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# Mole Concept / Stoichiometry

Mole concept has a fairly interesting history. Though originally put forward by Amedeo Avogadro many other scientists were involved in its final formulation. This law, put originally as a hypothesis, was confirmed many years after its formulation, only when high end techniques were available.

Mole has a very significant place in present day also. "Mole Day" is celebrated on October 23rd from 6:02 am to 6:02 pm (Avagadro's no. is $6.02 \times 10^{23}$).

Mole is not only an essential tool in chemistry rather it is a dignified part of chemistry.

So let's start with "Great Mole".

## Mole Concept

A mole (symbol mol) is defined as the amount of substance that contains as many atoms, molecules, ions, electrons or any other elementary entities as there are carbon atoms in exactly 12 gm of $^{12}C$. The number of atoms in 12 gm of $^{12}C$ is called Avogadro's number ($N_o$).

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

One atomic mass unit (amu) = $\frac{1}{N_A} = \frac{1}{6.023 \times 10^{23}}\text{gm} = 1.66 \times 10^{-24}$ gm $= 1.66 \times 10^{-27}$ kg

The number of moles of a substance can be calculated by various means depending on data available, as follows:

- Number of moles of molecules = $\frac{\text{Wt. in gm}}{\text{Molecular mass}}$
- Number of moles of atoms = $\frac{\text{Wt. in gm}}{\text{Atomic mass}}$
- Number of moles of gases = $\frac{\text{Volume at STP}}{\text{Standard molar volume}}$
- (Standard molar volume at STP = 22.4 lit)
- Number of moles of particles, e.g. atoms, molecules, ions etc. = $\frac{\text{Number of particles}}{\text{Avogadro's number}}$
- Number of moles of solute = Molarity $\times$ Volume of solution in litres $= \frac{\text{Molarity} \times \text{Volume in ml}}{1000}$
- For a compound $A_xB_y$, y moles of A = x moles of B.
- Mole fraction = Fraction of the substance in the mixture expressed in terms of moles is called its mole fraction (X).

  For example, for a mixture of substance A and B

  $X_A = \frac{n_A}{n_A + n_B}$ and $X_B = \frac{n_B}{n_A + n_B}$ (n number of moles)

  $X_A + X_B = 1 \Rightarrow X_A = (1 - X_B)$

**Example 1.** Calculate the weight of iron which will be converted into its oxide by the action of 18 g of steam. (Given: $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$)

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

$\frac{\text{Mole of Fe}}{\text{Mole of } H_2O} = \frac{3}{4}$ Mole of Fe = $\frac{3}{4} \times$ mol of $H_2O = \frac{3}{4} \times \frac{18}{18} = \frac{3}{4}$

Wt. of Fe = $\frac{3}{4} \times 56 = 42$ g

**Example 2.** Chlorophyll the green colouring material of plants contains 2.68 % of magnesium by mass. Calculate the number of magnesium atoms in 5. 00 g of the complex.

**Sol.** Mass of magnesium in 5.0 g of complex = $\frac{2.68}{100} \times 5.00 = 0.134$ g

Atomic mass of magnesium = 24

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

$\therefore$ 0.134 g of magnesium would contain= $\frac{6.023 \times 10^{23}}{24} \times 0.134 = 3.36 \times 10^{21}$ atoms

Therefore, 5.00 g of the given complex would contain 3.36 x $10^{21}$ = atoms of magnesium.

**Self Practice Problems 1**

(i) Calculate the mass of sodium which contains same number of atoms as are present in 4 g of calcium. Atomic masses of sodium and calcium are 23 and 40 respectively.

(ii) From 200 mg of $CO_2$, $10^{21}$ molecules are removed. How many moles of $CO_2$ are left?

## Principle of Atomic Conservation (POAC)

In chemical reaction, atoms are conserved, so moles of atoms shall also be conserved. This is known as principle of atomic conservation. This principle is helpful in solving Problems of nearly all stoichiometric calculations, e.g.

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

Applying POAC for K atoms

Moles of K atoms in $KClO_3$ = Moles of K atoms in KCl

Since one mole of $KClO_3$ contains 1 mol of K atom. Similarly, 1 mol of KCl contains one mole of K atoms.

$$\therefore 1 \times n_{KClO_3} = 1 \times n_{KCl} \Rightarrow 1 \times \frac{W_{KClO_3} \text{ in gm}}{M_{KClO_3}} = \frac{W_{KCl} \text{ in gm}}{M_{KClO_3}} \text{ (Mass-mass relationship)}$$

Applying POAC for O atoms

Moles of O atom in $KClO_3$ = Moles of O atom in $O_2$

$\therefore 3 \times n_{KClO_3} = 2 \times n_{O_2}$

$$\Rightarrow 3 \times \frac{W_{KClO_3} \text{ in gm}}{M_{KClO_3}} = 2 \times \frac{\text{Vol. of } O_2 \text{ at STP}}{\text{Standard Molar Volume}}$$

(Mass-volume relationship of reactant and product)

In this way, by applying POAC we can break the chemical equation into a number of arithmetic equations without balancing the chemical equation. Moreover, number of reactions and their sequence from reactants to products are not required. It is important to note that POAC can be applied for the atoms which remain conserved in chemical reactions.

**Example 3.** 27.6 g of $K_2CO_3$ was treated by a series of reagents so as to convert all of its carbon to $K_2Zn_3\left[Fe(CN)_6\right]_2$ Calculate the weight of product. Given $(\text{Mol.wt.of} K_2CO_3) = 138$, Mol. wt. of $K_2Zn_3\left[Fe(CN)_6\right]_2 = 698$

**Sol.** $K_2CO_3 \xrightarrow[\text{of steps}]{\text{Number}} K_2Zn_3\left[Fe(CN)_6\right]_2$

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

Moles of C atoms in $K_2CO_3$ = Moles of C in $K_2Zn_3\left[Fe(CN)_6\right]_2$

$1 \times$ moles of $K_2CO_3 = 12 \times$ moles of $K_2Zn_3\left[Fe(CN)_6\right]_2$

$$\therefore \frac{\text{Wt. of } K_2CO_3}{\text{Mol of } K_2CO_3} = 12 \times \frac{\text{Wt. of the product}}{\text{Mol. wt. of product}}$$

$$\therefore \text{Wt. of } K_2Zn_3\left[Fe(CN)_6\right]_2 = \frac{27.6}{138} \times \frac{698}{12} \Rightarrow = 11.6 \text{ g}$$

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

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

Wt. of $Na_2CO_3$ in the product = 2.00 – 0.248 = 1.752 g

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

$\therefore$ Wt. of $NaHCO_3 = (2.00 - x)g$

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

The wt. of $Na_2CO_3$ produced by $NaHCO_3$ = (1.752–x)

$$NaHCO_3 \longrightarrow Na_2CO_3 + (H_2O + CO_2)\uparrow$$

$(2.0 - x)$ $(1.752 - x)$

Applying POAC for Na atom,

$$1 \times \text{moles of } NaHCO_3 = 2 \times \text{moles of } Na_2CO_3 \Rightarrow \frac{(2-x)}{84} = 2 \times \frac{(1.752-x)}{106}$$

$$\therefore x = 1.328\,g \quad \therefore \%\text{ of } Na_2CO_3 = \frac{1.328}{2} \times 100 = 66.4\%$$

**Self Practice Problems 2**

1 g mixture of cuprous oxide and cupric oxide was quantitatively reduced to 0.839 g of metallic copper. What was the weight of cupric oxide in the original sample? (Cu = 63.5, O = 16)

## Concept of Limiting Reactant

In reactions involving more than one reactant, one has to identify the reactant, which is completely consumed (limiting reactant). One can identify the limiting reactant as described below:

| | $N_2$ | + | $3H_2$ | $\longrightarrow$ | $2NH_3$ |
|---|---|---|---|---|---|
| Initial mole | 5 | | 12 | | — |

If $N_2$ is the limiting reactant, moles of $NH_3$ produced is 10. If $H_2$ is the limiting reactant, moles of $NH_3$ produced $= \frac{2}{3} \times 12 = 8$. The reactant producing the least number of moles of the product is the limiting reactant, hence $H_2$ is the limiting reactant.

The limiting reactant can also be ascertained by knowing the initial number of equivalents or milli equivalents of each reactant. The reactant with least number of equivalents or milli equivalent is the limiting reactant. The equivalent method for identifying the limiting reactant does not require balancing of chemical equation.

**Example 5.** Calculate the weight of FeO from 2 gm VO and 5.75 gm of $Fe_2O_3$. Also report the limiting reactant.

$VO + Fe_2O_3 \longrightarrow FeO + V_2O_5$

**Sol.** Balanced equation

| | $2VO$ + | $3Fe_2O_3 \longrightarrow$ | $6FeO$ + | $V_2O_5$ |
|---|---|---|---|---|
| Moles before reaction | $\frac{2}{67}$ | $\frac{5.75}{160}$ | 0 | 0 |
| | = 0.0298 | 0.03590 | | |
| Moles after reaction | (0.0298 – 0.0359) | 0 | $\left(\frac{6}{3} \times 0.0359\right)$ | $\left(\frac{1}{3} \times 0.0359\right)$ |

As 2 moles of VO react with 3 moles of $Fe_2O_3$

$\therefore$ 0.0298 gm moles of VO = $\frac{3}{2} \times 0.0298 = 0.0447$ moles of $Fe_2O_3$

Moles of $Fe_2O_3$ available = 0.0359 only

Hence, $Fe_2O_3$ is the limiting reagent.

Moles of FeO formed = $\frac{6}{3} \times 0.0349$

$\therefore$ Weight of FeO formed = $0.0359 \times 2 \times 72 = 5.17$ gm

$$\left(\frac{n_{FeO}}{n_{Fe_2O_3}} = \frac{6}{3}\right) \Rightarrow n_{FeO} = \frac{6}{3} \times n_{Fe_2O_3}; \quad W_{FeO} = \frac{6}{3} \times n_{Fe_2O_3} \times M_{Fe_2O_3}$$

**Example 6.** A mixture of KBr, NaBr weighing 0.56 gm was treated with aqueous solution of $Ag^+$ and the bromide ion was recovered as 0.97 gm of pure AgBr. What was the weight of KBr in the sample?

**Sol.**

| KBr | + | NaBr | + | $Ag^+$ | $\longrightarrow$ | AgBr |
|---|---|---|---|---|---|---|
| a gm | | (0.56 – a) gm | | | | 0.97 gm |

Applying POAC for Br atoms,

Moles of Br in KBr + Moles of Br in NaBr = Moles of Br in AgBr

or 1 $\times$ Moles of KBr + 1 $\times$ Moles of NaBr = 1 $\times$ Moles of AgBr

$$\Rightarrow \frac{a}{119} + \frac{(0.56 - a)}{103} = \frac{0.97}{188} \quad (M_{KBr} = 119,\ M_{NaBr} = 103,\ M_{AgBr} = 188)$$

$\therefore$ a = 0.1332 gm

Percentage of KBr in the sample = $\frac{0.1332}{0.560} \times 100 = 23.78$

**Example 7.** The reaction $2C + O_2 \longrightarrow 2CO$ is carried out by taking 24 g of carbon and 96 g of $O_2$.

Find out:

(i) Which reactant is left in excess?

(ii) How much of it is left?

(iii) How many moles of CO are formed?

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

**Sol.**

| | $2C$ | + | $O_2 \longrightarrow$ | $2CO$ |
|---|---|---|---|---|
| Mole before reaction | $\frac{24}{12}$ | | $\frac{96}{32}$ | |
| Mole after reaction | 0 | | 2 | 2 |

$\because$ Mole ratio of $C : O_2 : CO :: 2 : 1 : 2$

(i) $O_2$ is left in excess.

(ii) 2 moles of $O_2$ or 64 g of $O_2$ is left.

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

(iv) To use $O_2$ completely, total 6 moles of carbon or 72 g of carbon is needed.

**Self Practice Problems 3**

How much magnesium sulphide can be obtained from 2.00 g of magnesium and 2.00 g of sulphur by the reaction: $Mg + S \longrightarrow MgS$ ? Which is the limiting reactant? Calculate the amount of one of the reactants which remains unreacted.

## Calculation involving Mass – Mass Relationship

In general, the following steps are adopted in making necessary calculations:

- Write down balanced molecular equation for the chemical change.
- Write down the no. of moles below the formula of each of the reactant and product.
- Write down the relative masses of the reactants and the products with the help of formula below the respective formula. These shall be the theoretical amounts of reactants and product.
- By the applications of unitary method, mole concept or proportionality method, the unknown factor or factors are determined.

**Example 8.** In a gravimetric determination of P of an aqueous solution of dihydrogen phosphate in $H_2PO_4^-$ is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate,$Mg(NH_4)PO_4.6H_2O$. This is heated and decomposed to magnesium pyrophosphate, $Mg_2P_2O_7$. A solution of $H_2PO_4^-$ yielded 1.054 gm of ($Mg_2P_2O_7$) which is weighed. What weight of $NaH_2PO_4$ was present originally?

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

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

$\Rightarrow 1 \times$ Moles of $NaH_2PO_4 = 2 \times$ Moles of $Mg_2P_2O_7$

$$\therefore \frac{W_{NaH_2PO_4}}{M_{NaH_2PO_4}} = 2 \times \frac{W_{Mg_2P_2O_7}}{M_{Mg_2P_2O_7}} \Rightarrow \frac{W_{NaH_2PO_4}}{120} = 2 \times \frac{1.054}{222}$$

$\therefore W_{NaH_2PO_4} = 1.14$ gm

**Example 9.** A solid mixture weighing 5.00 g containing lead nitrate and sodium nitrate was heated below $600^\circ C$ until the mass of the residue was constant. If the loss of mass is 28%, find the mass of lead nitrate and sodium nitrate in mixture.

$(\text{At. wt. of Pb} = 207,\ \text{Na} = 23,\ \text{N} = 14,\ \text{O} = 16)$

$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 \uparrow + O_2 \uparrow$$

$2 \times 331 \qquad 2 \times 223$

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2 \uparrow$$

$2 \times 85 \qquad 2 \times 69$

Let, wt. of $Pb(NO_3)_2$ in mixture = x

Wt. of $NaNO_3 = (5 - x)$ gm

662 gm of $Pb(NO_3)_2$ will give residue = 446

$\therefore$ x g of $Pb(NO_3)_3$ will give residue = $\frac{446}{662} \times (x) = 0.674$ x g

170 g of $NaNO_3$ give residue = 138 gm

$\therefore (5 - x)$ g $NaNO_3$ will give residue = $\frac{138}{170} \times (5 - x) = 0.812 \times (5 - x)$

Actual wt. of residue obtained = $\left(5 - 5 \times \frac{28}{100}\right) = 3.6$ gm

$\therefore 0.674x + 0.812 \times (5 - x) = 3.6$

$\Rightarrow 0.138x = 0.46$

$\Rightarrow x = 3.33$ gm = Wt. of $Pb(NO_3)_2$

$\therefore$ Wt. of $NaNO_3$ in the mixture = 1.67 gm

**Example 10.** 1.5 g of an impure sample of sodium sulphate dissolved in water was treated with excess of barium chloride solution when 1.74 g of $BaSO_4$ were obtained as dry precipitate. Calculate the percentage purity of sample.

**Sol.** $Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2NaCl$

142 g 223 gm

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

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

% purity of $Na_2SO_4 = \frac{1.06}{1.5} \times 100 = 70.67\%$

**Self Practice Problems 4**

Calculate the weight of 60% $H_2SO_4$ required to decompose 50 g of chalk (Calcium carbonate).

**Calculation involving Percentage Yield:**

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

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

**Weight – Volume Relationship**

$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

In the above reaction, one can find out the volume of $O_2$ at STP required to react with 10 gm of Mg. The mole of Mg is $\frac{10}{24}$. The moles of $O_2$ required would be ½ the moles of Mg. Therefore, moles of $O_2 = \frac{1}{2} \times \frac{10}{24}$. Since 1 mole of a gas (ideal) occupies 22.4 L at STP, therefore $\frac{1}{2} \times \frac{10}{24}$ moles of $O_2$ would occupy $\frac{1}{2} \times \frac{10}{24} \times 22.4$ L= 4.67 L

**Example 11.** How much marble ($CaCO_3$) of 96.5 % purity would be required to prepare 10 litres of $CO_2$ at STP when the marble is acted upon by dilute HCl?

**Sol.** $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

100 gm 22.4 litre

22.4 L of $CO_2$ at STP will be obtained from 100 gm of $CaCO_3$

$\therefore$ 10 L of $CO_2$ at STP will be obtained from pure $CaCO_3 = \frac{100}{22.4} \times 10 = 44.64$ g

$\therefore$ Impure marble required $= \frac{100}{96.5} \times 44.64 = 46.26$ g

**Self Practice Problems 5**

1.0 g of a mixture of carbonates of calcium and magnesium gave 240 $cm^3$ of $CO_2$ at STP. Calculate the percentage composition of the mixture.

**Volume – Volume Relationship**

Let us consider the reaction, $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$. We are given 10 litre of $H_2$ at a given temperature and pressure. How many litres of $O_2$ would react with hydrogen at the same temperature and pressure?

From the ideal gas equation [PV = nRT], it is clear that the volume of an ideal gas is directly proportional to its no. of moles.

Therefore, under the same conditions of P and T, $\frac{V_{H_2}}{V_{O_2}} = \frac{n_{H_2}}{n_{O_2}}$.

Since the molar ratio is 2:1 ($H_2$:$O_2$), the volume ratio would also be 2:1.

Therefore, the volume of $O_2$ required would be 5 litre.

On the other hand, if we need to calculate the volume of $O_2$ at a different T and P, then

$P_{H_2} V_{H_2} = n_{H_2} R T_{H_2}, P_{O_2} V_{O_2} = n_{O_2} R T_{O_2}$, and dividing we get $\frac{P_{H_2} V_{H_2}}{P_{O_2} V_{O_2}} = \frac{n_{H_2} T_{H_2}}{n_{O_2} T_{O_2}}$,

$\therefore \quad V_{O_2} = \frac{P_{H_2} V_{H_2}}{P_{O_2}} \times \frac{n_{O_2} T_{O_2}}{n_{H_2} T_{H_2}}$

**Example 12.** Find out the volume of $Cl_2$ at STP produced by the action of 100 $cm^3$ of 0.2N HCl on excess of $MnO_2$.

**Sol.** $MnO_2 + 4HCl \longrightarrow MCl_2 + 2H_2O + Cl_2$

$4 \times 36.5$ g 22400 $cm^3$ at STP

HCl present in $100 cm^3$ of 0.2 N HCl

$= \frac{0.2 \times 100}{1000} \times 36.5 = 0.73$ gm

$4 \times 36.5$ gm of HCl will give 22400 $cm^3$ of $Cl_2$ at STP

$\therefore$ 0.73 g of HCl will give = $\frac{22400}{4 \times 36.5} \times 0.73$ = 112 $cm^3$

**Example 13.** What volume of oxygen at STP is required to effect complete combustion of 200 $cm^3$ of acetylene and what would be the volume of carbon dioxide formed?

**Sol.** $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$

2 volume of $C_2H_2$ require $O_2$ for complete combustion = 5 vol.

$\therefore 200 cm^3$ of $C_2H_2$ will require $O_2$ for complete combustion = $\frac{5}{2} \times 200$

$= 500 cm^3$ at STP.

2 volume of $C_2H_2$ produce $CO_2 = 4$ volume

$\therefore 200 cm^3$ of $C_2H_2$ at STP will produce $CO_2 = \frac{4}{2} \times 200 = 400\ cm^3$

Thus, volume of $CO_2$ produced = 400 $cm^3$ at STP.

## Volume Strength Of $H_2O_2$

x volume of $H_2O_2$ means x litre of $O_2$ is liberated by 1 litre of $H_2O_2$ on decomposition

$2H_2O_2 \longrightarrow 2H_2O + O_2$

68 gm 22. 4 lit at STP

22.4 lit (at STP) of $O_2$ is given by 68 gm of $H_2O_2$

x litre of $O_2$ is released from $\frac{68x}{22.4}$ gm of $H_2O_2$ = $\frac{17x}{5.6}$

$\therefore$ x lit of $O_2$ is given by = $\frac{68x}{22.4} = \frac{17x}{5.6}$ (strength)

Strength (S) = $\frac{17x}{5.6}$

Normality = $\frac{S}{E}$ = $\frac{17x}{5.6 \times 34/2}$ = $\frac{x}{5.6}$ [x = N $\times$ 5.6]

Molarity = $\frac{1}{2}$ Normality = $\frac{x}{11.2}$

**Example 14.** 50 ml of an aqueous solution of $H_2O_2$ was treated with an excess of KI solution and dilute $H_2SO_4$. The liberated iodine required 20 ml 0.1 N $Na_2S_2O_3$ solution for complete reaction. Calculate the volume strength of $H_2O_2$.

**Sol.** Meq. of $H_2O_2$ in 25 ml = Meq. of $Na_2S_2O_3$ = 20 x 0.3 = 6

Normality of $H_2O_2 = \frac{6}{25}$

Volume strength of $H_2O_2$ = 5.6 x $N_{H_2O_2} \Rightarrow 5.6 \times \frac{6}{25} = 1.344$ V

## Answer to Self Practice Problems

**Self Practice Problem 1.** (i) 2.3 g (ii) 0.00288

**Self Practice Problem 2.** 0.55 g

**Self Practice Problem 3.** 0.4776 g of Mg.

**Self Practice Problem 4.** 81.67 g

**Self Practice Problem 5.** 37.5

## Subjective Illustrations

**1.** What volume of 0.20 M $H_2SO_4$ is required to produce 34.0 g of $H_2S$ by the reaction,

$8KI + 5H_2SO_4 \rightarrow 4K_2SO_4 + 4I_2 + H_2S + 4H_2O$?

**Sol.** 1 mole of $H_2S \equiv 5$ moles of $H_2SO_4$

34 g of $H_2S \equiv 5$ moles of $H_2SO_4$

$0.20 \times V_{H_2SO_4} = 5$

$\therefore V_{H_2SO_4} = \dfrac{5}{0.20} = 25$ litre

**2.** To 50 L of 0.2N NaOH, 5 L of 1N HCl and 15 L of 0.1N $FeCl_3$ solutions are added. What weight of $Fe_2O_3$ can be obtained from the precipitate? Also report the normality of NaOH left in resultant Sol.

**Sol.** Eq. of NaOH = 50 x 0.2 = 10

Eq. of HCl = 5 x 1 = 5

Eq. of NaOH left after reaction with HCl = 10–5 = 5

$FeCl_3 + NaOH \rightarrow Fe(OH)_3 \downarrow \xrightarrow{\Delta} Fe_2O_3$

$FeCl_3$ reacts with NaOH to give $Fe(OH)_3$ which on ignition gives $Fe_2O_3$

$\therefore$ Eq. of NaOH used for $FeCl_3$ = Eq. of $Fe(OH)_3$

= Eq. of $Fe_2O_3$

= 15 x 0.1 = 1.5

$\therefore$ Eq. of NaOH left finally = 5–1.5 = 3.5

Normality of NaOH in the resultant solution $= \dfrac{3.5}{70} = 0.05$

$\dfrac{W_{Fe_2O_3}}{M_{Fe_2O_3}} \times 6 = 1.5$ (n-factor for $Fe_2O_3 = 6$)

$\therefore W_{Fe_2O_3} = \dfrac{1.5 \times 160}{6} = 40$ g

**3.** One litre of a mixture of $O_2$ and $O_3$ at NTP was allowed to react with an excess of acidified solution of KI. The iodine liberated required 40 ml of M/10 $Na_2S_2O_3$ solution for titration. What is the weight per cent of ozone in the mixture?

Ultraviolet radiation of wavelength 300 mm can decompose ozone. Assuming that one photon can decompose one ozone molecule, how many photons would have been required for the complete decomposition of ozone in the original mixture?

**Sol.** $O_3 + 2KI + H_2O \rightarrow 2KOH + I_2 + O_2$

$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$

Millimoles of $O_3$ = Millimoles of $I_2$ = ½ x Millimoles of $Na_2S_2O_3$

= ½ x40 x 1/10 = 2 millimoles

= 0.002 moles

Total moles of $O_3$ and $O_2$ in the mixture:

PV = n RT

1 x 1 = n x 0.0821 x 273

$\therefore$ n = 0.044

Moles of $O_2$ = 0.044 – 0.002 = 0.042

$W_{O2}$ = 0.042 x 32 g = 1.344 g

$W_{O3-}$ = 0.002 x 48 g = 0.096 g

$\therefore$ % of $O_3 = \frac{0.096}{1.144} \times 100 = 6.7\%$

No. of photons required for decomposition of Ozone molecules = 0.002 x 6.023 x $10^{23}$ = 1.2 x $10^{21}$

**4.** A 10 g sample of only CuS and $Cu_2S$ was treated with 100 ml of 1.25 M $K_2Cr_2O_7$. The products obtained were $Cr^{3+}$, $Cu^{2+}$ and $SO_2$. The excess oxidant was reacted with 50 ml of $Fe^{2+}$ Sol. 25 ml of the same $Fe^{2+}$ solution required 0.875 M $KMnO_4$ under acidic condition, the volume of $KMnO_4$ used was 20 ml. Find the % of CuS and $Cu_2S$ in the sample.

**Sol.** Equivalents of dichromate initially = $\frac{1.25 \times 6 \times 100}{1000}$ = 0.75

Equivalents of $Fe^{2+}$ in 25 ml = $\frac{0.875 \times 5 \times 5 \times 20}{1000}$ = 0.0875

Equivalents of $Fe^{2+}$ in 50 ml = 0.0875 $\times$ 2 = 0.175

Equivalents of excess dichromate = 0.175

$\therefore$ Equivalents of dichromate consumed by (CuS and $Cu_2S$)

= 0.75 – 0.175 = 0.575

If x g is the mass of CuS, the mass of $Cu_2S$ is (10 – x) g

$\frac{x}{95.5} \times 6 + \frac{(10-x)}{159} \times 8 = 0.575$

$\therefore$ x = 5.74 gm

% CuS = $\frac{5.74}{10} \times 100$ = 57.4%

% $Cu_2S$ = 42.6%

**5.** 1.249 g of a sample of pure $BaCO_3$ and impure $CaCO_3$ containing some CaO was treated with dil. HCl and it evolved 168 ml of $CO_2$ at N.T.P. From this solution, $BaCrO_4$ was precipitated filtered and washed. The precipitate was dissolved in dil. $H_2SO_4$ and diluted to 100 ml. 10 ml of this solution when treated with KI solution liberated iodine which required exactly 20 ml of 0.05 N $Na_2S_2O_3$. Calculate the percentage of CaO in the sample.

**Sol.** Let, weight of $BaCO_3$, $CaCO_3$ and CaO are x, y and z respectively.

$\therefore$ x + y + z = 1.249

$BaCO_3 \rightarrow BaCrO_4$

Redox change $Cr^{6+} + 3e^- \longrightarrow Cr^{3+}$

$2I^- \longrightarrow I_2 + 2e^-$

Meq. of $BaCO_3$ = Meq. of $BaCrO_4$ = Meq. of $I_2$

$\therefore \frac{x}{197/3} \times 1000 = 20 \times 0.05 \times \frac{100}{10}$

$\therefore$ x = 0.657 gm … (1)

The equivalent weight of $BaCrO_4$ is M/3, therefore for $BaCO_3$, it should be M/3 also because mole ratio of $BaCO_3$ and $BaCrO_4$ is 1 : 1.

Applying POAC for C atom,

Moles of C in $BaCO_3$ + Moles of C in $CaCO_3$ = Moles of C in $CO_2$

$\therefore \frac{x}{197} + \frac{y}{100} = \frac{168}{22400}$

$\Rightarrow$ 200x + 294y = 295.5 … (2)

From equation (1) and (2)

y = 0.416 gm $\therefore$ 0.0657 + 0.416 + z = 1.249

z = 0.176

% of CaO = $\frac{0.176}{1.249}$ = **14.09%**

**6.** A sample of Mg was burnt in air to give a mixture of MgO and $Mg_3N_2$. The ash was dissolved in 60 Meq. of HCl and the resulting solution was back titrated with NaOH. 12 Meq. of NaOH were required to reach the end point. An excess of NaOH was then added and the solution was distilled. The ammonia released was then trapped in 10 Meq. of acid. Back titration of this solution required 6 Meq. of base. Calculate the % of Mg burnt to the nitride.

**Sol.** Let, total moles of Mg used for MgO and $Mg_3N_2$ be a and b respectively

$2Mg + O_2 \longrightarrow 2MgO$

a 0

0 a

$3Mg + N_2 \longrightarrow Mg_3N_2$

b 0

0 b/3

Now a, $\frac{b}{3}$ moles respectively of MgO and $Mg_3N_2$ are present in the mixture.

$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$

$Mg_3N_2 + 8HCl \longrightarrow 3MgCl_2 + 2NH_4Cl$

or solution contains (a) moles of $MgCl_2$ from MgO and (b) moles of $MgCl_2$ from $Mg_3N_2$ and $\frac{2b}{3}$ moles of $NH_4Cl$.

Now, moles of HCl or Meq. of HCl (monobasic) = 60 – 12 = 48

$2a + \frac{8b}{3} = 48$ … (1)

Moles of $NH_4Cl$ formed = Moles of $NH_3$ liberated = Moles of HCl used for absorbing $NH_3$.

$\frac{2b}{3} = (10 - 6) = 4$ … (2)

From (1), $2a + \frac{8 \times 6}{3} = 48$ or a = 16

$\therefore$ % of Mg used for $Mg_3N_2 = \frac{6}{(6+16)} \times 100 = 27.27\%$

## Objective Illustrations

**1.** If 0.5 moles of $BaCl_2$ is mixed with 0.2 moles of $Na_3PO_4$, the maximum amount of $Ba_3(PO_4)_2$ that can be formed is

(A) 0.7 mol (B) 0.5 mol (C) 0.2 mol (D) 0.1 mol

**Sol.** Let us first solve this Prob by writing the complete balanced reaction. **Ans [D]**

$3BaCl_2 + 2\,Na_3PO_4 \longrightarrow Ba_3(PO_4)_2 \downarrow + 6NaCl$

We can see that the moles of $BaCl_2$ used are $\frac{3}{2}$ times the moles of $Na_3PO_4$. Therefore, to react with 0.2 mol of $Na_3PO_4$, the moles of $BaCl_2$ required would be $0.2 \times \frac{3}{2} = 0.3$. Since $BaCl_2$ is 0.5 mol, we can conclude that $Na_3PO_4$ is the limiting reagent. Therefore, moles of $Ba_3(PO_4)_2$ formed is $0.2\ \frac{1}{2} = 0.1$ mol.

**2.** 0.52 g of a dibasic acid required 100 ml of 0.1N NaOH for complete neutralization. The equivalent weight of acid is

(A) 26 (B) 52 (C) 104 (D) 156

**Sol.** Meq. of Acid = Meq. of NaOH **Ans [B]**

$\frac{0.52}{E} \times 1000 = 100 \times 0.1$

$\therefore E = 52$

**3.** 34 g of hydrogen peroxide is present in 1120 ml of Sol. This solution is called

(A) 10 volume (B) 20 volume (C) 30 volume (D) 32 volume

**Sol.** Wt. of $H_2O_2$ in 1 ml $= \frac{34}{1120}$ g **Ans [A]**

$$H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$$

34 g of $H_2O_2$ gives 11200 ml of $O_2$ at STP.

$$\therefore \frac{34}{1120} \text{ g of } H_2O_2 \equiv \frac{11200}{34} \times \frac{34}{1120} = 10 \text{ ml of } O_2 \text{ at STP.}$$

**4.** 0.5 gm of fuming $H_2SO_4$ (oleum) is diluted with water. This solution is completely neutralized by 26.7 ml of 0.4 N NaOH. The percentage of free $SO_3$ in the sample is

(A) 30.6% (B) 40.6% (C) 20.6% (D) 50%

**Sol.** Meq. of $H_2SO_4$ + Meq. of $SO_3$ = Meq. of NaOH **Ans [C]**

$$\therefore \frac{(0.5 - x)}{98/2} \times 1000 + \frac{x}{80/2} \times 1000 = 26.7 \times 0.4$$

$x = 0.103$

$$\therefore \% \text{ of } SO_3 = \frac{0.103}{0.5} \times 100 = 20.6\%$$

**5.** The minimum quantity of $H_2S$ needed to precipitate 64.5 gm of $Cu^{2+}$ will be nearly

(A) 63.5 gm (B) 31.75 gm (C) 34 gm (D) 2.0 gm

**Sol.** Meq. of $H_2S$ = Meq. of $Cu^{2+}$ **Ans [C]**

$$\therefore \frac{w_{H_2S}}{34/2} \times 1000 = \frac{63.5}{63.5/2} \times 1000$$

$$\therefore w_{H_2S} = 34 \text{ gm}$$

**6.** Which of the following is correct?

(A) g mole wt. = mol. wt. in g = wt. of $6.02 \times 10^{23}$ molecules
(B) Mole = N molecule = $6.02 \times 10^{23}$ molecules
(C) Mole = g molecules
(D) None of the above

**Sol. (A), (B)** and **(C)**.

**7.** 8 g of $O_2$ has the same number of molecules as

(A) 7 g of CO (B) 14 g of CO (C) 28 g of CO (D) 11 g of $CO_2$

**Sol. (A)** and **(D).**

**8.** The eq. wt. of a substance is the weight which either combines or displaces

(A) 8 part of O (B) 2 part of H (C) 35.5 part of Cl (D) none of the above

**Sol. (A)** and **(C).**

**9.** A g of a metal displaces V ml of H-$_2$ at NTP. Eq. wt. of metal E is

(A) $E = \frac{A}{\text{Wt. of } H_2 \text{ displaced}} \times \text{Eq. wt. of H}$ (B) $E = \frac{A \times 1.008 \times 22400}{\text{Volume of } H_2 \text{ displaced} \times 2} \times \text{Eq. wt. of H}$

(C) $E = \frac{A \times 1.008}{\text{Volume of } H_2 \text{ displaced} \times 0.0000897}$ (D) none of the above

**Sol. (A), (B)** and **(C)**

## EXERCISE - I (A)

### Only one option correct type

Take approximately 3 minutes for answering each question.

**Section A: Elementary Mole Concept, Molar Volume of Ideal gases, Average Molar Mass**

1. Calculate number of neutrons present in $12 \times 10^{25}$ atoms of oxygen ($_8O^{17}$):
(Given: $N_A = 6 \times 10^{23}$)
(A) 1800 (B) 1600 (C) $1800\ N_A$ (D) $3200\ N_A$

2. Calculate number of electrons present in 9.5 g of $PO_4^{3-}$ :
(A) 6 (B) $5\ N_A$ (C) $0.1\ N_A$ (D) $4.7\ N_A$

3. What is the charge of 96 amu of $S^{2-}$ ?
(A) 2C (B) $3.2 \times 10^{-19}$ C (C) $9.6 \times 10^{-19}$ C (D) 6C

4. The total no. of neutrons present in 54 mL $H_2O$ (*l*) are:
(A) $3\ N_A$ (B) $2\ N_A$ (C) $24\ N_A$ (D) none of these

5. The number of neutron in 5 g of $D_2O$ (D is $^2_1H$ ) are:
(A) $0.25\ N_A$ (B) $2.5\ N_A$ (C) $1.1\ N_A$ (D) none of these

6. $3.011 \times 10^{22}$ atoms of an element weight 1.15 gm. The atomic mass of the element is:
(A) 10 (B) 2.3 (C) 35.5 (D) 23

7. The volume of a drop of water is 0.0018 ml then the number of water molecules present in two drop of water at room temperature is:
(A) $12.046 \times 10^{19}$ (B) $1.084 \times 10^{18}$ (C) $4.84 \times 10^{17}$ (D) $6.023 \times 10^{23}$

8. A 25.0 mm × 40.0 mm piece of gold foil is 0.25 mm thick. The density of gold is 19.32 g/cm$^3$. How many gold atoms are in the sheet? (Atomic weight: Au = 197.0)
(A) $7.7 \times 10^{23}$ (B) $1.5 \times 10^{23}$ (C) $4.3 \times 10^{21}$ (D) $1.47 \times 10^{22}$

9. The point given as full stop at the end of a sentence by a graphite pencil weighs $2 \times 10^{-12}$g. How many carbon atoms are present in such a point?
(A) $1.003 \times 10^{10}$ (B) $1.004 \times 10^{11}$ (C) $1.002 \times 10^{12}$ (D) $1.001 \times 10^{-11}$

10. Mass of 1 atom of Hydrogen is
(A) $1.66 \times 10^{-24}$ g (B) $10^{-22}$ g (C) $10^{-23}$ g (D) $10^{-25}$ g

11. Aspirin has the formula $C_9H_8O_4$. How many atoms of oxygen are there in a tablet weighing 360 mg?
(A) $1.204 \times 10^{23}$ (B) $1.08 \times 10^{22}$ (C) $1.204 \times 10^{24}$ (D) $4.81 \times 10^{21}$

12. A sample of ammonium phosphate, $(NH_4)_3PO_4$, contains 6 moles of hydrogen atoms. The number of moles of oxygen atoms in the sample is:
(A) 1 (B) 2 (C) 4 (D) 6

13. Which of the following contains the largest mass of hydrogen atoms?
(A) 5.0 moles $C_2H_2O_4$ (B) 1.1 moles $C_3H_8O_3$ (C) 1.5 moles $C_6H_8O_6$ (D) 4.0 moles $C_2H_4O_2$

14. Rearrange the following (I to IV) in the order of increasing masses:
(I) 0.5 mole of $0_3$ (II) 0.5 gm atom of oxygen
(III) $3.011 \times 10^{23}$ molecules of $O_2$ (IV) 5.6 litre of $CO_2$ at STP
(A) II < IV < III < I (B) II < I < IV < III (C) IV < II < III < I (D) I < II < III < IV

15. Dopamine is a neurotransmitter, a molecule that serves to transmit message in the brain. The chemical formula of dopamine is $C_8H_{11}O_2N$. How many moles are there in 1 g of dopamine?
(A) 0.00654 (B) 153 (C) 0.0654 (D) None of these

16. Ethanol is the substance commonly called alcohol. The density of liquid alcohol is 0.8 g/ml at 293 K. If 1.2 moles of ethanol is needed for a particular experiment, what volume of ethanol should be measured out?
(A) 55.2 ml (B) 57.5 ml (C) 69 ml (D) 47.9 ml

17. A given mixture consists only of pure substance X and pure substance Y. The total mass of the mixture is 3.72 g. The total number of moles is 0.06. If the mass of one mole of Y is 48 g and there is 0.02 mole of X in the mixture, what is the mass of one mole of X?
(A) 90 g (B) 75 g (C) 45 g (D) 180 g

18. A quantity of 0.25 g of a substance when vaporized displaced 50 $cm^3$ of air at 0°C and 1 atm. The gram molecular mass of the substance will be
(A) 50 g (B) 100 g (C) 112 g (D) 127.5 g

19. While resting, the average 70 kg human male consumes 16.628 Lit of oxygen per hour at 27°C and 100 kPa. How many moles of oxygen are consumed by the 70 kg man while resting for 1hour?
(A) 0.67 (B) 66.7 (C) 666.7 (D) 67.5

20. A quantity of 2.0 g of a triatomic gaseous element was found to occupy a volume of 448 ml at 76 cm of Hg and 273 K. The mass of its each atom is
(A) 100 amu (B) $5.53 \times 10^{-23}$ g (C) 33.3 g (D) 5.53 amu

21. From 2 mg calcium, $1.2 \times 10^{19}$ atoms are removed. The number of g-atoms of calcium left is (Ca = 40)
(A) $5 \times 10^{-5}$ (B) $2 \times 10^{-5}$ (C) $3 \times 10^{-5}$ (D) $5 \times 10^{-6}$

22. Equal masses of oxygen, hydrogen and methane are taken in identical conditions. What is the ratio of the volumes of the gases under identical conditions?
(A) 16 : 1 : 8 (B) 1 : 16 : 2 (C) 1 : 16 : 8 (D) 2 : 16 : 1

23. For $CuSO_4.5H_2O$, which is the correct mole relationship?
(A) 9 × mole of Cu = mole of O (B) 5 × mole of Cu = mole of O
(C) 9 × mole of Cu = mole of $O_2$ (D) mole of Cu = 5 × mole of O

24. A quantity of 5 g of a crystalline salt when rendered anhydrous lost 1.8 g of water. The formula mass of the anhydrous salt is 160. The number of molecules of water of crystallization in the salt is
(A) 3 (B) 5 (C) 2 (D) 1

25. A given sample of pure compound contains 9.81 gm of Zn, $1.8 \times 10^{23}$ atoms of chromium and 0.60 mole of oxygen atoms. What is the simplest formula ?
(A) $ZnCr_2O_7$ (B) $ZnCr_2O_4$ (C) $ZnCrO_4$ (D) $ZnCrO_6$

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

27. The formula of an acid is $HXO_2$. The mass of 0.0242 moles of the acid is 1.657 g. What is the atomic weight of X?
(A) 35.5 (B) 28.1 (C) 128 (D) 19.0

28. Calculate the molecular formula of compound which contains 20% Ca and 80% Br (by wt.) if molecular weight of compound is 200. (Atomic wt. Ca = 40, Br = 80)
(A) $Ca_{1/2}Br$ (B) $CaBr_2$ (C) CaBr (D) $Ca_2Br$

29. What is the empirical formula of vanadium oxide, if 2.74 g of the metal oxide contains 1.53 g of metal ?
(A) $V_2O_3$ (B) VO (C) $V_2O_5$ (D) $V_2O_7$

30. A compound prossess 8% sulphur by mass. The least molecular mass is:
(A) 200 (B) 400 (C) 155 (D) 355

31. Determine the empirical formula of Kelvar, used in making bullet proof vests, is 70.6% C, 4.2% H, 11.8% N and 13.4% O:
(A) $C_7H_5NO_2$ (B) $C_7H_5N_2O$ (C) $C_7H_9NO$ (D) $C_7H_5NO$

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

33. The hydrated salt $Na_2CO_3.xH_2O$ undergoes 63% loss in mass on heating and becomes anhydrous. The value of x is:
(A) 10 (B) 12 (C) 8 (D) 18

34. 64 g of an organic compound has 24 g carbon and 8 g hydrogen and the rest is oxygen. The empirical formula of the compound is :
(A) $CH_4O$ (B) $CH_2O$ (C) $C_2H_4O$ (D) none of these

35. The empirical formula of an acid is $CH_2O_2$, the probable molecular formula of acid may be
(A) $CH_2O$ (B) $CH_2O_2$ (C) $C_2H_4O_2$ (D) $C_3H_6O_3$

36. Twenty molecules of $SO_3$ will weigh as much as..... molecules of oxygen.
(A) 100 (B) 50 (C) 15 (D) 8

37. A mixture of $2 \times 10^{21}$ molecules of P and $3 \times 10^{21}$ molecules of Q weighs 0.60 g. If the molecular mass of P is 45, the molecular mass of Q will be ($N_A = 6 \times 10^{23}$)
(A) 45 (B) 180 (C) 90 (D) 270

38. The density of a DNA sample is 1.1g/ml and its molar mass determined by cryoscopic method was found to be $6 \times 10^8$ g/mole. What is the volume occupied by one DNA molecule? ($N_A = 6 \times 10^{23}$)
(A) $5.45 \times 10^8$ ml (B) $1.83 \times 10^{-9}$ ml (C) $9.06 \times 10^{-16}$ ml (D) $1.09 \times 10^{-13}$ ml

39. Vapour density of a volatile substance is 1.2 ($C_2H_6 = 1$). Its molecular mass would be
(A) 1.2 (B) 2.4 (C) 36 (D) 72

40. A compound contains equal masses of the elements A, B and C. If the atomic masses of A, B and C are 20, 40 and 60, respectively, the empirical formula of the compound is
(A) $A_3B_2C$ (B) $AB_2C_3$ (C) ABC (D) $A_6B_3C_2$

41. Flourine reacts with uranium to produce uranium hexafluoride, $UF_6$, as represented by this equation:

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

How many fluorine molecules are required to produce 2.0 mg of uranium hexafluoride, $UF_6$, from an excess of uranium? The molar mass of $UF_6$ is 352 gm/mol.
(A) $2.0 \times 10^{19}$ (B) $1.0 \times 10^{19}$ (C) $1.0 \times 10^{20}$ (D) $1.2 \times 10^{19}$

42. What volume of $CO_2$ will be liberated at NTP, if 12g of carbon is burnt in excess of oxygen?
(A) 11.2 L (B) 22.4 L (C) 2.24 L (D) 1.12 L

43. 3 gm of Mg is burnt in a closed vessel containing 3 gm of oxygen. The weight of excess reactant left is:
(A) 0.5 gm of oxygen (B) 1.0 gm of oxygen (C) 1.0 gm of Mg (D) 0.5 mg of Mg

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

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

How many grams of nitrogen dioxide are required in this reaction to produce 25.2 gm $HNO_3$ ?
(A) 27.6 gm (B) 26.7 gm (C) 72.6 gm (D) None of these

45. The amount of zinc required to produce 224mL of $H_2$ at NTP on treatment with dilute $H_2SO_4$ will be -
(A) 0.65 g (B) 6.5 g (C) 65 g (D) 0.065 g

46. 0.5 mole of $H_2SO_4$ is mixed with 0.2 mole of $Ca(OH)_2$. The maximum number of moles of $CaSO_4$ formed is -
(A) 0.2 (B) 0.5 (C) 0.4 (D) 1.5

47. Sulphuric acid is produced when sulphur dioxide reacts with oxygen and water in the presence of a catalyst: $2SO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 2H_2SO_4$. 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?
(A) 6.5 (B) 5.6 (C) 4.6 (D) 3.6

48. For the reaction: $A + 2B \longrightarrow C$

5 mole of A and 8 mole of B will produce -
(A) 5 mole of C (B) 4 mole of C (C) 8 mole of C (D) 13 mole of C

49. How many gram glucose burn completely to produce sufficient $CO_2$ needed for complete conversion of 12 g NaOH into $Na_2CO_3$:
(A) 5.5 g (B) 4.5 g (C) 6.5 g (D) 3.5 g

50. The mass of 70% pure $H_2SO_4$ required for neutralisation of 1 mol of NaOH:
(A) 49 gm (B) 98 gm (C) 70 gm (D) 34.3 gm

51. In the reaction, $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$, When 1 mole of ammonia and 1 mole of $O_2$ are made to react to completion
(A) 1.0 mole of $H_2O$ is produced (B) 1.0 mole of NO will be produced
(C) All the oxygen will be consumed (D) All the ammonia will be consumed

52. What volume of air at 1 atm and 273 K containing 21% of oxygen by volume is required to completely burn sulphur ($S_8$) present in 200 g of sample, which contains 20% inert material which does not burn. Sulphur burns according to the reaction

$$\frac{1}{8}S_8(s) + O_2(g) \longrightarrow SO_2(g)$$

(A) 23.52 litre (B) 320 litre (C) 112 litre (D) 533.33 litre

53. How many moles of $P_4$ can be produced by reaction of 0.10 moles $Ca_5(PO_4)_3F$, 0.36 moles $SiO_2$ and 0.90 moles C according to the following reaction?

$$4Ca_5(PO_4)_3F + 18\,SiO_2 + 30\,C \longrightarrow 3P_4 + 2CaF_2 + 18CaSiO_3 + 30\,CO$$

(A) 0.060 (B) 0.030 (C) 0.045 (D) 0.075

54. The mass of $N_2F_4$ produced by the reaction of 2.0 g of $NH_3$ and 8.0 g of $F_2$ is 3.56 g. What is the per cent yield?

$$2NH_3 + 5F_2 \longrightarrow N_2F_4 + 6HF$$

(A) 79.0 (B) 71.2 (C) 84.6 (D) None of these

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

(1) $P_4 + 5O_2 \longrightarrow P_4O_{10}$ (2) $P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

We allow 62 g of phosphorus to react with excess oxygen which form $P_4O_{10}$ in 85% yield. In the step (2) reaction 90% yield of $H_3PO_4$ is obtained. Produced mass of $H_3PO_4$ is:

(A) 37.485 g (B) 149.949 g (C) 125.47 g (D) 564.48 g

56. The chief ore of Zn is the sulphide, ZnS. The ore is concentrated by froth floatation process and then heated in air to convert ZnS to ZnO.

$$2ZnS + 3O_2 \xrightarrow{80\%} 2ZnO + 2SO_2$$

$$ZnO + H_2SO_4 \xrightarrow{100\%} ZnSO_4 + H_2O$$

$$2ZnSO_4 + 2H_2O \xrightarrow{80\%} 2Zn + 2H_2SO_4 + O_2$$

The number of moles of ZnS required for producing 2 moles of Zn will be:

(A) 3.125 (B) 2 (C) 2.125 (D) 4

57. What mass of solid ammonium carbonate $H_2NCOONH_4$, when vaporized at 273°C, will have a volume of 8.96 Lit. at 760 mm of pressure. Assume that the solid completely decomposes as

$$H_2NCOONH_4(s) \longrightarrow CO_2(g) + 2NH_3(g)$$

(A) 15.6 g (B) 6.4 g (C) 46.8 g (D) 7.8 g

58. The mass of sulphuric acid needed for dissolving 3 g magnesium carbonate is

(A) 3.5 g (B) 7.0 g (C) 1.7 g (D) 17.0 g

59. Hydrogen cyanide, HCN, is prepared from ammonia, air and natural gas ($CH_4$) by the following process.

$$2NH_3(g) + 3O_2(g) + 2CH_4(g) \xrightarrow{Pt} 2HCN(g) + 6H_2O(g)$$

If a reaction vessel contains 11.5 g $NH_3$, 10.0 g $O_2$ and 10.5 g $CH_4$, what is the maximum mass, in grams, of hydrogen cyanide that could be made, assuming the reaction goes to completion?

(A) 18.26 g (B) 5.625 g (C) 17.72 g (D) 16.875 g

60. What mass of carbon disulphide, $CS_2$ can be completely oxidized to $SO_2$ and $CO_2$ by the oxygen liberated when 325 g of $Na_2O_2$ react with water?

(A) 316.67 g (B) 52.78 g (C) 633.33 g (D) 211.11 g

61. An amount of 2 moles $KClO_3$ is decomposed completely to produce $O_2$ gas. How many moles of butane, $C_4H_8$ can be burnt completely by the $O_2$ gas produced?

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

62. On heating $KClO_3$ at a certain temperature, it is observed that one mole of $KClO_3$ yields one mole of $O_2$. What is the mole fraction of $KClO_4$ in the final solid mixture containing only KCl and $KClO_4$ the latter being formed by the parallel reaction?

(A) 0.50 (B) 0.25 (C) 0.33 (D) 0.67

63. When 12 g graphite is burnt in sufficient oxygen, CO as well as $CO_2$ is formed. If the product contains 40% CO and 60% $CO_2$ by mass and none of the reactant is left, what is the mass of oxygen gas used in combustion?

(A) 24.0 g (B) 21.33 g (C) 23.8 g (D) 15.6 g

64. A mixture of 254 g of iodine and 142 g of chlorine is made to react completely to give a mixture of ICl and $ICl_3$. How many moles of each product are formed? (I = 127, Cl = 35.5)

(A) 0.1 mol of ICl and 0.1 mol of $ICl_3$ (B) 1.0 mol of IC1 and 1.0 mol of $ICl_3$

(C) 0.5 mol of ICl and 0.1 mol of $ICl_3$ (D) 0.5 mol of ICl and 1.0 mol of $ICl_3$

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

$Ni + 4CO \rightarrow Ni(CO)_4$

If CO used in this process is obtained through a process, in which 6 g of carbon is mixed with 44 g $CO_2$.

(Ni = 59 u)

(A) 14.75 g (B) 29 g (C) 58 g (D) 28 g

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

$$CaCO_3 \longrightarrow CaO + CO_2$$
$$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$$

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

67. NX is produced by the following step of reactions

$$M + X_2 \longrightarrow MX_2$$
$$3MX_2 + X_2 \longrightarrow M_3X_8$$
$$M_3X_8 + N_2CO_3 \longrightarrow NX + CO_2 + M_3O_4$$

$$M_3X_8 + N_2CO_3 \rightarrow NX + CO_2 + M_3O_4$$

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

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

68. The following process has been used to obtain iodine from oil-field brines in California.
(At. wt. of Ag = 107.85u)

$$NaI + AgNO_3 \longrightarrow AgI + NaNO_3 \quad ; \quad 2AgI + Fe \longrightarrow FeI_2 + 2Ag$$
$$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$$

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

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

69. In a gravimetric determination of P, an aqueous solution of dihydrogen phosphate ion $H_2PO_4^-$ is treated with a mixture of ammonium and magnesium ions to precipitate magnesium ammonium phosphate, $Mg(NH_4)PO_4.6H_2O$. This is heated and decomposed to magnesium pyrophosphate($Mg_2P_2O_7$), which is weighed as 1.054g. What weight of $NaH_2PO_4$ was present originally?(Molar mass of $Mg_2P_2O_7$ = 222gm/mol)

(A) 1.14 g (B) 1.62 g (C) 2.34 g (D) 1.33 g

70. 10 g of a sample of a mixture of $CaCl_2$ and NaCl is treated with $Na_2CO_3$ to precipitate all the calcium as $CaCO_3$. This $CaCO_3$ is heated to convert all the $CaCO_3$ to CaO and $CO_2$. The final mass of CaO is 1.62 g . The percent by mass of $CaCl_2$ in the original mixture is.

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

71. If water sample are taken from sea, rivers or lake, they will be found to contain hydrogen and oxygen in the approximate ratio of 1: 8. This indicates the law of:

(A) Multiple proportion (B) Definite proportion (C) Reciprocal proportions (D) None of these

72. One of the following combinations illustrate law of reciprocal proportions:

(A) $N_2O_3$, $N_2O_4$, $N_2O_5$ (B) NaCl, NaBr, NaI (C) $CS_2$, $CO_2$, $SO_2$ (D) $PH_3$, $P_2O_3$, $P_2O_5$

73. The law of conservation of mass holds good for all of the following except:

(A) All chemical reactions (B) Nuclear reactions
(C) Endothermic reactions (D) Exothermic reactions.

74. 2 g of hydrogen combine with 16 g of oxygen to form water and with 6 g of carbon to form methane. In carbon dioxide 12 g of carbon are combined with 32 g of oxygen. These figures illustrate the law of

(A) Multiple proportions (B) Constant proportions
(C) Reciprocal proportions (D) Conservation of mass

75. The law of multiple proportion is illustrated by the two compounds :

(A) Sodium chloride and sodium bromide (B) Ordinary water and heavy water
(C) Caustic soda and caustic potash (D) Sulphur dioxide and sulphur trioxide

76. Which of the following is the best example of law of conservation of mass

(A) 12 g of carbon combines with 32 g of oxygen to form 44 g of $CO_2$
(B) When 12 g of carbon is heated in a vacuum there is no change in mass
(C) Asample of air increases in volume when heated at constant pressure but its mass remains unaltered
(D) The weight of a piece of platinum is the same before and after heating in air

77. In compound A, 1.00 g nitrogen unites with 0.57 g oxygen. In compound B, 2.00 g nitrogen combines with 2.24 g oxygen. In compound C, 3.00 g nitrogen combines with 5.11 g oxygen. These results obey the following law
(A) Law of constant proportion (B) Law of multiple proportion
(C) Law of reciprocal proportion (D) Dalton's law of partial pressure

78. Mol. wt. = vapour density × 2, is valid for:
(A) metals (B) non metals (C) solids (D) gases

79. The density of air is 0.001293 gm/ml at S.T.P. It's vapour density is:
(A) 147 (B) 14.7 (C) 1.47 (D) 0.147

80. 10 g of hydrogen and 64 g of oxygen were filled in a steel vessel and exploded. Amount of water produced in this reaction will be:
(A) 3 mol (B) 4 mol (C) 1 mol (D) 2 mol

81. Molecular mass of dry air is
(A) less than moist air (B) greater than moist air
(C) equal to moist air (D) may be greater or less than moist air

82. The mass composition of universe may be given as 90% $H_2$ and 10% He. The average molecular mass of universe should be
(A) 2.20 (B) 2.10 (C) 3.80 (D) 3.64

83. The density (in g/l) of an equimolar mixture of methane and ethane at 1 atm and 0°C is
(A) 1.03 (B) 2.05 (C) 0.94 (D) 1.25

84. A gaseous mixture contains 40% $H_2$ and 60% He, by volume. What is the total number of moles of gases present in 10 g of such mixture?
(A) 5 (B) 2.5 (C) 3.33 (D) 3.125

85. 500 mL of a glucose solution contains $6.02 \times 10^{22}$ molecules. The concentration of the solution is
(A) 0.1 M (B) 1.0 M (C) 0.2 M (D) 2.0 M

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

87. Decreasing order of mass of pure NaOH in each of the aqueous solution.
(I) 50 g of 40% (W/W) NaOH
(II) 50 ml of 50% (W/V) NaOH ($d_{sol}$ = 1.2 g/ml).
(III) 50 g of 15 M NaOH ($d_{sol}$ = 1 g/ml).
(A) I, II, III (B) III, II, I (C) II, III, I (D) III = II = I.

88. Mole fraction of A in $H_2O$ is 0.2. The molality of A in $H_2O$ is :
(A) 13.9 (B) 15.5 (C) 14.5 (D) 16.8

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

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

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

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

93. The volume of water that must be added to a mixture of 250 ml of 0.6 M HCl and 750 ml of 0.2 M HCl to obtain 0.25 M solution of HCl is :
(A) 750 ml (B) 100 ml (C) 200 ml (D) 300 ml

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

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

96. 2M of 100 ml $Na_2SO_4$ is mixed with 3M of 100 ml NaCl solution and 1M of 200 ml $CaCl_2$ solution. Then the ratio of the concentration of cation and anion.
(A) 1/2 (B) 2 (C) 1.5 (D) 1

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

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

99. 36.5% (w/w) HCl has density equal to 1.20 $gmL^{-1}$. The molarity (M) and molality (m), respectively, are
(A) 15.7, 15.7 (B) 12, 12 (C) 15.7, 12 (D) 12, 15.7

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

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

102. On mixing 15.0 ml of ethyl alcohol of density 0.792 g $ml^{-1}$ with 15 ml of pure water at $4^0$C, the resulting solution is found to have a density of 0.924 $gml^{-1}$ . The percentage contraction in volume is :
(A) 8 % (B) 2 % (C) 3 % (D) 4 %

103. Equal volumes of 10% (v/V) of HCl is mixed with 10% (v/V) NaOH solution. If density of pure NaOH is 1.5 times that of pure HCl then the resultant solution is
(A) basic (B) neutral (C) acidic (D) can't be predicted

104. A sample of oleum is labelled 109%. The % of free $SO_3$ in the sample is
(A) 40% (B) 80% (C) 60% (D) 9%

105. The density of solution prepared by dissolving 120 g of urea (molar mass =60 u) in 1000 g of water is 1.15 g/mL. The molarity of this solution is
(A) 0.50 M (B) 1.78 M (C) 1.02 M (D) 2.05 M

106. The molarity of a solution obtained by mixing 750 mL of 0.5 (M) HCl with 250 mL of 2(M) HCl will be
(A) 0.875 M (B) 1.00 M (C) 1.75 M (D) 0.0975 M

107. What is the $[OH^-]$ in the final solution prepared by mixing 20.0 mL of 0.050 M HCl with 30.0 mL of 0.10 M $Ba(OH)_2$?
(A) 0.12 M (B) 0.10 M (C) 0.40 M (D) 0.0050 M

108. Equal volumes of 0.1 M $AgNO_3$ and 0.2 M NaCl are mixed. The concentration of $NO_3^-$ ions in the mixture will be
(A) 0.1 M (B) 0.05 M (C) 0.2 M (D) 0.15 M

109. 20 ml of HCl solution requires 19.85 ml of 0.01 M NaOH solution for complete neutralization. The molarity of HCl solution is
(A) 0.0099 (B) 0.099 (C) 0.99 (D) 9.9

110. 2.5 L NaOH of 1 M solution is mixed with 3 L NaOH of 0.5 M solution. What is the molarity of the resulting solution:
(A) 0.80 M (B) 1.0 M (C) 0.73 M (D) 0.50 M

## EXERCISE - I (B)

**(Questions from JEE (Main) online sessions, year 2025–2026)**

### Only One Option Correct Type

Take approximately 3 minutes for answering each question.

### Basic Mole Calculation:

1. $2.8 \times 10^{-3}$ mol of $CO_2$ is left after removing $10^{21}$ molecules from its 'x' mg sample. The mass of $CO_2$ taken initially is **[Jan'25]**
   (A) 98.3 mg (B) 196.2 mg (C) 150.4 mg (D) 48.2 mg
2. Choose the correct statements.
   (1) Weight of a substance is the amount of matter present in it.
   (2) Mass is the force exerted by the gravity on an object.
   (3) Volume is the amount of space occupied by a substance.
   (4) Temperatures below 0°C are possible in Celsius scale, but in Kelvin scale negative temperature is not possible.
   (5) Precision refers to the closeness of various measurements for the same quantity.
   Choose the correct answer from the options given below: **[Jan'25]**
   (A) 2, 3 and 4 only (B) 1, 2 and 3 only (C) 3, 4 and 5 only (D) 1, 4 and 5 only
3. Among $10^{-9}$ g (each) of the following elements, which one will have the highest number of atoms?
   Element: Pb, Po, Pr and Pt **[Apr'2025]**
   (A) Pr (B) Pt (C) Po (D) Pb
4. In Dumas' method for estimation of nitrogen 0.4 g of an organic compound gave 60 mL of nitrogen collected at 300 K temperature and 715 mm Hg pressure. The percentage composition of nitrogen in the compound is:
   (Given : Aqueous tension at 300 K = 15 mmHg) **[Apr'2025]**
   (A) 15.71% (B) 17.46% (C) 7.85% (D) 20.95%
5. On combustion 0.210 g of an organic compound containing C, H and O gave 0.127 g $H_2O$ and 0.307 g $CO_2$. The percentages of hydrogen and oxygen in the given organic compound respectively are: **[Apr'2025]**
   (A) 7.55, 43.85 (B) 6.72, 53.41 (C) 6.72, 39.87 (D) 53.41,39.6
6. By usual analysis, 1.00 g of compound (X) gave 1.79 g of magnesium pyrophosphate. The percentage of phosphorus compound (X) is: (nearest integer)
   (Given, molar mass in $gmol^{-1}$: O = 16, Mg = 24, P = 31) **[Jan'2026]**
   (A) 50 (B) 20 (C) 40 (D) 30

### Empirical Formula:

7. The elemental composition of compound is 54.2 %C, 9.2% H and 36.6%O. If the molar mass of the compound is 132g $mol^{-1}$, the molecular formula of the compound is:
   [Given: The relative atomic mass of C : H : O = 12 : 1 : 16] **[Jan'25]**
   (A) $C_4H_8O_2$ (B) $C_6H_{12}O_6$ (C) $C_4H_9O_3$ (D) $C_6H_{12}O_3$
8. On complete combustion 1.0 g of an organic compound (X) gave 1.46 g of $CO_2$ and 0.567 g of $H_2O$. The empirical formula mass of compound (X) is _____g.
   (Given molar mass in $gmol^{-1}$ C: 12, H: 1, O: 16) **[Apr'2025]**
   (A) 60 (B) 45 (C) 30 (D) 15

### Stoichiometric Calculation:

9. $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$
   Consider the above reaction, what mass of $CaCl_2$ will be formed if 250 mL of 0.76 M HCl reacts with 1000 g of $CaCO_3$?
   (Given: Molar mass of Ca, C, O, H and Cl are 40, 12, 16, 1 and 35.5 g $mol^{-1}$, respectively) **[ Apr'2025]**
   (A) 3.908 g (B) 2.636 g (C) 10.545 g (D) 5.272 g
10. Mass of magnesium required to produce 220 mL of hydrogen gas at STP on reaction with excess of dil. HCl is
    Given: Molar mass of Mg is 24 g $mol^{-1}$. **[ Apr'2025]**
    (A) 0.24 mg (B) 235.7 g (C) 2.444 g (D) 236 mg
11. 14.0 g of calcium metal is allowed to react with excess HCl at 1.0 atm pressure and 273 K. Which of the following statement is incorrect ?
    [Given : Molar mass in g $mol^{-1}$ of Ca – 40, Cl – 35.5, H – 1] **[Jan'2026]**
    (A) The limiting reagent is calcium metal. (B) 33.3 g of $CaCl_2$ is produced.
    (C) 0.35 mol of $H_2$ gas is evolved. (D) 7.84 L of $H_2$ gas is evolved.

12. Aqueous HCl reacts with $MnO_2(s)$ to form $MnCl_2(aq)$, $Cl_2(g)$ and $H_2O(l)$. What is the weight (in g) of $Cl_2$ liberated when 8.7 g of $MnO_2(s)$ is reacted with excess aqueous HCl solution ?
(Given Molar mass in g $mol^{-1}$ Mn = 55, Cl = 35.5, O = 16, H = 1) **[Jan'2026]**
(A) 14.2 (B) 21.3 (C) 71 (D) 7.1

13. In the reaction, **[Jan'2026]**
$2Al(s) + 6HCl(aq) \rightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$
(A) 67.2 L $H_2(g)$ at STP is produced for every mole of Al that reacts.
(B) 12 L HCl(aq) is consumed for every 6L $H_2(g)$ produced.
(C) 33.6 L $H_2(g)$ is produced regardless of temperature and pressure for every mole of Al that reacts.
(D) 11,2 L $H_2(g)$ at STP is produced for every mole of HCl consumed

14. $A + 2B \longrightarrow AB_2$ **[Jan'2026]**
36.0 g of 'A' (Molar mass : 60 g $mol^{-1}$) and 56.0 g of 'B' (Molar mass : 80 g $mol^{-1}$) are allowed to react. Which of the following statements are correct?
A. 'A' is the limiting reagent.
B. 77.0 g of $AB_2$ is formed
C. Molar mass of $AB_2$ is 140 g $mol^{-1}$
D. 15.0 g of A is left unreacted after the completion of reaction.
Choose the correct answer from the options given below.
(A) A and C only (B) B and D only (C) C and D only (D) A and B only

15. For the given reaction, **[Jan'2026]**
$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$
If 90g $CaCO_3$ is added to 300 mL. of HCl which contains 38.55% HCl by mass and has density 1.13 g $mL^{-1}$, then which of the following option is correct ?
Given molar mass of H, Cl, Ca and O are 1, 35.5, 40 and 16 g $mol^{-1}$ respectively.
(A) 97.30 g of HCl reacted (B) 64.97 g of HCl remains unreacted
(C) 60.32 g of HCl remains unreacted (D) 32.85 g of $CaCO_3$ remains unreacted

## Eudiometry:

16. 80 mL of a hydrocarbon on mixing with 264 mL of oxygen in a closed U-tube undergoes complete combustion. The residual gases after cooling to 273 K occupy 224 mL. When the system is treated with KOH solution, the volume decreases to 64 ml. The formula of the hydrocarbon is : **[Jan'2026]**
(A) $C_2H_6$ (B) $C_2H_2$ (C) $C_2H_4$ (D) $C_4H_{10}$

## Conc Terms:

17. 10 mL of 2 M NaOH solution is added to 20 mL of 1 M HCl solution kept in a beaker. Now, 10 mL of this mixture is poured into a volumetric flask of 100 mL containing 2 moles of HCl and made the volume upto the mark with distilled water. The solution in this flask is : **[Apr'2025]**
(A) 0.2 M NaCl solution (B) 20 M HCl solution (C) Neutral solution (D) 10 M HCl solution

18. At T(K), 100 g of 98% $H_2SO_4$ (w/w) aqueous solution is mixed with 100 g of 49% $H_2SO_4$ (w/w) aqueous solution. What is the mole fraction of $H_2SO_4$ in the resultant solution?
(Given : Atomic mass H = 1 u ; S = 32 u ; O = 16 u) **[Jan'2026]**
(Assume that temperature after mixing remains constant)
(A) 0.663 (B) 0.9 (C) 0.1 (D) 0.337

## Composition:

19. Concentrated nitric acid is labelled as 75% by mass, The volume in mL of the solution which contains 30 g of nitric acid is _____. Given: Density of nitric acid solution is 1.25 g/mL. **[Jan'25]**
(A) 32 (B) 40 (C) 55 (D) 45

20. When 1 g of compouond (X) is subjected to Kjeldahl's method for estimation of nitrogen, 15 mL 1 M $H_2SO_4$ was neutralized by ammonia evolved. The percentage of nitrogen in compound (X) is **[Jan'2026]**
(A) 42 (B) 0.21 (C) 0.42 (D) 21

21. A student has been given 0.314 g of an organic compound and asked to estimate Sulphur. During the experiment, the student has obtained 0.4813 g of barium sulphate. The percentage of sulphur present in the compound_____.
(Given Molar mass in g $mol^{-1}$ S : 32, $BaSO_4$ : 233) **[Jan'2026]**
(A) 21.05% (B) 48.24% (C) 42.10% (D) 63.15%

## Integer Type

### Mole Concept:

22. 0.5 g of an organic compound on combustion gave 1.46 g of $CO_2$ and 0.9 g of $H_2O$. The percentage of carbon in the compound is _____. (Nearest integer)
[Given: Molar mass (in $gmol^{-1}$) C: 12, H: 1, O: 16] **[Apr'2025]**

23. Fortification of food with iron is done using $FeSO_4.7H_2O$. The mass in grams of the $FeSO_4.7H_2O$ required to achieve 12 ppm of iron in 150 kg of wheat is _____ (Nearest integer)
[Given: Molar mass of Fe, S and and O respectively are 56, 32 and 16 g $mol^{-1}$] **[Apr'2025]**

24. The amount of calcium oxide produced on heating 150 kg limestone (75% pure) is. _____ kg. (Nearest integer)
Given: Molar mass (in $gmol^{-1}$) of Ca-40, O-16, C-12 **[Apr'2025]**

### Empirical Formula:

25. Quantitative analysis of an organic compound (X) shows following % composition. C : 14.5%, Cl : 64.46%, H : 1.8%
(Empirical formula mass of the compound (X) is ____ × $10^{-1}$
(Given molar mass in g $mol^{-1}$ of C : 12, H : 1, O : 16, Cl : 35.5) **[Jan'25]**

### Stoichiometric Calculation:

26. When 81.0 g of aluminium is allowed to react with 128.0 g of oxygen gas, the mass of aluminium oxide produced in grams is ____. (Nearest integer) **[Jan'25]**
Given: Molar mass of Al is 27.0 g $mol^{-1}$, Molar mass of O is 16.0 g $mol^{-1}$

27. 0.01 mole of an organic compound (X) containing 10% hydrogen, on complete combustion produced 0.9 g $H_2O$. Molar mass of (X) is _____ g $mol^{-1}$. **[Jan'25]**

28. Xg of benzoic acid on reaction with aq $NaHCO_3$ released $CO_2$ that occupied 11.2 L volume at STP. X is ____ g. **[Jan'25]**

29. Consider the following reaction occurring in the blast furnace:

$$Fe_3O_{4(s)} + 4CO_{(g)} \longrightarrow 3Fe_{(l)} + 4CO_{2(g)}$$

'x' kg of iron is produced when $2.32 \times 10^3$ kg $Fe_3O_4$ and $2.8 \times 10^2$ kg CO are brought together in the furnace. The value of 'x' is _____. (nearest integer) **[Jan'25]Jan'25]**
(Given: molar mass of $Fe_3O_4$ = 232 g $mol^{-1}$, molar mass of CO = 28 g $mol^{-1}$, molar mass of Fe = 56 g $mol^{-1}$)

30. Butane reacts with oxygen to produce carbon dioxide and water following the equation given below.

$$C_4H_{10}(g) + \frac{13}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(\ell)$$ **[Apr'2025]**

If 174.0 kg of butane is mixed with 320.0 kg of O2, the volume of water formed in liters is _____ .(Nearest integer)
[Given: (a) Molar mass of C, H, O are 12, 1, 16 g $mol^{-1}$ respectively, (b) Density of water = 1 g $mL^{-1}$]

### Conc Terms:

31. 20 mL of sodium iodide solution gave 4.74 g silver iodide when treated with excess of silver nitrate solution. The molarity of the sodium iodide solution is _____ M. (Nearest Integer value)
(Given: Na = 23, I = 127, Ag = 108, N = 14, O = 16 g $mol^{-1}$) **[Apr'2025]**

32. x mg of pure HCl was used to make an aqueous solution. 25.0 mL of 0.1 M $Ba(OH)_2$ solution is used when the HCl solution was titrated against it. The numerical value of x is ____ × $10^{-1}$. (Nearest integer)
Given: Molar mass of HCl and $Ba(OH)_2$ are 36.5 and 171.0 g $mol^{-1}$ respectively. **[Jan'2026]**

### Composition:

33. During "S" estimation, 160 mg of an organic compound gives 466 mg of barium sulphate. The percentage of Sulphur in the given compound is ____ %. (Given molar mass in g $mol^{-1}$ of Ba : 137, S : 32, O : 16) **[Jan'25]**

34. X g of nitrobenzene on nitration gave 4.2 g of m -dinitrobenzene. X = _____ g. (nearest integer)
[Given: molar mass (in $gmol^{-1}$) C: 12, H: 1, O: 16, N: 14] **[Apr'2025]**

35. An organic compound weighing 500 mg, produced 220 mg of $CO_2$, on complete combustion. The percentage composition of carbon in the compound is ____ %. (nearest integer)
(Given molar mass in $gmol^{-1}$ of C: 12, O: 16) **[Apr'2025]**

36. Sodium fusion extract of an organic compound (Y) with $CHCl_3$ and chlorine water gives violet color to the $CHCl_3$ layer. 0.15 g of (Y) gave 0.12 g of the silver halide precipitate in Carius method. Percentage of halogen in the compound (Y) is _____. (Nearest Integer)
(Given : Molar mass g $mol^{-1}$ C : 12, H : 1, Cl : 35.5, Br : 80, I : 127) **[Jan'2026]**

37. The cycloalkene (X) on bromination consumes one mole of bromine per mole of (X) and gives the product (Y) in which C:Br ratio is 3 : 1. The percentage of bromine in the product (Y) is _____ %. (Nearest Integer)
(Given : molar mass in g $mol^{-1}$ H : 1, C : 12, O : 16, Br : 80) **[Jan'2026]**

38. The mass of benzanilide obtained from the benzoylation reaction of 5.8 of aniline, if yield of product is 82%, is _____g (Nearest Integer)
(Given molar mass in g $mol^{-1}$ H : 1, C : 12, N : 14, O : 16) **[Jan'2026]**

## EXERCISE - II

### One or More Options Correct Type / Comprehension / Match the Columns Type Questions

Take approximately 4 minutes for answering each question.

1. Which is/are correct statements about 1.7 g of $NH_3$ :
(A) It contain 0.3mol H . atom
(B) it contain $2.408\times10^{23}$ atoms
(C) Mass% of hydrogen is 17.65%
(D) It contains 0.3mol N-atom

2. If 27 g of Carbon is mixed with 88 g of Oxygen and is allowed to burn to produce $CO_2$ , then :
(A) Oxygen is the limiting reagent.
(B) Volume of $CO_2$ gas produced at NTP is 50.4 L.
(C) C and O combine in mass ratio 3 : 8.
(D) Volume of unreacted $O_2$ at STP is 11.2 L.

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

4. $$\begin{array}{l} C_2H_5 \\ | \\ (CH\text{–}COOH)_n \\ | \\ C_2H_5 \end{array} + AgNO_3\,(\text{Excess}) \longrightarrow \text{Silver salt} \longrightarrow Ag\,(\text{metal})$$

If 0.5 mole of silver salt is taken and weight of residue (Ag) obtained is 216 g. (Ag = 108 g/mol).Then which the following is correct :
(A) n = 4
(B) n = 2
(C) M.wt. of silver salt is 718 g/mol
(D) M.wt. of silver salt is 388 g/mol

5. (i) $K_4Fe(CN)_6 + 3H_2SO_4 \longrightarrow 2K_2SO_4 + FeSO_4 + 6HCN$
(ii) $6HCN + 12H_2O \longrightarrow 6HCOOH + 6NH_3$
(iii) (a) $6NH_3 + 3H_2SO_4 \longrightarrow 3(NH_4)_2SO_4$
(b) $6HCOOH \xrightarrow{H_2SO_4} 6CO + 6H_2O$

Above steps of reactions occur in a container starting with one mole of $K_4[Fe(CN)_6]$, 5 mole of $H_2SO_4$ and enough water. Find out the limiting reagent in step (i) and calculate maximum moles of CO gas and $(NH_4)_2SO_4$ that can be produced.
(A) LR = $H_2SO_4$
(B) LR = $K_4Fe(CN)_6$,
(C) 6 moles of CO, 2 moles of $(NH_4)_2SO_4$
(D) 5moles of CO, 2.5 moles of $(NH_4)_2SO_4$

6. A sample of a mixture of $CaCl_2$ and NaCl weighing 4.44 g was treated with $Na_2CO_3$ to precipitate all the Ca as $CaCO_3$, which was then heated and quantitatively converted to 1.12g of CaO. (At . wt. Ca = 40, Na = 23, Cl = 35.5)
(A)Mixture contains 50%NaCl
(B) Mixture contains 60%$CaCl_2$
(C) Mass of $CaCl_2$ is 2.22 g
(D) Mass of $CaCl_2$ 1.11 g

7. For the following reaction : $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$
106.0 g of $Na_2CO_3$ reacts with 109.5 g of HCl.
Which of the following is/are correct.
(A) The HCl is in excess.
(B) 117.0 g of NaCl is formed.
(C) The volume of $CO_2$ produced at NTP is 22.4 L.
(D) None of these

8. $A + B \rightarrow A_3B_2$ (unbalanced)
$A_3B_2 + C \rightarrow A_3B_2C_2$ (unbalanced)
Above two reactions are carried out by taking 3moles each of A and B and one mole of C. Then which option is/ are correct ?
(A) 1mole of $A_3B_2C_2$ is formed
(B) 1/2 mole of $A_3B_2C_2$ is formed
(C) 1/2mole of $A_3B_2$ is formed
(D) 1/2 mole of $A_3B_2$ is left finally

9. Which of the following statements is/are correct ? 1.0 g mixture of $CaCO_3$(s) and glass beads liberate 0.22 g of $CO_2$ upon treatment with excess of HCl. (Glass does not react with HCl)
$CaCO_3 + 2HCl \longrightarrow CO_2 + H_2O + CaCl_2$
[M.wt. of $CaCO_3$ = 100, M.wt. of $CO_2$ = 44, Atomic weight of Ca = 40]
(A) The weight of $CaCO_3$ in the original mixture is 0.5 g
(B) The weight of calcium in the original mixture is 0.2 g
(C) The weight percent of calcium in the original mixture is 40%.
(D) The weight percent of Ca in the original mixture is 20%.

10. 100 g sample of clay (containing 19% $H_2O$, 40% silica, and inert impurities as rest) is partially dried so as to contain 10% $H_2O$. Which of the following is/are correct statements (s)?
(A) The percentage of silica in partially dried clay is 44.4%
(B) The mass of partially dried clay is 90.0 g.
(C) The percentage of inert impurity in partially dried clay is 45.56%
(D) The mass of water evaporated is 10.0 g

11. 21.2 g sample of impure $Na_2CO_3$ is dissolved and reacted with a solution of $CaCl_2$, the weight of precipitate of $CaCO_3$ is 10.0 g. Which of the following statements is/are correct?
(A) The % purity of $Na_2CO_3$ is 50%
(B) The percentage purity of $Na_2CO_3$ is 60%
(C) The number of moles of $Na_2CO_3 = CaCO_3 = 0.1$mol.
(D) The number of moles of NaCl formed is 0.1mol.

12. Solutions containing 23 g HCOOH is/are :
(A) 46 g of 70% $\left(\frac{w}{v}\right)$ HCOOH ($d_{solution}$ = 1.40 g/mL) (B) 50 g of 10M HCOOH ($d_{solution}$ = 1 g/mL)
(C) 50 g of 25% $\left(\frac{w}{w}\right)$ HCOOH (D) 46 g of 5M HCOOH ($d_{solution}$ = 1 g/mL)

13. Select dimensionless quantity(ies) :
(A) vapour density (B) molality (C) specific gravity (D) mass fraction

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

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

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

17. Which of the following samples contain $2.0 \times 10^{23}$ atoms
(A) 8.0 g $O_2$ (B) 3.0 g Be (C) 4.0 g C (D) 1.0 g He

18. Which of the following have the same mass?
(A) 0.1 mol of $O_2$ gas (B) 0.1 mol of $SO_2$ gas
(C) $6.02 \times 10^{23}$ molecules of $O_2$ gas (D) $1.204 \times 10^{23}$ molecules of $O_2$ gas

19. Which of the following contain same number of molecules?
(A) 0.1 mol of $CO_2$ (B) 3.2 g of $O_2$ (C) 0.1 g atom of helium gas (D) 11.2 L of $SO_2$

20. On complete oxidation, 1 mole of an organic compound gave 4 moles of water. The compound should be
(A) methanol (B) propane (C) ethylene (D) but-1-ene

21. The vapour of an organic compound requires three times its own volume of oxygen for complete combustion and produces twice its own volume of carbon dioxide. Which of the following compounds would give these results?
(A) $CH_3CHO$ (B) $C_2H_5OH$ (C) $CH_{-3}COOH$ (D) $C_2H_4$

22. Each of the following metal on reaction with dilute hydrochloric acid produces $H_2(g)$. In which of the following reaction of metal, the molar ratio of the metal used and hydrogen produced is 2:3?
(A )Cu (B) Al (C) Si (D) Zn

23. Solution (s) containing 40gm NaOH is/ are
(A) 50 gm of 80% (w/w) NaOH (B) 50gm of 80% (w/v) NaOH [$d_{soln}$.=1.2 gm/ml]
(C) 50 gm of 20 M NaOH [$d_{soln}$.=1 gm/ml] (D) 50 gm of 5 m NaOH

24. The incorrect statements (s) regarding 2M $MgCl_2$ aqueous solution is/ are $[d_{solution} = 1.09gm/ml]$
(A) Molality of $Cl^-$ is 4.44 m (B) Mole fraction of $MgCl_2$ is exactly 0.038
(C) The conc. of $MgCl_2$ is 19% w/v (D) The conc. of $MgCl_2$ is $19x10^4$ ppm

25. 1 g atom of nitrogen represents :
(A) $6.02 \times 10^{23}$ $N_2$ molecules (B) 22.4 litre of $N_2$ at 1 atm and 273 K
(C) 11.2 litre of $N_2$ at 1 atm and 273 K (D) 14 g of nitrogen

26. 1 g molecule of $V_2O_5$ contains:
(A) 5 mole of oxygen atom (B) 2 mole of V atom
(C) 1 mole of oxygen atom (D) 2.5 mole of oxygen atom

27. Select the dimensionless quantity(ies):
(A) vapour density (B) molality (C) specific gravity (D) mass fraction

28. Which of the following concentration terms is/are affected by a change in temperature?
(A) Molarity (B) Molality (C) Normality (D) Specific gravity

29. 1 mole of $Ba(OH)_2$ will exactly neutralize :
(A) 0.5 mole HCl (B) 1 mole of $H_2SO_4$ (C) 1 mole of $H_3PO_3$ (D) 2 mole of $H_3PO_2$

30. The pair of species having different percentage (mass) of carbon is:
(A) $CH_3COOH$ and $C_6H_{12}O_6$ (B) $CH_3COOH$ and $C_2H_5OH$
(C) $HCOOCH_3$ and HCOOH (D) $C_2H_5OH$ and $CH_3OCH_3$

31. 30 mL of $CH_3OH$ (d = 0.8 g/cm$^3$) is mixed with 60 mL of $C_2H_5OH$ (d=0.92 g/cm$^3$) at 25°C to form a solution of density 0.88 g/cm$^3$. Select the correct option:
(A) Molarity and molality of resulting solution are 6.33 and 13.59 respectively
(B) The mole fraction of solute and molality are 0.385 and 13.59 respectively
(C) Molarity and % change in volume are 13.59 and zero respectively
(D) Mole fraction of solvent and molality are 0.615 and 13.59 respectively

32. Which of the following is/are correct for 17 g/L of $H_2O_2$ solution?
(A) Volume strengths is 5.6 at 273 K and 1 atm
(B) Molarity of solution is 0.5 M
(C) 1 mL of this solution gives 2.8 mL. $O_2$ at 273 K and 2 atm
(D) The normality of solution is 2 N

33. Solutions containing 23 g HCOOH is/are :
(A) 46 g of 70% $\left(\frac{w}{V}\right)$ HCOOH ($d_{solution}$ = 1.40 g/mL) (B) 50 g of 10 M HCOOH ($d_{solution}$ = 1 g/mL)
(C) 50 g of 25% $\left(\frac{w}{w}\right)$ HCOOH (D) 46 g of 5 M HCOOH ($d_{solution}$ = 1 g/mL.)

34. A sample of $H_2O_2$ solution labelled as “28 volume” has density of 265 g/L. Mark the correct option(s) representing concentration of same solution in other units:
(A) $M_{H_2O_2} = 2.5$ (B) $\%\frac{w}{V} = 17$
(C) Mole fraction of $H_2O_2$ = 0.2 (D) $m_{H_2O_2} = 13.88$

## Comprehension Type Questions

**(Paragraph for question nos. 35 to 37)**

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

$Fe + Br_2 \rightarrow FeBr_2$ ——————————(i)

$FeBr_2 + Br_2 \rightarrow Fe_3Br_8$ ——————————(ii) (Not balanced)

$Fe_3Br_8 + Na_2CO_3 \rightarrow NaBr + CO_2 + Fe_3O_4$ ——————————(iii) (Not balanced)

35. Mass of iron required to produce $2.06 \times 10^3$ kg NaBr
(A) 420 gm (B) 420 kg (C) $4.2 \times 10^5$kg (D) $4.2 \times 10^8$kg

36. If the yield of (ii) is 60% & (iii) reaction is 70% then mass of iron required to produce $2.06 \times 10^3$kg NaBr
(A) 105 kg (B) 105 gm (C) $10^3$ kg (D) none of these

37. If yield of (iii) reaction is 90% then mole of $CO_2$ formed when $2.06 \times 10^3$ gm NaBr is formed
(A) 20 (B) 10 (C) 40 (D) none of these

## Comprehension Type Questions

**(Paragraph for question nos. 38 to 41)**

Oleum is considered as a solution of $SO_3$ in $H_2SO_4$, which is obtained by passing $SO_3$ in solution of $H_2SO_4$. When 100 g sample of oleum is diluted with desired mass of $H_2O$ then the total mass of $H_2SO_4$ obtained after dilution is known as % labelling in oleum.

For example, a oleum bottle labelled as '109% $H_2SO_4$' means the 109 g total mass of pure $H_2SO_4$ will be formed when 100 g of oleum is diluted by 9 g of $H_2O$ which combines with all the free $SO_3$ present in oleum to form $H_2SO_4$ as

$SO_3 + H_2O \longrightarrow H_2SO_4$

38. What is the % of free $SO_3$ in an oleum that is labelled as '104.5% $H_2SO_4$' ?
(A) 6.73 (B) 20 (C) 40 (D) 3.67

39. 9.0 g water is added into oleum sample labelled as "112%" $H_2SO_4$ then the amount of free $SO_3$ remaining in the solution is: (STP = 1 atm and 273 K)
(A) 14.93 L at STP (B) 7.46 L at STP (C) 3.73 L at STP (D) 11.2 L at STP

40. If excess water is added into a bottle sample labelled as "112% $H_2SO_4$" and is reacted with 5.3 g $Na_2CO_3$, then find the volume of $CO_2$ evolved at 1 atm pressure and 300 K temperature after the completion of the reaction:
(A) 2.46 L (B) 24.6 L (C) 1.23 L (D) 12.3 L

41. 1 g of oleum sample is diluted with water. The solution required 54 mL of 0.4 N NaOH for complete neutralization. The % of free $SO_3$ in the sample is :
(A) 74 (B) 26 (C) 20 (D) None of these

## Comprehension Type Questions

**(Paragraph for question nos. 42 to 43)**

The strength of $H_2O_2$ is expressed in several ways like molarity, normality, % (w/v), volume strength, etc. The strength of "10 V" means 1 volume of $H_2O_2$ on decomposition gives 10 volumes of oxygen at 1 atm and 273 K or 1 litre of $H_2O_2$ gives 10 litre of $O_2$ at 1 atm and 273 K The decomposition of $H_2O_2$ is shown as under:

$$H_2O_2(aq) \longrightarrow H_2O(l) + \frac{1}{2} O_2(g)$$

$H_2O_2$ can acts as oxidising as well as reducing agent. As oxidizing agent $H_2O_2$ is converted into $H_2O$ and as reducing agent $H_2O_2$ is converted into $O_2$. For both cases its n-factor is 2.

$\therefore$ Normality of $H_2O_2$ solution = 2 × Molarity of $H_2O_2$ solution

42. What is the molarity of "11.2 V" $H_2O_2$?
(A) 1 M (B) 2 M (C) 5.6 M (D) 11.2 M

43. What is the percentage strength (% w/V) of "11.2 V" $H_2O_2$?
(A) 1.7 (B) 3.4 (C) 34 (D) None of these

## Comprehension Type Questions

**(Paragraph for question nos. 44 to 46)**

Consider the following series of reactions:

$$Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$$

$$3NaClO \longrightarrow 2NaCl + NaClO_3$$

$$4NaClO_3 \longrightarrow 3NaClO_4 + NaCl$$

44. How much $Cl_2$ is required to prepare 122.5 g of $NaClO_4$ by above sequencial reactions?
(A) 284 g (B) 213 g (C) 142 g (D) 71 g

45. How many moles of NaCl will be formed by using 1 mole $Cl_2$ and other reagents in excess?
(A) $\frac{1}{12}$mole (B) 1.67 mole (C) 1.75 mole (D) 0.75 mole

46. How many moles of $NaClO_3$ obtained after the complection of reaction by taking 1 mole $Cl_2$ and other reagents in excess?
(A) $\frac{1}{3}$mole (B) Zero (C) $\frac{1}{4}$mole (D) 1 mole

## Match the Column Type Questions

Column-I and Column-II contain four entries in each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

47.

| **Column-I** | **Column-II** |
|---|---|
| (A) 0.5 mole of $SO_2(g)$ | (P) Occupy 11.2 L at 1 atm and 273 K |
| (B) 1g of $H_2(g)$ | (Q) Weighs 24 g |
| (C) 0.5 mole of $O_3(g)$ | (R) Total no. of atoms = $1.5 \times N_A$ |
| (D) 1 g molecule of $O_2(g)$ | (S) Weighs 32 g |

48.

| **Column-I** | **Column-II** |
|---|---|
| (A) 44 g $CO_2$ gas | (P) 1g molecule |
| (B) 35.2 g of $CH_4$ | (Q) $N_A$ molecule |
| (C) 48 g of $O_3$ gas | (R) 22 $N_A$ electrons |
| (D) 44 g of $N_2O$ gas | (S) 49.28 L at 1 atm and 273 K |
| | (T) $N_A$ atoms of oxygen |

49.

| **Column-I** **[Atomic masses (M)]** | | | | **Column-II** **(% composition of heavier isotope)** |
|---|---|---|---|---|
| | Isotope-I | Isotope-II | Average | |
| (A) | (z – 1) | (z + 3) | z | (P) 25% by moles |
| (B) | (z + 1) | (z + 3) | (z + 2) | (Q) 50% by moles |
| (C) | z | 3z | 2 z | (R) % by mass dependent on z |
| (D) | (z – 1) | (z + 1) | z | (S) 75% by mass |

## EXERCISE - III

### Integer Type

### (Give answer of each questions upto 2 decimal place)

01. What volume of a liquid (in L) will contain 10 mole? If molar mass of liquid is 280 and its density is 1.4 g/mL.
02. 16 g of $SO_x$ gas occupies 5.6 L at 1 atm and 273 K. What will be the value of x?
03. 200 mL of 1 M HCl is mixed with 300 mL of 6 M HCl and the final solution is diluted to 1000 mL. Calculate molar concentration of $[H^+]$ ion.
04. $N_2(g)$ reacts with $H_2(g)$ in either of the following ways depending upon supply of $H_2(g)$:

    $$N_2(g) + H_2(g) \longrightarrow N_2H_2(l)$$

    $$N_2(g) + 2H_2(g) \longrightarrow N_2H_4(g)$$

    If 5 L $N_2(g)$ and 3 L $H_2(g)$ are taken initially (at same temperature and pressure), calculate the concentration in volume after the reaction (in L).
05. One commercial system removes $SO_2$ emission from smoke at 95°C by the following set of reaction:

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

    $$SO_2Cl_2(g) + H_2O(l) \longrightarrow H_2SO_4 + HCl$$

    $$H_2SO_4 + Ca(OH)_2 \longrightarrow CaSO_4 + H_2O$$

    How many grams of $CaSO_4$ may be produced from 3.78 g of $SO_2$?
06. W is the mass of iron (in g) which will be converted into $Fe_3O_4$ by the action of 18 g of steam on it. What is the value of W/7?

    $$Fe + H_2O \longrightarrow Fe_3O_4 + H_2$$

07. Calculate the total moles of atoms of each element present in 122.5 g of $KClO_3$.
08. One gram of a metallic chloride was found to contain 0.835 g of chlorine. Its vapour density is 85.5. If its molecular formula is $M_xCl_y$, then what is value of (x + y)?
09. A compound contains three elements C, H & N in mass ratio of 18 : 2 : 7. If molar mass of compound is 108 g/mol then how many moles of nitrogen atoms present in 1 mole of compound?
10. Hg reacts with $Cl_2$ to form $Hg_2Cl_2$ and $HgCl_2$. If 1.5 mole of Hg and 1.0 mole of $Cl_2$ are added. Calculate the final molar ratio of $HgCl_2$ to $Hg_2Cl_2$. (Multiply your answer by 4)
11. How many millilitre of 36.5% w/w HCl (aq) solution (d = 1.20 g/mL) will be required to prepare 1080 mL of decimolar solution $\left(\frac{M}{10}\right)$?
12. Calculate how much mass (in kg) of $(CF_2)_n$ will be produced if 1.52 kg $F_2$ is consumed in the following reaction?

    $$2CoF_2 + F_2 \longrightarrow 2CoF_3$$

    $$(CH_2)_n + 4nCoF_3 \longrightarrow (CF_2)_n + 2nHF + 4nCoF_2$$

13. A gaseous mixture of propane ($C_3H_8$) and butane ($C_4H_{10}$) of volume 3 L on complete combustion produces 10 L of $CO_2$ at STP.

    If $x = \frac{\text{Volume of propane}}{\text{Volume of butane}}$ then what is the value of x?
14. How many mole of NaOH is required to neutralise 198 g of equimolar mixture of $H_2SO_4$ and $H_3PO_4$ completely?
15. 0.1M aq. solution of $Al_2(SO_4)_3$ and 0.2 M solution of $CaCl_2$ are mixed such that ratio of molarity of negative ions to positive ions is 1.6, then calculate ratio of volume in which $Al_2(SO_4)_3$ and $CaCl_2$ solutions are mixed. (Assume no any precipitates is formed)
16. Density of a non-reacting gaseous mixture ($CH_4$ and $C_2H_6$) at 1 atm and 273 K is 0.75 gm/litre. Calculate mole % of $CH_4$ in the mixture.
17. 24 g carbon reacts with 48 g $O_2$ such that no any react will be left and simultaneously produced CO and $CO_2$ gases. Molar mass of final gaseous mixture is:

18. 21 g of solid $MgCO_3$ is dissolved in 200 mL, 7.3% $\left(\frac{w}{V}\right)$ aqueous HCl solution.

    Calculate volume of $CO_2$ gas evolved at 1 atm and 273 K.

    $MgCO_3(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$

19. Alcohol levels in blood can be determined by a redox titration with potassium dichromate according to the balanced equation

    $C_2H_5OH(aq) + 2Cr_2O_7^{2-}(aq) + 16H^+(aq) \longrightarrow 2CO_2(g) + 4Cr^{3+}(aq) + 11H_2O(\ell)$

    What is the blood alcohol level in mass percent if 10 mL of 0.05 M $K_2Cr_2O_7$ is required for titration of a 11.5 g sample of blood?

20. What volume of (in L) 40% $\frac{w}{w}$ aq. NaOH solution (d = 1.25 g/mL) is required to prepare 2M, 5L of NaOH solution?

21. An aqueous KCl solution of density 1.20 g $mL^{-1}$ has a molality of 3.30 mol $kg^{-1}$. The molarity of the solution in mol $L^{-1}$ is _____ . (Nearest integer) [Molar mass of KCl = 74.5]

22. If 250 mL of $\left(\frac{M}{2}\right)$ $HNO_3(aq)$ solution is mixed with another 750 mL of 9.45% w/V of $HNO_3(aq)$ solution. Find molarity of resultant solution.

23. A 500 mL fresh solution of $H_2O_2(aq)$ can liberate as much oxygen which is just sufficient for complete combustion of 4 g methane. The volume strength of $H_2O_2(aq)$ solution at STP, is _____.

24. Volume strength of an aqueous solution of $H_2O_2$(d = 1.2085g / mL) is 2.8375. Calculate molality of $H_2O_2$ solution.

25. In Carius method for estimation of halogens, 0.2 g of an organic compound gave 0.188 g AgBr. The percentage of bromine in the compound is ..... (Nearest integer) [Atomic mass: Ag = 108, Br = 80]

26. Calculate the mass of $SO_2$ (in g) produced if 110 g $P_4S_3$ is mixed with 192 g of $O_2$ and % yield is 75. Consider the chemical reaction as $P_4S_3 + O_2 \longrightarrow P_4O_{10} + SO_2$ (Unbalanced)

27. Consider following reaction:

    $$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$$

    400 mL of 20.8% $\left(\frac{w}{V}\right)$ $BaCl_2(aq)$ solution and 100 mL of 4.9% $\left(\frac{w}{V}\right)$ $H_2SO_4(aq)$ solution are mixed. If 0.045 mol of $BaSO_4$ obtained then calculate % yield of the reaction..

    (At. wt. Ba = 137, Cl = 35.5, S = 32, H = 1, O = 16)

28. 50% by volume of $C_3H_8$ present in a gaseous mixture of $C_3H_8$ , $CH_4$ and CO. If volume of $CO_2$ produced is V litre when 600 mL of gaseous mixture treated with excess of $O_2$ .Calculate the value of V.

29. 80 g of a mixture of MgO and CaO when treated with an excess of $H_2SO_4$, produced $\left(\frac{1368}{7}\right)$ g of the mixture of $MgSO_4$ and $CaSO_4$. What is the mass percentage of MgO present in original mixture?

30. $NH_3$ decompose as following $2NH_3 \longrightarrow N_2 + 3H_2$

    Calculate % decrease in vapour density of mixture when 100% reaction takes place.

31. Calculate the amount of $H_2SO_4$ produced (in gm) when 40 ml $H_2O$ (d-0.9 gm/ml) reacts with 49.26/$SO_3$ at 1 atm. and 300 K, according to the following reaction?

    $H_2O + SO_3 \longrightarrow H_2SO_4$

32. In Carius method for estimation of halogens, 0.2 g of an organic compound gave 0.188 g AgBr. The percentage of bromine in the compound is.....(Nearest integer)
    [Atomic mass: Ag = 108, Br = 80]

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

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

    According to the above sequence of reactions, how much $H_2SO_4$ (in gm) will 1200 gm of PbS produce? (Pb = 208)

34. 24g carbon reacts with 48 g $O_2$ such that no any reactant will be left and simultaneously produced CO and $CO_2$ gases. Molar mass of final gaseous mixture is:

35. An aqueous KCl solution of density 1.20g $mL^{-1}$ has a molality of 3.30 mol $kg^{-1}$.
The molarity of the solution in mol $L^{-1}$ is _____. (Nearest integer)
[Molar mass of KCl = 74.5]

36. Density of a non-reacting gaseous mixture ($CH_4$ and $C_2H_6$) at 1 atm and 273 K is 0.75 gm/litre.
Calculate mole % of $CH_4$ in the mixture.

37. 21g of solid $MgCO_3$ is dissolved in 200 mL, 7.3% $\left(\frac{w}{V}\right)$ aqueous HCl solution.

Calculate volume of $CO_2$ gas evolved at 1 atm and 273 K.

$$MgCO_3(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

38. Alcohol levels in blood can be determined by a redox titration with potassium dichromate according to the balanced equation

$$C_2H_5OH(aq) + 2Cr_2O_7^{2-}(aq) + 16H^+(aq) \longrightarrow 2CO_2(g) + 4Cr^{3+}(aq) + 11\,H_2O\,(l)$$

What is the blood alcohol level in mass percent if 10 mL of 0.05 M $K_2Cr_2O_7$ is required for titration of a 11.5g sample of blood?

39. What volume of (in L) 40% $\frac{w}{w}$ aq. NaOH solution (d = 1.25 g/mL) is required to prepare 2 M, 5 L of NaOH solution?

40. Volume strength of an aqueous solution of $H_2O_2$(d = 1.2085 g/mL) is 2.8375.
Calculate molality of $H_2O_2$ solution.

41. 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

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

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

$$KOH\,(s) + CO_2\,(g) \longrightarrow KHCO_3(s)$$

(A) What mass of $KO_2$ generates 48 gm of oxygen?
(B) What mass of $CO_2$ can be removed from the apparatus by 63.9 gm of $KO_2$?

42. Sodium chlorate, $NaClO_3$, can be prepared by the following series of reactions:

$$2KMnO_4 + 16\,HCl \longrightarrow 2\,KCl + 2\,MnCl_2 + 8H_2O + 5Cl_2$$

$$6Cl_2 + 6Ca(OH)_2 \longrightarrow Ca(ClO_3)_2 + 5\,CaCl_2 + 6H_2O$$

$$Ca(ClO_3)_2 + Na_2SO_4 \longrightarrow CaSO_4 + 2NaClO_3$$

What mass of $NaClO_3$ can be prepared from 100 ml of concentrated HCl (density 1.28 gm/ml and 36.5% by mass)? Assume all other substances are present in excess amounts.

43. $P_4S_3 + 8O_2 \longrightarrow P_4\,O_{10} + 3SO_2$
Calculate minimum mass of $P_4S_3$ is required to produce at least 0.96 gm of each product.

44. By the reaction of carbon and oxygen, a mixture of CO and $CO_2$ is obtained. What is the mass ratio of the mixture obtained when 20 grams of $O_2$ reacts completely with 12 grams of carbon?

45. In a gravimetric 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 $Mg(NH_4)PO_4.6H_2O$. This is heated and decomposed to magnesium pyrophosphate, $Mg_2P_2O_7$ which is weighed. Asolution of $NaH_2PO_4$ yielded 3.33 gm of $Mg_2P_2O_7$.What weight of $NaH_2PO_4$ was present originally?

# ANSWER KEY

## EXERCISE - I (A)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | C | 2. | B | 3. | C | 4. | C | 5. | B | 6. | D | 7. | A | 8. | D |
| 9. | B | 10. | A | 11. | D | 12. | B | 13. | D | 14. | A | 15. | A | 16. | C |
| 17. | A | 18. | C | 19. | A | 20. | B | 21. | C | 22. | B | 23. | A | 24. | B |
| 25. | B | 26. | B | 27. | A | 28. | B | 29. | C | 30. | B | 31. | D | 32. | D |
| 33. | A | 34. | A | 35. | B | 36. | B | 37. | C | 38. | C | 39. | C | 40. | D |
| 41. | B | 42. | B | 43. | B | 44. | A | 45. | A | 46. | A | 47. | B | 48. | B |
| 49. | B | 50. | C | 51. | C | 52. | D | 53. | A | 54. | D | 55. | B | 56. | A |
| 57. | B | 58. | A | 59. | B | 60. | B | 61. | A | 62. | B | 63. | C | 64. | B |
| 65. | A | 66. | B | 67. | A | 68. | A | 69. | A | 70. | A | 71. | B | 72. | C |
| 73. | B | 74. | C | 75. | D | 76. | A | 77. | B | 78. | D | 79. | B | 80. | B |
| 81. | B | 82. | B | 83. | A | 84. | D | 85. | C | 86. | B | 87. | B | 88. | A |
| 89. | C | 90. | B | 91. | C | 92. | A | 93. | C | 94. | B | 95. | D | 96. | D |
| 97. | A | 98. | A | 99. | D | 100. | B | 101. | D | 102. | C | 103. | A | 104. | A |
| 105. | D | 106. | A | 107. | B | 108. | B | 109. | A | 110. | C | | | | |

## EXERCISE - I (B)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | B | 2. | C | 3. | A | 4. | A | 5. | B | 6. | A | 7. | D | 8. | C |
| 9. | C | 10. | D | 11. | B | 12. | D | 13. | D | 14. | B | 15. | B | 16. | B |
| 17. | B | 18. | A | 19. | A | 20. | A | 21. | A | **22.** | 80 | **23.** | 9 | **24.** | 63 |
| **25.** | 1655 | **26.** | 153 | **27.** | 100 | **28.** | 61 | **29.** | 420 | **30.** | 138 | **31.** | 1 | **32.** | 1825 |
| **33.** | 40 | **34.** | 3 | **35.** | 12 | **36.** | 43 | **37.** | 66 | **38.** | 10 | | | | |

## EXERCISE-II

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | ABC | 2. | BCD | 3. | AB | 4. | AC | 5. | BC | 6. | AC | 7. | ABC | 8. | B |
| 9. | ABD | 10. | ABCD | 11. | AC | 12. | AB | 13. | ACD | 14. | ACD | 15. | BD | 16. | ABD |
| 17. | BC | 18. | BD | 19. | ABC | 20. | BD | 21. | BD | 22. | B | 23. | AC | 24. | BD |
| 25. | CD | 26. | AB | 27. | ACD | 28. | ACD | 29. | BCD | 30. | BC | 31. | BD | 32. | ABC |
| 33. | AB | 34. | ACD | 35. | B | 36. | C | 37. | B | 38. | D | 39. | C | 40. | C |
| 41. | B | 42. | A | 43. | B | 44. | A | 45. | C | 46. | B | | | | |

47. A $\rightarrow$ P, R, S; B $\rightarrow$ P; C $\rightarrow$ P, Q, R; D $\rightarrow$ S

48. A $\rightarrow$ P, Q, R; B $\rightarrow$ R, S; C $\rightarrow$ P,Q ; D $\rightarrow$ P, Q, R, T

49. A $\rightarrow$ P, R; B $\rightarrow$ Q, R; C $\rightarrow$ Q, S; D $\rightarrow$ Q, R

## EXERCISE-III

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | 2 | **2.** | 2 | **3.** | 2 | **4.** | 6 | **5.** | 8.03 | **6.** | 6 | **7.** | 5 | **8.** | 5 |
| **9.** | 2 | **10.** | 10 | **11.** | 9 | **12.** | 2 | **13.** | 2 | **14.** | 5.05 | **15.** | 4 | **16.** | 94.29 |
| **17.** | 36.00 | **18.** | 4.48 | **19.** | 0.10 | **20.** | 0.80 | **21.** | 3.00 | **22.** | 1.25 | **23.** | 22.70 | **24.** | 0.21 |
| **25.** | 40.00 | **26.** | 72.00 | **27.** | 90.00 | **28.** | 1.20 | **29.** | 2.50 | **30.** | 50.00 | **31.** | 60.34 | **32.** | 40 |
| **33.** | 490 | **34.** | 36 | **35.** | 3 | **36.** | 94.29 | **37.** | 4.48 | **38.** | 0.10 | **39.** | 0.80 | **40.** | 0.21 |

**41.** (A) 142 gm (B) 39.6gm **42.** 14.2 gm **43.** 1.1 gm **44.** $m_{CO} : m_{CO_2} = 21 : 11$ **45.** 3.6 gm