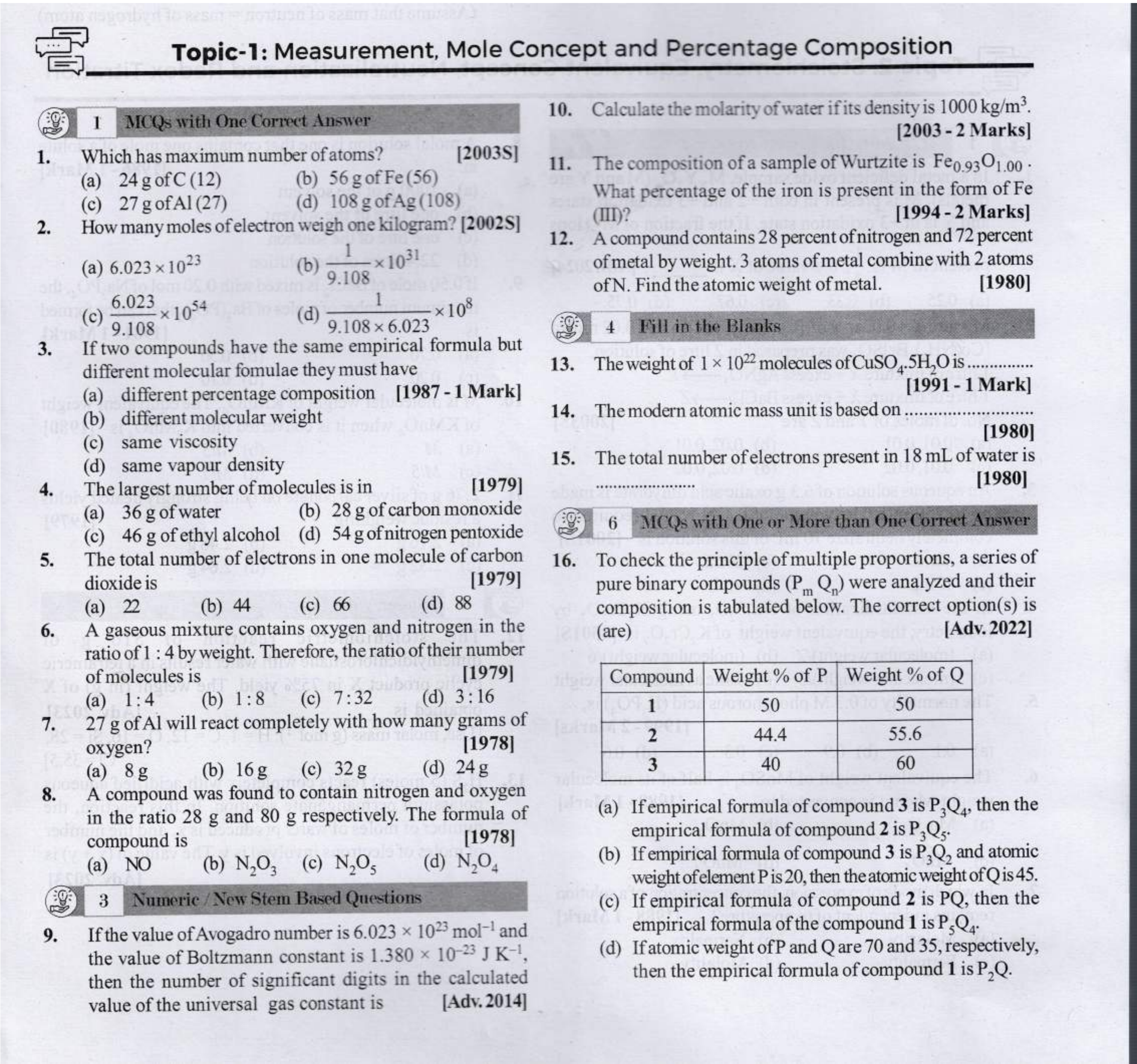
# Chapter
# Some Basic Concepts of Chemistry



## Topic-1: Measurement, Mole Concept and Percentage Composition

### 1 MCQs with One Correct Answer

1. Which has maximum number of atoms? **[2003S]**
   (a) 24 g of C (12) (b) 56 g of Fe (56)
   (c) 27 g of Al (27) (d) 108 g of Ag (108)

2. How many moles of electron weigh one kilogram? **[2002S]**
   (a) $6.023\times10^{23}$ (b) $\frac{1}{9.108}\times10^{31}$
   (c) $\frac{6.023}{9.108}\times10^{54}$ (d) $\frac{1}{9.108\times6.023}\times10^{8}$

3. If two compounds have the same empirical formula but different molecular fomulae they must have **[1987 - 1 Mark]**
   (a) different percentage composition
   (b) different molecular weight
   (c) same viscosity
   (d) same vapour density

4. The largest number of molecules is in **[1979]**
   (a) 36 g of water (b) 28 g of carbon monoxide
   (c) 46 g of ethyl alcohol (d) 54 g of nitrogen pentoxide

5. The total number of electrons in one molecule of carbon dioxide is **[1979]**
   (a) 22 (b) 44 (c) 66 (d) 88

6. A gaseous mixture contains oxygen and nitrogen in the ratio of 1 : 4 by weight. Therefore, the ratio of their number of molecules is **[1979]**
   (a) 1 : 4 (b) 1 : 8 (c) 7 : 32 (d) 3 : 16

7. 27 g of Al will react completely with how many grams of oxygen? **[1978]**
   (a) 8 g (b) 16 g (c) 32 g (d) 24 g

8. A compound was found to contain nitrogen and oxygen in the ratio 28 g and 80 g respectively. The formula of compound is **[1978]**
   (a) NO (b) $N_2O_3$ (c) $N_2O_5$ (d) $N_2O_4$

### 3 Numeric / New Stem Based Questions

9. If the value of Avogadro number is $6.023 \times 10^{23}$ $mol^{-1}$ and the value of Boltzmann constant is $1.380 \times 10^{-23}$ $J\,K^{-1}$, then the number of significant digits in the calculated value of the universal gas constant is **[Adv. 2014]**

10. Calculate the molarity of water if its density is 1000 $kg/m^3$. **[2003 - 2 Marks]**

11. The composition of a sample of Wurtzite is $Fe_{0.93}O_{1.00}$. What percentage of the iron is present in the form of Fe (III)? **[1994 - 2 Marks]**

12. A compound contains 28 percent of nitrogen and 72 percent of metal by weight. 3 atoms of metal combine with 2 atoms of N. Find the atomic weight of metal. **[1980]**

### 4 Fill in the Blanks

13. The weight of $1 \times 10^{22}$ molecules of $CuSO_4.5H_2O$ is .............. **[1991 - 1 Mark]**

14. The modern atomic mass unit is based on .......................... **[1980]**

15. The total number of electrons present in 18 mL of water is ...................... **[1980]**

### 6 MCQs with One or More than One Correct Answer

16. To check the principle of multiple proportions, a series of pure binary compounds ($P_m Q_n$) were analyzed and their composition is tabulated below. The correct option(s) is (are) **[Adv. 2022]**

| Compound | Weight % of P | Weight % of Q |
|---|---|---|
| 1 | 50 | 50 |
| 2 | 44.4 | 55.6 |
| 3 | 40 | 60 |

   (a) If empirical formula of compound **3** is $P_3Q_4$, then the empirical formula of compound **2** is $P_3Q_5$.
   (b) If empirical formula of compound **3** is $P_3Q_2$ and atomic weight of element P is 20, then the atomic weight of Q is 45.
   (c) If empirical formula of compound **2** is PQ, then the empirical formula of the compound **1** is $P_5Q_4$.
   (d) If atomic weight of P and Q are 70 and 35, respectively, then the empirical formula of compound **1** is $P_2Q$.

### 10 Subjective Problems

**17.** 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. **[1999 - 3 Marks]**

**18.** (a) One litre of a sample of hard water contains 1 mg of $CaCl_2$ and 1 mg of $MgCl_2$. Find the total hardness in terms of parts of $CaCO_3$ per $10^6$ parts of water by weight.

(b) A sample of hard water contains 20 mg of $Ca^{++}$ ions per litre. How many milli-equivalent of $Na_2CO_3$ would be required to soften 1 litre of the sample?

(c) 1 g of Mg is burnt in a closed vessel which contains 0.5 g of $O_2$.

(i) Which reactant is left in excess?

(ii) Find the weight of the excess reactants?

(iii) How may milliliters of 0.5 N $H_2SO_4$ will dissolve the residue in the vessel. **[1980]**

**19.** A hydrocarbon contains 10.5 g of carbon per gram of hydrogen. 1 litre of the vapour of the hydrocarbon at 127 °C and 1 atmosphere pressure weighs 2.8 g. Find the molecular formula. **[1980]**

**20.** Find **[1980]**

(i) The total number of neutrons and

(ii) The total mass of neutron in 7 mg of $^{14}C$.

(Assume that mass of neutron = mass of hydrogen atom)

## Topic-2: Stoichiometry, Equivalent Concept, Neutralization and Redox Titration

### 1 MCQs with One Correct Answer

**1.** In a metal deficient oxide sample, $M_XY_2O_4$ (M and Y are metals), M is present in both +2 and +3 oxidation states and Y is in +3 oxidation state. If the fraction of $M^{2+}$ ions present in M is $\frac{1}{3}$, the value of X is _____. **[Adv. 2024]**

(a) 0.25 (b) 0.33 (c) 0.67 (d) 0.75

**2.** Mixture $X$ = 0.02 mol of $[Co(NH_3)_5SO_4]Br$ and 0.02 mol of $[Co(NH_3)_5Br]SO_4$ was prepared in 2 litre of solution.

1 litre of mixture $X$ + excess $AgNO_3 \longrightarrow Y$.

1 litre of mixture $X$ + excess $BaCl_2 \longrightarrow Z$

No. of moles of $Y$ and $Z$ are **[2003S]**

(a) 0.01, 0.01 (b) 0.02, 0.01

(c) 0.01, 0.02 (d) 0.02, 0.02

**3.** An aqueous solution of 6.3 g oxalic acid dihydrate is made up to 250 mL. The volume of 0.1 N NaOH required to completely neutralize 10 mL of this solution is **[2001S]**

(a) 40 mL (b) 20 mL

(c) 10 mL (d) 4 mL

**4.** In the standardization of $Na_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is **[2001S]**

(a) (molecular weight)/2 (b) (molecular weight)/6

(c) (molecular weight)/3 (d) same as molecular weight

**5.** The normality of 0.3 M phosphorous acid ($H_3PO_3$) is, **[1999 - 2 Marks]**

(a) 0.1 (b) 0.9 (c) 0.3 (d) 0.6

**6.** The equivalent weight of $MnSO_4$ is half of its molecular weight when it is converted to : **[1988 - 1 Mark]**

(a) $Mn_2O_3$ (b) $MnO_2$

(c) $MnO_4^-$ (d) $MnO_4^{2-}$

**7.** In which mode of expression, the concentration of a solution remains independent of temperature? **[1988 - 1 Mark]**

(a) Molarity (b) Normality

(c) Formality (d) Molality

**8.** A molal solution is one that contains one mole of a solute in: **[1986 - 1 Mark]**

(a) 1000 g of the solvent

(b) one litre of the solvent

(c) one litre of the solution

(d) 22.4 litres of the solution

**9.** If 0.50 mole of $BaCl_2$ is mixed with 0.20 mol of $Na_3PO_4$, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is **[1981 - 1 Mark]**

(a) 0.70 (b) 0.50

(c) 0.20 (d) 0.10

**10.** $M$ is molecular weight of $KMnO_4$. The equivalent weight of $KMnO_4$ when it is converted into $K_2MnO_4$ is **[1980]**

(a) $M$ (b) $M/3$

(c) $M/5$ (d) $M/7$

**11.** 2.76 g of silver carbonate on being strongly heated yields a residue weighing **[1979]**

(a) 2.16 g (b) 2.48 g

(c) 2.32 g (d) 2.64 g

### 2 Integer Value Answer

**12.** The stoichiometric reaction of 516 g of dimethyldichlorosilane with water results in a tetrameric cyclic product X in 75% yield. The weight (in g) of X obtained is _____. **[Adv. 2023]**

[Use, molar mass (g $mol^{-1}$): H = 1, C = 12, O = 16, Si = 28, Cl = 35.5]

**13.** $H_2S$ (5 moles) reacts completely with acidified aqueous potassium permanganate solution. In this reaction, the number of moles of water produced is x, and the number of moles of electrons involved is y. The value of (x + y) is _____. **[Adv. 2023]**

## 3 Numeric / New Stem Based Questions

**Question Stem for Question Nos. 14 and 15**

A sample (5.6 g) containing iron is completely dissolved in cold dilute HCl to prepare a 250 mL of solution. Titration of 25.0 mL of this solution requires 12.5 mL of 0.03 M $KMnO_4$ solution to reach the end point. Number of moles of $Fe^{2+}$ present in 250 mL solution is $x \times 10^{-2}$ (consider complete dissolution of $FeCl_2$). The amount of iron present in the sample of $y$% by weight.

(Assume : $KMnO_4$ reacts only with $Fe^{2+}$ in the solution

Use : Molar mass of iron as 56 g $mol^{-1}$)

**14.** The value of $x$ is ____. **[Adv. 2021]**

**15.** The value of $y$ is ____. **[Adv. 2021]**

**16.** The ammonia prepared by treating ammonium sulphate with calcium hydroxide is completely used by $NiCl_2.6H_2O$ to form a stable coordination compound. Assume that both the reactions are 100% complete. If 1584 g of ammonium sulphate and 952 g of $NiCl_2.6H_2O$ are used in the preparation, the combined weight (in grams) of gypsum and the nickel-ammonia coordination compound thus produced is______.
(Atomic weights in g $mol^{-1}$: H = 1, N = 14, O = 16, S = 32, Cl = 35.5, Ca = 40, Ni = 59) **[Adv. 2018]**

**17.** Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in kg) of Pb produced per kg of $O_2$ consumed is______.
(Atomic weights in g $mol^{-1}$: O = 16, S = 32, Pb = 207) **[Adv. 2018]**

**18.** How many millilitres of 0.5 M $H_2SO_4$ are needed to dissolve 0.5 g of copper(II) carbonate? **[1999 - 3 Marks]**

**19.** One gram of commercial $AgNO_3$ is dissolved in 50 mL. of water. It is treated with 50 mL. of a KI solution. The silver iodide thus precipitated is filtered off. Excess of KI in the filtrate is titrated with (M/10) $KIO_3$ solution in presence of 6M HCl till all $I^-$ ions are converted into ICl. It requires 50 mL. of (M/10) $KIO_3$ solution. 20 mL. of the same stock solution of KI requires 30 mL. of (M/10)$KIO_3$ under similar conditions. Calculate the percentage of $AgNO_3$ in the sample.
(Reaction : $KIO_3 + 2KI + 6HCl \rightarrow 3ICl + 3KCl + 3H_2O$) **[1992 - 4 Marks]**

**20.** A 1.0 g sample of $Fe_2O_3$ solid of 55.2% purity is dissolved in acid and reduced by heating the solution with zinc dust. The resultant solution is cooled and made upto 100.0 mL. An aliquot of 25.0 mL of this solution requires 17.0 mL of 0.0167 M solution of an oxidant for titration. Calculate the number of electrons taken up by the oxidant in the reaction of the above titration. **[1991 - 4 Marks]**

**21.** Calculate the molality of 1 litre solution of 93% $H_2SO_4$ (weight/volume). The density of the solution is 1.84 g/mL. **[1990 - 1 Marks]**

**22.** A sample of hydrazine sulphate ($N_2H_6SO_4$) was dissolved in 100 mL of water, 10 mL of this solution was reacted with excess of ferric chloride solution and warmed to complete the reaction. Ferrous ion formed was estimated and it required 20 mL of M/50 potassium permanganate solution. Estimate the amount of hydrazine sulphate in one litre of the solution. **[1988 - 3 Marks]**

Reaction : $4Fe^{3+} + N_2H_4 \rightarrow N_2 + 4Fe^{2+} + 4H^+$

$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O.$

**23.** Hydroxylamine reduces iron (III) according to the equation:
$2NH_2OH + 4\,Fe^{3+} \rightarrow N_2O(g)\uparrow + H_2O + 4\,Fe^{2+} + 4H^+$
Iron (II) thus produced is estimated by titration with a standard permanganate solution. The reaction is :

$MnO_4^- + 5\,Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5\,Fe^{3+} + 4H_2O$

A 10 mL. sample of hydroxylamine solution was diluted to 1 litre. 50 mL. of this diluted solution was boiled with an excess of iron (III) solution. The resulting solution required 12 mL. of 0.02 M $KMnO_4$ solution for complete oxidation of iron (II). Calculate the weight of hydroxylamine in one litre of the original solution. (H = 1, N = 14, O = 16, K = 39, Mn = 55, Fe = 56) **[1982 - 4 Marks]**

**24.** A 1.00 g sample of $H_2O_2$ solution containing $X$ per cent $H_2O_2$ by weight requires $X$ mL of a $KMnO_4$ solution for complete oxidation under acidic conditions. Calculate the normality of the $KMnO_4$ solution. **[1981 - 3 Marks]**

**25.** 4.215 g of a metallic carbonate was heated in a hard glass tube and the $CO_2$ evolved was found to measure 1336 mL at 27°C and 700 mm pressure. What is the equivalent weight of the metal? **[1979]**

**26.** What weight of AgCl will be precipitated when a solution containing 4.77 g of NaCl is added to a solution of 5.77 g of $AgNO_3$? **[1978]**

**27.** Igniting $MnO_2$ converts it quantitatively to $Mn_3O_4$. A sample of pyrolusite is of the following composition : $MnO_2$ 80%, $SiO_2$ and other inert constituents 15%, rest being water. The sample is ignited in air to constant weight. What is the percentage of Mn in the ignited sample? **[1978]**
[O = 16, Mn = 54.9]

## 9 Assertion and Reason Statement Type Questions

Each question contains **STATEMENT-1 (Assertion)** and **STATEMENT-2 (Reason)**. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct. Mark your answer as

(a) If both Statement -1 and Statement -2 are correct, and Statement -2 is the correct explanation of the Statement -2.

(b) If both Statement -1 and Statement -2 are correct, but Statement -2 is not the correct explanation of the Statement -1.

(c) If Statement -1 is correct but Statement -2 is incorrect.

(d) If Statement -1 is incorrect but Statement -2 is correct.

**28.** Read the following statement and explanation and answer as per the options given below :

**Statement-1 :** In the titration of $Na_2CO_3$ with HCl using methyl orange indicator, the volume required at the equivalence point is twice that of the acid required using phenolphthalein indicator.

**Statement-2 :** Two moles of HCl are required for the complete neutralization of one mole of $Na_2CO_3$. **[1991 - 2 Marks]**

## 10 Subjective Problems

**29.** 3 g of a salt of molecular weight 30 is dissolved in 250 g of water. The molality of the solution is ...... . **[1983 - 1 Mark]**

**30.** Hydrogen peroxide solution (20 mL) reacts quantitatively with a solution of $KMnO_4$ (20 mL) acidified with dilute $H_2SO_4$. The same volume of the $KMnO_4$ solution is just decolourised by 10 mL of $MnSO_4$ in neutral medium simultaneously forming a dark brown precipitate of hydrated $MnO_2$. The brown precipitate is dissolved in 10 mL of 0.2 M sodium oxalate under boiling condition in the presence of dilute $H_2SO_4$. Write the balanced equations involved in the reactions and calculate the molarity of $H_2O_2$. **[2001 - 5 Marks]**

**31.** An aqueous solution containing 0.10 g $KIO_3$ (formula weight = 214.0) was treated with an excess of KI solution. The solution was acidified with HCl. The liberated $I_2$ consumed 45.0 mL of thiosulphate solution to decolourise the blue starch-iodine complex. Calculate the molarity of the sodium thiosulphate solution. **[1998 - 5 Marks]**

**32.** A 3.00 g sample containing $Fe_3O_4$, $Fe_2O_3$ and an inert impure substance, is treated with excess of KI solution in presence of dilute $H_2SO_4$. The entire iron is converted into $Fe^{2+}$ along with the liberation of iodine. The resulting solution is diluted to 100 mL. A 20 mL of the diluted solution requires 11.0 mL of 0.5 M $Na_2S_2O_3$ solution to reduce the iodine present. A 50 mL of the diluted solution, after complete extraction of the iodine requires 12.80 mL of 0.25 M $KMnO_4$ solution in dilute $H_2SO_4$ medium for the oxidation of $Fe^{2+}$. Calculate the percentages of $Fe_2O_3$ and $Fe_3O_4$ in the original sample. **[1996 - 5 Marks]**

**33.** $8.0575 \times 10^{-2}$ 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 the solution. **[1994 - 3 Marks]**

**34.** Upon mixing 45.0 mL. of 0.25 M lead nitrate solution with 25.0 mL of 0.10 M chromic sulphate solution, precipitation of lead sulphate takes place. How many moles of lead sulphate are formed? Also, calculate the molar concentrations of the species left behind in the final solution. Assume that lead sulphate is completely insoluble. **[1993 - 3 Marks]**

**35.** A 2.0 g sample of a mixture containing sodium carbonate, sodium bicarbonate and sodium sulphate is gently heated till the evolution of $CO_2$ ceases. The volume of $CO_2$ at 750 mm Hg pressure and at 298 K is measured to be 123.9 mL. A 1.5g of the same sample requires 150 mL. of (M/10) HCl for complete neutralisation. Calculate the % composition of the components of the mixture. **[1992 - 5 Marks]**

**36.** A solution of 0.2 g of a compound containing $Cu^{2+}$ and $C_2O_4^{2-}$ ions on titration with 0.02 M $KMnO_4$ in presence of $H_2SO_4$ consumes 22.6 mL. of the oxidant. The resultant solution is neutralized with $Na_2CO_3$, acidified with dil. acetic acid and treated with excess KI. The liberated iodine requires 11.3 mL of 0.05 M $Na_2S_2O_3$ solution for complete reduction. Find out the molar ratio of $Cu^{2+}$ to $C_2O_4^{2-}$ in the compound. Write down the balanced redox reactions involved in the above titrations. **[1991 - 5 Marks]**

**37.** A mixture of $H_2C_2O_4$ (oxalic acid) and $NaHC_2O_4$ weighing 2.02 g was dissolved in water and solution made upto one litre. Ten millilitres of the solution required 3.0 mL. of 0.1 N sodium hydroxide solution for complete neutralization. In another experiment, 10.0 mL. of the same solution, in hot dilute sulphuric acid medium. require 4.0 mL. of 0.1 N potassium permanganate solution for complete reaction. Calculate the amount of $H_2C_2O_4$ and $NaHC_2O_4$ in the mixture. **[1990 - 5 Marks]**

**38.** A solid mixture (5.0 g) consisting of lead nitrate and sodium nitrate was heated below 600 °C until the weight of the residue was constant. If the loss in weight is 28.0 per cent, find the amount of lead nitrate and sodium nitrate in the mixture. **[1990 - 4 Marks]**

**39.** An equal volume of a reducing agent is titrated separately with 1M $KMnO_4$ in acid neutral and alkaline media. The volumes of $KMnO_4$ required are 20 mL. in acid, 33.4 mL in neutral and 100 mL. in alkaline media. Find out the oxidation state of manganese in each reduction product. Give the balanced equations for all the three half reactions. Find out the volume of 1M $K_2Cr_2O_7$ consumed; if the same volume of the reducing agent is titrated in acid medium. **[1989 - 5 Marks]**

**40.** A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($C_{12}H_{22}O_{11}$). Calculate : (i) molal concentration and (ii) mole fraction of sugar in the syrup. **[1988 - 2 Marks]**

**41.** (*i*) What is the weight of sodium bromate and molarity of solution necessary to prepare 85.5 mL of 0.672 N solution when the half-cell reaction is

$$BrO_3^- + 6H^+ + 6e^- \rightarrow Br^- + 3H_2O$$

(*ii*) What would be the weight as well as molarity if the half-cell reaction is :

$$2\,BrO_3^- + 12H^+ + 10e^- \rightarrow Br_2 + 6H_2O$$

**[1987 - 5 Marks]**

**42.** Five mL of 8N nitric acid, 4.8 mL of 5N hydrochloric acid and a certain volume of 17M sulphuric acid are mixed together and made upto 2litre. Thirty mL. of this acid mixture exactly neutralise 42.9 mL of sodium carbonate solution containing one gram of $Na_2CO_3.10H_2O$ in 100 mL. of water. Calculate the amount in gram of the sulphate ions in solution. **[1985 - 4 Marks]**

**43.** $2.68 \times 10^{-3}$ moles of a solution containing an ion $A^{n+}$ require $1.61 \times 10^{-3}$ moles of $MnO_4^-$ for the oxidation of $A^{n+}$ to $AO_3^-$ in acid medium. What is the value of *n*? **[1984 - 2 Marks]**

**44.** The density of a 3 M sodium thiosulphate solution ($Na_2S_2O_3$) is 1.25 g per mL. Calculate (i) the percentage by weight of sodium thiosulphate, (ii) the mole fraction of sodium thiosulphate and (iii) the molalities of $Na^+$ and $S_2O_3^{2-}$ ions. **[1983 - 5 Marks]**

**45.** 4.08 g of a mixture of BaO and an unknown carbonate $MCO_3$ was heated strongly. The residue weighed 3.64 g. This was dissolved in 100 mL of 1 N HCl. The excess acid required 16 mL of 2.5 N NaOH solution for complete neutralization. Identify the metal *M*. **[1983 - 4 Marks]**
(At. wt. H = 1, C = 12, O = 16, Cl = 35.5, Ba = 138)

**46.** (i) A sample of $MnSO_4 \cdot 4H_2O$ is strongly heated in air. The residue is $Mn_3O_4$.
(ii) The residue is dissolved in 100 mL of 0.1 N $FeSO_4$ containing dilute $H_2SO_4$.
(iii) The solution reacts completely with 50 mL of $KMnO_4$ solution.
(iv) 25 mL of the $KMnO_4$ solution used in step (iii) requires 30 mL of 0.1 N $FeSO_4$ solution for complete reaction.

Find the amount of $MnSO_4 \cdot 4H_2O$ present in the sample. **[1980]**

**47.** A mixture contains NaCl and unknown chloride MCl.
(i) 1 g of this is dissolved in water. Excess of acidified $AgNO_3$ solution is added to it. 2.567 g of white ppt. is formed.
(ii) 1 g of original mixture is heated to 300 °C. Some vapours come out which are absorbed in acidified $AgNO_3$ solution. 1.341 g of white precipitate was obtained.

Find the molecular weight of unknown chloride. **[1980]**

**48.** 5 mL of a gas containing only carbon and hydrogen were mixed with an excess of oxygen (30 mL) and the mixture exploded by means of an electric spark. After the explosion, the volume of the mixed gases remaining was 25 mL. On adding a concentrated solution of potassium hydroxide, the volume further diminished to 15 mL of the residual gas being pure oxygen. All volumes have been reduced to N.T.P. Calculate the molecular formula of the hydrocarbon gas. **[1979]**

**49.** One gram of an alloy of aluminium and magnesium when treated with excess of dil. HCl forms magnesium chloride, aluminium chloride and hydrogen. The evolved hydrogen, collected over mercury at 0 °C has a volume of 1.20 litres at 0.92 atm. pressure. Calculate the composition of the alloy.
[H = 1, Mg = 24, Al = 27] **[1978]**

## Answer Key

### Topic-1 : Measurement, Mole Concept and Percentage Composition

**1.** (a) **2.** (d) **3.** (b) **4.** (a) **5.** (a) **6.** (c) **7.** (d) **8.** (c) **9.** (4) **10.** (55.55)
**11.** (15.05) **12.** (24) **13.** (4.14) **14.** (Carbon (C–12)) **15.** ($6.02 \times 10^{24}$) **16.** (b,c)

### Topic-2 : Stoichiometry, Equivalent Concept, Neutralization and Redox Titration

**1.** (d) **2.** (a) **3.** (a) **4.** (b) **5.** (d) **6.** (b) **7.** (d) **8.** (a) **9.** (d) **10.** (a)
**11.** (a) **12.** (222) **13.** (18) **14.** (1.875) **15.** (18.75) **16.** (2992) **17.** (6.47) **18.** (8.09) **19.** (85) **20.** (6.0)
**21.** (10.43) **22.** (6.5) **23.** (39.6) **24.** (0.58) **25.** (12.15) **26.** (4.87) **27.** (59.33) **28.** (b)

# Hints & Solutions

## Topic-1: Measurement, Mole Concept and Percentage Composition

1. **(a)** Atomic weight in gms = $6.023 \times 10^{23}$ atoms = 1 Mole atoms

(a) Number of atoms in 24 g of C

$$= \frac{24}{12} \times 6.023 \times 10^{23} = 2 \times 6.023 \times 10^{23} \text{ atom}$$

= 2 mole atoms

(b) Number of atoms in 56 g of Fe

$$= \frac{56}{56} \times 6.023 \times 10^{23} = 6.023 \times 10^{23} \text{ atom}$$

= 1 mole atoms

(c) Number of atoms in 27 g of Al

$$= \frac{27}{27} \times 6.023 \times 10^{23} = 6.023 \times 10^{23} \text{ atom}$$

= 1 mole atoms

(d) Number of atoms in 108 g of Ag

$$= \frac{108}{108} \times 6.023 \times 10^{23} = 6.023 \times 10^{23} \text{ atom}$$

= 1 mole atoms

$\therefore$ 24 g of C has maximum number of atoms.

2. **(d)** (i) Mass of one electron = $9.108 \times 10^{-31}$ kg

(ii) 1 mole of electron = $6.023 \times 10^{23}$ electrons

Weight of 1 mole of electron

= Mass of one electron × Avogadro Number

= $9.108 \times 10^{-31} \times 6.023 \times 10^{23}$ kg

$\therefore$ No. of moles of electrons in 1 kg

$$= \frac{1}{9.108 \times 10^{-31} \times 6.023 \times 10^{23}} = \frac{1}{9.108 \times 6.023} \times 10^{8}$$

3. **(b)** Molecular Formula = $n$ × Empirical formula

**Solution :** Since the molecular formula is $n$ times the empirical formula, therefore, different compounds having the same empirical formula must have different molecular weights.

4. **(a)** (a) 18 g of $H_2O = 6.02 \times 10^{23}$ molecules of $H_2O$

$\therefore$ 36 g of $H_2O = 2 \times 6.02 \times 10^{23}$ molecules of $H_2O$

$= 12.04 \times 10^{23}$ molecules of $H_2O$

(b) 28 g of $CO = 6.02 \times 10^{23}$ molecules of CO

(c) 46 g of $C_2H_5OH = 6.02 \times 10^{23}$ molecules of $C_2H_5OH$

(d) 108 g of $N_2O_5 = 6.02 \times 10^{23}$ molecules of $N_2O_5$

$$\therefore \quad 54 \text{ g of } N_2O_5 = \frac{1}{2} \times 6.02 \times 10^{23} \text{ molecules of } N_2O_5$$

$= 3.01 \times 10^{23}$ molecules of $N_2O_5$

$\therefore$ 36 g of water has highest number of molecules.

5. **(a)** No. of $e^-$ in C = 6 and in O = 8

$\therefore$ Total no. of $e^-$ in $CO_2 = 6 + 8 \times 2 = 22$

6. **(c)** Let mass of oxygen = 1g, Then mass of nitrogen = 4g

Mol. wt. of $N_2$ = 28g, Mol. wt. of $O_2$ = 32g

28 g of $N_2$ has = $6.02 \times 10^{23}$ molecules of nitrogen

$$4 \text{ g of } N_2 \text{ has} = \frac{6.02 \times 10^{23}}{28} \times 4 \text{ molecules of nitrogen}$$

$$= \frac{6.02 \times 10^{23}}{7} \text{ molecules of nitrogen}$$

32 g of $O_2$ has = $6.02 \times 10^{23}$ molecules of oxygen

$$\therefore \quad 1\text{g of } O_2 \text{ has} = \frac{6.02 \times 10^{23}}{32} \times 1$$

$$= \frac{6.02 \times 10^{23}}{32} \text{ molecules of oxygen}$$

Thus, ratio of molecules of oxygen : nitrogen

$$= \frac{6.02 \times 10^{23}/32}{6.02 \times 10^{23}/7} = 7 : 32$$

7. **(d)** $4\,Al + 3O_2 \longrightarrow 2\,Al_2O_3$

At. wt. of Al = 27

Thus 4 × 27 g of Al reacts with oxygen = 3 × 32 g

$$\therefore \quad 27 \text{ g of Al reacts with oxygen} = \frac{3 \times 32}{4 \times 27} \times 27 \text{ g} = 24 \text{ g}$$

8. **(c)** $$\text{No. of nitrogen atoms} = \frac{\text{Mass in grams}}{\text{Atomic wt.}} = \frac{28}{14} = 2$$

$$\text{No. of oxygen atoms} = \frac{\text{Mass in grams}}{\text{Atomic wt.}} = \frac{80}{16} = 5$$

$\therefore$ Formula of compound is $N_2O_5$.

9. **(4)** $R = N_A \times k$

$= 6.023 \times 10^{23} \times 1.380 \times 10^{-23}$

= 8.312 which has 4 significant figures

**10.** **(55.55)** 1 litre water = 1 kg *i.e.* 1000 g water ( $\because d = 1000\ \text{kg/m}^3$) $\equiv \frac{1000}{18} = 55.55$ moles of water

So, molarity of water = **55.55M**

**11.** **(15.05)** In pure iron oxide (FeO), iron and oxygen are present in the ratio 1 : 1.
However, here number of $Fe^{2+}$ present = 0.93
or No. of $Fe^{2+}$ ions missing = 0.07
Since each $Fe^{2+}$ ion has 2 positive charge, the total number of charge due to missing (0.07) $Fe^{2+}$ ions = 0.07 × 2 = 0.14
To maintain electrical neutrality, 0.14 positive charge is compensated by the presence of $Fe^{3+}$ ions. Now since, replacement of one $Fe^{2+}$ ion by one $Fe^{3+}$ ion increases one positive charge, 0.14 positive charge must be compensated by the presence of 0.14 $Fe^{3+}$ ions.
In short, 0.93 $Fe^{2+}$ ions have 0.14 $Fe^{3+}$ ions

100 $Fe^{2+}$ ions have = $\frac{0.14}{0.93} \times 100 = \mathbf{15.05\%}$

**12.** **(24)** According to problem, three atoms of M combine with 2 atoms of N.
$\therefore$ Formula of compound is $M_3N_2$ (Where M is the metal)

Equivalent wt of N = $\frac{14}{3}$ ($\because$ valency of N in compound is 3)

$\because$ 28 g N combines with = 72 g metal

$\therefore$ 14/3 g N combines with = $\frac{72}{28} \times \frac{14}{3} = 12$ g

$\therefore$ Eq. wt. of metal = 12
At wt of metal = Eq. wt × valency = 12 × 2 = **24**
[Valency of metal = 2]

**13.** **(4.14 g)** 1 Mole = $6.023 \times 10^{23}$ molecules = Molecular weight in gms.
Weight of $6.023 \times 10^{23}$ (Avogadro's number) molecules of $CuSO_4.5H_2O$ = Molecular wt. of $CuSO_4.5H_2O$ = 249 g.
$\therefore$ Weight of $1 \times 10^{22}$ molecules of $CuSO_4.5H_2O$

$$= \frac{249 \times 1 \times 10^{22}}{6.023 \times 10^{23}} = \mathbf{4.14\ g}$$

**14.** **Carbon (C – 12)**

**15.** **($6.02 \times 10^{24}$)**
18 mL $H_2O$ = 18 g $H_2O$ ($\because$ density of water = 1 g/cc)
= 1 mole of $H_2O$.
1 Mole of $H_2O = 10 \times 6.02 \times 10^{23}$ electrons
($\because$ Number of electrons present in one molecule of water = 2 + 8 = 10)
= $6.02 \times 10^{24}$ electrons

**16.** **(b, c)**
Let *M* represents the respective molecular mass.
(a) If empirical formula of compound 3 is $P_3Q_4$,

$$\frac{3M_P}{3M_P + 4M_Q} = \frac{40}{100} \Rightarrow 9M_P = 8M_Q$$

If empirical formula of compound 2 is $P_3Q_5$,

$$\%\text{ of P} = \frac{3M_P}{3M_P + 5M_Q} \times 100 = \frac{8/3M_Q}{8/3M_Q + 5M_Q} \times 100$$

= 34.78
Hence, option (a) is incorrect.

(b) If empirical formula of compound 3 is $P_3Q_2$,

$$\frac{3M_P}{3M_P + 2M_Q} = \frac{40}{100} \Rightarrow 4M_Q = 9M_P \Rightarrow M_Q = \frac{9}{4} \times 20 = 45$$

Hence, option (b) is correct.
(c) If empirical formula of compound 2 is PQ,

$$\frac{M_P}{M_P + M_Q} = \frac{44.4}{100} \Rightarrow 5M_P = 4M_Q$$

If empirical formula of compound 1 is $P_5Q_4$ then weight % of P : Q = 1 : 1
Hence, option (c) is correct.
(d) If empirical formula of compound 1 is $P_3Q$,

$$\%\ P = \frac{2M_P}{2M_P + M_Q} \times 100 = 50 \Rightarrow 2M_P = M_Q$$

Hence, atomic weight of P and Q cannot be 70 and 35, respectively.

**17.** (i) Volume of virus = $\pi r^2 \ell$ (Volume of cylinder)

(ii) Mass of single virus = $\frac{\text{Volume}}{\text{Sp. volume}}$

(iii) Molecular mass of virus = Mass of single virus × $6.02 \times 10^{23}$
Volume of virus = $\pi r^2 \ell$

$$= \frac{22}{7} \times \frac{150}{2} \times \frac{150}{2} \times 10^{-16} \times 5000 \times 10^{-8}$$
$$= 0.884 \times 10^{-16}\ \text{cm}^3$$

Weight of one virus = $\frac{0.884 \times 10^{-16}}{0.75}$ g

$= 1.178 \times 10^{-16}$ g

$\therefore$ Mol. wt. of virus = $1.178 \times 10^{-16} \times 6.02 \times 10^{23}$
= $\mathbf{7.09 \times 10^7}$

**18.** **(a)**

$$\begin{array}{lccc} & CaCl_2 & \equiv CaCO_3 & \equiv MgCl_2 \\ \text{M.wt.} & 111 & 100 & 95 \end{array}$$

From this it is evident, that
111 mg $CaCl_2$ will give $CaCO_3$ = 100 mg

$\therefore$ 1 mg $CaCl_2$ will give $CaCO_3 = \frac{100}{111}$ mg = 0.90 mg

95 mg $MgCl_2$ gives $CaCO_3$ = 100 mg

$\therefore$ 1 mg $MgCl_2$ gives $CaCO_3 = \frac{100}{95}$ mg = 1.05 mg

$\therefore$ Total $CaCO_3$ formed by 1 mg $CaCl_2$ and 1 mg $MgCl_2$ = 0.90 + 1.05 = 1.95 mg
$\therefore$ Amount of $CaCO_3$ present per litre of water = 1.95 mg
$\therefore$ wt of 1 mL of water = 1g = $10^3$ mg
$\therefore$ wt of 1000 mL of water = $10^3 \times 10^3 = 10^6$ mg
$\therefore$ Total hardness of water in terms of parts of $CaCO_3$ per $10^6$ parts of water by weight = **1.95 parts.**

(b) Eq wt of $Ca^{++} = \frac{\text{Mol.wt}}{\text{Charge}} = \frac{40}{2} = 20$

$$Ca^{2+} + Na_2CO_3 \longrightarrow CaCO_3 + 2Na^+$$

1 milliequivalent of $Ca^{2+}$ = 20 mg

**1 milliequivalent** of $Na_2CO_3$ is required to soften 1 litre of hard water.

(c)
$$\underset{2\times 24=48g}{2Mg} + \underset{32g}{O_2} \longrightarrow \underset{2(24+16)=80g}{2MgO}$$

$\because$ 32 g of $O_2$ reacts with = 48 g Mg

$$\therefore 0.5 \text{ g of } O_2 \text{ reacts with} = \frac{48}{32}\times 0.5 = 0.75 \text{ g}$$

Weight of unreacted Mg = 1.00 – 0.75 = 0.25 g
Thus, Mg is left in excess.

$$\text{Weight of MgO formed} = \frac{80}{48}\times 0.75 = 1.25 \text{ g}$$

$$\underset{(40\,g)}{MgO} + H_2SO_4 \longrightarrow MgSO_4 + H_2O$$

According to reaction,
$\because$ 40 g MgO is dissolved in 1000 mL of 1 N $H_2SO_4$
$\therefore$ 40 g MgO is dissolved in 2000 mL 0.5 N $H_2SO_4$
$\therefore$ 1.25 MgO is dissolved in

$$= \frac{2000\times 1.25}{40} \text{ mL of } 0.5 \text{ N } H_2SO_4$$

**= 62.5 mL of 0.5N $H_2SO_4$**

**19.** Given $P = 1$ atm $V = 1$ L, $T = 127\,°C = 127 + 273 = 400$ K
$PV = nRT$ (Ideal gas equation)

$$\text{or } n = \frac{PV}{RT} = \frac{1\times 1}{0.082\times 400} = 0.0304$$

$$\text{Mol. wt} = \frac{\text{Mass}}{\text{Moles}} = \frac{2.8}{0.0304} = 92.10$$

| Element | wt, of element | Relative no. of atoms | Ratio of of atoms | Whole no. of atoms |
|---|---|---|---|---|
| C | 10.5 | $10.5/12 = 0.875$ | $0.875/0.875 = 1$ | $1\times 7 = 7$ |
| H | 1.0 | $1.0/1 = 1$ | $1/0.875 = 1.14$ | $1.14\times 7 = 8$ |

$\therefore$ Empirical formula = $C_7H_8$
Empirical formula wt = $12\times 7 + 1\times 8 = 92$

$$n = \frac{\text{Molecular wt}}{\text{Empirical formula wt}} = \frac{92.10}{92} = 1$$

Molecular formula = $n$ × empirical formula
$= 1(C_7H_8) = \mathbf{C_7H_8}$

**20.** (i) No. of C atoms in 14g of $^{14}C = 6.02\times 10^{23}$
$\therefore$ No. of C atom in 7 mg (7/1000g) of $^{14}C$

$$= \frac{6.02\times 10^{23}\times 7}{14\times 1000} = 3.01\times 10^{20}$$

No. of neutrons in 1 carbon atom = 7
$\therefore$ Total no. of neutrons in 7 mg of $^{14}C = 3.01\times 10^{20}\times 7$
$= 21.07\times 10^{20}$

Wt of 1 neutron = wt of 1 hydrogen atom

$$= \frac{1}{6.02\times 10^{23}}\text{ g}$$

$\therefore$ Wt of $3.01\times 10^{20}\times 7$ neutrons

$$= \frac{3.0\times 10^{20}\times 7}{6.02\times 10^{23}} = \mathbf{3.5\times 10^{-3}g}$$

## Topic-2: Stoichiometry, Equivalent Concept, Neutralization and Redox Titration

**1.** **(d)** Let the fraction of $M^{2+}$ and $M^{3+}$ be:-

$$M^{+2} = \frac{X}{3},\ M^{+3} = \frac{2X}{3}$$

So, total of O.N. of all atoms would be :

$$\left[\frac{X}{3}(+2) + \frac{2X}{3}(+3)\right] + 2(+3) + 4(-2) = 0$$

$$\Rightarrow \frac{2X}{3} + 2X + 6 - 8 = 0$$

$$\Rightarrow \frac{8X}{3} = 2$$

$$\Rightarrow X = \frac{6}{8} = \frac{3}{4} = 0.75$$

**2.** **(a)** Write the reaction for chemical change during reaction and equate moles of products formed.
$[Co(NH_3)_5SO_4]$ Br has ionisable $Br^-$ ions & $[Co(NH_3)_5Br]SO_4$ has ionisable $SO_4^{--}$ ion.
Mixture $X$ has 0.02 mol. of $[Co(NH_3)_5SO_4]$ Br and 0.02 mol of $[Co(NH_3)_5Br]SO_4$ in 2 L of solution
$\therefore$ Conc. of $[Co(NH_3)_5SO_4]$ Br and $[Co(NH_3)_5Br]SO_4$ = 0.01 mol/L for each of them.

(i) 1 L mixture of $X$ + excess $AgNO_3 \rightarrow Y$

$$\underset{0.01\text{ mol/L soluble}}{[Co(NH_3)_5SO_4]\,Br} + \underset{\text{excess}}{AgNO_3} \longrightarrow [Co(NH_3)_5SO_4]NO_3 + \underset{\substack{(Y)\\0.01\,\text{mol}}}{AgBr}$$

$$\left[Ag^+ + Br^- \rightarrow AgBr\right]$$

$\therefore$ No. of moles of $Y = 0.01$

(ii) Also 1 L mixture of $X$ + excess $BaCl_2 \rightarrow Z$

$$\underset{0.01\text{ mol/L soluble}}{[Co(NH_3)_5Br]SO_4} + \underset{\text{excess}}{BaCl_2} \longrightarrow [Co(NH_3)_5Br]Cl_2 + \underset{\substack{(Z)\\0.01\,\text{mol}}}{BaSO_4}$$

$$\left[Ba^{++} + SO_4^{-} \rightarrow BaSO_4\right]$$

$\therefore$ moles of $Z = 0.01$.

**3.** **(a)** Equivalents of $H_2C_2O_4{\cdot}2H_2O$ = Equivalents of NaOH
(At equivalence point)

$$\text{Strength of } H_2C_2O_4{\cdot}2H_2O \text{ (in g/L)} = \frac{6.3}{250/1000} = 25.2 \text{ g/L}$$

$$\text{Normality of } H_2C_2O_4{\cdot}2H_2O = \frac{\text{Strength}}{\text{Eq. wt}} = \frac{25.2}{63} = 0.4\text{N}$$

$$\left\{\text{Eq. wt. of oxalic acid} = \frac{\text{Mol. wt}}{2} = \frac{126}{2} = 63\right\}$$

Using normality equation :

$N_1V_1 = N_2V_2$

$(H_2C_2O_4 \cdot 2H_2O)$ (NaOH)

$$0.4 \times 10 = 0.1 \times V_2 \text{ or } V_2 = \frac{0.4 \times 10}{0.1} = 40 \text{ mL.}$$

4. **(b)** (i) Find change in oxidation number of Cr atom.

(ii) $\text{Eq. wt.} = \frac{\text{Molecular wt.}}{\text{change in O.N.}}$

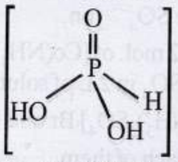
In iodometry, $K_2Cr_2O_7$ liberates $I_2$ from iodides (NaI or KI). Thus, it is titrated with $Na_2S_2O_3$ solution.
$2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6$
O.N. of Cr changes from +6 (in $K_2Cr_2O_7$) to +3. *i.e.* +3 change for each Cr atom

$$Cr_2O_7^{--} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Thus, one mole of $K_2Cr_2O_7$ accepts 6 mole of electrons.

$$\therefore \text{ Equivalent weight} = \frac{\text{Molecular weight}}{6}$$

5. **(d)** (i) $H_3PO_3$ is dibasic acid as it contains two –OH groups.



(ii) Normality = Molarity × basicity of acid.
(iii) Basicity of $H_3PO_3 = 2$
$\therefore$ Normality $= 0.3 \times 2 = 0.6$

6. **(b)** For equivalent weight of $MnSO_4$ to be half of its molecular weight, change in oxidation state must be equal to 2. It is possible only when oxidation state of Mn in product is + 4. Since oxidation state of Mn in $MnSO_4$ is + 2. So, $MnO_2$ is correct answer.
In $MnO_2$, O.S. of Mn = +4
$\therefore$ Change in O.S. of Mn $= +4 - (+2) = +2$

7. **(d)** Molality – Moles of solute/mass of solvent in kg
$\because$ Molality does not involve volume term.
$\therefore$ It is independent of temperature.

8. **(a)** $\text{Molality} = \frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}}$

A molal solution is one which contains one mole of solute per 1000 g of solvent. $\left\{\because 1\text{m} = \frac{1\text{mole}}{1\text{kg}}\right\}$

9. **(d)**
(i) Write balanced chemical equation for chemical change.
(ii) Find limiting reagent.
(iii) Amount of product formed will be determined by amount of limiting reagent.
The balanced equation is :

$$\begin{array}{lcccc} & 3BaCl_2 & + \; 2Na_3PO_4 & \rightarrow \; Ba_3(PO_4)_2 & + \; 6NaCl \\ \text{No. of} & 0.5 & 0.2 & & \\ \text{moles :} & 3\text{mole} & 2\text{mole} & 1\text{mole} & \end{array}$$

Limiting reagent is $Na_3PO_4$ (0.2 mol), $BaCl_2$ is in excess.

From the above equation :
2.0 moles of $Na_3PO_4$ yields $Ba_3(PO_4)_2 = 1$ mole

$$\therefore 0.2 \text{ moles of } Na_3PO_4 \text{ will yield } Ba_3(PO_4)_2 = \frac{1}{2} \times 0.2$$
$$= \mathbf{0.1\ mol.}$$

10. **(a)** The change involved is $MnO_4^- + e^- \longrightarrow MnO_4^{2-}$
*i.e.* it involves only one electron

$$\text{Eq.wt} = \frac{\text{Mol.wt}}{\text{No.of } e^- \text{ involved}} = \frac{M}{1} = M$$

$[\because \text{Mol. wt.} = M]$

11. **(a)**

$$\begin{tikzcd} \underset{2.76}{Ag_2CO_3} \arrow[r, "\Delta"] & Ag_2O + CO_2 \arrow[d, "\Delta"] \\ & \underset{\text{(residue)}}{2Ag + \frac{1}{2}O_2} \end{tikzcd}$$

$Ag_2O$ is thermally unstable and decompose on heating liberating oxygen.
Mol. wt. of $Ag_2CO_3 = 108 \times 2 + 12 + 16 \times 3 = 276$ g
$\therefore$ 276 g of $Ag_2CO_3$ on heating gives residue $= 2 \times 108 = 216$ g of Ag
$\therefore$ 2.76 g of $Ag_2CO_3$ on heating gives

$$= \frac{216}{276} \times 2.76 = 2.16 \text{ g of Ag}$$

12. **(222)**

$$4(CH_3)_2SiCl_2 + 4H_2O \longrightarrow \underset{(X)}{(CH_3)_8Si_4O_4} + 8HCl$$

4 moles of $(CH_3)_2SiCl_2$ produces, 0.75 mol of X.
$\therefore$ mass of product 'X' $= 0.75 \times 296 = 222$ g

13. **(18)** $2K\overset{+7}{Mn}O_4 + 5H_2S + 3H_2SO_4 \rightarrow$

$$K_2SO_4 + 2\overset{+2}{Mn}SO_4 + 5S + 8H_2O$$

x = 8 (moles of $H_2O$ produced)
y = 14 – 4 = 10 (number of electrons involved)
x + y = 10 + 8 = 18

14. **(1.875)**

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

For 25 mL
meq of $Fe^{2+}$ = meq of $MnO_4^-$
$= 12.5 \times 0.03 \times 5$
For 250 mL

$$\text{M moles of } Fe^{2+} = \frac{12.5 \times 0.03 \times 5 \times 250}{25}$$

$$\text{Moles of } Fe^{2+} = \frac{18.75}{1000} \text{ mol}$$
$$= 18.75 \times 10^{-3} = 1.875 \times 10^{-3}$$

x = 1.875

Weight of $Fe^{2+} = 1.875 \times 10^{-2} \times 56 = 1.05$ g

$$\% \text{ Purity of } Fe^{2+} = \frac{1.05}{5.6} \times 100 = 18.75\%$$

y = 18.75

**15. (18.75)**

**16. (2992)**

$$\underset{\substack{1584\,g\\=12\,mole}}{(NH_4)_2SO_4} + Ca(OH)_2 \rightarrow \underset{\substack{gypsum(M=172)\\12\,mole}}{CaSO_4.2H_2O} + \underset{24\,mole}{2NH_3}$$

$$\underset{952\,g=4\,mole}{NiCl_2.6H_2O} + \underset{24\,mole}{6NH_3} \rightarrow \underset{\substack{(M=232)\\4\,mole}}{[Ni(NH_3)_6]Cl_2} + 6H_2O$$

Total mass $= 12 \times 172 + 4 \times 232 = 2992$ g

**17. (6.47)**

$PbS + O_2 \longrightarrow Pb + SO_2$

No. of moles of $O_2 = \dfrac{10^3}{32}$

Moles of Pb formed $= \dfrac{10^3}{32}$

$\therefore$ Mass of Pb formed $= \dfrac{10^3}{32} \times 207 = 6468.75$ g
$= 6.46875$ kg
$= 6.47$ kg

**18. (8.09)**

Use molarity equation to find volume of $H_2SO_4$ solution.

$$\underset{\substack{63.5+12+48.98\\=123.5\,g}}{CuCO_3} + \underset{98g}{H_2SO_4} \rightarrow CuSO_4 + H_2O + CO_2\uparrow$$

$\therefore$ For 123.5 gms of Cu(II) carbonate 98 g of $H_2SO_4$ are required.

For 0.5 gms of Cu(II) carbonate weight of $H_2SO_4$ reqd.

$= \dfrac{98 \times 0.5}{123.5}$ g $= 0.39676$ g $H_2SO_4$

Weight of required $H_2SO_4 = 0.39676$ g

Weight of solute in grams

$= \dfrac{\text{Mol.wt.} \times \text{Molarity} \times \text{Volume in mL}}{1000}$

$0.39676 = \dfrac{98 \times 0.5 \times V}{1000}$ or $V = \dfrac{0.39676 \times 1000}{90 \times 0.5}$ mL

Volume of $H_2SO_4$ solution = **8.097 mL**

**19. (85)** Reaction involved titration is

$$\underset{1\,mole}{KIO_3} + \underset{2\,moles}{2KI} + 6HCl \rightarrow 3ICl + 3KCl + 3H_2O$$

20 mL. of stock KI solution $\equiv$ 30 mL. of $\dfrac{M}{10}$ $KIO_3$ solution

Molarity of KI solution $= \dfrac{30 \times 1 \times 2}{20 \times 10} = \dfrac{3}{10}$

Millimoles in 50 mL. of KI solution $= 50 \times \dfrac{3}{10} = 15$

Millimoles of KI left unreacted with $AgNO_3$ solution

$= 2 \times 50 \times \dfrac{1}{10} = 10$

$\therefore$ Millimoles of KI reacted with $AgNO_3 = 15 - 10 = 5$

Millimoles of $AgNO_3$ present in $AgNO_3$ solution = 5

Molecular weight of $AgNO_3 = 170$

$\therefore$ Wt. of $AgNO_3$ in the solution $= 5 \times 10^{-3} \times 170 = 0.850$ g

% $AgNO_3$ in the sample $= \dfrac{0.850}{1} \times 100 =$ **85%**

**20. (6.0)** Mass of $Fe_2O_3$ in the sample $= \dfrac{55.2}{100} \times 1 = 0.552$ g

Number of moles of $Fe_2O_3 = \dfrac{0.552}{159.8} = 3.454 \times 10^{-3}$

Number of moles of $Fe^{3+}$ ions $= 2 \times 3.454 \times 10^{-3}$
$= 6.9 \times 10^{-3}$ mol $= 6.90$ mmol

Since, only 1 electron is exchanged in the conversion of $Fe^{3+}$ to $Fe^{2+}$, the molecular mass is the same as equivalent mass.

$\therefore$ Amount of $Fe^{2+}$ ion in 100 mL. of sol. = 6.90 meq

Volume of oxidant used for 100 mL of $Fe^{2+}$ sol.
$= 17 \times 4 = 68$ mL.

Amount of oxidant used $= 68 \times 0.0167$ mmol
$= 1.1356$ mmol

Let the number of electrons taken by the oxidant $= n$

$\therefore$ No. of meq. of oxidant used $= 1.1356 \times n$

Thus $1.1356 \times n = 6.90 \Rightarrow n = \dfrac{6.90}{1.1356} = \mathbf{6}$

**21. (10.43)**

Molality $= \dfrac{\text{Mass of solute / M. wt. of solute}}{\text{Mass of solvent in kg}}$

Mass of $H_2SO_4$ in 100 ml of 93% $H_2SO_4$ solution = 93 g

$\therefore$ Mass of $H_2SO_4$ in 1000 ml of the $H_2SO_4$ solution = 930 g

Mass of 1000 ml $H_2SO_4$ solution $= 1000 \times 1.84 = 1840$ g

Mass of water in 1000 ml of solution $= 1840 - 930$ g
$= 910$ g $= 0.910$ kg

Moles of $H_2SO_4 = \dfrac{\text{Wt. of } H_2SO_4}{\text{Mol. wt. of } H_2SO_4} = \dfrac{930}{98}$

$\therefore$ Moles of $H_2SO_4$ in 1 kg of water

$= \dfrac{930}{98} \times \dfrac{1}{0.910} = 10.43$ mol

$\therefore$ Molality of solution = **10.43m**

**22. (6.5)**

No. of equivalents of $KMnO_4$

= No. of equivatents of hydrazine sulphate.

$\overset{(-2)}{N_2H_4} \longrightarrow \overset{(0)}{N_2}$

Change in oxidation state for each $N_2H_4 = 2 \times 2 = 4$

Equivalent weight of $N_2H_6SO_4 = \dfrac{130}{4} = 32.5$

Normality of $KMnO_4 = 5 \times 450$ ($\because$ valence factor = 5)

Number of equivalents of $KMnO_4$

$= n$-factor × no. of moles $= 5 \times \dfrac{20}{50 \times 1000} = \dfrac{1}{500}$

and if weight of hydrazin sulphate be $x$ g then equivalents of hydrazine sulphate $= \dfrac{x}{32.5}$

$\therefore \dfrac{1}{500} = \dfrac{x}{32.5}$ or $x = \dfrac{32.5}{500} = 0.065$ g

Hence, wt. of $N_2H_6SO_4$ in 10 mL solution = 0.065 g

$\therefore$ Wt. of $N_2H_6SO_4$ in 1000 mL solution = **6.5 g**

**23. (39.6)**

**Given** $2NH_2OH + 4Fe^{3+} \rightarrow N_2O + H_2O + 4Fe^{2+} + 4H^+$ .....(i)

and $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ ..(ii)

$\therefore 10NH_2OH + 4MnO_4^- + 12H^+ \rightarrow 5N_2O + 21H_2O + 4Mn^{2+}$

[On multiplying (i) by 5 and (ii) by 4 and then adding the resulting equations]

Molecular weight of $NH_2OH = 33$

Thus 4000 mL of 1M $MnO_4^-$ would react with $NH_2OH$ = 330g

$\therefore$ 12 mL of 0.02 M $KMnO_4$ would react with $NH_2OH$

$$= \frac{330 \times 12 \times 0.02}{400} \text{ g}$$

$\therefore$ Amount of $NH_2OH$ present in 1000 mL of diluted

$$\text{solution } = \frac{330 \times 12 \times 0.02 \times 1000}{4000 \times 50} \text{ g}$$

Since, 10 mL of sample of hydroxylamine is diluted to one litre

$\therefore$ Amount of hydroxyl amine in one litre of original

$$\text{solution } = \frac{330 \times 0.02 \times 12 \times 1000}{4000 \times 50} \times \frac{1000}{10} \text{ g}$$

= **39.6 g**

**24. (0.58)** The complete oxidation under acidic conditions can be represented as follows:

$$5H_2O_2 + 2MnO_4^- + 6H^+ \rightarrow 5O_2 + 2Mn^{2+} + 8H_2O$$

Since 34 g of $H_2O_2$ = 2000 mL of 1N . $H_2O_2$

$$\left(\because \text{Eq. wt or } H_2O_2 = \frac{34}{2}\right)$$

$\therefore$ 34 g of $H_2O_2$ = 2000 mL of 1N $KMnO_4$

$$[\because N_1V_1 = N_2V_2]$$

$$\text{or } \frac{X}{100} \text{ g of } H_2O_2 = \frac{2000 \times X}{100 \times 34} \text{ mL of 1N } KMnO_4$$

$$\text{Therefore the unknown normality} = \frac{2000 \times X}{34 \times 100 \times X}$$

$$= \frac{10}{17} \text{ or } \mathbf{0.588\ N}$$

**25. (12.15)**

(i) Find the volume of $CO_2$ at NTP

(ii) Find molecular wt. of metal carbonate

(iii) Find the wt. of metal

(iv) Calculate equivalent weight of metal

Given $P_1 = 700$ mm, $P_2 = 760$ mm, $V_1 = 1336$ mL, $V_2 = ?$

$T_1 = 300$ K, $T_2 = 273$ K

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}, \text{ or } V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{700 \times 1336 \times 273}{760 \times 300}$$

= 1119.78 mL = 1.12 L at NTP

$\because$ 1.12 L of $CO_2$ is given by carbonate = 4.215 g

$$\text{Molecular weight of metal carbonate} = \frac{4.215}{1.12} \times 22.4$$

$$= 84.3$$

Metal carbonate is $MCO_3 = M + 12 + 48 = M + 60$

Atomic weight of M = 84.3 – 60 = 24.3

$$\text{Eq. wt. of metal} = \frac{1}{2} \times \text{M. wt.} = \frac{1}{2} \times 24.3 = 12.15$$

**26. (4.87)**

Write the balance chemical equation and use mole concept for limiting reagent.

$$\underset{170\text{ g}}{AgNO_3} + \underset{58.5\text{ g}}{NaCl} \longrightarrow NaNO_3 + \underset{143.5\text{ g}}{AgCl}$$

From the given data, we find $AgNO_3$ is limiting reagent as NaCl is in excess.

$\because$ 170.0 g of $AgNO_3$ precipitates AgCl = 143.5 g

$\therefore$ 5.77 g of $AgNO_3$ precipitates AgCl

$$= \frac{143.5}{170.0} \times 5.77 = \mathbf{4.87\ g}$$

**27. (59.33)** $\underset{\substack{3(54.9+32)\\=260.7\text{ g}}}{3MnO_2} \longrightarrow \underset{\substack{(3\times 54.9+64)\\=228.7\text{ g}}}{Mn_3O_4} + O_2$

Let the amount of pyrolusite ignited = 100.00 g

$\therefore$ Wt. of $MnO_2$ = 80 g (80% of 100 g = 80 g)

Wt. of $SiO_2$ and other inert substances = 15 g

Wt. of water = 100 – (80 + 15) = 5 g

According to equation,

260.7 g of $MnO_2$ gives = 228.7 g of $Mn_3O_4$

$$\therefore 80 \text{ g of } MnO_2 \text{ gives} = \frac{228.7}{260.7} \times 80 = 70.2 \text{ g of } Mn_3O_4$$

During ignition, $H_2O$ present in pyrolusite is removed while silica and other inert substances remain as such.

$\therefore$ Total wt. of the residue = 70.2 + 15 = 85.2 g

Calculation of % of Mn in ignited $Mn_3O_4$

$$\underset{3 \times 54.9 = 164.7\text{ g}}{3\,Mn} = \underset{3 \times 54.9 + 64 = 228.7\text{g}}{Mn_3O_4}$$

Since, 228.7 g of $Mn_3O_4$ contains 164.7 g of Mn

$$70.2 \text{ g of } Mn_3O_4 \text{ contains} = \frac{164.7}{228.7} \times 70.2 = 50.55 \text{ g of Mn}$$

Weight of residue = 85.2 g

Hence, percentage of Mn is the ignited sample

$$= \frac{50.55}{85.2} \times 100 = \mathbf{59.33\%}$$

**28. (b)** Write reaction for titration between $Na_2CO_3$ and HCl.

**Method :**

$$\underset{\substack{\text{(yellow colour}\\\text{with HPh } i.e.\\\text{phenolphthalein)}}}{Na_2CO_3\,(aq) + HCl\,(aq)} \longrightarrow \underset{\substack{\text{(no colour}\\\text{with HPh } i.e.\\\text{phenolphthalein)}}}{NaHCO_3} + NaCl\,(aq)$$

(Half neutralisation)

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl + H_2O + CO_2$$

(Complete neutralisation)

$$\underset{\substack{\text{(yellow colour}\\\text{with methyl}\\\text{orange)}}}{NaHCO_3 + HCl} \longrightarrow \underset{\substack{\text{(red colour}\\\text{with methyl}\\\text{orange)}}}{NaCl} + H_2O + CO_2$$

From these reaction it is clear that

(i) 2 moles of HCl are required for complete neutralization of $Na_2CO_3$.

(ii) Titre value using phenolphthalein corresponds only to neutralisation of $Na_2CO_3$ to $NaHCO_3$, *i.e.* half of value required by $Na_2CO_3$ solution.

(iii) Titre value using methyl orange corresponds to complete neutralisation of $Na_2CO_3$

$\therefore$ Both S and E are correct but S is not correct explanation of E.

**29.** $$\text{Molality} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

$$= \frac{\text{wt. of solute in gram / M.wt. of solute}}{\text{Mass of solvent in kg}}$$

$$\text{Molality} = \frac{3/30}{250/1000} = \mathbf{0.4m}$$

**30.** Write the balanced chemical reaction for change and apply mole concept.

The given reactions are

$$MnO_2 \downarrow + Na_2C_2O_4 + 2H_2SO_4 \longrightarrow MnSO_4 + CO_2 + Na_2SO_4 + 2H_2O$$

$\therefore$ Meq. of $MnO_2 \equiv$ Meq of $Na_2C_2O_4 = 10 \times 0.2 \times 2 = 4$

$\therefore$ mM of $MnO_2$

$$= \frac{4}{2} = 2 \quad \begin{bmatrix} Mn^{4+} + 2e \rightarrow Mn^{2+} \\ \therefore \text{Valance factor of } MnO_2 = 2 \end{bmatrix}$$

Now $$2KMnO_4 + 3MnSO_4 + 2H_2O \longrightarrow 5MnO_2 \downarrow + K_2SO_4 + 2H_2O$$

Since, eq. wt. of $MnO_2$ is derived from $KMnO_4$ and $MnSO_4$ both, thus it is better to proceed by mole concept

mM of $KMnO_4 \equiv$ mM of $MnO_2 \times (2/5) = 4/5$

Also $$5H_2O_2 + 2KMnO_4 + 3H_2SO_4 \longrightarrow 2MnSO_4 + K_2SO_4 + 8H_2O + 5O_2$$

$$\therefore \text{mM of } H_2O_2 = \text{mM of } KMnO_4 \times \frac{5}{2} = \frac{4}{5} \times \frac{5}{2} = 2$$

$$\therefore M_{H_2O_2} \times 20 = 2 \text{ or } M_{H_2O_2} = \mathbf{0.1}$$

$$2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$$

$$2KMnO_4 + 3MnSO_4 + 2H_2O \longrightarrow 5MnO_2 + 2H_2SO_4 + K_2SO_4$$

$$MnO_2 + Na_2C_2O_4 + 2H_2SO_4 \longrightarrow MnSO_4 + 2CO_2 + Na_2SO_4 + 2H_2O$$

**31.** Write the reactions taking place, balance them and equate moles of $I_2$ and $Na_2S_2O_3$.

$$KIO_3 + 5KI \rightarrow 3K_2O + 3I_2 \quad i.e., 2I^{5+} + 10e^- \rightarrow I_2^0$$

$$2I^- \rightarrow I_2^0 + 2e^-$$

Now liberated $I_2$ reacts with $Na_2S_2O_3$

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

$2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$

$\therefore$ millimole ratio of $I_2 : S_2O_3 = 1 : 2$

Thus, m mole of $I_2$ liberated

$$= \text{m mole of } Na_2S_4O_6 \text{ used} \times \frac{1}{2} = 45 \times M \times \frac{1}{2}$$

[$M$ is molarity of thiosulphate]

$$\text{Also m mole of } KIO_3 = \frac{0.1}{214} \times 1000$$

Now m mole ratio of $KIO_3 : I_2 = 1 : 3$

$$\text{Thus, } \frac{(0.1/214) \times 1000}{(45M/2)} = \frac{1}{3}$$

$$\therefore M = \frac{0.1 \times 1000 \times 3 \times 2}{214 \times 45} = \mathbf{0.062}$$

**32.** Find the milliequivalents and equate them as per data given in question.

For $Fe_3O_4 \rightarrow 3FeO$

$2e + Fe_3^{(8/3)+} \rightarrow 3Fe^{2+}$

Thus, valence factor for $Fe_3O_4$ is 2 and for FeO is 2/3.

For, $Fe_2O_3 \rightarrow 2FeO; 2e + Fe_2^{3+} \rightarrow 2Fe^{2+}$ ...(1)

Thus, valence factor for $Fe_2O_3$ is 2 and for FeO is 1.

Let Meq. of $Fe_3O_4$ and $Fe_2O_3$ be $a$ and $b$ respectively.

$\therefore$ Meq. of $Fe_3O_4$ + Meq. $Fe_2O_3$ = Meq. of $I_2$ liberated
= Meq. of hypo used

$$a + b = \frac{11 \times 0.5 \times 100}{20} = 27.5$$

Now, the $Fe^{2+}$ ions are again oxidised to $Fe^{3+}$ by $KMnO_4$. Note that in the change

$Fe^{2+} \rightarrow Fe^{3+} + e^-$; valence factor of $Fe^{2+}$ is 1.

Thus,

Meq. of $Fe^{2+}$ (from $Fe_3O_4$) + Meq. of $Fe^{2+}$ (from $Fe_2O_3$)
= Meq. of $KMnO_4$ used .... (2)

If valence factor for $Fe^{2+}$ is 2/3 from Eq. (1),
then Meq. of $Fe^{2+}$ (from $Fe_3O_4$) = $a$

If valence factor for $Fe^{2+}$ is 1
then Meq. of $Fe^{2+}$ (from $Fe_3O_4$) = $3a/2$ ...(3)

Similarly, from Eq. (2), Meq. of $Fe^{2+}$ from ($Fe_2O_3$) = $b$.

$\therefore 3a/2 + b = 0.25 \times 5 \times 12.8 \times 100/50 = 32$

or $3a + 2b = 64$ ....(4)

From Eqs. (3) and (4)

Meq. of $Fe_3O_4 = a = 9$ & Meq. of $Fe_2O_3 = b = 18.5$

$$\therefore W_{Fe_3O_4} = \frac{9 \times 232}{2 \times 1000} = 1.044\text{ g}$$

$$\text{and } W_{Fe_2O_3} = \frac{18.5 \times 160}{2 \times 1000} = 1.48\text{ g}$$

$$\therefore \% \text{ of } Fe_3O_4 = \frac{1.044 \times 100}{3} = \mathbf{34.8}$$

$$\text{and } \% \text{ of } Fe_2O_3 = \frac{1.48 \times 100}{3} = \mathbf{49.33}$$

**33.** The formula of Glauber's salt is $Na_2SO_4.10H_2O$

Molecular mass of $Na_2SO_4.10H_2O$

$= [2 \times 23 + 32.1 + 4 \times 16] + 10(1.01 \times 2 + 16)$

$= 322.3\text{ g mol}^{-1}$

Weight of the Glauber's salt taken = 80.575 g

Out of 80.575 g of salt, weight of anhydrous $Na_2SO_4$

$$= \frac{142.1}{322.3} \times 80.575 = 35.525 \text{ g}$$

Number of moles of $Na_2SO_4$ per $dm^3$ of the solution

$$= \frac{35.525}{142.1} = 0.25$$

Molarity of the solution = **0.25 M**

Density of solution = 1077.2 $kgm^{-3}$

$$= \frac{1077.2 \times 10^3}{10^6} \text{ gm cm}^{-3} = 1.0772 \text{ g cm}^{-3}$$

Total weight of sol = $V \times d = 1\ dm^3 \times d$

$= 1000\ cm^3 \times 1.0772\ gcm^{-3} = 1077.2$ g

Weight of water = 1077.2 − 35.525 = 1041.67 g

$$\text{Molality of sol.} = \frac{0.25}{1041.67 \text{ g}} \times 1000 \text{ g} = 0.2399 = \mathbf{0.24\ m}$$

$$\text{Number of moles of water in the solution} = \frac{1041.67}{18}$$

= 57.87

Mole fraction of $Na_2SO_4$

$$= \frac{\text{No. of moles of } Na_2SO_4}{\text{Total number of moles}} = \frac{0.25}{0.25 + 57.87}$$

$$= 0.0043 = \mathbf{4.3 \times 10^{-3}}$$

**34.** Calculation of number of moles in 45 mL. of 0.025 M $Pb(NO_3)_2$

$$\text{Moles of } Pb(NO_3)_2 = 0.25 \times \frac{45}{1000} = 0.01125$$

∴ Initial moles of $Pb^{2+}$ = 0.01125

Moles of $NO_3^-$ = 0.01125 × 2 = 0.02250

[1 mole $Pb(NO_3)_2 \equiv$ 2 moles of $NO_3$]

Calculation of number of moles in 25 mL. of 0.1 M chromic sulphate

Moles of chromic sulphate $Cr_2(SO_4)_3$

$$= 0.1 \times \frac{25}{1000} = 0.0025 \text{ moles}$$

Moles of $SO_4^{2-}$ = 0.0025 × 3 = 0.0075 [1 Mole of chromic sulphate ≡ 3 moles of $SO_4^{2-}$]

Moles of $PbSO_4$ formed = **0.0075** [$SO_4^{2-}$ is totally consumed]

Moles of $Pb^{2+}$ left = 0.01125 − 0.0075 = 0.00375

Moles of $NO_3^-$ left = 0.02250 [$NO_3^-$ remain unreacted]

Moles of chromium ions = 0.0025 × 2 = 0.005

Total volume of the solution = 45 + 25 = 70 mL.

∴ Molar concentration of the species left

(*i*) $Pb^{2+} = \dfrac{0.00375}{70} \times 1000 = \mathbf{0.05357\ M}$

(*ii*) $NO_3^- = \dfrac{0.0225}{70} \times 1000 = \mathbf{0.3214\ M}$

(*iii*) $Cr^{3+} = \dfrac{0.005}{70} \times 1000 = \mathbf{0.0714\ M}$

**35.** 1.5 g of sample require = 150 mL. of $\frac{M}{10}$ HCl

$$\therefore 2 \text{ g of sample require} = \frac{150 \times 2}{1.5} \text{ mL. of } \frac{M}{10} \text{ HCl}$$

$$= 200 \text{ mL. of } \frac{M}{10} \text{ HCl}$$

On heating, the sample, only $NaHCO_3$ undergoes decomposition as given below.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2 \uparrow$$

2 moles 1 mole 1 mole

2 equ.

Neutralisation of the sample with HCl takes place as given below.

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

1 eq. 1 eq.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

1 mole 2 mole

2 eq. 2 eq.

Hence, 2 g sample ≡ 200 ml. of M/10 HCl

= 200 ml. of N/10 HCl = 20 meq = 0.020 eq

Number of moles of $CO_2$ formed, *i.e.*

$$n = \frac{PV}{RT} = \frac{750}{760} \times \frac{123.9}{1000} \times \frac{1}{0.082 \times 298} = 0.005$$

Moles of $NaHCO_3$ in the sample (2 g) = 2× 0.005 = 0.01

Equivalent of $NaHCO_3$ = 0.01

Wt. of $NaHCO_3$ = 0.01 × 84 = 0.84 g

$$\% \text{ of } NaHCO_3 = \frac{0.84 \times 100}{2} = \mathbf{42\%}$$

Equivalent of $Na_2CO_3$ = 0.02 − 0.01 = 0.01

Wt. of $Na_2CO_3$ = 0.01 × 53 = 0.53 g

$$\therefore \% \text{ of } Na_2CO_3 = \frac{0.53 \times 100}{2} = \mathbf{26.5\%}$$

∴ % of $Na_2SO_4$ in the mixture = 100 − (42 + 26.5) = **31.5%**

**36.** In the given problem, a solution containing $Cu^{2+}$ and $C_2O_4^{2-}$ is titrated first with $KMnO_4$ and then with $Na_2S_2O_3$ in presence of KI. In titration with $KMnO_4$, it is the $C_2O_4^{2-}$ ions that react with the $MnO_4^-$ ions. The concerned balanced equation may be written as given below.

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Thus, according to the above reaction

$$2 \text{ mmol } MnO_4^- \equiv 5 \text{ mmol } C_2O_4^{2-}$$

However,

No. of mmol of $MnO_4^-$ used in titration = Vol. in ml × M

$$= 22.6 \times 0.02 = 0.452 \text{ mmol } MnO_4^-$$

$$\text{Since } 2 \text{ mmol } MnO_4^- \equiv 5 \text{ mmol } C_2O_4^{2-}$$

$$0.452 \text{ mmol } MnO_4^- \equiv \frac{5}{2} \times 0.452 = 1.130 \text{ mmol } C_2O_4^{2-}$$

*Titration with $Na_2S_2O_3$ in the presence of KI.*

Here $Cu^{2+}$ react and the reactions involved during titration are :

$2Cu^{2+} + 2I^- \rightarrow 2Cu^+ + I_2, 2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$

Thus $2Cu^{2+} \equiv I_2 \equiv 2S_2O_3^{2-}$

No. of m mol of $S_2O_3^{2-}$ used in titration

$= 0.05 \times 11.3 = 0.565$ mmol $S_2O_3^{2-}$

Now since 2 mmol $S_2O_3^{2-} \equiv 2$ mmol $Cu^{2+}$

0.565 mmol $S_2O_3^{2-} \equiv 0.565$ mmol $Cu^{2+}$

$\therefore$ Molar ratio of $Cu^{2+}$ to $C_2O_4^{2-} = \dfrac{0.565 \text{ mmol}}{1.130 \text{ mmol}} = \mathbf{1:2}$

*Balanced equations in two cases*

**Case I.** $Mn^{+7} + 5e^- \rightarrow Mn^{+2}$
$C_2^{+3} \rightarrow 2C^{+4} + 2e^-$

**Case II.** $2Cu^{+2} + 2e^- \rightarrow Cu_2^+$
$2I^- \rightarrow I_2 + 2e^-$

and $I_2 + 2e^- \rightarrow 2I^-$
$2S_2^{+2} \rightarrow S_4^{+3/2} + 2e^-$

**37.** No. of equivalents of $KMnO_4$
= No. of equivatents of reducing agents.

**Case I.** Reaction of NaOH with $H_2C_2O_4$ and $NaHC_2O_4$.

(*i*) $H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

(*ii*) $NaHC_2O_4 + NaOH \rightarrow Na_2C_2O_4 + H_2O$

Number of milliequivalents of NaOH $= N \times V = 3.0 \times 0.1 = 0.3$

$\therefore$ Combined normality of the mixture titrated with NaOH

$= \dfrac{0.3}{10} = 0.03$

**Case II.** Reaction of $C_2O_4^-$ ion and $KMnO_4$

(*iii*) $5C_2O_4^- + MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

$KMnO_4$ will react in same manner with both $NaHC_2O_4$ and $H_2C_2O_4$ as it can be seen from the above reaction.

Number of milliequivalents of $KMnO_4 = 4.0 \times 0.1 = 0.4$

$\therefore$ Combined normality of the mixture titrated with $KMnO_4$

$= \dfrac{0.4}{10} = 0.04$

The difference (0.04 N – 0.03 N = 0.01 N) is due to $NaHC_2O_4$

The total normality of $NaHC_2O_4$ will be = 0.01 + 0.01 = 0.02 N

From equation (*ii*) in case I.

Eq. wt. of $NaHC_2O_4 = 112$

Amount of $NaHC_2O_4$ in one litre of solution formed $= 0.01 \times 112 = \mathbf{1.12\ g}$ and amount of $H_2C_2O_4$ $= 2.02 -$ Wt. of $NaHC_2O_4 = 2.02 - 1.12 = \mathbf{0.90\ g}$

**38.** Let the amount of $NaNO_3$ in the mixture = $x$ g

$\therefore$ The amount of $Pb(NO_3)_2$ in the mixture $= (5 - x)$ g

Heating effect of sodium nitrate and lead nitrate

$$\underset{2(23+14+48)=170\text{ g}}{2NaNO_3} \xrightarrow{\Delta} 2NaNO_2 + \underset{2\times16=32\text{ g}}{O_2}$$

$$\underset{2(207+28+96)=662\text{ g}}{2Pb(NO_3)_2} \xrightarrow{\Delta} 2PbO_2 + \underbrace{\underset{4(14+32)=184\text{ g}}{4NO_2} + \underset{2\times16=32\text{ g}}{O_2}}_{216\text{ g}}$$

Now since, 170 g of $NaNO_3$ gives = 32 g of $O_2$

$\therefore$ $x$ g of $NaNO_3$ gives $= \dfrac{32}{170} \times x$ g of $O_2$

Similarly, 662 g of $Pb(NO_3)_2$ gives = 216 g of gases $(NO_2 + O_2)$

$(5 - x)$ g of $Pb(NO_3)_2$ gives $= \dfrac{216}{662} \times (5 - x)$ g of gases

Actual loss, on heating, is 28% of 5 g of mixture

$= \dfrac{5 \times 28}{100} = 1.4$ g

$\therefore \dfrac{32x}{170} + \dfrac{216}{662} \times (5 - x) = 1.4$

$\Rightarrow x = 1.676$ g

Wt. of $NaNO_3 = \mathbf{1.676\ g}$

and Wt. of $Pb(NO_3)_2 = 5 - 1.676\text{ g} = \mathbf{3.324\ g}$

**39.** No. of equivalents of $KMnO_4$ in neutral medium
= No. of equivalents of reducing agent.

Assuming that $KMnO_4$ shows the following changes during its oxidising nature.

Acidic medium $Mn^{7+} + n_1e^- \rightarrow Mn^{a+}$ $\quad \therefore n_1 = 7 - a$

Neutral medium $Mn^{7+} + n_2e^- \rightarrow Mn^{b+}$ $\quad \therefore n_2 = 7 - b$

Alkaline medium $Mn^{7+} + n_3e^- \rightarrow Mn^{c+}$ $\quad \therefore n_3 = 7 - c$

Let $V$ ml. of reducing agent be used for $KMnO_4$ in different medium.

$\therefore$ Meq. of reducing agent
= Meq. of $KMnO_4$ in acid medium

Meq. of $KMnO_4$ in neutral medium
= Meq. of $KMnO_4$ in alkaline medium

$\Rightarrow 1 \times n_1 \times 20 = 1 \times n_2 \times 33.4 = 1 \times n_3 \times 100$

$\Rightarrow n_1 = 1.667\, n_2 = 5\, n_3$

Since $n_1$, $n_2$ and $n_3$ are integers and $n_1$ is not greater than 7

$\therefore \quad n_3 = 1$

Hence, $n_1 = 5$ and $n_2 = 3$

$\therefore$ Different oxidation states of Mn in

Acidic medium $Mn^{7+} + 5e^- \rightarrow Mn^{a+}$

or $a = \mathbf{+2}$

Neutral medium $Mn^{7+} + 3e^- \rightarrow Mn^{b+}$

or $b = \mathbf{+4}$

Alkaline medium $Mn^{7+} + 1e^- \rightarrow Mn^{c+}$

or $c = \mathbf{+6}$

Further, same volume of reducing agent is treated with $K_2Cr_2O_7$ and therefore

Meq. of reducing agent = Meq. of $K_2Cr_2O_7$

$1 \times 5 \times 20 = 1 \times 6 \times V$ $\quad [\because Cr^{+6} + 6e^- \rightarrow 2Cr^{+3}]$

$V = \mathbf{16.66\ mL}$ $\quad \therefore 1M = 6 \times 1N$

**40.** (i) Weight of sugar syrup = 214.2 g

Weight of sugar in the syrup = 34.2 g

$\therefore$ Weight of water in the syrup = 214.2 – 34.2 = 180.0 g

Mol. wt. of sugar, $C_{12}H_{22}O_{11} = 342$

∴ Molal concentration $= \frac{34.2 \times 1000}{342 \times 180} = \mathbf{0.56}$

(ii) Mol. wt. of water, $H_2O = 18$

∴ Mole fraction of sugar $= \frac{34.2/342}{180/18 + 34.2/342}$

$= \frac{0.1}{10 + 0.1} = \frac{0.1}{10.1} = \mathbf{0.0099}$

**41.** (i) From the given half-cell reaction,

Here, Eq. wt. of $NaBrO_3 = \frac{\text{Mol. wt.}}{6} = \frac{151}{6} = 25.17$

[∵ number of electron involved = 6]

Now we know that

Meq. = Normality × Vol. in mL = 85.5 × 0.672 = 57.456

Also, Meq. $= \frac{W_{NaBrO_3}}{\text{Eq. wt.}_{NaBrO_3}} \times 1000$

$\Rightarrow \frac{W_{NaBrO_3}}{25.17} \times 1000 = 57.456$ g

$\therefore \quad W_{NaBrO_3} = \mathbf{1.446\ g}$

Molarity of $NaBrO_3 = \frac{\text{Normality}}{\text{Valence factor}}$

$= \frac{0.672}{6} = \mathbf{0.112\ M}$

(ii) From the given half-cell reaction,

Eq. wt. of $NaBrO_3 = \frac{\text{Mol. wt.}}{5} = \frac{151}{5} = 30.2$

[Number of electron involved per $BrO_3^- = \frac{10}{2} = 5$]

Thus, the amount of $NaBrO_3$ required for preparing 1000 mL of 1 N $NaBrO_3 = 30.2$ g

∴ The amount of $NaBrO_3$ required for preparing 85.5 mL of 0.672 N $NaBrO_3$

$= \frac{30.2 \times 0.672 \times 85.5}{1000} = \mathbf{1.7532\ g}$

Also, Molarity $= \frac{0.672}{5} = \mathbf{0.1344\ M}$

**42.** (i) Find normality of acid mixture and $Na_2CO_3 . 10H_2O$. Equate them to find volume of $H_2SO_4$.

(ii) Meq. of $H_2SO_4 = V \times N = \frac{V \times N}{1000}$ eq.

(iii) Equivalent of $SO_4^{2-}$ = equivalents of $H_2SO_4$ × Eq. wt. of $SO_4^{2-}$

$N \times V(\text{mL.}) = \text{meq.}$

Acid mixture contains 5 mL of 8N, $HNO_3$, 4.8 mL of 5N, HCl and say, '$V$' mL of 17 M ≡ 34 N, $H_2SO_4$.

[$1M\ H_2SO_4 = 2NH_2SO_4$]

$N$ of the acid mixture $= \frac{\text{meq. (total) of acid}}{\text{mL. of solution}}$

$= \frac{5 \times 8 + 4.8 \times 5 + V \times 34}{2000}$ [Total volume = 2 L = 2000 mL]

or, $N_{\text{mixture}} = \frac{64 + 34V}{2000}$

∵ Eq. of wt. of $Na_2CO_3 . 10H_2O = \frac{\text{Mol. wt.}}{2}$

$= \frac{106 + 180}{2} = 143$

$N$ of $Na_2CO_3 = \frac{\text{Meq. of } Na_2CO_3}{\text{Volume of solution (mL)}}$

$= \frac{\frac{1}{143}}{\frac{100}{1000}} = \frac{1}{143} \times \frac{1000}{100} = 0.069\text{N}$

$N_1V_1 = N_2V_2$

or $30 \times N_{\text{mixture}} = 42.9 \times 0.069$

(acid) (sod. carbonate)

$\therefore N_{\text{mixture}} = \frac{42.9 \times 0.069}{30} = 0.0986\ N$

Hence $\frac{64 + 34V}{2000} = 0.0986$

$64 + 34V = 0.0986 \times 2000,\ 64 + 34V = 197.2$

$34V = 197.2 - 64.0 = 133.2 \quad \therefore$ or $V = \frac{133.2}{34} = 3.9$ mL.

Hence, meq. of $H_2SO_4 = V \times N$ of $H_2SO_4$

$= 3.9 \times 34 = 132.6$ meq.

$= 0.1326$ eq. of $H_2SO_4$

$= 0.1326$ eq. of $SO_4^{2-}$

$= 0.1326 \times 48$ g of $SO_4^{2-}$

$\left(\because \text{Eq. wt. of } SO_4^{2-} = \frac{32 + 64}{2} = 48\right)$

$= \mathbf{6.3648\ g}$ of $SO_4^{2-}$ are in 3.9 mL of 17M $H_2SO_4$

**43.** Equivalents of $A$ oxidised = Equivalents of $A$ reduced. Since in acidic medium, $A^{n+}$ is oxidised to $AO_3^-$, the change in oxidation state from

$(+5)$ to $(+n) = 5 - n$ [∵ O.S. of A in $AO_3^- = +5$]

∴ Total number of electrons that have been given out during oxidation of $2.68 \times 10^{-3}$ moles of $A^{n+}$

$= 2.68 \times 10^{-3} \times (5 - n)$

Thus the number of electrons added to reduce $1.61 \times 10^{-3}$ moles of $MnO_4^-$ to $Mn^{2+}$, *i.e.*

$(+7)$ to $(+2) = 1.61 \times 10^{-3} \times 5$

[Number of electrons involved = +7 − (+2) = 5]

$\therefore \quad 1.61 \times 10^{-3} \times 5 = 2.68 \times 10^{-3} \times (5 - n)$

$5 - n = \frac{1.61 \times 5}{2.68}$ or $n = 5 - \frac{8.05}{2.68} \approx \mathbf{2}$

**44.** (i) Mole fraction $= \frac{\text{Moles of substance}}{\text{Total moles}}$

(ii) 1 mole of $Na_2S_2O_3$ gives 2 moles of $Na^+$ and 1 mole of $S_2O_3^{2-}$

Molecular wt. of sodium thiosulphate solution ($Na_2S_2O_3$) $= 23 \times 2 + 32 \times 2 + 16 \times 3 = 158$

(i) The percentage by weight of $Na_2S_2O_3$

$$= \frac{\text{wt of } Na_2S_2O_3}{\text{wt of solution}} \times 100 = \frac{3 \times 158 \times 100}{1000 \times 1.25} = \mathbf{37.92}$$

[Wt. of $Na_2S_2O_3$ = Molarity × Mol wt]

(ii) Mass of 1 litre solution $= 1.25 \times 1000$ g $= 1250$ g [∵ density = 1.25g/l]

Mole fraction of $Na_2S_2O_3$

$$= \frac{\text{Number of moles of } Na_2S_2O_3}{\text{Total number of moles}}$$

$$\text{Moles of water} = \frac{1250 - 158 \times 3}{18} = 43.1$$

$$\text{Mole fraction of } Na_2S_2O_3 = \frac{3}{3 + 43.1} = 0.065$$

(iii) 1 mole of sodium thiosulphate ($Na_2S_2O_3$) yields 2 moles of $Na^+$ and 1 mole of $S_2O_3^{2-}$

$$\text{Molality of } Na_2S_2O_3 = \frac{3 \times 1000}{776} = 3.87$$

Molality of $Na^+ = 3.87 \times 2 = \mathbf{7.74m}$

**45.** Weight of $MCO_3$ and BaO = 4.08 g (given)

Weight of residue = 3.64 g (given)

∴ Weight of $CO_2$ evolved on heating = (4.08 – 3.64) g

$$= 0.44 \text{ g} = \frac{0.44}{44} = 0.01 \text{ mole}$$

Number of moles of $MCO_3 \equiv$ 0.01 mole

$$\left[\because MCO_3 \xrightarrow{\text{heat}} MO + CO_2\right]$$

Volume of 1N HCl in which residue is dissolved = 100 mL

Volume of 1N HCl used for dissolution = (100 – 2.5 × 16) mL = 60 ml

$$= \frac{60}{1000} = 0.06 \text{ equivalents}$$

The chemical equation for dissolution can be written as

$$\underbrace{BaO + MO}_{\text{Residue}} + 4HCl \longrightarrow BaCl_2 + MCl_2 + 2H_2O$$

[Number of moles of BaO and MO = 1 + 1 = 2]

$$\text{Number of moles of BaO} + \text{Number of moles of MO} = \frac{0.06}{2} = 0.03$$

Number of moles of BaO = (0.03 – 0.01) = 0.02 moles

Molecular weight of BaO = 138 + 16 = 154

∴ Weight of BaO = (0.02 × 154) g = 3.08 g

Weight of $MCO_3$ = (4.08 – 3.08) = 1.0 g

Since weight of 0.01 mole of $MCO_3$ = 1.0 g

$$\therefore \text{Mol. wt. of } MCO_3 = \frac{1}{0.01} = 100$$

Hence, atomic weight of unknown M = (100 – 60) = **40**

The atomic weight of metal is **40** so the metal M is **Ca**.

**46.** Following reactions take place-

$$3MnSO_4{\cdot}4H_2O \xrightarrow{\text{heat}} \underset{\text{(residue)}}{Mn_3O_4} + 4H_2O\uparrow + 3SO_2\uparrow + O_2\uparrow$$

$$Mn_3O_4 + 2FeSO_4 + 4H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + 3MnSO_4 + 4H_2O$$

Milliequivalents of $FeSO_4$ in 30 mL of 0.1N $FeSO_4$ = 30 × 0.1 = 3 m. eq.

According to problem step (iv)

25 mL of $KMnO_4$ reacts with = 3 m eq of $FeSO_4$

Thus in step (iii) of the problem,

$$50 \text{ mL of } KMnO_4 \text{ reacts with} = \frac{3}{25} \times 50 \text{ m.eq. of } FeSO_4 = 6 \text{ meq of } FeSO_4$$

Milli eq. of 100 mL of 0.1N $FeSO_4$ = 100 × 0.1 = 10 m eq.

$FeSO_4$ which reacted with $Mn_3O_4$ = (10–6) = 4 m eq.

Milli eq of $FeSO_4$ = Milli eq. of $Mn_3O_4$

(∵ Milli eq of oxidising agent and reducing agent are equal)

∵ $Mn_3O_4 \equiv 3MnSO_4.4H_2O$

∴ 1 Meq of $Mn_3O_4$ = 3 Meq of $MnSO_4 \cdot 4H_2O$

∴ 4 Meq of $Mn_3O_4$ = 12 Meq of $MnSO_4 \cdot 4H_2O$

$$\text{Eq. wt of } MnSO_4.4H_2O = \frac{\text{Mol wt.}}{2} = \frac{223}{2} = 111.5$$

Wt of $MnSO_4.4H_2O$ in sample = 12 × 111.5 = 1338 mg = **1.338g.**

**47.** Weight of AgCl formed = 2.567 g

Amount of AgCl formed due to MCl = 1.341 g

(∵ NaCl does not decompose on heating to 300 °C)

∴ Weight of AgCl formed due to NaCl = 2.567 – 1.341 = 1.226 g

$$\left\{\begin{matrix} NaCl + AgNO_3 \rightarrow AgCl + NaNO_3 \\ MCl + AgNO_3 \rightarrow AgCl + MNO_3 \end{matrix}\right\}$$

∵ 143.5 g of AgCl is obtained from NaCl = 58.5 g

∴ 1.226 g of AgCl is obtained from NaCl

$$= \frac{58.5}{143.5} \times 1.226 = 0.4997 \text{ g}$$

∴ Wt of MCl in 1 g of mixture = 1.000 – 0.4997 = 0.5003 g

∵ 1.341 g of AgCl is obtained from MCl = 0.5003 g

∴ 143.5g of AgCl is obtained from MCl

$$= \frac{0.5003}{1.341} \times 143.5 = 53.53 \text{ g}$$

∴ Molecular weight of MCl = **53.53**

**48.** Volume of oxygen taken = 30 mL,

Volume of unused oxygen = 15 mL

Volume of $O_2$ used = Volume of $O_2$ added – Volume of $O_2$ left = 30 – 15 = 15 mL

Volume of $CO_2$ produced

= Volume of gaseous mixture after explosion – Volume of unused oxygen

or Volume of $CO_2$ produced = 25 – 15 = 10 mL

Volume of hydrocarbon = 5 mL

General equation for combustion of a hydrocarbon is as follows -

$$\underset{\text{(Hydrocarbon)}}{C_xH_y} + \left(x+\frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

$$5\text{ mL} \qquad 5\left(x+\frac{y}{4}\right)\text{mL} \qquad 5x$$

$\therefore$ Volume of $CO_2$ produced $= 5x$, Since Volume of $CO_2 = 10$ mL

$\therefore\ 5x = 10 \Rightarrow x = 2$, Volume of $O_2$ used = 15 mL

$$\therefore\ 5\left(x+\frac{y}{4}\right) = 15 \Rightarrow x+\frac{y}{4} = 3$$

$$\Rightarrow 2+\frac{y}{4} = 3 \quad (\because x=2) \qquad \Rightarrow 8+y=12 \therefore\ y=4$$

Hence, Molecular formula of hydrocarbon is $\mathbf{C_2H_4}$.

**49.** Given conditions N.T.P conditions

$P_1 = 0.92$ atm. $P_2 = 1$ atm.

$V_1 = 1.20$ litres $V_2 = ?$

$T_1 = 0 + 273 = 273$ K $T_2 = 273$ K

Applying ideal gas equation, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\frac{0.92\times 1.20}{273} = \frac{1\times V_2}{273},\ V_2 = \frac{0.92\times 1.20\times 273}{273\times 1}\text{ litres}$$

= 1.104 litres = 1104 mL

The relevant chemical equations are

(i) $2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

$2\times 27$ $3\times 22400$

$= 54$ g $= 67200$ mL at NTP

(ii) $Mg + 2HCl \longrightarrow MgCl_2 + H_2$

24 g 22400 mL at NTP

Wt. of alloy = 1 g

Let the wt. of aluminium in alloy = $x$ g

$\therefore$ Wt. of magnesium in alloy = $(1-x)$ g

According to equation (i)

54 g of Al = 67200 mL of $H_2$ at N.T.P

$$\therefore x\text{ g of Al} = \frac{67200}{54}\times x = 1244.4\,x\text{ mL of } H_2 \text{ at N.T.P}$$

Similarly, from equation (ii)

24 g of Mg = 22400 mL of $H_2$ at N.T.P

$$(1-x)\text{ g of Mg} = \frac{22400}{24}\times(1-x) = 933.3\,(1-x)\text{ mL of } H_2$$

Hence, total vol. of $H_2$ collected at N.T.P

$= 1244.4\,x + 933.3\,(1-x)$ mL

But total vol. of $H_2$ as calculated above = 1104 mL

$\therefore\ 1244.4\,x + 933.3\,(1-x) = 1104$ mL

$\Rightarrow\ x = 0.5487$

Hence, 1 g of alloy contains Al = 0.5487 g

$$\therefore\ \text{Percentage of Al in alloy} = \frac{0.5487\times 100}{1} = \mathbf{54.87\%}$$

% of Mg in alloy = 100 − 54.87 = **45.13%**