2

Mole Concept and Equivalent Concept

For Elements

$$1 \text{ g-atom} = N \text{ atoms} = 6.023 \times 10^{23} \text{ atoms}$$
$$= \text{g-atomic mass}$$

e.g., $1 \text{ g-atom of oxygen} = N \text{ atoms of oxygen}$
$$= 6.023 \times 10^{23} \text{ atoms of oxygen}$$
$$= 16 \text{ g}$$

g-atomic mass : It is the mass of Avogadro's number (N) atoms in g.

Mass of one oxygen atom $= 16$ amu
$$= 16 \times 1.66 \times 10^{-24} \text{ g}$$

$\therefore$ Mass of N oxygen atom
$$= 16 \times 1.66 \times 10^{-24} \times 6.023 \times 10^{23} \text{ g} = 16 \text{ g}$$

$$\text{g-atom of element} = \frac{\text{Mass of element}}{\text{Atomic mass of element}} \quad \text{...(1)}$$

$$\text{No. of atoms of element} = \text{g-atom of element} \times \text{Av. No.} \quad \text{...(2)}$$

For Compounds

$$1 \text{ g-molecule or } 1 \text{ mole} = N \text{ molecules}$$
$$= 6.023 \times 10^{23} \text{ molecules}$$
$$= \text{g molar mass}$$

$$1 \text{ mole of } O_2 = N \text{ molecules of } O_2$$
$$= 6.023 \times 10^{23} \text{ molecules of } O_2 = 32 \text{ g}$$

g-molar mass : It is the mass of Avogadro's number (N) molecules in g.

Mass of one O_2 molecule $= 32 \text{ amu} = 32 \times 1.66 \times 10^{-24}$ g

$\therefore$ Mass of N molecules of O_2
$$= 32 \times 1.66 \times 10^{-24} \times 6.023 \times 10^{23} = 32 \text{ g}$$

$$\text{Mole} = \frac{\text{mass}}{\text{molar mass}} \quad \text{...(3)}$$

$$\text{Molecules} = \text{mole} \times \text{Av. No.} \quad \text{...(4)}$$

Avogadro's hypothesis : Equal volumes of gases or vapours obeying gas laws under similar conditions of P and T contain equal no. of molecules.

The statement reveals the following facts:

(1) If $P_1 = P_2, T_1 = T_2$ (for two gases)
Then at $V_1 = V_2$; $n_1 = n_2$

(2) One mole of all gases contain N molecules.

Dulong and Petits law

Atomic mass × specific heat (cal/g) ≈ 6.4 (for metals only)

Equivalent mass

Equivalent mass of a substance depends upon the nature of chemical reaction in which substance takes part. The evaluation of equivalent mass of a substance may therefore be cautiously made.

(A) Equivalent mass of an element in a redox change:

Equivalent mass of a compound
$$= \frac{\text{Molar mass}}{\text{No. of '}e\text{' lost or gained during redox change by one molecule of that compound}} \quad \text{...(5)}$$

Equivalent mass of an element
$$= \frac{\text{Atomic mass}}{\text{No. of '}e\text{' lost or gained during redox change by one atom of that element}} \quad \text{...(6)}$$

NOTE : (i) For details see Chapter 8.
(ii) In case of redox change, determine equivalent mass by the formulae given above and do not use any other formulae given below.

(B) Equivalent mass of an element or compound in a non redox change:

(1) Equivalent mass of an element

$$E = \frac{\text{Atomic mass of element}}{\text{Valency of element}} \quad \text{...(7)}$$

(2) Equivalent mass of ionic compound

$$E=\frac{\text{Formula mass of ionic compound}}{\text{Total charge on cations or anions}} \qquad ...(8)$$

Also Equivalent mass of an ionic compound
= Equivalent mass of I part + Equivalent mass of II part ...(9)

Eq. (9) is not valid for hydrated compounds.

e.g., (i) $E_{\text{NaCl}}=\frac{\text{F. mass of NaCl}}{1}=\frac{58.5}{1}=58.$ By (8)

(ii) $E_{\text{AlCl}_3}=\frac{\text{F. mass of AlCl}_3}{3}=\frac{133.5}{3}=44.5$ By (8)

$E_{\text{AlCl}_3}=\text{E. mass}_{\text{Al}}+\text{E. mass}_{\text{Cl}}=\frac{27}{3}+35.5=44.5$ By (9)

(iii) $K_2SO_4\cdot Al_2(SO_4)_3\cdot 24H_2O : E_{\text{Alum}}=\frac{M}{8}$ By (9)

(3) Equivalent mass of an acid or base:

$$\text{Eq. mass}_{\text{Acid}}=\frac{\text{Molar mass of acid}}{\text{Basicity}} \qquad ...(10)$$

(Basicity is no. of H atoms replaced from one molecule of acid)

$$\text{Eq. mass}_{\text{Base}}=\frac{\text{Molar mass of base}}{\text{Acidity}} \qquad ...(11)$$

(Acidity is the no. of OH groups replaced from one molecule of base)

e.g., $\underset{\text{Basicity}=2}{H_3PO_3}+\underset{\text{Acidity}=1}{2NaOH}\longrightarrow Na_2HPO_3+2H_2O$

$\therefore \quad E_{H_3PO_3}=\frac{M}{2} \qquad E_{\text{NaOH}}=\frac{M}{1}$

Note : However if reaction is given as:

(i) $H_3PO_3+NaOH\longrightarrow NaH_2PO_3+H_2O$

$E_{H_3PO_3}=\frac{M}{1}$

(ii) $Al(OH)_3+HCl\longrightarrow Al(OH)_2Cl+H_2O$

$E_{Al(OH)_3}=\frac{M}{1}$

(4) Equivalent mass of an ion or radical :

$$\text{Eq. mass of ion or radical}=\frac{\text{Formula mass of ion or radical}}{\text{Charge on ion}} \qquad ...(12)$$

(5) Equivalent mass of an acid salt :

$$E=\frac{\text{Molar mass of acid salt}}{\text{Replaceable } H \text{ atoms in acid salt}} \qquad ...(13)$$

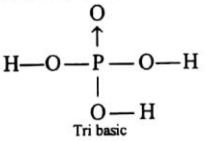
e.g. $E_{NaH_2PO_4}=\frac{M}{2}$

However if reaction is given as :

$NaH_2PO_4+NaOH\longrightarrow Na_2HPO_4+H_2O$

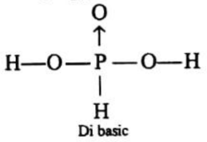
then $E_{NaH_2PO_4}=\frac{M}{1}$

An acid salt is one which has replaceable H atom, *e.g.*, $NaHCO_3, NaHSO_4, Na_2HPO_4$. However, Na_2HPO_3 is not an acid salt since it does not have replaceable H atom because H_3PO_3 is dibasic acid. In oxy acids only those H are replaceable which are attached on O atom, *e.g.*,



$H{-}O{-}\overset{\overset{O}{\uparrow}}{\underset{\underset{O-H}{|}}{P}}{-}O{-}H$

Tri basic



$H{-}O{-}\overset{\overset{O}{\uparrow}}{\underset{\underset{H}{|}}{P}}{-}O{-}H$

Di basic

(6) Equivalent mass of basic salt :

$$E=\frac{\text{Molar mass of basic salt}}{\text{Replaceable OH gp in basic salt}} \qquad ...(14)$$

e.g. $E_{Al(OH)_2Cl}=\frac{M}{2}$

NOTE : 1. The unit of equivalent mass is $g\,eq^{-1}$.

2. However in some cases either of these formula reported does not give equivalent of the species required, *e.g.*, equivalent mass of O_3 in the reaction $2O_3\longrightarrow 3O_2$. The equivalent mass in such cases can be determined by the concept of equivalent mass, *i.e.*, definition—Eq. mass of an species is the mass which either reacts or displaces 1 part H or 8 part O or 35.5 part Cl. For the above reaction stoichiometry suggests,

$2 \text{ mole } O_3 \equiv 3 \text{ mole } O_2$

$\equiv 96\,g\ O_2$

$\equiv 12\,\text{eq. } O_2 \qquad (8\,g\ O_2=1\,\text{eq.})$

$\therefore \quad 1 \text{ mole } O_3\equiv 6\,\text{eq. } O_2=6\,\text{eq. } O_3$

or Valence factor for $O_3=6$

$\therefore \quad E_{O_3}=\frac{48}{6}=\mathbf{8}$

Stoichiometric concept :

	$2H_2(g)$	+	$O_2(g)$	$\longrightarrow$	$2H_2O(g)$
Mole ratio for reaction	2	:	1	:	2
Molecule ratio for reaction	2	:	1	:	2
Mass ratio for reaction	4	:	32	:	36
Volume ratio for reaction	2	:	1	:	2

(Volume ratio for gaseous phase reaction only at same *P*, *T*)

Percentage yield : $\%\ \text{yield}=\frac{\text{Actual yield}}{\text{Theoretical yield}}\times 100$ ...(15)

Limiting reagent : The substance that is completely consumed in a reaction is called **limiting reagent** as it determines or limits, the amount of product. The other reactant present in excess is called excess reagent, *e.g.*,

	$2H_2(g)$	$+\,O_2(g)\longrightarrow$	$2H_2O(g)$
Mole before reaction	10	7	0
Mole after reaction	0	2	10

Thus O_2 is excess reagent and H_2 in limiting reagent

Methods for expressing concentration of solutions

1. Normality : It is defined as no. of equivalents of a solute present in one litre of solution. Its unit is eq. litre.

$$N=\frac{\text{Equivalent of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{Mass of solute}}{\text{Equivalent mass of solute} \times V \text{ in litre}}$$

$$N = \frac{w}{E \times V \text{ in } (l)} \qquad \text{...(16)}$$

$$= \frac{w \times 1000}{E \times V \text{ in (mL)}} \qquad \text{...(17)}$$

Also, **Equivalent** $= N \times V$ **(in L)** $= \dfrac{\textbf{Mass of solute}}{\textbf{Eq. mass of solute}}$ ...(18)

and **Milli equivalent** $= N \times V$ **(in L)**

$$= \frac{\textbf{Mass of solute}}{\textbf{Eq. mass of solute}} \times \mathbf{1000} \qquad \text{...(19)}$$

NOTE :
1. No doubt milli equivalent should be written as meq. (milli equivalent) but for the sake of our problems by milli equivalent, we have used Meq.
2. Eqs. (18) and (19) are commonly used in solving numericals practically in each chapter. One should be able to learn, understand and apply these equations in order to move advance to get solutions in easy and precise manner.
3. Another striking fact regarding equivalent and milli equivalent is—**Equivalent and milli equivalent of reactants reacts in equal number to give same number of equivalent or milli equivalent of products separately.**

Example. *20 mL of 0.1N $BaCl_2$ is mixed with 30 mL of 0.2N $Al_2(SO_4)_3$. How many g of $BaSO_4$ are formed?*

	$BaCl_2$ +	$Al_2(SO_4)_3 \longrightarrow$	$AlCl_3$ +	$BaSO_4$
Meq. before reaction reaction	20×0.1	30×0.2	0 $= 2$	0 $= 6$
Meq. after reaction	0	4	2	2

$\therefore$ Meq. of $BaSO_4$ formed $= 2$

or $$\frac{w}{E} \times 1000 = 2$$

$\therefore$ $$w = \frac{2 \times E}{1000} = \frac{2 \times 233}{2 \times 1000} = \mathbf{0.233\ g}$$

2. Molarity : It is defined as the mole of solute present in one litre of solution. Its unit is mol litre^{-1}.

$$M = \frac{\text{Mole of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{Mass of solute}}{\text{Molar mass of solute} \times V \text{ in litre}}$$

$$= \frac{\text{Mass of solute} \times 1000}{\text{Molar masss of solute} \times V \text{ in mL}}$$

$$M = \frac{w}{m \times V\ (l)} \qquad \text{...(20)}$$

$$M = \frac{w \times 1000}{m \times V \text{ (mL)}} \qquad \text{...(21)}$$

Also, Mole of solute $= M \times V$ in l

$$= \frac{\text{mass of solute}}{\text{molar mass of solute}} \qquad \text{...(22)}$$

Milli mole of solute $= M \times V$ in mL $= \dfrac{w}{m} \times 1000$ ...(23)

$$\because \quad \left.\begin{aligned} \text{Molarity} &= \frac{\text{Mole}}{V \text{ in litre}} \\ \text{and} \quad \text{Normality} &= \frac{\text{Equivalent}}{V \text{ in litre}} \end{aligned}\right\} \text{for a given solution}$$

$$\therefore \quad \frac{M}{N} = \frac{\text{Mole}}{\text{Equivalent}} = \frac{w \times E}{m \times w} = \frac{E}{m} = \frac{1}{\text{Valency factor}}$$

$$\therefore \quad \text{Normality} = \text{Molarity} \times \text{Valency factor} \qquad \text{...(24)}$$

NOTE :
1. Mole and milli mole react according to stoichiometry of equation.
2. It is better to solve a numerical by equivalent or Meq. rather than using mole and milli mole. For this purpose molarity should be changed into normality by Eq. (24).
3. Equation 18, 19, 24 can be used to evaluate any problem of volumetric analysis and gravimetric analysis.
4. Problems of eudiometry can be solved in terms of stoichiometry and mole.

Example. *20 mL of 0.1M $BaCl_2$ in mixed with 30 mL of 0.2 M $Al_2(SO_4)_3$. What is the mass of $BaSO_4$ formed?*

By mole and milli mole : First balance it.

	$3BaCl_2$ +	$Al_2(SO_4)_3 \longrightarrow$	$3BaSO_4$ +	$2AlCl_3$
m mole before reaction	20×0.1 $= 2$	30×0.2 $= 6$	0	0
m mole after reaction	0	$\left(6 - \frac{2}{3}\right)$	2	$2 \times \frac{2}{3}$

$\because$ Reaction ratio is

$$BaCl_2 : Al_2(SO_4)_3 : BaSO_4 : AlCl_3 :: 3 : 1 : 3 : 2$$

$\therefore$ Milli mole of $BaSO_4 = 2$

$$\frac{w}{233} \times 1000 = 2$$

$\therefore$ $$w = \frac{2 \times 233}{1000} = 0.466\ g$$

By equivalent or Meq : No need for balancing.

	$BaCl_2$ +	$Al_2(SO_4)_3 \longrightarrow$	$BaSO_4$ +	$AlCl_3$
Meq. before reaction [$V \times M \times$ Valency factor]	$20 \times 0.1 \times 2$ $= 4$	$30 \times 0.2 \times 6$ $= 36$	0	0
Meq. after reaction	0	32	4	4

$\therefore$ Meq. of $BaSO_4 = 4$

$$\frac{w}{E} \times 1000 = 4$$

$$w = \frac{4 \times 233}{2 \times 1000} = 0.466\ g$$

3. Molality : Mole of solute present in one kg of solvent. Its unit is mol kg^{-1} solvent.

$$\text{Molality} = \frac{\text{mole of solute}}{\text{mass of solvent in kg}}$$

$$= \frac{\text{mass of solute}}{\text{molar mass of solute} \times \text{mass of solvent in kg}}$$

$$= \frac{\text{mass of solute} \times 1000}{\text{molar mass of solute} \times \text{mass of solvent in g}} \qquad \text{...(25)}$$

mass of solvent = mass of solution − mass of solute

mass of solution = volume of solution − specific gravity ...(26)

4. Strength of Solution : Amount of solute present in one litre solution. Its unit is g litre^{-1}.

$$S = \frac{\text{mass of solute}}{\text{volume of solution in litre}} = \frac{w}{V \text{ in } (l)} \quad ...(27)$$

$\because$ By Eq. (15), $N = \frac{w}{E} \times \frac{1}{V \text{ in } (l)}$

$$\therefore \quad S = N \times E \quad (S \text{ in g litre}^{-1}) \quad ...(28)$$

5. In terms of percentage :

$$\% \text{ by mass (mass/mass)} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100 \quad ...(29)$$

$$\% \text{ by strength (vol./vol.)} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100 \quad ...(30)$$

$$\% \text{ by volume (mass/vol.)} = \frac{\text{mass of solute}}{\text{volume of solution}} \times 100 \quad ...(31)$$

Example. A solution is 35% by ...... means

35% by mass : 100 g solution contains 35 g solute

by strength : 100 mL solution contains 35 mL solute

by volume : 100 mL solution contains 35 g solute

6. Mole fraction :

Mole fraction of solute

$$(X_A) = \frac{\text{mole of solute}}{\text{mole of solute + mole of solvent}} = \frac{n}{n+N} \quad ...(32)$$

Mole fraction of solvent

$$(X_B) = \frac{\text{mole of solvent}}{\text{mole of solute + mole of solvent}} = \frac{N}{n+N} \quad ...(33)$$

By Eqs. (31) and (32),

$$\therefore \quad X_A + X_B = \frac{n}{n+N} + \frac{N}{n+N} = 1 \quad ...(34)$$

$$\text{Also,} \quad \frac{X_A}{X_B} = \frac{n}{N} \quad ...(35)$$

NOTE :
1. Molality, % by mass, mole fractions are independent of temperature since these involve masses.
2. Rest all, *i.e.*, normality, molarity, % by vol., % by strength and strength are temperature dependent, normally decrease with increase in temperature since volume of solution increases with T.
3. Sometimes term formality is used in place of molarity.
4. Normal, molar solution means for solutions having normality $1N$ and molarity $1M$ respectively.
5. Standard solution is one whose N or M are known.
6. On diluting a solution, eq, milli equivalent mole or milli mole of solute do not change however N and M change.

Use of specific gravity

(1) Specific gravity of solution (mass of 1 mL solution)

$$= \frac{\text{mass of solution}}{\text{volume of solution}} \quad ...(36)$$

(2) It is commonly used to obtain either mass of solution or volume of solution as desired.

7. Formality : Since molar mass of ionic solids is not determined accurately experimentally due to their dissociation nature and therefore molar mass of ionic solid is often referred as formula mass and molarity as formality.

$$\text{Formality} = \frac{\text{mass of solute}}{\text{Formula mass} \times V_l \text{ (in } l)} \quad ...(37)$$

NOTE : For all practically purposes formality is molarity.

8. Ionic strength : Ionic strength (μ) of a solution is given by:

$$\mu = \frac{1}{2} \Sigma c Z^2 \quad ...(38)$$

where c is concentration (in mole litre^{-1}) of ion and Z is its valence.

Some general points :

(1) Under similar conditions of P and T, combination of gases may be made in terms of volume ratio since mole of gas $\propto$ volume of gas at constant P and T.

(2) Acidic oxides such as CO_2, oxides of N(NO_2, N_2O_3, N_2O_5), oxides of P, Si, halogens are absorbed by alkalines, *e.g.*, NaOH, KOH, CaO etc.

(3) Basic oxides such as Na_2O, CuO, ... etc., are absorbed by acids.

Hardness of water :

(1) The hardness of water is due to the presence of bicarbonates, chlorides and sulphates of Ca and Mg.

(2) The hardness is temporary due to bicarbonates and permanent due to chlorides and sulphates of Ca and Mg.

(3) The extent of hardness is known as degree of hardness defined as the no. of parts by mass of $CaCO_3$ present per million parts by mass of water or 10^6 parts by mass or volume of water since $d_{H_2O} = 1$

$$\text{Hardness (in ppm) of water} = \frac{\text{mass of } CaCO_3}{\text{mass of water}} \times 10^6$$

$$= \frac{\text{mass of } CaCO_3}{\text{Volume of water (in mL)}} \times 10^6 \quad ...(39)$$

NOTE : 1. Equivalent and Meq. of reactants react in equal amount to give same no. of equivalent or Meq. of products separately.

(i) *e.g.*, In a given reaction,

$$\alpha A + bB \longrightarrow mM + nN$$

Meq.of A = Meq. of B = Meq. of M = Meq. of N

(ii) In a compound M_xN_y

Meq. of M_xN_y = Meq. of M = Meq. of N

or Eq. of M_xN_y = Meq. of M = Meq. of N

(iii) In a series of reaction for complete reaction,

$$\alpha A + bB \longrightarrow cC \xrightarrow[\text{excess}]{dD} eE \xrightarrow[\text{excess}]{fF} gG$$

Meq. of A used = Meq. of B used = Meq. of C formed = Meq. of D used = Meq. of E formed = Meq. of F used = Meq. of G formed

2. Mole and millimole react according to equation.
3. Molarity × Valency factor = Normality
4. On diluting a solution, mole, *mM*, Equivalents and Meq. of solute do not change.
5. For reporting concentration of H_2O_2, direct conversions can be made as :
   (i) % strength of
   $$H_2O_2 = \frac{17}{56} \times \text{Volume strength of } H_2O_2$$
   (ii) Volume strength of
   $$H_2O_2 = 5.6 \times \text{Normality of } H_2O_2$$
   (iii) Volume strength of
   $$H_2O_2 = 11.2 \times \text{Molarity of } H_2O_2$$

Use of double indicator: In the titration of alkali mixtures *e.g.*, $(NaOH + Na_2CO_3)$ or $(Na_2CO_3 + NaHCO_3)$ two indicators phenolphthalein and methyl orange are used. The indicator phenolphthalein is a weak organic acid and gives end point between pH 8 to 10, while methyl orange, a weak base indicates end point sharply between pH 3.1 to 4.4. Following points are to be remembered therefore,

1. Phenolphthalein is not a good indicator for weak alkali titrations.
2. Methyl orange is not a good indicator for weak acid titrations.
3. Titration in between strong acid and strong base using phenolphthalein or methyl orange as indicator gives reading for complete neutralization, *i.e.*, Meq. of acid = Meq. of base.
4. Titration between strong acid and strong base such as Na_2CO_3 using phenolphthalein as indicator, the Meq. of acid are utilized only for the end point upto $NaHCO_3$ state.

$$Na_2CO_3 + H^+ \longrightarrow \underset{\text{weak}}{NaHCO_3} + Na^+$$

$\frac{224.4}{63.5}$: $\frac{\overset{3.5}{\cancel{224.4}}}{\cancel{63.5}}$

i.e., $\text{Meq. of Acid} = \frac{1}{2}\text{Meq. of } Na_2CO_3$

(if Eq. mass of Na_2CO_3 is taken as $M/2$)

or $\text{Meq. of Acid Meq. of } Na_2CO_3$

(if Eq. mass of Na_2CO_3 is taken as $M/1$ since one H is replaced)

However, in titration with methyl orange as indicator, the Meq. of acid corresponds to total Meq. of alkali present at that time in mixture.

5. It is to be clearly noted that methyl orange is used as indicator in titration for fresh mixture or in continuation of phenolphthalein *e.g.*,

Na_2CO_3 + NaOH mixture *Vs* HCl

Case I. I end point is determined using phenolphthalein as indicator and then methyl orange is used to get II end point in continuation.

I end point : Meq. of Acid

$$= \text{Meq. of NaOH} + \frac{1}{2}\text{Meq. of } Na_2CO_3$$

II end point : $\text{Meq. of Acid} = \frac{1}{2}\text{Meq. of } Na_2CO_3$

Case II. End point is determined using phenolphthalein as indicator. Next time end point is determined by taking another (fresh) same volume of mixture using methyl orange as indicator.

For phenolphthalein:

$\text{Meq. of Acid} = \text{Meq. of NaOH} + \frac{1}{2}\text{Meq. of } Na_2CO_3$

For methyl orange:

$\text{Meq. of Acid} = \text{Meq. of NaOH} + \text{Meq. of } Na_2CO_3$

Representation of % of oleum: $(100 + a)\%$ m oleum means a g H_2O reacts with equivalent amount of free SO_3 dissolved in H_2SO_4 *i.e.* oleum.

• NUMERICAL PROBLEMS •

1. How many g-atom and no. of atoms are there in (a) 60 g 5 5N_A carbon, (b) 224.4 g Cu? 3·5 N_A 3·5
   Given atomic masss of C and Cu are 12 and 63.5 respectively. Avogadro's no. $= 6.02 \times 10^{23}$.
2. Find the no. of g-atoms and mass of an element having 2×10^{23} atoms. Atomic mass of elemment is 32.
3. In 4 g-atoms of Ag. Calculate :
   (a) mass of Ag
   (b) mass of one atom of Ag; atomic mass of Ag $= 108$.
4. How many g-atoms are there in one atom?
5. If the diameter of a carbon atom is 0.15 nm, calculate the mass of carbon when atoms of carbon are placed side by side across the line of length 10^4 km.
6. Calculate mass of 1 atom of hydrogen.
7. Calculate the no. of atoms and volume of 1 g He gas at NTP.
8. How many mole and molecules of O_2 are there in 64 g O_2? What is the mass of one molecule of O_2?
9. How many year it would take to spend Avogadro's number of rupees at the rate of 10 lac rupees per second?
10. From 200 mg of CO_2, 10^{21} molecules are removed. How many g and mole of CO_2 are left?
11. Mass of one atom of an element is 6.644×10^{-23} g. Calculate g-atom of element in 40 kg.
12. How many g-atom of S are present in 49 g H_2SO_4 ?
13. The density of O_2 at NTP is 1.429 g/L. Calculate the standard molar volume of gas.
14. The measured density at NTP of He is 0.1784 g/L. What is the mass of one mole of He?
15. How many g of S are required to produce 100 mole and 100 g H_2SO_4 separately?
16. An alloy has Fe, Co and Mo equal to 71%, 12% and 17% respectively. How many cobalt atoms are there in a cylinder of radius 2.50 cm and a length of 10.0 cm? The density of alloy is 8.20 g/mL. Atomic mass of cobalt $= 58.9$.
17. Calculate the number of Cl^- and Ca^{2+} ions in 222 g anhydrous $CaCl_2$.
18. The dot at the end of this sentence has a mass of about one microgram. Assuming that black stuff is carbon, calculate approximate atoms of carbon needed to make such a dot.
19. Calculate the mole of water in 488 g $BaCl_2 \cdot 2H_2O$.
20. What is the molar mass of a substance, each molecule of which contains 9 carbon atoms, 13 hydrogen atoms and 2.33×10^{-23} g of other component?
21. A plant virus is found to consist of uniform cylindrical particles of 150 Å in diameter and 5000 Å long. The specific volume of the virus is 0.75 cm^3/g. If the virus is considered to be a single particle, find its molar mass. **(IIT 1999)**
22. K-40 is a naturally occurring radioactive isotope having natural abundance 0.012% of potassium isotopes. How many K-40 atoms do you ingest by drinking one cup of whole milk containing 370 mg K?
23. The vapour density of a mixture containing NO_2 and N_2O_4 is 38.3 at 27°C. Calculate the mole of NO_2 in 100g mixture.
24. The vapour density of a mixture containing NO_2 and N_2O_4 is 38.3 at 27°C. Calculate the mole of NO_2 in 100 mole mixture.
25. Calculate molecules of methane, C and H atoms in 25 g methane.
26. Calculate no. of oxalic acid molecules in 100 mL of 0.02N oxalic acid. **(Roorkee 1992)**
27. Calculate the number of atoms of oxygen present in 88 g CO_2. What would be the mass of CO having the same no. of oxygen atoms?
28. A compound contains 28% N and 72% of a metal by mass. Three atoms of metal combine with two atoms of N. Find the atomic mass of metal.
29. Insulin contains 3.4% sulphur. Calculate minimum molar mass of insulin.
30. Haemoglobin contains 0.25% iron by mass. The molar mass of Haemoglobin is 89600. Calculate the no. of iron atom per molecule of Haemoglobin.
31. P and Q are two elements which forms P_2Q_3 and PQ_2. If 0.15 mole of P_2Q_3 weighs 15.9 g and 0.15 mole of PQ_2 weighs 9.3 g, what are atomic masses of P and Q?
32. Calculate the residue obtained on strongly heating 2.76g Ag_2CO_3.
33. By heating 10 g $CaCO_3$, 5.6 g CaO is formed. What is the mass of CO_2 obtained in this reaction?
34. On heating 1.763 g of hydrated $BaCl_2$ to dryness, 1.505 g of anhydrous salt remained. What is the formula of hydrate?
35. Calculate the mass of iron which will be converted into its oxide by the action of 18 g of steam.
36. Copper forms two oxides. For the same amount of copper, twice as much oxygen was used to form first oxide than to form second one. What is the ratio of the valencies of copper in first and second oxides?
37. Calculate the volume of O_2 and volume of air needed for combustion of 1 kg carbon at STP.
38. Nitrogen content in a sample of urea is 42.5%. What is the percentage purity of urea in urea sample?

39. Calculate the mass of lime (CaO) obtained by heating 200 kg of 95% pure limestone ($CaCO_3$).

40. 4.125 g of a metallic carbonate was heated and the CO_2 evolved was found to measure 1336 mL at 27°C and 700 mm pressure. What is equivalent mass of metal?

41. From the following reaction sequence

$$Cl_2 + 2KOH \longrightarrow KCl + KClO + H_2O$$
$$3KClO \longrightarrow 2KCl + KClO_3$$
$$4KClO_3 \longrightarrow 3KClO_4 + KCl$$

Calculate the mass of chlorine needed to produce 100 g of $KClO_4$.

42. Potassium selenate is isomorphous with potassium sulphate and contains 45.42% selenium by mass. Calculate the atomic mass of selenium. Also report the equivalent mass of potassium selenate.

43. A hydrocarbon contains 10.5 g of carbon per g of H. One litre vapours of hydrocarbon at 127°C and 1 atm pressure weighs 2.8 g. Find molecular formula of hydrocarbon.

44. The reaction, $2C + O_2 \longrightarrow 2CO$ is carried out by taking 24 g of carbon and 96 g O_2, find out:

(a) Which reactant is left in excess?
(b) How much of it is left?
(c) How many mole of CO are formed?
(d) How many g of other reactant should be taken so that nothing is left at the end of reaction?

45. Calculate the mass of FeO produced from 2 g VO and 5.75 g of Fe_2O_3. Also report the limiting reagent.

$$VO + Fe_2O_3 \longrightarrow FeO + V_2O_5$$

46. A polystyrene, having formula $Br_3C_6H_3(C_8H_8)_n$ was prepared by heating styrene with tribromobenzoyl peroxide in the absence of air. If it was found to contain 10.46% bromine by mass, find the value of n.

47. One litre of a mixture of CO and CO_2 is passed through red hot charcoal in tube. The new volume becomes 1.4 litre Find out % composition of mixture by volume. All measurements are made at same P and T.

48. One litre of CO_2 is passed over hot coke. The volume becomes 1.4 litre. Find the composition of products, assuming measurements at NTP.

49. 5 mL of a gaseous hydrocarbon was exposed to 30 mL of O_2. The resultant gas, on cooling is found to measure 25 mL of which 10 mL are absorbed by NaOH and the remainder by pyrogallol. Determine molecular formula of hydrocarbon. All measurements are made at constant pressure and temperature.

50. When a mixture of 10 mole of SO_2, 15 mole of O_2 was passed over catalyst, 8 mole of SO_3 was formed. How many mole of SO_2 and O_2 did not enter into combination?

51. A mixture of 20 mL of CO, CH_4 and N_2 was burnt in excess of O_2 resulting in reduction of 13 mL of volume. The residual gas was then treated with KOH solution to show a contraction of 14 mL in volume. Calculate volume of CO, CH_4 and N_2 in mixture. All measurements are made at constant pressure and temperature. **(IIT 1995)**

52. 50 mL of dry ammonia gas was sparked for a long time in an eudiometer tube over mercury. After sparking, the volume becomes 97 mL. After washing the gas with water and drying, the volume becomes 49 mL. This was mixed with 60.5 mL of oxygen and the mixture was burnt. After the completion of the combustion of H_2, the volume of the residual gas was 48.75 mL. Derive molecular formula of ammonia.

53. The percentage by volume of C_3H_8 in a mixture of C_3H_8, CH_4 and CO is 36.5. Calculate the volume of CO_2 produced when 100 mL of the mixture is burnt in excess of O_2.

54. 100 mL of any gas at NTP was heated with Tin. Tin converted into stannous sulphide and hydrogen was left. This hydrogen when passed over hot CuO, produced 0.081 g of water. If the vapour density of the gas is 17, find its formula.

55. A gaseous alkane is exploded with oxygen. The volume of O_2 for complete combustion to CO_2 formed is in the ratio of 7 : 4. Deduce molecular formula of alkane.

56. 40 mL ammonia gas taken in an eudiometer tube was subjected to sparks till the volume did not further change. The volume was found to increase by 40 mL. 40 mL of oxygen was then mixed and the mixture was further exploded. The gases remained were 30 mL. Deduce formula of ammonia. All measurements are made at constant P and T. Assume H_2O in liquid phase.

57. The mass of one litre sample of ozonised oxygen at NTP was found to be 1.5 g. When 100 mL of this mixture at NTP were treated with terpentine oil, the volume was reduced to 90 mL. Hence calculate the molar mass of ozone.

58. 60 mL of a mixture of nitrous oxide and nitric oxide was exploded with excess of hydrogen. If 38 mL of N_2 was formed, calculate the volume of each gas in mixture. All measurements are made at constant P and T. Assume H_2O in liquid phase.

59. 50 mL of pure and dry oxygen was subjected to a silent electric discharge and on cooling to the original temperature, the volume of ozonised oxygen was found to be 47 mL. The gas was then brought into contact with terpentine oil, when after the absorption of ozone, the remaining gas occupied a volume of 41 mL. Find molecular formula of ozone. All measurements are made at constant P and T.

60. A sample of gaseous hydrocarbon occupying 1.12 litre at NTP, when completely burnt in air produced 2.2 g CO_2 and 1.8 g H_2O. Calculate the mass of hydrocarbon taken and the volume of O_2 at NTP required for its combustion.
61. 16 mL of a gaseous aliphatic compound $C_nH_{3n}O_n$ was mixed with 60 mL O_2 and sparked. The gas mixture on cooling occupied 44 mL. After treatment with KOH solution, the volume of gas remaining was 12 mL. Deduce the formula of compound. All measurements are made at constant pressure and room temperature.
62. A 5.0 g sample of a natural gas consisting of CH_4, C_2H_4 was burnt in excess of oxygen yielding 14.5 g CO_2 and some H_2O as products. What is mass percentage of CH_4 and C_2H_4 in mixture?
63. 4 g C_3H_8 and 14 g O_2 are allowed to react to the maximum possible extent to form only CO and H_2O. Find the mass of CO formed.
64. Assume that the nucleus of the F atom is a sphere of radius 5×10^{-13} cm. Calculate the density of matter in F nucleus.
65. A metal *M* of atomic mass 54.94 has a density of 7.42 g/cm^3. Calculate the volume occupied and the radius of the atom of this metal assuming it to be sphere.
66. A granulated sample of aircraft alloy (Al, Mg, Cu) weighing 8.72 g was first treated with alkali and then with very dilute HCl, leaving a residue. The residue after alkali boiling weigh 2.10 g and the acid insoluble residue weigh 0.69 g. What is the composition of the alloy?
67. Calculate the mass of CaO required to remove the hardness of 10^6 litre of water containing 1.62 g of calcium bicarbonate per litre.
68. One litre of sample of hard water contains 1 mg of $CaCl_2$ and 1 mg of $MgCl_2$. Find the total hardness of water in terms of $CaCO_3$ per 10^6 parts of water by mass.
69. 1.60 g of a metal were dissolved in HNO_3 to prepare its nitrate. The nitrate was strongly heated to give 2 g oxide. Calculate equivalent mass of metal.
70. 1.0 g of metal nitrate gave 0.86 g of metal sulphate. Calculate equivalent mass of metal.
71. 1.35 g of pure Ca metal was quantitatively converted into 1.88 g of pure CaO. What is atomic mass of Ca?
72. 2 g of a metal in H_2SO_4 gives 4.51 g of the metal sulphate. The specific heat of metal is 0.057 cal/g. Calculate the valency and atomic mass of metal.
73. 1.878 g of MBr_x, when heated in a stream of HCl gas, was completely, converted to chloride MCl_x, which weighed 1.0 g. The specific heat of metal is 0.14 cal/g. Calculate molar mass of metal bromide.
74. A hydrated sulphate of metal contained 8.1% metal and 43.2% SO_4^{-2} by mass. The specific heat of metal is 0.24 cal / g. What is hydrated sulphate?
75. Find the milli equivalent of :
    (a) $Ca(OH)_2$ in 74 g.
    (b) NaOH in 20 g.
    (c) H_2SO_4 in 2.45 g.
76. Find the mass of NaOH in its 50 milli equivalents.
77. Find the normality of H_2SO_4 having 50 milli equivalents in 2 litre.
78. 1.2048 g sample of impure Na_2CO_3 is dissolved and allowed to react with a solution of $CaCl_2$. The resulting $CaCO_3$, after precipitation, filtration and drying was found to mass 1.0362 g. Assuming impurities do not contribute to the mass of precipitate, calculate per cent purity of Na_2CO_3.
79. Calculate normality and molarity of the following :
    (a) 0.74 g of a $Ca(OH)_2$ in 5 mL of solution.
    (b) 3.65 g of HCl in 200 mL of solution.
    (c) 1/10 mole of H_2SO_4 in 500 mL of solution.
80. Find the mass of H_2SO_4 in 1200 mL of a solution of 0.2 *N* strength.
81. Calculate the mass of calcium oxide required when it reacts with 852 g of P_4O_{10}. **(IIT 2005)**
82. What mass of Na_2CO_3 of 95% purity would be required to neutralize 45.6 mL of 0.235 *N* acid?
83. How many millilitre of 0.5 *M* H_2SO_4 are needed to dissolve 0.5 g of copper II carbonate? **(IIT 1999)**
84. What is the strength in g per litre of a solution of H_2SO_4, 12 mL of which neutralized 15 mL of *N*/10 NaOH solution?
85. The formula mass of an acid is 82.0. 100 cm^3 of a solution of this acid containing 39.0 g of the acid per litre were completely neutralized by 95.0 cm^3 of aqueous NaOH containing 40.0g of NaOH per litre. What is the basicity of the acid? **(Roorkee 2000)**
86. Calculate the normality of the resulting solution made by adding 2 drops (0.1 mL) of 0.1*N* H_2SO_4 in 1 litre of distilled water.
87. What volume at NTP of ammonia gas weill be required to be passed into 30 mL of *N* H_2SO_4 solution to bring down the acid normality to 0.2*N*?
88. Two litre of NH_3 at 30°C and 0.20 atmosphere is neutralized by 134 mL of a solution of H_2SO_4. Calculate normality of H_2SO_4.
89. One g of calcium was burnt in excess of O_2 and the oxide was dissolved in water to make up one litre solution. Calculate normality of alkaline solution.
90. 1.82 g of a metal required 32.5 mL of *N* HCl to dissolve it. What is equivalent mass of metal?

91. Calculate normality of mixture obtained by mixing:

(a) 100 mL of 0.1 N HCl + 50 mL of 0.25 N NaOH.

(b) 100 mL of 0.2 M H_2SO_4 + 200 mL of 0.2 M HCl.

(c) 100 mL of 0.2 M H_2SO_4 + 100 mL of 0.2 M NaOH.

(d) 1 g-equivalent of NaOH + 100 mL of 0.1 N HCl.

92. In what ratio should you mix 0.2 M $NaNO_3$ and 0.1 M $Ca(NO_3)_2$ solution so that in resulting solution, the concentration of $-ve$ ion is 50% greater than the concentration of $+ve$ ion?

93. Calculate the mass of KOH required to neutralize 15 Meq. of the following:

(a) HCl, (b) $KHSO_4$, (c) N_2O_5, (d) CO_2.

94. What volume of water is required to make 0.20N solution from 1600 mL of 0.2050N solution?

95. How much $BaCl_2 \cdot 2H_2O$ and pure water are to be mixed to prepare 50 g of 12.0% (by mass) $BaCl_2$ solution?

96. What volume of a solution of hydrochloric acid containing 73 g of acid per litre would suffice for the exact neutralization of sodium hydroxide obtained by allowing 0.46 g of metallic sodium to act upon water?

97. 20 mL of 0.2M $Al_2(SO_4)_3$ is mixed with 20 mL of 0.6 M $BaCl_2$. Calculate the concentration of each ion in solution.

98. Find out equivalent mass of H_3PO_4 in the reaction.

$$Ca(OH)_2 + H_3PO_4 \longrightarrow CaHPO_4 + 2H_2O$$

99. What volume of 0.20 M H_2SO_4 is required to produce 34.0 g of H_2S by the reaction?

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

100. How much AgCl will be formed by adding 200 mL of 5N HCl to a solution containing 1.7g $AgNO_3$?

101. What mass of AgCl will be precipitated when a solution containing 4.77 g NaCl is added to a solution of 5.77 g of $AgNO_3$?

102. How much $BaCl_2$ would be needed to make 250 mL of a solution having same concentration of Cl^- as the one containing 3.78 g of NaCl per 100 mL?

103. Upon mixing 45.0 mL of 0.25 M lead nitrate solution with 25 mL of 0.10M chromtic sulphate, precipitation of lead sulphate takes place. How many mole of lead sulphate are formed? Also calculate the molar concentrations of the species left behind in final solution. Assume that lead sulphate is completely insoluble. **(IIT 1993)**

104. What is the normality and nature of a mixture obtained by mixing 0.62 g of $Na_2CO_3.H_2O$ to 100 mL of 0.1N H_2SO_4?

105. A sample of an alloy weighing 0.50 g and containing 90% Ag was dissolved in conc. HNO_3. Ag was analysed by Volhard method in which 25 mL of KCNS were required for complete neutralization. Determine normality of KCNS.

106. What is the purity of conc. H_2SO_4 solution (specific gravity 1.8 g/mL), if 5.0 mL of this solution is neutralized by 84.6 mL of 2.0 N NaOH?

107. A sample of H_2SO_4 (density 1.787 g mL^{-1}) is labeled as 86% by mass. What is molarity of acid? What volume of acid has to be used to make 1 litre of 0.2 M H_2SO_4?

108. A piece of Al weighing 2.7 g is titrated with 75.0 mL of H_2SO_4 (sp. gr. 1.18 g mL^{-1} and 24.7% H_2SO_4 by mass). After the metal is completely dissolved, the solution is diluted to 400 mL. Calculate molarity of free H_2SO_4 in solution.

109. A 6.90M solution of KOH in water has 30% by mass of KOH. Calculate density of solution.

110. Mole fraction ofI_2 in C_6H_6 is 0.2. Calcualte molality of I_2 in C_6H_6.

111. A drop (0.05 mL) of 12 M HCl is spread over a thin sheet of aluminium foil (thickness 0.10 mm and density of Al = 2.70 g /mL). Assuming whole of the HCl is used to dissolve Al, what will be the maximum area of hole produced in foil?

112. Calculate the volume of NH_3 in a solution (density 0.99 g /cm^3 and 2.3% by mass) which will be required to precipitate $Fe(OH)_3$ from a sample of 0.70 g of 25% Fe_2O_3 purity.

113. Calculate molality of 1 litre solution of 93% H_2SO_4 by volume. The density of solution is 1.84 g mL^{-1}. **(IIT 1990)**

114. The gases produced when 18 g carbon reacts with 5 litre of oxygen at 18°C and 5 atm pressure are treated with 0.5 litre of 2 M NaOH. Calculate the concentration of sodium carbonate and sodium bicarbonate produced by the reaction of CO_2 with NaOH.CO has no reaction under these conditions.

115. What would be the molality of a solution obtained by mixing equal volumes of 30% by mass H_2SO_4 ($d = 1.218$ g mL^{-1}) and 70% by mass H_2SO_4 ($d = 1.610$ g mL^{-1})? If the resulting solution has density 1.425 g/mL, calculate its molarity.

116. Calculate molarity of water, if its density is 1000 kg /m^3. **(IIT 2003)**

117. To 50 litre of 0.2 N NaOH, 5 litre of 1N HCl and 15 litre of 0.1N $FeCl_3$ solution are added. What mass of Fe_2O_3 can be obtained from the precipitate? Also report the normality of NaOH left in the resultant solution.

118. The molar mass of an organic acid was determined by the study of its barium salt. 4.290 g of salt was quantitatively converted to free acid by the reaction with 21.64mL of 0.477 M H_2SO_4. The barium salt was found to have two mole of water of hydration per Ba^{2+} ion and the acid is monobasic. What is the molar mass of anhydrous acid?

119. A solution is 0.5 M in $MgSO_4$, 0.1 M in $AlCl_3$ and 0.2 M in $(NH_4)_2SO_4$. What is the total ionic strength?

120. What volume of 0.010 M NaOH (aq.) is required to react completely with 30 g of an aqueous acetic acid solution in which mole fraction of acetic acid is 0.15?

121. A solution contains 1 mol of total amount of solute and solvent. The mole fraction of solute being X_1 and that of solvent being X_2, prove :

(a) $X_1 = \dfrac{MM_2}{\rho + M(M_2 - M_1)}$ where M_1 and M_2 are molar masses of solute and solvent respectively and M is molarity of solution; ρ is density of solution in g /dm^3.

(b) $M = \dfrac{X_1\rho}{M_2}$ for dilute solution; ρ is density of solvent.

122. A mixture of Al and Zn weighing 1.67 g was completely dissolved in acid and evolved 1.69 litre of H_2 at NTP. What was the mass of Al in original mixture?

123. A mixture of HCOOH and $H_2C_2O_4$ is heated with conc. H_2SO_4. The gas produced is collected and on treating with KOH solution the volume of the gas decreases by $\frac{1}{6}$*th.* Calculate molar ratio of two acids in original mixture. **(Roorkee 1990)**

124. 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 distilled. The ammonia released was then trapped in 10 Meq. of second acid solution. Back titration of this solution required 6 Meq. of the base. Calculate the percentage of Mg burnt to the nitride. **(Roorkee 1998)**

125. For the reaction, $N_2O_5(g) \rightleftharpoons 2NO_2(g) + 0.5O_2(g)$, calculate the mole fraction of $N_2O_5(g)$ decomposed at a constant volume and temperature, if the initial pressure is 600 mm Hg and the pressure at any time is 960 mm Hg. Assume ideal gas behaviour.

126. A gas mixture of 3 litre of propane (C_3H_8) and butane (C_4H_{10}) on complete combustion at 25°C produced 10 litre CO_2. Find out the composition of gas mixture.

127. 8.0575×10^{-2} kg of Glauber's salt is dissolved in water to obtain 1 dm^3 of a solution of density 1077.2 kg m^{-3}. Calculate the molarity, molality and mole fraction of Na_2SO_4 in solution. **(IIT 1994)**

128. A solid mixture 5 g consists of lead nitrate and sodium nitrate was heated below 600°C until mass of residue was constant. If the loss in mass is 28%, find the mass of lead nitrate and sodium nitrate in mixture. **(IIT 1990)**

129. A mixture of ethane (C_2H_6) and ethene (C_2H_4) occupies 40 litre at 1.00 atm and at 400 K. The mixture reacts completely with 130 g of O_2 to produce CO_2 and H_2O. Assuming ideal gas behaviour, calculate the mole fractions of C_2H_4 and C_2H_6 in the mixture. **(IIT 1995)**

130. A sample of hard water contains 96 ppm of SO_4^{2-} and 183 ppm of HCO_3^-, with Ca^{2+} as the only cation. How many mole of CaO will be required to remove HCO_3^- from 1000 kg of this water? If 1000 kg of this water is treated with the mass of CaO calculated above, what will be the concentration (in ppm) of residual Ca^{2+} ions (Assume $CaCO_3$ to be completely insoluble in water)? If the Ca^{2+} ions in one litre of the treated water are completely exchanged with hydrogen ions, what will be its pH (One ppm means one part of the substance in one million part of water, mass/mass)? **(IIT May 1997)**

131. 1.20 g sample of Na_2CO_3 and K_2CO_3 was dissolved in water to form 100 mL of a solution. 20 mL of this solution required 40 mL of 0.1 N HCl for complete neutralization. Calculate the mass of Na_2CO_3 in mixture. If another 20 mL of this solution is treated with excess of $BaCl_2$, what will be the mass of precipitate? **(Roorkee 1997)**

132. 25 mL of a solution of Na_2CO_3 having a specific gravity of 1.25 g mL^{-1} required 32.9 mL of a solution of HCl containing 109.5 g of the acid per litre for complete neutralization. Calculate the volume of 0.84 N H_2SO_4 that will be completely neutralized by 125 g of Na_2CO_3 solution.

133. 200 mL of a M solution of HCl is mixed with 500 mL of b M solution of HCl. The mixture is diluted to 2 litre to obtain the solution of molarity 1.5 M. If $a : b :: 5 : 4$, what are the values of a and b?

134. Calculate the % of free SO_3 in oleum that is labelled as 106%.

SOLUTIONS (Numerical Problems)

1. $\because$ g-atom $= \dfrac{\text{mass}}{\text{atomic mass}}$ and No. of atoms $= \dfrac{\text{mass} \times \text{Av. No.}}{\text{atomic mass}}$

(a) $\therefore$ **For 60 g C :** g-atom $= \dfrac{60}{12} = \mathbf{5}$

No. of atoms $= \dfrac{60 \times 6.02 \times 10^{23}}{12} = \mathbf{30.1 \times 10^{23}}$

(b) **For 224.4 g Cu :** g-atom $= \dfrac{224.4}{63.6} = \mathbf{3.53}$

No. of atoms $= \dfrac{224.4 \times 6.02 \times 10^{23}}{63.6} = \mathbf{21.24 \times 10^{23}}$

2. $\because$ N atoms have 1 g-atom

$\therefore$ 2×10^{23} atoms have $= \dfrac{2 \times 10^{23}}{6.023 \times 10^{23}} = \mathbf{0.33}$ **g atom**

$\because$ N atoms of element weigh 32g

$\because$ 2×10^{23} atoms of element weigh

$$= \frac{32 \times 2 \times 10^{23}}{6.023 \times 10^{23}} = \mathbf{10.63\ g}$$

3. (a) $\because$ 1 g-atom of Ag weighs 108 g

4g-atom of Ag weighs $108 \times 4 = \mathbf{432\ g}$

(b) $\because$ N atoms of Ag weigh 108 g

$\therefore$ 1 atom of Ag weighs $\dfrac{108}{6.023 \times 10^{23}} = \mathbf{17.93 \times 10^{-23}\ g}$

4. $\because$ N atom has 1 g-atom

$\therefore$ 1 atom has $\dfrac{1}{6.023 \times 10^{23}} = \mathbf{1.66 \times 10^{-24}}$ **g atom**

5. Carbon atoms occupies the distance

$$= 10^4 \text{ km} = 10^4 \times 10^3 \text{ m}$$
$$= 10^4 \times 10^3 \times 10^2 \text{ cm} = 10^9 \text{ cm}$$

$\therefore$ No. of carbon atoms placed across the line

$$= \frac{10^9}{0.15 \times 10^{-7}} = 6.67 \times 10^{16}$$

Mass of these carbon atoms $= \dfrac{12 \times 6.67 \times 10^{16}}{6.023 \times 10^{23}}$

$$= 1.328 \times 10^{-6} \text{ g} = \mathbf{1.328\ \mu g}$$

6. $\because$ N atom of H weigh 1 g

$\therefore$ 1 atom of H weigh $\dfrac{1}{6.023 \times 10^{23}} = \mathbf{1.66 \times 10^{-24}\ g}$

7. $\because$ 4 g He has 6.023×10^{23} atoms

$\therefore$ 1 g He has $\dfrac{6.023 \times 10^{23}}{4}$ atoms $= \mathbf{1.506 \times 10^{23}}$ **atoms**

Also, $\because$ 4 g He $\equiv$ 22.4 L at NTP

$\therefore$ 1 g He $\equiv \dfrac{22.4}{4} \equiv$ **5.6 litre at NTP**

8. $\because$ 32 g O_2 has mole = 1

$\therefore$ 64 g O_2 has mole $= \dfrac{64 \times 1}{32} = \mathbf{2\ mol}$

$\because$ 32 g O_2 contain 6.023×10^{23} molecules

$\therefore$ 64 g O_2 contain $\dfrac{6.023 \times 10^{23} \times 64}{32}$

$$= \mathbf{12.04 \times 10^{23}\ molecules}$$

$\therefore$ N molecules of O_2 weigh 32 g

$\therefore$ 1 molecule of O_2 weighs

$$= \frac{32}{6.023 \times 10^{23}} = \mathbf{5.313 \times 10^{-23}\ g}$$

9. Total rupees to be expanded $= 6.023 \times 10^{23}$

Rupees spent per second $= 10^6$

$\therefore$ Rupees spent per year $= 10^6 \times 60 \times 60 \times 24 \times 365$

$\because$ $10^6 \times 60 \times 60 \times 24 \times 365$ Rupees are spent in 1 year

$\therefore$ 6.023×10^{23} Rupees are spent

$$= \frac{6.023 \times 10^{23}}{10^6 \times 60 \times 60 \times 24 \times 365} \text{ year}$$
$$= \mathbf{1.9099 \times 10^{10}\ year}$$

10. $\because$ 6.023×10^{23} molecules of $CO_2 \equiv 44$ g

$\therefore$ 10^{21} molecules of $CO_2 \equiv \dfrac{44 \times 10^{21}}{6.023 \times 10^{23}}$ g

$$= 7.31 \times 10^{-2} \text{ g} = 73.1 \text{ mg}$$

$\therefore$ CO_2 left $\equiv 200 - 73.1 = \mathbf{126.9\ mg}$

Also, Mole of CO_2 left $= \dfrac{\text{mass}}{\text{molar mass}} = \dfrac{126.9 \times 10^{-3}}{44}$

$$= \mathbf{2.88 \times 10^{-3}}$$

11. Mass of 1 atom of element $= 6.644 \times 10^{-23}$ g

$\therefore$ Mass of N atom of element

$$= 6.644 \times 10^{-23} \times 6.023 \times 10^{23} = 40$$

$\because$ 40g of element has a 1 g atom

$\therefore$ 40×10^3 g of element $= \dfrac{40 \times 10^3}{40} = \mathbf{10^3}$ **g atom**

12. $\because$ 98 g $H_2SO_4 \equiv 32$ g S $\equiv$ 1 g atom S

$\therefore$ 49 g $H_2SO_4 \equiv \dfrac{1 \times 49}{98}$ g atom S $=$ **0.5 g atom of S**

13. Standard molar volume is the volume occupied by 1 mole of gas at NTP.

$\because$ 1.429 g of $O_2 \equiv$ 1 litre at NTP

$\therefore$ 32 g of $O_2 \equiv \dfrac{32}{1.429}$ litre at NTP = 22.39 litre at NTP

$\therefore$ Molar volume = **22.39 litre mol**$^{\mathbf{-1}}$

14. One mole of He occupies 22.4 litre volume

$\because$ 1 litre volume weigh = 0.1784g

$\therefore$ 22.4 litre volume weigh $= 0.1784 \times 22.4 = \mathbf{4\ g\ mol^{-1}}$

15. $\because$ 1 mole of $H_2SO_4 \equiv 32$ g S

$\therefore$ 100 mole $H_2SO_4 \equiv 32 \times 100 \equiv \mathbf{3200\ g\ S}$

$\because$ 98 g $H_2SO_4 \equiv 32$ g S

$\therefore$ 100 g $H_2SO_4 \equiv \dfrac{32 \times 100}{98} = \mathbf{32.65\ g\ S}$

16. Mass of alloy cylinder = Volume × density $= \pi r^2 h \times d$

$$= \frac{22}{7} \times (2.5)^2 \times 10 \times 8.20 = 1610.7\,\text{g}$$

Mass of cobalt in alloy $= \frac{1610.7 \times 12}{100} = 193.3\,\text{g}$

$\because$ 58.9 g cobalt has atoms $= 6.023 \times 10^{23}$

$\therefore$ 193.3 g cobalt has atoms

$$= \frac{6.023 \times 10^{23} \times 193.3}{58.9} = \mathbf{19.8 \times 10^{23}}$$

17. Molar mass $CaCl_2 = 111\,\text{g}$

$\because$ $111\,\text{g}\ CaCl_2 \equiv$ N ions of Ca $\equiv$ N ions of Ca^{2+}

$\therefore$ $222\ \text{g}\ CaCl_2 \equiv \frac{N \times 222}{111} = \mathbf{2\ N\ ions\ of\ Ca^{2+}}$

$\because$ $111\ \text{g}\ CaCl_2 \equiv 2\text{N ions of } Cl^-$

$\therefore$ $222\ \text{g}\ CaCl_2 \equiv \frac{2 \times N \times 222}{111}$ ions of Cl^-

$= \mathbf{4\ N\ ions\ of\ Cl^-}$

18. Mass of carbon in dot $= 1 \times 10^{-6}$ g

$\because$ $12\ \text{g C} \equiv 6.023 \times 10^{23}$ atoms

$\therefore$ $1 \times 10^{-6}\ \text{g C} \equiv \frac{6.023 \times 10^{23} \times 1 \times 10^{-6}}{12}$

$= \mathbf{5 \times 10^{16}}$ **atoms of C**

19. Molar mass of $BaCl_2 \cdot 2H_2O = 244\,\text{g}$

$\because$ $244\ \text{g}\ BaCl_2 \cdot 2H_2O \equiv 36\text{g}\ H_2O = 2\,\text{mole}$

$\therefore$ $488\ BaCl_2 \cdot 2H_2O \equiv \frac{2 \times 488}{244} = \mathbf{4\ mole\ H_2O}$

20. Molecule has C, H and other component

$\therefore$ Mass of 9 C atoms $= 12 \times 9 = 108$ amu

$\because$ Mass of 13 H atoms $= 13 \times 1 = 13$ amu

Mass of 2.33×10^{-23} g of other atom

$$= \frac{2.33 \times 10^{-23}}{1.66 \times 10^{-24}} = 14.04\ \text{amu}$$

$\therefore$ Total mass of one molecule

$= 108 + 13 + 14.04 = \mathbf{135.04\ amu}$

$\therefore$ molar mass $= \mathbf{135.04\ g}$

21. Volume of virus

$$= \pi r^2 l = \frac{22}{7} \times \frac{150}{2} \times \frac{150}{2} \times 10^{-16} \times 5000 \times 10^{-8}$$

$= 0.884 \times 10^{-16}\ \text{cm}^3$

$\therefore$ Mass of one virus

$$= \frac{0.884 \times 10^{-16}}{0.75}\ \text{g} = 1.178 \times 10^{-16}\ \text{g}$$

$\therefore$ molar mass of virus

$= 1.178 \times 10^{-16} \times 6.023 \times 10^{23} = \mathbf{7.095 \times 10^7}$

22. Mass of K-40 in 370 mg K

$$= \frac{370 \times 0.012}{100}\ \text{mg} = 0.0444\ \text{mg}$$

$\therefore$ 40 g K-40 has atoms of K-40 $= 6.023 \times 10^{23}$

$\therefore$ 0.0444×10^{-3} g K-40 has atoms

$$= \frac{6.023 \times 10^{23} \times 0.0444 \times 10^{-3}}{40}$$

$= \mathbf{6.69 \times 10^{17}}$ **atoms**

23. Molar mass of mixture of NO_2 and $N_2O_4 = 38.3 \times 2 = 76.6$

Let a g of NO_2 present in 100 g mixture

$\therefore$ Mole of NO_2 + Mole of N_2O_4 = Mole of mixture

$$\frac{a}{46} + \frac{100 - a}{92} = \frac{100}{76.6}$$

$$a = 20.10\,\text{g}$$

$\therefore$ Mole of NO_2 in mixture $= \frac{20.10}{46} = \mathbf{0.437}$

24. Molar mass of mixture of NO_2 and $N_2O_4 = 38.3 \times 2 = 76.6$

Let a mole of NO_2 are present in mixture

g of NO_2 + g of N_2O_4 = Total g of mixture

$$a \times 46 + (100 - a)92 = 100 \times 76.6$$

$$a = \mathbf{33.48\ mol}$$

25. Molar mass of $CH_4 = 16$

$\because$ $16\ \text{g}\ CH_4 \equiv N$ molecules

$\therefore$ $25\text{g}\ CH_4 \equiv \frac{6.023 \times 10^{23} \times 25}{16}$ molecules

$= \mathbf{9.41 \times 10^{23}}$ **molecules**

$16\text{g}\ CH_4 \equiv N$ atom of C

$\therefore$ $25\ \text{g}\ CH_4 \equiv \frac{6.023 \times 10^{23} \times 25}{16}$ atoms of C

$= \mathbf{9.41 \times 10^{23}}$ **atoms of C**

$16\text{g}\ CH_4 \equiv 4N$ atoms of H

$\therefore$ $25\ \text{g}\ CH_4 \equiv \frac{4 \times 25 \times 6.023 \times 10^{23}}{16}$ atoms of H

$= \mathbf{3.764 \times 10^{24}}$ **atoms of H**

26. Normality $= 0.02$

$\therefore$ Molarity $= \frac{0.02}{2}$ ($\because$ valency factor = 2)

$\therefore$ Mole of oxalic acid $= \frac{0.02}{2} \times \frac{100}{1000}$ [$\because$ mole $= M \times V\ (l)$]

$\therefore$ No. of molecules of oxalic acid

$= 0.001 \times 6.023 \times 10^{23} = \mathbf{6.023 \times 10^{20}}$

27. $\because$ Molar mass of $CO_2 = 44$ and it has 32 g O_2 and one molecule of O_2 has 2 atoms.

$\because$ $44\ \text{g}\ CO_2 \equiv 2N$ atoms of O

$\therefore$ $88\ \text{g}\ CO_2 \equiv \frac{2 \times 6.023 \times 10^{23} \times 88}{44}$ atoms of O

$= 24.092 \times 10^{23}$ atoms of Oxygen

Also molar mass of CO = 28 and it has 16 g O and one atom of O in one molecule of CO.

$\because$ N atoms of O are present in = 28 g CO

$\therefore$ 24.092×10^{23} atoms of O are present in

$$= \frac{28 \times 24.092 \times 10^{23}}{6.023 \times 10^{23}} = \mathbf{112\ g\ CO}$$

28. Given that, $3M + 2\mathrm{N} \longrightarrow M_3\mathrm{N}_2$

Let a is atomic mass of metal

$\because$ $(3a+28)$g $M_3\mathrm{N}_2$ has metal $= 3a$

$\therefore$ 100 g $M_3\mathrm{N}_2$ has metal $= \dfrac{3a \times 100}{(3a+28)}$

$\because$ $\dfrac{3a \times 100}{(3a+28)} = 72$

$\therefore$ $a = \mathbf{24}$

29. For minimum molar mass, insulin must have at least one S atom in its one molecule.

$\because$ 3.4 g S then molar mass of insulin = 100

$\therefore$ 32 g S then molar mass of insulin $= \dfrac{100 \times 32}{3.4} = 941.176$

$\therefore$ Minimum molar mass of insulin = **941.176**

30. $\because$ 100 g Haemoglobin has = 0.25 g Fe

$\therefore$ 89600 g Haemoglobin has

$= \dfrac{0.25 \times 89600}{100}$ g Fe = 224 g Fe

i.e., 1 mole or N molecules of Haemoglobin has

$= \dfrac{224}{56}$ g atom Fe = 4g atom Fe

$\therefore$ **1 molecule of Haemoglobin has 4 atom of Fe.**

31. Let atomic mass of P and Q are a and b respectively.

$\therefore$ molar mass of $P_2Q_3 = 2a + 3b$

and molar mass of $PQ_2 = a + 2b$

Now given that 0.15 mole of P_2Q_3 mass 15.9 g

$$(2a+3b) = \frac{15.9}{0.15} \quad \left(\because \frac{\text{mass}}{\text{molar mass}} = \text{mole}\right)$$

Similarly, $(a+2b) = \dfrac{9.3}{0.15}$

Solving these two equation $b = \mathbf{18}$

$a = \mathbf{26}$

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

and molar mass of $\mathrm{Ag_2CO_3} = 276$

atomic mass of Ag = 108

$\because$ 276 g $\mathrm{Ag_2CO_3}$ gives Ag = 216 g

$\therefore$ 2.76 g $\mathrm{Ag_2CO_3}$ gives Ag = **2.16 g**

33. $\mathrm{CaCO_3} \longrightarrow \mathrm{CaO} + \mathrm{CO_2}$

molar mass 100 56 44

$\because$ 100 g $\mathrm{CaCO_3}$ gives 56 g CaO and 44 g $\mathrm{CO_2}$

$\therefore$ **10 g $\mathrm{CaCO_3}$ gives 5.6 g CaO and 4.4 g $\mathrm{CO_2}$**

34. $\mathrm{BaCl_2} \cdot n\mathrm{H_2O} \xrightarrow[208]{\Delta} \mathrm{BaCl_2} + n\mathrm{H_2O}$

molar mass $(208 + 18n)$

$\because$ $(208 + 18n)$ g $\mathrm{BaCl_2} \cdot n\mathrm{H_2O}$ gives = 208 g $\mathrm{BaCl_2}$

$\because$ 1.763 g $\mathrm{BaCl_2} \cdot n\mathrm{H_2O} = \dfrac{208 \times 1.763}{208 + 18n}$ g $\mathrm{BaCl_2}$

$\therefore$ $\dfrac{208 \times 1.763}{208 + 18n} = 1.505$

$n = 1.98 \approx 2$

$\therefore$ **Formula is $\mathrm{BaCl_2 \cdot 2H_2O}$**

35. The reaction occurs as :

$$3\mathrm{Fe} + 4\mathrm{H_2O} \longrightarrow \mathrm{Fe_3O_4} + 4\mathrm{H_2}$$

Mole ratio of reaction suggests:

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

$\therefore$ Mole of Fe $= \dfrac{18}{18} \times \dfrac{3}{4} = \dfrac{3}{4}$

$\therefore$ Mass of Fe $= \dfrac{3}{4} \times 56 = \mathbf{42\ g}$

36. Let valencies of Cu in two oxides be x and y, then

I oxide is $\mathrm{Cu_2O}_x$

II oxide is $\mathrm{Cu_2O}_y$

In I oxide : Equivalent of Cu = Equivalent of oxygen

$$\frac{w}{A/x} = \frac{a}{8} \qquad \text{...(1)}$$

where w, A, x_1 and a are mass of Cu, atomic mass of Cu, valency of Cu and mass of oxygen.

In II oxide : $\dfrac{w}{A/y} = \dfrac{a}{2 \times 8}$ ...(2)

($\because$ Oxygen used half of I)

By Eqs. (1) and (2) $\dfrac{x}{y} = \dfrac{2}{1}$

$\therefore$ Valency of Cu in I and II oxides are in the ratio **2 : 1.**

37. $\mathrm{C} + \mathrm{O_2} \longrightarrow \mathrm{CO_2}$

$\because$ 12 g C requires $\mathrm{O_2}$ = 22.4 litre = 1 mole = 32g

$\therefore$ 1000 g C requires

$\mathrm{O_2} = \dfrac{22.4 \times 1000}{12}$ litre = 1866.67 litre $\mathrm{O_2}$

$\therefore$ $V_{\text{air}} = 5 \times V_{\mathrm{O_2}} = 5 \times 1866.67 = \mathbf{9333.35\ litre}$

38. Urea is $\mathrm{NH_2CONH_2}$, having molar mass = 60 and nitrogen in it is 28.

$\because$ 28g nitrogen ≡ 60g urea

$\therefore$ 42.5 g nitrogen $\equiv \dfrac{60 \times 42.5}{28} = \mathbf{91.07\ g\ urea}$

Since, 42.5 g nitrogen is present in 100 g sample, therefore, percentage of urea in sample = 91.07%

39. 100 kg impure sample has $\mathrm{CaCO_3}$ = 95 kg

$\therefore$ 200 kg impure sample has $\mathrm{CaCO_3} = \dfrac{95 \times 200}{100} = 190$ kg

Now $\mathrm{CaCO_3} \longrightarrow \mathrm{CaO} + \mathrm{CO_2}$

M. mass 100 g 56 g 44 g

$\because$ 100 kg $\mathrm{CaCO_3}$ gives CaO = 56 kg

$\therefore$ 190 kg $\mathrm{CaCO_3}$ gives CaO $= \dfrac{56 \times 190}{100} = \mathbf{106.4\ kg}$

40. $PV = \dfrac{w}{m}RT$ (for $\mathrm{CO_2}$ gas)

$$\frac{700}{760} \times \frac{1336}{1000} = \frac{w}{44} \times 0.0821 \times 300$$

$\therefore$ $w_{\mathrm{CO_2}} = 2.20$ g

Let carbonate be $M_2(\mathrm{CO_3})_n$ and atomic mass of metal be a

$$M_2(\mathrm{CO_3})_n \longrightarrow M_2O_n + n\mathrm{CO_2}$$

$\because$ $(2a + 60n)$g $M_2(\mathrm{CO_3})_n$ gives $44n$ g $\mathrm{CO_2}$

$\therefore$ 4.215 g $M_2(CO_3)_n$ gives $\frac{44n \times 4.215}{(2a+60n)}$ g CO_2

$$\therefore \quad \frac{44n \times 4.215}{2a+60n} = 2.20$$

$$\therefore \quad \text{Eq. mass} = \frac{a}{n} = \mathbf{12.15}$$

41. Taking the given reactions

$$\begin{array}{rl}
 & 4KClO_3 \longrightarrow 3KClO_4 + KCl \\
 & 12KClO \longrightarrow 8KCl + 4KClO_3 \\
 & \underline{12Cl_2 + 24KOH \longrightarrow 12KClO + 12H_2O + 12KCl} \\
\text{Adding} & 12Cl_2 + 24KOH \longrightarrow 3KClO_4 + 21KCl + 12H_2O
\end{array}$$

$$\text{molar mass of } KClO_4 = 138.5$$

$\because$ 3×138.5 g $KClO_4$ is formed by $= 12 \times 71$ g Cl_2

$\therefore$ 100g $KClO_4$ will be formed

$$= \frac{12 \times 71 \times 100}{3 \times 138.5} = \mathbf{205.05\ g}$$

42. Potassium selenate is isomorphous to K_2SO_4 and thus its molecular formula is K_2SeO_4.

Now molar mass of $K_2SeO_4 = (39 \times 2 + a + 4 \times 16)$

$$= (142 + a)$$

where a is atomic mass of Se.

$(142+a)$g K_2SeO_4 has Se $= a$g

$$100 \text{ g } K_2SeO_4 \text{ has Se} = \frac{a \times 100}{142+a}$$

$$\therefore \quad \% \text{ of Se} = 45.42$$

$$\therefore \quad \frac{a \times 100}{142+a} = 45.42$$

$$\therefore \quad a = \mathbf{118.168 \approx 118.2}$$

Also Eq. mass of $K_2SeO_4 = \frac{\text{Molar mass}}{2}$

$$= \frac{2 \times 39 + 118.2 + 64}{2} = \mathbf{130.1}$$

43. Given, C : H

10.5 1 $\therefore$ Total $= 11.5$

Now from $PV = \frac{w}{M}RT$ for vapours of compound

$$1 \times 1 = \frac{2.8}{M} \times 0.0821 \times 400$$

$\therefore$ Molar mass of compound $= 92$

$\because$ 11.5 g has 1 g H

$\therefore$ 92 g has $\frac{92 \times 1}{11.5} = 8$ g H $= 8$ g atom of H

and thus, 92 g has 84 g carbon $= 7$ g atom carbon

$\therefore$ Molecular formula $= \mathbf{C_7H_8}$

44.

$$\begin{array}{lcccl}
 & 2C & + \; O_2 & \longrightarrow 2CO & \\
\text{Mole before reaction} & \frac{24}{12} & \frac{96}{32} & & \\
 & = 2 & = 3 & 0 & \because \text{mole ratio of} \\
\text{Mole after reaction} & 0 & 2 & 2 & C : O_2 : CO :: 2 : 1 : 2
\end{array}$$

(a) $\therefore$ $\mathbf{O_2}$ is left in excess.

(b) **2 mole of O_2** or 64 g O_2 is left.

(c) **2 mole of CO** or 56 g CO is formed.

(d) To use O_2 completely total 6 mole of carbon or **72 g** carbon is needed.

45. Balancing the given equation

$$\begin{array}{lcccc}
 & 2VO & + \; 3Fe_2O_3 & \longrightarrow 6FeO & + \; V_2O_5 \\
\text{Mole before reaction} & \frac{2}{67} & \frac{5.75}{160} & & \\
 & = 0.0298 & 0.0359 & 0 & 0 \\
\text{Mole after reaction} & \left(0.0298 - \frac{0.0359 \times 2}{3}\right) & 0 & 0.0359 \times 2 & 0.0359 \times \frac{1}{3}
\end{array}$$

$\therefore$ Mole of FeO formed $= 0.0359 \times 2$

$\therefore$ Mass of FeO formed $= 0.0359 \times 2 \times 72 = \mathbf{5.17\ g}$

The limiting reagent is one which is used completely, *i.e.*, Fe_2O_3 here.

46. Let the mass of polystyrene prepared by 100 g.

$\therefore$ No. of mole of Br in 100 g of polystyrene

$$= \frac{10.46}{80} = 0.1308 \text{ mole}$$

From the formula of polystyrene, we have,

No. of mole of Br $= 3 \times$ mole of $Br_3C_6H_3(C_8H_8)_n$

$$0.1308 = 3 \times \frac{\text{mass}}{\text{molar mass}} = \frac{3 \times 100}{315 + 104n}$$

$$n = \mathbf{19}$$

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

$$\begin{array}{lccc}
 & CO \; + \; C & \longrightarrow & \text{No reaction} \\
\text{Volume} & a & & \\
 & CO_2 \; + \; C & \longrightarrow & 2CO \\
\text{Volume before reaction} & b & & 0 \\
\text{Volume after reaction} & 0 & & 2b \\
\text{As given} & a + b = 1 & \text{and} & a + 2b = 1.4
\end{array}$$

$\therefore$ $b = \mathbf{0.4\ litre}$ $\therefore$ % of $b = \frac{0.4}{1} \times 100 = \mathbf{40\%}$

$\therefore$ $a = \mathbf{0.6\ litre}$ $\therefore$ % of $a = \frac{0.6}{1} \times 100 = \mathbf{60\%}$

48.

$$\begin{array}{lccc}
 & CO_2 \; + \; C & \longrightarrow & 2CO \\
\text{Initial volume} & 1 & & 0 \\
\text{Final volume} & (1-a) & & 2a \\
\text{Given} & 1 - a + 2a = 1.4 & &
\end{array}$$

$$\therefore \quad a = 0.4 \text{ litre}$$

$$\therefore \quad CO_2 = 1 - 0.4 = \mathbf{0.6\ litre}$$

$$\text{and} \quad CO = 2 \times 0.4 = \mathbf{0.8\ litre}$$

49. Let formula of hydrocarbon be C_aH_b

$$\begin{array}{lcccc}
\therefore & C_aH_b & + \left[a + \frac{b}{4}\right]O_2 & \longrightarrow aCO_2 & + \frac{b}{2}H_2O(l) \\
\text{Volume taken} & 5 \text{ mL} & 30 \text{ mL} & 0 & — \\
\text{Volume left} & 0 & 30 - 5\left[a + \frac{b}{4}\right] & 5a & —
\end{array}$$

Also given

Volume absorbed by NaOH is of CO_2 formed $= 10$ mL

Volume absorbed by pyrogallol is of O_2 left $= 15$ mL

Volume of O_2 used $= 30 - 15 = 15$ mL

$\therefore \quad 5a = 10$ or $a = 2$

$\therefore \quad 5\left(a+\frac{b}{4}\right) = 15$ or $5\left(2+\frac{b}{4}\right) = 15$

$\therefore \quad b = 4$

$\therefore$ Hydrocarbon is $\mathbf{C_2H_4}$.

50.

$$\begin{array}{lccc} & 2SO_2 & + \; O_2 & \longrightarrow \; 2SO_3 \\ \text{Initial mole} & 10 & 15 & 0 \\ \text{Final mole} & (10-2x) & (15-x) & 2x \end{array}$$

Given $2x = 8$

$\therefore \quad x = 4$

$\therefore$ Mole of SO_2 left $= 10 - 2\times 4 = \mathbf{2}$

Mole of O_2 left $= 15 - 4 = \mathbf{11}$

51. Let a mL CO, b mL CH_4 and c mL N_2 be present in mixture,

Then $\quad a+b+c = 20 \quad$ ...(1)

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

$\because$ Volume of CO $= a$; $\quad \therefore$ Volume of $CO_2 = a$

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

$\because$ Volume of $CH_4 = b$; $\quad \therefore$ Volume of $CO_2 = b$

$$N_2 + O_2 \longrightarrow \text{No reaction}$$

Volume of CO_2 formed = Volume absorbed by KOH

$a + b = 14$ mL $\quad$ ...(2)

Now Initial volume of CO + CH_4 + N_2 + vol. of O_2 taken − volume of CO_2 formed − volume of N_2 − volume of O_2 left = 13 (the contraction)

$\therefore a+b+c+$ vol O_2 taken − vol. of O_2 left − (a + b) − c = 13

$\therefore$ Vol. of O_2 used = 13

$\therefore \quad \frac{a}{2} + 2b = 13 \quad$ ...(3)

$\left(\because \text{volume of } O_2 \text{ used} = \frac{a}{2} + 2b\right)$

Solving Eqs. (1), (2) and (3), we get

$\mathbf{a = 10\ mL;} \quad \mathbf{b = 4\ mL;} \quad \mathbf{c = 6\ mL}$

52. Let formula of ammonia be N_aH_b

$$\begin{array}{lccc} & N_aH_b & \rightleftharpoons \frac{a}{2}N_2 & + \; \frac{b}{2}H_2 \\ \text{Initial volume} & 50 & 0 & 0 \\ \text{Final volume} & (50-x) & \frac{a\cdot x}{2} & \frac{b\cdot x}{2} \end{array}$$

$\therefore \quad (50-x) + \frac{ax}{2} + \frac{bx}{2} = 97$

Washing of gas dissolves NH_3 and therefore, since washing reduces the volume by 3 mL, thus

$50 - x = 3$

$\therefore \quad x = 47$ mL

Thus, $\quad N_2 = \frac{47a}{2}$ mL; $\quad H_2 = \frac{47b}{2}$ mL

Also, $\quad \frac{47a}{2} + \frac{47b}{2} = 94$

$\therefore \quad a + b = 4 \quad$ ...(1)

Also,

$$\begin{array}{ccc} H_2 & + \; \frac{1}{2}O_2 & \longrightarrow H_2O \\ \frac{47b}{2} & 60.5 & (H_2 \text{ is completely oxidized}) \\ 0 & \left(60.5 - \frac{47b}{4}\right) & \end{array}$$

$\therefore$ Residual gases after combustion $= N_2 + O_2$ left

$48.75 = \frac{47a}{2} + 60.5 - \frac{47b}{4} \quad$ ...(2)

By Eqs. (1) and (2), $a = 1$ and $b = 3$

$\therefore$ Formula is $\mathbf{NH_3}$

53.

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O(l)$$
$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O(l)$$
$$CO + \frac{1}{2}O_2 \longrightarrow CO_2$$

Let a mL, b mL and c mL be volumes of C_3H_8, CH_4 and CO respectively in 100 mL given sample, then

$a + b + c = 100$

and $\quad a = 36.5$

Now CO_2 is formed as a result of combustion of mixture.

$\therefore$ Vol. of CO_2 formed

$$= 3a + b + c \begin{pmatrix} \because 1 \text{ vol. } C_3H_8 \text{ gives 3 vol. } CO_2 \\ 1 \text{ vol. } CH_4 \text{ gives 1 vol. } CO_2 \\ 1 \text{ vol. CO gives 1 vol. } CO_2 \end{pmatrix}$$

$= 3\times 36.5 + (100 - 36.5) = \mathbf{173\ mL}$

54. Tin is converted into sulphide and hydrogen is left, this gas contains H and S say H_aS_b

$$H_aS_b + bSn \longrightarrow bSnS + \frac{a}{2}H_2 \xrightarrow{CuO} \frac{a}{2}H_2O$$

The reaction suggests that

$\because$ Mole of H_2 : mole of H_2O formed :: 1 : 1

and $\quad$ Mole of H_aS_b : mole of H_2 :: 1 : $a/2$

$\therefore \quad \frac{100}{22400} = \frac{0.081}{18} \times \frac{2}{a}$

$\therefore \quad a = 2$

$\because$ Molar mass of H_aS_b = V.D. × 2 = 17 × 2 = 34

$\therefore \quad 1\times a + 32\times b = 34$

$1\times 2 + 32\times b = 34$

$\therefore \quad b = 1$

Thus gas is $\mathbf{H_2S}$.

55. Let formula of alkane be C_nH_{2n+2}

$$C_nH_{2n+2} + \left[n + \frac{n+1}{2}\right]O_2 \longrightarrow nCO_2 + (n+1)H_2O(l)$$

Given $\quad \frac{\text{Volume of } O_2 \text{ used}}{\text{Volume of } CO_2 \text{ formed}} = \frac{7}{4}$

$\therefore \quad \frac{n + (n+1)/2}{n} = \frac{7}{4}$

$\therefore \quad n = 2$

$\therefore$ Alkane is $\mathbf{C_2H_6}$.

56. Let formula of ammonia be N_aH_b

$$N_aH_b \longrightarrow \frac{a}{2}N_2 + \frac{b}{2}H_2$$

	N_aH_b	$\frac{a}{2}N_2$	$\frac{b}{2}H_2$
Volume before reaction	40	0	0
Volume after reaction	0	$20a$	$20b$

$\therefore$ $20a+20b=40+40=80$

($\because$ an increase in volume occurs by 40 mL)

or $a+b=4$ ...(1)

Now 40 mL O_2 is added,

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O(l)$$

	H_2	$\frac{1}{2}O_2$
Volume before combination	$20b$	40
Volume after combination	0	$\left(40-\frac{20b}{2}\right)$

Gases left after the end of reaction = 30 mL

$\therefore$ Volume of O_2 left + Volume of N_2 left = 30 mL

$$40-10b+20a=30$$

$\therefore$ $b-2a=1$ ...(2)

By Eqs. (1) and (2) $a=1$ and $b=3$

$\therefore$ Molecular formula of ammonia is $\mathbf{NH_3}$.

57. Volume absorbed by terpentine oil = 10 mL

$\therefore$ Volume of ozone = 10 mL (terpentine oil absorbs O_3)

$\therefore$ Volume of $O_2 = 100-10=90$

Molar mass of ozonised oxygen

$$=\frac{WRT}{PV}=\frac{1.5\times 0.0821\times 273}{1\times 1}=33.62$$

Volume or mole ratio of O_2 and O_3 is $900:100$

$\therefore$ Molar mass of ozonised oxygen $=\dfrac{900\times 32+100\times a}{1000}$

or $33.62=\dfrac{900\times 32+100\times a}{1000}$ or $a=48.2$

$\therefore$ molar mass of ozone = **48.2**

58. Let the volume of NO and N_2O be a and b mL respectively, then,

$a+b=60$ ...(1)

$$NO + N_2O + H_2 \longrightarrow \frac{3}{2}N_2 + H_2O(l)$$

	NO	N_2O	H_2	$\frac{3}{2}N_2$	$H_2O(l)$
Volume before reaction	a mL	b mL	excess	0	0
Volume after reaction	0	0		38 mL	

$\because$ 1 mole or 1 vol. NO gives $\frac{1}{2}$ vol. N_2

and 1 mole or 1 vol. N_2O gives 1 vol. N_2

$\therefore$ $\frac{a}{2}+b=38$ ...(2)

By Eqs. (1) and (2), $\mathbf{a=44}$ **mL**

$\mathbf{b=16}$ **mL**

59.

$$nO_2 \longrightarrow 2O_n$$

	nO_2	$2O_n$
Volume before reaction	50 mL	0
Volume after reaction	$(50-a)$ mL	$\frac{2a}{n}$ mL

(Let a mL of O_2 forms O_n)

$\therefore$ Volume of O_2 left $=(50-a)$

or $41=50-a$

$\therefore$ $a=9$

Also Volume of O_3 formed $=47-41=6$ mL

$\therefore$ $\frac{2a}{n}=6$ or $n=3$

$\therefore$ Molecular formula of ozone is $\mathbf{O_3}$.

60. Formula of hydrocarbon be C_aH_b

$\therefore$ $C_aH_b+\left(a+\frac{b}{4}\right)O_2 \longrightarrow aCO_2+\frac{b}{2}H_2O(l)$

$\because$ 22.4 litre C_aH_b gives $44a$ g CO_2

$\therefore$ 1.12 litre C_aH_b gives $=\dfrac{44a\times 1.12}{22.4}$ g CO_2

$\therefore$ $\dfrac{44a\times 1.12}{22.4}=2.2$

$\therefore$ $a=1$

$\because$ 22.4 litre or 1 mole C_aH_b gives $\frac{b}{2}\times 18$ g H_2O

$\therefore$ 1.12 litre C_aH_b gives $\dfrac{b}{2}\times\dfrac{18\times 1.12}{22.4}$ g H_2O

$\therefore$ $\dfrac{b\times 18\times 1.12}{2\times 22.4}=1.8$

$b=4$

$\therefore$ Hydrocarbon is $\mathbf{CH_4}$

$\therefore$ Mass of 1.12 litre CH_4 at NTP $=\dfrac{16\times 1.12}{22.4}=\mathbf{0.8\ g}$

Also, volume of O_2 used in combustion for 22.4 litre CH_4

$$=a+\frac{b}{4}=1+1=2 \text{ mole}$$

$\because$ 22.4 litre CH_4 requires 2 mole O_2 or 2×22.4 litre O_2

$\therefore$ 1.12 litre CH_4 requires 2 mole O_2

$$=\frac{2\times 22.4\times 1.12}{22.4}=\mathbf{2.24\ litre\ O_2}$$

61. $C_nH_{3n}O_m+\left(n+\frac{3n}{4}-\frac{m}{2}\right)O_2 \longrightarrow nCO_2+\frac{3n}{2}H_2O(l)$

	$C_nH_{3n}O_m$	O_2	nCO_2	$H_2O(l)$
Volume taken	16	60	0	0
Volume left	—	$60-16\left(n+\frac{3n}{4}-\frac{m}{2}\right)$	$16n$	—

$\therefore$ Volume of $CO_2=16n$ = volume absorbed by KOH

$16n=44-12=32$

$\therefore$ $n=2$

Volume of O_2 left = 12

$\therefore$ Volume of O_2 used $=60-12=48$

$16\left(n+\frac{3n}{4}-\frac{m}{2}\right)=48$ $\because$ $m=1$

$\therefore$ Formula of Compound $=\mathbf{C_2H_6O}$

62. Mole of CO_2 formed $=\dfrac{14.5}{44}=0.330$

$$\underset{a \text{ mole}}{CH_4} + 2O_2 \longrightarrow CO_2+2H_2O;$$

$$\underset{b \text{ mole}}{C_2H_4} + 3O_2 \longrightarrow 2CO_2+2H_2O$$

$\therefore$ CO_2 formed $=a+2b=0.330$ ...(1)

Also $a\times 16+b\times 28=5.0$ ...(2)

By Eqs. (1) and (2) $b=0.07$

$a=0.19$

$\therefore$ $w_{CH_4}=0.19\times 16=3.04$

$$w_{C_2H_4} = 0.07 \times 28 = 1.96$$

$$\therefore \quad \%C_2H_4 = \frac{1.96}{5} \times 100 = \mathbf{39.2}$$

$$\%CH_4 = \frac{3.04}{5} \times 100 = \mathbf{60.8}$$

63.

$$\begin{array}{lcccccc} & C_3H_8 & + & \frac{7}{2}O_2 & \longrightarrow 3CO & + & 4H_2O(l) \\ \text{Mole before reaction} & \frac{4}{44} & & \frac{14}{32} & & & \\ \text{Mole after reaction} & 0 & & \left(\frac{14}{32} - \frac{4}{44} \times \frac{7}{2}\right) & \frac{3 \times 4}{44} & & \end{array}$$

$$\therefore \quad \text{Mole of CO formed} = \frac{3 \times 4}{44}$$

$$\therefore \quad \text{Mass of CO formed} = \frac{3 \times 4}{44} \times 28\,\text{g} = \mathbf{7.636\ g}$$

64. For spherical shape of nucleus, since whole mass of atom is in nucleus and therefore,

$$\text{Mass of one nucleus} = \text{Volume of nucleus} \times \text{density}$$

$$\frac{\text{Atomic mass}}{\text{Avogadro's no.}} = \frac{4}{3}\pi r^3 \times d$$

For F nucleus

$$\therefore \quad \frac{19}{6.023 \times 10^{23}} = \frac{4}{3}\pi(5 \times 10^{-13})^3 \times d$$

$$\therefore \quad d = \mathbf{6.02 \times 10^{13}\ g\ mL^{-1}}$$

65.

$$\frac{\text{Atomic mass}}{\text{Av. No.}} = \text{volume of atom} \times \text{density}$$

$$\frac{54.94}{6.023 \times 10^{23}} = \frac{4}{3}\pi r^3 \times 7.42$$

$$\therefore \quad r = \mathbf{1.432 \times 10^{-8}\ cm}$$

and $\text{Volume} = \frac{4}{3}\pi r^3 = \mathbf{1.23 \times 10^{-23}\ cm^3}$

66. Let Al, Mg and Cu be a, b, c g respectively.

$$2Al + 2NaOH \xrightarrow{2H_2O} 2NaAlO_2 + 3H_2$$

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

$$Cu + HCl \longrightarrow \text{No reaction}$$

i.e., only Al reacts with NaOH and then only Mg reacts with HCl

$\therefore \quad a + b + c = 8.72$

$b + c = 2.10$ (Residue left after alkali treatment)

$c = 0.69$ (Residue left after acid treatment)

$\therefore \quad b = 1.41\,\text{g}$

and $\quad a = 6.62\,\text{g}$

$$\therefore \quad \%\text{ of Al} = \frac{6.62}{8.72} \times 100 = \mathbf{75.9}$$

$$\%\text{ of Mg} = \frac{1.41}{8.72} \times 100 = \mathbf{16.2}$$

$$\%\text{ of Cu} = \frac{0.69}{8.72} \times 100 = \mathbf{7.9}$$

67. The reaction,

$$CaO + Ca(HCO_3)_2 \longrightarrow 2CaCO_3 + H_2O$$

$\because$ Eq. of $Ca(HCO_3)_2$ present in hard water (1 litre)

$$\frac{1.62}{162/2} = 0.02$$

$\therefore$ Eq. of CaO required to remove $Ca(HCO_3)_2$ in 1 litre $= 0.02$

$\therefore$ Eq. of CaO required to remove $Ca(HCO_3)_2$ in 10^6 litre $= 0.02 \times 10^6$

$$\therefore \quad \text{Mass of CaO} = 0.02 \times 10^6 \times \frac{56}{2}\,\text{g} = \mathbf{5.6 \times 10^5\ g}$$

68. $\text{mM of } MgCl_2 = \frac{1 \times 10^{-3} \times 10^3}{95} = \frac{1}{95}$

$$\left(\text{milli mole} = \frac{\text{mass}}{\text{Molar mass}} \times 1000\right)$$

$\text{mM of } CaCl_2 = \frac{1 \times 10^{-3} \times 10^3}{111} = \frac{1}{111}$

$\therefore$ mM of $CaCO_3$ if $MgCl_2$ and $CaCl_2$ are taken in form of $CaCO_3$

$$= \frac{1}{95} + \frac{1}{111} = \frac{106}{111 \times 95}$$

($\because$ Ca, Mg are both bivalent $\therefore$ mole ratio is 1 : 1)

$$\therefore \quad \text{Mass of } CaCO_3 \text{ in 1000 mL} = \frac{206}{111 \times 95} \times \frac{100}{1000}\,\text{g}$$

$\therefore$ Hardness in ppm (part per million)

$$= \frac{\text{g of } CaCO_3}{10^6 \text{ g of } H_2O} = \frac{206 \times 100 \times 10^6}{111 \times 95 \times 1000 \times 1000} = \mathbf{1.953}$$

$\therefore$ **Hardness = 1.953 ppm**

69.

$$M \xrightarrow{HNO_3} M(NO_3)_n \xrightarrow{\Delta} M_2O_n$$

where n is valency of metal

$\therefore$ Eq. of metal = Eq. of nitrate = Eq. of metal oxide = Eq. of oxygen

$$\frac{w_{\text{metal}}}{E_{\text{metal}}} = \frac{w_{\text{oxygen}}}{E_{\text{oxygen}}}$$

$$\frac{1.60}{E} = \frac{2 - 1.6}{8}$$

$$\therefore \quad E = \mathbf{32}$$

70.

$$M(NO_3)_n \longrightarrow M_2(SO_4)_n$$

$\therefore$ Eq. of $M(NO_3)_n$ = Eq. of $M_2(SO_4)_n$

$$\frac{1}{\frac{a}{n} + \frac{62}{1}} = \frac{0.86}{\frac{a}{n} + \frac{96}{2}}$$

where, a is atomic mass of metal and n is its valency

$$\therefore \quad \frac{a}{n} = E$$

$$\frac{1}{E + 62} = \frac{0.86}{E + 48}$$

$$\therefore \quad E = \mathbf{38}$$

71. Let Eq. mass of Ca be E

$$Ca + \frac{1}{2}O_2 \longrightarrow CaO$$

Equivalent of Ca = Equivalent of CaO

$$\frac{1.35}{E} = \frac{1.88}{E + 8}$$

$\therefore$ Eq. mass of Ca = 20.375

$\therefore$ atomic mass of Ca $= 20.375 \times 2 = \mathbf{40.75}$

72. Atomic mass × specific heat = 6.4

$$a \times 0.057 = 6.4$$

$$a = 112.28$$

Now Equivalent of metal = Equivalent of metal sulphate

$$\frac{2}{E} = \frac{4.51}{E+48} \quad (\because \text{Eq. mass of } SO_4^{-2} = 48)$$

$\therefore$ $E = 38.24$

$\therefore$ Valency of metal $= \frac{\text{Atomic mass}}{\text{Eq. mass}} = \frac{112.28}{38.24} = 2.93$

≈ 3 $(\because$ Valency is integer)

$\therefore$ Exact atomic mass of metal = Eq. mass × Valency

$= 38.24 \times 3 = \mathbf{114.72}$

73. $MBr_x + xHCl \longrightarrow MCl_x + xHBr$

Mass of $MBr_x = 1.878\,g$

Mass of $MCl_x = 1.0\,g$

For the reaction, Equivalent of MBr_x = Equivalent of MCl_x

$$\frac{1.878}{E+80} = \frac{1.0}{E+35.5}$$

$\therefore$ $E = 15.18$

$\because$ atomic mass × sp. heat ≈ 6.4

$\therefore$ atomic mass of metal $M = \frac{6.4}{0.14} = 45.71$

$\therefore$ Valency of metal $= \frac{\text{Atomic mass}}{\text{Eq. mass}} = \frac{45.71}{15.18} \approx 3.01 = 3$

(integer)

$\therefore$ Exact atomic mass of metal $= 15.18 \times 3 = 45.54$

$\therefore$ Molar mass of $MBr_x = 45.54 + 80 \times 3 = \mathbf{285.54}$

74. Let hydrated sulphate be $M_2(SO_4)_n \cdot mH_2O$

where n is valency of metal

Also, atomic mass × specific heat = 6.4

$\therefore$ atomic mass of metal $= \frac{6.4}{0.24} = 26.67$

Now, Eq. of metal = Equivalent of SO_4^{-2}

$$\frac{8.1}{a/n} = \frac{43.2}{96/2}$$

$\therefore$ $n = \frac{43.2 \times 2 \times a}{96 \times 8.1} = \frac{43.2 \times 2 \times 26.67}{96 \times 8.1} = 2.96$

$n \approx 3$

$\therefore$ Exact atomic mass of metal $= 9 \times 3 = 27$

$M_2(SO_4)_3 \cdot mH_2O$

$\therefore$ M. mass $= 2 \times 27 + 96 \times 3 + 18m = 342 + 18m$

$\because$ $(342+18m)\,g$ $M_2(SO_4)_3 \cdot mH_2O$ has $18m\,g$ H_2O

$\therefore$ $100\,g$ $M_2(SO_4)_3 \cdot mH_2O$ has $\frac{18m \times 100}{342+18m}\,g$ H_2O

$\therefore$ $\frac{18m \times 100}{342+18m} = \%$ of $H_2O = 100 - 8.1 - 43.2 = 48.7$

$\therefore$ $m = 18$

$\therefore$ **Formula of hydrated sulphate $M_2(SO_4)_3 \cdot 18H_2O$**

Since, metal has atomic mass 27, it will be Al. Thus, sulphate is $Al_2(SO_4)_3 \cdot 18H_2O$.

75. Meq. of $Ca(OH)_2 = \frac{w}{E} \times 1000 = \frac{74}{74/2} \times 1000 = \mathbf{2000}$

Meq. of NaOH $= \frac{20}{40} \times 1000 = \mathbf{500}$ $(\because E_{NaOH} = 40)$

Meq. of $H_2SO_4 = \frac{2.45}{49} \times 1000 = \mathbf{50}$ $(\because E_{H_2SO_4} = 49)$

76. $\because$ Meq. $= \frac{w}{E} \times 1000$

$\therefore$ $50 = \frac{w}{40} \times 1000$

$\therefore$ $w = \mathbf{2\,g}$

77. $\because$ $N \times V$ (in l) = Equivalent

$\therefore$ $N \times 2 = \frac{50}{1000}$

$\therefore$ $N = \mathbf{0.025}$

78. $Na_2CO_3 \xrightarrow{CaCl_2} CaCO_3$

Meq. of Na_2CO_3 = Meq. of $CaCO_3$

$$\frac{w}{106/2} \times 1000 = \frac{1.0362 \times 1000}{100/2}$$

$\therefore$ $w_{Na_2CO_3} = 1.0984\,g$

$\therefore$ % purity $= \frac{1.0984}{1.2048} \times 100 = \mathbf{91.16\%}$

79. (a) $\because$ Eq. of $Ca(OH)_2 = \frac{0.74}{74/2}$ $\left(\text{Eq.} = \frac{w}{E}\right)$

Volume of solution = 5/ 1000 litre

$\therefore$ $N = \frac{0.74 \times 1000 \times 2}{74 \times 5}$

$N = \mathbf{4}$ $\therefore$ $M = \frac{N}{\text{Valency}} = \frac{4}{2} = \mathbf{2}$

(b) $\because$ Eq. of HCl $= \frac{3.65}{36.5}$

and Volume of solution = 200/ 1000 litre

$\therefore$ $N = \frac{3.65 \times 1000}{36.5 \times 200} = \mathbf{0.5}$

and $M = \frac{N}{\text{Valency}} = \frac{0.5}{1} = \mathbf{0.5}$

(c) Eq. of $H_2SO_4 = \frac{1}{10} \times 2$ $(\because$ Eq. = mole × valency)

Volume of solution = 500/ 1000 litre

$\therefore$ $N = \frac{2 \times 1000}{10 \times 500} = \mathbf{0.4}$ and $M = \frac{0.4}{2} = \mathbf{0.2}$

80. Meq. of $H_2SO_4 = 0.2 \times 1200$ $(\because$ Meq. $= N \times V$ in mL)

$\therefore$ $\frac{w}{49} \times 1000 = 240$

$\therefore$ $w = \mathbf{11.76\,g}$

81.

$$\underset{\text{Base}}{6CaO} + \underset{\text{Acid}}{P_4O_{10}} \longrightarrow \underset{\text{Salt}}{2Ca_3(PO_4)_2}$$

Mole ratio of reactant $= \frac{CaO}{P_4O_{10}} = \frac{6}{1}$

Molar mass of $P_4O_{10} = 284$

$\therefore$ Mole of CaO required $= 6 \times$ mole of $P_4O_{10} = 6 \times \frac{852}{284}$

$\therefore$ Mass of CaO required $= \frac{6 \times 852}{284} \times 56 = \mathbf{1008\,g}$

82. $\because$ Meq. of Na_2CO_3 = Meq. of H_2SO_4

(for complete neutralization)

Meq. of $Na_2CO_3 = 45.6 \times 0.235$

$\therefore$ $\frac{w}{106/2} \times 1000 = 45.6 \times 0.235$

$\therefore$ $w = 0.5679\,g$

$\because$ 95 g pure Na_2CO_3 is to be taken then weighed sample $= 100\,g$

$\therefore$ 0.5679 g pure Na_2CO_3 is to be taken, weighed sample

$$= \frac{100 \times 0.5679}{95} = \mathbf{0.5978\ g}$$

83. Meq. of H_2SO_4 = Meq. of $CuCO_3$

$$\left(\text{Eq. mass of } CuCO_3 = \frac{M}{2}\right)$$

$$0.5 \times 2 \times V = \frac{0.5 \times 2 \times 1000}{123.5}$$

$\therefore$ $V = \mathbf{8.097\ mL}$

84. Meq. of H_2SO_4 = Meq. of NaOH ($\because$ Meq. $= N \times V$ in mL)

$$N \times 12 = 15 \times \frac{1}{10}$$

$$N = \frac{15}{10 \times 12}$$

$\therefore$ $\text{Strength} = \frac{15}{10 \times 12} \times 49$ ($\because$ $S = N \times E$)

$$= \mathbf{6.125\ g/litre}$$

85. Normality of acid $= \frac{39}{82/n \times 1}$ (n is basicity of acid)

Normality of NaOH $= \frac{40}{40} \times \frac{1000}{1000} = 1$

Now, Meq. of acid = Meq. of NaOH

$$\frac{39n}{82} \times 100 = 1 \times 95$$

$\therefore$ $n = 2$; *i.e.*, acid is dibasic.

86. $\because$ Meq. of solute does not change on dilution

Meq. of H_2SO_4 (conc.) = Meq. of H_2SO_4 (dil.)

$$0.1 \times 0.1 = N \times 1000$$

($\because$ Meq. $= N \times V$ in mL)

$$n = \mathbf{10^{-5}}$$

87. Meq. of original $H_2SO_4 = 30 \times 1 = 30$

Meq. of H_2SO_4 after passing $NH_3 = 30 \times 0.2 = 6$

$\therefore$ Meq. of H_2SO_4 lost $= 30 - 6 = 24$

$\therefore$ Meq. of NH_3 passed = Meq. of H_2SO_4 lost

$\because$ $\frac{w}{17} \times 1000 = 24$

$\therefore$ $w_{NH_3} = 0.408\,g$

$\therefore$ Volume of NH_3 at STP $= \frac{22.4 \times 0.408}{17} = 0.5376$ litre

$$= \mathbf{537.6\ mL}$$

88. For NH_3, $PV = \frac{w}{m} RT$

$\therefore$ $\frac{w}{m} = \frac{PV}{RT} = \frac{0.2 \times 2}{0.0821 \times 303} = 0.01608$

$\therefore$ Mole of NH_3 = Equivalent of $NH_3 = 0.01608$

$\therefore$ Meq. of $NH_3 = 16.08$

Now Meq. of H_2SO_4 = Meq. of NH_3

$$N \times 134 = 16.08$$

$\therefore$ $N = \mathbf{0.12}$

89.

$$Ca + \frac{1}{2}O_2 \longrightarrow CaO$$

Equivalent taken	1/20	excess	
Equivalent after reaction	0	—	1/20 ($\because$ Eq. $= w/E$)

$\therefore$ $N_{CaO} = \frac{1}{20 \times 1} = \mathbf{0.05}$ $\left(\because N = \frac{\text{Eq.}}{V \text{ in litre}}\right)$

90. $\because$ Meq. of metal = Meq. of HCl

$$\frac{1.82}{E} \times 1000 = 32.5 \times 1$$

$\therefore$ $E = \mathbf{56}$

91. (a) Meq. of HCl $= 100 \times 0.1 = 10$

Meq. of NaOH $= 50 \times 0.25 = 12.5$

$\because$ HCl and NaOH neutralize each other with equal equivalent

Meq. of NaOH left $= 12.5 - 10 = 2.5$

Volume of new solution $= 100 + 50 = 150$ mL

$\therefore$ N_{NaOH} left $= \frac{2.5}{150} = \mathbf{0.0167}$

(b) Meq. of $H_2SO_4 = 100 \times 0.2 \times 2 = 40$

($\because$ $N = M \times$ Valency)

Meq. of HCl $= 200 \times 0.2 \times 1 = 40$

$\therefore$ Total Meq. of acid $= 40 + 40 = 80$

Total volume of solution = 300 mL

$\therefore$ $N_{\text{Acid Solution}} = \frac{80}{300} = \mathbf{0.267}$

(c) Meq. of $H_2SO_4 = 100 \times 0.2 \times 2 = 40$

Meq. of NaOH $= 100 \times 0.2 \times 1 = 20$

$\therefore$ Meq. of H_2SO_4 left after reaction $= 40 - 20 = 20$

Total volume of solution $= 100 + 100 = 200$ mL

$\therefore$ $N_{H_2SO_4}$ left $= \frac{20}{200} = \mathbf{0.1}$

(d) Meq. of NaOH $= 1 \times 1000 = 1000$

Meq. of HCl $= 100 \times 0.1 = 10$

$\therefore$ Meq. of NaOH left after reaction $= 1000 - 10 = 990$

Total volume of solution = 100 mL

$\therefore$ N_{NaOH} left $= \frac{990}{100} = \mathbf{9.9}$

92. Let V_1 mL of $NaNO_3$ is mixed with V_2 mL of $Ca(NO_3)_2$

mM of $NaNO_3$ mixed $= 0.2 \times V_1$

mM of $Ca(NO_3)_2$ mixed $= 0.1 \times V_2$

$\because$ Mole ratio of $Ca^{2+} : NO_3^-$ in $Ca(NO_3)_2$ is 1 : 2

$\therefore$ Molarity of NO_3^- in mixture

$$= [NO_3^-] \text{ of } NaNO_3 + [NO_3^-] \text{ of } Ca(NO_3)_2$$

$$= \frac{0.2 \times V_1}{(V_1 + V_2)} + \frac{0.1 \times 2 \times V_2}{(V_1 + V_2)}$$

$$= \frac{(0.2V_1 + 0.2V_2)}{V_1 + V_2}$$

Similarly, Molarity of Na^+ and Ca^{2+} in mixture

$$= \frac{0.2 \times V_1}{V_1 + V_2} + \frac{0.1 \times V_2}{V_1 + V_2}$$

$$= \frac{(0.2V_1 + 0.1V_2)}{(V_1 + V_2)}$$

Now, given that, Molarity of NO_3^-

$$= \frac{3}{2} \text{ Molarity of } Na^+ \text{ and } Ca^{2+}$$

$$\therefore \quad \frac{0.2V_1 + 0.2V_2}{(V_1 + V_2)} = \frac{3}{2}\left[\frac{(0.2V_1 + 0.1V_2)}{(V_1 + V_2)}\right]$$

$$\therefore \quad \frac{V_1}{V_2} = \frac{1}{2}$$

93. $\because$ 15 Meq. of each separately react with KOH and therefore only 15 Meq. of KOH are required every time.

$\therefore$ Meq. of KOH required = 15

$$\frac{w}{56} \times 1000 = 15$$

$$\therefore \quad w = \mathbf{0.84\ g}$$

94. Meq. of conc. solution = $1600 \times 0.2050 = 328$

Let after dilution volume becomes V mL

Meq. of dil. solution = $0.20 \times V$

$$\therefore \quad 328 = 0.20 \times V$$

$$\therefore \quad V = 1640 \text{ mL}$$

Thus, volume of water used to preapare 1640 mL of 0.20N solution

$$= 1640 - 1600 = \mathbf{40\ mL}$$

95. $w = 12 \text{ g } BaCl_2$; $W = 100 \text{ g}$ solution

$\therefore$ **For 50 g solution:** $w_{BaCl_2} = 6\text{g}$; $W_{\text{solution}} = 50\text{g}$

$$\therefore \quad w_{BaCl_2 \cdot 2H_2O} = \frac{6 \times 244}{208} = \mathbf{7.038\ g}$$

$$\therefore \quad w_{H_2O} = 50 - 7.038 = \mathbf{42.962\ g}$$

96.

$$Na + H_2O \longrightarrow NaOH + \frac{1}{2}H_2$$

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

Thus, Meq. of Na = Meq. of NaOH formed = Meq. of HCl used

$$\frac{0.46}{23} \times 1000 = \frac{73}{36.5} \times V \quad (\text{Meq. of HCl} = N \times V)$$

$$\therefore \quad V = \mathbf{10\ mL}$$

97.

	$Al_2(SO_4)_3$ +	$BaCl_2 \longrightarrow$	$BaSO_4 \downarrow$ +	$AlCl_3$
Meq. before mixing	$20 \times 0.2 \times 6$	$20 \times 0.6 \times 2$	0	0
	= 24	= 24		
Meq. after mixing	0	0	24	24

(Meq.= $N \times V$ in mL = $M \times$ valency $\times V$ in mL)

$$\therefore \quad [Al^{3+}] = \frac{24}{40 \times 3} = \mathbf{0.2}\ \boldsymbol{M}$$

$$[Cl^-] = \frac{24}{40} = \mathbf{0.6}\ \boldsymbol{M}$$

No concentration of Ba^{2+} or SO_4^{2-} in solution since $BaSO_4$ gets precipitated.

98. The reaction shows two H atoms replaced from H_3PO_4

$$\therefore \quad \text{Basicity of } H_3PO_4 = 2$$

$$\therefore \quad \text{Eq. mass } H_3PO_4 = \frac{M}{2} = \frac{98}{2} = \mathbf{49}$$

99.

$$1 \text{ mole of } H_2S = 5 \text{ mole of } H_2SO_4$$

$$\therefore \quad \frac{34}{34} = 1 \text{ mole of } H_2S = 5 \text{ mole of } H_2SO_4$$

$$\therefore \quad 0.20 \times V = 5$$

$$\therefore \quad V = \frac{5}{0.20} = \mathbf{25\ litre}$$

100.

	$AgNO_3$ +	$HCl \longrightarrow$	$AgCl$ +	HNO_3
Meq. mixed	$\frac{1.7}{170} \times 1000$	200×5		
	= 10	= 1000	0	0
Meq. after reaction	0	990	10	10

$\therefore$ Meq. of AgCl formed = 10

$$\therefore \quad \frac{w}{143.5} \times 1000 = 10$$

$$\therefore \quad w_{AgCl} = \mathbf{1.435\ g}$$

101.

	$AgNO_3$ +	$NaCl \longrightarrow$	$AgCl$ +	$NaNO_3$
Meq. mixed	$\frac{5.77}{170} \times 1000$	$\frac{4.77}{58.5} \times 1000$		
	= 33.94	= 81.54	0	0
Meq. left	0	47.60	33.94	33.94

$\therefore$ Meq. of AgCl formed = 33.94

$$\frac{w}{143.5} \times 1000 = 33.94$$

$$\therefore \quad w_{AgCl} = \mathbf{4.87\ g}$$

102.

$$N_{NaCl} = \frac{3.78}{58.5 \times 100/1000} = 0.646 \quad \left(\because N = \frac{\text{Eq.}}{V \text{ in litre}}\right)$$

Let w g of $BaCl_2$ is dissolved in 250 mL then

$$N_{BaCl_2} = \frac{w}{\frac{208}{2} \times \frac{250}{1000}} = 0.0385w$$

$\therefore$ $[Cl^-]$ in both is same.

$$\therefore \quad N_{NaCl} = N_{BaCl_2}$$

$$\therefore \quad 0.646 = 0.0385w$$

$$\therefore \quad w = \mathbf{16.80\ g}$$

103. Given,

	$3Pb(NO_3)_2$ +	$Cr_2(SO_4)_3 \longrightarrow$	$3PbSO_4 \downarrow$ +	$2Cr(NO_3)_3$
Meq. before reaction	$45 \times 0.25 \times 2$	$25 \times 0.1 \times 6$		
	= 22.5	= 15	0	0
Meq. after reaction	7.5	0	15	15

$\therefore$ Meq. of $PbSO_4$ precipitated = 15

$\therefore$ mM of $PbSO_4$ precipitated = $\frac{15}{2}$

$\therefore$ Mole of $PbSO_4$ precipitated = $\frac{15}{2} \times \frac{1}{1000} = \mathbf{0.0075}$

$$\because \quad [\text{Normality}] = \frac{\text{Meq.}}{\text{total volume} \times \text{valency}}$$

Also,

$$[Pb^{2+}] = \frac{7.5}{70 \times 2} = \mathbf{0.0536}\ \boldsymbol{M}$$

$$[NO_3^-] = \frac{7.5 + 15}{70 \times 1} = \mathbf{0.32}\ \boldsymbol{M}$$

$$[Cr^{3+}] = \frac{15}{70 \times 3} = \mathbf{0.0714}\ \boldsymbol{M}$$

104. $\text{Meq. of } Na_2CO_3 \cdot H_2O = \dfrac{0.62}{62} \times 1000 \quad \left(\dfrac{w}{E} \times 1000 = \text{Meq.}\right)$

$= 10$

$\text{Meq. of } H_2SO_4 = 100 \times 0.1 = 10$

$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2 \uparrow$

	Na_2CO_3	H_2SO_4	Na_2SO_4	H_2O	CO_2
Meq. added	10	10	0	0	0
Meq. left	0	0	10	10	10

$\therefore \quad N_{Na_2SO_4} = \dfrac{10}{100} = \mathbf{0.1}$

Solution becomes neutral since both acid and base are used up and Na_2SO_4 does not show hydrolysis.

105. $\text{Mass of Ag} = \dfrac{90 \times 0.5}{100} = 0.45$

$\therefore \quad \text{Meq. of Ag} = \dfrac{0.45}{108} \times 1000 = 4.17$

Now, $\quad Ag \xrightarrow{HNO_3} AgNO_3 \xrightarrow{KCNS} AgCNS$

$\because$ Equal Meq. reacts and therefore,

$\text{Meq. of KCNS} = \text{Meq. of } AgNO_3$

$= \text{Meq. of } HNO_3 = \text{Meq. of Ag}$

$\therefore \quad N \times 25 = 4.17$

$\therefore \quad N = \mathbf{0.167}$

106. $\text{Meq. of } H_2SO_4 = \text{Meq. of NaOH}$

$N \times 5 = 84.6 \times 2$

$\therefore \quad N = \dfrac{84.6 \times 2}{5} = 33.84 \text{ eq. litre}^{-1}$

$\therefore$ Mass of H_2SO_4 in 1 litre $= 33.84 \times 49$

$\therefore$ Density or mass of H_2SO_4 in 1 mL

$= \dfrac{33.84 \times 49}{1000} = 1.658 \text{ g / mL}$

$\therefore \quad \text{Purity} = \dfrac{1.658}{1.8} \times 100 = \mathbf{92.12\%}$

107. H_2SO_4 is 86% by mass.

$\therefore \quad \text{Mass of } H_2SO_4 = 86 \text{g}$

$\text{Mass of solution} = 100 \text{g}$

$\therefore \quad \text{Volume of solution} = \dfrac{100}{1.787} \text{ mL} = \dfrac{100}{1.787 \times 1000} \text{ litre}$

$\therefore \quad M_{H_2SO_4} = \dfrac{86}{98 \times \dfrac{100}{1.787 \times 1000}} = \mathbf{15.68}$

Let V mL of this H_2SO_4 are used to prepare 1 litre of $0.2M$ H_2SO_4

$\therefore$ mM of H_2SO_4 conc. $=$ mM of H_2SO_4 dilute

$V \times 15.68 = 1000 \times 0.2$

$\therefore \quad V = \mathbf{12.75 \text{ mL}}$

108. Given, $\quad \text{Mass of Al} = 2.7 \text{g}$

$\therefore \quad \text{Equivalent of Al} = \dfrac{2.7}{9} = 0.3$

$\therefore \quad \text{Meq. of Al} = 0.3 \times 1000 = 300$

For H_2SO_4 given that solution is 24.7% by mass

$\therefore \quad \text{Mass of } H_2SO_4 = 24.7 \text{g}$

and $\quad$ Mass of solution $= 100 \text{g}$

$\therefore \quad \text{Volume of solution} = \dfrac{100}{1.18} \text{ mL} = 84.75 \text{ mL}$

$N_{H_2SO_4} = \dfrac{24.7}{49 \times \dfrac{100}{1.18 \times 1000}} = 5.95$

Now, Meq. of H_2SO_4 in 75 mL $5.95 \times 75 = 446.25$

and Meq. of Al added $= 300$

$\therefore$ Meq. of H_2SO_4 left after reaction

$= 446.25 - 300 = 146.25$

$\because$ Solution is diluted to 400 mL

$\therefore \quad N_{H_2SO_4} \text{ left} = \dfrac{146.25}{400} = \mathbf{0.367}$

$\therefore \quad M_{H_2SO_4} \text{ left} = \dfrac{0.367}{2} = \mathbf{0.183}$

109. KOH solution is 30% by mass.

$\therefore \quad \text{Mass of KOH} = 30 \text{g}$

and $\quad$ Mass of solution $= 100 \text{g}$

$\therefore \quad \text{Volume of solution} = \dfrac{100}{d}$

(where d is density of solution)

$\therefore \quad \text{Molarity} = 6.90 = \dfrac{30}{56 \times \dfrac{100}{1000 \times d}}$

$d = \mathbf{1.288 \text{ g mL}^{-1}}$

110. Given mole fraction of $I_2 = 0.2$

$\therefore \quad \dfrac{n}{n+N} = 0.2 \qquad \text{...(1)}$

Also mole fraction of $C_6H_6 = 1 - 0.2 = 0.8$

$\therefore \quad \dfrac{N}{n+N} = 0.8 \qquad \text{...(2)}$

where n and N are mole of I_2 and C_6H_6 respectively.

By Eqs. (1) and (2) $\quad \dfrac{n}{N} = \dfrac{0.2}{0.8} = \dfrac{1}{4}$

or $\quad \dfrac{n \times M_{C_6H_6}}{w_{C_6H_6}} = \dfrac{1}{4} \quad$ or $\quad \dfrac{n}{w_{C_6H_6}} = \dfrac{1}{4 \times 78}$

or $\quad \dfrac{n}{w_{C_6H_6}} \times 1000 = \dfrac{1000}{4 \times 78}$

or $\quad \text{Molality} = \dfrac{1000}{4 \times 78} = \mathbf{3.205}$

111. $\text{Meq. of Al} = \text{Meq. of HCl} = 12 \times 0.05 = 0.6$

$\therefore \quad \text{Mass of Al} = \dfrac{0.6 \times 9}{1000} = 0.0054 \text{ g}$

$\therefore \quad \text{Volume of Al foil} = \dfrac{0.0054}{2.7} \text{ mL or cm}^3 = 0.002 \text{cm}^3$

Now, $\quad$ Area × thickness = Volume

$\therefore \quad \text{Area} = \dfrac{0.002}{0.01} = \mathbf{0.2 \text{ cm}^2}$

(thickness = 0.01 cm)

Note : The maximum area is possible when 0.01 cm foil of Al is completely attacked.

112. $\text{Mass of } Fe_2O_3 = \dfrac{0.70 \times 25}{100}$

$\therefore \quad \text{mole of } Fe_2O_3 = \dfrac{0.70 \times 25}{100 \times 160}$

$\therefore \quad \text{mole of } Fe^{3+} = \dfrac{2 \times 0.70 \times 25}{100 \times 160} = 2.1875 \times 10^{-3}$

$\therefore \quad \text{Eq. of } Fe^{3+} = 2.1875 \times 10^{-3} \times 3 = 6.5625 \times 10^{-3}$

Also, Normality of NH_3 (aq.) $= \frac{2.3\times0.99\times1000}{17\times100} = 1.34$

$$\text{Eq. of } NH_3 = \text{Eq. of } Fe^{3+}$$

$$1.34\times V = 6.5625\times10^{-3}$$

$$\therefore \quad V = 4.9\times10^{-3} \text{ litre} = \mathbf{4.9\ mL}$$

113. Given, H_2SO_4 is 93% by volume.

$\therefore$ Mass of $H_2SO_4 = 93\,g$

Volume of solution $= 100$ mL

$\therefore$ Mass of solution $= 100\times1.84 = 184$ g

$\therefore$ Mass of water $= 184-93 = 91$ g

$$\therefore \quad \text{Molality} = \frac{\text{Mole}}{\text{Mass of water in kg}} = \frac{93}{98\times\frac{91}{1000}} = \mathbf{10.42}$$

114.

$$C+\frac{1}{2}O_2 \longrightarrow CO \qquad \text{...(1)}$$

$$C+O_2 \longrightarrow CO_2 \qquad \text{...(2)}$$

Let *a* mole of C reacts according to Eq. (1) and *b* mole of C reacts according to Eq. (2).

Then, $a+b=\frac{18}{12}=1.5$ ...(3)

Also, Mole of O_2 used $=\frac{a}{2}+b=\frac{5\times5}{0.0821\times291}$ $\left(n=\frac{PV}{RT}\right)$

or $\frac{a}{2}+b=1.046$ ...(4)

By Eqs. (3) and (4), $a = 0.908$

$b = 0.592$

$\therefore$ CO_2 formed $= 0.592$ mole

m mole of NaOH given $= 2\times500 = 1000$

m mole of CO_2 formed $= 592$

Now the reaction of CO_2 with NaOH will occur as :

	$2NaOH\ +$	$CO_2 \longrightarrow$	$Na_2CO_3 + H_2O$
m mole before reaction	1000	592	0
m mole after reaction	0	92	500

	$Na_2CO_3\ +$	$CO_2 + H_2O \longrightarrow$	$2NaHCO_3$
m mole before reaction	500	92	0
m mole after reaction	408	0	$2\times92=184$

$$\therefore \quad M_{Na_2CO_3} = \frac{408}{500} = \mathbf{0.816\ M}$$

$$M_{NaHCO_3} = \frac{184}{500} = \mathbf{0.368\ M}$$

115. Let *V* mL of each are mixed

For I solution. H_2SO_4 is 30% by mass.

$\therefore$ Mass of $H_2SO_4 = 30\,g$

and Mass of solution $= 100\,g$

$\therefore$ Volume of solution $= \frac{100}{1.218}$ mL

i.e., $\frac{100}{1.218}$ mL contains 30 g H_2SO_4

$\therefore$ *V* mL contains $\frac{30\times V\times1.218}{100}$ g H_2SO_4

For II solution. H_2SO_4 is 70% by mass.

$\therefore$ Mass of $H_2SO_4 = 70\,g$

Mass of solution $= 100\,g$

$\therefore$ Volume of solution $= \frac{100}{1.610}$ mL

i.e., $\frac{100}{1.610}$ mL contains 70 g H_2SO_4

$\therefore$ *V* mL contains $\frac{70\times V\times1.610}{100}$ g H_2SO_4

On mixing these two, total mass of H_2SO_4

$$=\left[\frac{30\times1.218}{100}+\frac{70\times1.610}{100}\right]V\ g = 1.4924\ V\ g$$

Total volume of solution $= 2V$ mL

$$\therefore \quad \text{Molarity of solution} = \frac{1.4924V}{98\times\frac{2V}{1000}} = \mathbf{7.61}$$

Now, Mass of total solution $= 2V\times1.425\,g = 2.85V$ g

$\therefore$ Mass of water $= (2.85V-1.4924V)g = 1.3576V$ g

$$\therefore \quad \text{Molality of solution} = \frac{1.4924V}{98\times\frac{1.3576V}{1000}} = \mathbf{11.22}$$

116. Consider one litre water or 10^{-3} m^3 of water

$\therefore$ Volume of water $= 1$ litre $= 10^{-3}$ m^3 $= 1000$ mL

$\therefore$ 1 m^3 H_2O weigh 10^3 kg $H_2O = 10^6$ g H_2O

$\therefore$ 10^{-3} m^3 H_2O weigh $= 10^6\times10^{-3}$ g $H_2O = 10^3$ g H_2O

$\therefore$ Mole of water $= \frac{10^3}{18}$

Molarity $= \frac{1000}{18\times1}$

Molarity $= \mathbf{55.6}$

117. Eq. of NaOH $= 50\times0.2 = 10$

Eq. of HCl $= 5\times1 = 5$

$\therefore$ Eq. of NaOH left after reaction with HCl $= 10-5 = 5$

Also NaOH reacts with $FeCl_3$ 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 $= 15\times0.1 = 1.5$

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

$$\therefore \quad N_{NaOH} \text{ left} = \frac{3.5}{70} = \mathbf{0.05}\ N$$

$\because$ Total volume $= 70$ litre

Also, Eq. of $Fe_2O_3 = 1.5$

$$\therefore \quad \frac{w}{M/6} = 1.5$$

$$\therefore \quad w_{Fe_2O_3} = \frac{1.5\times160}{6} = \mathbf{40\ g}$$

118. Meq. of barium salt = Meq. of acid

$$\frac{4.290}{M/2}\times1000 = 21.64\times0.477\times2$$

Molar mass of salt $= 415.61$

$$\text{Molar mass of anion} = \frac{415.61-137-36}{2} = 121.31$$

$\therefore$ Molar mass of acid $= 121.31+1 = \mathbf{122.31}$

119. The ionic strength (μ) of a solution is given by

$$\mu = \frac{1}{2}\Sigma cZ^2$$

where, c is the concentration of ion and Z is its valency.

$$\mu = \frac{1}{2}[0.5\times 2^2 + 0.5\times 2^2 + 0.1\times 3^2 + 0.3\times 1^2 + 0.4\times 1^2 + 0.2\times 2^2]$$

$$= \mathbf{3.2}$$

120.
$$\frac{n_{AA}}{n_{AA} + n_{H_2O}} = 0.15$$

$$\therefore \quad \frac{n_{H_2O}}{n_{AA} + n_{H_2O}} = 0.85$$

$$\therefore \quad \frac{n_{AA}}{n_{H_2O}} = \frac{15}{85} \quad \text{or} \quad \frac{\frac{w_{AA}}{60}}{\frac{w_{H_2O}}{18}} = \frac{15}{85}$$

$$\therefore \quad \frac{w_{AA}}{w_{H_2O}} = \frac{15}{85}\times\frac{60}{18} = 0.59 \qquad \text{...(i)}$$

Also, $w_{AA} + w_{H_2O} = 30$ ...(ii)

$\therefore \quad w_{AA} = 11.13\,g$

$\therefore$ Meq. of acetic acid = Meq. of NaOH

$$\frac{11.13}{60}\times 1000 = 0.01\times V_{mL}$$

$\therefore \quad V = 18550\text{ mL} = \mathbf{18.55\ litre}$

121. Let n_1 mole of solute and n_2 mole of solvent be present in solution.

Given, $n_1 + n_2 = 1$

$$\because \quad X_1 = \frac{n_1}{n_1 + n_2} \quad \text{and} \quad X_2 = \frac{n_2}{n_1 + n_2}$$

and thus, $X_1 + X_2 = 1$ and $\dfrac{X_1}{X_2} = \dfrac{n_1}{n_2}$

(a) $\therefore$ Mole of solute, $n_1 \propto$ mole fraction of solute, X_1
mole of solvent, $n_2 \propto$ mole fraction of solvent, X_2

$\therefore$ Total mass of solution $= (X_1 \cdot M_1 + X_2 \cdot M_2)$

$\therefore$ Total volume of solution $= \left[\dfrac{X_1M_1 + X_2M_2}{\rho}\right]$ litre

$$\therefore \quad \text{Molarity } M = \frac{X_1}{(X_1M_1 + X_2M_2)/\rho}$$

$$= \frac{X_1\rho}{(X_1M_1 + X_2M_2)} \qquad \text{...(i)}$$

$$\therefore \quad MX_1M_1 + MX_2M_2 = X_1\rho$$

$$\text{or} \quad MX_1M_1 + MM_2(1 - X_1) = X_1\rho$$

$$\text{or} \quad X_1(\rho - MM_1 + MM_2) = MM_2$$

$$\therefore \quad \boldsymbol{X_1 = \frac{MM_2}{\rho + M(M_2 - M_1)}}$$

(b) For a dilute solution $X_1M_1 << X_2M_2$;

$X_2 \longrightarrow$ unity, *i.e.*, 1

and $\rho_{solution} = \rho_{solvent}$

Thus from Eq. (i), $M = \dfrac{X_1\rho}{M_2}$

Thus molarity, M of a dilute solution is directly proportional to mole fraction of solute, *i.e.*, $M \propto X_1$.

122. Let a and b g are masses of Al and Zn in mixture.

$\therefore \quad a + b = 1.67$ ...(1)

$$Al + 3HCl \longrightarrow AlCl_3 + \frac{3}{2}H_2$$

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

$\because$ 27 g Al gives $\frac{3}{2}\times 22.4$ litre H_2

a g Al gives $\dfrac{3\times 22.4\times a}{2\times 27}$ litre H_2 ($\because$ atomic mass of Al = 27)

Similarly 65 g Zn gives 22.4 litre H_2 ($\because$ atomic mass of Zn = 65)

$\therefore$ b g Zn gives $\dfrac{22.4\times b}{65}$ litre H_2

$$\therefore \quad \frac{3\times 22.4\times a}{2\times 27} + \frac{22.4\times b}{65} = 1.69 \qquad \text{...(2)}$$

Solving Eqs. (1) and (2) $\quad a = \mathbf{1.25\ g}$
$\quad b = \mathbf{0.42\ g}$

Alternate solution

$$a + b = 1.67 \qquad \text{...(1)}$$

Meq. of Al + Meq. of Zn = Meq. of H_2

$$\frac{a}{27/3}\times 1000 + \frac{b}{65/2}\times 1000 = \frac{1.69}{22.4/2}\times 1000 \qquad \text{...(2)}$$

Solve Eqs. (1) and (2) to get a and b.

123.
$$HCOOH \xrightarrow[\Delta]{H_2SO_4} H_2O + CO$$

$$H_2C_2O_4 \xrightarrow[\Delta]{H_2SO_4} H_2O + CO + CO_2$$

Let a mole of HCOOH and b mole of $H_2C_2O_4$ are present in original mixture.

$\therefore$ Mole of CO formed $= \underset{\text{from HCOOH}}{a} + \underset{\text{from } H_2C_2O_4}{b}$

Mole of CO_2 formed $= \underset{\text{from } H_2C_2O_4}{b}$

Total mole of gases $= a + b + b = a + 2b$

$\because$ CO_2 is absorbed by KOH and volume reduces by $\frac{1}{6}$

$$\therefore \quad \text{Mole of } CO_2 = \frac{1}{6}(a + 2b)$$

$$b = \frac{1}{6}(a + 2b)$$

$$\therefore \quad a/b = 4$$

$$\therefore \quad a : b :: \mathbf{4 : 1}$$

124. Let total millimole of Mg used for MgO and Mg_3N_2 be a and b respectively.

	$2Mg + O_2 \longrightarrow$	$2MgO$
Before reaction	a	0
After reaction	0	a

	$3Mg + N_2 \longrightarrow$	Mg_3N_2
Before reaction	b	0
After reaction	0	$b/3$

Now, $\left(a + \frac{b}{3}\right)$ millimole 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 the solution contains a millimole of $MgCl_2$ from MgO and b millimole of $MgCl_2$ and $\frac{2b}{3}$ millimole of NH_4Cl from Mg_3N_2.

Also, millimole of HCl used for this purpose

$$= \underset{\text{for MgO}}{2a} + \underset{\text{for } Mg_3N_2}{\frac{8b}{3}}$$

Now, millimole of HCl or Meq. of HCl (monobasic acid) $= 60-12 = 48$

$$2a + \frac{8b}{3} = 48 \qquad ...(1)$$

Further, millimole of NH_4Cl formed = millimole of NH_3 liberated = millimole of HCl used for absorbing NH_3

$$\therefore \quad \frac{2b}{3} = 4 \quad \text{or} \quad b = 6 \qquad ...(2)$$

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

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

125. $$N_2O_5 \rightleftharpoons 2NO(g) + \frac{1}{2}O_2(g)$$

Initial pressure	600	0	0
Final pressure	$600-P$	$2P$	$P/2$

[$P \propto$ mole if V, T are constant (where mole equivalent] to pressure P are decomposed)

Thus, $\quad 600 - P + 2P + P/2 = 960 \quad \text{or} \quad P = 240$ mm Hg

Thus, $\quad$ mole fraction of N_2O_5 decomposed $= \frac{240}{600} = \mathbf{0.4}$

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

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

Let a litre of C_3H_8 and b litre of C_4H_{10} be present in mixture.

$$\therefore \quad a + b = 3 \qquad ...(1)$$

Also volume of CO_2 formed $= 10 =$ CO_2 formed by C_3H_8 + CO_2 formed by C_4H_{10}

$$10 = 3a + 4b \qquad ...(2)$$

Solving Eqs. (1) and (2) $\quad b = \mathbf{1}$ **litre**

127. Glauber's salt is $Na_2SO_4 \cdot 10H_2O$ having molar mass = 322 g mol^{-1}

$\because$ Mass of Na_2SO_4 in 8.0575×10^{-2} kg glauber salt

$$= \frac{142 \times 8.0575 \times 10^{-2}}{322} = 3.5533 \times 10^{-2} \text{ kg}$$

$\therefore$ Molarity 'M' of $Na_2SO_4 = \frac{3.5533 \times 10^{-2}}{142 \times 10^{-3} \times 1}$

$$\left(\because M = \frac{\text{mole}}{\text{volume in litre}}\right)$$

$$= \mathbf{0.2502\ M}$$

$\because$ Mass of solution $= 1077.2 \times 10^{-3}$ kg

$$= 1077.2 \times 10^{-3} \times 10^3 \text{ g} = 1077.2 \text{ g}$$

Mass of $Na_2SO_4 = 3.5533 \times 10^{-2} \times 10^3 \text{ g} = 35.533$ g

$\therefore$ Mass of water $= 1077.2 - 35.533 = 1041.667$ g

$\because$ Molality of $Na_2SO_4 = \frac{\text{Mole of } Na_2SO_4}{\text{Mass of water in kg}}$

$$= \frac{3.5533 \times 10^{-2}}{142 \times 10^{-3} \times \frac{1041.667}{10^3}} = \mathbf{0.24\ m}$$

Also, $\quad$ Mole fraction of Na_2SO_4

$$= \frac{\text{Mole of } Na_2SO_4}{\text{Mole of } Na_2SO_4 + \text{Mole of } H_2O}$$

$$= \frac{\frac{3.5533 \times 10^{-2}}{142 \times 10^{-3}}}{\frac{3.5533 \times 10^{-2}}{142 \times 10^{-3}} + \frac{1041.667}{18}} = \mathbf{4.3 \times 10^{-3}}$$

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

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

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

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

$\therefore \quad$ Residue left $= 5 - 1.4 = 3.6$ g

The residue contains PbO + $NaNO_2$

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

$\therefore \quad$ a g $Pb(NO_3)_2$ gives $= \frac{223 \times a}{331}$ g PbO

Similarly,

$\because \quad$ 85 g $NaNO_3$ gives = 69 g $NaNO_2$

$\therefore \quad$ b g $NaNO_3$ gives $= \frac{69 \times b}{85}$ g $NaNO_2$

$$\therefore \quad \frac{223 \times a}{331} + \frac{69 \times b}{85} = 3.6 \qquad ...(2)$$

Solving Eqs. (1) and (2),

$\therefore \quad a = \mathbf{3.32\ g}$

$b = \mathbf{1.68\ g}$

129. For a gaseous mixture of C_2H_6 and C_2H_4

$$PV = nRT$$

$$\therefore \quad 1 \times 40 = n \times 0.082 \times 400$$

$\therefore$ Total mole of $(C_2H_6 + C_2H_4) = 1.2195$

Let mole of C_2H_6 and C_2H_4 be a, b respectively

$$a + b = 1.2195 \qquad ...(1)$$

$$C_2H_6 + (7/2)O_2 \longrightarrow 2CO_2 + 3H_2O$$

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

$\therefore$ Mole of O_2 needed for complete reaction of mixture $= 7a/2 + 3b$

$$\therefore \quad \frac{7a}{2} + 3b = \frac{130}{32} \qquad ...(2)$$

By Eqs. (1) and (2), $\quad a = 0.808$

$b = 0.4115$

$\therefore \quad$ Mole fraction of $C_2H_6 = 0.808/1.2195 = \mathbf{0.66}$

and $\quad$ Mole fraction of $C_2H_4 = \mathbf{0.34}$

130. Sample of hard water contains 96 ppm SO_4^{2-} and 40 ppm Ca^{2+} ($CaSO_4$). Also it contains 183 ppm HCO_3^- and 60 ppm Ca^{2+} [$Ca(HCO_3)_2$].

To remove $Ca(HCO_3)_2$ from 10^3 kg or 10^6 g sample of hard water which contains 243 g $Ca(HCO_3)_2$ or 3/2 mole of $Ca(HCO_3)_2$, CaO required is 3/2 mole.

$$Ca(HCO_3)_2 + CaO \longrightarrow 2CaCO_3 + H_2O$$

Thus, mole of CaO required = 3/2 or 1.5

Also, Ca^{2+} ions left in solution are of $CaSO_4$ *i.e.*, **40 ppm**

Now, 1 litre water contains Ca^{2+} after removal of $Ca(HCO_3)_2$

$$= \frac{40 \times 10^3}{10^6} = 40 \times 10^{-3} \text{ g}$$

or $$[Ca^{2+}] = \frac{40 \times 10^{-3}}{40} = 10^{-3}$$

If these Ca^{2+} are exchanged with H^+, then $[H^+]$ in solution $= 2 \times 10^{-3}$

$\therefore$ $$pH = -\log 2 \times 10^{-3} = \mathbf{2.6989}$$

131. Mass of $Na_2CO_3 = a$ g

Mass of $K_2CO_3 = b$ g

$\therefore$ $$a + b = 1.20 \qquad ...(1)$$

For neutralization reaction 100 mL solution

Meq. of Na_2CO_3 + Meq. of K_2CO_3 = Meq. of HCl

$$\frac{a}{106/2} \times 1000 + \frac{b}{138/2} \times 1000 = \frac{40 \times 0.1 \times 100}{20}$$

$\therefore$ $$69a + 53b = 73.14 \qquad ...(2)$$

By Eqs. (1) and (2), $a = \mathbf{0.5962\ g}$

$b = \mathbf{0.6038\ g}$

Further, solution of $Na_2CO_3 + K_2CO_3$ gives ppt of $BaCO_3$ with $BaCl_2$.

Meq. of $BaCO_3$ = Meq. of Na_2CO_3 + Meq. of K_2CO_3 (in 20 mL)

= Meq. of HCl for 20 mL mixture

$= 40 \times 0.1 = 4$

$\therefore$ $$\frac{w}{197/2} \times 1000 = 4$$

$\therefore$ Mass of $BaCO_3$ = **0.394 g**

132. $$N_{HCl} = \frac{109.5}{36.5 \times 1} = 3$$

Since, Na_2CO_3 is completely neutralized by HCl

$\therefore$ Meq. of Na_2CO_3 = Meq. of HCl

$$N \times 25 = 32.9 \times 3$$

$\therefore$ $$N_{Na_2CO_3} = 3.948$$

Now, Na_2CO_3 fresh solution reacts with H_2SO_4

Mass of Na_2CO_3 solution = 125 g

$\therefore$ Volume of Na_2CO_3 solution $= \frac{125}{1.25} = 100$ mL

$\therefore$ Meq. of H_2SO_4 = Meq. of Na_2CO_3

$$0.84 \times V = 100 \times 3.948$$

$\therefore$ Volume of H_2SO_4 required = **470 mL**

133. m M of HCl $= 200 \times a + 500 \times b$

$\therefore$ Molarity after diluting to 2 litre $= \frac{200 \times a + 500 \times b}{2000}$

Thus $$1.5 = \frac{200a + 500b}{2000}$$

Also $$\frac{a}{b} = \frac{5}{4}$$

$\therefore$ $$1.5 \times 2000 = 200 \times \frac{5}{4} b + 500b$$

$\therefore$ **b = 4 and a = 5**

134. $$H_2O + SO_3 \longrightarrow H_2SO_4$$

$\because$ 18 g H_2O reacts with 80 g SO_3

$\therefore$ 6 g H_2O reacts with $\frac{80 \times 6}{18} = 26.67$g

$\therefore$ % of free SO_3 = **26.67 g**

• SINGLE INTEGER ANSWER PROBLEMS •

1. The number of mole of N_2O_4 in 276 g N_2O_4 are ......
2. 10 mL of 'a' M solution of HCl is mixed with 40 mL of $1M$ HCl to produce a mixture of $2M$. The value of a is ......
3. Molar ratio in a mixture of water and absolute alcohol is 0.2. The mole fraction ratio of alcohol and water is ......
4. 6 g of H_2 reacts with 14 g N_2 to form NH_3 till the reaction completely consumes the limiting reagent. The mass of other reactant (in g) left are ......
5. 1 g of titanium (atomic mass 48) reacts with Cl_2 to give 3.21875 g compound. The valence of titanium is ......
6. A reaction requires two atoms of P for five atoms of O. The amount in g of O_2 required for 3.10 g P :
7. A mixture of C_2H_4 and H_2 (in excess) has a pressure of 60 cm Hg. The mixture on passing over Ni catalyst gives : $C_2H_4(g) + H_2(g) \longrightarrow C_2H_6(g)$. The resultant pressure of mixture after completion of reaction at same T and V is 40 cm Hg. The ratio of mole fraction of H_2 and C_2H_4 in original mixture are ......
8. Haemoglobin contains 0.25% iron by mass. The molar mass of haemoglobin is 89600. Number of iron atoms present in one mole of haemoglobin are ......
9. A gaseous alkane C_nH_{2n+2} an explosion with O_2 gives CO_2. The volume of O_2 required for complete combustion of alkane to CO_2 formed is 7 : 4. The value of n is ......
10. Compound S_4N_4 decompose completely into $S_X(g)$ and $N_2(g)$. If all measurements are made of same P and T each volume of S_4N_4 gives 4.0 volume of gaseous product. The value of X is ......
11. 0.98 g of a polybasic acid (molar mass 98) requires 30 mL of 0.5 M $Ba(OH)_2$ for complete neutralisation. The basicity of acid is ......
12. A solution of H_2O_2 has normality $\frac{N}{1.7}$. Its % strength is ......
13. Number of water molecules attached on Cu^{2+} ion in $CuSO_4 \cdot 5H_2O$ is ......
14. Number of water molecules present in Mohr's salt is ......
15. 'n' factor for potash alum is ......
16. 100 mL solution of an acid (molar mass 82) containing 39 g acid per litre was completely neutralised by 95.0 mL of aqueous NaOH solution containing 40 g NaOH per litre. The basicity of acid is ......
17. The acidity of acid salt $BaHPO_4$ is ......
18. The basicity of acid salt $BaHPO_4$ is ......
19. 3 mole of $BaCl_2$ are mixed with 5 mole of Na_3PO_4 in 1000 mL water. The maximum number of mole of $Ba_3(PO_4)_2$ formed are.....
20. A gaseous alkane C_nH_{2n+2} is exploded with oxygen. The volume of oxygen for complete combustion of alkane to CO_2 formed is in the ratio 7 : 4. The value of n is :
21. In what volume ratio 0.1M $Ca(NO_3)_2$ and 0.2 M $NaNO_3$ solutions should be mixed, so that the concentration of negative ion is 50% greater than the concentration of +ve ions.
22. The molality of 49% by volume of H_2SO_4 solution having density 1.49 g/mL is....
23. The ratio of mole of H_2 and CH_4 in a mixture having equal masss of both is....
24. A mixture of C_2H_4 and excess of H_2 has a pressure of 60 cm Hg. The mixture on passing over catalyst forms ethane. The pressure of resultant mixture under identical conditions is 40 cm of Hg. The mole ratio of H_2 and C_2H_4 in the mixture is....
25. Two acid solutions A and B are titrated separately each with 25 mL of $1N$ Na_2CO_3 solution. The volume of each acid used for titration is 10 mL and 40 mL respectively for the complete neutralisation. The volume ratio of V_B and V_A which is mixed to prepare one mL $1N$ solution is...
26. The oxidation of toluene with $KMnO_4$ gives potassium benzoate yield of 76.66%. The amount to closest integer value of toluene to obtain 12g potassium benzoate required is....
27. 500 mL of aM and 500 mL of bM solution of a solute are mixed and diluted to 2 litre to prepare a solution of 1.5 M. If a and b are in the ratio 2 : 1, then value of a is....
28. A sample of crystalline $Ba(OH)_2 \cdot X\, H_2O$ weighing 1.578 g was dissolved in water. The solution required 40 mL of 0.25N HNO_3 for complete reaction. Determine the number of molecules of water of crystallisation in base.
29. The specific gravity of a solution of 1.8 g mL^{-1} having 62% by mass of acid. It is to be diluted to specific gravity of 1.2 g mL^{-1}. What volume of water (in litre) should be added to 1 litre of this solution?
30. A mixture of Xe and F_2 was heated and the white solid so formed reacted with H_2 to give 81 mL of Xe at STP and HF. The HF formed required 68.43 mL of 0.3172 M NaOH for complete neutralization. The empirical formula of white solid is XeF_n. The value of n is....
31. 100 g HCl solution having density 1.20 g/mL contains 36.5 g HCl. How much volume in litre of this HCl is required to neutralise exactly 36 litre of N NaOH solution.
32. An element A forms a thiocyanate of formula $A(CNS)_m \cdot nH_2O$. Analysis shows that compound

contains 19.7% of *A* and 19% water. If atomic mass of *A* is 55.96, the value of *m* is....

33. In the above problem14 value of *n* is....

34. A certain metal *M* forms an insoluble oxalate $M_4O_3(C_2O_4)_3 \cdot 12H_2O$. If 61.87g of the complex are formed from *n* g oxalic acid ($H_2C_2O_4$). The atomic mass of metal is 100. The value of *n* is......

35. 1 g dry algae absorbs 7.4×10^{-3} mole of CO_2 per sec by photosynthesis. If the fixed carbon atoms were all stored after the photosynthesis as starch $(C_6H_{10}O_5)_m$, the time required in sec for absorption of CO_2 by algae to double its own mass.

36. One litre of milk mass 1.035 kg. The density of butter fat and fat free skimmed milk are 875 kg m^{-3} and 1042 kg m^{-3}. The vol/vol per cent of butter fat in milk is...

37. Chloride samples are prepared for analysis by using NaCl, KCl and NH_4Cl separately or as mixture. What minimum volume of 5% by mass $AgNO_3$ solution (sp. gravity 1.19 g/mL) must be added to a sample of 0.1498 g in order to ensure precipitation of chloride in every possible case?

38. Valence factor of potash alum is....

39. Valence factor of S in SO_2 is four and in SO_3 is six. Valence factor of S in $2SO_2 + O_2 \longrightarrow 2SO_3$ is....

40. 2×10^{10} atoms of carbon are arranged in a straight line occupying 2.4 cm putting side by side. The radius of carbon atom in nm is....

41. 23.1 mL of 0.115 *M* solution of NaOH is required for the end point using bromocresol green for 25 mL of 0.107 H_3PO_4. If the indicator phenolphthalein is used then 46.2 mL of same NaOH requires 25 mL of 0.107 *M* H_3PO_4. What is the ratio of replaceable H-atom in phenolphthalein and bromocresol indicators titrations?

42. Number of equivalents of oxygen in 1*M* $K_2Cr_2O_7$ acting as oxidant in presence of acid are....

43. 1 mL of 12*M* HCl is spread over a thin Al foil of thickness 0.1 mm and density 2.70 g/mL. Assuming area covered by HCl dissolves Al only, the area in cm^2 of hole produced in Al foil is....

44. A hydrated salt $MSO_4 \cdot nH_2O$ undergoes 43.9% loss in mass on heating and becomes anhydrous. If atomic mass of metal is 65, the value of *n* is....

45. The volume strength of H_2O_2 solution is 11.2. What is its normality?

46. Mole of 400 g $CaCO_3$ is ......

47. A mixture of HCOOH and $H_2C_2O_4$ is heated with conc. H_2SO_4. The gaseous mixture on passing through KOH shows a reduction of $\frac{1}{6}$ in volume at same *P* and *T*. The mole ratio of HCOOH and $H_2C_2O_4$ in mixture is.

48. Atomicity of sulphur in vapour state is ......

49. An aqueous solution of 6.3 g oxalic acid $(H_2C_2O_4 \cdot 2H_2O)$ is dissolved in water to prepare 250 mL solution. The volume of 1 N NaOH required to neutralise 10 mL solution of oxalic acid is ......

50. Equal masses of hydrogen and methane are taken in a container under identical conditions of *P* and *T*. The mole ratio of H_2 and CH_4 is.

51. An inorganic compound $ZnCr_2O_x$, 9.81 g Zn, 1.8×10^{23} atoms of Cr and 0.6 g-atom of O. The value of *x* is ......

52. The equilibrium molarity of OH^- is 0.08 *M* in a solution of $0.1\,M(OH)_2$. The % of dissociation of $Ca(OH)_2$ is ....

53. The normality of $0.5\ M\ H_3PO_3$ solution is ......

54. How much of the following have equilibrium molality of $[H^+]=0.6\,M$

$0.3\,M\ H_2SO_4$, $0.3\,M\ H_3PO_3$, $0.6\,M$ HI, $0.2\,M\ H_3PO_4$, $0.6\,M\ HNO_3$.

55. How much of the following are temperature independent in case of solution.

Meq. of solute, mole of solute, % by mass, mole fraction, molarity, normality, % by strength, strength, molality.

56. How much of the following are dilution independent in case of solution. Meq. of solute, mole of solute, % by mass, mole fraction, molarity, molality % by strength, strength, molality.

57. 245 g impure $KClO_3$ decomposes to give 2.4 g O_2. The % yield of product O_2 is ......

58. Equilibrium molarity of 196 g H_2SO_4 present in 1 litre solution is ......

59. Ionic strength of Ba^{2+} present in a solution obtained by mixing 30 mL 0.1 *N* $BaCl_2$ with 40 mL of 0.2 *N* $Al_2(SO_4)_3$ is ......

60. A student performs a titration with different burettes and finds titre value of 25.2 mL, 25.25 mL, 25.0 mL. The number of significant figures in the average titre value is ...... **(IIT 2010)**

61. The volume (in mL) of 0.10 M $AgNO_3$ required for complete precipitation of chloride ions present in 30 mL of 0.01 M solution of $[Cr(H_2O)_5Cl]Cl_2$ as silver chloride is close to ...... **(IIT 2011)**

62. 29.2% (mass/mass) HCl stock solution has a density of 1.25 g mL^{-1}. The molar mass of HCl is 36.5 g mol^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution of 0.4 *M* HCl is: **(IIT 2012)**

ANSWERS

1. Three **2.** Six **3.** Five **4.** Three **5.** Three **6.** Four **7.** Two **8.** Four **9.** Two **10.** Two **11.** Three **12.** One
13. Four **14.** Six **15.** Eight **16.** Two **17.** Two **18.** One **19.** One **20.** Two **21.** Two **22.** Five **23.** Eight **24.** Two
25. Four **26.** Nine **27.** Four **28.** Eight **29.** Three **30.** Six **31.** Three **32.** Three **33.** Three **34.** Two **35.** Five **36.** Four
37. Eight **38.** Eight **39.** Two **40.** Six **41.** Two **42.** Six **43.** Four **44.** Seven **45.** Two **46.** Four **47.** Four **48.** Two
49. Four **50.** Eight **51.** Four **52.** Four **53.** One **54.** Three **55.** Five **56.** Two **57.** Five **58.** Zero **59.** Zero **60.** Three
61. Six **62.** Eight

OBJECTIVE PROBLEMS (One Answer Correct)

1. A sample contains 9.81 g Zn (atomic mass 65), 1.8×10^{23} atoms of Cr and 0.6 g-atoms of Cr. The simple formula of this compound is :
(a) $ZnCrO_4$ (b) $ZnCr_2O_4$
(c) Zn_2CrO_4 (d) $ZnCrO_3$

2. The number of H^+ ions present in 100 mL of 0.001 M H_2SO_4 solution is :
(a) 1.2×10^{20} (b) 6×10^{19}
(c) 2.4×10^{20} (d) 1.2×10^{23}

3. The atomic masses of two elements A and B are 30 and 90 respectively. If 'a' g of element A contains 'b' atoms, then number of atoms of B in $2a$ g is :
(a) $2b/3$ (b) $b/3$
(c) $b/4$ (d) $b/2$

4. A nugget of gold and quartz weighs 100 g. Specific gravity of gold, quartz and nugget are 20.0, 4.0 and 5.0 g mL^{-1} respectively. The mass of gold in nugget is:
(a) 30 g (b) 35 g
(c) 25 g (d) 20 g

5. The mass of wet NaOH containing 20% water required to neutralise 6 litre of 0.5 M H_2SO_4 solution is:
(a) 3 kg (b) 1.5 kg
(c) 0.3 kg (d) 0.15 kg

6. 1 g of an acid (molar mass 146) is completely neutralised by 0.768 g KOH. The number of neutralisable protons in acid are :
(a) 1 (b) 3
(c) 2 (d) 4

7. The volume ratio of 6 N and 2 N HCl required to prepare 100 mL of 5 N HCl is :
(a) 3 : 1 (b) 1 : 3
(c) 4 : 1 (d) 1 : 4

8. 105 mL of pure water at 4°C is saturated with NH_3 producing a solution of 30% by mass of NH_3. The total mass of solution after saturation becomes :
(a) 105 g (b) 130 g
(c) 150 g (d) 160 g

9. The total ionic strength of solution on mixing 10 mL of 1 N $AgNO_3$ and 90 mL of 1 N $BaCl_2$ solution is :
(a) 2.8 (b) 2.6
(c) 1.35 (d) 1.2

10. The mass of 5 litre C_6H_6 is maximum at :
(a) 10°C (b) 20°C
(c) 30°C (d) 40°C

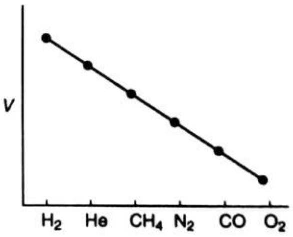
11. An aqueous solution of glucose is 10% by mass/mass of solution. The percentage by mass/mass of solvent is : (assume $d_{H_2O} = 1$)
(a) 11.11% (b) 15%
(c) 20.22% (d) 22.22%

12. The equivalent mass of a metal is double that of oxygen. The ratio of masses of metal oxide and mass of the metal is :
(a) 2 (b) 1.5
(c) 2.5 (d) 3.0

13. The volume and radius of 1 molecule of water is : (assume $d_{H_2O} = 1\,g/mL$)
(a) 3.0×10^{-20}, 19.25 Å (b) 6.0×10^{-23}, 2.42 Å
(c) 3.0×10^{-23}, 1.925 Å (d) 6.0×10^{-23}, 1.925 Å

14. If $a = 49\,g\ H_2SO_4 + (3 \times 10^{23}$ molecule $H_2SO_4) - (0.02\ N\ H_2SO_4)$, then the value of a is :
(a) 0.9 mol (b) 0.99 mol
(c) 0.8 mol (d) 0.88 mol

15. Which of the following gases does not show correct variation in figure where volume *vs.* gas plots are made. Each gas is taken in equal mol at STP ?



(a) He and H_2 (b) CH_4 and He
(c) CO and N_2 (d) O_2 and CO

16. A solution requires $[OH^-] = 2\,M$. If degree of dissociation of $Mg(OH)_2$ is α, what analytical molarity solution of $Mg(OH)_2$ needed is equal to:
(a) α (b) 2α
(c) $\frac{1}{\alpha}$ (d) $\frac{1}{2\alpha}$

17. Hardness of water is 400 ppm. The molarity of $CaCO_3$ in this water is :
(a) $4 \times 10^{-6}\,M$ (b) $4 \times 10^{-2}\,M$
(c) $4 \times 10^{-3}\,M$ (d) $4 \times 10^{-1}\,M$

18. The volume strength of 1.5 N H_2O_2 solution is :
(a) 4.8 (b) 8.4
(c) 3.0 (d) 8.0

19. The normality of 0.3 M phosphorous acid :
(a) 0.1 (b) 0.9
(c) 0.3 (d) 0.6

20. How many g of KCl would have to be dissolved in 60 g H_2O to give 20% by mass of solution:
(a) 1.5 g (b) 15 g
(c) 25 g (d) 12 g

21. 10 mL of oxygen and 60 mL of H_2 is sparked till reaction is complete to form $H_2O_{(l)}$. After attaining the initial condition of *P* and *T*, the reduction in volume (in mL) of gases after reaction is:
(a) 30 (b) 40
(c) 20 (d) 10

22. 10 mL of CH_4 was burnt in limited supply of oxygen forming CO_2 and CO in the ratio 99 : 1 along with water vapours. The volume of oxygen needed in mL for the change is:
(a) 19.95 (b) 19.9
(c) 9.95 (d) 9.9

23. The formula of a hydrated salt of barium is $BaCl_2 \cdot XH_2O$. If 1.936 g of this compound gives 1.846 g of anhydrous $BaSO_4$ on treatment with H_2SO_4, the value of *X* is :
(a) 7 (b) 5
(c) 3 (d) 2

24. 40% (mass/vol) NaCl has specific gravity 1.12 g/mL. In ppm the concentration of NaCl is:
(a) 5.5×10^5 ppm (b) 3.57×10^6 ppm
(c) 1×10^6 ppm (d) 4×10^5 ppm

25. What mass of NH_3 contains same number of atoms as in 4g-atom of oxygen:
(a) 17 g (b) 68 g
(c) 42 g (d) 34 g

26. The ratio of oxygen atoms in $Ca_3(PO_4)_2$ and H_3PO_3 if each sample of $Ca_3(PO_4)_2$ and H_3PO_4 contains same number of *P* atoms:
(a) $\frac{3}{4}$ (b) $\frac{4}{3}$
(c) $\frac{2}{3}$ (d) $\frac{3}{2}$

27. Select the incorrect statement for exact neutralisation of 1 mole of $Ba(OH)_2$ by:
(a) 1.5 mole of H_3PO_3 (b) 1 mole of H_2SO_4
(c) $\frac{2}{3}$ mole of H_3PO_4 (d) 2 mole of H_3PO_2

28. A gaseous mixture of H_2 and CO_2 contains 44% of CO_2 by mass. The vapour density of mixture is:
(a) 2.72 (b) 1.72
(c) 3.45 (d) 1.36

29. On heating 17.0 g $AgNO_3$, the residue left is :
(a) 1.16 g (b) 10.8 g
(c) 2.32 g (d) 1.08 g

30. How many gram of dibasic acid (molar mass 200) should be present in 100 mL of the aqueous solution to give 0.1 N solution :
(a) 1 g (b) 1.5 g
(c) 0.5 g (d) 20 g

31. Specific volume of a cylindrical virus particle is 6.02×10^{-2} mL / g, having the radius and length 7 Å and 10 Å respectively. What is the molar mass of virus:
(a) 15.4 kg/mol (b) 1.54×10^4 kg /mol
(c) 4.68×10^4 kg /mol (d) 2.08×10^4 kg /mol

32. Percentage of Se (atomic mass = 78.4) in peroxidase anhydrous enzyme is 0.5% by mass. The minimum molar mass of enzyme is :
(a) 1.568×10^3 (b) 1.568×10^4
(c) 25.68 (d) 4.316×10^4

33. 2.5 litre of 1 *M* NaOH solution is mixed with another 3 litre solution of 0.5 *M* NaOH. The molarity of resultent solution is :
(a) 1.0 *M* (b) 0.84 *M*
(c) 0.73 *M* (d) 0.56 *M*

34. What volume of O_2 gas at 0°C and 1 atm is needed to burn completely one litre of propane under same conditions :
(a) 5 litre (b) 10 litre
(c) 7 litre (d) 6 litre

35. How many mole of lead (II) chloride will be formed from a reaction between 6.5 g PbO and 3.2 g HCl.
(a) 0.011 (b) 0.029
(c) 0.044 (d) 0.33

36. The maximum number of molecules is present in :
(a) 15 litre of H_2 gas at STP
(b) 5 litre N_2 gas at STP
(c) 0.5 g of H_2 gas
(d) 5 g of O_2 gas

37. 27g Al will react completely with .... g oxygen:
(a) 8 (b) 16
(c) 24 (d) 32

38. 10 g $CaCO_3$ contains:
(a) 10 mole of $CaCO_3$ (b) 1g-atom of Ca
(c) 6×10^{22} atoms of Ca (d) 0.1 equivalent of Ca

39. Which of the following has highest mass?
(a) 20 g phosphorus
(b) 5 moles of water
(c) 2 equivalent of Na_2CO_3
(d) 12×10^{24} atoms of hydrogen

40. When the same mass of Zn is treated separately with excess of H_2SO_4 and excess of NaOH, the ratio of volumes of H_2 evolved is:
(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 9 : 4

41. 2.76 g silver carbonate on heating strongly yields a residue weighing:
(a) 2.16 g (b) 2.48 g
(c) 2.32 g (d) 2.64 g

42. A gaseous mixture contains oxygen and nitrogen in the ratio of 1 : 4 by mass. Therefore the ratio of their molecules is:
(a) 1 : 4 (b) 1 : 8
(c) 7 : 32 (d) 3 : 16

43. The largest number of molecules is in:
(a) 36g H_2O (b) 28g CO
(c) 46g C_2H_5OH (d) 54g N_2O_5

44. 0.50 mole of $BaCl_2$ is mixed with 0.20 mole of Na_3PO_4, the maximum number of mole of $Ba_3(PO_4)_2$ that can be formed is:
(a) 0.70 (b) 0.50
(c) 0.20 (d) 0.10

45. A molal solution is one that contains one mole of solute in :
(a) 1000 g of the solvent (b) 1 litre of the solvent
(c) 1 litre of solution (d) 22.4 litres of solution

46. The pair of compounds which can not exist together in solution is:
(a) $NaHCO_3$ and NaOH (b) Na_2CO_3 and $NaHCO_3$
(c) Na_2CO_3 and NaOH (d) $NaHCO_3$ and NaOH

47. In which mode of expression, the concentration of a solution remains independent of temperature?
(a) Molarity (b) Normality
(c) Formality (d) Molality

48. At 1000°C and 1 atm, if the density of the liquid water is $1.0\,g\,cm^{-3}$ and that of water vapour is $0.006\,g\,cm^{-3}$, then the volume occupied by water molecules in 1 litre of steam at this temperature is:
(a) $6\,cm^3$ (b) $60\,cm^3$
(c) $0.6\,cm^3$ (d) $0.06\,cm^3$

49. The difference in the volume of gases obtained after complete decomposition of 100 mL sample of NH_3 and PH_3 each separately. Given that both produce all the product in vapour state:
(a) 25 mL (b) 50 mL
(c) 75 mL (d) 100 mL

50. The molar ratio of Fe^{2+} and Fe^{3+} ions in a mixture of $FeSO_4$ and $Fe_2(SO_4)_3$ if each component of mixture provides equal no. of sulphate ions :
(a) 2 : 3 (b) 3 : 2
(c) 1 : 2 (d) 1 : 4

51. Number of mole of Na^+ ions in 20 litre of 0.4 M Na_3PO_4 is :
(a) 8 (b) 24
(c) 16 (d) 12

52. 28 g KOH is used to completely neutralize CO_2 produced by heating 60 g impure sample $CaCO_3$. The percentage purity of $CaCO_3$ is :
(a) 83.32 (b) 20.83
(c) 41.66 (d) 40.00

53. An aqueous solution of 6.3 g oxalic acid dihydrate is made upto 250 mL. The volume of 0.1 *N* NaOH required to completely to neutralise 10 mL of this solution is : **(IIT 2001)**
(a) 40 mL (b) 20 mL
(c) 10 mL (d) 4 mL

54. How many mole of electron weigh one kilogram ? **(IIT 2002)**
(a) 6.023×10^{23} (b) $\frac{1}{9.108} \times 10^{23}$
(c) $\frac{6.023 \times 10^{54}}{9.108}$ (d) $\frac{1}{9.108 \times 6.023} \times 10^{8}$

55. 0.02 mole of $[Co(NH_3)_5SO_4]Br$ and 0.02 mole of $[Co(NH_3)_5Br]SO_4$ were used to prepare 2 litre solution. One litre of this solution on treatment with excess of $AgNO_3$ gives *Y* and *Z* respectively. Number of mole of *Y* and *Z* obtained are : **(IIT 2003)**
(a) 0.01, 0.02 (b) 0.02, 0.02
(c) 0.01, 0.01 (d) 0.02, 0.01

56. Which has the maximum number of atoms? **(IIT 2003)**
(a) 24 g C (12) (b) 56 g Fe (56)
(c) 27 g Al (27) (d) 108 g Ag (108)

57. Dissolving 120 g of urea (molar mass 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is : **(IIT 2011)**
(a) 1.78 *M* (b) 2.00 *M*
(c) 2.05 *M* (d) 2.22 *M*

58. A gaseous hydrocarbon gives upon combustion 0.72 g. of water and 3.08 g. of CO_2. The empirical formula of the hydrocarbon is : **[JEE (Main) 2013]**
(a) C_6H_5 (b) C_7H_8
(c) C_2H_4 (d) C_3H_4

59. The molarity of a solution obtained by mixing 750 mL of 0.5(*M*) HCl with 250 mL of 2(*M*) HCl will be : **[JEE (Main) 2013]**
(a) 1.75 *M* (b) 0.975 *M*
(c) 0.875 *M* (d) 1.00 *M*

SOLUTIONS (One Answer Correct)

1. (b) Mole ratio of

$$\begin{array}{lccccc} & \text{Zn} & : & \text{Cr} & : & \text{O} \\ & =\dfrac{9.81}{65} & : & \dfrac{1.8\times10^{23}}{6.023\times10^{23}} & : & 0.6 \\ & =0.15 & : & 0.30 & : & 0.6 \\ & =1 & : & 2 & : & 4 \end{array}$$

$\therefore$ $ZnCr_2O_4$

2. (d) Meq. of H^+ = Meq. of $H_2SO_4 = 100\times0.001\times2 = 0.2$

$\therefore$ Number of $H^+ = 0.2\times6.023\times10^{23} = 1.2\times10^{23}$

3. (a) No. of atom of A in a g $= \dfrac{N\times a}{30} = b$

No. of atoms of B in $2a$ g $= \dfrac{N\times2a}{90} = \dfrac{N\times2\times a}{3\times30} = \dfrac{b\times2}{3}$

4. (c) Volume of nugget = Volume of gold + Volume of quartz

$\dfrac{100}{5} = \dfrac{a}{20} + \dfrac{100-a}{4}$ $\therefore$ $a = 25\,g$

5. (c) Eq. of NaOH = Eq. of $H_2SO_4 = 6\times0.5\times2 = 6$

$\therefore$ $\dfrac{w}{40} = 6$

$w_{NaOH} = 240\,g$

Now, $80\,g\ NaOH \equiv 100\,g$ wet NaOH

$240\,g\ NaOH = \dfrac{100\times240}{80} = 300\,g$

6. (c) Meq. of acid = Meq. of KOH

$\dfrac{1}{146/n}\times1000 = \dfrac{0.768}{56}\times1000$ $\therefore$ $n = 2$

7. (a) Let a mL of $6N$ and $(100-a)$ mL of $2N$ are mixed

$\therefore$ $a\times6 + (100-a)\times2 = 100\times5$

$\therefore$ $a = 75\,mL$

$\therefore$ $(100-a) = 25\,mL$

8. (c) Let a g NH_3 is dissolved in 105 mL H_2O or 105 g H_2O

$\therefore$ % by mass of NH_3 in solution $= \dfrac{a}{105+a} = \dfrac{30}{100}$

$\therefore$ $a = 45\,g$

$\therefore$ Mass of solution $= 105 + 45 = 150\,g$

9. (c)

$$\begin{array}{lcccc} & AgNO_3 & +\ BaCl_2 & \longrightarrow Ba(NO_3)_2 & +\ AgCl\downarrow \\ \text{Meq. added} & 10\times1 & 90\times1 & 0 & 0 \\ & 10 & 90 & 0 & 0 \\ & 0 & 80 & 10 & 10 \end{array}$$

$\therefore$ $[BaCl_2] = \dfrac{80}{2\times100} = 0.4\,M;$

$Ba(NO_3)_2 = \dfrac{10}{2\times100} = 0.05\,M$

Ionic strength $= \dfrac{1}{2}\Sigma CZ^2 = \dfrac{1}{2}[0.4\times2^2 + 0.4\times2\times1^2 + 0.05\times2^2 + 0.05\times2\times1^2]$

$= 1.35$

10. (a) The volume of a liquid increases with temperature and thus same volume masss more in winter.

11. (a) $w_g = 10$ $W_{Solution} = 100\,g$ $\therefore W_{Solvent} = 90$

$\therefore$ % by mass of solute/mass of solvent

$= \dfrac{10}{90}\times100 = 11.11\%$

12. (b) $E_M = 2\times E_O = 2\times8 = 16,$

$E_{MO} = E_M + E_O = 16 + 8 = 24$

Let w_1 g of metal gives w_2 g oxide

$\dfrac{w_1}{16} = \dfrac{w_2}{24}$ $\therefore$ $\dfrac{w_2}{w_1} = \dfrac{24}{16} = 1.5$

13. (c) $18\,mL\ H_2O = 18\,g\ H_2O\,(d = 1\,g/mL)$

$\therefore$ Volume of one water molecule

$= \dfrac{18}{6.023\times10^{23}} = 3.0\times10^{-23}\,cm^3$

$\therefore$ $\dfrac{4}{3}\pi r^3 = 3.0\times10^{-23}$

$\therefore$ $r = 1.925\,Å$

14. (b) $a = \dfrac{49}{98}$ mole $H_2SO_4 + \dfrac{3\times10^{23}}{6\times10^{23}}$ mole H_2SO_4

$- \dfrac{0.02}{2}$ mole H_2SO_4

$\therefore$ $a = 0.5 + 0.5 - 0.01$ mole $H_2SO_4 = 0.99$ mol

15. (c) Molar mass of CO = N_2 $\therefore$ $V_{CO} = V_{N_2}$

16. (c) $[OH^-] = 2\,M$

$$\begin{array}{ccc} Mg(OH)_2 & \rightleftharpoons Mg^{2+} & +\ 2OH^- \\ c & 0 & 0 \\ c(1-\alpha) & c\alpha & 2c\alpha \end{array}$$

$\because$ $2c\alpha = 2\,M$

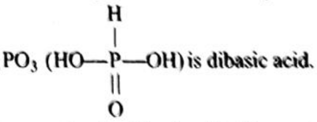
$\therefore$ $c = \dfrac{2}{2\times\alpha} = \dfrac{1}{\alpha}$

17. (c) Hardness is mass (in g) of $CaCO_3$ in 10^6 g water $= 10^6$ mL H_2O

$\therefore$ Molarity $= \dfrac{400\times10^3}{100\times10^6} = 4\times10^{-3}\,M$

18. (b) Volume strength = 5.6 × Normality

19. (d) H_3PO_3



$(HO-\overset{\overset{\large H}{|}}{\underset{\underset{\large O}{\|}}{P}}-OH)$ is dibasic acid.

20. (b) Let w g solute be dissolved in 60 g water

$\therefore$ Mass of solution $= (w + 60)\,g$

% by mass $= 20 = \left[\dfrac{w}{w+60}\right]\times100$

$\therefore$ $w = 15\,g$

21. (a)

$$\begin{array}{lccc} & H_2 & +\ \frac{1}{2}O_2 & \longrightarrow 2H_2O \\ \text{Initial} & 60 & 10 & 0 \\ \text{Find} & 40 & 0 & - \end{array}$$

i.e., Reduction in volume $= 60 + 10 - 40 = 30$ mL

22. (a) Let a mL CH_4 be used to form CO and b mL for CO_2

$2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

$\therefore$ Volume of O_2 needed $= \frac{3a}{2} + 2b$

Volume of CO formed $= a$

Volume of CO_2 formed $= b$

$\frac{a}{b} = \frac{1}{99}$ (given) ; Also $a + b = 10$

$\therefore a = 0.1$ mL $\therefore b = 9.9$

$\therefore O_2$ needed $= \frac{3 \times 0.1}{2} + 9.9 \times 2 = 19.95$

23. (d) Moles of $BaSO_4 = \frac{1.846}{233}$ (Ba in both)

Moles of $BaCl_2 \cdot XH_2O = \frac{1.936}{(137 + 71 + 18x)}$

$$\therefore \quad \frac{1.936}{137 + 71 + 18x} = \frac{1.846}{233}$$

$$\therefore \quad x = 2$$

24. (a) 100 mL solution $= 100 \times 1.12$ g solution $= 112$ g solution

i.e., 72 gH_2O has 40 gNaCl

$\therefore$ ppm $= \frac{40}{72} \times 10^6 = 5.5 \times 10^5$ ppm

25. (a) No. of atoms in 4g-atom of O $= 4 \times N$

One NH_3 molecule contains 4 atoms

$\therefore 4N$ atom will be present in N molecule of $NH_3 = 17$g NH_3

26. (b) 1 molecule $Ca_3(PO_4)_2$ has 2 P and 8 O atom

1 molecule H_3PO_3 has 1 P and 3 O atom

If H_3PO_3 sample has 2 P atoms than it should have 6 O atoms

$$\therefore \quad \frac{\text{No. of O in } Ca_3(PO_4)_2}{\text{No. of O in } H_3PO_3} = \frac{8}{6} = \frac{4}{3}$$

27. (a) 1 mole $Ba(OH)_2$ gives 2 mole OH^- and thus requires 2 mole of H^+

1.5 mole $H_3PO_3 = 2 \times 1.5$ mole H^+

$\frac{2}{3}$ mole $H_3PO_4 = 3 \times \frac{2}{3}$ mole H^+

1 mole $H_2SO_4 = 2$ mole H^+

2 mole $H_3PO_2 = 2 \times 1$ mole H^+

28. (b)
$$\frac{44}{44} + \frac{56}{2} = \frac{100}{M}$$

$$\therefore \quad M = 3.45$$

$$\therefore \quad \text{V.D.} = 1.72$$

29. (b) $2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$

1 mole (170g) $AgNO_3$ gives 1 mole Ag(108g)

30. (a)
$$\text{Meq.} = N \times V$$

$$\frac{w}{200/2} \times 1000 = 0.1 \times 100$$

$$\therefore \quad w = 1.0\text{g}$$

31. (a) Volume of one virus

$$= \pi r^2 l = \frac{22}{7} \times (7 \times 10^{-8})^2 \times 10 \times 10^{-8}$$

$$= 1.54 \times 10^{-21} \text{ mL}$$

$$\therefore \text{Molar mass of virus} = \frac{1.54 \times 10^{-21}}{6.02 \times 10^{-2}} \times 6.02 \times 10^{23}$$

$$= 15400 \text{ g/mol} = 15.4 \text{ kg mol}^{-1}$$

32. (a) 0.5 g Se than molar mass $= 100$

78.4 g Se than molar mass $= \frac{100 \times 78.4}{0.5} = 1.568 \times 10^3$

1 molecule of enzyme should contain at least are atom of Se to show minimum molar mass

33. (c) Mole of NaOH in I solution $= 2.5 \times 1 = 2.5$

Mole of NaOH in II solution $= 3 \times 0.5 = 1.5$

Total mole $= 2.5 + 1.5 = 4.0$

$\therefore$ Molarity $\times$ total volume $=$ Total mole

$$\therefore \quad M = \frac{4}{5.5} = 0.73 \text{ M}$$

34. (a) $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

22.4 litre C_3H_8 at NTP requires 5×22.4 litre O_2

35. (b) $PbO + 2HCl \longrightarrow PbCl_2 + H_2O$

	PbO	$2HCl$	$PbCl_2$	H_2O
Mole at $t = 0$	$\frac{6.5}{224}$	$\frac{3.2}{36.5}$ mole	0	0
	0.029	0.087	0	0
Mole after reaction	0	0.031	0.029	

36. (a) Mole of H_2 in 15 l $= \frac{15}{22.4} = 0.67$

Mole of N_2 in 5 l $= \frac{5}{22.4} = 0.22$

Mole of H_2 in 0.5 g $= \frac{0.5}{2} = 0.25$

Mole of O_2 in 5 g $= \frac{5}{32} = 0.16$

37. (c) $2Al + \frac{3}{2}O_2 \longrightarrow Al_2O_3$

2 mole of Al reacts with $= \frac{3}{2}$ mole O_2

1 mole of Al reacts with $= \frac{3}{2 \times 2} = \frac{3}{4}$ mole O_2

(27 g) of Al reacts with $= \frac{3}{4} \times 32 = 24$ g O_2

38. (c) 10g $CaCO_3 = 0.1$ mole $CaCO_3 = 0.1$ mole Ca $= \frac{0.1}{2}$ eq. Ca $= 6 \times 10^{22}$ atoms Ca $= 0.1$g -atom Ca

39. (c) $W_P = 20g, W_{H_2O} = 90g, W_{H_2} = 20g$

$W_{Na_2CO_3} = 106g$

40. (a) $Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

41. (a) $\underset{276g}{Ag_2CO_3} \longrightarrow \underset{216g}{2Ag} + CO_2 + \frac{1}{2}O_2$

42. (c) $\frac{n_{O_2}}{n_{N_2}} = \frac{\frac{w_{O_2}}{32}}{\frac{w_{N_2}}{28}} = \frac{w_{O_2}}{w_{N_2}} \times \frac{28}{32} = \frac{1}{4} \times \frac{28}{32} = \frac{7}{32}$

43. (a) 36g $H_2O = 2$ mole H_2O (the largest no. of mole)

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

$3BaCl_2$	$2Na_3PO_4$	$Ba_3(PO_4)_2$	$6NaCl$
0.50	0.20	0	0
0.20	0.00	0.10	0.60

45. (a) Molality $= \dfrac{\text{Mole of solute}}{\text{mass of solvent in kg}}$

46. (a) $NaHCO_3$ is acid salt and NaOH is base:

$NaHCO_3 + NaOH \longrightarrow Na_2CO_3 + H_2O$

47. (d) Molality involves only mass which is independent of *T*.

48. (c) Mass of 1000 mL steam $= 1000 \times 0.0006 = 0.6\text{g}$

$\therefore$ Volume of liquid water $= \dfrac{0.6}{1} = 0.6\,\text{cm}^3$

49. (a)

$$\begin{array}{lccc} & 2NH_3 & \longrightarrow N_2(g) + & 3H_2(g) \\ \text{V at t} = 0 & 100 & 0 & 0 \\ & 0 & 50 & 150 \end{array}$$

$\therefore\ V_1 = 50 + 150 = 200\,\text{mL}$

$$\begin{array}{lccc} & 4PH_3 & \longrightarrow P_4(g) + & 6H_2(g) \\ \text{V at t} = 0 & 100 & 0 & 0 \\ & 0 & 25 & 150 \end{array}$$

$\therefore\ V_2 = 25 + 150 = 175\,\text{mL}$

$\therefore\ \Delta V = 200 - 175 = 25\,\text{mL}$

50. (b) The mixture should contain 3 mole $FeSO_4$ and one mole $Fe_2(SO_4)_3$.

$3FeSO_4 \longrightarrow 3Fe^{2+} + 3SO_4^{2-}$

$Fe_2(SO_4)_3 \longrightarrow 2Fe^{3+} + 3SO_4^{2-}\ \therefore Fe^{2+} : Fe^{3+} :: 3 : 2$

51. (b) Mole of $Na_3PO_4 = 20 \times 0.4 = 8$

1 mole Na_3PO_4 contains 3 mole Na^+ ions

52. (c) Mole of KOH used $= \dfrac{28}{56} = 0.5$

$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$

$\therefore$ Mole of CO_2 required to neutralise KOH $= \dfrac{0.5}{2} = \dfrac{1}{4}$

$CaCO_3 \longrightarrow CaO + CO_2$

$\therefore$ mole of pure $CaCO_3 = \dfrac{1}{4} = 25$ g $CaCO_3$

$\therefore$ % purity $= \dfrac{25}{60} \times 100 = 41.66$

53. (a) Meq. of oxalic acid = Meq. of NaOH

$$\frac{6.3}{63} \times \frac{1000}{250} \times 10 = 0.1 \times V$$

$$\therefore \qquad V = 40\,\text{mL}$$

54. (d) $9.108 \times 10^{-31}\ \text{kg} = 1\,\text{electron}$

$$\therefore \quad 1\,\text{kg} = \frac{1}{9.108 \times 10^{-31}}\ \text{electron}$$

$$= \frac{1}{9.108 \times 10^{-31}} \times \frac{1}{6.023 \times 10^{23}}\ \text{mole electron}$$

$$= \frac{10^8}{9.108 \times 6.023}$$

55. (c) 0.01 mole of AgBr and 0.01 mole of Ag_2SO_4.

56. (a) 24 g carbon has $\dfrac{24}{12}$ mol

57. (c) Mass of solute = 120 g

Mass of water = 1000 g

Mass of solution = 1120 g

$\therefore$ Volume of solution $\left(\dfrac{m}{d}\right) = \dfrac{1120}{1.15}$ mL

Now Milli mole $= M \times V_{\text{in mL}}$

$$\frac{120}{60} \times 1000 = \frac{M \times 1120}{1.15}$$

$$\therefore \qquad M = 2.05$$

58. (b) Let the formula of hydrocarbon be C_aH_b

$C_aH_b + O_2 = aCO_2 + \dfrac{b}{2}H_2O$

mole of CO_2 (*a*) formed $= \dfrac{3.08}{44} = 0.07$

mole of H_2O formed $\left(\dfrac{b}{2}\right) = \dfrac{0.72}{18} = 0.04$

$\therefore \quad \dfrac{a}{b/2} = \dfrac{0.07}{0.04}$

or $\quad \dfrac{a}{b} = \dfrac{0.07}{0.08} = \dfrac{7}{8}$

$\therefore$ mole ratio of C and H :: 7 : 8

Thus empirical formula is C_7H_8

59. (c) milli mole of solution I $= 750 \times 0.5 = 375$

milli mole of solution II $= 250 \times 2 = 500$

Total milli mole in mixture $= 375 + 500 = 875$

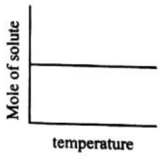
Total volume = 1000 mL

$\therefore$ Molarity $= \dfrac{875}{1000} = 0.875\,M$

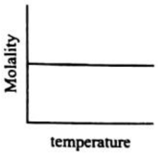
OBJECTIVE PROBLEMS (More Than One Answer Correct).

1. 1 mole of a mixture of CO and CO_2 requires exactly 1 litre solution of 1 *M* NaOH for complete neutralisation. If CO present in mixture is now converted to CO_2 and again the mixture is treated with NaOH, then after this conversion :
   (a) mole of CO_2 present initially in mixture = 1
   (b) 2 litre NaOH solution of 1 *M* is more required for neutralisation
   (c) 2 litre solution of $\frac{1}{2}$ *M* NaOH is required more for neutralisation
   (d) 56 g KOH in aqueous solution is required more for neutralisation
2. 2 g of oleum is diluted with water. The solution was then neutralised by 432.5 mL of 0.1 *N* NaOH. Select the correct statements :
   (a) % of oleum is 108.11
   (b) % of free SO_3 is 26.5 in oleum
   (c) Equivalent of H_2SO_4 are 0.03
   (d) Equivalent of $SO_3 = 6.625 \times 10^{-3}$
3. Which one is not correct about
   $$VO + Fe_2O_3 \longrightarrow FeO + V_2O_5?$$
   (a) 2 mole of VO reacts completely with 5 mole of Fe_2O_3
   (b) 1 mole of VO reacts completely with 1.5 mole of Fe_2O_3
   (c) Eq. mass of $V_2O_5 = M/6$ and of Fe_2O_3 is $M/2$
   (d) Eq. mass of $VO = M/3$ and of FeO is $2M/3$
4. 1 mole of H_3PO_3 reacts with NaOH in solution. Select the correct statements:
   (a) 1 mole of NaOH will replace *N* H^+ ion from H_3PO_3
   (b) 2 mole of NaOH will replace 2 *N* H^+ ions from H_3PO_3
   (c) 3 mole of NaOH will replace 3 *N* H^+ ions from H_3PO_3
   (d) On complete neutralisation of H_3PO_3, the equivalent mass of $H_3PO_3 = 41$
5. 100 mL of 0.8 *M* NaOH are used to neutralised 100 mL solution obtained by passing 2.70 g SO_2Cl_2 in water. Select the correct statement:
   (a) The solution of SO_2Cl_2 has 0.2 *M* H_2SO_4 and 0.4 *M* HCl
   (b) The volume ratio of NaOH used for H_2SO_4 and HCl is 1 : 2
   (c) The volume ratio of NaOH used for H_2SO_4 and HCl is 1 : 1
   (d) Molarity of SO_2Cl_2 solution is 0.1 *M*
6. Which one are correct about the solution that contains 3.42 ppm $Al_2(SO_4)_3$ and 1.42 ppm Na_2SO_4?
   (a) $[Al^{3+}] = [Na^+]$
   (b) $[SO_4^{2-}] = [Na^+] = [Al^{3+}]$
   (c) $[SO_4^{2-}] = [Na^+] + [Al^{3+}]$
   (d) $[SO_4^{2-}] = [Na^+]$
7. 1 u is equal to:
   (a) 931.48 MeV (b) 1.67×10^{-24} g
   (c) $\frac{1}{12}$th mass of C^{12} (d) 1 dalton
8. $\frac{1}{N_A}$ is equal to:
   (a) 1.67×10^{-27} kg (b) 1 u
   (c) 1 dalton (d) Logschmidt number
9. H_3BO_3 is:
   (a) Monobasic acid
   (b) Lewis acid
   (c) Electron pair acceptor
   (d) Na_3BO_3 exist as ionic compound
10. Which of the following are primary standard solution?
    (a) Oxalic acid (b) NaOH
    (c) Borax (d) $Na_2CO_3 \cdot 10H_2O$
11. Which of the following graphs correctly represents the variations ?

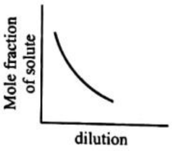
(a)



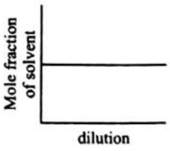
(b)



(c)



(d)



SOLUTIONS (More Than One Answer Correct)

1. (c, d)

$$\underset{a}{CO} + \underset{b}{CO_2}$$

$\therefore \quad a+b=1$

$$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$$

Meq. of CO_2 = Meq. of NaOH $= 1 \times 1000$

$\therefore$ Mole of $CO_2 = \dfrac{1 \times 1000}{2 \times 1000} = 0.5$ (v.f of $CO_2 = 2$)

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

$\therefore$ 0.5 mole CO_2 is formed more.

$\therefore$ NaOH required more = 2 litre of 1/2 *M* NaOH

$= 56\,g$ KOH $= 1$ mol KOH

2. (a, b, c)

$$\underset{a}{H_2SO_4} + \underset{b}{SO_3}$$

$\therefore \quad a+b=2 \quad ...(1)$

Also, Meq. of

H_2SO_4 + Meq. of SO_3 = Meq. of NaOH

$$\frac{a}{49} \times 1000 + \frac{b}{40} \times 1000 = 0.1 \times 432.5$$

$\therefore \quad 40a + 49b = 84.77 \quad ...(2)$

$\therefore \quad a = 1.47\,g \quad b = 0.53\,g$

$\therefore$ Equivalent of $H_2SO_4 = \dfrac{1.47}{49} = 0.03$

$\therefore \quad SO_3 + H_2O \longrightarrow H_2SO_4$

Eq. of $SO_3 = \dfrac{0.53}{40} = 0.01325$

Mass of H_2O to react with SO_3

$= \dfrac{0.53 \times 18}{80} = 0.11925\,g$

$\because$ 1.47 g H_2SO_4 is associated with 0.53 g H_2O

$\therefore$ 100 g H_2SO_4 is associated with $\dfrac{0.53 \times 100}{1.47}$ g H_2O

or 8.11 g H_2O

$\therefore$ Solution of oleum is 100 + 8.11 = 108.11%

$\therefore$ 108.11% oleum = 100g H_2SO_4 + 8.11g H_2O

$= 100\,g\ H_2SO_4 + \dfrac{8.11 \times 80}{18}$

$= 100\,g\ H_2SO_4 + 36\,g\ SO_3$

$= 136\,g$ oleum

136 g oleum has 36g SO_3

$\therefore$ 2 g oleum has $\dfrac{36 \times 2}{136} = 0.53\,g\ SO_3$

$\therefore$ % of free $SO_3 = \dfrac{0.53 \times 100}{2} = 26.5$

3. (b, c, d)

$$2V^{2+} \longrightarrow (V^{5+})_2 + 6e$$

$$2e + (Fe^{3+})_2 \longrightarrow 2Fe^{2+} \times 3$$

$\therefore \quad 2VO + 3Fe_2O_3 \longrightarrow 6FeO + V_2O_5$

$$E = \frac{M}{3} \quad E = \frac{M}{2} \quad E = \frac{M}{3/2} \quad E = \frac{M}{6}$$

4. (a, b, d) H_3PO_3 is dibasic acid.

5. (a, c) $[SO_2Cl_2] = \dfrac{2.70 \times 1000}{135 \times 100} = 0.2\,M$

$$\begin{array}{cccc} SO_2Cl_2 & + 2H_2O \longrightarrow & H_2SO_4 & + 2HCl \\ 100 \times 0.2 & & & \\ = 20 & & 0 & 0 \\ 0 & & 20 & 40 \end{array}$$

$\therefore \quad M_{H_2SO_4} = \dfrac{20}{100}; \quad M_{HCl} = \dfrac{40}{100}$

$\therefore \quad N_{H_2SO_4} = 0.4$ and $N_{HCl} = 0.4$

6. (a, c) 3.42 ppm $Al_2(SO_4)_3 \equiv \dfrac{96 \times 3 \times 3.42}{342}$ ppm $[SO_4^{2-}]$

$= 2.88$ ppm SO_4^{2-}

$\equiv \dfrac{27 \times 2 \times 3.42}{342}$ ppm Al^{3+}

$= 0.54$ ppm Al^{3+}

1.42 ppm $Na_2SO_4 \equiv \dfrac{96 \times 1.42}{142}$ ppm SO_4

$= 0.96$ ppm SO_4^{2-}

$\equiv \dfrac{46 \times 1.42}{142}$ ppm Na^+

$= 0.46$ ppm Na^+

$$\therefore \quad [Al^{3+}] = \frac{0.54 \times 10^3}{27 \times 10^6} = 2.0 \times 10^{-5}\ M$$

$$[SO_4^{2-}] = \frac{(2.88 + 0.96) \times 10^3}{96 \times 10^6} = 4 \times 10^{-5}\ M$$

$$[Na^+] = \frac{0.46 \times 10^3}{23 \times 10^6} = 2 \times 10^{-5}\ M$$

7. (a,b,c,d) 1u or 1amu = 1dalton. Also amu is replaced by *u* (now-a-days).

8. (a,b,c) Logschmidt number is referred as the number of molecules of a gas present in 1 mL at STP *i.e.*,

$$\frac{\text{Av. no.}}{22400} = 2.689 \times 10^{19}$$

9. (a,b,c,d) These all are facts.

10. (a,c,d) Standard solution of NaOH can not be prepared by weighing since it reacts with CO_2 on exposure to air.

11. (a,b,c) Mole fraction of solute and solvent change with dilution, however mole of solute remains constant and mole fraction of solute decrease with dilution, mole of solute and molality does not change with temperature.

COMPREHENSION BASED PROBLEMS

Comprehension 1 : Estimation of N in a compound is made by Kjeldahl's method. A sample containing 0.4775 g of $(NH_4)_2C_2O_4$ and inert materials was dissolved in water and made strongly alkaline with KOH, which converted NH_4^+ to NH_3. The liberated ammonia was distilled into exactly 50.0 mL of 0.05035 *M* H_2SO_4. The excess H_2SO_4 was back titrated with 11.3 mL of 0.1214 *M* NaOH.

[Molar mass of $(NH_4)_2C_2O_4 = 124.10$ and atomic mass of $N = 14.00$]

[1] Per cent of $(NH_4)_2C_2O_4$:

(a) 10.74 (b) 47.8
(c) 12.74 (d) 42.8

[2] Per cent of N in sample :

(a) 47.8 (b) 40.8
(c) 42.8 (d) 10.74

Comprehension 2 : 50 mL of a solution, containing 1 g each of Na_2CO_3, $NaHCO_3$ and NaOH was titrated with *N* HCl. What will be the titre readings if :

[1] Only phenolphthalein is used as indicator?

(a) 21.3 mL (b) 55.8 mL
(c) 34.4 mL (d) 68.4 mL

[2] Only methyl orange is used as indicator from the very beginning?

(a) 55.8 mL (b) 21.3 mL
(c) 34.4 mL (d) 68.4 mL

[3] Methyl orange is added after the first end point with phenolphthalein?

(a) 21.3 mL (b) 55.8 mL
(c) 34.4 mL (d) 68.4 mL

Comprehension 3 : HNO_3 used as a reagent has specific gravity of 1.42 g mL^{-1} and contains 70% by strength HNO_3.

[1] Normality of acid is.

(a) 16.78 (b) 15.78
(c) 14.78 (d) 17.78

[2] Volume of acid that contains 63 g pure acid is.

(a) 100 mL (b) 40.24 mL
(c) 63.38 mL (d) 70.68 mL

[3] Volume of water required to make 1*N* solution from 2 mL conc. HNO_3.

(a) 29.56 mL (b) 30.56 mL
(c) 28.56 mL (d) 31.56 mL

Comprehension 4 : The density of 3*M* solution of $Na_2S_2O_3$ is 1.25 g mL^{-1}.

[1] The % by mass of $Na_2S_2O_3$ is :

(a) 36.24 (b) 37.92
(c) 40.24 (d) 38.34

[2] Mole fraction of $Na_2S_2O_3$ is :

(a) 0.015 (b) 0.025
(c) 0.065 (d) 0.035

[3] Molalities of Na^+ and $S_2O_3^{2-}$ ions are respectively :

(a) 7.732, 3.866 (b) 3.866, 7.732
(c) 3.732, 7.866 (d) 7.866, 3.732

Comprehension 5 : Oxides of non metals are acidic although N_2O, NO, CO and H_2O are neutral. On the other hand oxides of metals are either amphoteric or basic. However in higher oxidation state same metals forms acidic oxides.

[1] Which is used for absorbing CO :

(a) Amm. $AgNO_3$ (b) Amm. Cu_2Cl_2
(c) Turpentine oil (d) Pyrogallol

[2] SO_2 can be absorbed in :

(a) Lime water (b) Baryta water
(c) KOH (d) All of these

[3] Acetylene can be absorbed in :

(a) Amm. $AgNO_3$ (b) H_2SO_4
(c) NaOH (d) Na_2CO_3

SOLUTIONS

Comprehension 1

[1] (b) Meq. of $(NH_4)_2C_2O_4$ = Meq. of NH_3

= Meq. of H_2SO_4 used

$$\frac{w}{124.10/2} \times 1000 = \text{Meq. of } NH_3 = 3.663$$

[Meq. of H_2SO_4 used

$= (0.05035 \times 2 \times 50 - 11.3 \times 0.1214) = 3.663$]

$\therefore\ w_{(NH_4)_2C_2O_4} = 0.2273\text{ g}$

$\therefore$ Percentage of $(NH_4)_2C_2O_4 = \frac{0.2273}{0.4775} \times 100 = \mathbf{47.8\%}$

[2] (d) Meq. of N = Meq. of NH_3

or $\frac{w}{14} \times 1000 = 3.663$

or $w_{N_2} = 0.0513\text{ g}$

$\therefore$ Percentage of N $= \frac{0.0513}{0.4775} \times 100 = \mathbf{10.74\%}$

Comprehension 2

[1] (c) The end point using phenolphthalein as indicator uses complete NaOH and half Meq. of Na_2CO_3.

$\therefore$ Meq. of NaOH + $\frac{1}{2}$ Meq. of Na_2CO_3

= Meq. of HCl

$$\frac{1}{40} \times 1000 + \left[\frac{1}{2} \times \frac{1}{53} \times 1000\right] = 1 \times V_1$$

$$V_1 = \mathbf{34.4\ mL}$$

[2] (a) The end point using methyl orange from the beginning uses all the equivalents of bases taken.

$\therefore$ Meq. of NaOH + Meq. of Na_2CO_3 +

Meq. of $NaHCO_3$ = Meq. of HCl

$$\frac{1}{40} \times 1000 + \frac{1}{53} \times 1000 + \frac{1}{84} \times 1000 = 1 \times V_2$$

$\therefore$ $V_2 = \mathbf{55.8\ mL}$

[3] (a) The end point using methyl orange when I end point using phenolphthalein has already been detected, consumes half Meq. of Na_2CO_3 and complete $NaHCO_3$.

$\frac{1}{2}$ Meq. of Na_2CO_3 + Meq. of $NaHCO_3$ = Meq. of HCl

$$\frac{1}{2} \times \frac{1}{53} \times 1000 + \frac{1}{84} \times 1000 = 1 \times V_3$$

$\therefore$ $V_3 = \mathbf{21.3\ mL}$

Comprehension 3

[1] (b) Strength of $HNO_3 = 70\%$

Volume of solution = 100 mL

and Volume of HNO_3 = 70 mL

$\therefore$ Mass of HNO_3 in solution $= 70 \times 1.42$ g

$\therefore$ Eq. of HNO_3 in solution $= \frac{70 \times 1.42}{63}$

$$\therefore\quad N_{HNO_3} = \frac{70 \times 1.42}{63 \times 100/1000} \quad \left(\because N = \frac{\text{Eq.}}{V \text{ in litre}}\right)$$

$$= \mathbf{15.78}$$

[2] (c) $\because$ 70×1.42 g of pure acid is present in 100 mL

$\therefore$ 63 g of pure acid present in $= \frac{100 \times 63}{70 \times 1.42} = \mathbf{63.38\ mL}$

[3] (a) Meq. of conc. HNO_3 = Meq. of dil. HNO_3

($\because$ Meq. does not change on dilution)

$\therefore$ $2 \times 15.78 = V \times 1$

$\therefore$ $V = 31.56$ mL

$\therefore$ Volume of water added $= 31.56 - 2 = \mathbf{29.56\ mL}$

Comprehension 4

Molarity of $Na_2S_2O_3$ is 3 *M*.

$\therefore$ Mole of $Na_2S_2O_3 = 3$

$\therefore$ Mass of $Na_2S_2O_3 = 3 \times 158 = 474$ g

and V of solution = 1 litre = 1000 mL

$\therefore$ Mass of solution $= 1000 \times 1.25 = 1250$ g

$\therefore$ Mass of water $= 1250 - 474 = 776$ g

[1] (b) % by mass of $Na_2S_2O_3 = \frac{\text{mass of } Na_2S_2O_3}{\text{mass of solution}} \times 100$

$$= \frac{474}{1250} \times 100 = \mathbf{37.92}$$

[2] (c) Mole fraction of $Na_2S_2O_3$

$$= \frac{\text{Mole of } Na_2S_2O_3}{\text{Mole of } Na_2S_2O_3 + \text{Mole of } H_2O}$$

$$= \frac{3}{3 + 776/18} = \mathbf{0.065}$$

[3] (a) Molality of $Na^+ = \frac{\text{Mole of } Na^+}{\text{Mass of water in g}} \times 1000$

$$= \frac{6 \times 1000}{776} = \mathbf{7.732}$$

Molality of $S_2O_3^{2-} = \frac{3 \times 1000}{776} = \mathbf{3.866}$

Comprehension 5

[1] (b) It is a fact.

[2] (d) SO_2 is acidic oxide and reacts with bases.

[3] (a) $CH \equiv CH + AgNO_3 \longrightarrow AgC \equiv CAg$

STATEMENT EXPLANATION PROBLEMS

Read the following statements **(S)** and explanations **(E)**. Choose the correct answers from the codes (a), (b), (c) and (d) :

(a) **S** is correct but **E** is wrong

(b) **S** is wrong but **E** is correct

(c) Both S and **E** are correct and **E** is correct explanation of S

(d) Both S and **E** are correct but **E** is not correct explanation of S

1. S : Equivalent mass of H_3BO_3 and Na_3BO_3 are $M / 3$.

E : Equivalent mass of H_3BO_3 is M/1 and Na_3BO_3 is M/3.

2. S : 1 equivalent of H_2SO_4 contains 1 equivalent of H, S and O each.

E : A species contains same number of equivalents of its components.

3. S : Equivalent mass of ozone in the change $O_3 \longrightarrow O_2$ is 8.

E : 1 mole of O_3 on decomposition gives 3 /2 mole of O_2.

4. S : CO and C_2H_2 both can be absorbed in ammoniacal CuCl.

E : CH_4 is absorbed on animal charcoal.

5. S : Acidimetry and alkalimetry are the terms used in volumetric analysis.

E : The reactant left after the chemical reaction is called limiting reagent.

6. S : $NaNO_3$ has no definite mclecule.

E : Its formula mass is 85.

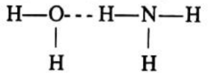
7. S : 31.26 mL of 0.165 M solution of $Ba(OH)_2$ is exactly neutralised by 25 mL of citric acid $C_6H_8O_7$ of molarity 0.138.

E : The acid is tribasic in nature.

8. S : 1 equivalent of $K_2Cr_2O_7$ has 1 equivalent of K, Cr and O each.

E : Equivalent and milliequivalent reacts in equal number to give same equivalent of product.

9. S : The H-bonding of NH_3 and H_2O is represented as:



$$\underset{\displaystyle H}{\underset{|}{H—O}}\text{---}\underset{\displaystyle H}{\underset{|}{H—N}}—H$$

E : H_2O is more acidic than NH_3 and thus, H_2O is a proton donor.

10. S : H_3BO_3 is monobasic Lewis acid but salt Na_3BO_3 exist.

E : H_3BO_3 reacts with NaOH to give Na_3BO_3.

11. S : Av. No. was proposed 6.019×10^{23} on O–16 scale and 6.02×10^{23} on C–12 scale.

E : The numerical value of Avogadro's number depends upon the atomic mass scale.

12. S : Atomicity of phosphorus is four.

E : Atomicity is the number of atoms present in 1 molecule.

13. S : Density = specific gravity × 0.99823 at 20°C.

E : Density = specific gravity at 4°C.

14. S : Density is expressed as g mL^{-1} whereas specific gravity is dimension less.

E : Specific gravity is ratio of the masses of solution and solvent.

15. S : In the titration of Na_2CO_3 with HCl using methyl orange indicator, the volume of acid required is twice that of the acid required using phenolphthalien as indicator.

E : Two moles of HCl are required for the complete neutralisation of one mole of Na_2CO_3.

16. S : Sulphate is estimated as $BaSO_4$ and not as $MgSO_4$.

E : Ionic radius of Mg^{2+} is smaller than Ba^{2+}.

17. S : Atomic masses of most of the elements are fractional.

E : Atomic mass $= \frac{\Sigma MX}{100}$; where M is mass of isotope and X is its % abundance.

18. S : Analytical molarity of 1 M HCl is zero.

E : Equilibrium molarity of 1 M HCl is zero.

19. S : Equivalence point is a theoretical value.

E : End point is an experimental value.

20. S : Actual yield in case of most of the reaction is lesser than theoretical yield.

E : The reactants are either not 100% pure or some side reactions follows.

ANSWERS (Statement Explanation Problems)

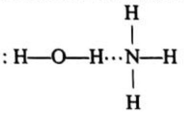
1. (b) H_3BO_3 is monobasic acid; Na_2CO_3 is a salt having total charge on cation or anion = 3
2. (c) Equivalent reacts in equal number.
3. (d) $2O_3 \longrightarrow 3O_2$,

   i.e., 2 mole $O_3 \equiv 3$ mole $O_2 = 3 \times 4$ eq. O_2

   $\therefore \quad E_{O_3} = \frac{M}{6} = \frac{48}{6} = 8$
4. (d) Both are facts.
5. (a) The reactant used is called limiting reagent.
6. (d) $NaNO_3$ has solid lattice.
7. (c) Meq. of $Ba(OH)_2$ = Meq. of acid

   $31.26 \times 0.165 \times 2 = 25 \times M \times n = 25 \times 0.138 \times n$

   $\therefore \quad n = 3$
8. (c) Explanation is correct reason for statement.
9. (b) H—bonding is as :



$$H{-}O{-}H\cdots\underset{\displaystyle H}{\overset{\displaystyle H}{N}}{-}H$$

10. (a) $B(OH)_3 + NaOH \longrightarrow Na[B(OH)_4]$
11. (c) Explanation is correct reason for statement.
12. (c) — do —
13. (d) Both are facts.
14. (c) Statement is correct reason for statement.
15. (d) $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$,

    phenolphthalein is used for

    $Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl + CO_2$
16. (d) $BaSO_4$ is insoluble.
17. (c) Explanation is correct reason for statement.
18. (b) $HCl \longrightarrow H^+ + Cl^-$

	HCl	H^+	Cl^-
	1	0	0
After dissociation	0	1	1

19. (d) These are facts.
20. (c) Explanation is correct reason for statement.

MATCHING TYPE PROBLEMS

Type I : Only One Match Possible

1. Match the given concentrations with their property.

Concentration	Property
A. Molality	a. Ionic solute
B. Ionic strength	b. Very low concentration
C. ppb	c. $\frac{1}{2}\Sigma CZ^2$
D. Formality	d. Independent of temperature

2.

List-A Gases	List-B Adsorbents
A. Cl_2	a. $FeSO_4$ solution
B. O_3	b. Alkaline pyragallol
C. NO	c. Turpentine oil
D. CO	d. $NaOH_{aq.}$ or $KOH_{aq.}$
E. O_2	e. Amm. $CuCl_2$

Type II : More Than One Match Are Possible

3. Experimental determination of molar mass of compounds may be made by the following methods. Match them properly. More than one match are possible :

A. Gases	a. Victor Meyer's method
B. Volatile liquids	b. Hofmann's method
C. Non volatile solids	c. Duma's method
D. Solids of low m. mass	d. Ebullioscopy or cryoscopy
E. Solids of high m. mass such as polymers	e. Osmotic pressure
	f. Raoult's law

4.

List A	List B
A. 1.8 mL H_2O_l $(d = 1\,g/mL)$	a. $\frac{1}{10}N_A$ molecules of H_2O
B. 1.8 mL H_2O_v at STP	b. 2.24 litre at STP H_2O_v
C. 8.03×10^{-5} mole $H_2O(v)$	c. 1.8 g of H_2O_v
	d. 1.446×10^{-3} g H_2O
	e. 4.84×10^{19} molecules of H_2O

5.

List-A Concentrations expressed in	List-B Factors influencing
A. Molarity	a. Temperature
B. Molality	b. Dilution
C. Mole fraction of solute	c. Addition of solute
D. Strength of solution	

6.

List-A Adsorbent	List-B Gases
A. Lime water	a. SO_2
B. Conc. H_2SO_4	b. H_2S
C. Heated Mg	c. H_2O_v
	d. NH_3
	e. O_2
	f. N

ANSWERS

1. A–d; B–c; C–b; D–a.
2. A–d; B–c; C–a; D–e; E–b.
3. A–a, b, c; B–a, b, c, f; C–d, e, f; D–d, f; E–e.
4. A–a, b, c; B–d, e; C–d, e.
5. A–a, b, c; B–b, c; C–b, c; D–a, b, c.
6. A–a, b; B–c, d; C–e, f.