# 1 Stoichiometry

**QUICK LOOK**

The concentration of a solution can be expressed in number of ways.

**Normality**

It is defined as the number of equivalent of a solute present in 1 litre of solution.

$$N = \frac{\text{Equivalent of a solute}}{\text{Volume of solution in litre}} = \frac{E_q}{V\left(\text{in L}\right)} \quad \ldots(i)$$

$\because$ Equivalent of substance ($E_q$)

$$E_q = \frac{\text{Mass of substance}}{\text{Equivalent mass of substance}}$$

$$N = \frac{\text{Mass of solute} \times 100}{\text{Equivalent mass of solute} \times \text{V in mL}}$$

or $$W = \frac{N \cdot E \cdot V\left(\text{in mL}\right)}{1000} \quad \ldots(ii)$$

Equivalent

$$= N \times V\left(\text{in litre}\right) = \frac{\text{Mass of solute}}{\text{Equivalent mass of solute}} \quad \ldots(iii)$$

Also, Milli equivalent of solute = $N \times V\left(\text{in mL}\right)$ $\quad \ldots(iv)$

$$\text{Meq. of solute } N = \frac{\text{Mass of solute}}{\text{Eq. mass of solute}} \times 1000 \quad \ldots(v)$$

**Note**

- Equivalent and milli equivalent reacts in equal number to give the same number of equivalent of milli equivalent of products.
- An equivalent represents the mass of material providing Avogadro's number of electrons from reacting unit.
- Normality of any solute depends up on the nature of reaction (like equivalent mass) but molarity not.

**Molarity:** It is defined as the number of moles of solute present in 1 litre solution.

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

$$M = \frac{\text{Mass of solute} \times 1000}{\text{Molar mass of solute} \times \text{V (in mL)}}$$

$$W = \frac{\text{Molarity} \times \text{Molar mass} \times V\left(\text{in mL}\right)}{\text{1000 in mL}} \quad \ldots(vi)$$

$$\therefore \text{Moles} = M \times V_{(\text{in litre})} \frac{\text{Mass of solute}}{\text{Moles mass of solute}} \quad \ldots(vii)$$

$\therefore$ Milli moles = $M \times V$ in mL

$$\frac{\text{Mass of solute}}{\text{Molar mass of solute}} \times 1000 \quad \ldots(viii)$$

**Note**

- Moles and milli moles of reactants react according to stoichiometry of equation and give products accordingly.
- $$\text{Molarity} = \frac{\text{Moles}}{\text{Volume }\left(\text{in litre}\right)}$$

  $$\text{Normality} = \frac{\text{Equivalent}}{\text{Volume }\left(\text{in litre}\right)}$$

  $$\therefore \frac{M}{N} = \frac{\text{Moles}}{\text{Equivalent}}; \frac{W \times \text{Eq. mass}}{\text{Molar mass} \times W} = \frac{1}{\text{Valence factor}}$$

  Molarity × Valence factor = Normality $\quad \ldots(ix)$
- Analytical molarity (usually molarity) and equilibrium molarity are two different terms. Equilibrium molarity represents the moles of particular species in one litre of solutions.
- The equilibrium molarity of a strong electrolyte is zero. For example consider analytical molarity of 1 M HCl. The equilibrium molarity of HCl is zero because of 100% ionization as.

  $$\begin{array}{lcc} HCl \longrightarrow & H^+ + & Cl^- \\ 1 & 0 & 0 \\ 0 & 1 & 1 \end{array}$$

  Whereas equilibrium molarities of $H^+$ and $Cl^-$ and 1 M each. Similarly a solution of a strong electrolyte say $A_xB_y$ having analytical molarity 1 M shows equlilibrium molarities of $A_xB_y$, $A^{y+}$ and $B^{x-}$ as 0 M, xM and yM respectively.
- In case of weak electrolytes (either a weak acid or weak base) analytical molarity of C HA has the equilibrium molarities of HA, $H^+$ and $A^-$ are $C\left(1-\alpha\right), C\alpha$ and $C\alpha$ respectively. Since it shows partial dissociation

  $$\begin{array}{lcc} HA \rightleftharpoons & H^+ + & A^- \\ 1 & \alpha & 0 \\ 1-\alpha & \alpha & \alpha \end{array}$$

  ($\alpha$ is degree of dissociation)
- In case of non electrolytes analytical molarity and equilibrium molarity are same.

**Molality:** It is defined as number of moles of solute present in 1 kg of solvent.

$$m = \frac{\text{Moles of solute}}{\text{Mass of solute in kg}} \quad \ldots(x)$$

$$m = \frac{\text{Mass of solute} \times 1000}{\text{Molar mass of solute} \times \text{Mass of solvent in gram}} \quad \ldots(xi)$$

Mass of solvent = mass of solution–mass of solute

**Note:** Molarity, normality and molality are extensive properties.

**Strength of Solution:** It is expressed as amount of solute (in g) in 1 litre solution.

$$S = \frac{\text{Mass of solute}}{\text{Volume of solution in litre}} = \frac{w}{V\,(\text{in L})} \quad \ldots(xii)$$

$$\because \quad N = \frac{w}{E \times V(\text{in L})} = \frac{S}{E} \quad \ldots(xiii)$$

Also, $S = N \times E$ or $S = M \times \text{Molar mass}$ $\quad \ldots(xiv)$

**In Terms of Percentage**

$$\text{\% by mass (or w/w)} = \frac{\text{Mass of solute} \times 100}{\text{Mass of solution}} \quad \ldots(xv)$$

$$\text{\% by strength (or V/V)} = \frac{\text{Volume of solute} \times 100}{\text{Volume of solution}} \quad \ldots(xvi)$$

$$\text{\% by volume (or mass/vol)} = \frac{\text{Mass of solute} \times 100}{\text{Volume of solution}} \quad \ldots(xvii)$$

A solution is 65% by…
65% by mass, *i.e.,* 100 g solution has 65 g solute
65% by strength, *i.e.,* 100 mL solution has 65 mL solute
65% by volume, *i.e.,* 100 mL solution has 65 g solute

**Note**

- **Use of Specific Gravity:** Specific gravity term is used for density in case of solution. The term 'density' refers for the ratio (mass/volume) for pure solvent.

  $$\text{Density} = \frac{\text{Mass of solvent}}{\text{Volume of solvent}}$$

  *i.e.,* density is the mass of 1 mL of solvent.
- Density is the mass per unit volume at the specified temperature, usually g/mL or g/cm$^3$ at 20°C. Specific gravity is defined as the ratio of the mass of a solution at 20°C, to the mass of an equal volume of water at 4°C (or sometimes 20°C). Thus, specific gravity is a dimensionless quantity. The density of water at 4°C is $1.0000\ \text{g/mL}$. Density and specific gravity are equal when referred to water at 4°C. When specific gravity is referred to water at 20°C, then (since density of water at 20°C is 0.99823 g / mL) Density = specific gravity × 0.99823

**Mole Fraction**

Mole fraction of solute $(X_A)$

$$(X_A) = \frac{\text{Moles of solute}}{\text{Total moles present in solution}}$$

$$= \frac{\text{Moles of solute}}{\text{Moles of solute + Moles of solvent}} = \frac{n}{n+N}$$

Mole fraction of solvent $(X_B)$

$$(X_B) = \frac{\text{Moles of solvent}}{\text{Total moles present in solution}}$$

$$= \frac{\text{Moles of solvent}}{\text{Moles of solute + Moles of solvent}} = \frac{N}{n+N}$$

$$\text{Also, } X_A = \frac{n}{n+N} = \frac{w/m}{(w/m)+(W/M)} \quad \ldots(xviii)$$

$$X_B = \frac{N}{n+N} = \frac{W/M}{(w/m)+(W/M)} \quad \ldots(xix)$$

Also, for a binary system $X_A + X_B = 1$ $\quad \ldots(xx)$

*i.e.*, sum of all the mole fractions in a solution is unity.

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

**Note**

- Molality, % by mass, mole fractions are independent of temperature since all these involve mass which does not depend upon temperature.
- **Standard Solution:** The solution whose molarity or normality is known. A standard solution is prepared by dissolving an accurately weighed quantity of a highly pure material called a primary standard (*e.g.,* oxalic acid, Borax ($Na_2B_4O_7 \cdot 10H_2O$) $Na_2CO_3 \cdot 10H_2O$ and potassium acid phthalate, *etc.*) and diluting to an accurately known volume of solution. If the material is not sufficiently pure (*e.g.,* NaOH) a solution is prepared to give approximately the desired concentration and this is standardized by titrating a weighed quantity of primary standard. Such solutions are called secondary standard.
- **Normal or Molar Solution:** Solution having normality = 1 N or molarity = 1 M respectively.
- **On diluting a solution:** Normality, molarity and molality change with dilution whereas, equivalent, mill equivalent, moles or milli moles of solute do not change or during dilution conservation of moles of solute take place.
- The volume of a liquid increases with temperature. It is therefore, 5 litre of $C_6H_6$ masses more in winter than in summer.

**Formality:** Some confusion can arise concerning the molar mass of substances in which no discrete molecule exists. For example in ionic solids say NaCl, there are no identifiable NaCl molecules, only ions of $Na^+$ and $Cl^-$ are present. In such cases the term formula mass is used which refers for sum of masses of each ion present in one molecule and therefore, the molar mass of NaCl mean only the mass of material that contains $6.023 \times 10^{23}$ ions of each type and carry no implication about the existence of molecule in crystal. Strictly, we should refer to the formula masses in case of ionic molecules.

Therefore, the concentrations of ionic solids are normally expressed in terms of formality since neither the substance is composed of molecules nor their molar masses determined accurately by experiments. We normally use their formula mass as molar mass.

$$\text{Formality} = \frac{\text{Weight of solute}}{\text{Formula mass} \times \text{V(litre)}} \qquad \ldots(xxii)$$

**Note**

- However the word molar mass are frequently used for formula mass of such substances.
- For all practical purposes formality of an ionic compound is its molarity.

**Ionic Strength:** The ionic strength $(\mu)$ of solution obtained by mixing two or more ionic compounds is given by:

$$\mu = \frac{1}{2}\sum cZ^2 \qquad \ldots(xxiii)$$

Where c is the concentration (molarity) of that ion and Z is its valence.

**Emperical and Molecular Formulas**

**(i) Emperical Formula:** It is the simplest formula of a compound which gives the simplest whole number ratio of the atoms of the various elements present in one molecule of the compound *e.g.,* emperical formula of glucose $(C_6H_{12}O_6)$ is $CH_2O$.

**Calculation of Emperical Formulas**

First calculate % of oxygen = 100 – Sum of % of all other elements. Then E.F. is calculated through the following steps:

Element $\rightarrow$ % of element $\rightarrow$ Atomic mass$\rightarrow$ Relative no. of atoms $= \frac{\%}{\text{At. mass}} \rightarrow$ Simplest atomic ratio $\rightarrow$ Simplest whole no. ratio

**(ii) Molecular Formula:** It is the actual formula of a compound which gives the actual number of atoms of various elements present in one molecule of the compound *e.g.,* molecular formula of glucose is $C_6H_{12}O_6$.

**Determination of Molecular Formula**

Molecular formula $= n \times$ Empirical formula, where n may be equal to 1 or a higher whole number integer.

In order to find the value of n, the Molecular weight of the compound is divided by its Empirical formula weight (the wt. of the atoms present in its Empirical formula).

Thus, $\frac{\text{Molecular formula}}{\text{Empirical formula}} = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = n$

Having determined the value of n, Empirical formula is accordingly multiplied by n to obtain the molecular formula.

**Laws of Chemical Combinations**

Based on the quantitative results of chemical reactions dealing with the weight–weight and weight-volume relationships, few laws were formulated which are–

- **Law of Conservation of Mass:** "In all physical and chemical changes, the total mass of the reactants is equal to that of the products" or "Matter can neither be created nor destroyed".
- **Law of Constant Composition or Definite Proportions:** "A chemical compound is always found to be made up of the same elements combined together in the same fixed ratio by weight"
- **Law of Multiple Proportions:** "When two element combine together to form two or more chemical compounds, then the weights of one of the elements which combine with a fixed weight of the other bear a simple ratio to one another."
- **Law of Reciprocal Proportions:** The ratio of the weights of two elements A and B which combine with a fixed weight of the third element C is either the same or a simple multiple of the ratio of the weights of A and B which directly combine with each other. Law of reciprocal proportion can be used to obtain equivalent weights of elements. Hence it is also called law of equivalent proportion.
- **Gay Lussac's Law of Gaseous Volumes:** "When gases react together, they always do so in volumes which bear a simple ratio to one another and to the volumes of the products, if gaseous, all measurements are made under the same conditions of temperature and pressure.

**Equivalent Weights**

The equivalent weight of a substance is the number of parts by weight of the substance that combine with or displace directly or indirectly 1.008 parts by weight of hydrogen or 8 parts by weight of oxygen or 35.5 parts by weight of chlorine.

Eq. wt. of an element $= \frac{\text{Atomic mass}}{\text{Valency}}$

## MULTIPLE CHOICE QUESTIONS

### Significant Figures, Units for Measurement, Matter and Separation of Mixture

**1.** In the final answer of the expression

$$\frac{(29.2-20.2)(1.79\times10^5)}{1.37}.$$

The number of significant figures is:

**a.** 1 **b.** 2 **c.** 3 **d.** 4

**2.** The prefix zepto stands for:

**a.** $10^9$ **b.** $10^{-12}$ **c.** $10^{-15}$ **d.** $10^{-21}$

**3.** The number of significant figures in 60.0001 is:

**a.** 5 **b.** 6 **c.** 3 **d.** 2

### Laws of Chemical Combination

**4.** Which of the following is the best example of law of conservation of mass?

**a.** 12 *g* of carbon combines with 32 *g* of oxygen to form 44 *g* of $CO_2$

**b.** When 12 *g* of carbon is heated in a vacuum there is no change in mass

**c.** A sample of air increases in volume when heated at constant pressure but its mass remains unaltered

**d.** The weight of a piece of platinum is the same before and after heating in air

**5.** n g of substance X reacts with m g of substance Y to form p g of substance R and q g of substance S. This reaction can be represented as, $X+Y=R+S$. The relation which can be established in the amounts of the reactants and the products will be

**a.** $n-m=p-q$ **b.** $n+m=p+q$

**c.** $n=m$ **d.** $p=q$

### Atomic, Molecular and Equivalent Masses

**6.** Sulphur forms the chlorides $S_2Cl_2$ and $SCl_2$. The equivalent mass of sulphur in $SCl_2$ is:

**a.** 8 *g*/mole **b.** 16 *g*/mole

**c.** 64.8 *g*/mole **d.** 32 *g*/mole

**7.** What is the concentration of nitrate ions if equal volumes of 0.1 M $AgNO_3$ and 0.1 M NaCl are mixed together?

**a.** 0.1 M **b.** 0.2 M

**c.** 0.05 M **d.** 0.25 M

**8.** 74.5 *g* of a metallic chloride contain 35.5 g of chlorine. The equivalent weight of the metal is:

**a.** 19.5 **b.** 35.5 **c.** 39.0 **d.** 78.0

**9.** One litre of a gas at STP weight 1.16 *g* it can possible be:

**a.** $C_2H_2$ **b.** CO

**c.** $O_2$ **d.** $CH_4$

**10.** 1.25 *g* of a solid dibasic acid is completely neutralised by 25 *ml* of 0.25 molar $Ba(OH)_2$ solutions. Molecular mass of the acid is:

**a.** 100 **b.** 150

**c.** 120 **d.** 200

**11.** The atomic weights of two elements A and B are 40 and 80 respectively. If x g of A contains y atoms, how many atoms are present in 2x g of B?

**a.** $\frac{y}{2}$ **b.** $\frac{y}{4}$

**c.** y **d.** 2y

**12.** 1.520 *g* of the hydroxide of a metal on ignition gave 0.995 *gm* of oxide. The equivalent weight of metal is:

**a.** 1.520 **b.** 0.995

**c.** 19.00 **d.** 9.00

**13.** What should be the equivalent weight of phosphorous acid, if P=31; O=16; H=1?

**a.** 82 **b.** 41

**c.** 20.5 **d.** None of these

**14.** The weight of a molecule of the compound $C_{60}H_{122}$ is:

**a.** $1.4\times10^{-21}$ g **b.** $1.09\times10^{-21}$ g

**c.** $5.025\times10^{23}$ g **d.** $16.023\times10^{23}$ g

**15.** Caffeine has a molecular weight of 194. If it contains 28.9% by mass of nitrogen, number of atoms of nitrogen in one molecule of caffeine is:

**a.** 4 **b.** 6

**c.** 2 **d.** 3

**16.** A gaseous mixture contains $CH_4$ and $C_2H_6$ in equimolecular proportion. The weight of 2.24 litres of this mixture at NTP is:

**a.** 4.6 *g* **b.** 1.6 *g*

**c.** 2.3 *g* **d.** 23 *g*

**17.** Volume of a gas at STP is $1.12\times10^{-7}$ cc. Calculate the number of molecules in it:

**a.** $3.01\times10^{20}$ **b.** $3.01\times10^{12}$

**c.** $3.01\times10^{23}$ **d.** $3.01\times10^{24}$

**18.** The number of moles of oxygen in 1 *L* of air containing 21% oxygen by volume, in standard conditions, is:

**a.** 0.186 *mol* **b.** 0.21 *mol*

**c.** 2.10 *mol* **d.** 0.0093 *mol*

**19.** The equivalent weight of a metal is 9 and vapour density of its chloride is 59.25. The atomic weight of metal is:

**a.** 23.9 **b.** 27.3
**c.** 36.3 **d.** 48.3

**20.** Equivalent weight of a bivalent metal is 37.2. The molecular weight of its chloride is:

**a.** 412.2 **b.** 216
**c.** 145.4 **d.** 108.2

**21.** The number of molecules in 4.25 *g* of ammonia are:

**a.** $0.5\times10^{23}$ **b.** $1.5\times10^{23}$
**c.** $3.5\times10^{23}$ **d.** $1.8\times10^{32}$

## The Mole Concept

**22.** Which one of the following pairs of gases contains the same number of molecules?

**a.** 16 g of $O_2$ and 14 g of $N_2$
**b.** 8 g of $O_2$ and 22 g of $CO_2$
**c.** 28 g of $N_2$ and 22 g of $CO_2$
**d.** 32 g of $O_2$ and 32 g of $N_2$

**23.** 250 *ml* of a sodium carbonate solution contains 2.65 grams of $Na_2CO_3$. If 10 *ml* of this solution is diluted to one litre, what is the concentration of the resultant solution (mol. wt. of $Na_2CO_3$ =106) ?

**a.** 0.1 M **b.** 0.001 M
**c.** 0.01 M **d.** $10^{-4}$ M

**24.** The number of oxygen atoms in 4.4 *g* of $CO_2$ is approx:

**a.** $1.2\times10^{23}$ **b.** $6\times10^{22}$
**c.** $6\times10^{23}$ **d.** $12\times10^{23}$

**25.** 19.7 kg of gold was recovered from a smuggler. How many atoms of gold were recovered? (Au =197)

**a.** 100 **b.** $6.02\times10^{23}$
**c.** $6.02\times10^{24}$ **d.** $6.02\times10^{25}$

**26.** The number of water molecules in 1 litre of water is:

**a.** 18 **b.** $18\times1000$
**c.** $N_A$ **d.** $55.55\,N_A$

**27.** **b.** Which of the following is Loschmidt number?

**a.** $6\times10^{23}$ **b.** $2.69\times10^{19}$
**c.** $3\times10^{23}$ **d.** None of these

**28.** The total number of gm-molecules of $SO_2Cl_2$ in 13.5g of sulphuryl chloride is:

**a.** 0.1 **b.** 0.2 **c.** 0.3 **d.** 0.4

**29.** Molarity of liquid HCl with density equal to 1.17g/cc is:

**a.** 36.5 **b.** 18.25
**c.** 32.05 **d.** 4.65

**30.** A sample of phosphorus trichloride $(PCl_3)$ contains 1.4 moles of the substance. How many atoms are there in the sample?

**a.** 4 **b.** 5.6
**c.** $8.431\times10^{23}$ **d.** $3.372\times10^{24}$

## Percentage Composition and Molecular Formula

**31.** The percentage of oxygen in NaOH is:

**a.** 40 **b.** 60
**c.** 8 **d.** 10

**32.** The percentage of nitrogen in urea is about:

**a.** 46 **b.** 85
**c.** 18 **d.** 28

**33.** The empirical formula of a compound is $CH_2O$. 0.0835 moles of the compound contains 1.0 *g* of hydrogen. Molecular formula of the compound is:

**a.** $C_2H_{12}O_6$ **b.** $C_5H_{10}O_5$
**c.** $C_4H_8O_8$ **d.** $C_3H_6O_3$

**34.** In which of the following pairs of compounds the ratio of C, H and O is same?

**a.** Acetic acid and methyl alcohol
**b.** Glucose and acetic acid
**c.** Fructose and sucrose
**d.** All of these

## Chemical Stoichiometry

**35.** How much of NaOH is required to neutralise 1500 $cm^3$ of 0.1 N HCl (Na = 23)?

**a.** 40 *g* **b.** 4 *g*
**c.** 6 *g* **d.** 60 *g*

**36.** 2.76 *g* of silver carbonate on being strongly heated yield a residue weighing:

**a.** 2.16 *g* **b.** 2.48 *g*
**c.** 2.64 *g* **d.** 2.32 *g*

**37.** Haemoglobin contains 0.33% of iron by weight. The molecular weight of haemoglobin is approximately 67200. The number of iron atoms (At. wt. of Fe = 56) present in one molecule of haemoglobin is:

**a.** 6 **b.** 1
**c.** 4 **d.** 2

38. The percentage of $P_2O_5$ in diammonium hydrogen phosphate $(NH_4)_2HPO_4$ is:

**a.** 23.48 **b.** 46.96
**c.** 53.78 **d.** 71.00

39. The percentage of *Se* in peroxidase anhydrous enzyme is 0.5% by weight (atomic weight=78.4). Then minimum molecular weight of peroxidase anhydrous enzyme is:

**a.** $1.568\times10^4$ **b.** $1.568\times10^3$
**c.** 15.68 **d.** $3.136\times10^4$

40. What is the % of $H_2O$ in $Fe(CNS)_3.3H_2O$ ?

**a.** 45 **b.** 30
**c.** 19 **d.** 25

41. What is the normality of a 1 *M* solution of $H_3PO_4$ ?

**a.** 0.5 *N* **b.** 1.0 *N*
**c.** 2.0 *N* **d.** 3.0 *N*

42. How many *g* of a dibasic acid (Mol. wt. = 200) should be present in 100 *ml* of its aqueous solution to give decinormal strength?

**a.** 1 *g* **b.** 2 *g*
**c.** 10 *g* **d.** 20 *g*

43. 0.16 *g* of dibasic acid required 25 *ml* of decinormal NaOH solution for complete neutralisation. The molecular weight of the acid will be:

**a.** 32 **b.** 64
**c.** 128 **d.** 256

44. In order to prepare one *litre* normal solution of $KMnO_4$ , how many *grams* of $KMnO_4$ are required if the solution is used in acidic medium for oxidation?

**a.** 158 *g* **b.** 31.6 *g*
**c.** 790 *g* **d.** 62 *g*

45. In the preceeding question, the amount of $Na_2CO_3$ present in the solution is:

**a.** 2.650 *g* **b.** 1.060 *g*
**c.** 0.530 *g* **d.** 0.265 *g*

46. The mass of $BaCO_3$ produced when excess $CO_2$ is bubbled through a solution of 0.205 mol $Ba(OH)_2$ is?

**a.** 81 *g* **b.** 40.5 *g*
**c.** 20.25 *g* **d.**162 *g*

47. How many grams of caustic potash required to completely neutralise 12.6 *gm* $HNO_3$ ?

**a.** 22.4 KOH **b.** 1.01 KOH
**c.** 6.02 KOH **d.** 11.2 KOH

48. On electrical decomposition of 150 ml dry and pure $O_2$, 10% of $O_2$ gets changed to *O*, then the volume of gaseous mixture after reaction and volume of remaining gas left after passing in turpentine oil will be:

**a.** 145 *ml* **b.** 149 *ml*
**c.** 128 *ml* **d.** 125 *ml*

49. A solution of 10 ml $\frac{M}{10}FeSO_4$ was titrated with $KMnO_4$ solution in acidic medium. The amount of $KMnO_4$ used will be:

**a.** 5 ml of 0.1 M **b.** 10 ml of 1.1 M
**c.** 10 ml of 0.5 M **d.** 10 ml of 0.02 M

50. 100 g $CaCO_3$ reacts with 1litre 1 N HCl. On completion of reaction how much weight of $CO_2$ will be obtain?

**a.** 5.5 *g* **b.** 11 *g*
**c.** 22 *g* **d.** 33 *g*

**Chemical Arithmetic**

51. A mixture of sand and iodine can be separated by:

**a.** Crystallisation
**b.** Sublimation
**c.** Distillation
**d.** Fractional distillation

52. The maximum amount of $BaSO_4$ precipitated on mixing equal volumes of $BaCl_2$ (0.5 M) with $H_2SO_4$ (1M) will correspond to:

**a.** 0.5 M **b.** 1.0 M
**c.** 1.5 M **d.** 2.0 M

53. M is the molecular weight of $KMnO_4$. The equivalent weight of $KMnO_4$ when it is converted into $K_2MnO_4$ is?

**a.** *M* **b.** M/3
**c.** M/5 **d.** M/7

54. The equivalent weight of phosphoric acid $(H_3PO_4)$ in the reaction $NaOH+H_3PO_4 \longrightarrow NaH_2PO_4+H_2O$ is:

**a.** 25 **b.** 49
**c.** 59 **d.** 98

55. Volume of 0.6 M NaOH required to neutraliz $30\,cm^3$ of 0.4 M HCl is:

**a.** 30 $cm^3$ **b.** 20 $cm^3$
**c.** 50 $cm^3$ **d.** 45 $cm^3$

## NCERT EXEMPLAR PROBLEMS

### More than One Answer

**56.** 2 moles of $CaCO_3$ present in 1 litre aqueous solution has a density equal to 1.2 g/cc equal to:
**a.** 2 M solution of $CaCO_3$
**b.** 4 N solution of $CaCO_3$
**c.** Solution with mole fraction of $CaCO_3$ is 0.0347
**d.** Solution which contains 55.5 moles of water

**57.** The vapour density of a mixture containing $NO_2$ and $N_2O_4$ is 38.3 at 27°C. Which of the following is correct for 100 moles of mixture?
**a.** Moles of $NO_2$ in mixture are 33.48
**b.** Moles of $N_2O_4$ in mixture are 66.52
**c.** Weight of $NO_2$ in mixture is 1540 g
**d.** Weight of $N_2O_4$ in mixture is 1540 g

**58.** Select the correct statements:
**a.** At STP, volume occupied by one mole liquid water is 22.4 litre
**b.** Volume occupied by $1\,g\,H_2$ gas at STP is equal to volume occupied by 2 g He at STP
**c.** 1 g of $CH_4$ real gas occupies 1.4 litre volume at STP
**d.** $SO_2Cl_2$ reacts with $H_2O$ to give mixture of $H_2SO_4, HCl$. Aqueous solution of 1 mole $SO_2Cl_2$ will be neutralized by 2 mole of $Ca(OH)_2$

**59.** In which of the following number, all zeroes are significant?
**a.** 4,00004 **b.** 0.0060
**c.** 20.000 **d.** 0.800

**60.** Which of the following statements are true?
**a.** One gram atom of carbon contains Avogadro's number of atoms
**b.** One mole oxygen gas contains Avogardro's number of molecules
**c.** One mole of the hydrogen molecules contains Avogardro's number of atoms
**d.** One mole of electrons stands for $6.023\times10^{23}$ electrons

**61.** Which of the statements are true? Where Mw is the molecular weight of the respective compounds:
**a.** The equivalent weight of $Ca_3(PO_4)_2$ is Mw/6.
**b.** The equivalent weight of $Na_3PO_4\cdot12H_2O$ is Mw/3
**c.** The equivalent weight of $K_2SO_4$ is Mw/2
**d.** The equivalent weight of potash alum $K_2SO_4Al_2(SO4)_3\cdot24H_2O$ is Mw/8

**62.** Two bulbs A and B contain 16g $O_2$ and 16g $O_3$, respectively. Which of the statements are true?
**a.** Both bulbs contain same number of atoms
**b.** Both bulbs contain different number of atoms
**c.** Both bulbs contain same number of molecules
**d.** Bulb A contains $N_A/2$ molecules while bulb B contains $N_A/3$ molecules. ($N_A$ = Avogadro's number).

**63.** A bulb contains 1.6 g of $O_2$. It contains.
**a.** 0.05 mol of $O_2$
**b.** $3.011\times10^{22}$ molecules of $O_2$
**c.** 1.12 L of $O_2$ at STP
**d.** 1.22 L of $O_2$ at SATP

**64.** Which of the following statements is/are correct?
**a.** Chloropicrin ($CCl_3{\cdot}NO_2$) can be made cheaply for use as an insecticide by the following reaction: $CH_3NO_2 + Cl_2 \longrightarrow CCl_3\cdot NO_2 + HCl$
**b.** In a rocket motor fueled with butane ($C_4H_{10}$), 0.1 mol of butane requires 14.56L of $O_2$ at STP for complete combustion.
**c.** A portable hydrogen generator utilizes the reaction $(CaH_2 + H_2O \longrightarrow Ca(OH)_2 + H_2)$ 2.1g of $CaH_2$ would produce 2.24 L of $H_2$ at STP.
**d.** In the Mond process for purifying nickel, the volatile nickel carbonyl $[Ni(CO)_4]$ is produced by the reaction. $Ni + CO \longrightarrow Ni(CO)_4$.58.7 g of Ni utilizes 89.6 L of CO at standard conditions.

**65.** Which of the following statements is/are correct?
**a.** $CaC_2$ is made in an electric furnace by the reaction: $CaO + C \longrightarrow CaC_2 + CO$. 16.0g of $CaC_2$ is obtained from 9.0 g of C.
**b.** Polyethene can be produced form $CaC_2$ as follows:
$CaC_2 + H_2O \longrightarrow CaO + HC\equiv CH$
$HC\equiv CH + H_2 \longrightarrow H_2C = CH_2$
$n(CH_2 = CH_2) \longrightarrow (CH_2 - CH_2)_n$ (Polyethene)
32.0 kg of $CaC_2$ produces 14.0 kg of polyethene.
**c.** 1.435g of AgCl is obtained from 17.75g of $[Ag(NH_3)_2]Cl$ by the following reaction:
$[Ag(NH_3)_2]Cl + 2HNO_3 \longrightarrow AgCl + 2NH_4NO_3$.
**d.** Commercial sodium 'hydrosulfite' is 50% pure $Na_2S_2O_4$. It is prepard as follows: (i) $Zn + 2SO_2 \longrightarrow ZnS_2O_4$
(ii) $ZnS_2O_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2S_2O_4$
174.0 metric ton of commercial product ($Na_2S_2O_4$) can be made from 65.4 metric ton of Zn, with a sufficient supply of other reactants.

### Assertion and Reason

**Note:** Read the Assertion (A) and Reason (R) carefully to mark the correct option out of the options given below:

**a.** If both assertion and reason are true and the reason is the correct explanation of the assertion.
**b.** If both assertion and reason are true but reason is not the correct explanation of the assertion.
**c.** If assertion is true but reason is false.
**d.** If the assertion and reason both are false.
**e.** If assertion is false but reason is true.

**66.** **Assertion:** One mole of $SO_2$ contains double the number of molecules present in one mole of $O_2$.
**Reason:** Molecular weight of $SO_2$ is double to that of $O_2$.

**67.** **Assertion:** Volume of a gas is inversely proportional to the number of moles of a gas.
**Reason:** The ratio by volume of gaseous reactants and products is in agreement with their mole ratio.

**68.** **Assertion:** Molecular weight of oxygen is 16.
**Reason:** Atomic weight of oxygen is 16.

**69.** **Assertion:** Atoms can neither be created nor destroyed.
**Reason:** Under similar condition of temperature and pressure, equal volume of gases does not contain equal number of atoms.

**70.** **Assertion:** 22.4 L of $N_2$ at NTP and 5.6 L $O_2$ at NTP contain equal number of molecules.
**Reason:** Under similar conditions of temperature and pressure all gases contain equal number of molecules.

**71.** **Assertion:** One atomic mass unit (amu) is mass of an atom equal to exactly one-twelfth the mass of a carbon-12 atom.
**Reason:** Carbon-12 isotope was selected as standard.

**72.** **Assertion:** As mole is the basic chemical unit, the concentration of the dissolved solute is usually specified in terms of number of moles of solute.
**Reason:** The total number of molecules of reactants involved in a balanced chemical equation is known as molecularity of the reaction.

**73.** **Assertion:** Equivalent weight of Cu in CuO is 63.6 and in $Cu_2O$ 31.8.
**Reason:** Equivalent weight of an element
$$= \frac{\text{Atomic weight of the element}}{\text{Valency of the element}}$$

**74.** **Assertion:** 1 amu equals to $1.66\times10^{-24}$ g.
**Reason:** $1.66\times10^{-24}$g equals to $\frac{1}{12}$th of mass of $C^{12}$ atom.

**75.** **Assertion:** Atomicity of oxygen is 2.
**Reason:** 1 mole of an element contains $6.023\times10^{23}$ atoms.

### Comprehension Based

**Paragraph –I**

An aqueous solution of NaOH having density 1.1 kg / $dm^3$ contains 0.02 mole fraction of NaOH.

**76.** The molality and molarity of NaOH solution respectively are:
**a.** 0.986, 1.134 **b.** 1.134, 1.193
**c.** 1.134, 1.02 **d.** 1.034, 1.134

**77.** The % by weight of NaOH solution is:
**a.** 4.34 **b.** 2.17
**c.** 5.28 **d.** 8.34

**78.** The strength of NaOH solution is:
**a.** 30.44 **b.** 45.36
**c.** 39.44 **d.** 47.7

**79.** The pH of NaOH solution is:
**a.** 13.9939 **b.** 0.0061
**c.** 12.0218 **d.** 14

**80.** Number of molecules of NaOH present in its 10 mL solution is:
**a.** $6.023\times10^{23}$ **b.** $5.94\times10^{25}$
**c.** $6.023\times10^{20}$ **d.** $7.18\times10^{25}$

**81.** Volume of water required to prepare 1 litre 0.5 M solution of NaOH from V mL solution of NaOH: [V < 1000 mL]
**a.** 336 mL **b.** 118 mL
**c.** 653 mL **d.** 580 mL

**82.** The 10 mL NaOH solution is completely neutralized by 0.1 M $H_2SO_4$. The volume of $H_2SO_4$ needed is:
**a.** 98.6 mL **b.** 49.3 mL
**c.** 24.7 mL **d.** 59.65 mL

**Paragraph –II**

The process of the addition of the standard solution of intermediate solution of a reactant *i.e.,* titrant from the burette to the measured volume of solution of the substance to be estimated until the reaction between the two is just complete, *i.e.,* till the 2$^{nd}$ substance is completely used up *i.e.,* upto the end point is termed as titration or volumetric estimation. Titration is classified in following two categories.
(1) Acid-base titrations (2) Redox titrations
The acid-base titration is further classified in following three categories
(1) Simple titration, (2) Back titration, (3) Double titration

In simple titration, we can find the concentration of substance witht eh help of the standard solution of another substance which can react with it. Back titration is usually used to calculate % purity of a sample.

In double titration mainly using two indicators, phenolphthalein (Ph) and methyl orange (MeOH) respectively. The titration of the mixture may be carried by two different methods as summarized below:

| | Meq. of N HCl used with given mixture | | Meq. of N HCl used with given mixture | |
|---|---|---|---|---|
| Mixture | HPh from beginning | MeOH from beginning | HPh from beginning | MeOH orange after first end point |
| NaOH $+Na_2CO_3$ | Meq. of NaOH $+\frac{1}{2}$ Meq. of $Na_2CO_3$ | Meq. of NaOH+ Meq. of $Na_2CO_3$ | Meq. of NaOH$+\frac{1}{2}$ Meq. of $Na_2CO_3$ | $\frac{1}{2}$Meq. of $Na_2CO_3$ |
| NaOH +NaHCO | Meq. of NaOH | Meq. of NaOH+ Meq. of $NaHCO_3$ | Meq. of NaOH | Meq. of $NaHCO_3$ |
| $Na_2CO_3$ $+NaHCO_3$ | $\frac{1}{2}$Meq. of $Na_2CO_3$ | Meq. of $Na_2CO_3$ + Meq. of $NaHCO_3$ | $\frac{1}{2}$Meq. of $Na_2CO_3$ | $\frac{1}{2}$Meq. of NaOH $Na_2CO_3$ + Meq. of $NaHCO_3$ |

**83.** The 150mL of $\frac{N}{10}$HCl is required to react completely with 1.0g of a sample of limestone. Calculate the percentage purity of $CaCO_3$.

**a.** 65% **b.** 25%
**c.** 75% **d.** 85%

**84.** 0.63 g of dibasic acid with dissolved in water. The volume of the solution was made 100mL. 20mL of this acid solution required 10mL $\frac{N}{5}$NaOH solution. What is the molecular mass of the acid?

**a.** 63 **b.** 126
**c.** 252 **d.** 128

**85.** An aqueous solution of 6.3 g of oxalic acid dehydrate is made upto 250mL. The volume of 0.1N NaOH required to complete neutralize 10mL of this solution is:

**a.** 40 mL **b.** 20 mL
**c.** 10 mL **d.** 4 mL

**86.** Mixture of 1mol $BaF_2$ and 2 mol $H_2SO_4$ can be neutralized by:

**a.** 1 mol KOH or 2 mol $Ca(OH)_2$
**b.** 2 mol $Ca(OH)_2$ or 4 mol NaOH
**c.** 2 mol NaOH or 4 mol $Ca(OH)_2$
**d.** 2 mol KOH or 1 mol $Ca(OH)_2$

**87.** A solution contained $NaCO_3$ and $NaHCO_3$. 15mL of the solution required 5mL of $\frac{N}{10}$HCl for neutralization using phenolphthalein as an indicator. Addition of methyl orange after I end point required a further 15mL of the acid for neutralization. The amount of $Na_2CO_3$ present in one litre of the solution is:

**a.** 21.2 g **b.** 3.53 g
**c.** 0.212 g **d.** 4.24 g

**88.** The indicators are:

**a.** salts of strong organic acids and strong organic bases
**b.** salts of weak organic acids and weak organic bases
**c.** either weak organic acids or weak organic bases
**d.** either strong organic acids or strong organic bases

**89.** A mixture of KOH and $Na_2CO_3$ solution required 15mL of $\frac{N}{20}$HCl for its titration using phenolphthalein as indicator. KOH and $Na_2CO_3$ present in mixture are:

**a.** 0.014 g KOH + 0.053 g $Na_2CO_3$
**b.** 0.053 g KOH + 0.014 g $Na_2CO_3$
**c.** 0.106 g KOH + 0.014 g $Na_2CO_3$
**d.** 0.014 g KOH + 0.106 g $Na_2CO_3$

**90.** The volume of 0.1 N HCl required to neutralize completely 2g of equimolar mixture of $Na_2CO_3$ and $NaHCO_3$ is:

**a.** 316mL **b.** 158mL
**c.** 632mL **d.** 237mL

### Match the Column

**91.** Match the statement of Column with those in Column II:

| Column I | Column II |
|---|---|
| **(A)** Molarity (M) | **1**. Temperature |
| **(B)** Molality (m) | **2.** Dilution |
| **(C)** Mole fraction ($\chi$) | **3.** Volume |
| **(D)** Normality (N) | |

**a.** A→1,2,3; B→2; C→2; D→1,2,3
**b.** A→2; B→1,2,3; C→1; D→1,2,3
**c.** A-→1,2,3; B→3; C→1,2; D→2
**d.** A→2; B→1; C→1,2,3; D→2

**92.** Match the weight of reactants given in column I with weight of products marked (?) given in column II:

| Column I | Column II |
|---|---|
| **(A)** $\underset{1.0g}{2H_2}+\underset{1.0g}{O_2}\longrightarrow\underset{?}{2H_2O}$ | **1.** 0.56 g |
| **(B)** $\underset{1.0g}{N_2}+\underset{1.0g}{3H_2}\longrightarrow\underset{?}{2NH_3}$ | **2.** 1.333 g |
| **(C)** $\underset{1.0g}{CaCO_3}\xrightarrow{\Delta}CaO+\underset{?}{CO_2}$ | **3.** 1.125 g |
| **(D)** $\underset{1.0g}{C}+\underset{1.0g}{2H_2}\longrightarrow\underset{?}{CH_4}$ | **4.** 1.214 g |

**a.** A→3, B→1, C→4, D→2
**b.** A→3, B→4, C→1, D→2
**c.** A→1, B→3, C→2, D→4
**d.** A→4, B→1, C→3, D→2

**93.** Match the amount of reactant given in column I with neutralisation reactions given in column II:

| Column I | Column II |
|---|---|
| **(A)** $4.9\,g\,H_2SO_4$ | **1.** 200 mL of 0.5 N NaOH is used for complete neutralisation |
| **(B)** 4.9 g of $H_3PO_4$ | **2.** 200 mmol oxygen atoms |
| **(C)** 4.5 of $H_2C_2O_4$ | **3.** Central atom has its highest oxidation state. |
| **(D)** 5.3 g $Na_2CO_3$ | **4.** May react with an oxidising agent |
| | **5.** Shape and geometry around the central atom is same |

**a.** A→1,2,3,5; B→2,3,5; C→1,2,3,4; D→3,5
**b.** A→2,3,5; B→1,2,3,4; C→1,2,3,5; D→3,5
**c.** A→1,2,3,4; B→3,5; C→1,2,3,5; D→2,3,5
**d.** A→3,5; B→1,2,3,4; C→1,2,35; D→2,3,5

**94.** Match the statement of Column I with those in Column II:

| Column I | Column II |
|---|---|
| **(A)** 9.8% $H_2SO_4$ by weight (density $=1.8\,g\,mL^{-1}$) | **1.** 3.6 N |
| **(B)** 9.8% $H_3PO_4$ by weight (density $=1.2\,g\,mL^{-1}$) | **2.** 1.2 M |
| **(C)** $1.8\,N_A$ molecules of HCl is 500 mL | **3.** 1.8 Equivalents |
| **(D)** 250 mL of 4N NaOH + 250 mL of 1.6 M $Ca(OH)_2$ | **4.** 1.10 m |

**a.** A→1,3; B→2,4; C→4; D→3
**b.** A→1,2; B-→4; C→1,2,3; D→2
**c.** A→1,4; B→1,2,4; C→1,3; D-3
**d.** A→2,4; B→1,3; C→3; D→1,4

**95.** Match the statement of Column I with those in Column II:

| Column I | Column II |
|---|---|
| **(A)** 15.8 g $KMnO_4$ | **1.** $6.023\times10^{22}$ molecules |
| **(B)** 9.0 g $H_2C_2O_4$ | **2.** $24.092\times10^{22}$ atoms of oxygen |
| **(C)** 8.8 g $CO_2$ | **3.** 0.1 mol |
| **(D)** 5.6 g CO | **4.** 0.2 mol |

**a.** A-→2,3,4; B→2,4; C→1,2,3; D-4
**b.** A→1,2,3; B→4; C→1,2,3; D→2,4
**c.** A→1,3,4; B→1,2,3; C→2; D→1,4
**d.** A→1,2,3; B→1,2,3; C→2,4; D→4

**Integer**

**96.** 50mL of 1M HCl, 100 mL of 0.5 M $HNO_3$, and *x* mL of $5M\,H_2SO_4$ are mixed together and the total volume is made upto 10 L with water. 100 mL of this solution exactly neutralizes 10mL of M/3 $Al_2(CO_3)_3$. Calculate the value of *x*.

**97.** HCl gas is passed into water, yielding a solution of density $1.095\,g\,mL^{-1}$ and containing 30% HCl by weight. Calculate the molarity of the solution.

**98.** A sample contains a mixture of $NaHCO_3$ and $Na_2CO_3$. HCl is added to 15.0 g of the sample, yielding 11.0 g of NaCl. What percent of the sample is $Na_2CO_3$?

Reactions are:

$$\begin{bmatrix} Na_2CO_3+2HCl\longrightarrow 2NaCl+CO_2+H_2O \\ NaHCO_3+HCl\longrightarrow NaCl+CO_2+H_2O \end{bmatrix}$$

Mw of NaCl = 58.5, Mw of $NaHCO_3=84$, Mw of $Na_2CO_3=106\,g\,mol^{-1}$

**99.** The specific gravity of a salt solution is 1.025. If V mL of water is added to 1.0 L of this solution to make its density 1.02 g $mL^{-1}$, what is value of *V* in mL approximately?

**100.** A 19.6g of a given gaseous sample contains 2.8g of molecules (d = 0.75g$L^{-1}$), 11.2g of molecules (d = 3 g$L^{-1}$), and 5.6g of molecules (d=1.5g$L^{-1}$). All density measurements are made at STP. Calculate the total number of molecules (N) present in the given sample. Report your answer in '$10^{23}$N'. Assume Avogardro's number as $6\times10^{23}$.

## ANSWER

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

## SOLUTION

### Multiple Choice Questions

**1.** **(b)** $\frac{(29.2-20.2)(1.79\times10^5)}{1.37} = \frac{9.0\times1.79\times10^5}{1.37}$

Least precise terms *i.e.,* 9.0 has only two significant figures. Hence, final answer will have two significant figures.

**2.** **(d)** 1 zepto $=10^{-21}$

**3.** **(b)** All the zeroes between two non zero digit are significatn. Hence in 60.0001 significant figures is 6.

**4.** **(a)** 12 $g$ of carbon combines with 32 $g$ of oxygen to form 44 $g$ of $CO_2$

**5.** **(b)** $\underset{ng}{X}+\underset{mg}{Y} \rightleftharpoons \underset{pg}{R}+\underset{qg}{S}$

$n+m=p+q$ by low of conservation of mass.

**6.** **(b)** The atomic weight of sulphur = 32

In $SCl_2$ valency of sulphur = 2

So equivalent mass of sulphur $=\frac{32}{2}=16.$

**7.** **(c)** 0.1M $AgNO_3$ will react with 0.1M NaCl to form 0.1M $NaNO_3$. But as the volume doubled, conc. of $NO_3^- = \frac{0.1}{2} = 0.05M$ .

**8.** **(c)** wt. of metallic chloride $=74.5$

wt. of chlorine = 35.5

$\therefore$ wt. of metal $=74.5-35.5=39$

Equivalent weight of metal $=\frac{\text{weight of metal}}{\text{weight of chlorine}}\times35.5$

$=\frac{39}{35.5}\times35.5=39$

**9.** **(a)** $\because$ $1L$ of gas at S.T.P. weight $1.16g$

$\therefore$ 22.4 $L$ of gas at S.T.P. weight $=22.4\times1.16=25.984\approx26$

This molecular weight indicates that given compound is $C_2H_2$.

**10.** **(d)** Molarity $=\frac{W(gm)\times1000}{V(ml)\times\text{molecular weight}}$

$0.25=\frac{1.25\times1000}{25\times\text{molecular weight}}$

$\therefore$ Molecular weight $=\frac{1.25\times1000}{0.25\times25}=200$ .

**11.** **(c)** Number of moles of A $=\frac{x}{40}$

Number of atoms of A $=\frac{x}{40}\times$ Avogadro no. $=y$ (say)

Or $x=\frac{40y}{\text{Avogadro no.}}$

Number of moles of B $=\frac{2x}{80}$

Number of atoms of B

$=\frac{2x}{80}\times$ Av. no. $=\frac{2}{80}\times\frac{40y}{\text{Av. no.}}\times$ Av. no. = y

**12.** **(d)** $\frac{\text{wt. of metal hydroxide}}{\text{wt. of metal oxide}}=\frac{EM+EOH^-}{EM+EO^-}$

$=\frac{1.520}{0.995}=\frac{x+17}{x+8}=1.520x+1.520\times8$

$=0.995x+0.995\times17$

$1.520x+12.160=0.995x+16.915$ or $0.525x=4.755$

$x=\frac{4.755}{0.525}=9.$

**13.** **(b)** The acid is dibasic.

Molecular weight of $H_3PO_3=3+31+48=82$

$\therefore$ Equivalent weight $=\frac{\text{Molecular weight}}{\text{Basicity}}=\frac{82}{2}=41.$

**14.** **(a)** Molecular weight of $C_{60}H_{122}=12\times60+122\times1$

$=720+122=842$

$\because$ $6\times10^{23}$ molecule $C_{60}H_{122}$ has mass = 842 $gm$

$\therefore$ 1 molecule $C_{60}H_{122}$ has mass $\frac{842}{6\times10^{23}}$

$=140.333\times10^{-23}\,gm\ =1.4\times10^{-21}\,gm$.

**15.** **(a)** 100*gm* caffeine has 28.9*gm* nitrogen

194*gm* caffeine has $=\frac{28.9}{100}\times194=56.06\,gm$

$\therefore$ No. of atoms in caffeine $=\frac{56.06}{14}\approx4$.

**16.** **(c)** Equimolecular proportion means both gases occupied equal volume $=\frac{2.24}{2}=1.12L$

For $CH_4$ :: 22.4$L$ $CH_4$ has mass $=16gm$

1.12$L$ $CH_4$ has mass $=\frac{16}{22.4}\times1.12=0.8gm$.

For $C_2H_6$ : 22.4$L$ $C_2H_6$ has mass = 30*gm*

1.12$L$ $C_2H_6$ has mass $=\frac{30}{22.4}\times1.12=\frac{3.0}{2}gm=1.5gm$

**17.** **(b)** $\because$ 22400*cc* of gas at STP has $6\times10^{23}$ molecules

$\therefore$ $1.12\times10^{-7}$ of gas at STP has $\frac{6\times10^{23}\times1.12\times10^{-7}}{22400}$

$=.03\times10^{14}=3\times10^{12}$.

**18.** **(d)** 1$L$ of air = 210*cc* $O_2$ ; 22400*cc* = 1 mole

$210\,cc=\frac{1}{22400}\times210=0.0093$.

**19.** **(a)** Given equivalent weight of metal = 9

Vapour density of metal chloride = 59.25

$\therefore$ molecular weight of metal chloride

$= 2 \times$ V.D $= 2 \times 59.25 = 118.5$

$\therefore$ valency of metal $=\frac{\text{molecular weight of metal chloride}}{\text{equivalnet weight of metal }+35.5}$

Valency of metal $=\frac{118.5}{9+35.5}=\frac{118.5}{44.5}=2.66$

Therefore atomic weight of the metal

= equivalent weight $\times$ valency $=9\times2.66=23.9$

**20.** **(c)** Equivalent weight of bivalent metal = 37.2

$\therefore$ Atomic weight of metal $=37.2\times2=74.4$

$\therefore$ Formula of chloride $=MCl_2$

Hence, molecular weight of chloride

$(MCl_2)=74.4+2\times35.5=145.4$

**21.** **(b)** Molecular weight of $NH_3$ is 17

According to the mole concept

17gm $NH_3$ has molecules $=6.02\times10^{23}$

$\therefore$ 1 gm $NH_3$ has molecules $=\frac{6.02\times10^{23}}{17}$

$\therefore$ 4.25*gm* $NH_3$ has molecules

$=\frac{6.02\times10^{23}\times4.25}{17}=1.5\times10^{23}$ molecule

**22.** **(a)** 16$g$ $O_2$ has no. of moles $=\frac{16}{32}=\frac{1}{2}$

14$g$ $N_2$ has no. of moles $=\frac{14}{28}=\frac{1}{2}$

No. of moles are same, so no. of molecules are same.

**23.** **(b)** Molarity $=\frac{W(gm)\times1000}{\text{molecular wt.}\times V(ml.)}=\frac{2.65\times1000}{106\times250}=0.1M$

10*ml* of this solution is diluted to 1000*ml* $N_1V_1=N_2V_2$

$10\times0.1=1000\times x$

$x=\frac{0.1\times10}{1000}=0.001M$.

**24.** **(a)** 44$g$ of $CO_2$ has $2\times6\times10^{23}$ atoms of oxygen

4.4$g$ of $CO_2$ has $=\frac{12\times10^{23}}{44}\times4.4$

**25.** **(d)** Amount of gold $=19.7kg=19.7\times1000gm=19700gm$

No. of moles $=\frac{19700}{197}=100$

$\therefore$ No. of atoms $=100\times6.023\times10^{23}=6.023\times10^{25}$ atoms.

**26.** **(d)** $d=\frac{M}{V}$ (d = density, M= mass, V =volume)

Since d = 1; So, M=V ;’ 18gm = 18ml

18ml = $N_A$ molecules ($N_A$ = avogadro's no.)

1000ml $=\frac{N_A}{18}\times1000=55.555\,N_A$.

**27.** **(b)** The no. of molecules present in 1*ml* of gas at STP is known as Laschmidt number.

22400*ml* of gas has total no. of molecules $=6.023\times10^{23}$

1*ml* of gas has total no. of molecules $=\frac{6.023\times10^{23}}{22400}$

$=2.69\times10^{19}$.

**28.** **(a)** Molecular weight of $SO_2Cl_2$

$=32+32+2\times35.5=135gm$

$\because$ 135 *gm* of $SO_2Cl_2$ = 1*gm* molecule

$\therefore$ 13.5*gm* of $SO_2Cl_2$ $=\frac{1}{135}\times13.5=0.1$

**29.** **(c)** Molarity = mole/litre

$\because$ 1*cc* contains 1.17*gm*

$\therefore$ 1000*cc* contains 1170*gm* $\frac{1170gm}{\text{Mol. wt.}}$

$= \frac{1170}{36.5} = 32.05 mole/litre$ (Mol. wt. of HCl=36.5)

**30.** **(c)** No. of atoms in one molecule

$= \text{no. of moles} \times 6.022 \times 10^{23}$

$= 1.4 \times 6.022 \times 10^{23} = 8.432 \times 10^{23}$

**31.** **(a)** $\because$ 40*gm* NaOH contains 16gm of oxygen

$\therefore$ 100gm of NaOH contains $\frac{16}{40} \times 100 = 40\%$ oxygen.

**32.** **(a)** Urea- $NH_2–CO–NH_2$

$\because$ 60*gm* of urea contains 28*gm* of nitrogen

$\therefore$ 100*gm* of urea contains $\frac{28}{60} \times 100 = 46.66$ .

**33.** **(a)** $\because$ 0.0835 mole of compound contains 1*gm* of hydrogen

$\therefore$ 1*gm* mole of compound contain $= \frac{1}{0.0835} = 11.97$

= 12*gm* of hydrogen.

12 *gm* of $H_2$ is present in $C_2H_{12}O_6$

**34.** **(b)** Glucose - $C_6H_{12}O_6$

Ratio of C, H and $O$ $= 1:2:1$

In acetic acid $CH_3-\underset{\underset{O}{\parallel}}{C}-O-H$

Ratio of C, H and O $1:2:1$.

**35.** **(c)** $N = \frac{W(gm) \times 1000}{V \times \text{Eq.wt.}}$ ; 1500*ml* of 0.1*N* HCl = 150ml (N)

$1 = \frac{W(gm) \times 1000}{150 \times 40}$ , $W(gm) = \frac{150 \times 40}{1000} = 6gm.$

**36.** **(a)** $2Ag_2CO_3 \xrightarrow{\Delta} 4Ag + 2CO_2 + O_2$

$2 \times 276\, gm$ $\quad 4 \times 108\, gm$

$\because$ $2 \times 276gm$ of $Ag_2CO_3$ gives $4 \times 108\, gm$

$\therefore$ $1gm$ of $Ag_2CO_3$ gives $= \frac{4 \times 108}{2 \times 276}$

$\therefore$ $2.76gm$ of $Ag_2CO_3$ gives $\frac{4 \times 108 \times 2.76}{2 \times 276} = 2.16\, gm$

**37.** **(c)** $\because$ 100*gm* Hb contain = 0.33*gm* Fe

$\therefore$ 67200*gm* Hb $= \frac{67200 \times 0.33}{100}$ *gm* Fe

*gm* atom of Fe $= \frac{672 \times 0.33}{56} = 4$ .

**38.** **(c)** $\underset{2(36+1+31+64)=264}{2(NH_4)_2HPO_4} \equiv \underset{62+80=142}{P_2O_5}$

% of $P_2O_5 = \frac{\text{wt. of } P_2O_5}{\text{wt of salt}} \times 100 = \frac{142}{264} \times 100 = 53.78\%$ .

**39.** **(a)** 0.5*gm Se* $\rightarrow$ 100*gm* peroxidase anhydrous enzyme

78.4*gm Se* $\rightarrow \frac{100 \times 78.4}{0.5} = 1.568 \times 10^4$

Minimum m.w. $\rightarrow$ molecule at least contain one selenium.

**40.** **(c)** In $Fe(CNS)_3 . 3H_2O$ ; % of $H_2O = \frac{3 \times 18}{284} \times 100 = 19\%$ .

**41.** **(d)** $H_3PO_4$ is tribasic so $N = 3M = 3 \times 1 = 3$ .

**42.** **(a)** For Dibasic acid $E = \frac{M}{2} = \frac{200}{2} = 100$

$N = \frac{W \times 1000}{E \times V(\text{in ml})}$ ; $\frac{1}{10} = \frac{W \times 1000}{100 \times 100} = W = 1gm$ .

**43.** **(c)** Dibasic acid NaOH; $N_1V_1 = N_2V_2$

$\frac{W}{E} \times 1000 = \frac{1}{10} \times 25$ ; $\frac{0.16}{E} \times 1000 = \frac{25}{10}$

$M = 2 \times E = 2 \times 64 = 128$.

**44.** **(b)** Acidic medium $E = \frac{M}{5} = \frac{158}{5} = 31.6gm$ .

**45.** **(c)** From solution of (31); From equation (1)

$a = Na_2CO_3 = 0.53gm$ .

**46.** **(b)** $Ba(OH)_2 + CO_2 \longrightarrow BaCO_3 + H_2O$

Atomic wt. of $BaCO_3$ $= 137 + 12 + 16 \times 3 = 197$

No. of mole $= \frac{\text{wt. of substance}}{\text{mol wt.}}$

$\because$ 1 mole of $Ba(OH)_2$ gives 1 mole of $BaCO_3$

$\therefore$ 205 mole of $Ba(OH)_2$ will give .205 mole of $BaCO_3$

$\therefore$ wt. of 0.205 mole of $BaCO_3$ will be

$.205 \times 197 = 40.385gm \approx 40.5\, gm$

**47.** **(d)** $HNO_3 + KOH \longrightarrow KNO_3 + H_2O$

$\frac{12.6}{63} = 0.2$ mole; $HNO_3 \equiv KOH$

0.2 mole $\equiv$ 0.2 mole; $0.2 \times 56 = 11.2gm$ .

**48.** **(a)** $\because$ 3ml (O) $\longrightarrow$ 1ml $O_3$

30ml (O) $\longrightarrow$ 10ml $O_3$

$x = \frac{150 \times 10}{100} = 15ml$

V of $O_2$+V of $O_3 = 135 + 10 = 145ml$

Turpentine oil absorb ozone.

**49.** **(d)** $KMnO_4$ $FeSO_4$

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}; \ M_1V_1 = \frac{n_1}{n_2}M_2V_2$$

$$= \frac{2}{10}\times 10\times\frac{1}{10} = \frac{1}{5} = 0.2, \ M_1V_1 = 0.02\times 10 = \frac{1}{5}$$

**50.** **(c)** $\underset{100g}{CaCO_3} + \underset{2N}{2HCl} \longrightarrow CaCl_2 + \underset{44\,g}{CO_2} + H_2O$

100 *g* $CaCO_3$ with 2 *N* HCl gives 44 *g* $CO_2$

100 *g* $CaCO_3$ with 1 N HCl gives 22 *g* $CO_2$

**51.** **(b)** Iodine shows sublimation and hence volatalizes on heating, the vapour condenses on cooling to give pure iodine.

**52.** **(a)** $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$

One mole of $BaCl_2$ reacts with one mole of $H_2SO_4$. Hence 0.5 mole will react with 0.5 mole of $H_2SO_4$ *i.e.* $BaCl_2$ is the limiting reagent.

**53.** **(a)** $K\overset{+7}{Mn}O_4 \longrightarrow K_2\overset{+6}{Mn}O_4$

Change in 0.5 per atom $= 7 - 6 = 1$

$\therefore$ Equivalent weight of $KMnO_4$

$$= \frac{\text{Molecular weight of } KMnO_4}{\text{Change of 0.5 per atom}} = \frac{M}{1} = M.$$

**54.** **(d)** $NaOH + \underset{(PO_4^{-3})}{H_3PO_4} \longrightarrow \underset{(NaPO_4^{-2})}{NaH_2PO_4}$

$$EW = \frac{MW}{\text{no. of ionisable } H^+} = \frac{98}{1}.$$

**55.** **(b)** NaOH HCl

$N_1V_1 = N_2V_2$; $0.6\times V_1 = 0.4\times 30$;

$V_1 = 20\,ml$.

## NCERT Exemplar Problems

### More than One Answer

**56.** **(a, b, c, d)** 2M solution of $CaCO_3$, 4N solution of $CaCO_3$, Solution with mole fraction of $CaCO_3$ is 0.0347, Solution which contains 55.5 moles of water

**57.** **(b, d)** Moles of $N_2O_4$ in mixture are 66.52, Weight of $N_2O_4$ in mixture is 1540 g

**58.** **(a, b, d)** At STP, volume occupied by one mole liquid water is 22.4 litre, Volume occupied by 1 g $H_2$ gas at STP is equal to volume occupied by 2g He at STP, $SO_2Cl_2$ reacts with $H_2O$ to give mixture of $H_2SO_4$, HCl. Aqueous solution of 1 mole $SO_2Cl_2$ will be neutralized by 2 mole of $Ca(OH)_2$

**59.** **(a, b, c)** 4,00004,0.0060, 20.000

**60.** **(a, c)** One gram atom of carbon contains Avogadro's number of atoms, One mole of the hydrogen molecules contains Avogadro's number of atoms.

**61.** **(a, b, c, d)** **(a)** Valency factor = 6 $\left[\overset{+2\times 3}{Ca_3}\,\overset{-3\times 2}{(PO_4)_2}\right]$

**(b)** Valency factor = 3 $\left[\overset{+1\times 3}{Na_3}\,\overset{-3}{(PO_4)}\right]$

**(c)** Valency factor = 2 $\left[\overset{+1\times 2}{K_2}\,\overset{-2}{SO_4}\right]$

**(d)** Valency factor = 8 $\left[\overset{+1\times 2}{K_2}\,\overset{-2}{SO_4}\,\overset{+3\times 2}{Al_2}\,\overset{-2\times 3}{(SO_4)_3}\right]$

**62.** **(a, d)** (a) Number of $O_2$ atoms $= \frac{16}{32}\times 2\times N_A = 1\times N_A$

**(b)** Number of $O_2$ atoms $= \frac{16}{48}\times 3\times N_A = 1\times N_A$

**(c)** (i) Number of $O_2$ molecules $= \frac{16}{32}\times N_A = \frac{1}{2}N_A$

(ii) Number of $O_2$ molecules $= \frac{16}{48}\times N_A = \frac{1}{3}N_A$

**63.** **(a, b, c, d)** (a) Moles of $O_2 = \frac{1.6}{32} = 0.05$

**(b)** Molecules of $O_2 = 0.05\times 6.023\times 10^{23} = 3.011\times 10^{22}$

**(c)** Volume of $O_2$ at STP $= 0.05\times 22.4 = 1.12\,L$

**(d)** $V_{O_2}$ at SATP $= 0.05\times 24.4 = 1.22\,L$

**64.** **(a, b, c)** **(a)** $CH_3NO_2 + \underset{3\,mol}{3Cl_2} \longrightarrow \underset{1\,mol}{CCl_3\cdot NO_2} + 3HCl$

Volume of $Cl_2$ at STP $= 3\times 0.54\times 22.4 = 33.6\,L$

**(b)** $\underset{1\,mol}{C_4H_{10}} + \underset{13/2\,mol}{\frac{13}{2}O_2} \longrightarrow 4CO_2 + 5H_2O$

Volume of $O_2$ at STP $= \frac{13}{2}\times 0.1\times 22.4 = 14.56\,L$

**(c)** $\underset{(1\,mol = 42\,g)}{CaH_2} + 2H_2O \longrightarrow Ca(OH)_2 + \underset{2\,mol}{2H_2}$

Mol of $H_2 = \frac{2.1}{42} = \frac{1}{20}$

Volume of $H_2$ at STP $= 2\times\frac{1}{20}\times 22.4 = 2.24\,L$

**(d)** $\underset{1\,mol}{Ni} + \underset{4\,mol}{4CO} \longrightarrow Ni(CO_4) = 58.7$ g

Volume of CO at standard conditions
$= 4 \times 24.4 = 97.6$ L

**65.** **(a, b) (a)** $\underset{1\,\text{mole}}{CaO} + \underset{3\,\text{mol}}{3C} \longrightarrow \underset{(1\,\text{mol}=64\,g)}{CaC_2} + CO$

Mole of $CaC_2 = \frac{16}{64} = \frac{1}{4}$ mol

Weight of C $= 3 \times \frac{1}{4} \times 12 = 9.0\,g$

**(b)** Weight of $C_2H_4$

$$(32.0\text{kg})\left(\frac{10^3\,g}{kg}\right)\left(\frac{1\,mol\,CaC_2}{64g}\right)\left(\frac{1\,mol\,C_2H_4}{mol\,CaC_2}\right)\left(\frac{28g\,C_2H_4}{mol\,C_2H_4}\right)$$

$$= \frac{32 \times 10^3 \times 1 \times 1 \times 28}{64} = 14 \times 10^3\,g = 14.0\,kg$$

**(c)** [Mw of $[Ag(NH_3)_2]Cl$=177.5,
Mw of AgCl = 143.5 $gmol^{-1}$]
Weight of $AgCl = [17.75\,g\,Ag(NH_3)_2Cl]$

$$\left(\frac{1\,mol\,Ag(NH_3)_2Cl}{177.5\,g\,Ag(NH_3)_2Cl}\right)$$

$$\left(\frac{1\,mol\,AgCl}{mol\,Ag(NH_3)_2Cl}\right)\left(\frac{143.5\,g\,AgCl}{mol\,AgCl}\right)$$

$= \frac{17.75 \times 143.5}{177.5} = 14.35\,g$ Hence, (c) is wrong.

**(d)** (Atomic weight of Zn = 65.4 g, Mw of $Na_2S_2O_4 = 174$ )

Weight of pure $Na_2S_2O_4 = (65.4 \times 10^6\,g\,Zn)$

$$\left(\frac{1\,mol\,Zn}{65.4\,g\,Zn}\right)\left(\frac{1\,mol\,Na_2S_2O_4}{mol\,Zn}\right)\left(\frac{174\,g\,Na_2S_2O_4}{mol\,Na_2S_2O_4}\right)$$

$= \frac{65.4 \times 10^6 \times 1 \times 1 \times 74}{65.4} = 174 \times 10^6\,g$ = 174 metric ton

Weight of 50% pure $Na_2S_2O_4 = \frac{174 \times 100}{50}$

= 348 metric ton. Hence, (d) is wrong.

**Assertion and Reason**

**66.** **(e)** One mole of any substance corresponding to $6.023 \times 10^{23}$ entities is respective of its weight.

Molecular weight of $SO_2 = 32 + 2 \times 16 = 64$gm.

Molecular weight of $O_2 = 16 \times 2 = 32$gm.

$\therefore$ Molecular weight of $SO_2$ is double to that of $O_2$.

**67.** **(e)** We know that from the reaction $H_2 + Cl_2 \longrightarrow 2HCl$ that the ratio of the volume of gaseous reactants and products is in agreement with their molar ratio. The ratio of $H_2 : Cl_2 : HCl$ volumes is $1:1:2$ which is the same as their molar ratio. Thus volume of gas is directly related to the number of moles. Therefore, the assertion is false but reason is true.

**68.** **(e)** We know that molecular weight of substance is calculated by adding the atomic weight of atoms present in one molecules. We also know that molecular weight of oxygen $(O_2) = 2x$ (Atomic weight of oxygen) =2×16 = 32 a.m.u. Atomic weight of oxygen is 16, because it is 16 times heavier than1/12$^{th}$ of carbon atom. Therefore assertion is false but reason is true.

**69.** **(c)** According to Dalton's atomic theory atoms can neither be created nor destroyed and according to berzelius hypothesis, under similar condition of temperature and pressure equal volumes of all gases contain equal no. of atom. Therefore assertion is true but reason is false.

**70.** **(d)** Molar volume (at NTP) = 22.4L

Now 22.4 L of $N_2$ = volume occupied by one mole of $N_2$ = 28gm = $6.023 \times 10^{23}$ molecules.

Similarly, $O_2 = 2 \times 16 = 32$gm,

32gm = $6.023 \times 10^{23}$ molecules = 22.4 L

$\therefore$ $22.4L = 6.023 \times 10^{23}$ or $5.6L = \frac{6.023 \times 10^{23} \times 5.6}{22.4}$

$= \frac{1}{4} \times 6.023 \times 10^{23}$

According to avagadro's hypothesis equal volume of all gases contain equal no. of molecules under similar condition of temperature and pressure.

**71.** **(a)** For universally accepted atomic mass unit in 1961, C-12 was selected as standard. However the new symbol used is 'v' (unified mass) in place of amu.

**72.** **(b)** The number of moles of a solute present in litre of solution is known is as molarity (M). The total no. of molecules of reactants present in a balanced chemical equation is known as molecularity. For example,

$PCl_5 \longrightarrow PCl_3 + Cl_2$ (Unimolecular)

$2HCl \longrightarrow H_2 + I_2$ (Bimolecular)

$\therefore$ Molarity and molecularity are used in different sense.

**73.** **(e)** Equivalent wt. of Cu in CuO $= \frac{63.6}{2} = \frac{\text{At.wt.}}{\text{Valency}} = 31.8$

Equivalent wt. of Cu in $Cu_2O = \frac{63.6}{1} = 63.6$

(Valency of Cu = 1).

**74.** **(a)** 12gm of C–12 contain $6.023 \times 10^{23}$ atom

$\therefore$ $\frac{12}{6.023} \times 10^{-23} = 1.66 \times 10^{-24}$.

**75.** **(b)** No. of atoms present in a molecules of a gaseous element is called atomicity.

For example, $O_2$ has two atoms and hence its atomicity is 2.

**Comprehension Based**

**76.** **(b)** $\frac{n}{n+N} = 0.02$ and $\frac{N}{n+N} = 0.98,$

where n and N are moles of NaOH

and $H_2O$ $\frac{n}{N} = \frac{2}{98}$ or $\frac{n \times M}{W} = \frac{2}{98}$ or molality $= \frac{n \times 1000}{W}$

$= \frac{2 \times 1000}{98 \times M} = \frac{2000}{98 \times 18} = 1.134$

Also NaOH solution contain 1.134 mole of NaOH in 1000 kg water

$\therefore$ weight of solution $= 1.134 \times 40 + 1000 = 1045.36\,g$

$\therefore$ volume of solution $= \frac{1045.36}{1.1} = 950.32\,mL$

$(d = 1.1\,kg/dm^3 = 1.1\,g/cm^3)$

$\therefore$ Molarity of solution $= \frac{1.134 \times 1000}{950.32} = 1.193.$

**77.** **(a)** % by weight $= \frac{\text{weight of solute} \times 100}{\text{weight of solution}}$

$= \frac{1.134 \times 40}{1045.36} \times 100 = 4.34$

**78.** **(d)** Strength $= \frac{\text{weight of solute}}{\text{volume of solution in } (\ell)}$

$= \frac{1.134 \times 40 \times 1000}{950.32} = 47.7.$

**79.** **(d)** $pH = -\log[H^+]$ and $pOH = -\log OH^-$

$= -\log[1.19] = -0.07$ $[M_{NaOH} = M_{OH^-} = 1.19\,M]$

Solution is highly concentrated pH = 14.

**80.** **(d)** Number of molecules of NaOh present in 1000 mL solution $= 1.193 \times 6.023 \times 10^{23}$

$\therefore$ Number of molecules of NaOH present in 10 mL solution

$\frac{1.193 \times 6.023 \times 10^{23} \times 1000}{10} = 7.18 \times 10^{25}.$

**81.** **(d)** Meq. of dilute solution = Meq. of conc. solution

$1000 \times 0.5 = V \times 1.193 \quad \therefore V = 419.1$

$\therefore$ Volume of water = 1000 – 419.1 = 580.9 mL

**82.** **(d)** Meq. of NaOH = Meq. of $H_2SO_4$

$10 \times 1.193 = 0.1 \times V \times 2 \quad \therefore V = 59.65$ mL.

**83.** **(c)** Meq. of limestone = Meq. of HCl

$\frac{w}{100/2} \times 1000 = 150 \times \frac{1}{10}$ ; $\therefore$ $w_{CaCO_3 = 0.75\,g}$

$\therefore$ $\%CaCO_3 = \frac{0.75}{1} \times 100 = 75\%.$

**84.** **(b)** Meq. of acid in 20 mL = Meq. of NaOH $= 10 \times \frac{1}{5} = 2$

$\therefore$ Meq. of acid in 100 mL $= \frac{2 \times 100}{20} = 10$

or $\frac{2}{M/2} \times 1000 = 10$ or $\frac{0.63}{M/2} \times 1000 = 10$

$\therefore$ M = 126.

**85.** **(a)** Meq. of oxalic acid in 250 mL $= \frac{6.3}{126/2} \times 1000 = 100$

$\therefore$ Meq. of oxalic acid in 10 mL $= \frac{100 \times 10}{250} = 4$

Meq. of NaOH = Meq. of oxalic acid 0.1 × V = 4

$\therefore$ V = 40 mL.

**86.** **(b)** Meq. of NaOH = Meq. of $H_2SO_4$

($BaF_2$ does not react with NaOH) $= 2 \times 2 \times 1000 = 4000$

$\therefore$ Mole of NaOH used = 4

$\therefore$ Mole of $Ca(OH)_2$ used $= \frac{4}{2} = 2$

**87.** **(b)** **I.** $\frac{1}{2}$ Meq. of $Na_2CO_3$ in 15 mL

$=$ Meq. of HCl $= 5 \times \frac{1}{10} = 0.5$

**II.** $\frac{1}{2}$ Meq. of $Na_2CO_3$ in 15 mL + Meq. of $NaHCO_3$

$= 15 \times \frac{1}{10} = 1.5$

Meq. of $Na_2CO_3$ in 15 mL = 1.0 $\frac{w}{106/2} \times 1000 = 1$

$\therefore$ $w = \frac{106}{2000} = 0.053\,g/15\,mL.$

$\therefore$ $w_{Na_2CO_3}$ in 1 litre $= \frac{0.053 \times 1000}{15} = 3.53\,g$

**88.** **(c)** All acid-base indicators are themselves a weak acid (Hph) or a weak base (MeOH)

**89.** **(a)** Meq. of KOH $+ \frac{1}{2}$ Meq. of $Na_2CO_3$

$=$ Meq. of acid $= 15 \times \frac{1}{20} = 0.75$

Meq. of KOH + Meq. of $Na_2CO_3$

$= \text{Meq. of acid} = 25 \times \dfrac{1}{20} = 1.25$

$\dfrac{1}{2}\text{Meq. of } Na_2CO_3 = 1.25 - 0.75 = 0.5$

$\dfrac{w_{Na_2CO_3} \times 1000}{106/2} = 2 \times 0.5$

$\text{Meq. of KOH} = 0.75 - 0.50 \dfrac{w \times 1000}{56} = 0.25$

$\therefore \quad w_{KOH} = 0.014\,g.$

**90.** **(a)** Let a, b g of $Na_2CO_3$ and $NaHCO_3$ be present, then

$a + b = 2 \quad \ldots(i)$

$\dfrac{a}{106} = \dfrac{b}{84}$ or $84a - 106b = 0 \quad \ldots(ii)$

by equations (*i*) and (*ii*) a = 1.12 g, b = 0.88 g

$\therefore$ Meq. of acid = Meq. of $Na_2CO_3$ + Meq. of $NaHCO_3$

$0.1 \times V = \dfrac{1.12}{106/2} \times 1000 + \dfrac{0.88}{84/1} \times 1000$

$V = \dfrac{31.60}{0.1} = 316\,mL.$

**Match the Column**

**91.** **(a)** A→1,2,3; B→2; C→2; D→1,2,3

**(A)** Molarity (M) depends on temperature, dilution, and volume.

**(B)** Molality (m) depends only on dilution.

**(C)** Mole fraction $(\chi)$ also depends only on dilution

**(D)** Normality like molarity depends on all.

**92.** **(b)** A→3, B→4, C→1, D→2

**(A)** $\underset{1.0g}{2H_2} + \underset{1.0g}{O_2} \longrightarrow 2H_2O$

$\dfrac{1}{2}\text{mol} \quad \dfrac{1}{32}\text{mol}$

$O_2$ is the limiting reagent: $1\,mol\,O_2 \equiv 2\,mol\,H_2O$

$\Rightarrow \dfrac{1}{32}mol\,O_2 \equiv \dfrac{1}{16}mol\,H_2O \equiv \dfrac{18}{16}g \text{ of } H_2O = 1.125g$

**(B)** $\underset{1.0g}{N_2} + \underset{1.0g}{3H_2} \longrightarrow 2NH_3$

$\dfrac{1}{28}\text{mol} \quad \dfrac{1}{2}\text{mol}$

$N_2$ is the limiting reagent.

$\therefore \dfrac{1}{28}mol\,N_2 \equiv \dfrac{1}{14}mol\,NH_3 \equiv \dfrac{1}{14} \times 17\,g = 1.214\,g$

**(C)** $\underset{1.0g}{CaCO_3} \xrightarrow{\Delta} CaO + CO_2$

$\dfrac{1}{100}\text{mol} \quad \dfrac{1}{100}\text{mol} \quad \dfrac{1}{100}\text{mol} \quad = \dfrac{1}{100} \times 56\,g\,CaO = 0.56g$

**(D)** $\underset{1.0g}{C} + \underset{1.0g}{2H_2} \longrightarrow CH_4$

$\dfrac{1}{12}\text{mol} \quad \dfrac{1}{2}\text{mol}$; C is the limiting reagent.

$\therefore \dfrac{1}{12}mol\,C \equiv \dfrac{1}{12}mol\,CH_4 \equiv \dfrac{16}{12}g = 1.333\,g$

**93.** **(a)** A→1,2,3,5; B→2,3,5; C→1,2,3,4; D→3,5

**(A)** 1. mEq of NaOH $= 200 \times 0.5 = 100\,mEq \equiv 100\,mEq$ of $H_2SO_4$

2. 4.9 g $H_2\overset{+6}{S}O_4 = \dfrac{4.9}{98} \times 10^3$

$= 50$ mmol $\equiv$ 100 mEq (n factor = 2)

$\equiv$ 200 mmol of O atoms. (1 mol $H_2SO_4 \equiv 4$ mol O atoms)

3. Highest oxidation state of S = +6

5. Hybridiation = $sp^3$; geometry and shape $\Rightarrow$ Tetrahedral

**(B)** 4.9 g $H_3PO_4 \equiv \dfrac{4.9}{98} \times 1000 = 50$ mmol

$= 50 \times 3$ (n factor) $\equiv 150\,mEq$

2. 50 mmol of $H_3PO_4 \equiv 50 \times 4 = 200$ mmol of O atoms.

(1 mol $H_3PO_4 \equiv 4$ mol O atoms)

1. But 150 mEq $H_3PO_4 \neq$ mEq of NaOH

5. Hybridisation is $sp^3$, so geometry and shape is tetrahedral.

3. Maximum oxidation state of P = +5

**(C)** 1. 4.9 g $H_2C_2O_4 \equiv \dfrac{4.9}{90} \times 1000 = 50$ mmol

= 100 mEq (n factor = 2)

2. 50 mmoles of $H_2C_2O_4 \equiv 50 \times 4 = 200$ mmoles O atoms

(1 mol $H_2C_2O_4$ = 4 mol O atoms) $\equiv 100\,mEq$ NaOH

3. Highest oxidation state of C = +4

4. Reacts with oxidation agents such as $MnO_4^-$ and $Cr_2O_7^{2-}$.

**(D)** (i) 5.3 g of $Na_2CO_3 = \dfrac{5.3}{106} \times 1000 = 50$ m moles

(ii) $Na_2CO_3$ does not react with NaOH.

3. Highest oxidation states of C = 44

5. $CO_3^{2-}$, hybridization is $sp^2$, so geometry and shape is planar.

6. 1 mol $Na_2CO_3 \equiv 3$ mol O atoms

**94.** **(c)** A→1,4; B→1,2,4; C→1,3; D-3

**(A)** 1. $M = \dfrac{9.8 \times 10 \times 1.8}{98} = 1.8$; $N = 1.8 \times 2 = 3.6$

4. $d = M\left(\dfrac{Mw_2}{1000} + \dfrac{1}{m}\right)$

$1.8 = 1.8\left(\dfrac{98}{1000} + \dfrac{1}{m}\right) \Rightarrow m = 1.10$

**(B)** 2. $M = \frac{9.8 \times 10 \times 1.2}{98} = 1.2$

1. $N = 1.2 \times 3 = 3.6$

4. $d = M\left(\frac{Mw_2}{1000} + \frac{1}{m}\right)$

$1.8 = 1.8\left(\frac{98}{1000} + \frac{1}{m}\right) \Rightarrow m = 1.10$

**(C)** $1.8\,N_A$ molecules = 1.8 mol of HCl 500 mL = 1.8 Eq.

$M = \frac{1.8 \times 1000}{500} = 3.6\,M = 3.6\,N$ (n factor = 1)

**(D)** mEq of base $= 250 \times 4 + 250 \times 1.6 \times 2$

$= 1000 + 800 = 1800$ mEq = 1.8 Eq

**95.** **(d)** A→1,2,3; B→1,2,3; C→2,4; D→4

**(A)** 1,3. Mol of $KMnO_4 = \frac{15.8}{158} = 0.1\,\text{mol}$

$= 6.023 \times 10^{22}$ molecules

2. 0.1 mol $KMnO_4 = 0.4$ mol O atoms

$= 0.4 \times 6.023 \times 10^{22}$ atoms

$= 24.092 \times 10^{22}$ atoms of oxygen

**(B)** 1, 3. mol of $H_2C_2O_4 = \frac{9.0}{9.0} = 0.1\,\text{mol}$

$= 6.023 \times 10^{22}$ molecules

2. 0.1 mol $H_2C_2O_4 = 0.4$ mol O atoms

$= 24.092 \times 10^{22}$ atoms of oxygen

**(C)** Mol of $CO_2 = \frac{8.8}{44} = 0.2\,\text{mol}$

1 mol $CO_2 = 2$ mol of O atoms

0.2 mol $CO_2 = 0.4$ of O atoms

$= 24.092 \times 10^{22}$ atoms of oxygen

**(D)** Mol of $CO = \frac{5.6}{28} = 0.2\,\text{mol}$

**Integer**

**96.** **(10)** Total mEq of acid $= 50 \times 1 + 100 \times 0.5 + x \times 5 \times 2$ (n factor)

$= (100 + 10x)\text{mEq} = \frac{(100+10x)}{100\,\text{mL}}\text{N}$

$N_1V_1\,(\text{Acid}) = N_1V_1[Al_2(CO_3^{2-})_3]$ (Total charge=6) (n=6)

$\therefore \quad \frac{(100+10x)}{100\,\text{mL}}\text{N} \times 100\,\text{mL}$

$= 10\,\text{mL} \times \frac{1}{3} \times 6 \quad (100 + 10x) = 200 \quad \therefore x = 10\,\text{mL}$

**97.** **(9)** $M = \frac{\%\,\text{by weight} \times 10 \times d}{Mw_2}$

$= \frac{30 \times 10 \times 1.095}{36.5} = 9\,M$

**98.** **(9)** Let x of $Na_2CO_3$.

Then, weight of $NaHCO_3 = (15 - x)$g

Moles of NaCl produced $= \frac{11.0\,g}{58.5\,g} = 0.18\,\text{mol}$

The NaCl is produced by the reaction of $\left(\frac{x}{106}\right)$ mol of $Na_2CO_3$ and $\frac{(15-x)}{84}$ mol of $NaHCO_3$.

Each mol of $Na_2CO_3$ produces 2 mol of NaCl.

$\therefore \quad \frac{2x}{106} + \frac{15-x}{84} = 0.188$

Solve x: $= 13.5\,g\,Na_2CO_3,\ NaHCO_3 = (15 - 1.35) = 13.6\,g$

$\%\,Na_2CO_3 = \frac{1.35}{15} \times 100 = 9.0\%\,Na_2CO_3$

**99.** **(5)** $V_{New} = (V + 1000)\,\text{mL}$

Number of moles of salt remains same.

$\therefore \quad (V + 1000) \times 1.02 = 1.025 \times 1000$

$V = 4.9\,\text{mL} = 5\,\text{mL}.$

**100.** **(3)** Total weight = 19.6 g

**(a)** 2.8 g of molecules, $d = 0.765\,g\,L^{-1}$

Volume $= \frac{\text{Mass}}{d} = \frac{2.8}{0.75}$ L at STP

Moles $= \frac{2.8}{0.75} \times \frac{1}{22.4}$

Molecules $= \frac{2.8}{0.75} \times \frac{1}{22.4} \times 6 \times 10^{23} = 1 \times 10^{23}$

**(b)** 11.2 g molecules, $d = 3\,g\,L^{-1}$

Molecules $= 1 \times 10^{23}$

**(c)** 5.6 molecules, $d = 1.5\,g\,L^{-1}$

Molecules $= 1 \times 10^{23}$

Total number of molecules $= 3 \times 10^{23} = 3$

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