) (P = 31)

MC0072

Comprehension based on "Law of Conservation of Mass" (12 & 13)

It states that matter can neither be created nor destroyed.

This law was put forth by Antoine Lavoisier in 1789. He performed careful experimental studies for combustion reactions for reaching to the above conclusion. This law formed the basis for several later developments in chemistry. Infact, this was the result of exact measurement of masses of reactants and products, and carefully planned experiments performed by Lavoisier.

12 What weight (in gm) of silver nitrate will react with 0.585 gm NaCl to produce 1.435 gm AgCl and 0.85 gm $NaNO_3$

MC0073

13 6.3 gm sodium bicarbonate is added to 15 gm acetic acid solution. CO_2 formed is allowed to escape. The weight of the solution left is 18 gm. What is the mass (in gm) of CO_2 formed.

MC0073

Comprehension based on "Law of Definite Proportions" (14 & 15)

This law was given by, a French chemist, Joseph Proust. He stated that a given compound always contains exactly the same proportion of elements by weight.

Proust worked with two samples of cupric carbonate —one of which was of natural origin and the other was synthetic one. He found that the composition of elements present in it was same for both the samples as shown below :

	% of copper	% of oxygen	% of carbon
Natural Sample	51.35	9.74	38.91
Synthetic Sample	51.35	9.74	38.91

Thus, irrespective of the source, a given compound always contains same elements in the same proportion. The validity of this law has been confirmed by various experiments. It is sometimes also referred to as **Law of constant composition**.

Limitation :

The law is not applicable if the compound is formed from different isotopes of an element. The two isotopes of carbon C-12 and C-14 form carbondioxide $C^{12}O_2$ and $C^{14}O_2$. The ratio of C : O is 12 : 32 and 14 : 32 respectively. It is not a constant ratio.

14 0.5 gm silver is dissolved in excess of nitric acid. This solution is treated with excess of NaCl solution when 0.66 gm AgCl is formed. One gram metallic silver wire is heated in dry Cl_2, 1.32 gm AgCl is formed. Show that these data confirm the law of constant proportion.

MC0074

15. 6.488 gm lead reacts with 1.002 gm oxygen to form an oxide. This oxide is also obtained by heating $Pb(NO_3)_2$, It is found that % of lead in this oxide is 86.62. Show that these date illustrate the law of definite proportions.

MC0075

Comprehension based on "Law of Multiple Proportions" (16 to 17)

This law was proposed by Dalton in 1803. According to this law, if two elements combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

For example, hydrogen combines with oxygen to form two compounds, namely, water and hydrogen peroxide.

$$\underset{2g}{\text{Hydrogen}} + \underset{16g}{\text{Oxygen}} \rightarrow \underset{18g}{\text{Water}}$$

$$\underset{2g}{\text{Hydrogen}} + \underset{32g}{\text{Oxygen}} \rightarrow \underset{34g}{\text{Hydrogen Peroxide}}$$

Here, the masses of oxygen (i.e. 16 gm and 32 gm) which combine with a fixed mass of hydrogen (2 gm) bear a simple ratio, i.e. 16:32 or 1: 2.

16. An element forms two oxides. In one oxide, one gram of the oxide contains 0.5 gm of the element. In another oxide, 4 gm of the oxide contains 0.8 gm of the element. Show that these data confirm the law of multiple proportion.

MC0076

17. 0.11gm of an oxide of nitrogen gives 56 mL N_2 at 273 K and 1atm. 0.15 gm of another oxide of nitrogen gives 56 mL N_2 at 1atm, 273K. Show that these data confirm the law of multiple proportion.

MC0077

18. 10 ml of a mixture of CH_4, C_2H_4 and CO_2 were exploded with excess of air. After explosion and further cooling, there was contraction of 17 ml and after treatment with KOH, there was further reduction of 14 ml. What is the composition of the mixture (in ml)?

MC0078

19. 40 ml of a mixture of C_2H_2 and CO is mixed with 100 ml of O_2 gas and the mixture is exploded. The residual gases occupied 104 ml and when these are passed through KOH solution, the volume becomes 48 ml. All the volume are at same temperature and pressure. If ratio of volume of C_2H_2 & CO is y : 1, then value of y is

MC0079

20. 10 mL of gaseous organic compound containing C, H and O only, was mixed with 100 mL of O_2 and exploded under identical conditions and then cooled. The volume left after cooling was 90 mL. On treatment with KOH a contraction of 20 mL was observed. If vapour density of compound is 23, if molecular formula of the compound is $C_xH_yO_z$, then find (x + y + z).

MC0080

EXERCISE O-I

Single Correct :

1 One atomic mass unit in kilogram is

(A) $1/N_A$ (B) $12 / N_A$ (C) $1/1000\ N_A$ (D) $1000 / N_A$

MC0081

2 A gaseous mixture contains CO_2 (g) and N_2O (g) in a 2 : 5 ratio by mass. The ratio of the number of molecules of CO_2 (g) and N_2O (g) is

(A) 5 : 2 (B) 2 : 5 (C) 1 : 2 (D) 5 : 4

MC0082

3 Which of the following contain largest number of carbon atoms?

(A) 15 gm ethane, C_2H_6 (B) 40.2 gm sodium oxalate, $Na_2C_2O_4$

(C) 72 gm glucose, $C_6H_{12}O_6$ (D) 35 gm pentene, C_5H_{10}

MC0083

4 The number of hydrogen atoms in 0.9 gm glucose, $C_6H_{12}O_6$, is same as

(A) 0.048 gm hydrazine, N_2H_4 (B) 0.17 gm ammonia, NH_3

(C) 0.30 gm ethane, C_2H_6 (D) 0.03 gm hydrogen, H_2

MC0084

5 Ethanol, C_2H_5OH, is the substance commonly called alcohol. The density of liquid alcohol is 0.7893 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) 70 ml (D) 79 ml

MC0085

6 An iodized salt contains 0.5 % of NaI. A person consumes 3 gm of salt everyday. The number of iodide ions going into his body everyday is (I = 127)

(A) 10^{-4} (B) 6.02×10^{-4} (C) 6.02×10^{19} (D) 6.02×10^{23}

MC0086

7 The percentage by mole of NO_2 in a mixture of NO_2(g) and NO(g) having average molecular mass 34 is :

(A) 25% (B) 20% (C) 40% (D) 75%

MC0087

8 The number of carbon atoms present in a signature, if a signature written by carbon pencil, weighing 1.2×10^{-3} g is

(A) 12.04×10^{20} (B) 6.02×10^{19} (C) 3.01×10^{19} (D) 6.02×10^{20}

MC0088

9 The average atomic mass of a mixture containing 79 mole % of ^{24}Mg and remaining 21 mole % of ^{25}Mg and ^{26}Mg , is 24.31. **% mole** of ^{26}Mg is

(A) 5 (B) 20 (C) 10 (D) 15

MC0089

10. How many litres of oxygen at 1atm & 273K will be required to burn completely 2.2 g of propane (C_3H_8)

(A) 11.2 L (B) 22.4 L (C) 5.6 L (D) 44.8 L

MC0090

11. If 1/2 moles of oxygen combine with aluminium to form Al_2O_3 then weight of Aluminium metal used in the reaction is (Al= 27)

(A) 27 g (B) 18 g (C) 54 g (D) 40.5 g

MC0091

12. Volume of CO_2 obtained at STP by the complete decomposition of 9.85 g $BaCO_3$ is (Ba = 137)

(A) 2.24 lit (B) 1.12 lit (C) 1.135 lit (D) 2.27 lit

MC0092

13. The drain cleaner, **Drainex** contains small bits of aluminium (Al = 27) which reacts with caustic soda to produce dihydrogen. What is the volume (in ml) of dihydrogen at 27ºC and 1.013 bar that is produced when 0.27 gm of aluminium reacts :

$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

(A) 0.369 (B) 369.0 (C) 246.0 (D) 540.0

MC0093

14. Volume of O_2 obtained at 2 atm & 546K, by the complete decomposition of 8.5 g $NaNO_3$ is

$2NaNO_3 \rightarrow 2NaNO_2 + O_2$

(A) 2.24 lit (B) 1.12 lit (C) 0.84 lit (D) 0.56 lit

MC0094

15 The minimum mass of mixture of A_2 and B_4 required to produce at least 1 kg of each product is :

(Given At. mass of 'A' = 10 ; At. mass of 'B' = 120)

$5A_2 + 2B_4 \longrightarrow 2AB_2 + 4A_2B$

(A) 2120 gm (B) 1060 gm (C) 560 gm (D) 1660 gm

MC0095

16 The mass of CO_2 produced from 620 gm mixture of $C_2H_4O_2$ & 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

MC0096

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

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

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

MC0097

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

$$Mg + NH_3 \longrightarrow Mg_3N_2 + H_2$$

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

MC0098

19. An ideal gaseous mixture of ethane (C_2H_6) and ethene (C_2H_4) occupies 28 litre at 1atm, 0°C. The mixture reacts completely with 128 gm O_2 to produce CO_2 and H_2O. Mole fraction of C_2H_6 in the mixture is–

(A) 0.6 (B) 0.4 (C) 0.5 (D) 0.8

MC0099

20. 280 g of a mixture containing CH_4 and C_2H_6 in 5 : 2 molar ratio is burnt in presence of excess of oxygen. Calculate total moles of CO_2 produced.

(A) 9 (B) 18 (C) 7 (D) 12

MC0100

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

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

MC0101

22. A metal carbonate decomposes according to following reaction

$M_2CO_3(s) \longrightarrow M_2O(s) + CO_2(g)$

Percentage loss in mass on complete decomposition of $M_2CO_3(s)$

(Atomic mass of M = 102)

(A) $\frac{100}{3}$ % (B) $\frac{50}{3}$ % (C) $\frac{25}{3}$ % (D) 15%

MC0102

23. 90 gm mixture of H_2 and O_2 is taken in stoichiometric ratio and gives H_2O with 50% yield. The produced mass of H_2O (in gm) is :

(A) 45 gm (B) 36 gm (C) 20 gm (D) 90 gm

MC0103

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

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

MC0104

25. The vapour density of sample of partially decomposed cyclobutane (C_4H_8) gas is 20. The degree of dissociation of C_4H_8 into C_2H_4 gas is -

(A) 0.25 (B) 0.50 (C) 0.60 (D) 0.40

MC0105

26. A sample of NH_3 gas is 20% dissociated into N_2 and H_2 gases. The mass ratio of N_2 and NH_3 gases in the final sample is -

(A) $\frac{7}{34}$ (B) $\frac{7}{17}$ (C) $\frac{14}{17}$ (D) $\frac{21}{17}$

MC0106

27. The density of a sample of SO_3 gas is 2.5 g/L at 0ºC and 1 atm. It's degree of dissociation into SO_2 and O_2 gases is -

(A) $\frac{6}{7}$ (B) $\frac{1}{7}$ (C) $\frac{3}{7}$ (D) $\frac{5}{7}$

MC0107

28. Polyethene can be prepared by CaC_2 by the following sequence of reactions.

$CaC_2 + H_2O \rightarrow CaO + C_2H_2$

$C_2H_2 + H_2 \rightarrow C_2H_4$

$nC_2H_4 \rightarrow \underset{\text{(Polyethene)}}{(C_2H_4)_n}$

The mass in kg of polyethene that can be prepared by 20 kg CaC_2.

(A) 4.1 kg (B) 8.75 kg (C) 3.78 kg (D) 10 kg

MC0108

29. 25.4 gm of iodine and 14.2 gm of chlorine are made to react completely to yield a mixture of ICl and ICl_3. Ratio of moles of ICl & ICl_3 formed is (Atomic mass : I = 127, Cl = 35.5)

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

MC0109

30. One commercial system removes SO_2 emission from smoke at 95ºC by the following set of reactions-

$SO_2(g) + Cl_2(g) \rightarrow SO_2Cl_2(g)$

$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$

Assuming the process to be overall 95% efficient. How many moles of $CaSO_4$ may be produced from 128 gm SO_2. [Ca = 40, S- 32, O-16]

(A) 1.9 moles (B) 2 mol (C) 3.8 mol (D) 0.95 mol

MC0110

31. Equal masses of $KClO_3$ undergoes different reaction in two different container :

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

(ii) $4KClO_3 \longrightarrow KCl + 3KClO_4$

Mass ratio of the KCl produced in respective reaction is x : 1. Value of '**x**' will be.

(A) 4 (B) 2 (C) 0.25 (D) 3

MC0111

32. A compound contains 10^{-2} % of phosphorous. If atomic mass of phosphorus is 31, the molecular mass of the compound having one phosphorus atom per molecule is :–

(A) 31 (B) 3.1×10^3 (C) 3.1×10^5 (D) 3.1×10^4

MC0112

33. 13.4 gm of a sample of unstable hydrated salt : $Na_2SO_4.xH_2O$ was strongly heated. Weight loss on heating is found to be equal to 6.3 gm. Calculate the value of x.

(A) 6 (B) 5 (C) 7 (D) 8

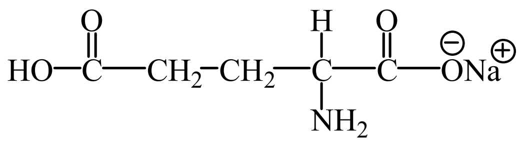
MC0113

34. An organic compound contains 4% sulphur by mass. Its minimum molecular weight is :

(A) 200 (B) 400 (C) 800 (D) 1600

MC0114

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



Mass % of Na in MSG is-

(A) 14.8 (B) 15.1 (C) 13.6 (D) 16.5

MC0115

36. Which of the following series of compounds have same mass percentage of carbon ?

(A) CO_2, CO (B) CH_4, C_2H_6,C_2H_2

(C) C_2H_2, C_6H_6,$C_{10}H_8$ (D)HCHO, CH_3COOH,$C_6H_{12}O_6$

MC0116

37. A compound contains 69.5% oxygen and 30.5% nitrogen and its molecular weight is 92. The formula of that compound is :-

(A) N_2O (B) NO_2 (C) N_2O_4 (D) N_2O_5

MC0117

38. 1 lt. of a hydrocarbon weighs as much as one litre of CO_2. The molecular formula of the hydrocarbon is -

(A) C_3H_8 (B) C_2H_6 (C) C_2H_4 (D) C_3H_6

MC0118

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

(A) CH_3CHO (B) CH_3COOH (C) CH_3OH (D) C_2H_6

MC0119

40. Two oxides of a metal contains 50% and 40% of a metal respectively. The formula of the first oxide is MO.Then the formula of the second oxide is -

(A) MO_2 (B) M_2O_3 (C) M_2O (D) M_2O_5

MC0120

41. A compound of X and Y has equal mass of them. If their atomic weights are 30 and 20 respectively. The molecular formula of compound is -

(A) X_2Y_2 (B) X_3Y_3 (C) X_2Y_3 (D) X_3Y_2

MC0121

42. 10 ml CH_4 gas is burnt completely in air (O_2 = 20%, by volume). The minimum volume of air needed is -

(A) 20 ml (B) 50 ml (C) 80 ml (D) 100 ml

MC0122

43. $C_6H_5OH\ (g) + O_2\ (g) \longrightarrow CO_2\ (g) + H_2O\ (l)$

Magnitude of volume change if 30 ml of C_6H_5OH (g) is burnt with excess amount of oxygen, is

(A) 30 ml (B) 60 ml (C) 20 ml (D) 10 ml

MC0123

44. A mixture of C_2H_2 and C_3H_8 occupied a certain volume at 80 mm Hg. The mixture was completely burnt to CO_2 and $H_2O(l)$. The pressure of CO_2 was found to be 230 mm Hg at the same temperature and volume. The fraction of C_2H_2 in mixture is

(A) 0.125 (B) 0.5 (C) 0.85 (D) 0.25

MC0124

45. 20 mL of a mixture of CO and H_2 were mixed with excess of O_2 and exploded & cooled. There was a volume contraction of 23 mL. All volume measurements corresponds to room temperature (27°C) and one atmospheric pressure. Determine the volume ratio $V_1 : V_2$ of CO and H_2 in the original mixture

(A) 6.5 : 13.5 (B) 5 : 15 (C) 9 : 11 (D) 7 : 13

MC0125

46. Each volume of a gaseous organic compound containing C, H and S only produce 1 volume CO_2, 2 volume H_2O vapours and 1 volume SO_2 gases on complete combustion. The molecular formula of compound is -

(A) CH_2S (B) CH_4S (C) C_2H_4S (D) C_2H_6S

MC0126

47. For a chemical reaction occuring at constant pressure and temperature.

$$2A(g) + 5B(g) \longrightarrow C(g) + 2D(g)$$

(A) contraction in volume is double the volume of A taken if B is taken in excess.

(B) contraction in volume is more than the volume of B taken if A is in excess.

(C) volume contracts by 20 mL if 10 mL A is reacted with 20 mL B.

(D) no change in volume due to reaction

MC0127

48. When one litre of CO_2 is passed over hot coke, the volume becomes 1.4 litres. The composition of final products will not be.

(A) $V_{CO_2} : V_{CO} = 3:4$ (B) $V_{CO} = 1.6\,ltr.$ (C) $n_{CO_2} : n_{CO} = 3:4$ (D) % V of CO $= \frac{400}{7}$

MC0128

49. 10 ml of a compound containing 'N' and 'O' is mixed with 30 ml of H_2 to produce H_2O (l) and 10 ml of N_2 (g). Molecular formula of compound if both reactants reacts completely, is

(A) N_2O (B) NO_2 (C) N_2O_3 (D) N_2O_5

MC0129

50. When a definite volume of a gaseous alkyne (C_nH_{2n-2}) is burnt completely in excess of air, a contraction in volume equal to twice the volume of alkyne burnt occured. The value of 'n' is -

(A) 4 (B) 6 (C) 3 (D) 20

MC0130

EXERCISE O-II

1. A sample of iron ore, weighing 0.700g, is dissolved in nitric acid. The solution is then diluted with water, following with sufficient concentrated aqueous ammonia, to quantitative precipitation the iron as $Fe(OH)_3$. The precipitate is filtered, ignited and weighed as Fe_2O_3. If the mass of the ignited and dried preciipitate is 0.541g, what is the mass percent of iron in the original iron ore sample (Fe = 56)

(A) 27.0 % (B) 48.1 % (C) 54.1 % (D) 81.1 %

MC0131

2. A sample of pure Cu (4.00g) heated in a stream of oxygen for some time, gains in weight with the formation of black oxide of copper (CuO). The final mass is 4.90 g. What percent of copper remains unoxidized (Cu = 64)

(A) 90 % (B) 10 % (C) 20 % (D) 80 %

MC0132

3. 1120 ml of ozonised oxygen ($O_2 + O_3$) at 1 atm & 273K weighs 1.76 gm. The reduction in volume on passing this through alkaline pyrogallol solution is -

(A) 896 ml (B) 224 ml (C) 448 ml (D) 672 ml

MC0133

ASSERTION REASON:

4. **Statement-1 :** When a gaseous hydrocarbon is burnt in excess of oxygen and the products of combustion are cooled to the orignal temperatrue and pressure, a contraction in volume occurs.

Statement-2 : The contraction in volume is solely due to the liquifaction of water vapour.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

MC0134

5. **Statement -1** : $2A + 3B \longrightarrow C$

4/3 moles of 'C' are always produced when 3 moles of 'A' & 4 moles of 'B' are added.

Statement -2 : 'B' is the limiting reactant for the given data.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is false, statement-2 is true.

(D) Statement-1 is true, statement-2 is false.

MC0135

6. **Assertion** : During a chemical reaction, total moles remains constant.

Reason : During a chemical reaction, total mass remains constant.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

MC0136

MULTIPLE CORRECT :

7. 40 gm of a carbonate of an **alkali metal** or **alkaline earth metal** containing some inert impurities was made to react with excess HCl solution. The liberated CO_2 occupied 12.315 lit. at 1 atm & 300 K. The correct option is

(A) Mass of impurity is 1 gm and metal is Be
(B) Mass of impurity is 3 gm and metal is Li
(C) Mass of impurity is 5 gm and metal is Be
(D) Mass of impurity is 2 gm and metal is Mg

MC0137

8. 1 mole of H_2SO_4 will exactly neutralise :

(A) 2 mole of ammonia
(B) 1 mole of $Ba(OH)_2$
(C) 0.5 mole of $Ca(OH)_2$
(D) 2 mole of KOH

MC0138

9. 12 g of Mg was burnt in a closed vessel containing 32 g oxygen. Which of the following is /are correct.

(A) 2 gm of Mg will be left unburnt.
(B) 0.75 gm-molecule of O_2 will be left unreacted.
(C) 20 gm of MgO will be formed.
(D) The mixture at the end will weight 44 g.

MC0139

10. 50 gm of $CaCO_3$ is allowed to react with 68.6 gm of H_3PO_4 then select the correct option(s)-

$$3CaCO_3 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3H_2O + 3CO_2$$

(A) 51.67 gm salt is formed
(B) Amount of unreacted reagent = 35.93 gm
(C) n_{CO_2} formed = 0.5 moles
(D) n_{H_2O} formed = 0.7 mole

MC0140

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

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

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

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

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

MC0141

12. Two gases A and B which react according to the equation

$$aA_{(g)} + bB_{(g)} \longrightarrow cC_{(g)} + dD_{(g)}$$

to give two gases C and D are taken (amount not known) in an Eudiometer tube (operating at a constant Pressure and temperature) to cause the above.

If on causing the reaction there is no volume change observed then which of the following statement is/are correct.

(A) $(a + b) = (c + d)$

(B) average molecular mass may increase or decrease if either of A or B is present in limited amount.

(C) Vapour Density of the mixture will remain same throughout the course of reaction.

(D) Total moles of all the component of mixture will change.

MC0142

13. 100 ml mixture of CO and CO_2 mixed with 30 mL of O_2 and sparked in eudiometer tube. The residual gas after treatment with aq. KOH has a volume of 10 mL which remains unchanged when treated with alkaline pyrogallol. If all the volumes are under the same conditions, point out **correct** options(s):

(A) The volume of CO that reacts, is 60 mL

(B) The volume of CO that remains unreacted, is 10 mL

(C) The volume of O_2 that remains unreacted, is 10 mL

(D) The volume of CO_2 that gets absorbed by aq.KOH, is 90 mL.

MC0143

Paragraph for Q.14 to Q.15

For the given series of reaction

$$4NH_3\ (g) + 5O_2\ (g) \longrightarrow 4NO\ (g) + 6H_2O\ (l)$$

$$2NO\ (g) + O_2\ (g) \longrightarrow 2NO_2\ (g)$$

14. If 20 ml of NH_3 is mixed with 100 ml of O_2. Volume contraction at the completion of above reactions is

(A) 20 ml (B) 85 ml (C) 35 ml (D) 100 ml

MC0144

15. Total volume of O_2 used if 20 ml NH_3 is mixed with 100 ml O_2

(A) 40 (B) 60 (C) 35 (D) None of these

MC0144

Paragraph for Q.16 to Q.18

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

$Fe + Br_2 \longrightarrow FeBr_2$ ....(i)

$FeBr_2 + Br_2 \longrightarrow Fe_3Br_8$ ....(ii) (not balanced)

$Fe_3Br_8 + Na_2CO_3 \longrightarrow NaBr + CO_2 + Fe_3O_4$ ....(iii) (not balanced)

(At. mass : Fe = 56, Br = 80)

16. Mass of iron required to produce 2.06×10^3 kg NaBr

(A) 420 gm (B) 420 kg (C) 4.2×10^5 kg (D) 4.2×10^8 gm

MC0145

17 If the yield of (ii) is 60% & (iii) reaction is 70% then mass of iron required to produce 2.06×10^3 kg NaBr

(A) 10^5 kg (B) 10^5 gm (C) 10^3 kg (D) None

MC0146

18 If yield of (iii) reaction is 90% then mole of CO_2 formed when 2.06×10^3 gm NaBr is formed

(A) 20 (B) 10 (C) 9 (D) 440

MC0147

Comprehension Q.19 and Q.20 (2 questions)

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

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

19 0.15gm of an organic compound gave 0.12 gm of silver bromide by the Carius method. Find the percentage of bromine in the compound. (Ag = 108, Br = 80)

(A) 34.0 (B) 46.0 (C) 80.0 (D) 50.0

MC0148

20 0.32 gm of an organic substance when treated by Carius method gave 0.466 gm of $BaSO_4$. Calculate the percentage of sulphur in the compound. (Ba = 137)

(A) 10.0 (B) 34.0 (C) 20.0 (D) 30.0

MC0148

Comprehension Q.21 and Q.22 (2 questions)

Estimation of phosphorous : A known mass of compound is heated with fuming HNO_3 or sodium peroxide (Na_2O_2) in Carius tube which converts phosphorous to H_3PO_4. Magnesia mixture ($MgCl_2$ + NH_4Cl) is then added, which gives the precipitate of magnesium ammonium phosphate ($MgNH_4.PO_4$) which on heating gives magnesium pyrophosphate ($Mg_2P_2O_7$), which is weighed.

21 0.124 gm of an organic compound containing phosphorus gave 0.222 gm of $Mg_2P_2O_7$ by the usual analysis. Calculate the percentage of phosphorous in the compound.(Mg = 24, P = 31)

(A) 25 (B) 75 (C) 62 (D) 50

MC0149

22 An organic compound has 6.2 % of phosphorus. On sequence of reaction, the phosphorous present in the 10 gm of organic compound is converted to $Mg_2P_2O_7$. Find the weight of $Mg_2P_2O_7$ formed.

(A) 2.22 gm (B) 10.0 gm (C) 4.44 gm (D) 1.11 gm

MC0149

TABLE TYPE :

Column-I	**Column-II**	**Column-III**
(P) 60 gram sample of hydro carbon that contain 20% H and rest C	(1) %C = 40	(i) No. of atoms of C and O $= 8N_A$
(Q) 240 gram urea	(2) $\%H = \frac{20}{3}$	(ii) No. of C atoms $= 4N_A$
(R) 120 gram acetic acid	(3) $\% O = \frac{160}{3}$	(iii) No. of total atoms $= 16N_A$
(S) 120 gram glucose	(4) % N =46.7	(iv) No. of total atoms is 2 times of no. of H atom

23. Out of below correct matching is -

(A) P – 1 – i (B) P – 1 – ii (C) Q – 2 – iii (D) S – 2 – iv

MC0150

24. In which of following is incorrect -

(A) Q – 2 – iv (B) R – 3 – iv (C) P – 4 – iii (D) R – 1 – ii

MC0150

25. Out of below correct matching is -

(A) S – 4 – iv (B) R – 1 – ii (C) P – 4 – iii (D) P – 2 – ii

MC0150

Table type question :

Column-I (Gas taken)	**Column-II (O_2 needed for complete combustion)**	**Column-III (Contraction in volume)**
(1) 20 ml C_2H_4	(i) 60 ml	(I) 50 ml
(2) 25 ml C_3H_4	(ii) 100 ml	(II) 40 ml
(3) 30 ml C_2H_6	(iii) 70 ml	(III) 75 ml
(4) 35 ml CH_4	(iv) 105 ml	(IV) 70 ml

All volumes are measured at 25ºC and 1 atm.

26. Which of the following is correct match -

(A) 1 – i – II (B) 1 – iii – IV (C) 2 – iv – II (D) 2 – ii – III

MC0151

27. Which of the following is correct match -

(A) 3 – iii – III (B) 3 – iv – III (C) 4 – iii – III (D) 4 – iv – IV

MC0151

28. Which of the following is incorrect **(One or more than one correct)**

(A) 2 – ii – I (B) 4 – iii – IV (C) 3 – iv – IV (D) 1 – iii – II

MC0151

Match the column :

29. One type of artifical diamond (commonly called YAG for yttrium aluminium garnet) can be represented by the formula $Y_3Al_5O_{12}$.**[Y = 89, Al =27]**

Column I		**Column II**	
Element		Weight percentage	
(A)	Y	(P)	22.73%
(B)	Al	(Q)	32.32%
(C)	O	(R)	44.95%

MC0152

30. 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		**Column II**	
(A)	O-atoms present in daily dose	(P)	10^{-4} mole
(B)	Moles of vitamin C in 1 gm of vitamin C	(Q)	5.68×10^{-3}
(C)	Moles of vitamin C that should be consumed daily	(R)	3.6×10^{20}

MC0153

31. Gaseous alkane (C_nH_{2n+2}) exploded with oxygen. Ratio of the mol of O_2 for complete combustion to the mole of CO_2 formed is given in column-I & in column II formula is given.

Column-I		**Column-II**	
(A)	7 : 4	(P)	C_3H_8
(B)	2 : 1	(Q)	C_4H_{10}
(C)	5 : 3	(R)	C_2H_6
(D)	13 : 8	(S)	CH_4

MC0154

Matching list type :

32. **Column-I** | **Column-II (mass of product)**

Column-I	Column-II (mass of product)
(P) $\underset{1g}{2H_2} + \underset{1g}{O_2} \rightarrow 2H_2O$	(1) 1.028 g
(Q) $\underset{1g}{3H_2} + \underset{1g}{N_2} \rightarrow 2NH_3$	(2) 1.333 g
(R) $\underset{1g}{H_2} + \underset{1g}{Cl_2} \rightarrow 2HCl$	(3) 1.125 g
(S) $\underset{1g}{2H_2} + \underset{1g}{C} \rightarrow CH_4$	(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

MC0155

EXERCISE JEE -MAINS

1. $NaClO_3$ is used, even in spacecrafts, to produce O_2. The daily consumption of pure O_2 by a person is 492L at 1 atm, 300K. How much amount of $NaClO_3$, in grams, is required to produce O_2 for the daily consumption of a person at 1 atm, 300 K ? **[JEE(Main)-2020 (Jan)]**

$NaClO_3(s) + Fe(s) \rightarrow O_2(g) + NaCl(s) + FeO(s)$ R = 0.082 L atm mol^{-1} K^{-1}

MC0156

2. 5 g of zinc is treated separately with an excess of **[JEE(Main)-2020 (Jan)]**

(a) dilute hydrochloric acid and

(b) aqueous sodium hydroxide.

The ratio of the volumes of H_2 evolved in these two reactions is :

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

MC0157

3. The ammonia (NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide (NaOH) can be neutralized by : **[JEE(Main)-2020 (Jan)]**

(1) 100 ml of 0.1 N HCl (2) 200 ml of 0.4 N HCl

(3) 100 ml of 0.2 N HCl (4) 200 ml of 0.2 N HCl

MC0158

4. Amongst the following statements, that which was not proposed by Dalton was :

(1) all the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.

(2) chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

(3) when gases combine or reproduced in a chemical reaction they do so in a simple ratio by volume provided all gases are at the same T & P. **[JEE(Main)-2020 (Jan)]**

(4) matter consists of indivisible atoms.

MC0159

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

(1) 16.8 (2) 8.4 **[JEE(Main)-2019 (Jan.)]**

(3) 0.84 (4) 33.6

MC0160

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

$2C_{57}H_{110}O_6(s) + 163O_2(g) \rightarrow 114CO_2(g) + 110\ H_2O(l)$ **[JEE(Main)-2019 (Jan.)]**

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

MC0161

7. The percentage composition of carbon by mole in methane is : **[JEE(Main)-2019 (-april)]**
(1) 80% (2) 25% (3) 75% (4) 20%

MC0162

8. For a reaction, **[JEE(Main)-2019 (-april)]**
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$;
identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures.
(1) 14g of N_2 + 4g of H_2 (2) 28g of N_2 + 6g of H_2
(3) 56g of N_2 + 10g of H_2 (4) 35g of N_2 + 8g of H_2

MC0163

9. 5 moles of AB_2 weigh 125×10^{-3} kg and 10 moles of A_2B_2 weigh 300×10^{-3} kg. The molar mass of $A(M_A)$ and molar mass of $B(M_B)$ in kg mol^{-1} are : **[JEE(Main)-2019 (April)]**
(1) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$
(2) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$
(3) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$
(4) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$

MC0164

10. The minimum amount of $O_2(g)$ consumed per gram of reactant is for the reaction :
(Given atomic mass : Fe = 56, O = 16, Mg = 24, P = 31, C = 12, H = 1)
(1) $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l)$ **[JEE(Main)-2019 (April)]**
(2) $P_4(s) + 5\ O_2(g) \rightarrow P_4O_{10}(s)$
(3) $4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ FeO_3(s)$
(4) $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$

MC0165

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

MC0166

12. 25 g of an unknown hydrocarbon upon burning produces 88 g of CO_2 and 9 g of H_2O. This unknown hydrocarbon contains. **[JEE(Main)-2019 (Jan)]**
(1) 20g of carbon and 5 g of hydrogen (2) 24g of carbon and 1 g of hydrogen
(3) 18g of carbon and 7 g of hydrogen (4) 22g of carbon and 3 g of hydrogen

MC0167

13. The ratio of mass percent of C and H of an organic compound ($C_XH_YO_Z$) is 6 : 1. If one molecule of the above compound ($C_XH_YO_Z$) contains half as much oxygen as required to burn one molecule of compound C_XH_Y completely to CO_2 and H_2O. The empirical formula of compound $C_XH_YO_Z$ is **[JEE(Main)-2018 (offline)]**

(1) C_2H_4O (2) $C_3H_4O_2$ (3) $C_2H_4O_3$ (4) $C_3H_6O_3$

MC0168

14. For per gram of reactant, the maximum quantity of N_2 gas is produced in which of the following thermal decomposition reactions ? **[JEE(Main)-2018 (online)]**

(Given : Atomic wt. – Cr = 52u, Ba = 137u)

(1) $2NH_4NO_3(s) \rightarrow 2N_2(g) + 4H_2O(g) + O_2(g)$ (2) $Ba(N_3)_2(s) \rightarrow Ba(s) + 3N_2(g)$

(3) $(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + 4H_2O(g)$ (4) $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

MC0169

15. An unknown chlorohydrocarbon has 3.55% of chlorine. If each molecule of the hydrocarbon has one chlorine atom only; chlorine atoms present in 1 g of chlorohydrocarbon are :

(Atomic wt. of Cl = 35.5 u; Avogadro constant = 6.023×10^{23} mol^{-1})**[JEE(Main)-2018 (online)]**

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

MC0170

16. The most abundant elements by mass in the body of a healthy human adult are :

Oxygen (61.4%) ; Carbon (22.9%), Hydrogen (10.0%) ; and Nitrogen (2.6%). The weight which a 75 kg person would gain if all ^1H atoms are replaced by ^2H atoms is **[JEE(Main)-2017]**

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

MC0171

17. 1 gram of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO_2. the molar mass of M_2CO_3 in g mol^{-1} is :- **[JEE(Main)-2017]**

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

MC0172

18. In Carius method of estimation of halogens, 250 mg of an organic compound gave 141 mg of AgBr. The percentage of bromine in the compound is :

(Atomic mass Ag = 108; Br = 80) **[JEE(Main)-2015]**

(1) 48 (2) 60 (3) 24 (4) 36

MC0173

19. 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]**

(1) 1 : 8 (2) 3 : 16 (3) 1 : 4 (4) 7 : 32

MC0174

20. A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g of CO_2. The empirical formula of the hydrocarbon is **[JEE(Main)-2013]**

(1) C_2H_4 (2) C_3H_4 (3) C_6H_5 (4) C_7H_8

MC0175

21. 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)]**

(1) MCl_2 (2) MCl_4 (3) MCl_5 (4) MCl_3

MC0176

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

(Atomic mass : C = 12, O = 16 and Avogadro's constant $N_A = 6.0 \times 10^{23}$ mol^{-1})

[AIEEE 2012 (Online)]

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

MC0177

EXERCISE JEE-ADVANCED

1. The ammonia prepared by treating ammonium sulphate with calcium hydroxide is completely used by $NiCl_2.6H_2O$ to form a stable coordination compound. Assume that both the reactions are 100% complete. If 1584 g of ammonium sulphate and 952g of $NiCl_2.6H_2O$ are used in the preparation, the combined weight (in kg) of gypsum and the nickel-ammonia coordination compound thus produced is___. **[JEE 2018]**

$$(NH_4)_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4.2H_2O + 2NH_3$$

$$NiCl_2 \cdot 6H_2O + 6NH_3 \rightarrow [Ni(NH_3)_6]Cl_2 + 6H_2O$$

(Atomic weights in g mol^{-1}: H = 1, N = 14, O = 16, S = 32, Cl = 35.5, Ca = 40, Ni = 59)

MC0178

2. 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 furnance such that the contents undergo self-reduction. The weight (in kg) of Pb produced per kg of O_2 consumed is ______ .
$PbS + O_2 \longrightarrow Pb + SO_2$ **[JEE 2018]**
(Atomic weights in g mol^{-1} : O = 16, S = 32, Pb = 207)

MC0179

3. If the value of Avogadro number is 6.023×10^{23} mol^{-1} and the value of Boltzmann constant is 1.380×10^{-23} JK^{-1}, then the number of significant digits in the calculated value of the universal gas constant is **[JEE 2014]**

MC0180

ANSWER KEY

EXERCISE S-I

1.	(i) 0.16 or 0.17		(ii) 3200.00		
	(iii) 23.38		(iv) (18.06 or 18.07) , (54.19 or 54.20)		
	(v) 12.04				
2.	1.99	3.	3.20	4.	180.00
5.	2.43 or 2.44	6.	Ans. (9.48)	7.	Ans(55.00)
8.	Ans. (34.05)	9.	Ans.(2.00)	10.	Ans.(102.50)
11.	36.50	12.	27.60	13	3.61
14.	0.63	15.	58.80	16	6.41 or 6.42
17.	0.11 or 0.12	18.	0.25	19.	5.60
20.	%Al = 60; %Mg = 40				
21.	$\%CaCO_3$ = 28.40 or 28.41, $\%MgCO_3$ = 71.59				
22.	$\%NaHCO_3$ = 16.80 ; $\%Na_2CO_3$ = 83.20				
23.	0.75	24.	1.70	25	0.50
26.	39.18	27	4.48	28	61.50
29	0.20	30.	Ans. (50.00)	31.	Ans. (31.42 or 31.43)
32.	Ans. (0.64)	33.	Ans. (40.00)	34.	Ans. (0.72)
35.	Ans.(0.04)	36.	Ans.(3.04)	37.	6.40
38.	(a) 0.71 (b) 61.97	39.	1.20	40.	Ans. (4.00)
41.	Ans. (33.33)	42	5.28	43.	Ans. (4.00)
44.	Ans.(2.00)	45.	Ans.(0.07)	46.	(19.00)
47.	$C_6H_4Cl_2$	48	Ans (3.00)	49.	Ans. ($C_2H_4O_2$)
50.	Ans. (0.50)	51.	Ans. 140.00	52.	30.00
53.	70.00	54.	Ans.(10.00)	55.	73.33
56.	10.00	57.	Ans.(N_2O_5)	58.	Ans. (C_2H_6)
59.	(3.00)	60.	Ans. (5.00)		

EXERCISE S-II

1.	(i) 0.5 , 0.5 ; (ii) 2, 1 (iii) 1, 2	2.	(65.62)	3.	0.66
4	%NaCl = 77.80				
5.	(i) $Fe_2O_3 + 2\,Al \longrightarrow Al_2O_3 + 2Fe$; (ii) 2.96 ; (iii) 10,000 units				
6.	Ans. 5.74	7.	Ans. 6.02	8.	(1.50)
9.	Ans. (222.00)	10.	(11.00)	11.	Ans. (5.00)
12	Ans.(1.70)	13	Ans.(3.30)		

14. $\%\ Ag = \dfrac{0.5}{0.66}\times 100 = 75.75$

$\%\ Ag = \dfrac{1}{1.32}\times 100 = 75.75$

In both AgCl, % Ag is same.

15. $\% \text{ Pb} = \dfrac{6.488}{(6.488+1.002)} \times 100 = 86.62\%$

16. Oxide = 1 gm $\Rightarrow$ oxygen = 0.5 gm + element = 0.8 gm

Ratio = 1 : 1

Oxide = 4 gm $\Rightarrow$ oxygen = 3.2 gm + element = 0.8 gm

Ratio = 4 : 1

17. 0.11 gm oxide gives $\Rightarrow$ 0.07 gm N , Hence ; 0.07 gm N + 0.04 gm O

0.15 gm oxide gives $\Rightarrow$ 0.07 gm N , Hence ; 0.07 gm N + 0.08 gm O

18. CH_4 = 4.50, CO_2 = 1.50, C_2H_4 = 4.00

19. (0.66 or 0.67)

20. 9.00

EXERCISE O-I

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

EXERCISE O-II

1.	Ans.(C)	2.	Ans.(B)	3.	Ans. (A)	4.	Ans.(C)
5.	Ans.(C)	6.	Ans.(D)	7.	Ans.(B)	8.	Ans.(A,B,D)
9.	Ans (B,C,D)	10.	Ans.(A,B,C)	11.	Ans. (A, B)	12.	(A, C)
13.	(A, B, D)	14.	Ans.(C)	15.	Ans.(C)	16.	Ans.(B)
17.	Ans.(C)	18.	Ans.(B)	19	Ans.(A)	20	Ans.(C)
21	Ans.(D)	22.	Ans.(A)	23.	Ans.(D)	24.	Ans.(C)
25.	Ans.(B)	26.	Ans.(A)	27.	Ans.(B)	28.	Ans.(C,D)

29. Ans. (A) R, (B) P, (C) Q

30 Ans. (A) R, (B) Q, (C) P

31. Ans.A - R ; B - S ; C - P ; D - Q

32. Ans.(A)

EXERCISE JEE -MAINS

1.	Ans. (2120 to 2140)	2.	Ans. (4)	3.	Ans. (3)	4.	Ans. (3)
5.	Ans.(2)	6.	Ans.(1)	7.	Ans.(4)	8.	Ans.(3)
9.	Ans.(3)	10.	Ans.(3)	11.	Ans.(4)	12	Ans.(2)
13.	Ans.(3)	14.	Ans.(4)	15.	Ans.(3)	16.	Ans.(3)
17.	Ans.(2)	18.	Ans.(3)	19.	Ans.(4)	20.	Ans.(4)
21.	Ans.(2)	22.	Ans.(4)				

J-ADVANCE

1.	Ans. (2.99)	2.	Ans. (6.47)	3.	Ans. (4)

Important Notes