

1

Some Basic Concepts of Chemistry



Topic-1: Measurement, Mole Concept and Percentage Composition



1 MCQs with One Correct Answer

- 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)
- How many moles of electron weigh one kilogram? [2002S]
(a) 6.023×10^{23} (b) $\frac{1}{9.108} \times 10^{31}$
(c) $\frac{6.023}{9.108} \times 10^{54}$ (d) $\frac{1}{9.108 \times 6.023} \times 10^8$
- If two compounds have the same empirical formula but different molecular formulae they must have [1987 - 1 Mark]
(a) different percentage composition
(b) different molecular weight
(c) same viscosity
(d) same vapour density
- 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
- The total number of electrons in one molecule of carbon dioxide is [1979]
(a) 22 (b) 44 (c) 66 (d) 88
- 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
- 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
- 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

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

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

- The composition of a sample of Wurtzite is $\text{Fe}_{0.93}\text{O}_{1.00}$. What percentage of the iron is present in the form of Fe (III)? [1994 - 2 Marks]
- 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

- The weight of 1×10^{22} molecules of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is [1991 - 1 Mark]
- The modern atomic mass unit is based on [1980]
- The total number of electrons present in 18 mL of water is [1980]



6 MCQs with One or More than One Correct Answer

- To check the principle of multiple proportions, a series of pure binary compounds (P_mQ_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

- If empirical formula of compound 3 is P_3Q_4 , then the empirical formula of compound 2 is P_3Q_5 .
- 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.
- If empirical formula of compound 2 is PQ, then the empirical formula of the compound 1 is P_5Q_4 .
- 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 cm³/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 CaCl₂ and 1 mg of MgCl₂. Find the total hardness in terms of parts of CaCO₃ per 10⁶ parts of water by weight.
(b) A sample of hard water contains 20 mg of Ca⁺⁺ ions per litre. How many milli-equivalent of Na₂CO₃ 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 O₂.
(i) Which reactant is left in excess?
(ii) Find the weight of the excess reactants?
(iii) How may milliliters of 0.5 N H₂SO₄ 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 ¹⁴C.
(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. Mixture *X* = 0.02 mol of [Co(NH₃)₅SO₄]Br and 0.02 mol of [Co(NH₃)₅Br]SO₄ was prepared in 2 litre of solution.
1 litre of mixture *X* + excess AgNO₃ → *Y*.
1 litre of mixture *X* + excess BaCl₂ → *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
2. 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
3. In the standardization of Na₂S₂O₃ using K₂Cr₂O₇ by iodometry, the equivalent weight of K₂Cr₂O₇ is [2001S]
(a) (molecular weight)/2 (b) (molecular weight)/6
(c) (molecular weight)/3 (d) same as molecular weight
4. The normality of 0.3 M phosphorous acid (H₃PO₃) is, [1999 - 2 Marks]
(a) 0.1 (b) 0.9 (c) 0.3 (d) 0.6
5. The equivalent weight of MnSO₄ is half of its molecular weight when it is converted to : [1988 - 1 Mark]
(a) Mn₂O₃ (b) MnO₂
(c) MnO₄⁻ (d) MnO₄²⁻
6. 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
7. 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
8. If 0.50 mole of BaCl₂ is mixed with 0.20 mol of Na₃PO₄, the maximum number of moles of Ba₃(PO₄)₂ that can be formed is [1981 - 1 Mark]
(a) 0.70 (b) 0.50
(c) 0.20 (d) 0.10
9. *M* is molecular weight of KMnO₄. The equivalent weight of KMnO₄ when it is converted into K₂MnO₄ is [1980]
(a) *M* (b) *M*/3
(c) *M*/5 (d) *M*/7
10. 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

11. 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]
12. H₂S (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]



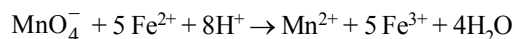
3 Numeric / New Stem Based Questions

Question Stem for Question Nos. 13 and 14

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 KMnO₄ solution to reach the end point. Number of moles of Fe²⁺ present in 250 mL solution is *x* × 10⁻² (consider complete dissolution of FeCl₂). The amount of iron present in the sample of *y*% by weight. (Assume : KMnO₄ reacts only with Fe²⁺ in the solution)
Use : Molar mass of iron as 56 g mol⁻¹)

13. The value of x is _____. [Adv. 2021]
 14. The value of y is _____. [Adv. 2021]
 15. The ammonia prepared by treating ammonium sulphate with calcium hydroxide is completely used by $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ to form a stable coordination compound. Assume that both the reactions are 100% complete. If 1584 g of ammonium sulphate and 952 g of $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ 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]
 16. 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]
 17. How many millilitres of 0.5 M H_2SO_4 are needed to dissolve 0.5 g of copper(II) carbonate? [1999 - 3 Marks]
 18. 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 : $\text{KIO}_3 + 2\text{KI} + 6\text{HCl} \rightarrow 3\text{ICl} + 3\text{KCl} + 3\text{H}_2\text{O}$) [1992 - 4 Marks]
 19. 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]
 20. 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]
 21. A sample of hydrazine sulphate ($\text{N}_2\text{H}_6\text{SO}_4$) 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 : $4\text{Fe}^{3+} + \text{N}_2\text{H}_4 \rightarrow \text{N}_2 + 4\text{Fe}^{2+} + 4\text{H}^+$
 $\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$
 22. Hydroxylamine reduces iron (III) according to the equation:
 $2\text{NH}_2\text{OH} + 4\text{Fe}^{3+} \rightarrow \text{N}_2\text{O(g)} \uparrow + \text{H}_2\text{O} + 4\text{Fe}^{2+} + 4\text{H}^+$
 Iron (II) thus produced is estimated by titration with a

standard permanganate solution. The reaction is :



- 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]
 23. 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]
 24. 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]
 25. 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]
 26. 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 -1.
 (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.
 27. 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

28. 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]
 29. 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]

30. 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]

31. 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 $\text{Na}_2\text{S}_2\text{O}_3$ 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]

32. 8.0575×10^{-2} kg of Glauber's salt is dissolved in water to obtain 1 dm³ 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]

33. 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]

34. 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 % composition of the components of the mixture. [1992 - 5 Marks]

35. A solution of 0.2 g of a compound containing Cu^{2+} and $\text{C}_2\text{O}_4^{2-}$ 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 $\text{Na}_2\text{S}_2\text{O}_3$ solution for complete

reduction. Find out the molar ratio of Cu^{2+} to $\text{C}_2\text{O}_4^{2-}$ in the compound. Write down the balanced redox reactions involved in the above titrations. [1991 - 5 Marks]

36. A mixture of $\text{H}_2\text{C}_2\text{O}_4$ (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 $\text{H}_2\text{C}_2\text{O}_4$ and NaHC_2O_4 in the mixture. [1990 - 5 Marks]

37. 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]

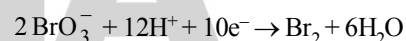
38. An equal volume of a reducing agent is titrated separately with 1M KMnO_4 in acid neutral and alkaline media. The volumes of KMnO_4 required are 20 mL in acid, 33.4 mL in neutral and 100 mL in alkaline media. Find out the oxidation state of manganese in each reduction product. Give the balanced equations for all the three half reactions. Find out the volume of 1M $\text{K}_2\text{Cr}_2\text{O}_7$ consumed; if the same volume of the reducing agent is titrated in acid medium. [1989 - 5 Marks]

39. A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$). Calculate : (i) molal concentration and (ii) mole fraction of sugar in the syrup. [1988 - 2 Marks]

40. (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



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



[1987 - 5 Marks]

41. 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 2 litre. Thirty mL of this acid mixture exactly neutralise 42.9 mL of sodium carbonate solution containing one gram of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ in 100 mL of water. Calculate the amount in gram of the sulphate ions in solution. [1985 - 4 Marks]

42. 2.68×10^{-3} moles of a solution containing an ion A^{n+} require 1.61×10^{-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]

43. The density of a 3 M sodium thiosulphate solution ($\text{Na}_2\text{S}_2\text{O}_3$) 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 $\text{S}_2\text{O}_3^{2-}$ ions. [1983 - 5 Marks]

44. 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)

45. (i) A sample of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ 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 $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ present in the sample. [1980]
46. 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]
47. 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]
48. 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. [$\text{H} = 1, \text{Mg} = 24, \text{Al} = 27$] [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. (6.02×10^{24}) 16. (b,c)

Topic-2 : Stoichiometry, Equivalent Concept, Neutralization and Redox titration

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