Topic 1 Mole Concept

Objective Questions I (Only one correct option)

- **1.** 5 moles of AB_2 weight 125 10 ³ kg and 10 moles of A_2B_2 weight 300 10 ³ kg. The molar mass of $A(M_A)$ and molar mass of $B(M_B)$ in kg mol ¹ are (2019 Main, 12 April I)
 - (a) M_A 10 10 3 and M_B 5 10 3
 - (b) M_A 50 10 3 and M_B 25 10 3
 - (c) M_A 25 10 ³ and M_B 50 10 ³
 - (d) M_A 5 10 3 and M_B 10 10 3
- The minimum amount of O₂(g) consumed per gram of reactant is for the reaction (Given atomic mass : Fe 56, O 16, Mg 24, P 31, C 12, H 1) (2019 Main, 10 April II)

- At 300 K and 1 atmospheric pressure, 10 mL of a hydrocarbon required 55 mL of O₂ for complete combustion and 40 mL of CO₂ is formed. The formula of the hydrocarbon is (2019 Main, 10 April I)
 (a) C₄H₇Cl (b) C₄H₆ (c) C₄H₁₀ (d) C₄H₈
- 4. 10 mL of 1 mM surfactant solution forms a monolayer covering 0.24 cm² on a polar substrate. If the polar head is approximated as a cube, what is its edge length?
 (2019 Main, 9 April II)

(a) 2.0 pm (b) 0.1 nm (c) 1.0 pm (d) 2.0 nm

5. For a reaction,

 $\begin{array}{ll} N_2(g) & 3H_2(g) & 2NH_3(g), \mbox{ identify dihydrogen } (H_2) \\ \mbox{ as a limiting reagent in the following reaction mixtures.} \\ & (2019 \mbox{ Main, 9 April I}) \\ \mbox{ (a) 56 g of } N_2 & 10 g \mbox{ of } H_2 \mbox{ (b) 35 g of } N_2 & 8 g \mbox{ of } H_2 \end{array}$

(a) $50 \text{ g} \text{ of } N_2$ $10 \text{ g} \text{ of } H_2$ (b) $53 \text{ g} \text{ of } N_2$ $0 \text{ g} \text{ of } H_2$ (c) $14 \text{ g} \text{ of } N_2$ $4 \text{ g} \text{ of } H_2$ (d) $28 \text{ g} \text{ of } N_2$ $6 \text{ g} \text{ of } H_2$

- 6. The percentage composition of carbon by mole in methane is (2019 Main, 8 April II)
 (a) 75%
 (b) 20%
 (c) 25%
 (d) 80%
- 8 g of NaOH is dissolved in 18 g of H₂O. Mole fraction of NaOH in solution and molality (in mol kg⁻¹) of the solution respectively are (2019 Main, 12 Jan II)
 (a) 0.2, 11.11
 (b) 0.167, 22.20
 (c) 0.2, 22.20
 (d) 0.167, 11.11
- 8. The volume strength of $1 \text{ M H}_2\text{O}_2$ is (Molar mass of H_2O_2 34 g mol⁻¹) (2019 Main, 12 Jan II) (a) 16.8 (b) 22.4 (c) 11.35 (d) 5.6
- 10. For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is :

 $2C_{57}H_{110}O_6(s) = 163O_2(g) = 114CO_2(g) = 110 H_2O(l)$ (2019 Main, 9 Jan II)

(a) 490 g (b) 495 g (c) 445 g (d) 890 g

- 11. A solution of sodium sulphate contains 92 g of Na ions per kilogram of water. The molality of Na ions in that solution in mol kg⁻¹ is (2019 Main, 9 Jan I)
 (a) 16 (b) 4 (c) 132 (d) 8
- **12.** The most abundant elements by mass in the body of a healthy human adult are oxygen (61.4%), carbon (22.9%), hydrogen (10.0%), and nitrogen (2.6%). The weight which a 75 kg person would gain if all ¹ Hatoms are replaced by ² Hatoms is (2017 JEE Main)

(a) 15 kg	(b) 37.5 kg
(c) 7.5 kg	(d) 10 kg

13. 1 g of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO₂. The molar mass of M_2CO_3 in g mol⁻¹ is (2017 JEE Main) (a) 1186 (b) 84.3 (c) 118.6 (d) 11.86

- **14.** At 300 K and 1 atm, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O₂ by volume for complete combustion. After combustion, the gases occupy 330 mL. Assuming that the water formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is (**2016 JEE Main**) (a) C_3H_8 (b) C_4H_8 (c) C_4H_{10} (d) C_3H_6
- **15.** The molecular formula of a commercial resin used for exchanging ions in water softening is $C_8H_7SO_3Na$ (molecular weight 206). What would be the maximum uptake of Ca^2 ions by the resin when expressed in mole per gram resin? (2015 JEE Main)
 - (a) $\frac{1}{103}$ (b) $\frac{1}{206}$ (c) $\frac{2}{309}$ (d) $\frac{1}{412}$
- 16. 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is (2015 JEE Main)

(a) 18 mg (b) 36 mg (c) 42 mg (d) 54 mg

17. The ratio mass of oxygen and nitrogen of a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is (2014 Main)

(a) 1:4 (b) 7:32 (c) 1:8 (d) 3:16

- 18. The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 mL of 2 M HCl will be (2013 Main)
 (a) 0.875 M (b) 1.00 M (c) 1.75 M (d) 0.0975M
- 19. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is (2011)
 (a) 1.78 M (b) 2.00 M (c) 2.05 M (d) 2.22 M
- **20.** Given that the abundances of isotopes ${}_{54}$ Fe, ${}_{56}$ Fe and ${}_{57}$ Fe are 5%, 90% and 5%, respectively, the atomic mass of Fe is

(a) 55.85	(b) 55.95
(c) 55.75	(d) 56.05

21. Mixture X $0.02 \text{ mole of } [Co(NH_3)_5 SO_4]Br \text{ and } 0.02 \text{ mole of } [Co(NH_3)_5 Br]SO_4 \text{ was prepared in 2 L solution.}$

1 L of mixture X + excess of	AgNO ₃ solution	Y
1 L of mixture X + excess of	BaCl ₂ solution	Ζ
Number of moles of <i>Y</i> and <i>Z</i>	are	(2003, 1M)
(a) 0.01, 0.01	(b) 0.02, 0.01	
(c) 0.01, 0.02	(d) 0.02, 0.02	

- 22. Which has maximum number of atoms?
 (2003, 1M)

 (a) 24 g of C (12)
 (b) 56 g of Fe (56)

 (c) 27 g of Al (27)
 (d) 108 g of Ag (108)
- **23.** How many moles of electron weighs 1 kg?

(a)
$$6.023 10^{23}$$
 (b) $\frac{1}{9.108} 10^{31}$ (2002, 3M)
(c) $\frac{6.023}{9.108} 10^{54}$ (d) $\frac{1}{9.108} 6.023 10^{8}$

24. The normality of 0.3 M phosphorus acid (H_3PO_3) is (1999, 2M) (a) 0.1 (b) 0.9 (c) 0.3 (d) 0.6

	(a) 0.1	(0) 0.9	(0) 0.5	(u) 0.0
25.	In which mo	de of express	sion, the concentra	tion of a solution
	remains inde	ependent of t	emperature?	(1988, IM)
	(a) Molarity	(b) Normal	ity (c) Formality	(d) Molality
26.	A molal solu	tion is one th	hat contains one n	nole of solute in
				(1986, 1M)
	(a) 1000 g of	f solvent	(b) 1.0 L of sc	olvent
	(c) 1.0 L of s	solution	(d) 22.4 L of s	solution
27.	If 0.50 mole	of BaCl_2 is	mixed with 0.20	mole of Na ₃ PO ₄ ,
	the maximum	m number of	f moles of Ba ₃ (P	O_4) ₂ that can be
	formed is			(1981, 1M)
	(a) 0.70	(b) 0.50	(c) 0.20	(d) 0.10

- 2.76 g of silver carbonate on being strongly heated yields a residue weighing (1979, 1M)
 (a) 2.16 g (b) 2.48 g (c) 2.32 g (d) 2.64 g
- 29. When the same amount of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volumes of hydrogen evolved is (1979, 1M)
 (a) 1:1
 (b) 1:2
 (c) 2:1
 (d) 9:4
- 30. The largest number of molecules is in (1979, 1M)
 (a) 36 g of water
 (b) 28 g of CO
 (c) 46 g of ethyl alcohol
 (d) 54 g of nitrogen pentaoxide (N₂O₅)
- 31. The total number of electrons in one molecule of carbon dioxide is (1979, 1M)
 (a) 22 (b) 44 (c) 66 (d) 88
- 32. 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, 1M)
 (a) 1:4
 (b) 1:8
 (c) 7:32
 (d) 3:16

Numerical Value Based Questions

33. Galena (an ore) is partially oxidised 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 content undergo self-reduction. The weight (in kg) of Pb produced per kg of O_2 consumed is

(Atomic weights in g mol¹: O = 16, S 32, Pb 207)

- (2018 Adv.)
- **34.** To measure the quantity of MnCl₂ dissolved in an aqueous solution, it was completely converted to KMnO₄ using the reaction,

 $MnCl_2 + K_2S_2O_8 + H_2O$ $KMnO_4 + H_2SO_4 + HCl$ (equation not balanced).

Few drops of concentrated HCl were added to this solution and gently warmed. Further, oxalic acid (225 mg) was added in portions till the colour of the permanganate ion disappeared. The quantity of $MnCl_2$ (in mg) present in the initial solution is

(Atomic weights in g mol 1 : Mn 55, Cl 35.5) (2018 Adv.)

35. In the following reaction sequence, the amount of D (in gram) formed from 10 moles of acetophenone is

(Atomic weights in g mol¹: H = 1, C = 12, N = 14, O = 16, Br = 80. The yield (%) corresponding to the product in each step is given in the parenthesis)

(2018 Adv.)

Fill in the Blanks

- **37.** 3.0 g of a salt of molecular weight 30 is dissolved in 250 g water. The molarity of the solution is (1983, 1M)
- **39.** The modern atomic mass unit is based on the mass of(1980, 1M)

Integer Answer Type Questions

40. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm⁻³. The ratio of the

molecular weights of the solute and solvent, $\frac{m_{\text{solute}}}{m_{\text{solvent}}}$ is ...

(2016 Adv.)

- **41.** A compound H_2X with molar weight of 80 g is dissolved in a solvent having density of 0.4 g mL¹. Assuming no change in volume upon dissolution, the molality of a 3.2 molar solution is (2014 Adv.)
- **42.** 29.2% (*w*/*W*) HCl stock solution has density of 1.25g mL ¹. The molecular weight of HCl is 36.5 g mol ¹. The volume (mL) of stock solution required to prepare a 200 mL solution 0.4 M HCl is (2012)

Subjective Questions

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43. 20% surface sites have adsorbed N_2 . On heating N_2 gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm³. Density of surface sites is 6.023 10^{14} /cm² and surface area is 1000 cm², find out the number of surface sites occupied per molecule of N_2 . (2005, 3M)

- **44.** In a solution of 100 mL 0.5 M acetic acid, one gram of active charcoal is added, which adsorbs acetic acid. It is found that the concentration of acetic acid becomes 0.49 M. If surface area of charcoal is $3.01 \quad 10^2 \text{ m}^2$, calculate the area occupied by single acetic acid molecule on surface of charcoal. (2003)
- **45.** Find the molarity of water. Given: $= 1000 \text{ kg/m}^3$ (2003)
- 46. 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 cm³/g. If the virus is considered to be a single particle, find its molar mass. (1999, 3M)
- **47.** 8.0575 10^{2} kg of Glauber's salt is dissolved in water to obtain 1 dm³ of solution of density 1077.2 kg m³. Calculate the molality, molarity and mole fraction of Na₂SO₄ in solution. (1994, 3M)
- **48.** *A* is a binary compound of a univalent metal. 1.422 g of *A* reacts completely with 0.321 g of sulphur in an evacuated and sealed tube to give 1.743 g of a white crystalline solid *B*, that forms a hydrated double salt, *C* with $Al_2(SO_4)_3$. Identify *A*, *B* and *C*. (1994, 2M)
- 49. Upon mixing 45.0 mL 0.25 M lead nitrate solution with 25.0 mL of a 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 species left behind in the final solution. Assume that lead sulphate is completely insoluble. (1993, 3M)
- **50.** Calculate the molality of 1.0 L solution of 93% H₂SO₄, (weight/volume). The density of the solution is 1.84 g/mL. (1990, 1M)
- **51.** 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, 4M)
- **52.** *n*-butane is produced by monobromination of ethane followed by Wurtz's reaction.Calculate volume of ethane at NTP required to produce 55 g *n*-butane, if the bromination takes place with 90% yield and the Wurtz's reaction with 85% yield. (1989, 3M)
- **53.** 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 syrup. (1988, 2M)
- 54. An unknown compound of carbon, hydrogen and oxygen contains 69.77% C and 11.63% H and has a molecular weight of 86. It does not reduces Fehling's solution but forms a bisulphate addition compound and gives a positive iodoform test. What is the possible structure(s) of unknown compound? (1987, 3M)
- **55.** 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, 5M)

- **56.** (a) 1.0 L of a mixture of CO and CO₂ is taken. This mixture is passed through a tube containing red hot charcoal. The volume now becomes 1.6 L. The volumes are measured under the same conditions. Find the composition of mixture by volume.
 - (b) A compound contains 28 per cent of nitrogen and 72 per cent of a metal by weight. 3 atoms of metal combine with 2 atoms of nitrogen. Find the atomic weight of metal. (1980, 5M)
- **57.** 5.00 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 electric spark. After explosion, the volume of the mixed gases remaining was 25 mL.

On adding a concentrated solution of KOH, the volume further diminished to 15 mL, the residual gas being pure oxygen. All volumes have been reduced to NTP. Calculate the molecular formula of the hydrocarbon gas. (1979, 3M)

- 58. In the analysis of 0.5 g sample of feldspar, a mixture of chlorides of sodium and potassium is obtained, which weighs 0.1180 g. Subsequent treatment of the mixed chlorides with silver nitrate gives 0.2451 g of silver chloride. What is the percentage of sodium oxide and potassium oxide in the sample? (1979, 5M)
- **59.** The vapour density (hydrogen = 1) of a mixture consisting of NO_2 and N_2O_4 is 38.3 at 26.7°C. Calculate the number of moles of NO_2 in 100 g of the mixture. (1979, 5M)
- 60. Accounts for the following. Limit your answer to two sentences, "Atomic weights of most of the elements are fractional". (1979, 1M)
- 61. Naturally occurring boron consists of two isotopes whose atomic weights are 10.01 and 11.01. The atomic weight of natural boron is 10.81. Calculate the percentage of each isotope in natural boron. (1978, 2M)

Topic 2 Equivalent Concept, Neutralisation and Redox Titration

Objective Questions I (Only one correct option)

1. An example of a disproportionation reaction is

(2019 Main, 12 April I)

8H₂O

- (a) $2MnO_4$ 10I 16H $2Mn^2$ 5I₂
- (b) $2NaBr Cl_2 2NaCl Br_2$
- (c) $2KMnO_4$ K_2MnO_4 MnO_2 O_2
- (d) 2CuBr CuBr₂ Cu
- In an acid-base titration, 0.1 M HCl solution was added to the NaOH solution of unknown strength. Which of the following correctly shows the change of pH of the titration mixture in this experiment? (2019 Main, 9 April II)



3. 0.27 g of a long chain fatty acid was dissolved in 100 cm³ of hexane. 10 mL of this solution was added dropwise to the surface of water in a round watch glass. Hexane evaporates and a monolayer is formed. The distance from edge to centre

of the watch glass is 10 cm. What is the height of the monolayer? [Density of fatty acid 0.9 g cm^{-3} ; 3]

(2019 Main, 8 April II)

(a) 10 ° m	(b) 10 ⁻ m
(c) 10^{8} m	(d) 10 2 m

() 10.6

- 4. In order to oxidise a mixture of one mole of each of FeC₂O₄, Fe₂(C₂O₄)₃, FeSO₄ and Fe₂(SO₄)₃ in acidic medium, the number of moles of KMnO₄ required is (2019 Main, 8 April I) (a) 2 (b) 1 (c) 3 (d) 1.5
- **5.** 100 mL of a water sample contains 0.81 g of calcium bicarbonate and 0.73 g of magnesium bicarbonate. The hardness of this water sample expressed in terms of equivalents of $CaCO_3$ is (molar mass of calcium bicarbonate is 162 g mol⁻¹ and magnesium bicarbonate is 146 g mol⁻¹)

(2019 Main, 8 April I)

(a)	5,000 ppm	(b)	1,000 ppm	
(c)	100 ppm	(d)	10,000 ppm	

6. 50 mL of 0.5 M oxalic acid is needed to neutralise 25 mL of sodium hydroxide solution. The amount of NaOH in 50 mL of the given sodium hydroxide solution is
 (2019 Main 12 Ian I)

(a)
$$40 \text{ g}$$
 (b) 80 g (c) 20 g (d) 10 g

- 7. 25 mL of the given HCl solution requires 30 mL of 0.1 M sodium carbonate solution. What is the volume of this HCl solution required to titrate 30 mL of 0.2 M aqueous NaOH solution? (2019 Main, 11 Jan II)
 (a) 75 mL (b) 25 mL (c) 12.5 mL (d) 50 mL
- 8. In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO₂ is (2019 Main, 10 Jan II) (a) 2 (b) 5 (c) 1 (d) 10

- 9. The ratio of mass per cent of C and H of an organic compound (C_xH_yO_z) is 6 : 1. If one molecule of the above compound (C_xH_yO_z) contains half as much oxygen as required to burn one molecule of compound C_xH_y completely to CO₂ and H₂O. The empirical formula of compound C_xH_yO_z is (2018 Main)

 (a) C₃H₆O₃
 (b) C₂H₄O
 (c) C₃H₄O₂
 (d) C₂H₄O₃
- 10. An alkali is titrated against an acid with methyl orange as indicator, which of the following is a correct combination? (2018 Main)

	Base	Acid	End point
(a)	Weak	Strong	Colourless to pink
(b)	Strong	Strong	Pinkish red to yellow
(c)	Weak	Strong	Yellow to pinkish red
(d)	Strong	Strong	Pink to colourless

From the following statements regarding H₂O₂ choose the incorrect statement. (2015 Main)

(a) It can act only as an oxidising agent

- (b) It decomposed on exposure to light
- (c) It has to be stored in plastic or wax lined glass bottles in dark
- (d) It has to be kept away from dust
- 12. Consider a titration of potassium dichromate solution with acidified Mohr's salt solution using diphenylamine as indicator. The number of moles of Mohr's salt required per mole of dichromate is (2007, 3M)
 (a) 3 (b) 4 (c) 5 (d) 6
- **13.** In the standardisation of $Na_2S_2O_3$ using $K_2Cr_2O_7$ by iodometry, the equivalent weight of $K_2Cr_2O_7$ is (2001, 1M) (a) (molecular weight)/2 (b) (molecular weight)/6 (c) (molecular weight)/3 (d) same as molecular weight
- **14.** The reaction, 3ClO (aq) $ClO_3^-(aq) + 2Cl (aq)$ is an example of (2001)
 - (a) oxidation reaction
 - (b) reduction reaction
 - (c) disproportionation reaction
 - (d) decomposition reaction
- 15. 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 neutralise 10 mL of this solution is (2001, 1M) (a) 40 mL (b) 20 mL (c) 10 mL (d) 4 mL
- **16.** Among the following, the species in which the oxidation number of an element is + 6 (2000) (a) MnO₄ (b) Cr(CN)³₆

(c)
$$\operatorname{NiF}_6^2$$
 (d) $\operatorname{CrO}_2\operatorname{Cl}_2$

- 17. The oxidation number of sulphur in S₈, S₂F₂, H₂S respectively, are (1999)
 (a) 0, +1 and -2 (b) +2, +1 and -2
 - (c) 0, +1 and +2 (d) -2, +1 and -2(d) -2, +1 and -2

18. The number of moles of KMnO₄ that will be needed to react completely with one mole of ferrous oxalate in acidic medium is (1997) (a) $\frac{2}{-}$ (b) $\frac{3}{-}$ (c) $\frac{4}{-}$ (d) 1

$$\frac{1}{5} = \frac{1}{5} = \frac{1}$$

The number of moles of KMnO₄ that will be needed to react with one mole of sulphite ion in acidic solution is
 (1997)

(a)
$$\frac{2}{5}$$
 (b) $\frac{3}{5}$ (c) $\frac{4}{5}$ (d) 1

20. For the redox reaction

$$MnO_4 + C_2O_4^2 + H^+$$
 $Mn^{2+} + CO_2 + H_2O$

The correct coefficients of the reactants for the balanced reaction are

	MnO_4	$C_2O_4^2$	H^{+}	(1992)
(a)	2	5	16	
(b)	16	5	2	
(c)	5	16	2	
(d)	2	16	5	

21. The volume strength of $1.5 \text{ N H}_2\text{O}_2$ is (1990, 1M) (a) 4.8 (b) 8.4 (c) 3.0 (d) 8.0

- **22.** The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is (a) +3 (b) +2 (1988) (c) +1 (d) -1
- **23.** The equivalent weight of $MnSO_4$ is half of its molecular weight, when it converts to (1988, 1M) (a) Mn_2O_3 (b) MnO_2 (c) MnO_4 (d) MnO_4^2

Objective Question II (More than one correct option)

- **24.** For the reaction, I CIO_3 H_2SO_4 $Cl + HSO_4$ I_2 the correct statement(s) in the balanced equation is/are (a) stoichiometric coefficient of HSO_4 is 6 (2014 Adv) (b) iodide is oxidised
 - (c) sulphur is reduced
 - (d) H_2O is one of the products

Numerical Value Based Question

25. 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 mol¹:
$$H = 1$$
, $N = 14$, $O = 16$, $S = 32$,
Cl = 35.5, Ca = 40, Ni = 59) (2018 Adv.)

Assertion and Reason

Read the following questions and answer as per the direction given below :

- (a) Statement I is true; Statement II is true; Statement II is the correct explanation of Statement I.
- (b) Statement I is true; Statement II is true; Statement II is not the correct explanation of Statement I.
- (c) Statement I is true; Statement II is false.
- (d) Statement I is false; Statement II is true.
- **26.** Statement I 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 II Two moles of HCl are required for the complete neutralisation of one mole of Na_2CO_3 . (1991, 2M)

Fill in the Blanks

27. The compound YBa₂Cu₃O₇, which shows super conductivity, has copper in oxidation state Assume that the rare earth element yttrium is in its usual + 3 oxidation state. (1994, 1M)

Integer Answer Type Questions

- **28.** The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is (2011)
- **29.** Among the following, the number of elements showing only one non-zero oxidation state is O, Cl, F, N, P, Sn, Tl, Na, Ti (2010)
- **30.** A student performs a titration with different burettes and finds titrate values of 25.2 mL, 25.25 mL, and 25.0 mL. The number of significant figures in the average titrate value is (2010)

Subjective Questions

- **31.** Calculate the amount of calcium oxide required when it reacts with 852 g of P_4O_{10} . (2005, 2M)
- **32.** 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)
- **33.** How many millilitres of $0.5 \text{ M H}_2\text{SO}_4$ are needed to dissolve 0.5 g of copper (II) carbonate? (1999, 3M)
- **34.** 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 I₂ consumed 45.0 mL of thiosulphate solution decolourise the blue starch-iodine complex. Calculate the molarity of the sodium thiosulphate solution. (1998, 5M)

- **35.** To a 25 mL H_2O_2 solution, excess of acidified solution of potassium iodide was added. The iodine liberated required 20 mL of 0.3 N sodium thiosulphate solution. Calculate the volume strength of H_2O_2 solution. (1997, 5M)
- **36.** 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 Na₂S₂O₃ solution to reduce the iodine present. A 50 mL of the dilute solution, after complete extraction of the iodine required 12.80 mL of 0.25 M KMnO₄ solution in dilute H_2SO_4 medium for the oxidation of Fe^{2+} . Calculate the percentage of Fe_2O_3 and Fe_3O_4 in the original sample. (1996, 5M)
- **37.** A 20.0 cm³ mixture of CO, CH₄ and He gases is exploded by an electric discharge at room temperature with excess of oxygen. The volume contraction is found to be 13.0 cm³.

A further contraction of 14.0 cm^3 occurs when the residual gas is treated with KOH solution. Find out the composition of the gaseous mixture in terms of volume percentage.

(1995, 4M)

- **38.** A 5.0 cm³ solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. (1995, 3M)
- **39.** 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) KIO₃ solution in presence of 6 M HCl till all I ions are converted into ICl. It requires 50 mL of (M/10) KIO₃ solution, 20 mL of the same stock solution of KI requires 30 mL of (M/10) KIO₃ under similar conditions. Calculate the percentage of AgNO₃ in the sample.

Reaction $KIO_3 + 2KI + 6HCl$ $3ICl + 3KCl + 3H_2O$ (1992, 4M)

- **40.** 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 1.5 g of the same sample requires 150 mL of (M/10) HCl for complete neutralisation. Calculate the percentage composition of the components of the mixture. (1992, 5M)
- **41.** 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 up to 100.0 mL. An aliquot of 25.0 mL of this solution requires for titration. Calculate the number of electrons taken up by the oxidant in the reaction of the above titration. (1991, 4M)
- **42.** A solution of 0.2 g of a compound containing Cu^{2+} and $C_2O_4^2$ ions on titration with 0.02 M KMnO₄ in presence of H_2SO_4 consumes 22.6 mL of the oxidant. The resultant

solution is neutralised with Na₂CO₃, acidified with dilute acetic acid and treated with excess KI. The liberated iodine requires 11.3 mL of 0.05 M Na₂S₂O₃ solution for complete reduction. Find out the mole ratio of Cu^{2+} to $C_2O_4^2$ in the compound. Write down the balanced redox reactions involved in the above titrations. (1991, 5M)

- **43.** A mixture of $H_2C_2O_4$ (oxalic acid) and NaHC_2O_4 weighing 2.02 g was dissolved in water and the solution made up to one litre. Ten millilitres of the solution required 3.0 mL of 0.1 N sodium hydroxide solution for complete neutralisation. In another experiment, 10.0 mL of the same solution, in hot dilute sulphuric acid medium, required 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, 5M)
- 44. An organic compound X on analysis gives 24.24 per cent carbon and 4.04 per cent hydrogen. Further, sodium extract of 1.0 g of X gives 2.90 g of silver chloride with acidified silver nitrate solution. The compound X may be represented by two isomeric structures Y and Z. Y on treatment with aqueous potassium hydroxide solution gives a dihydroxy compound while Z on similar treatment gives ethanal. Find out the molecular formula of X and gives the structure of Y and Z. (1989, 5M)
- **45.** An equal volume of a reducing agent is titrated separately with 1 M KMnO₄ in acid, neutral and alkaline medium. The volumes of KMnO₄ required are 20 mL in acid, 33.3 mL in neutral and 100 mL in alkaline media. Find out the oxidation state of manganese in each reduction product. Give the

Some Basic Concepts of Chemistry **7**

balanced equations for all the three half reaction. Find out the volume of 1M K₂Cr₂O₇ consumed, if the same volume of the reducing agent is titrated in acid medium. (1989, 5M)

46. 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.

Reaction
$$4Fe^{3+} + N_2H_4$$
 $N_2 + 4Fe^{2+} + 4H^+$
 $MnO_4 + 5Fe^{2+} + 8H^+$ $Mn^{2+} + 5Fe^{3+} + 4H_2O$
(1988, 3M)

- 47. 5 mL of 8 N nitric acid, 4.8 mL of 5 N hydrochloric acid and a certain volume of 17 M sulphuric acid are mixed together and made up to 2 L. 30 mL of this acid mixture exactly neutralise 42.9 mL of sodium carbonate solution containing one gram of Na₂CO₃ 10H₂O in 100 mL of water. Calculate the amount in gram of the sulphate ions in solution. (1985, 4M)
- **48.** 2.68 10⁻³ moles of a solution containing an ion A^{n+} require 1.61 10⁻³ moles of MnO₄ for the oxidation of A^{n+} to AO_3 in acidic medium. What is the value of n? (1984, 2M)
- **49.** 4.08 g of a mixture of BaO and 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 neutralisation. Identify the metal *M*. (1983, 4M)

Answers

55. (i) 37.92, (ii) 0.065, (iii) 7.73m 56. (a) 0.6, (b) 24 58. (i) 0.0179 g, (ii) 10.6 % **59.** (0.437) **61.** 20 % **1.** (d) 2. (c) 3. (b) **4.** (a) 5. (d) **6.** (b) 7. (d) 8. (c) Topic 2 9. (b) **10.** (b) 11. (b) 12. (c) **1.** (d) 2. (b) 3. (a) **4.** (a) **13.** (b) 14. (*) 15. (d) 16. (d) 5. (d) 6. (*) 7. (b) 8. (c) 17. (b) 18. (a) 19. (c) 20. (b) 9. (d) 12. (d) 10. (c) **11.** (a) **21.** (a) 22. (a) 23. (d) 24. (d) 13. (b) 16. (d) 14. (c) 15. (a) 25. (d) 26. (a) 27. (d) 28. (a) **17.** (a) 18. (b) 19. (a) 20. (a) **29.** (a) **30.** (a) 31. (a) 32. (c) 21. (b) 22. (c) 23. (b) 24. (a, b, d) 33. (6.47kg) 34. (126 mg) 35. (495 g) **36.** (4.14 g) 25. (2992) 26. (b) 27.7/3 28. (5) **38.** $(6.023 \ 10^{24})$ 37. (0.4) **39.** C-12 isotope **40**. 31. (1008 g) 33. (8.096 mL) **29.** (2) **30.** (3) (9) **34.** (0.062 M) **35.** (1.334 V) **41.** (1.04 10⁴) 39. (85%) **44.** (5 10¹⁹ m²) **41.** (8) 42. (8 mL) **43.** (2) **45.** (16.67 mL) **46.** (6.5gL⁻¹) **47.** (6.5376 g) **42.** (1:2) **45.** $(55.56 \text{ mol L}^{-1})$ **46.** $(70.91 \ 10^{6}\text{g})$ **47.** $(4.3 \ 10^{-3})$ **50.** (10.42)**48.** (2) 49. (Ca) **51.** (1.7 g) **52.** (55.55 L) **53.** $(9.9 \ 10^{-3})$

Topic 1

Hints & Solutions

Topic 1 Mole Concept

1.	Key Idea To find the mass of <i>A</i> and <i>B</i> in the given question, mole concept is used					
	Number of n	Number of moles(<i>n</i>)		$\frac{\text{given mass } (w)}{\text{molecular mass } (M)}$		
	Compound	Mas	s of <i>A</i> (g)	Mass of B	(g)	
	AB_2		M_A	$2M_B$		
	A_2B_2	2	$2M_A$	$2M_B$		
	We know that,					
	Number of moles (<i>n</i>)	giv molect	en mass (w ular mass ((\overline{M})		
	n M	1 w			(A)	
	Using equation (A), it	can be c	oncluded the	at		
	$5(M_A 2M_A)$	_B) 125	10^{-3} kg		(i)	
	$10(2M_A - 2M_B)$	₃) 300	10 ³ kg		(ii)	
	From equation (i) and	(ii)				
	$\frac{1}{2} \frac{(M_A 2M_B)}{(2M_A 2M_B)}$	$\frac{1}{3}$ $\frac{123}{300}$	5 0			
	On solving the equation, we obtain					
	1	M _A 5	10 ³			
	and M	<i>I</i> _B 10	10 ³			
	So, the molar mass of $5 \ 10^{-3}$ kg mol ⁻¹ and 1	$A(M_A)$ i $B(M_B)$ is	s 10 10 ³ kg	mol ¹ .		
2.	(a) $C_{3}H_{8}(g) + 5O_{2}(g)$ 44g 160g) 30	CO ₂ (g) 4H	₂ O(<i>l</i>)		
	1g of reactant	$\frac{160}{44}$ g o	f O ₂ consum	ed 3.64 g		
	(b) $P_4(s) + 5O_2(g)$ 124g 160g	P_4O_{10}	(s)			
	1 g of reactant	$\frac{160}{124}$ g o	f O_2 consum	ed 1.29 g		
	(c) $4Fe(s) + 3O_2(g)$ $_{244g} \qquad 96g$ 1 g of reactant	$\frac{2\text{Fe}}{\frac{96}{224}}\text{g}$	${}_{2}O_{3}(s)$ of O_{2} consu	med 0.43 g		
	(d) $2Mg(s) + O_2(g)$ $_{48 g} g + O_2(g)$ $_{32 g}$	2Mg	gO(s)			
	1 g of reactant	$\frac{32}{48}$ g of	O_2 consum	ed 0.67 g		

So, minimum amount of O2 is consumed per gram of reactant (Fe) in reaction (c).

3. In eudiometry,

 $\begin{array}{cccc} & \text{C}_{x}\text{H}_{y} & x & \frac{y}{4} & \text{O}_{2} & \begin{array}{c} 300 \text{ K} \\ 1 \text{ atm} & x & \text{CO}_{2} & \frac{y}{2} \text{ H}_{2}\text{O} \end{array}$ $\begin{array}{cccc} 1 \text{ mol} & x & \frac{y}{4} \text{ mol} & x \text{ mol} \end{array}$ $\begin{array}{cccc} 1 \text{ mL} & x & \frac{y}{4} \text{ mL} & x \text{ mL} \end{array}$ 10 mL x $\frac{y}{4}$ 10 mL 10x mLGiven, (i) V_{CO_2} 10x 40 mL x 4 (ii) V_{O_2} 10 x $\frac{y}{4}$ mL = 55 mL

$$10 \ 4 \ \frac{y}{4} \ 55 \qquad [\because x \ 4]$$

$$40 \ \frac{y \ 10}{4} \ 55 \qquad y \ \frac{10}{4} \ 15 \ y \ 15 \ \frac{4}{10} \ 6$$

So, the hydrocarbon $(C_x H_v)$ is $C_4 H_6$.

4. Given, volume 10 mL Molarity 1mM 10³ M Number of millimoles 10 mL 10 3 M 10 2 Number of moles 10⁵ Now, number of molecules Number of moles Avogadro's number 10^{5} 6 10^{23} 6 10^{18} Surface area occupied by 6 10^{18} molecules 0.24 cm² Surface area occupied by 1 molecule $\frac{0.24}{6 \ 10^{18}} \quad 0.04 \quad 10^{-18} \ \mathrm{cm}^2$ As it is given that polar head is approximated as cube. Thus, surface area of cube a^2 , where *a* edge length a^2 4 10 20 cm² a 2 10 ¹⁰ cm 2 pm

Key Idea The reactant which is present in the lesser amount, 5. i.e. which limits the amount of product formed is called limiting reagent.

When 56 g of N_2 10g of H_2 is taken as a combination then dihydrogen (H₂) act as a limiting reagent in the reaction.

 28 g N_2 requires 6 g H_2 gas.

56g of N₂ requires
$$\frac{6g}{28g}$$
 56g 12g of H₂

12 g of H_2 gas is required for 56 g of N_2 gas but only 10 g of H_2 gas is present in option (a). Hence, H_2 gas is the limiting reagent. In option (b), i.e. 35 g of N_2 8 g of H_2 .

As 28 g N_2 requires 6 g of H_2 .

 $35 \text{g N}_2 \text{ requires } \frac{6 \text{g}}{28 \text{g}} \quad 35 \text{g H}_2 \qquad 7.5 \text{ g of } \text{H}_2.$

Here, H_2 gas does not act as limiting reagent since 7.5 g of H_2 gas is required for 35 g of N_2 and 8 g of H_2 is present in reaction mixture. Mass of H_2 left unreacted 8 7.5 g of H_2 . 0.5 g of H_2 .

Similarly, in option (c) and (d), $\rm H_2$ does not act as limiting reagent.

 $\label{eq:Formula} For 14\,g \mbox{ of } N_2 \quad 4\,g \mbox{ of } H_2.$

As we know 28 g of N_2 reacts with 6 g of $H_2.$

14 g of N₂ reacts with $\frac{6}{28}$ 14 g of H₂ 3 g of H₂.

For 28g of $N_2 \quad$ 6g of $H_2,$ i.e. 28g of N_2 reacts with 6g of H_2 (by equation I).

6. Key Idea The percentage composition of a compound is given by the formula.
% composition [Composition of a substance in a compound /

Total composition total of compound] 100

In CH_4 , mole of carbon 1 mole of hydrogen 4

% of carbon by mole in CH₄ $\frac{1}{1-4}$ 100 20%

7. Mole fraction of solute

Solute
$$\frac{n_{\text{Solute}}}{n_{\text{Solute}}} \frac{\frac{W_{\text{Solute}}}{Mw_{\text{Solute}}}}{\frac{W_{\text{Solute}}}{Mw_{\text{Solute}}}} \frac{\frac{W_{\text{Solute}}}{Mw_{\text{Solute}}}}{\frac{W_{\text{Solute}}}{Mw_{\text{Solute}}}}$$
Given, w_{Solute} w_{NaOH} 8 g

$$Mw_{\text{Solute}}$$
 Mw_{NaOH} 40 g mol^{-1}

$$w_{\text{Solvent}}$$
 $w_{\text{H}_2\text{O}}$ 18 g

$$Mw_{\text{Solvent}}$$
 18 g mol^{-1}
Solute NaOH $\frac{8/40}{\frac{8}{40}}$ $\frac{0.2}{0.2}$ 1.2 0.167
Now, molality (m) $\frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$

$$\frac{\frac{W_{\text{Solute}}}{W_{\text{Solvent}}}}{1000}$$
 $\frac{\frac{8}{40}}{18}$ 1000
 $\frac{0.2}{18}$ 1000 11.11 mol kg ⁻¹

Thus, mole fraction of NaOH in solution and molality of the solution respectively are 0.167 and 11.11 mol kg $^{-1}$.

8. Concentration of H_2O_2 is expressed in terms of volume strength, i.e. "volume of O_2 liberated by H_2O_2 at NTP". Molarity is connected to volume strength as: Molarity (*M*) $\frac{x}{11.2}$ or x Molarity 11.2 where, x volume strength So, for 1 M H₂O₂, *x* 1 11.2 11.2 Among the given options, 11.35 is nearest to 11.2. Number of moles of solute (*n*) **9.** Molarity Volume of solution (in L) Also, $n = \frac{w_B(g)}{M_B(gmol^{-1})}$ Molarity $\frac{w_B / M_B}{V}$ Given, w_B mass of solute (B) in g M_B Gram molar mass of $B(C_{12}H_{22}O_{11})$ 342 g mol⁻¹ Molarity 0.1 M Volume (V) 2 L 0.1 $\frac{w_B / 342}{2}$ w_B 0.1 342 2 g 68.4 g **10.** $2 C_{57} H_{110} O_6(s) + 163 O_2(g)$ $110H_2O(l) + 114CO_2(g)$ Molecular mass of $C_{57}H_{110}O_6$ 2 (12 57 1 110 16 6)g 1780g Molecular mass of 110 H_2O 110 (2 16) = 1980 g 1780 g of $C_{57}H_{110}O_6$ produced 1980 g of H_2O . 445g of $C_{57}H_{110}O_6$ produced $\frac{1980}{1780}$ 445 g of H_2O 495of H₉O Number of moles of solute **11.** Molality (m)1000 Mass of solvent (in g) Mass of solute (in g) 1000 Molecular weight of solute mass of solvent (in g) 1000 $\frac{92 \ 1000}{23 \ 1000}$ 4 mol kg⁻¹ M_{Na} $W_{\rm H_2O}$ **12.** Given, abundance of elements by mass oxygen 61.4%, carbon 22.9%, hydrogen 10% and nitrogen 2.6% Total weight of person 75 kg Mass due to ${}^{1}\text{H} = \frac{75 \ 10}{100}$ 7.5 kg ¹H atoms are replaced by ²H atoms, Mass due to 2 H = (7.5 2) kg Mass gain by person 7.5 kg 2*M* Cl H₂O CO₂ 0.01186 mole **13.** *M*₂CO₃ 2HCl Number of moles of M_2 CO₃ reacted Number of moles of CO₂ evolved 0.01186 $[M \text{ molar mass of } M_2 \text{CO}_3]$

$$M = \frac{1}{0.01186} = 84.3 \text{ g mol}^{-1}$$

14.
$$C_x H_y(g) + x + \frac{y}{4} O_2(g)$$
 $x CO_2(g) \frac{y}{30 \text{ mL}} H_2O(l)$
 75 mL $XCO_2(g) \frac{y}{2} H_2O(l)$
 $O_2 \text{ used}$ 20% of 375 75 mL
Inert part of air 80% of 375 300 mL
Total volume of gases CO_2 Inert part of air
 $30 300 330 \text{ mL}$
 $\frac{x}{1} \frac{30}{15} x 2$
 $\frac{x}{4} \frac{y}{4} \frac{75}{15} x \frac{y}{4} 5$
 $x 2, y 12 C_2 H_{12}$
15. We know the molecular weight of $C_8 H_7 SO_3 Na$
 $12 8 1 7 32 16 3 23 206$
we have to find, mole per gram of resin.
 $1g \text{ of } C_8 H_7 SO_3 Na \text{ has number of mole}$
 $\frac{\text{weight of given resin}}{Molecular, weight of resin} \frac{1}{206} \text{ mol}$
Now, reaction looks like
 $2C_8 H_7 SO_3 Na Ca^2 (C_8 H_7 SO_3)_2 Ca 2Na$

 \therefore 2 moles of C₈H₇SO₃Na combines with 1 mol Ca²

1 mole of $C_8H_7SO_3Na$ will combine with $\frac{1}{2}$ mol Ca^2

 $\frac{1}{206}$ mole of C₈H₇SO₃ Na will combine with

$$\frac{1}{2}$$
 $\frac{1}{206}$ mol Ca² $\frac{1}{412}$ mol Ca²

 16. Given, initial strength of acetic acid 0.06 N

 Final strength 0.042 N;
 Volume 50 mL

 Initial millimoles of CH₃COOH 0.06 50 3

Final millimoles of CH₃COOH 0.042 50 2.1 Millimoles of CH₃COOH adsorbed 3 2.1 0.9 mmol

0.9 60 mg 54 mg

17.
$$\frac{n_{O_2}}{n_{N_2}} = \frac{\frac{(m_{O_2})}{(M_{O_2})}}{\frac{(m_{N_2})}{(M_{N_2})}}$$

(100)

where, m_{O_2} given mass of O_2 , m_{N_2} given mass of N_2 , M_{O_2} molecular mass of O_2 , M_{N_2} molecular mass of N_2 , n_{O_2} number of moles of O_2 , n_{N_2} number of moles of N_2

$$\frac{m_{O_2}}{m_{N_2}} \quad \frac{28}{32} \quad \frac{1}{4} \quad \frac{28}{32} \quad \frac{7}{32}$$

18. From the formula,
$$M_f = \frac{M_1V_1 - M_2V_2}{V_1 - V_2}$$

Given, $V_1 = 750$ mL, $M_1 = 0.5$ M
 $V_2 = 250$ mL, $M_2 = 2$ M
 $\frac{750 - 0.5 - 250 - 2}{750 - 250} = \frac{875}{1000} = 0.875$ M

19. Molarity
$$\frac{\text{Moles of solute}}{\text{Volume of solution (L)}}$$

Moles of urea $\frac{120}{60}$ 2
Weight of solution Weight of solvent Weight of solute
 $1000 + 120$ 1120 g
Volume $\frac{1120 \text{ g}}{1.15 \text{ g/mL}} \frac{1}{1000 \text{ mL/L}}$ 0.973 L
Molarity $\frac{2.000}{0.973}$ 2.05M

20. From the given relative abundance, the average weight of Fe can be calculated as

$$4 \quad \frac{54}{100} = 55.95$$

- **21.** 1.0 L of mixture X contain 0.01 mole of each $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$. Also, with AgNO₃, only $[Co(NH_3)_5SO_4]Br$ reacts to give AgBr precipitate as $[Co(NH_3)_5SO_4]Br$ AgNO₃ $[Co(NH_3)_5SO_4]NO_3 + AgBr$ 1.0 mol Excess 1.0 mol With BaCl₂, only $[Co(NH_3)_5Br]SO_4$ reacts giving BaSO₄ precipitate as $[Co(NH_3)_5Br]SO_4$ BaCl₂ $[Co(NH_3)_5Br]Cl_2 + BaSO_4$ 1.0 mol Excess 1 mol Hence, moles of Y and Z are 0.01 each.
- **22.** Number of atoms Number of moles

Avogadro's number (N_A) Number of atoms in 24 g C $= \frac{24}{12}$ $N_A = 2N_A$ Number of atoms in 56 g of Fe $= \frac{56}{56} N_A$ N_A Number of atoms in 27 g of Al $= \frac{27}{27} N_A$ N_A Number of atoms in 108 g of Ag $= \frac{108}{108} N_A$ N_A

Hence, 24 g of carbon has the maximum number of atoms.

23. Mass of an electron = $9.108 10^{31}$ kg

: 9.108 10³¹ kg = 1.0 electron
1 kg
$$\frac{1}{9.108 \ 10^{31}}$$
 electrons $\frac{10^{31}}{9.108} \frac{1}{6.023 \ 10^{23}}$
 $\frac{1}{9.108 \ 6.023} \ 10^8$ mole of electrons

24. Phosphorus acid is a dibasic acid as :

H-P-OH only two replaceable hydrogens

OH

Therefore, normality molarity basicity 0.3 2 0.60

- **25.** Molality is defined in terms of weight, hence independent of temperature. Remaining three concentration units are defined in terms of volume of solution, they depends on temperature.
- **26.** Molality of a solution is defined as number of moles of solute present in 1.0 kg (1000 g) of solvent.

27. The balanced chemical reaction is

$$3BaCl_2 + 2Na_3PO_4$$
 $Ba_3(PO_4)_2 + 6NaCl$

In this reaction, 3 moles of BaCl₂ combines with 2 moles of Na₃PO₄. Hence, 0.5 mole of of BaCl₂ require

0.5 0.33 mole of Na_3PO_4 .

Since, available Na₃PO₄ (0.2 mole) is less than required mole (0.33), it is the limiting reactant and would determine the amount of product $Ba_3(PO_4)_2$.

$$\therefore$$
 2 moles of Na₃PO₄ gives 1 mole Ba₃(PO₄)₂

0.2 mole of Na₃PO₄ would give
$$\frac{1}{2}$$
 0.2 = 0.1 mole Ba₃(PO₄)₂

28. Unlike other metal carbonates that usually decomposes into metal oxides liberating carbon dioxide, silver carbonate on heating decomposes into elemental silver liberating mixture of carbon dioxide and oxygen gas as :

Ag₂CO₃(s) Heat
$$2Ag(s) + CO_2(g) + \frac{1}{2}O_2(g)$$

MW = 276 g $2 \ 108 = 216 \text{ g}$

Hence, 2.76 g of Ag_2CO_3 on heating will give

$$\frac{216}{276}$$
 2.76 2.16g Ag as residue

29. The balanced chemical reaction of zinc with sulphuric acid and NaOH are

$$Zn + H_2SO_4 \qquad ZnSO_4 + H_2(g)$$

$$Zn + 2NaOH + 2H_2O \qquad Na_2[Zn(OH)_4] + H_2(g)$$

Since, one mole of $H_2(g)$ is produced per mole of zinc with both sulphuric acid and NaOH respectively, hydrogen gas is produced in the molar ratio of 1:1 in the above reactions.

20

30. Number of molecules present in 36 g of water

$$\frac{36}{18} N_A = 2N_A$$
Number of molecules present in 28 g of CO $\frac{28}{28} N_A = N_A$
Number of molecules present in 46 g of C₂H₅OH $\frac{46}{46} N_A = N_A$
Number of molecules present in 54 g of N₂O₅ $\frac{54}{108} N_A = 0.5 N_A$

Here, N_A is Avogadro's number. Hence, 36 g of water contain the largest $(2N_A)$ number of molecules.

- 31. In a neutral atom, atomic number represents the number of protons inside the nucleus and equal number of electrons around it. Therefore, the number of total electrons in molecule of CO₂ = electrons present in one carbon atom
 - +2 electrons present in one oxygen atom

$$= 6 + 2 \quad 8 = 22.$$

32.
$$\frac{\text{Weight of a compound in gram}(w)}{\text{Molar mass}(M)} = \text{Number of moles}(n)$$

$$= \frac{\text{Number of molecules } (N)}{\text{Avogadro number } (N_A)}$$
$$\frac{w (O_2)}{32} \quad \frac{N(O_2)}{N_A} \qquad \dots (i)$$

And
$$\frac{w(N_2)}{28} \frac{N(N_2)}{N_A}$$
 ...(ii)
Dividing Eq. (i) by Eq. (ii) gives
 $N(\Omega_2) = w(\Omega_2) - 28$

$$\frac{N(O_2)}{N(N_2)} \quad \frac{w(O_2)}{w(N_2)} \quad \frac{28}{32} \\ \frac{1}{4} \quad \frac{28}{32} \quad \frac{7}{32}$$

33. The equations of chemical reactions occurring during the process are

$$2PbS + 3O_2$$
 $2PbO + 2SO_2$...(i)

By self reduction

$$2PbO + PbS$$
 $3Pb + SO_2$

Thus 3 moles of O₂ produces 3 moles of Pb

i.e. 32 3 96 g of O₂ produces 3 207 621 g of Pb So 1000 g (1kg) of oxygen will produce

From the direct equation,

PbS
$$O_{32 g}$$
 Pb + SO₂
So, 32 g of O₂ gives 207 g of Pb
1 g of O₂ will give $\frac{207}{32}$ g of Pb
1000g of O₂ will give $\frac{207}{32}$ 1000 = 6468.75 g
= 6.46875 kg 6.47kg

34. The balanced equations are

$$\begin{array}{rrrr} (1) \ 2MnCl_2 & 5K_2S_2O_8 & 8H_2O \\ & 2KMnO_4 & 4K_2SO_4 & 6H_2SO_4 & 4HCl \end{array}$$

Given, mass of oxalic acid added =
$$225 \text{mg}$$

So, millimoles of oxalic acid added = $\frac{225}{90}$ 2.5

Now from equation 2

Millimoles of KMnO4 used to react with oxalic acid=1 and Millimoles of MnCl2 required initially=1

Mass of $MnCl_2$ required initially = 1 (55 71) = 126mg **Alternative Method**

m moles of MnCl₂ *m* moles of KMnO₄ *x* (let) and M_{eq} of KMnO₄ M_{eq} of oxalic acid

So,
$$x = 5 - \frac{225}{90} - 2$$

Hence, x = 1

m moles of $MnCl_2$ 1

Hence mass of MnCl₂ (55 71) 1 126 mg.

35. Given,





10 moles of acetophenone.

36. Molar mass of $CuSO_4$ 5H₂O

$$= 63.5 + 32 + 4$$
 16 + 5 18
= 249.5 g

Also, molar mass represents mass of Avogadro number of molecules in gram unit, therefore

$$\therefore$$
 6.023 10²³ molecules of CuSO₄ 5H₂O weigh 249.5 g

$$10^{22}$$
 molecules will weigh $\frac{249.3}{6.023}$ 10^{22} 4.14 g

37. Molarity
$$\frac{\text{Number of moles of solute}}{\text{Volume of solution in litre}}$$
$$\frac{\text{Weight of solute}}{\text{Molar mass}} = \frac{1000}{\text{Volume in mL}}$$
$$\frac{3}{30} = \frac{1000}{250} = 0.4 \text{ M}$$

- **38.** Considering density of water to be 1.0 g/mL, 18 mL of water is 18 g (1.0 mol) of water and it contain Avogadro number of molecules. Also one molecule of water contain
 - 2 (one from each H-atom) + 8 (from oxygen atom) = 10 electrons. 1.0 mole of H₂O contain 10 6.023 10^{23} 6.023 10^{24} electrons.
- **39.** Carbon-12 isotope. According to modern atomic mass unit, one atomic mass unit (amu) is defined as one-twelfth of mass of an atom of C-12 isotope, i.e.

1 amu (u)
$$\frac{1}{12}$$
 weight of an atom of C-12 isotope.
Moles of solute $n_1 = \frac{w_1}{2}$. Moles of solvent $n_2 = \frac{w_2}{2}$

40. Moles of solute,
$$n_1 = \frac{w_1}{m_1}$$
; Moles of solvent, $n_2 = \frac{w_2}{m_2}$
1 (solute) 0.1 and 2 (solvent) 0.9
 $\frac{-1}{2} = \frac{n_1}{n_2} = \frac{w_1}{m_1} = \frac{m_2}{w_2} = \frac{-9}{9}$
Molarity Solute (moles) $\frac{w_1 = 1000}{m_1 (w_1 = w_2)}$
Note Volume Total mass of solution $\frac{w_1 = w_2}{m_1 (w_1 = w_2)}$ mL
Molality Solute (moles) $\frac{w_1 = 1000}{m_1 = w_2}$ mL
Molality Solute (moles) $\frac{w_1 = 1000}{m_1 = w_2}$
Given, molarity molality
hence, $\frac{2000w_1}{m_1 (w_1 = w_2)} = \frac{1000w_1}{m_1 w_2}$
 $\frac{w_2}{w_1 = w_2} = \frac{1}{2} = w_1 = w_2 = 1$
 $\frac{w_1 m_2}{m_1 w_2} = \frac{1}{9} = \frac{m_1(\text{solute})}{m_2} = 9$

41. PLAN This problem can be solved by using concept of conversion of molarity into molality.

Molarity 3.2 M

Let volume of solution 1000 mL Volume of solvent Mass of solvent 1000 0.4 400 g

Since, molarity of solution is 3.2 molar

$$n_{\text{solute}} = \frac{3.2 \text{ mol}}{3.2}$$

Molality (m) $\frac{3.2}{400/1000}$ 8

Hence, correct integer is (8).

42. Mass of HCl in 1.0 mL stock solution

1.25
$$\frac{29.2}{100}$$
 0.365 g

Mass of HCl required for 200 mL 0.4 M HCl 200 0.4 36.5 0.08 36.5 g 1000 0.365 g of HCl is present in 1.0 mL stock solution. 0.08 36.5 g HCl will be present in $\frac{0.08 \ 36.5}{0.21}$ 8.0 mL 0.365 **43.** Partial pressure of N_2 0.001 atm, $T = 298 \text{ K}, V = 2.46 \text{ dm}^3$. From ideal gas law : *pV nRT* $n(N_2) = \frac{pV}{RT} = \frac{0.001 - 2.46}{0.082 - 298}$ 10 7 10^{-7} Number of molecules of $N_2 = 6.023 = 10^{23}$ 10^{16} = 6.023 Now, total surface sites available $= 6.023 \quad 10^{14} \quad 1000 = 6.023 \quad 10^{17}$ Surface sites used in adsorption $=\frac{20}{100}$ 6.023 10^{17} $2 \quad 6.023 \quad 10^{16}$ Sites occupied per molecules $\frac{\text{Number of sites}}{\text{Number of molecules}} \quad \frac{2 \quad 6.023 \quad 10^{16}}{6.023 \quad 10^{16}} = 2$ **44.** Initial millimol of $CH_3COOH = 100$ 0.5 = 50millimol of CH3COOH remaining after adsorption 100 0.49 49 millimol of CH_3COOH adsorbed = 50 - 49 = 1number of molecules of CH₃COOH adsorbed $\frac{1}{1000} \quad 6.023 \quad 10^{23} \quad 6.023 \quad 10^{20}$ Area covered up by one molecule $\frac{3.01 \quad 10^2}{6.02 \quad 10^{20}}$ 5 10¹⁹ m² **45.** Mass of 1.0 L water = 1000 gMolarity = $\frac{1000}{18}^{\circ}$ 55.56 mol L⁻¹ **46.** Volume of one cylinderical plant virus $r^2 l$ $3.14(75 \ 10^{8})^{2}$ 5000 10^{8} cm^{3} 8.83 10^{17} cm^{3} Mass of one virus = $\frac{\text{Volume of a virus}}{\text{Specific volume}}$ $\frac{8.83 \quad 10^{-17} \text{ cm}^3}{0.75 \text{ cm}^3 \text{ g}^{-1}} = 1.1773 \quad 10^{-16} \text{ g}$ Molar mass of virus Mass of one virus Avogadro's number 1.1773 10 16 6.023 10 23 g $= 70.91 \quad 10^6 \text{ g}$

- **47.** Molar mass of Glauber's salt (Na_2SO_4 10H₂O)
 - 23 2 32 64 10 18 322g

 $\begin{array}{l} \text{Mole of Na}_2\text{SO}_4 \ 10\text{H}_2\text{O in 1.0 L solution} = \frac{80.575}{322} = 0.25 \\ \text{Molarity of solution} = 0.25 \text{ M} \\ \text{Also, weight of 1.0 L solution} = 1077.2 \text{ g} \\ \text{weight of Na}_2\text{SO}_4 \text{ in 1.0 L solution} \ 0.25 \ 142 \ 35.5 \text{ g} \\ \text{Weight of water in 1.0 L solution} \ 1077.2 - 35.5 \ 1041.7 \text{ g} \\ \text{Molality} \ \frac{0.25}{1041.7} \ 1000 = 0.24 \text{ m} \\ \text{Mole of Na}_2\text{SO}_4 \ \frac{\text{Mole of Na}_2\text{SO}_4}{\text{Mole of Na}_2\text{SO}_4} \ \frac{0.25}{1041.7} \\ \frac{0.25}{1.25} \ \frac{1041.7}{1.8} \\ 4.3 \ 10^{-3}. \end{array}$

48. Compound *B* forms hydrated crystals with $Al_2(SO_4)_3$. Also, *B* is formed with univalent metal on heating with sulphur. Hence, compound *B* must has the molecular formula M_2SO_4 and compound *A* must be an oxide of *M* which reacts with sulphur to give metal sulphate as

$$+ S \qquad M_2 SO_2$$

 $\therefore 0.321 \text{ g sulphur gives } 1.743 \text{ g of } M_2 \text{SO}_4$ 32.1 g S (one mole) will give 174.3 g $M_2 \text{SO}_4$

A

52.1 g S (one mole) will give 1/4.3 g M_2 SO Therefore, molar mass of M_2 SO₄ = 174.3 g

174.3 = 2 Atomic weight of M 32.1 + 64

Atomic weight of M = 39, metal is potassium (K)

 K_2SO_4 on treatment with aqueous $Al_2(SO_4)_3$ gives potash-alum. $K_2SO_4 + Al_2(SO_4)_3 + 24H_2O$ $K_2SO_4Al_2(SO_4)_3 24H_2O$ If the metal oxide *A* has molecular formula MO_x , two moles of it combine with one mole of sulphur to give one mole of metal sulphate as

$$\begin{array}{ccc} 2\mathrm{KO}_{x} & \mathrm{S} & \mathrm{K}_{2}\mathrm{SO}_{4} \\ x & 2, \text{ i.e. } A \text{ is } \mathrm{KO}_{2}. \end{array}$$

49. The reaction involved is

 $3Pb(NO_3)_2 + Cr_2(SO_4)_3$ $3PbSO_4(s) + 2Cr(NO_3)_3$

millimol of $Pb(NO_3)_2$ taken 45 0.25 = 11.25

millimol of $Cr_2(SO_4)_3$ taken = 2.5

Here, chromic sulphate is the limiting reagent, it will determine the amount of product.

: 1 mole $Cr_2(SO_4)_3$ produces 3 moles PbSO₄. 2.5 millimol $Cr_2(SO_4)_3$ will produce 7.5 millimol PbSO₄. Hence, mole of PbSO₄ precipitate formed = 7.5 10⁻³

Also, millimol of Pb(NO₃)₂ remaining unreacted 11.25 - 7.50 = 3.75Molarity of Pb(NO₃)₂ in final solution

$$\frac{\text{millimol of Pb(NO_3)}_2}{\text{Total volume}} \quad \frac{3.75}{70} = 0.054 \text{ M}$$

Also, millimol of $Cr(NO_3)_2$ formed

= 2 millimol of $Cr_2(SO_4)_3$ reacted

Molarity of
$$Cr(NO_3)_2 = \frac{5}{70}$$
 0.071 M

- **50.** 93% H₂SO₄ solution weight by volume indicates that there is 93 g H₂SO₄ in 100 mL of solution.
 - If we consider 100 mL solution, weight of solution = 184 g Weight of H_2O in 100 mL solution = 184 – 93 = 91 g Males of solute

Molality
$$\frac{\text{Moles of solute}}{\text{Weight of solvent (g)}}$$
 1000
 $\frac{93}{98} \frac{1000}{91} = 10.42$

51. Heating below 600°C converts $Pb(NO_3)_2$ into PbO but to NaNO₃ into NaNO₂ as

 $\begin{array}{cccc} Pb(NO_3)_2 & PbO(s) + 2NO_2 & +\frac{1}{2}O_2 \\ MW : & 330 & 222 \\ NaNO_3 & NaNO_2(s) + \frac{1}{2}O_2 \\ MW : & 85 & 69 \\ Weight loss & 5 & \frac{28}{100} & 1.4 \text{ g} \end{array}$

Weight of residue left 5 - 1.4 3.6 g Now, let the original mixture contain x g of Pb(NO₃)₂. \therefore 330 g Pb(NO₃)₂ gives 222 g PbO

$$x \text{ g Pb(NO_3)}_2$$
 will give $\frac{222 x}{330}$ g PbC

Similarly, 85 g NaNO₃ gives 69 g NaNO₂

$$(5-x) \text{ g NaNO}_3 \text{ will give } \frac{69(5-x)}{85} \text{ g NaNO}_2$$

Residue : $\frac{222 x}{330} = \frac{69(5-x)}{85} = 3.6 \text{ g}$
Solving for x gives, $x = 3.3 \text{ g Pb(NO}_3)_2$
NaNO₃ = 1.7 g.

52. Reactions involved are

 $\begin{array}{ll} C_2H_6+Br_2 & C_2H_5Br+HBr\\ 2C_2H_5Br+2Na & C_4H_{10}+2NaBr \end{array}$

Actual yield of C_4H_{10} 55 gwhich is 85% of theoretical yield. Theoretical yield of C H $55 \ 100 = 64.70$ =

Theoretical yield of
$$C_4H_{10} = 64.70 \text{ g}$$

Also, 2 moles (218 g) C_2H_5Br gives 58 g of butane. 64.70 g of butane would be obtained from

$$\frac{2}{58}$$
 64.70 2.23 moles C₂H₅Br

Also yield of bromination reaction is only 90%, in order to have 2.23 moles of C_2H_5Br , theoretically

$$\frac{2.23 \quad 100}{90}$$
 2.48 moles of C₂H₅Br required

Therefore, moles of C_2H_6 required = 2.48

Volume of C_2H_6 (NTP) required = 2.48 22.4 = 55.55 L.

53. Moles of sugar =
$$\frac{34.2}{342}$$
 0.1

Moles of water in syrup =
$$214.2 - 34.2 = 180$$
 g
Therefore, (i) Molality $\frac{\text{Moles of solute}}{\text{Weight of Solvent (g)}}$ 1000
 $\frac{0.1}{180}$ 1000 0.55

(ii) Mole fraction of sugar	Mole of sugar
	Mole of sugar + Mole of water
	$\frac{0.1}{0.1 \ 10}$ 9.9 10 ³

54. From the given elemental composition, empirical formula can be derived as :

Element	С	Н	0
Weight %	69.77	11.63	18.60
Mole %	5.81	11.63	1.1625 (obtained by dividing from M)
Simple ratio	5	10	1

Hence, empirical formula is $C_5H_{10}O$ and empirical formula weight is 86.

Since, empirical formula weight and molecular weight both are (86), empirical formula is the molecular formula also.

Also, the compound does not reduce Fehling's solution, therefore it is not an aldehyde, but it forms bisulphite, it must be a ketone.

Also, it gives positive iodoform test, it must be a methyl ketone.

Based on the above information, the compound may be one of the following :

$$\begin{array}{c} CH_3CH_2CH_2 {-\!\!\!\!-\!\!\!-\!\!\!C-\!\!\!-\!\!CH_3} & \text{or} \quad CH_3 {-\!\!\!\!-\!\!\!-\!\!CH_-\!\!\!-\!\!C-\!\!\!-\!\!CH_3} \\ \hline & \text{2-pentanone} & \text{3-methyl-2-butanone} \end{array}$$

Weight of Na₂S₂O₃
$$\frac{3}{5}$$
 158 $\frac{4}{4}$ g
Weight percentage of Na₂S₂O₃ $\frac{474}{1250}$ 100 $\frac{37.92}{100}$

(ii) Weight of H₂O in 1 L solution 1250 474 776 g

Mole fraction of Na₂S₂O₃
$$\frac{3}{3} \frac{776}{18}$$
 0.065
(iii) Molality of Na $\frac{3}{776}$ 100 7.73 m

56. (a) After passing through red-hot charcoal, following reaction occurs

$$C(s) + CO_2(g)$$
 $2CO(g)$

If the 1.0 L original mixture contain x litre of CO₂, after passing from tube containing red-hot charcoal, the new volumes would be :

$$2x$$
 (volume of CO obtained from CO₂) 1

-
$$x$$
(original CO) 1 x 1.6 (given)

Hence, original 1.0 L mixture has 0.4 L CO and 0.6 L of CO₂, i.e. 40% CO and 60% CO₂ by volume.

(b) According to the given information, molecular formula of the compound is M_3N_2 . Also, 1.0 mole of compound has 28 g of nitrogen. If X is the molar mass of compound, then :

$$\begin{array}{rrrr} X & \frac{28}{100} & 28 \\ X & 100 & 3 & \text{Atomic weight of } M + 28 \\ \text{Atomic weight of } M & \frac{72}{3} & 24 \end{array}$$

57. In the present case, V = n (:: all the volumes are measured under identical conditions of temperature and pressure) Hence, the reaction stoichiometry can be solved using volumes as :

$$C_x H_y(g) = x - \frac{y}{4} O_2(g) = x CO_2(g) - \frac{y}{2} H_2 O(l)$$

- volume of $CO_2(g) + O_2(g)$ (remaining unreacted) = 25 Volume of $CO_2(g)$ produced
 - $= 10 \text{ mL} (15 \text{ mL O}_2 \text{ remaining})$
- $\therefore 1 \text{ mL } C_x H_y \text{ produces } x \text{ mL of } CO_2$ 5 mL $C_x H_y \text{ will produce 5 } x \text{ mL of } CO_2 = 10 \text{ mL}$ x = 2

Also, 1 mL C_xH_y combines with
$$x = \frac{y}{4}$$
 mL of O₂

5 mL C_xH_y will combine with 5 x $\frac{y}{4}$ mL of O₂

5 x
$$\frac{y}{4}$$
 15 (15 mL of O₂ out of 30 mL)

(remaining unreacted)

- y 4, hence hydrocarbon is C₂H₄.
- **58.** Oxides of sodium and potassium are converted into chlorides according to following reactions :

 $\begin{array}{ll} Na_2O+2HCl & 2NaCl+H_2O \\ K_2O+2HCl & 2KCl+H_2O \end{array}$

Finally all the chlorides of NaCl and KCl are converted into AgCl, hence

moles of (NaCl + KCl) = moles of AgCl(one mole of either NaCl or KCl gives one mole of AgCl) Now, let the chloride mixture contain *x* g NaCl.

$$\frac{x}{58.5} = \frac{0.118}{74.5} \frac{x}{143.5}$$
Solving for x gives x = 0.0338 g (mass of NaCl)
Mass of KCl = 0.118 - 0.0338
= 0.0842 g
Also, moles of Na₂O = $\frac{1}{2}$ = moles of NaCl
Mass of Na₂O = $\frac{1}{2}$ = $\frac{0.0338}{58.5}$ = 62 = 0.0179 g
Similarly, mass of K₂O = $\frac{1}{2} = \frac{0.0842}{74.5}$ = 94 = 0.053 g
Mass % of Na₂O = $\frac{0.0179}{0.5}$ = 100 = 3.58%
Mass % of K₂O = $\frac{0.053}{0.5}$ = 100 = 10.6%

59. From the vapour density information
Molar mass Vapour density 2 (∵ Molar mass of H₂ 2)
38.3 2 76.6

Now, let us consider 1.0 mole of mixture and it contains x mole of NO₂.

Moles of NO₂ in mixture
$$\frac{100}{76.6}$$
 0.3348 0.437

- **60.** Most of the elements found in nature exist as a mixture of isotopes whose atomic weights are different. The atomic weight of an element is the average of atomic weights of all its naturally occurring isotopes.
- **61.** Average atomic weight

e.g.

$$\begin{array}{r}
\begin{array}{r}
\begin{array}{r}
\begin{array}{r}
\begin{array}{r}
\begin{array}{r}
100\\
10.81\\ \hline 10.01x \\ 100\\ \hline 100\\ \hline \end{array} \\ x \\ 20\%\\ \end{array}
\end{array}$$

Therefore, natural boron contains 20% (10.01) isotope and 80% other isotope.

Topic 2 Equivalent Concept, Neutralisation and Redox Titration

1. In disproportionation reactions, same element undergoes oxidation as well as reduction.

$$2CuBr \longrightarrow CuBr_2 + Cu$$

Here, CuBr get oxidised to $CuBr_2$ and also it get reduced to Cu. Other given reactions and their types are given below.

Reduction

$$2 \underset{\text{Oxidation}}{\overset{+7}{\text{MnO}_4^-}} +10\overline{I} + 16 \text{ H}^+ \xrightarrow{2} 2\text{Mn}^{+2} + 5\text{I}_2 + 8\text{H}_2\text{O}$$

In the given reaction, MnO_4 get oxidised to Mn^2 and I get reduced to I_2 . It is an example of redox reaction. The reaction takes place in acidic medium.

$$2KMnO_4 \qquad \qquad K_2MnO_4 \quad MnO_2 \quad O_2$$

The given reaction is an example of decomposition reaction. Here, one compound split into two or more simpler compounds, atleast one of which must be in elemental form.

The given reaction is an example of displacement reaction. In this reaction, an atom (or ion) replaces the ion (or atom) of another element from a compound.

2. The graph that shows the correct change of pH of the titration mixture in the experiment is



In this case, both the titrants are completely ionised.

$$HCl + NaOH \implies NaCl + H_2O$$

As H is added to a basic solution, $[OH^{\circ}]$ decreases and [H] increases. Therefore, pH goes on decreasing. As the equivalence point is reached, $[OH^{\circ}]$ is rapidly reduced. After this point $[OH^{\circ}]$ decreases rapidly and pH of the solution remains fairly constant. Thus, there is an inflexion point at the equivalence point.

The difference in the volume of NaOH solution between the end point and the equivalence point is not significant for most of the commonly used indicators as there is a large change in the pH value around the equivalence point. Most of them change their colour across this pH change.

3. 100 mL (cm³) of hexane contains 0.27 g of fatty acid. In 10 mL solution, mass of the fatty acid,

$$m = \frac{0.27}{100} = 10 = 0.027 \,\mathrm{g}$$

Density of fatty acid, $d = 0.9 \text{ g cm}^{-3}$

Volume of the fatty acid over the watch glass,

$$V = \frac{m}{d} = \frac{0.027}{0.9} = 0.03 \text{ cm}^3$$

Let, height of the cylindrical monolayer $h \operatorname{cm}$

: Volume of the cylinder Volume of fatty acid



4. The oxidation of a mixture of one mole of each of FeC_2O_4 , Fe_2 (C_2O_4)₃ $FeSO_4$ and

 $\operatorname{Fe}_2(\operatorname{SO}_4)_3$ in acidic medium with KMnO_4 is as follows :

$$FeC_2O_4$$
 KMnO_4
 Fe^{3^+}
 CO_2
 Mn^2
 ...(i)

 $Fe_2(C_2O_4)_3$
 KMnO_4
 Fe^{3^+}
 CO_2
 Mn^2
 ...(ii)

 $FeSO_4$
 KMnO_4
 Fe^{3^+}
 SO_2^+
 Mn^2
 ...(iii)

Change in oxidation number of Mn is 5. Change in oxidation number of Fe in (i), (ii) and (iii) are 3, 6, 1, respectively.

$$\begin{array}{rrrr} n_{\rm eq} {\rm KMnO_4} & n_{\rm eq} [{\rm FeC_2O_4} & {\rm Fe_2} \, ({\rm C_2O_4})_3 & {\rm FeSO_4}] \\ n & 5 & 1 & 3 & 1 & 6 & 1 & 1 \\ n & 2 & & & \end{array}$$

5. Given, $W_{Ca(HCO_3)_2}$ 0.81g

$$W_{Mg_{(HCO_3)_2}} = 0.73 \text{ g}$$

 $M_{Ca_{(HCO_3)_2}} = 162 \text{ g mol}^{-1}$,
 $M_{Mg(HCO_3)_2} = 146 \text{ mol}^{-1}$

 $V_{\rm H_2O} = 100 \text{mL}$ Now, $n_{\rm eq}({\rm CaCO_3}) = n_{\rm eq}[{\rm Ca(HCO_3)_2}] = n_{\rm eq}[{\rm Mg(HCO_3)_2}]$ $\frac{W}{100} = 2 = \frac{0.81}{162} = 2 = \frac{0.73}{146} = 2$ $\frac{W}{100} = 0.005 = 0.005$ W = 0.01 = 100 = 1Thus, hardness of water sample = $\frac{1}{100} = 10^6 = 10,000 \text{ ppm}$

6. The reaction takes place as follows,

$$H_2C_2O_4 + 2NaOH$$
 $Na_2C_2O_4 + 2H_2O$

Now, 50 mL of 0.5 M $H_2C_2O_4$ is needed to neutralize 25 mL of NaOH.

Meq of $H_2C_2O_4$ = Meq of NaOH

50 0.5 2 25
$$M_{\text{NaOH}}$$
 1
 M_{NaOH} 2M
Now, molarity $\frac{\text{Number of moles}}{\text{Volume of solution (in L)}}$
 $\frac{\text{Weight / molecular mass}}{\text{Volume of solution (in L)}}$
2 $\frac{W_{\text{NaOH}}}{40} \frac{1000}{50}$
 $w_{\text{NaOH}} = \frac{2 40 50}{1000} 4g$

Thus, (*) none option is correct.

7. The reaction of HCl with Na_2CO_3 is as follows:

2HCl Na₂CO₃ 2NaCl H₂O CO₂
We know that,
$$M_{eq}$$
 of HCl M_{eq} of Na₂CO₃
$$\frac{25}{1000} \ 1 \ M_{HCl} \quad \frac{30}{1000} \quad 0.1 \ 2$$
$$M_{HCl} \quad \frac{30 \ 0.2}{25} \quad \frac{6}{25} M$$
The reaction of HCl with NaOH is as follows:

$$\frac{6}{25} \quad 1 \quad \frac{V}{1000} \quad \frac{30}{1000} \quad 0.2 \quad 1$$
$$V \quad 25 \,\mathrm{mL}$$

8. Reaction of oxalate with permanganate in acidic medium.

	$5\mathrm{C}_2\mathrm{O}_4^2$	2	2Mr	nO_4	$10 \text{CO}_2 2 \text{Mn}^2$	$8H_2O$
<i>n</i> -factor :	(4	3)	2	2	(7 2) 5	
Number of mol	e		5		2	10

 $5C_2O_4^{2-}$ ions transfer 10*e* to produce 10 molecules of CO_2 .

So, number of electrons involved in producing 10 molecules of CO_2 is 10. Thus, number of electrons involved in producing 1 molecule of CO_2 is 1.

9. We can calculate the simplest whole number ratio of C and H from the data given, as

Element	Relative mass	Molar mass	Relative mole	Simplest whole number ratio
С	6	12	$\frac{6}{12}$ 0.5	$\frac{0.5}{0.5}$ 1
Н	1	1	$\frac{1}{1}$ 1	$\frac{1}{0.5}$ 2

Alternatively this ratio can also be calculated directly in the terms of x and y as

 $\frac{12x}{y} = \frac{6}{1}$ (given and molar mass of C 12, H 1)

Now, after calculating this ratio look for condition 2 given in the question i.e. quantity of oxygen is half of the quantity required to burn one molecule of compound $C_x H_y$ completely to CO_2 and H_2O . We can calculate number of oxygen atoms from this as consider the equation.

$$C_x H_y = x - \frac{y}{4} O_2 = x CO_2 - \frac{y}{2} H_2 O_2$$

Number of oxygen atoms required 2 $x \frac{y}{4} = 2x \frac{y}{2}$

Now given, $z \quad \frac{1}{2} \quad 2x \quad \frac{y}{2} \qquad x \quad \frac{y}{4}$

Here we consider x and y as simplest ratios for C and H so now putting the values of x and y in the above equation.

 $z \quad x \quad \frac{y}{4} \quad 1 \quad \frac{2}{4} \quad 1.5$

Thus, the simplest ratio figures for x, y and z are x 1, y 2 and z 1.5

Now, put these values in the formula given i.e. $C_x H_y O_z C_1 H_2 O_{1.5}$

So, empirical formula will be $[C_1H_2O_{1.5}] = C_2H_4O_3$

10. Methyl orange show Pinkish colour towards more acidic medium and yellow orange colour towards basic or less acidic media. Its working pH range is

Weak base have the pH range greater than 7. When methyl orange is added to this weak base solution it shows yellow orange colour.

Now when this solution is titrated against strong acid the pH move towards more acidic range and reaches to end point near 3.9 where yellow orange colour of methyl orange changes to Pinkish red resulting to similar change in colour of solution as well.



11. H_2O_2 acts as an oxidising as well as reducing agent, because oxidation number of oxygen in H_2O_2 is 1. So, it can be oxidised to oxidation state 0 or reduced to oxidation state -2.

 H_2O_2 decomposes on exposure to light. So, it has to be stored in plastic or wax lined glass bottles in dark for the prevention of exposure. It also has to be kept away from dust.

12. *n*-factor of dichromate is 6.

Also, *n*-factor of Mohr's salt is 1 as :

$$\frac{\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4}{\text{Mohr's salt}} 6\text{H}_2\text{O} \quad \overset{\text{O.A}}{\longrightarrow} \text{Fe}^{3+}$$

 \therefore 1 mole of dichromate = 6 equivalent of dichromate.

6 equivalent of Mohr's salt would be required. Since, *n*-factor of Mohr's salt is 1, 6 equivalent of it would also be equal to 6 moles.

Hence, 1 mole of dichromate will oxidise 6 moles of Mohr's salt.

13. The following reaction occur between $S_2O_3^2$ and $Cr_2O_7^2$:

$$26H^{+} + 3S_{2}O_{3}^{2} + 4Cr_{2}O_{7}^{2} \qquad 6SO_{4}^{2} = 8Cr^{3+} + 13H_{2}O$$

Change in oxidation number of $Cr_2O_7^2$ per formula unit is 6 (it is always fixed for $Cr_2O_7^2$).

Hence, equivalent weight of $K_2 Cr_2 O_7 = \frac{Molecular weight}{6}$

14. It is an example of disproportionation reaction because the same species (ClO) is being oxidised to ClO_3 as well as reduced to Cl .

15. Oxalic acid dihydrate
$$H_2C_2O_4$$
 $2H_2O$: mw = 126

It is a dibasic acid, hence equivalent weight =
$$63$$

Normality
$$\frac{0.5}{63} + \frac{1000}{250} = 0.4 \text{ N}$$

 $N_1V_1 + N_2V_2$
 $0.1 + V_1 + 0.4 + 10$
 $V_1 + 40 \text{ mL}$

16. In MnO_4 , oxidation state of Mn is +7 In $Cr(CN)_6^3$, oxidation state of Cr is +3 In NiF_6^2 , Ni is in + 4 oxidation state. In CrO_2Cl_2 , oxidation state of Cr is +6.

Hence.

- 17. In S_8 , oxidation number of S is 0, elemental state. In S_2F_2 , F is in – 1 oxidation state, hence S is in + 1 oxidation state. In H_2S , H is in +1 oxidation state, hence S is in – 2 oxidation state.
- **18.** The balanced redox reaction is :

3MnO₄ 5FeC₂O₄ 24H

$$(n^{2+} + 5Fe^{3+} + 10CO_2 - 12H_2O)$$

$$\therefore$$
 5 moles of FeC₂O₄ require 3 moles of KMnO₄

mole of
$$\text{FeC}_2\text{O}_4$$
 will require $\frac{3}{5}$ mole of KMnO₄.

19. The balanced chemical reaction is :

$$2MnO_4 + 5SO_3^2 + 6H^+ \qquad 2Mn^{2+} \quad 5SO_4^2 + 3H_2O$$

$$\therefore 5 \text{ moles } SO_3^2 \text{ reacts with } 2 \text{ moles of } KMnO_4$$

$$1 \text{ mole of } SO_3^2 \text{ will react with } \frac{2}{5} \text{ mole } KMnO_4.$$

20. The balanced redox reaction is :

$$2MnO_4 = 5C_2O_4^2 + 16H^+ = 2Mn^{2+} = 10CO_2 = 16H_2O_2$$

Hence, the coefficients of reactants in balanced reaction are 2, 5 and 16 respectively.

21. Volume strength of H_2O_2 Normality 5.6 1.5 5.6 8.4 V

In Ba(H₂PO₂)₂, oxidation number of Ba is +2. Therefore
H₂PO₂ : 2 (+1) +
$$x$$
 + 2 (2) 1
 x 1

23. Equivalent weight in redox system is defined as :

22.

$$E \quad \frac{\text{Molar mass}}{n\text{-factor}}$$

Here *n*-factor is the net change in oxidation number per formula unit of oxidising or reducing agent. In the present case, *n*-factor is 2 because equivalent weight is half of molecular weight. Also,

<i>n</i> -factor MnSO ₄	$\frac{1}{2}$ Mn ₂ O ₃	1 (+ 2	+3)
$MnSO_4$	MnO_2	2 (+ 2	+ 4)
$MnSO_4$	MnO_4	5 (+ 2	+ 7)
$MnSO_4$	MnO_4^2	4 (+ 2	+ 6)

Therefore, $MnSO_4$ converts to MnO_2 .

24. PLAN This problem includes concept of redox reaction. A redox reaction consists of oxidation half-cell reaction and reduction half-cell reaction. Write both half-cell reactions, i.e. oxidation half-cell reaction and reduction half-cell reaction. Then balance both the equations.

Now determine the correct value of stoichiometry of H_2SO_4 . Oxidation half-reaction, 2 I I_2 2e ...(i)

Here, I is converted into I_2 . Oxidation number of I is increasing from -1 to 0 hence, this is a type of oxidation reaction.

Reduction half-reaction

6H

$$ClO_3$$
 6e Cl $3H_2O$...(ii)

• Here, H₂O releases as a product. Hence, option (d) is correct.

Multiplying equation (i) by 3 and adding in equation (ii) 6I ClO₃ 6H Cl 3I₂ + 3H₂O

$$6I \quad ClO_3 \quad 6H_2SO_4 \qquad Cl \quad 3I_2 \quad 3H_2O \quad 6HSO_4$$

• Stoichiometric coefficient of HSO_4 is 6.

Hence, option (a), (b) and (d) are correct.

25. Balanced equations of reactions used in the problem are as follows

(i)
$$(NH_4)_2SO_4$$
 Ca(OH)₂ CaSO₄ 2H₂O 2NH₃
1 mol 132 g 12 mol 2 mol 172 g (2 17) = 34 g
(ii) NiCl 6H O 6NH [Ni(NH)] Cl 6H O

Now, in Eq. (i)

if, 1584 g of ammonium sulphate is used.

i.e., 1584 g (NH₄)₂SO₄
$$\frac{1584}{132}$$
 12 mol

So, according to the Eq. (i) given above 12 moles of $(\rm NH_4)_2 SO_4$ produces

(a) 12 moles of gypsum

(b) 24 moles of ammonia

Here, 12 moles of gypsum 12 172 2064 g

and $24 \text{ moles of } NH_3 24 17 408 g$

Further, as given in question,

24 moles of NH_3 produced in reaction (i) is completly utilised by 952g or 4 moles of $NiCl_2$ $6H_2O$ to produce 4 moles of $[Ni(NH_3)_6]$ Cl_2 .

So, 4 moles of $[Ni(NH_3)_6]$ Cl₂ 4 232 928gms

Hence, total mass of gypsum and nickel ammonia coordination compound [Ni(NH₃)₆] Cl₂ 2064 928 2992

- **26.** Both assertion and reason are factually true but the reason does not exactly explain the assertion. The correct explanation is, methyl orange and phenolphthalein changes their colour at different pH.
- **27.** If *x* is the oxidation state of Cu then :

3 2 2 3x 7 (2) 0
$$x \frac{1}{2}$$

28. $Na_2S_4O_6$ is a salt of $H_2S_4O_6$ which has the following structure

$$HO \xrightarrow{||}_{O} S \xrightarrow{(0)}_{O} S \xrightarrow{||}_{O} OH$$

Difference in oxidation number of two types of sulphur = 5

29. Only F and Na show only one non-zero oxidation state.

0	$0, 0^2, 0^2;$
Cl	1 to 7
Ν	3 to 5
Р	3 to 5
Sn	2, 4
Tl	1, 3 (rare but does exist)
Ti	2, 3, 4

- **30.** Average titrate value is 25.15, but the number of significant figure cannot be greater than the same in either of them being manipulated.
- **31.** The balanced reaction is

Meq of MnO₂ formed Meq of oxalate 4
Meq of KMnO₄ in 20 mL 4
Normality of H₂O₂ 20 4
Normality of H₂O₂ 0.20 N
Molarity of H₂O₂
$$\frac{0.20}{2}$$
 0.10 M
The balanced reactions are

 $2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \qquad 2MnSO_4 + 5O_2$ $+ K_2SO_4 + 8H_2O$ $MnO_2 + Na_2C_2O_4 + 2H_2SO_4 \qquad MnSO_4 + Na_2SO_4$ $+ 2CO_2 + 2H_2O$

- **33.** The balanced chemical reaction is $CuCO_3 H_2SO_4 CuSO_4 H_2O CO_2$ millimol of CuCO₃ $\frac{0.5 \ 1000}{123.5} = 4.048$ Millimol of H₂SO₄ required 4.048 \therefore Millimol Molarity Volume (in mL) Volume $\frac{4.048}{0.50}$ 8.096 mL
- **34.** The redox reaction involved are

$$\begin{split} & IO_3 + 5I + 6H^+ & 3I_2 + 3H_2O \\ & I_2 + 2S_2O_3^2 & 2I + S_4O_6^2 \\ & \text{millimol of KIO}_3 \text{ used } \frac{0.1}{214} & 1000 & 0.467 \\ & \text{millimol of } I_2 \text{ formed } 3 & 0.467 & 1.4 \\ & \text{millimol of } Na_2S_2O_3 \text{ consumed } 2 & 1.4 & 2.8 \\ & \text{Molarity of } Na_2S_2O_3 & \frac{2.8}{45} & 0.062 \text{ M} \end{split}$$

- **35.** Meq of H_2O_2 Meq of I_2 Meq of $Na_2S_2O_3$ If N is normality of H_2O_2 , then N 25 0.3 20 N 0.24 Volume strength N 5.6 1.334 V
- **36.** Let the original sample contains x millimol of Fe_3O_4 and y millimol of Fe_2O_3 . In the first phase of reaction,

Meq of MnO_4 Meq of Fe^{2+}

$$3x \ 2y \ 12.8 \ 0.25 \ 5 \ 2 \ 32 \ ...(ii)$$

Solving Eqs. (i) and (ii), we get

x 4.5 and y 9.25
Mass of Fe₃O₄
$$\frac{4.5}{1000}$$
 232 = 1.044 g
% mass of Fe₃O₄ $\frac{1.044}{3}$ 100 = 34.80%
Mass of Fe₂O₃ $\frac{9.25}{1000}$ 160 = 1.48 g
% mass of Fe₂O₃ $\frac{1.48}{3}$ 100 49.33%

37. The reaction involved in the explosion process is

$$\begin{array}{rcl} \operatorname{CO}(g) &+& \frac{1}{2} \operatorname{O}_2(g) && \operatorname{CO}_2(g) \\ x & \operatorname{mL} && \frac{x}{2} & \operatorname{mL} && x & \operatorname{mL} \\ \operatorname{CH}_4(g) &+& 2\operatorname{O}_2(g) && \operatorname{CO}_2(g) + 2\operatorname{H}_2\operatorname{O}(l) \\ y & \operatorname{mL} && 2 & y & \operatorname{mL} && y & \operatorname{mL} \end{array}$$

The first step volume contraction can be calculated as : $x \quad \frac{x}{2} \quad y \quad 2y \quad (x \quad y) \quad 13$

$$x \quad 4y \quad 26 \qquad \dots(i)$$
The second volume contraction is due to absorption of CO₂.
Hence, $x \quad y \quad 14 \qquad \dots(ii)$
Now, solving equations (i) and (ii),
 $x \quad 10 \text{ mL}, y \quad 4 \text{ mL}$ and volume of He = 20 - 14 = 6 mL
 $Vol \% \text{ of } CO = \frac{10}{20} \quad 100 \quad 50\%$
 $Vol \% \text{ of } CH_q = \frac{4}{20} \quad 100 = 20\%$
 $Vol \% \text{ of } CH_q = \frac{4}{20} \quad 100 = 20\%$
 $Vol \% \text{ of } He = 30\%$
38. The redox reaction involved is :
 $H_2O_2 + 21 + 2H^+ \qquad 2H_2O + I_2$
If *M* is molarity of H₂O₂ solution, then
 $5M \quad \frac{0.508 \quad 1000}{254} \quad (\because 1 \text{ mole } H_2O_2 \quad 1 \text{ mole } I_2)$
 $M \quad 0.4$
Also, *n*-factor of H₂O₂ is 2, therefore normality of H₂O₂ solution
is 0.8 N.
Volume strength = Normality 5.6 $0.8 \quad 5.6 = 4.48 \text{ V}$
39. The reaction is
 $KIO_3 \quad 2KI + 6HC1 \qquad 3ICl + 3KCl + 3H_2O$
 $KIO_3 \quad 2KI + 6HC1 \qquad 3ICl + 3KCl + 3H_2O$
 $KIO_3 \quad 2KI + 6HC1 \qquad 3ICl + 3KCl + 3H_2O$
 $KIO_3 \quad 2KI + 6HC1 \qquad 3ICl + 3KCl + 3H_2O$
 $KIO_3 \quad 2KI + 6HC1 \qquad 3ICl + 3KCl + 3H_2O$
 $KIO_3 \quad 2KI + 6HC1 \qquad 3ICl + 3KCl + 3H_2O$
 $KIO_3 \quad Colume strength 5 millimol of KIO_3 is required, i.e. 10$
millimol KI solution contain 15 millimol of KI.
After $AgNO_3$ treatment 5 millimol of $AgNO_3$.
 $Mass of $AgNO_3 \quad \frac{5}{1000} \quad 170 = 0.85 \text{ g}$
 $Mass percentage of $AgNO_3 = 85\%$
40. CO_2 is evolved due to following reaction :
 $2NaHCO_3 \qquad Na_2CO_3 + H_2O + CO_2$
 $Moles of CO_2 produced \qquad \frac{pV}{RT}$
 $\frac{750}{760} \quad \frac{123.9}{1000} \quad \frac{1}{0.082} \quad 2298$
 $5 \quad 10^{-3}$
 $Moles of NaHCO_3$ in 1.5 g sample
 $\frac{0.01}{2} \quad 1.5 \quad 1000 = 7.5$
Let the 1.5 g sample contain *x* millimol of HCl = 15
 $x \quad 3.75$$$

Mass of NaHCO₃
$$\frac{7.5 \ 84}{1000} = 0.63 \text{ g}$$

Mass of Na₂CO₃ $= \frac{3.75 \ 106}{1000} = 0.3975 \text{ g}$
% mass of NaHCO₃ $= \frac{0.63}{1.50} \ 100 = 42 \%$
% mass of Na₂CO₃ $\frac{0.3975}{1.5} \ 100$
 $= 26.5\%$

41. Mass of $Fe_2O_3 = 0.552$ g

millimol of
$$Fe_2O_3 = \frac{0.552}{160} = 1000 = 3.45$$

During treatment with Zn-dust, all Fe^{3+} is reduced to Fe $^+$, hence

millimol of Fe $^+$ (in 100 mL) = 3.45 2 = 6.90

In 25 mL aliquot, $\frac{6.90}{4} = 1.725$ millimol Fe²⁺ ion.

Finally Fe^{2+} is oxidised to Fe^{3+} , liberating one electron per Fe^{2+} ion. Therefore, total electrons taken up by oxidant.

42. With $KMnO_4$, oxalate ion is oxidised only as :

 $5C_2O_4^2$ $2MnO_4 + 16H^+$ $2Mn^{2+} + 10CO_2 + 8H_2O$ Let, in the given mass of compound, *x* millimol of $C_2O_4^2$ ion is present, then

Meq of $C_2O_4^2$ Meq of MnO_4 2x 0.02 5 22.6 x 1.13

At the later stage, with I $\,$, Cu^{2+} is reduced as :

 $2Cu^{2+} + 4I$ $2CuI + I_2$

and $I_2 + 2S_2O_3^2 = 2I + S_4O_6^2$ Let there be x millimol of Cu^{2+} .

Meq of Cu^{2+} Meq of $I_2 = meq$ of hypo

 $x \quad 11.3 \quad 0.05 = 0.565$

Moles of
$$Cu^{2+}$$
: moles of $C_2O_4^2$ 0.565 : 1.13 1 : 2

43. Let us consider 10 mL of the stock solution contain *x* millimol oxalic acid $H_2C_2O_4$ and *y* millimol of $NaHC_2O_4$.

When titrated against NaOH, basicity of oxalic acid is 2 while that of $NaHC_2O_4$ is 1.

$$2x \quad y \quad 3 \quad 0.1 \quad 0.3 \qquad \dots (i)$$

When titrated against acidic KMnO₄, *n*-factors of both oxalic acid and NaHC₂O₄ would be 2.

$$2x \quad 2y \quad 4 \quad 0.1 \quad 0.4 \qquad \dots$$
 (ii)

0 1

Solving equations (i) and (ii) gives

In 1.0 L solution, mole of
$$H_2C_2O_4 = \frac{0.1}{1000} = 100 = 0.01$$

Mole of NaHC₂O₄ $= \frac{0.1}{1000} = 100 = 0.01$

Mass of $H_2C_2O_4$ 90 0.01 = 0.9 g Mass of $NaHC_2O_4$ 112 0.01 = 1.12 g

44. Mass of chlorine in 1.0 g $X = \frac{35.5}{143.5}$ 2.9 = 0.717 g

Now, the empirical formula can be derived as :

	С	Н	Cl
% wt :	24.24	4.04	71.72
Mole :	2	4	2
Simple ratio :	1	2	1

Empirical formula = CH_2Cl .

Because X can be represented by two formula of which one gives a dihydroxy compound with KOH indicates that X has two chlorine atoms per molecule.

 $X = C_2H_4Cl_2$ with two of its structural isomers.

$$Cl-CH_2-CH_2-Cl$$
 and CH_3-CHCl_2
II

On treatment with KOH, I will give ethane-1, 2-diol, hence it is *Y*. *Z* on treatment with KOH will give ethanal as

$$ClCH_2CH_2Cl + OH CH_2 - CH_2$$

$$CH_{3}CHCl_{2} + KOH \qquad CH_{3}CH(OH)_{2} \xrightarrow{-H_{2}O} CH_{3}CHO$$
Unstable (Z)

45. Let the *n*-factor of KMnO₄ in acid, neutral and alkaline media are N_1 , N_2 and N_3 respectively. Also, same volumes of reducing agent is used everytime, same number of equivalents of KMnO₄ would be required every time.

$$20N_1 \quad \frac{100}{3}N_2 \quad 100N_3 \qquad N_1 \quad \frac{5}{3}N_2 \quad 5N_3$$

Also, *n*-factors are all integer and greater than or equal to one but less than six, N_3 must be 1.

$$\begin{array}{cccc} & & & N_1 & 5, N_2 & 3 \\ \text{In acid medium} & & & \text{MnO}_4 & & \text{Mn}^{2+} \\ \text{In neutral medium} & & & \text{MnO}_4 & & & \text{Mn}^{4+} \\ \text{In alkaline medium} & & & \text{MnO}_4 & & & \text{Mn}^{6+} \end{array}$$

meq of
$$K_2Cr_2O_7$$
 required = 100
100 = 1 6 V (*n*-factor = 6)
V 100/6 = 16.67 mL

46. Meq of MnO₄ required 20 $\frac{1}{50}$ 5 2 Meq of Fe² present in solution = 2

> millimol of Fe^2 present in solution = 2 (*n*-factor = 1) Also,

 \therefore 4 millimol of Fe² are formed from 1 millimol N₂H₄

2 millimol Fe^2 from $\frac{1}{4}$ 2 $\frac{1}{2}$ millimol $\operatorname{N}_2\operatorname{H}_4$

Therefore, molarity of hydrazine sulphate solution

$$\frac{1}{2}$$
 $\frac{1}{10}$ $\frac{1}{20}$

- In 1 L solution $\frac{1}{20}$ mol N₂H₆SO₄ is present. Amount of N₂H₆SO₄ $\frac{1}{20}$ 130 6.5 gL¹
- **47.** Molecular weight of Na_2CO_3 10H₂O = 286

Molarity of carbonate solution $\frac{1}{286} = \frac{1000}{100} = 0.035$ Normality of carbonate solution 2 0.035 = 0.07 N In acid solution : Normality of HNO₃ $\frac{8}{2000} = 0.02$ Normality of HCl = $\frac{5}{2} = \frac{4.8}{2000} = 0.012$

$$\frac{1}{2000} = \frac{1}{2000} = \frac{1$$

Let normality of H_2SO_4 in final solution be *N*.

Gram equivalent of SO_4^2 in 2 L solution 2 0.0681 0.1362

Mass of SO₄² in solution = 0.1362
$$\frac{96}{2}$$
 = 6.5376 g

48. For the oxidation of A^{n+} as :

 A^{n+} AO_3 n-factor = 5 - nGram equivalent of A^{n+} = 2.68 10⁻³ (5 n) Now equating the above gram equivalent with gram equivalent of KMnO₄:

49. During heating MCO_3 is converted into MO liberating CO_2 while BaO is remaining unreacted :

$$MCO_3(s) \xrightarrow{\text{Heat}} MO(s) + CO_2(g) = 0.44 \text{ g} = 0.01 \text{ mol}$$

 $\frac{\text{BaO}(s)}{4.08 \text{ g}} = \frac{\text{BaO}(s)}{3.64 \text{ g}}$

From the decomposition information, it can be deduced that the original mixture contained 0.01 mole of MCO_3 and the solid residue, obtained after heating, contain 0.01 mole (10 millimol) of MO.

Also, millimol of HCl taken initially = 100

millimol of NaOH used in back-titration $16 \quad 2.5 = 40$ millimol of HCl reacted with oxide residue = 60

HCl reacts with oxides as :

Also,

$$\frac{MO}{10 \text{ millimol}} + \frac{2\text{HCl}}{20 \text{ millimol}} \qquad MCl_2 \qquad \text{H}_2\text{O}$$

 $BaO + 2HCl BaCl_2 + H_2O$ 60 - 20 = 40 millimol

Therefore, the residue contain 20 millimol of BaO.

molar mass of BaO =
$$138 + 16$$

= 154
Mass of BaO $\frac{154 \quad 20}{1000} = 3.08 \text{ g}$

Mass of $MCO_3 = 4.08 - 3.08 = 1.0$ g

 \therefore 0.01 mole of *M*CO₃ weight 1.0 g

1 mole of $MCO_3 = 100$ g

 $100 = (\text{Atomic weight of metal}) + (12 + 3 \quad 16)$

Atomic weight of metal = 40, i.e. Ca