1 Chapter

SOME BASIC CONCEPTS OF CHEMISTRY (Mole-Concept & Stoichiometry)

A SINGLE CORRECT CHOICE TYPE

Each of these questions has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct.

1. 0.64 g of a gas occupies a volume of 224 ml at STP. The gas could be
   (a) N_2O (b) O_2
   (c) SO_3 (d) SO_2

2. Vapour density of a gaseous substance is 4 with respect to oxygen (molecular mass = 32). The molar mass of the substance is:
   (a) 8 g (b) 16 g
   (c) 64 g (d) 128 g

3. Amount of glucose required to be dissolved in 81.0 g of water to give 10% by mass of solution is
   (a) 8.1 g (b) 9 g
   (c) 10 g (d) 18 g

4. The hydrated salt $Na_2CO_3.x\ H_2O$ undergoes 63% loss in mass on heating and becomes anhydrous. The value of x is
   (a) 3 (b) 5
   (c) 7 (d) 10

5. 1 mole mixture of CO and CO_2 requires exactly 28 g of KOH in solution for complete conversion of all the CO_2 into K_2CO_3. How much amount more of KOH will be required for conversion into K_2CO_3 if one mole of mixture is completely oxidized to CO_2.
   (a) 28 g (b) 56 g
   (c) 84 g (d) 112 g

6. On adding excess of $CaCl_2$ to a solution containing Na_2CO_3 and $NaHCO_3$, x g of precipitate was obtained. On adding in drops to the filtrate, a further y g of precipitate was obtained. In another experiment to the same amount of solution excess of $CaCl_2$ was added, boiled and filtered. The amount of the precipitate in the second experiment would be
   (a) $x+y$ (b) $x+\frac{y}{2}$
   (c) $\frac{x+y}{2}$ (d) none of these

7. The volume of chlorine at STP required to liberate all the bromine and iodine in 100 ml of 0.1 M each of KI and MBr_2 will be:
   (a) 0.224 L (b) 0.336 L
   (c) 0.448 L (d) 0.560 L

8. When burnt in air, 14.0g mixture of carbon and sulphur gives a mixture of CO_2 and SO_2 in the volume ratio of 2 : 1, volumes being measured at the same conditions of temperature and pressure. Moles of carbon in the mixture is:
   (a) 0.25 (b) 0.40
   (c) 0.5 (d) 0.75

9. 0.5400 g of a metal X yields 1.020 g of its oxide X_2O_3. The number of moles of X is :
   (a) 0.01 (b) 0.02
   (c) 0.04 (d) 0.05

10. Consider the reaction $2A+B+3C \rightarrow P+2Q$. Starting with 3 mol of A, 2 mol of B and 6 mol of C, number of moles of the products P and Q would respectively be:
    (a) 2 and 4 (b) 4 and 2
    (c) 3 and 1.5 (d) 1.5 and 3

MARK YOUR RESPONSE					
	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ

11. Samples of 1.0 g of aluminium are treated separately with an excess of H_2SO_4 and an excess of NaOH solutions. The ratio of volumes (under same conditions) of hydrogen gas evolved will be :

(a) 1 : 2 (b) 2 : 1
(c) 1 : 1 (d) 2 : 3

12. A gas '*X*' is passed through water to form saturated solution. The aqueous solution on treatment with $AgNO_3$ solution gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribon with the evolution of colourless gas '*Y*'. Identify '*X*' and '*Y*'.

(a) $X = H_2, Y = Cl_2$ (b) $X = CO_2, Y = Cl_2$
(c) $X = Cl_2, Y = H_2$ (d) $X = Cl_2, Y = CO_2$

13. 2.24 ml of a gas '*X*' is produced at STP by the action of 4.6 mg of alcohol ROH with methyl magnesium iodide . The molecular mass of alcohol and the gas '*X*' are respectively.

(a) 46, C_2H_6 (b) 46, CH_4
(c) 4.6, C_2H_6 (d) 0.46, CH_4

14. A mixture of CH_4, N_2 and O_2 is enclosed in a container of 1 litre capacity at 0°C. Total pressure of gaseous mixture is 2660 mm Hg. If the ratio of partial pressures of the gases is 1 : 4 : 2 respectively, the number of moles of oxygen present in the vessel is:

(a) $\frac{1}{22.4}$ (b) 1.0
(c) 0.1 (d) none of these

15. A mixture containing 28 g of CaO and 20 g of NaOH is treated with aqueous HCl till the reactions are complete. The resulting solution is evaporated to dryness. What is the mass of the solid obtained?

(a) 169.50 g (b) 84.75 g
(c) 42.37 g (d) 100.0 g

16. The specific heat of a metal is 0.16 cal g^{-1}. The equivalent mass of the metal is 20.04, the correct atomic mass of the metal is :

(a) 40 (b) 20.04
(c) 40.08 g (d) 80.16 g

17. A mixture of methane and ethane in the mole ratio of $x : y$ has a mean molecular mass equal to 20. What would be the mean molecular mass of a mixture of the same gases present in the ratio $y : x$?

(a) 20 (b) 22
(c) 24 (d) none of these

18. A partially dried clay mineral contains 8% water. The original sample contained 12% water and 45% silica. The percentage of silica in the partially dried sample is nearly

(a) 50% (b) 49%
(c) 51% (d) 47%

19. H_2O_2 in aqueous solution decomposes on warming as :

$$2H_2O_{2(aq)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$$

If 1 mol of gas occupies a volume of 25 L under the conditions of measurement and 200 ml of *x* M solution of H_2O_2 produces 5L of O_2, the value of *x* is

(a) 0.2 (b) 2.0
(c) 1.0 (d) 2.5

20. A commercial sample of H_2O_2 is marked as 33.6 'volume'. The molarity of H_2O_2 in the sample and mass of O_2 available from 100 ml sample respectively are:

(a) 1.5 M, 2.4 g (b) 3 M, 4.8 g
(c) 2 M, 3.2 g (d) 1 M, 1.6 g

21. Sulfuryl chloride (SO_2Cl_2) reacts with water to give a mixture of H_2SO_4 and HCl. How many moles of baryta would be required to neutralize the solution formed by adding 1 mol of SO_2Cl_2 to excess of water?

(a) 4 (b) 3
(c) 2 (d) 1

22. When 2g of a gas *A* is introduced into an evacuated flask kept at 25°C, the pressure is found to be 1 atm. If 3g of another gas *B* is then added to the same flask, the pressure becomes 1.5 atm. Assuming ideal gas behavior, calculate the ratio of molecular masses $M_A : M_B$

(a) 1 : 2 (b) 2 : 1
(c) 3 : 1 (d) 1 : 3

23. Suppose two elements *X* and *Y* combine to form two compounds XY_2 and X_3Y_2 when 0.1 mol of former weighs 10 g while 0.05 mol of the latter weighs 9 g. The atomic masses of *X* and *Y* are respectively

(a) 40 and 60 (b) 40 and 30
(c) 30 and 40 (d) 60, 40

24. 25.4 g of iodine and 7.1 g chlorine are made to react to give a mixture of ICl and ICl_3. Number of moles of ICl and ICl_3 formed are respectively

(a) 0.1 & 0.1 (b) 0.1 & 0.05
(c) 0.5 & 0.5 (d) 0.05 & 0.05

MARK YOUR RESPONSE					
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ
	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	

25. Aniline is diazotized and the diazonium salt hydrolysed to yield phenol which is brominated to produce $C_6H_2(Br_3)OH$. Calculate the mass of the final product obtained from 9.3 g of aniline if the yield in the two steps is 45% and 70% (Atomic mass of Br = 80)

(a) 1.04 g (b) 10.43 g
(c) 14.89 g (d) 23.17 g

26. 1.50 g sample of potassium bicarbonate having 80% purity is strongly heated. Assuming the impurity to be thermally stable, calculate the loss of mass of the sample on heating.

(a) 3.72 g (b) 0.72 g
(c) 0.372 g (d) 0.186 g

27. A mixture of CO and CO_2 having a volume of 20 ml is mixed with *X* ml of oxygen and electrically sparked. The volume after explosion is 16 + *X* ml under the same conditions. What would be the residual volume if 30 ml of the original mixture is treated with aqueous NaOH?

(a) 12 ml (b) 10 ml
(c) 9 ml (d) 8 ml

28. 2 g of a mixture of CO and CO_2 on reaction with excess I_2O_5 produced 2.54 g of I_2. What would be the mass % of CO_2 in the original mixture?

(a) 60 (b) 30
(c) 70 (d) 35

29. The vapour density of a mixture containing NO_2 and N_2O_4 is 27.6 . Mole fraction of NO_2 in the mixture is

(a) 0.2 (b) 0.4
(c) 0.6 (d) 0.8

30. Mole fraction of methanol in its aqueous solution is 0.5. The concentration of solution in terms of percent by mass of methanol is

(a) 36 (b) 50
(c) 64 (d) 72

31. Percent by mass of a solute (molar mass = 28 g) in its aqueous solution is 28. Calculate the mole fraction (*X*) and molality (*m*) of the solute in the solution.

(a) $X = 0.2, m = 10$ (b) $X = 0.2, m = 125/9$
(c) $X = 0.8, m = 125/9$ (d) $X = 0.8, m = 10$

32. On subjecting 10 ml mixture of N_2 and CO to repeated electricspark, 7 ml of O_2 was required for combustion. What was the mole percent of CO in the mixture? (All volumes were measured under identical conditions)

(a) 4 (b) 6
(c) 40 (d) 60

33. 100 L of hard water required 5.6 g of lime for removing temporary hardness. The temporary hardness in *ppm* of $CaCO_3$ is

(a) 56 (b) 100
(c) 200 (d) 112

34. 1.500g of hydroxide of a metal gave 1.000g of its oxide on heating. The equivalent mass of the metal is

(a) 5.0 (b) 10.0
(c) 12.0 (d) 15.0

35. If 0.20g chloride of a certain metal, when dissolved in water and treated with excess of $AgNO_3$, yields 0.50g of AgCl, the equivalent mass of the metal is (Ag = 108, Cl = 35.5)

(a) 21.90 (b) 20.04
(c) 40.08 (d) 43.80

36. 5.0g of a certain element *X* forms 10.0g of its oxide having the formula X_4O_6. The atomic mass of *X* is

(a) 12.0 amu (b) 24.0 amu
(c) 30.0 amu (d) 32.0 amu

37. The density of 0.5 *M* glucose solution is 1.0900g ml^{-1}. The molality of the solution is

(a) 0.1000 (b) 0.2000
(c) 0.2500 (d) 0.5000

38. A chloride of a metal (*M*) contains 65.5% of chlorine. 100 ml of vapour of the chloride of metal at STP weighs 0.72 g. The molecular formula of the metal chloride is :

(a) MCl (b) MCl_2
(c) MCl_3 (d) MCl_4

39. In an experiment, 100 ml of ozonised oxygen was reduced to 60 ml when treated with turpentine. What would be the increase in volume if the original sample was heated until no further change occurred? (All volumes were measured under identical conditions).

(a) 10 ml (b) 20 ml
(c) 30 ml (d) 40 ml

40. A colourless compound weighing 0.84 g on heating (in absence of air) gives 0.22 g of CO_2 and 0.09 g of H_2O, and leaves a white residue behind. The molecular mass of the compound is:

(a) 100 (b) 106
(c) 84 (d) 168

41. A portable hydrogen generator utilizes the reaction between calcium hydride and water to produce hydrogen. What mass of hydrogen can be produced by 70 g cartridge of calcium hydride ?

(a) 6.7 g (b) 3.5 g
(c) 4.5 g (d) 5.5 g

MARK YOUR RESPONSE					
	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ
	30. ⓐⓑⓒⓓ	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	33. ⓐⓑⓒⓓ	34. ⓐⓑⓒⓓ
	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	37. ⓐⓑⓒⓓ	38. ⓐⓑⓒⓓ	39. ⓐⓑⓒⓓ
	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ			

42.. 1.12 ml of a gas *X* is produced at STP by the action of 2.3 mg of an alcohol with methyl magnesium iodide. The molecular mass of alcohol and the gas *X* are respectively

(a) 32 ; CH_4 (b) 46 ; CH_4
(c) 46 ; C_2H_6 (d) None of these

43. Dichloroacetic acid ($CHCl_2COOH$) is oxidized to CO_2, H_2O and Cl_2 by 1.2 equivalent of an oxidizing agent. Same amount of the acid can neutralize *x* moles of NH_3 to give ammonium dichloroacetate. *x* is

(a) 0.4 (b) 0.3
(c) 0.2 (d) 0.1

44. In what ratio the amounts of H_2SO_4 and H_3PO_4 react with the same amount of NaOH to form normal salts?

(a) 1 : 1 (b) 3 : 2
(c) 2 : 3 (d) 1 : 3

45. 0.02 *M* solution of an acid HX ionizes to the extent of 50%. Then, at equilibrium

(a) $[HX] = [H_3O^+] = [X^-] = 0.01\ M$

(b) $[HX] = [H_3O^+] = [X^-] = 0.02\ M$

(c) $[HX] > [H_3O^+] = [X^-]$

(d) $[HX] < [H_3O^+] = [X^-]$

46. Consider aqueous solutions containing 6 g each of (I) CH_3COOH, (II) C_3H_7OH and (III) urea in 100 ml of solution. Which of them has the maximum molarity of all the particles (molecules and ions) ?

(a) I (b) II
(c) III (d) All equal

47. 1 mol of N_2 and 4 mol of H_2 are allowed to react in a sealed container and after the reaction some water is introduced in it. The aqueous solution formed required 1 L of 1 *M* HCl for neutralization. The mole fraction of the gaseous product in the mixture after the reaction was

(a) 0.5 (b) 0.40
(c) 0.30 (d) 0.25

48. How many gram of sulphur can be obtained by the reaction of 1 mol of SO_2 with 22.4 L of H_2S at STP?

(a) 96 g (b) 48 g
(c) 32 g (d) None of these

49. 4.0 g of NaOH added to which of the following will give normal salt ?

(a) 9.8 g of H_2SO_4 in 100 mL of solution

(b) 9.8 g of H_3PO_4 in 100 mL

(c) 8.2 g of H_3PO_3 in 100 mL

(d) 6.6 g of H_3PO_2 in 100 mL

50. Under standard conditions, the values of equivalent volumes of oxygen and chlorine are

(a) 11.2 L each (b) 5.6 L each
(c) 5.6 L and 11.2 L (d) 11.2 L and 5.6 L

51. Equivalent mass of a metal *M* is 2.5 times that of oxygen. The minimum molecular mass of its oxide is

(a) 28 (b) 42
(c) 56 (d) 112

52. 10 g of a metal gives 14 g of its oxide. The equivalent mass of its oxide and hydroxide will be respectively

(a) 20 and 37 (b) 28 and 37
(c) 56 and 74 (d) None of these

53. The same amount of a metal combines with 0.100 g of oxygen and with 1.000 g of a halogen. Hence, the equivalent mass of halogen is

(a) 9 (b) 35.5
(c) 80 (d) 127

54. A sample of hard water contains 20 ppm Ca^{2+}. Moles of Na_2CO_3 required to remove the hardness of 10 L of water will be

(a) 1.0×10^{-4} (b) 2.0×10^{-4}
(c) 5.0×10^{-4} (d) 5.0×10^{-3}

55. 3 g of Mg is burnt in a closed vessel containing 3 g of oxygen. The weight of excess reactant left is

(a) 0.5 g of oxygen (b) 1.0 g of oxygen
(c) 1.0 g of Mg (d) 0.5 g of Mg

56. A mixture containing equimolar amounts of CaO and Al_2O_3 requires 0.5 L of 4.0 *M* HCl to react with it completely. Moles of CaO or Al_2O_3 in the mixture are

(a) 0.25 (b) 0.50
(c) 0.60 (d) 0.80

57. Calculate the molarity of each ion in the solution after 2.0 L of 3 *M* $AgNO_3$ is mixed with 3 L of 1.0 *M* $BaCl_2$.

(a) $[Ba^{2+}] = 0.6$ M; $[NO_3^-] = 1.2$ M
(b) $[Ag^+] = [Cl^-] = 1.2$ M
(c) $[Ba^{2+}] = 1.0$ M; $[NO_3^-] = 3.0$ M
(d) None of these

58. How many moles of P_4O_6 and P_4O_{10} will be produced by the combustion of 12.4 g of phosphorous (atomic mass 31) in 12.8 g of oxygen, leaving no P_4 or O_2?

(a) 0.1 and 0.3 mol
(b) 0.15 mol and 0.25 mol
(c) 0.05 mol each
(d) 0.1 mol each

MARK YOUR RESPONSE					
	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ	46. ⓐⓑⓒⓓ
	47. ⓐⓑⓒⓓ	48. ⓐⓑⓒⓓ	49. ⓐⓑⓒⓓ	50. ⓐⓑⓒⓓ	51. ⓐⓑⓒⓓ
	52. ⓐⓑⓒⓓ	53. ⓐⓑⓒⓓ	54. ⓐⓑⓒⓓ	55. ⓐⓑⓒⓓ	56. ⓐⓑⓒⓓ
	57. ⓐⓑⓒⓓ	58. ⓐⓑⓒⓓ			

59. A metal oxide has 40% by mass of oxygen. What volume of H_2 (STP) would be obtained on reaction of 6 g of metal with water?

(a) 22.4 L (b) 11.2 L
(c) 5.6 L (d) 16.8 L

60. 10 g of a metal carbonate on heating gives 5.6 g of its oxide. The equivalent mass of the metal is

(a) 40 (b) 20
(c) 10 (d) 5

61. 8 g of a metal hydroxide on heating produces 5 g of metal oxide. If the atomic mass of the metal is 7, the formula of its chloride is

(a) MCl_3 (b) MCl_2
(c) MCl (d) None of these

62. The reduction of 1.4 g of a metal oxide required 560 mL of H_2 at STP. If atomic mass of metal is 40, formula of its chloride will be

(a) M_2Cl (b) MCl
(c) MCl_2 (d) MCl_3

63. Malachite has the formula $Cu_2CO_3(OH)_2$. What percentage by mass of malachite is copper?

(a) 25% (b) 50.9%
(c) 57.5% (d) 63.5%

64. Blue vitriol ($CuSO_4 . 5H_2O$) is often added to swimming pools to kill algae. It is prepared by the reaction between copper metal and hot sulphuric acid to give $CuSO_4$ (*aq*) and SO_2 (*g*). If one mole of copper is reacted with one mole of sulphuric acid, then the molecules of SO_2 (*g*) obtained will be

(a) 3.0×10^{23} (b) 6.023×10^{23}
(c) 3.0×10^{24} (d) $64 \times 6.023 \times 10^{23}$

65. The interaction of O_3 with potassium hydroxide gives ozonide according to the following equation.

$$\underset{168g}{3KOH(s)} + 2O_3(g) \longrightarrow \underset{174g}{2KO_3(s)} + KOH.H_2O(s) + \frac{1}{2}O_2(g)$$

The ozonide KO_3 slowly decomposes to KO_2 and oxygen

$$\underset{174g}{2KO_3(s)} \longrightarrow \underset{142g}{2KO_2(s)} + O_2(g)$$

The mass of KO_2 produced by the reaction of 75.0g of KOH is

(a) 6.34 *g* (b) 63.4 *g*
(c) 634*g* (d) 0.634 *g*

66. In the reaction

$$NaOH + Al(OH)_3 \longrightarrow NaAlO_2 + H_2O$$

The equivalent mass of $Al(OH)_3$ is

(a) 78 (b) 26
(c) 52 (d) unpredictable

MARK YOUR RESPONSE					
	59. ⓐⓑⓒⓓ	60. ⓐⓑⓒⓓ	61. ⓐⓑⓒⓓ	62. ⓐⓑⓒⓓ	63. ⓐⓑⓒⓓ
	64. ⓐⓑⓒⓓ	65. ⓐⓑⓒⓓ	66. ⓐⓑⓒⓓ		

B COMPREHENSION TYPE

This section contains groups of questions. Each group is followed by some multiple choice questions based on a paragraph. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct.

PASSAGE-1

Sometimes, one may need to know the number of moles of a substance present. This can be efficiently done by reacting the substance with a reagent which would lead to the production of a gas. Using the ideal gas equation and the stoichiometry of the reaction, one could then determine the number of moles of gas produced and hence the number of moles of the substance present. A good example of this is the determination of the percentage of manganese present in a steel sample. The manganese is extracted from the alloy and converted to the purple permanganate (VII) ion (MnO_4^-). This is then made to react with excess of hydrochloric acid according to the reaction

$$2MnO_4^- + 16H^+ + 10Cl^- \longrightarrow 2Mn^{2+} + 5Cl_2(g) + 8H_2O$$

The chlorine gas thus produced is collected in a container and the pressure and volume of the gas are determined. Since the temperature of the system is known, the ideal gas equation can now be used to calculate the number of moles of chlorine gas present. From this value, the number of moles of manganese can then be determined.

1. What type of reaction is the above reaction?

(a) Lewis acid - Lewis base
(b) double replacement
(c) Oxidation - reduction
(d) Dissociation

MARK YOUR RESPONSE					
	1. ⓐⓑⓒⓓ				

2. How can the ideal gas equaiton be rearranged to allow for the determination of number of moles, n?

(a) $n = \frac{PV}{RT}$ (b) $n = \frac{RT}{PV}$

(c) $n = \frac{PT}{RV}$ (d) $n = \frac{RV}{PT}$

3. What would be the approximate ratio between the mass of manganese in the steel sample and the mass of chlorine gas produced?

(a) 2 : 5 (b) 3 : 2
(c) 3 : 4 (d) 1 : 3

4. The above reaction is endothermic and hence the actual temperature of the reaction vessel may be different from that expected. Given that the initial temperature of the reaction vessel was used in the calculations, how would this affect the predicted value of n?

(a) It would be greater than the actual value
(b) It would be less than the actual value
(c) It would be the same as the actual value
(d) This cannot be determined from the information given

5. Pig iron consists of iron with about 5% manganese. Which of the following most accurately describes pig iron?

(a) It is a colloid
(b) It is a solid solution
(c) It is a complex molecule
(d) It is an alloy

PASSAGE-2

From a mixture which makes up crude oil, a particular hydrocarbon ingredient (that is one containing hdyrogen and carbon atoms only) has been isolated. 10 g of this liquid are burned in excess of oxygen and the products are 31.4 g of carbon dioxide and 12.4 g of water.

6. The ratio of carbon dioxide and water mole present is

(a) 1 : 2 (b) 1 : 1
(c) 2 : 1 (d) 1 : 4

7. The ratio of C : H in the substance i.e., the products) formed:

(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 4 : 1

8. If we burn an equimolar mixture of the above hydrocarbon and oxygen in a closed vessel, then after the reaction the gaseous mixture present in the vessel will consist of

(a) CO_2 and H_2O
(b) CO_2, H_2O and O_2
(c) CO_2, H_2O and hydrocarbon
(d) CO_2, H_2O, hydrocarbon and oxygen

PASSAGE-3

Hardness of water that is cuased due to presence of HCO_3^- of Ca and Mg in water is known as temporary hardness and this type of hardness can easily be removed by boiling. It can also be removed by addition of slaked lime.

Hardness of water that is caused due to presence of Cl^- and SO_4^{2-} of Ca and Mg in water in known as permanent hardness. This type of hardness can be removed with the help of washing soda. It can also be removed by use of ion exchange resins.

The degree of hardness is measured in terms of ppm of $CaCO_3$.

9. A sample of hard water was found to contain 305 ppm of HCO_3^- ions. What is the minimum mass of CaO required to remove HCO_3^- completely from 1 kg of such a water sample?

(a) 56 mg (b) 140 mg
(c) 240 mg (d) 28 mg

10. A sample of hard water was found to contain 136 mg of $CaSO_4$ and 190 mg of Mg Cl_2. The total hardness of water in terms of $CaCO_3$ is

(a) 326 ppm (b) 54 ppm
(c) 100 ppm (d) 300 ppm

11. 200g sample of hard water is passed through a cation exchanger in which H^+ ions are exchanged by Ca^{2+} ions. The water coming out of cation exchanger needed 75 ml of 0.1 N. NaOH for complete neutralisation. The hardness of water due to Ca^{2+} ion is

(a) 250 ppm (b) 500 ppm
(c) 750 ppm (d) 1000 ppm

MARK YOUR RESPONSE					
	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ
	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ

C REASONING TYPE

In the following questions two Statement-1 (Assertion) and Statement-2 (Reason) are provided. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct. Mark your responses from the following options:

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.
(b) Both Statement-1 and Statement-2 are true and Statement-2 is not the correct explanation of Statement-1.
(c) Statement-1 is true but Statement-2 is false.
(d) Statement-1 is false but Statement-2 is true.

1. **Statement-1** : One mole of SO_2 contains double the number of molecules present in one mole of O_2.
Statement-2 : Molecular weight of SO_2 is double to that of O_2.

2. **Statement-1** : 1.34×10^{-3} and 1.23 both have three significant figures.
Statement-2 : Number other than zero are all significant.

3. **Statement-1** : Molar volume of gases changes considerably with temperature and pressure.
Statement-2 : Molar volume of a substance is the volume occupied by 1 mole of that substance.

4. **Statement-1** : One atomic mass unit (amu) is mass of an atom equal to exactly one-twelfth the mass of a carbon -12 atom.
Statement-2 : Carbon - 12 isotope was selected as standard.

5. **Statement-1** : Atomic mass has no units but expressed in amu.
Statement-2 : It is the average mass of an atom taking care of relative abundance of all its possible isotopes.

6. **Statement-1** : Isomorphous substances form crystals of same shape and can grow in saturated solution of each other.
Statement-2 : They have similar constitution and chemical formulae.

7. **Statement-1** : S.I. unit of atomic mass and molecular mass is kg.
Statement-2 : It is equal to the mass of 6.023×10^{23} atoms.

8. **Statement-1** : 1 amu equals to 1.66×10^{-24} g.
Statement-2 : 1.66×10^{-24} g equals to $\frac{1}{12}$th mass of C^{12} atom.

9. **Statement-1** : In CO molecule 12 parts by mass of carbon combine with 16 parts by mass of oxygen and in CO_2, 12 parts by mass of carbon combine with 32 parts by mass of oxygen.
Statement-2 : When two elements combine separately with a fixed mass of a third element, then the ratio of their masses in which they do so is either the same or whole number multiple of the ratio in which they combine with each other.

10. **Statement-1** : The ratio by volume of gaseous reactants and products is in agreement with their molar ratio.
Statement-2 : Volume of a gas is inversely proportional to the number of moles of a gas.

11. **Statement-1** : The molality of a solution does not change with change in temperature.
Statement-2 : The molality is expressed in units of moles per 1000 gm of solvent.

12. **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.

13. **Statement-1** : The normality of 0.3 *M* aqueous solution of H_3PO_3 is equal to 0.6 *N*.
Statement-2 : Equivalent weight of H_3PO_3
$$= \frac{\text{Molecular weight of } H_3PO_3}{3}$$

MARK YOUR RESPONSE					
	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ		

14. **Statement-1** : 5 mole of $KClO_3$ (40% pure) on heating yields 3 mole of oxygen. The yield in this reaction is 100%.

$$2KClO_3 \longrightarrow 3\,KCl + 3O_2$$

Statement-2 : When 2 moles of $KClO_3$ are heated strongly 67.2 L of O_2 at NTP will be obtained.

15. **Statement-1** : Dichromate ion in acidic medium oxidizes stannous ion as :

$$x\,Sn^{2+} + y\,Cr_2O_7^{2-} + zH^+ \longrightarrow a\,Sn^{4+} + bCr^{3+} + cH_2O$$

The ratio $x : y$ in it is 1 : 3

Statement-2 : The value of $x + y + z = 18$

MARK YOUR RESPONSE	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ			

D MULTIPLE CORRECT CHOICE TYPE

Each of these questions has 4 choices (a), (b), (c) and (d) for its answer, out of which ONE OR MORE is/are correct.

1. 0.220 g of a gas occupies a volume of 112 ml at a pressure of 1atm and temperature of 273 K. The gas can be

(a) nitrogen dioxide (b) nitrous oxide
(c) carbon dioxide (d) propane

2. Which of the following contains the same number of molecules?

(a) 1g of O_2, 2 g of SO_2
(b) 1g of CO_2, 1g of N_2O
(c) 112 ml of O_2 at STP, 224 ml of He at 0.5 atm and 273K
(d) 1g of oxygen, 1g of ozone

3. 0.2 mol of Na_3PO_4 and 0.5 mol of $Ba(NO_3)_2$ are mixed in 1L of solution. Which of the following is/ are correct about this system?

(a) 0.2 mol of barium phosphate precipitate is obtained
(b) 0.1 mol of barium phosphate precipitate is obtained.
(c) Molarity of Ba^{2+} ions in the resulting solution is 0.2
(d) Molarities of Na^+ and NO_3^- ions are 0.6 and 1.0 respectively.

4. 0.5 mole of sodium nitrite and 1 mole of ammonium chloride are mixed in aqueous solution. The solution is heated and the evolved gas is collected. Then which is/ are correct about the gas ?

(a) 22.4 L of gas at STP
(b) 11.2 L of gas at STP
(c) 0.5 mole of gas
(d) 14 g of gas

5. 100 ml mixture of CO and CO_2 is mixed with 30 ml of oxygen and sparked in a eudiometer tube. The residual gas after treatment with aqueous KOH has a volume of 10 ml which remains unchanged when treated with alkaline pyrogallol. If all the volumes are under the same conditions, point out the correct option(s).

(a) The volume of CO that reacts, is 60 ml.
(b) The volume of CO that remains unreacted, is 10 ml.
(c) The volume of O_2 that remains unreacted, is 10 ml.
(d) The volume of CO_2 that gets absorbed by aqueous KOH, is 90 ml.

6. A 100 ml mixture of CO and CO_2 is passed through a tube containing red hot charcoal. The volume now becomes 160 ml. The volumes are measured under the same conditions of temperature and pressure. Amongst the following, select the correct statement(s).

(a) Mole percent of CO_2 in the mixture is 60.
(b) Mole fraction of CO in the mixture is 0.40
(c) The mixture contains 40 ml of CO_2
(d) The mixture contains 40 ml of CO

7. SO_2 gas is slowly passed through an aqueous suspension containing 12 g $CaSO_3$ till the milkiness just disappears. What amount of SO_2 would be required ?

(a) 12.8 g (b) 6.4 g
(c) 0.1 mole (d) 0.2 mole

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ			

8. 100 ml of 1 *M* NaOH and 100 ml of X g L^{-1} H_2SO_4, both being at the same temperature, are mixed. The highest rise in temperature would occur when X is.

(a) 0.49 g (b) 4.9 g
(c) 49 g (d) 60 g

9. For the reaction :

$H_3PO_3 + Ba(OH)_2 \rightarrow BaHPO_3 + 2H_2O$

The correct statement(s) is/are

(a) The equivalent mass of H_3PO_3 is 41.

(b) $BaHPO_3$ is the acid salt

(c) $BaHPO_3$ is normal salt

(d) 1 mole of H_3PO_3 is completely neutralized by 1.5 moles of $Ba(OH)_2$

10. A mixture containing 1 mole of CaF_2 and 1.5 moles of H_2SO_4 will be neutralized by

(a) 1.5 mol of NaOH (b) 3 moles of NaOH
(c) 1.5 mole of $Ba(OH)_2$ (d) 5 moles of NaOH

11. Which of the following gives the molarity of a 17% (mass/mass) solution of CH_3COONa in water. The density of the solution is 1.09 g ml^{-1}

(a) 2.26×10^{-2} M (b) 0.207 M
(c) 2.07 M (d) 2.26 M

12. A sample of hard water from some source was found to release carbon dioxide gas when boiled. It is possible to titrate the sample of water from the same source with

(a) dil HCl (b) dil NaOH
(c) neither (a) nor (b)
(d) a good reducing agent such as sodium metal.

13. A certain oxide of iodine has been found to contain iodine and oxygen. The ratio iodine : oxygen is 254 : 112. On being dissolved in water this oxide can produce

(a) HIO_2 (b) HIO_3
(c) HIO_4 (d) H_5IO_6

14. Which of the following statements are correct for a solution of H_2O_2 having a strengh of 17 g/litre ?

(a) The volume strength of H_2O_2 solution is 5.6 at 1 atmosphere pressure and 273 *K* temperature.

(b) The molarity of given H_2O_2 solution is 0.5 *M*

(c) 1 ml of the given H_2O_2 solution will give out 2.8 ml of O_2 at 2 atmosphere pressure and 273 *K* temperature

(d) The normality of given H_2O_2 solution is 2*N*.

15. A solution of solute '*X*' contains 30% *X* by weight of solution. 500 *g* of this solution was cooled when 50 *g* of solute gets precipitated. The % age composition of the remaining solution is

(a) 11.1% (b) 22.2%
(c) 33.3% (d) 50%

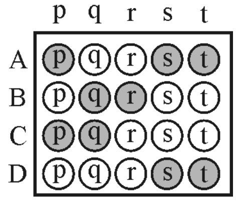
16. 10 ml of a gaseous hydrocarbon is exploded with 200 ml of oxygen. The gaseous product was then allowed to cool and attain room temperature and pressure, the volume was then found to be 180 ml. This mixture of gases was then passed through KOH solution followed by anhydrous $CaCl_2$. The resulting gas measured 100 ml. The hydrocarbon is

(a) C_4H_8 (b) C_8H_6
(c) C_8H_8 (d) None of these

MARK YOUR RESPONSE					
	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ
	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	

E MATRIX-MATCH TYPE

Each question contains statements given in two columns, which have to be matched. The statements in Column-I are labeled A, B, C and D, while the statements in Column-II are labelled p, q, r, s and t. Any given statement in Column -I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:
If the correct matches are A–p, s and t; B–q and r; C–p and q; and D–s then the correct darkening of bubbles will look like the given.



1. **Starting with 2 moles of A and 1 mole of B, the following reaction :**

$$2A + 3B \longrightarrow X + 2Y$$

is made to take place. Assume the reaction to go to completion, match the number of moles listed in Column II with various species listed in Column I.

Column I	**Column II**
(A) A	p. 1/3
(B) B	q. 2/3
(C) X	r. 0.0
(D) Y	s. 4/3

2. **Match the type of the salt formed with the appropriate reaction.**

Reaction	**Type of Salt**
(A) 1 mole of oxalic acid + 1 Mole of NaOH	p. Mixed salt
(B) 1 mole of H_3PO_2 + 1 mole KOH	q. Basic salt
(C) 1 mole of $Ca(OH)_2$ + 1 mole of HCl	r. Acid salt
(D) 1 mole of tartaric acid + 1 mole of NaOH + 1 mole of KOH	s. Normal salt

3. **Match the stoichiometric coefficients listed in Column II with the species listed in Column I that are involved in the balanced equation of the reaction :**

$$FeC_2O_4 + MnO_4^- + H^+ \longrightarrow$$

Column I	**Column II**
(A) FeC_2O_4	p. 10
(B) MnO_4^-	q. 24
(C) H^+	r. 5
(D) CO_2	s. 3

4. **2.0 L water gas was mixed with 8.0 L of air ($H_2 : O_2$ = 4 : 1 by volume) and ignited. The resulting gaseous mixture was cooled to 25° C and successively brought in contact with aqueous KOH and alkaline pyrogallol. If all volumes were measured at 25°C and 1 atm pressure, match the following :**

Column I	**Column II**
(A) Total volume of mixture that results	p. 6.4 L
(B) Contraction in volume by aqueous KOH	q. 0.6 L
(C) Contraction in volume by alkaline pyrogallol	r. 1.0 L
(D) Volume of residual gas	s. 8.0 L

5.

Column I	**Column II**
(A) 1.5 mole of $CO_2(g)$	p. 33600 ml at STP
(B) 3.0 g of H_2	q. Total number of atoms $= 4.5 \times N_A$
(C) 1.5 mole of $O_3(g)$	r. Weighs 72 g
(D) 1 mole of oxygen	s. Weighs 32 g

6.

Column I	**Column II**
(A) Istopic masses of two isotopes present in mixture are $(Z-1)$ and $(Z+3)$ respectively. The average atomic mass is Z.	p. The mixture contains 25% by moles of the heavier isotope
(B) Isotopic masses of two isotopes present in mixture are $(Z+1)$ and $(Z+3)$ respectively. The average atomic mass is $(Z+2)$	q. The mixture contains 50% by moles of the heavier isotope
(C) Isotopic masses of two isotopes present in the mixture are Z and $3Z$ respectively. The average atomic masses is $2Z$	r. Mass % age of heavier isotope depends on Z
(D) The isotopic masses of two isotopes present in mixture are $(Z-1)$ and $(Z+1)$ respectively. The average atomic mass is Z.	s. The mixture contains 75% by mass of the heavier isotope.

MARK YOUR RESPONSE

	1.	2.	3.	4.	5.	6.
	p q r s	p q r s	p q r s	p q r s	p q r s	p q r s
A	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ
B	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ
C	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ
D	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ	ⓟⓠⓡⓢ

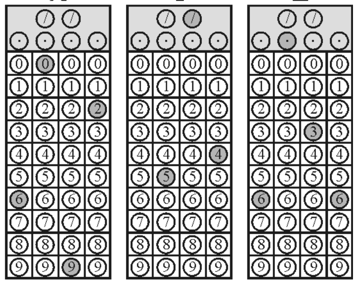
F — NUMERIC/INTEGER ANSWER TYPE

The answer to each of the questions is either numeric (eg. 304, 40, 3010, 3 etc.) or a fraction (2/3, 23/7) or a decimal (2.35, 0.546).

The appropriate bubbles below the respective question numbers in the response grid have to be darkened.

For example, if the correct answers to question X, Y & Z are 6092, 5/4 & 6.36 respectively then the correct darkening of bubbles will look like the following.

For single digit integer answer darken the extreme right bubble only.



1. A 20 cm^3 mixture of CO, CH_4 and He gases was exploded by an electric discharge at room temperature with excess oxygen. The volume contraction was found to be 13.0 cm^3. A further contraction of 14.0 cm^3 occurred when the residual gas was treated with KOH solution. Find out the composition of CH_4 in the mixture in terms of volume percentage.

2. A mixture of HCOOH and $H_2C_2O_4$ is heated with concentrated H_2SO_4. The gas produced is collected and on treating with KOH solution, the volume of gas decreases by one-sixth. Calculate the molar ratio of the two acids (HCOOH : $H_2C_2O_4$) in the original mixture.

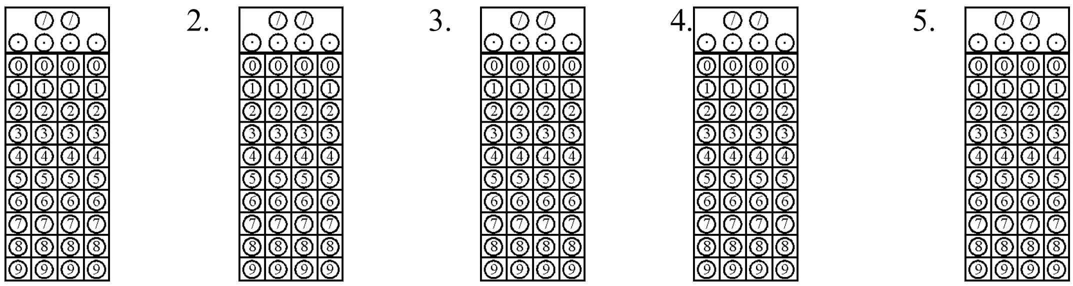
3. A mineral consists of an equimolar mixture of the carbonates of two bivalent metals. One metal is present to the extent of 13.2% by weight. 2.58g of mineral on heating lost 1.233 g of CO_2. Calculate the percentage by weight of the other metal.

4. A two litre vessel contains nitrogen and water vapour in 3 : 5 molar proportions at a pressure of 10^{-3} torr at 300 K. Find the percent loss of mass when the mixture is cooled to – 50°C. (R = 0.082 L atm $K^{-1}mol^{-1}$)

5. Gaseous benzene reacts with hydrogen gas in the presence of nickel catalyst to gaseous cyclohexane. A mixture of benzene vapour and excess of hydrogen had a pressure of 60 mm Hg in a vessel. After all benzene converted to cyclohexane, the pressure of the gas was 30 mm Hg in the same volume and at the same temperature. What fraction (by volume) of the original mixture was benzene ?

MARK YOUR RESPONSE

1. 2. 3. 4. 5.



Answerkey

A SINGLE CORRECT CHOICE TYPE

1.	d	**11.**	c	**21.**	c	**31.**	b	**41**	a	**51**	c	**61**	c
2.	d	**12.**	c	**22.**	d	**32.**	d	**42**	b	**52**	b	**62**	c
3.	b	**13.**	b	**23**	b	**33.**	c	**43**	c	**53**	c	**63**	c
4.	d	**14.**	a	**24.**	d	**34.**	b	**44**	b	**54**	d	**64**	a
5.	c	**15.**	b	**25.**	b	**35.**	a	**45**	a	**55**	b	**65**	b
6.	b	**16.**	c	**26.**	c	**36.**	b	**46**	a	**56**	a	**66**	c
7.	b	**17.**	c	**27.**	a	**37.**	d	**47**	d	**57**	a		
8.	c	**18.**	d	**28.**	b	**38.**	c	**48**	b	**58**	c		
9.	b	**19.**	b	**29.**	d	**39.**	b	**49**	d	**59**	c		
10.	d	**20.**	b	**30.**	c	**40.**	c	**50**	c	**60**	b		

B COMPREHENSION TYPE

1	(c)	**3**	(d)	**5**	(d)	**7**	(b)	**9**	(c)	**11**	(c)
2	(a)	**4**	(b)	**6**	(b)	**8**	(c)	**10**	(d)		

C REASONING TYPE

1	(d)	**4**	(a)	**7**	(c)	**10**	(c)	**13**	(c)
2	(c)	**5**	(a)	**8**	(a)	**11**	(a)	**14**	(b)
3	(b)	**6**	(a)	**9**	(b)	**12**	(b)	**15**	(d)

D MULTIPLE CORRECT CHOICE TYPE

1	b,c,d	**3**	b,c,d	**5**	a,b,d	**7**	b,c	**9**	a,c	**11**	d	**13.**	c, d	**15.**	b
2	a,b,c	**4**	b,c,d	**6**	a,b,d	**8**	c,d	**10**	b,c	**12.**	a, b	**14.**	a, b, c	**16.**	c

E MATRIX-MATCH TYPE

1. **A - s; B - r; C - p; D - q**

2. **A - r; B - s; C - q; D - p, s**

3 **A - r; B - s; C - q; D - p**

4. **A - s; B - r; C - q; D - p**

5. **A - p, q; B - p; C - p, q, r; D - s**

6. **A - p, r; B - q, r; C - q, s; D - q, r**

F NUMERIC/INTEGER ANSWER TYPE

1	20	**2**	4	**3**	21.7	**4**	51.7	**5**	0.167

Solutions

A SINGLE CORRECT CHOICE TYPE

1. **(d)** Molar mass of gas $= \dfrac{0.64 \times 22400}{224} = 64\text{g}$; hence SO_2.

2. **(d)** Molar mass = V.D. w.r.t. oxygen × molar mass of oxygen = 4 × 32 = 128

3. **(b)** Let x g be required. Then $\dfrac{x \times 100}{x+81} = 10;\ x \Rightarrow 9\text{g}$

4. **(d)** The loss in mass is due to elimination of water of crystallisation of $Na_2CO_3.xH_2O$.

   Hence, $\dfrac{18x \times 100}{106 + 18x} = 63 \Rightarrow x = 10$

5. **(c)** $CO_2 + 2KOH \rightarrow K_2CO_3 + H_2O;$

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

   Mol of CO_2 initially present

   $= \dfrac{1}{2} \times \text{mol of KOH} = \dfrac{1}{2} \times \dfrac{28}{56} = 0.25$

   Mol of $CO = 1 - 0.25 = 0.75$ = mol of CO_2 further formed.

   Hence, Mol of more KOH required = 2 × 0.75 = 1.5 (= 1.5 × 56 = 84 g)

6. **(b)** On adding $CaCl_2$, only $CaCO_3$ will be precipitated whereas $Ca(HCO_3)_2$ is soluble.

   $Na_2CO_{3(aq)} + CaCl_{2(aq)} \rightarrow Na_2CO_3 + H_2O$

   On boiling, $Ca(HCO_3)_2$ changes into sparingly soluble $CaCO_3$ as :

   $Ca(HCO_3)_{2(aq)} \rightarrow CaCO_{3(s)} + CO_{2(g)} + H_2O_{(\ell)}$

   Hence, total mass of precipitate in second case

   $= x + \dfrac{y}{2} g$

7. **(b)** $2KI_{(aq)} + Cl_{2(g)} \rightarrow 2KCl_{(aq)} + I_2;$

   $MBr_{2(aq)} + Cl_{2(g)} \rightarrow MCl_{2(aq)} + Br_2$

   Mol of Cl_2 required for liberating iodine from KI

   $= \dfrac{1}{2} \times \text{mol of KI} = \dfrac{1}{2} \times 100 \times 10^{-3} \times 0.1 = 0.005$

   Mol of Cl_2 required for liberating bromine from MBr_2 = mol of MBr_2 = 0.1 × 100 × 10^{-3} = 0.01

   Hence, volume of Cl_2 (STP) required = (0.005 + 0.01) × 22.4 = 0.336 L

8. **(c)** Let x g be the mass of carbon in the mixture.

   $\dfrac{\text{Volume of } CO_2}{\text{Volume of } SO_2} = \dfrac{\text{mol of } CO_2}{\text{mol of } SO_2} = \dfrac{2}{1}$

   $= \dfrac{x/12}{(14-x)/32} \Rightarrow x = 6\text{g}$

   Hence, moles of carbon $= \dfrac{6}{12} = 0.5$

9. **(b)** Mass of oxygen combined with 0.5400 g of X = 1.0200 − 0.5400 = 0.4800 g

   Mol of $X = \dfrac{2 \times 0.48}{48} = 0.02$

10. **(d)** For 3 mol of A : mol of $P = \dfrac{1}{2} \times 3 = 1.5$; mol of $P = \dfrac{2}{2} \times 3 = 3$

    For 2 mol of B : mol of P = 2 ; mol of Q = 2 × 2 = 4

    For 6 mol of C : mol of $P = \dfrac{1}{3} \times 6 = 2;$

    mol of $Q = \dfrac{2}{3} \times 6 = 4$

    A is limiting reactant. Hence, mol of P = 1.5 and mol of Q = 3

11. **(c)** $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$;

    $2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

12. **(c)** White precipitate with $AgNO_3$ must be of AgCl. Hence 'X' = Cl_2

    $Cl_2 + H_2O \rightarrow HCl + HClO$;

    $2HCl + Mg \rightarrow MgCl_2 + H_2,\ 'Y' = H_2$

13. **(b)** $ROH + CH_3MgI \rightarrow CH_4 + Mg\langle^{I}_{OR}$

    1 mol of ROH ≡ 1 mol of CH_4 ≡ 22400 ml at STP

    Hence, molar mass of ROH

    $= \dfrac{4.6 \times 10^{-3}}{2.24} \times 22400 = 46\text{g}$

14. **(a)** Partial pressure of $O_2 = \dfrac{2}{7} \times 2660 = 760$ mm Hg

    At STP one mol of a gas occupies a volume of 22.4 L. Hence, number of moles of O_2 in 1L = 1/22.4

15. **(b)** $CaO_{(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(\ell)}$;

$NaOH_{(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O\,(\ell)$

Mol of $CaCl_2$ = mol of CaO $= \frac{28}{56} = 0.5$; Mol of NaCl = mol of NaOH $= \frac{20}{40} = 0.5$

On evaporation of solution, only $CaCl_2$ and NaCl are left as solids. Hence mass of the solid left

$= 0.5 \times 111 + 0.5 \times 58.5 = 84.75\,g$

16. **(c)** Following Dulong-Pettit law, approx. atomic mass

$= \frac{6.4}{\text{Specific heat}} = \frac{6.4}{0.16} = 40$

Valency of the metal $= \frac{40}{\text{Equiv.mass}} = \frac{40}{20.04} = 2$

Correct atomic mass = valency × eq.mass = 2 × 20.04 = 40.08

17. **(c)** Mean molecular mass $= 20 = \frac{16x + 28y}{x + y} \Rightarrow x = 2y$

Mean molecular mass in the second case $= \frac{28x + 16y}{x + y} = 24$

18. **(d)** Let x % be silica in the partially dried mineral. Then, mass of other non-volatile substances in 100g of this mineral $= 100 - x - 8 = 92 - x$ g

Mass of other substances in 100 g of original sample $= 100 - 45 - 12 = 43$ g

Hence, $\frac{x}{92 - x} = \frac{45}{43} \Rightarrow x = 47$

19. **(b)** Mol. of H_2O_2 in 200 ml of x M $H_2O_2 = \frac{200}{1000} \times x = 0.2x$

Volume of O_2 produced in litres

$= \frac{25}{2} \times 0.2x = 5(\text{given}) \Rightarrow x = 2$

20. **(b)** $H_2O_{2(aq)} \rightarrow H_2O_{(l)} + \frac{1}{2}O_{2(g)}$; $1M \equiv 0.5$ mol of O_2

$\equiv 11.2$ L (STP). Hence, molarity $= \frac{33.6}{11.2} = 3$

Mol of H_2O_2 in 100 ml

$= MV(L) = 3 \times 100 \times 10^{-3} = 0.3$

Mass of O_2 that can be obtained = 0.3 × 16 = 4.8 g

21. **(c)** $SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

$H_2SO_4 + \underset{\text{Baryta}}{Ba(OH)_2} \rightarrow BaSO_4 + 2H_2O$

$2HCl + Ba(OH)_2 \rightarrow BaCl_2 + 2H_2O$

22. **(d)** Number of mol of $A = 2/M_A$ and those of $B = 3/M_B$

Pressure due to $2/M_A$ mol of $A = 1.0$ atm

Pressure due to $3/M_B$ mol of $B = 1.5 - 1.0 = 0.5$ atm

Since, pressures are proportional to molar concentrations of the gaseous substances,

$\frac{2/M_A}{3/M_B} = \frac{1.0}{0.5} \Rightarrow M_A/M_B = \frac{1}{3}$

23. **(b)** Molar mass of $XY_2 = \frac{10}{0.1} = 100$

Molar mass of $X_3Y_2 = \frac{9}{0.05} = 180$

Let a and b be the atomic masses of X and Y respectively. Then,

$a + 2b = 100, \quad 3a + 2b = 180$

Hence, $a = 40; \quad b = 30$

24. **(d)** $I_2 + 2Cl_2 \rightarrow ICl + ICl_3$

Mol of $I_2 = \frac{25.4}{254} = 0.1$; Mol of $Cl_2 = \frac{7.1}{71} = 0.1$

Chlorine is limiting reactant. Hence, number of mol of ICl = number of mol of $ICl_3 = \frac{0.1}{2} = 0.05$

25. **(b)** $C_6H_5NH_2 \xrightarrow{45\%\text{ yield}} C_6H_5OH$

$\xrightarrow{70\%\text{ yield}} C_6H_2(Br_3)OH$

Mol of C_6H_5OH formed $= \frac{9.3}{93} \times \frac{45}{100} = 0.045$

Mol of $C_6H_2(Br_3)OH = 0.045 \times \frac{70}{100} = 0.0315$

Mass of $C_6H_2(Br_3)OH$ formed = 0.0315 × 331 = 10.43 g

26. **(c)** $2KHCO_{3(s)} \xrightarrow{\Delta} K_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$

Mol of pure $KHCO_3 = \frac{1.5 \times 80}{100 \times 100} = 0.012$

Loss of mass due to elimination of CO_2 and H_2O

$= \frac{0.012 \times 44}{2} + \frac{0.012 \times 18}{2} = 0.372g$

27. **(a)** $2CO + O_2 \rightarrow 2CO_2$; volume of O_2 consumed

$= (20 + X) - (16 + X) = 4$ ml

Volume of CO in 20 ml = 2 × 4 = 8 ml

Volume of CO in 30 ml $= \frac{8}{20} \times 30 = 12$ ml = volume of residual gas (CO_2 is absorbed by NaOH)

28. **(b)** $5CO + I_2O_5 \rightarrow 5CO_2 + I_2$

1 mol of $I_2 \equiv 1$ mol of $I_2O_5 \equiv 5$ mol of CO

Hence, mol of $CO = 5 \times \frac{2.54}{254} = 0.05$

Mass of $CO = 0.05 \times 28 = 1.4g$

Mass of $CO_2 = 2 - 1.4 = 0.6g$

Mass % of $CO_2 = \frac{0.6}{2} \times 100 = 30$

29. **(d)** $(V.D)_{mix} = X_{NO_2}(V.D.)_{NO_2} + X_{N_2O_4} \times (V.D.)_{N_2O_4}$

$27.6 = x \times 23 + (1-x) \times 46$ (x = mole fraction of NO_2)

$\Rightarrow x = 0.8$

30. **(c)** Mass of methanol in 1 mol solution = 0.5 × 32 = 16 g
Mass of water in solution = 0.5 × 18 = 9 g

% by mass of methanol $= \frac{16 \times 100}{16+9} = 64$

31. **(b)** Mol. of solute in 100 g solution $= \frac{28}{28} = 1$

Mol. of water in 100 g solution $= \frac{100-28}{18} = 4$

Mol. fraction of solute $= \frac{1}{1+4} = 0.2$;

Molality $= \frac{1 \times 1000}{72} = \frac{125}{9}$

32. **(d)** $N_2 + O_2 \rightarrow 2NO$

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

Let x ml be the volume of N_2 in 10 ml mixture.

Volume of O_2 required $= x + \frac{10-x}{2} = 7$(given)

$\Rightarrow x = 4$ ml.

Volume of CO $= 10 - 4 = 6$ ml.

Mol.% of CO $= \frac{6 \times 100}{10} = 60$

33. **(c)** Temporary hardness is due to the bicarbonates of calcium and magnesium.

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$

Mass of $CaCO_3$ formed in 100 L water

$= \frac{2 \times 100 \times 5.6}{56} = 20g$

Hardness in ppm $= \frac{20 \times 10^6}{100 \times 10^3} = 200$

34. **(b)** By the law of equivalents :

$$\frac{E + \text{Eq. mass of } OH^-}{E + \text{Eq. mass of O}} = \frac{\text{mass of metal hydroxide}}{\text{mass of metal oxide}}$$

(E = Eq. mass of metal)

or $\frac{E+17}{E+8} = \frac{1.5}{1} \Rightarrow E = 10$

35. **(a)** $\frac{E + \text{Eq.mass of } Cl^-}{\text{Eq. mass of Ag} + \text{Eq. mass of } Cl^-} = \frac{E + 35.5}{108 + 35.5}$

$= \frac{0.2}{0.5} \Rightarrow E = 21.90$

36. **(b)** Using the relationship

$$\frac{\text{Mol. mass of oxide}}{\text{Mass of metal in molar mass}} = \frac{\text{mass of oxide}}{\text{mass of metal}}$$

$\frac{4x+96}{4x} = \frac{10}{5} \Rightarrow x = 24$

37. **(d)** Mass of 1 L (= 1000 ml) solution = 1000 × 1.090 = 1090g
Mass of glucose in 1L = 0.5 × 180 = 90 g.
Mass of water = 1090.0 g – 90.0 g = 1000 g

Hence, molality $= \frac{0.5 \times 1000}{1000} = 0.5$

38. **(c)** Molecular mass of metal chloride

$= \frac{0.72 \times 22400}{100} = 161.28$

Mass of chlorine in molar mass of chloride

$= \frac{65.5 \times 161.28}{100} = 105.64g$

Mole atoms of chlorine in one mole of chloride

$= \frac{105.64}{35.5} = 3$

39. **(b)** Ozone in absorbed by turpentine. Hence, volume of ozone = 100– 60 = 40 ml

Increase in volume $= \frac{3}{2} \times 40 - 40 = 20$ ml ;

$O_{3(g)} \rightarrow \frac{3}{2}O_{2(g)}$

40. **(c)** $\frac{\text{Mass of the compound}}{\text{Molar mass}} = \frac{0.22}{44} + \frac{0.09}{18} = 1 \times 10^{-2}$

or molar mass = $0.84/10^{-2}$ = 84

41. **(a)** $CaH_2 + 2H_2O_{(\ell)} \longrightarrow Ca(OH)_2 + 2H_2$

Mass of $H_2 = \frac{2 \times 2 \times 70}{42} = 6.67$ g

(Molar mass of $CaH_2 = 42$ g)

42. (b) $CH_3MgI + ROH \longrightarrow CH_4 + Mg(OR)(I)$

(1 mol of ROH ≡ 1 mol of CH_4 = 22400 mL)

Hence, molar mass of ROH $= \frac{2.3\times10^{-3}\times22400}{1.12} = 46$ g

43. (c) On oxidation of $CHCl_2COOH$, O. N. of carbon changes from + 2 to + 4 and that of Cl atom changes from – 1 to 0.
Hence, n-factor of the acid during oxidation = 2 (4 – 2) + 2 [0 – (– 1)] = 6

Moles of the acid $= \frac{\text{Number of equiv.}}{6} = \frac{1.2}{6} = 0.2$

= Moles of NH_3 required for neutralization.

44. (b) $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$;

Mol. of H_2SO_4 required for 1 mol of NaOH $= \frac{1}{2} = 0.5$

$H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O$;

Mol. of H_3PO_4 required for 1 mol of NaOH $= \frac{1}{3}$

Hence, mass of H_2SO_4 : mass of H_3PO_4 $= \frac{1}{2} : \frac{1}{3}$

$= 3 : 2 \quad (M_{H_2SO_4} = M_{H_3PO_4} = 98)$

45. (a) $HX + H_2O \rightleftharpoons H_3O^+ + X^-$;

α = degree of ionization $= \frac{50}{100} = 0.5$

Hence, $[HX]_{ionized} = 0.02 \times 0.5 = 0.01$ M

$= [H_3O^+] = [X^-]$

And $[HX]_{nonionized} = 0.02 - 0.01 = 0.01$ M

46. (a) Since molar mass is 60 g in each case, the molarity in each case $= \frac{6\times1000}{100\times60} = 1$ M

CH_3COOH is a weak electrolyte and ionizes to some extent ($CH_3COOH \rightleftharpoons CH_3COO^- + H^+$).
Hence, total molarity = 1 – α + α = 1 + α (other substances are non-electrolytes)

47. (d) $N_2 + 3H_2 \rightleftharpoons 2NH_3$,

$NH_3 + HCl \longrightarrow NH_4Cl$

Moles of NH_3 formed ≡ 1 L of 1 M HCl = 1 mol

Moles of N_2 left $= 1 -$ Moles of N_2 reacted $= 1 - \frac{1}{2}$

$= 0.5$

Moles of H_2 left $= 4 -$ Moles of H_2 reacted $= 4 - \frac{3}{2}$

$= 2.5$

Hence, mole fraction of NH_3 $= \frac{\text{Moles of } NH_3}{\text{Total moles}}$

$= \frac{1}{1+0.5+2.5} = 0.25$

48. (b) $SO_2 + 2H_2S \longrightarrow 2H_2O + 3S$

22.4 L (STP) of H_2S = 1 mol

Mass of S produced $= \frac{3\times32}{2}$ g = 48 g

49. (d) 4.0 g NaOH = 4/40 = 0.1 mol;
All acid solutions (100 mL each) contain 0.1 mol.
H_2SO_4 and H_3PO_3 are dibasic acids, H_3PO_4 is tribasic acid whereas H_3PO_2 is monobasic acid.

$H_3PO_2 + NaOH \longrightarrow NaH_2PO_2$ (normal salt)

50. (c) Equivalent mass of oxygen = 8g $= \frac{8}{32} = 0.25$ mol;

Equivalent volume of oxygen = 0.25 × 22.4 L (STP) = 5.6 L

Equivalent mass of chlorine = 35.5 g $= \frac{35.5}{71} = 0.5$ mol

Equivalent volume of chlorine = 0.5 × 22.4 (STP) = 11.2 L

51. (c) Equivalent mass of oxygen = 8; Equivalent mass of metal = 2.5 × 8 = 20
For mininum molecular mass, the oxide must contain one mol atom of oxygen i.e., 16 g or two equivalents. Mass of two equivalents of metal = 2 × 20 = 40 g. Hence, molar mass of the metal oxide = 40 + 16 = 56 g

52. (b) Equivalent mass of metal $= \frac{10}{(14-10)} \times 8 = 20$ g

Hence, equivalent mass of metal oxide = Eq mass of metal + equivalent mass of oxygen = 20 + 8 = 28
Equivalent mass of hydroxide = Equivalent mass of metal + Equivalent mass of OH^- = 20 + 17 = 37

53. (c) 0.1 g of oxygen ≡ 1 g of halogen.

Hence equivalent mass of halogen $= \frac{1}{0.1} \times 8 = 80$

(Equivalent mass of O = 8)

54. (d) Moles of Ca^{2+} ion per L (= 1000 g) of water

$= \frac{20\times10^3}{10^6\times40} = 5\times10^{-4}$

Moles of Na_2CO_3 required $= 10\times5\times10^{-4}$

$= 5\times10^{-3} \quad (Ca^{2+} + CO_3^{2-} \rightarrow CaCO_{3(s)})$

55. **(b)** $Mg + \frac{1}{2}O_2 \longrightarrow MgO$

Mass of oxygen required for 3 g of Mg $= \frac{16 \times 3}{24} = 2g$

Hence, excess reactant = 3 – 2 = 1g oxygen

56. **(a)** $CaO + 2HCl \longrightarrow CaCl_2 + H_2O$;

$Al_2O_3 + 6HCl \longrightarrow 2\,AlCl_3 + 3\,H_2O$

Let x mol each of CaO and Al_2O_3 be present.

Then, mol of HCl required $= 2x + 6x = 8x = 4 \times 0.5 = 2$ (given) $\Rightarrow x = 0.25$

57. **(a)** $2\,AgNO_3 + BaCl_2 \longrightarrow 2AgCl_{(s)} + Ba(NO_3)_2\,(aq)$

$[Ba^{2+}] = \frac{1.0 \times 3}{2+3} = 0.6\,M$

$[NO_3^-] = \frac{2 \times 1 \times 3}{2+3} = 1.2\,M$

Moles of Ag^+ mixed $= 3 \times 2 = 6$; Moles of Cl^- mixed $= 2 \times 1 \times 3 = 6$

Almost all Ag^+ and Cl^- will be precipitated out to give 6 mol of AgCl.

58. **(c)** Moles of $P_4 = \frac{12.4}{4 \times 31} = 0.1$

Moles of $O_2 = \frac{12.8}{32} = 0.4$

Let x moles of P_4 form P_4O_6.

Then, moles of O_2 required $= x \times 3 + (0.1 - x) \times 5 = 0.4$ (given) $\Rightarrow x = 0.05$

59. **(c)** Equivalent mass of metal $= \frac{(100-40) \times 8}{40} = 12$

$M\,(\text{one equivalent}) + H_2O \longrightarrow MOH + \frac{1}{2}H_2$

(= 11.2 L STP)

Hence, volume of H_2 produced $= \frac{11.2 \times 6}{12} = 5.6\,L$

60. **(b)** $\frac{\text{Mass of metal carbonate}}{\text{Equiv. mass of metal carbonate}}$

$= \frac{\text{Mass of metal oxide}}{\text{Equiv. mass of metal oxide}}$

or $\frac{10}{E_M + E_{CO_3^{2-}}} = \frac{10}{E_M + 30} = \frac{5.6}{E_M + E_O}$

$= \frac{5.6}{E_M + 8} \Rightarrow E_M = 20$

61. **(c)** $\frac{\text{Mass of hydroxide}}{\text{Equiv. mass of hydroxide}} = \frac{\text{Mass of oxide}}{\text{Equiv. mass of oxide}}$

or $\frac{8}{E_M + E_{OH^-}} \left(= \frac{8}{E_M + 17} \right)$

$= \frac{5}{E_M + E_O} \left(= \frac{5}{E_M + 8} \right) \Rightarrow E_M = 7$

Valency $= \frac{\text{Atomic mass}}{\text{Equiv. mass}} = \frac{7}{7} = 1$;

Hence, metal chloride = MCl

62. **(c)** Equiv. mass of oxide $= \frac{1.4 \times 11200}{560} = 28$

Equiv. mass of metal = 28 – 8 = 20

Valency $= \frac{40}{20} = 2$

Metal chloride – MCl_2

63. **(c)** Percentage by mass of copper in malachite

$= \frac{2 \times 63.5}{221} = 57.5\%$

64. **(a)** $\underset{1\text{ mole}}{Cu} + \underset{2\text{ mole}}{2H_2SO_4(aq)} \longrightarrow CuSO_4(aq) + 2H_2O + \underset{1\text{ mole}}{SO_2(g)}$

From the above equation we find that 1 mole of Cu reacts with 2 mole of H_2SO_4. Since we have only 1 mole of H_2SO_4 so it is the limiting reagent.

From the above equation

2 moles of H_2SO_4 react with Cu to produce SO_2 = 1 mole

$\therefore$ 1 mole of H_2SO_4 reacts with Cu to produce SO_2 $= \frac{1}{2}$ mole

Now one mole of $SO_2 = 6.023 \times 10^{23}$ molecules of SO_2

$\therefore \frac{1}{2}$ mole of $SO_2 = \frac{6.023 \times 10^{23}}{2}$ molecules of SO_2

$= 3 \times 10^{23}$ molecules of SO_2

65. **(b)** From the given equations we have

$168g\,KOH \equiv 174g\,KO_3 \equiv 142\,g\,KO_2$

Mass of KO_2 produced by action of 168g KOH = 142g

$\therefore$ Mass of KO_2 produced by action of 75 g KOH

$= \frac{142}{168} \times 75g = 63.4\,g$

66. **(c)** 1 equivalent of NaOH $\equiv$ 1 equivalent of $Al(OH)_3$

$\therefore$ 40g of NaOH $\equiv$ 78g of $Al(OH)_3$

Hence equivalent mass of $Al(OH)_3$ = 78

B COMPREHENSION TYPE

1. **(c)** The oxidation state of Mn decreases from + 7 (in MnO_4^-) to + 2 (in Mn^{2+}) and the oxidation state of Cl increases from – 1 (in HCl) to zero in Cl_2. Hence, it is the oxidation-reduction reaction.

2. **(a)** From the ideal gas equation $PV = nRT$, $n = \frac{PV}{RT}$

3. **(d)** From the reaction, mole ratio between Mn and Cl_2 = 2 : 5
Therefore, the mass ratio between Mn and Cl_2 = 2 × 55 : 5 × 71 = 1 : 3 approximately

4. **(b)** Due to absorption of heat in endothermic reaction, the temperature of the reaction vessel will be lower than the initial temperature. Thus, $n = \frac{PV}{RT}$ will be lower than the actual value.

5. **(d)** A solid mixture of two or more metals is referred to as an alloy.

6. **(b)** Mole of $CO_2 = \frac{31.4}{44}$ or 0.71

Mole of $H_2O = \frac{12.9}{13}$ or 0.71

∴ The ratio is 0.71 : 0.71 or 1 : 1

7. **(b)** In one mole of CO_2 the number of C atom = 1 mole
In one mole of H_2O the number of H atoms = 2 mole
Since the mole ratio of CO_2 and H_2O is 1 : 1
∴ C : H ratio is 1 : 2

8. **(c)** It will consists of CO_2, H_2O and hydrocarbon.
Since the hydrocarbon is C_2H_4 (the atomic ratio C : H is 1 : 2 and and so the hydrocarbon is C_2H_4)

$$\underset{\substack{1\text{ mole}\\(28\ g)}}{C_2H_4} + \underset{3\text{ mole}}{3O_2} \longrightarrow 2CO_2 + 2H_2O$$

Since the mole of O_2 required is three times the mole of hydrocarbon so in a mixture containing equal number of moles of hydrocarbon and oxygen, hydrocarbon will be in excess and some of it will remain unreacted while whole of O_2 will be consumed. Thus the mixture in vessel after the completion of reaction will consist of products (i.e., CO_2 and H_2O) and excess of hydrocarbon that has remained unreacted.

9. **(c)** $\underset{1\text{ mole}}{Ca(HCO_3)_2} = \underset{2\text{ mole}}{2HCO_3^-}$

HCO_3^- present in 10^6 *g* hard water = 305 *g*

HCO_3^- present in 1 kg (1000 g) of hard water

$= \frac{305}{10^6} \times \frac{10^3}{61} = 5\ m$ mole

Consider the reaction

$$\underset{1\ m\text{ mole}}{Ca(HCO_3)_2} + \underset{56\text{ mg}}{CaO} \longrightarrow 2CaCO_3 + H_2O$$

1 *m* mole of $Ca(HCO_3)_2 = 2\ m$ mole of HCO_3^-

∴ 2 *m* mole of HCO_3^- require CaO = 56 mg

∴ 5 *m* mole of HCO_3 require CaO $= \frac{56}{2} \times 5$ mg

= 140 mg

10. **(d)** 136 mg of $CaSO_4 \equiv$ 100 mg of $CaCO_3$

$$[\underset{136\text{ g}}{CaSO_4} + Na_2CO_3 \longrightarrow \underset{100\text{ g}}{CaCO_3} + Na_2SO_4]$$

Again 190 mg of $MgCl_2 \equiv$ 200 mg of $CaCO_3$

$$[\underset{\substack{95\ g\\(1\text{ mole})}}{MgCl_2} + Na_2CO_3 \longrightarrow \underset{\substack{84\ g\\(1\text{ mole})}}{MgCO_3} + 2NaCl]$$

Also 1 mole $MgCl_2 \equiv$ 1 mole $CaCO_3$
∴ 95 ppm $MgCl_2 \equiv$ 100 ppm $CaCO_3$
Thus 190 mg $MgCl_2$ = 200 mg $CaCO_3$
Thus total hardness in terms of $CaCO_3$ = (100 + 200) = 300 ppm

11. **(c)** *m* mole of H^+ ion present in 200 g of water coming out of exchanger = 75 × 0.1 = 7.5 $[N_1V_1 = N_2V_2]$

∴ *m* mole of Ca^{2+} ion present in hard water $= \frac{7.5}{2}$

[1 Ca^{2+} is replaced by 2 H^+ ions)

Hence mg of Ca^{2+} ions $= \frac{7.5}{2} \times 40 = 150$ mg

∴ Amount of Ca^{2+} present in 200 g of hardwater = 150 mg

Amount of Ca^{2+} present in 10^6g of hardwater

$= \frac{150}{200} \times 10^6 \times 10^{-3} = 750$ ppm

C REASONING TYPE

1. **(d)** One mole of any substance corresponds to 6.023×10^{23} entities irrespective of its weight. Molecular weight of $SO_2 = 32 + 2 \times 16 = 64$ g.
Molecular weight of $O_2 = 2 \times 16 = 32$ g
Therefore, mol wt of SO_2 is double to that of O_2.
2. **(c)** For a number written in scientific notation all digits are significant. All the zeros to the right of the decimal point are significant.
3. **(b)** Volume occupied changes with change in temperature and pressure. For example increase in temperature increases the K.E of the molecules and gases expand, and hence occupy more volume.
4. **(a)** For universally accepted atomic mass unit in 1961, C-12 was selected as standard. However, the new symbol used is '*u*' (unified mass) in place of amu.
5. **(a)** $$\text{Atomic mass} = \frac{\text{Average mass of an atom}}{\frac{1}{12} \times \text{Mass of an atom of } ^{12}\text{C}}$$
Average mass of an atom
$$= \frac{\text{R.A}(1) \times \text{M.No.} + \text{R.A}(2) \times \text{M.No.}}{\text{R.A}(1) + \text{R.A}(2)}$$
Here R.A = Relative abundance, M.No = Mass number, and 1 and 2 refer to the two possible isotopes. As atomic mass is a ratio so it has no unit.
6. **(a)** Examples of isomorphous compounds are K_2SO_4, K_2CrO_4, K_2SeO_4, (valency of S, Cr, Se = 6) and $ZnSO_4.7H_2O$, $MgSO_4.7H_2O$ $FeSO_4.7H_2O$ (valency of Zn, Mg, Fe = 2).
7. **(c)** Atomic mass and molecular mass are the ratios and have no units.
$$\text{Mol. mass} = \frac{\text{Wt. of one molecule of the substance}}{\frac{1}{12} \times \text{wt. of one atom of C}-12}$$
8. **(a)** 12g of C - 12 contains 6.023×10^{23} atom
$$\therefore \ 1\text{amu} = \frac{1}{12} \times \frac{12}{6.023} \times 10^{-23} = 1.66 \times 10^{-24} \text{ g}$$
9. **(b)** When two elements combine with each other to form two or more compounds, the masses of one of the elements which combine with fixed mass of the other, have a simple whole number ratio to one another, (law of multiple proportions. Reason is the statement of law of reciprocal proportions.
10. **(c)** The ratio of the volume of gaseous reactants and products is in agreement with their molar ratio. For example :
$$H_2 + Cl_2 \rightarrow 2HCl$$
The ratio of $H_2 : Cl_2 : HCl$ by volume is 1 : 1 : 2 which is the same as their molar ratio.
11. **(a)** Molality does not depend upon volume and hence it does not depend on temperature.
12. **(b)** $Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$
$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$
From the above reactios E is clearly true that 2 moles of HCl are required for complete neutralisation of Na_2CO_3. Further the titre value using methyl orange corresponds to complete neutralisation of Na_2CO_3; the titre value using phenolphthalein corresponds only to the neutralisation of Na_2CO_3 to $NaHCO_3$, *i.e.*, half of the value required by Na_2CO_3 solution. Hence S is also true. But E is not the correct explanation of S.
13. **(c)** Assertion is true, reason is false.
$$\text{Eq. wt. of } H_3PO_3 = \frac{\text{mol.wt}}{2} \ [\because \text{Basicity of } H_3PO_3 = 2]$$
14. **(b)** Assertion is true, reason is true but reason is not the correct explanation of assertion.
Since $KClO_3$ is 40% pure, so amount (in mole) of pure $KClO_3$ present in 5 mole of impure $KClO_3$ is $\frac{40}{100} \times 5 =$ 2 moles i.e., 2 moles of $KClO_3$ gives 3 mole of oxygen so the yield is 100 %.
15. **(d)** Assertion is wrong. The ratio of $x : y$ in it is not 1 : 3
The balanced reaction is
$$3\,Sn^{2+} + Cr_2O_7^{2-} + 14H^+ \longrightarrow 3\,Sn^{4+} + 2Cr^{3+} + 7H_2O$$
So the ratio $x : y$ is 3 : 1 and not 1 : 3
Reason is true i.e., $x + y + z = 18$

D MULTIPLE CORRECT CHOICE TYPE

1. **(b,c,d)** Molar mass of gas $= \frac{0.220}{112} \times 22400 = 44$
3. **(b,c,d)** $2Na_3PO_{4(aq)} + 3Ba(NO_3)_{2(aq)}$
$$\longrightarrow Ba_3(PO_4)_{2(s)} + 6NaNO_{3(aq)}$$
Na_3PO_4 is the limiting reactant and is completely consumed.
Mol of $Ba_3(PO_4)_2$ formed $= \frac{0.2}{2} = 0.1$;
mol of $Ba(NO_3)_2$ reacted $= \frac{3}{2} \times 0.2 = 0.3$
Mol of unreacted $Ba(NO_3)_2 = 0.5 - 0.3 = 0.2$ = mol of Ba^{2+} ion
Mol of Na^+ in solution $= 0.2 \times 3 = 0.6$;
Mol of NO_3^- in solution $= 0.5 \times 2 = 1$
4. **(b,c,d)** $NaNO_2 + NH_4Cl \rightarrow NH_4NO_2 + NaCl$;
$NH_4NO_2 \rightarrow N_2 + 2H_2O$
$NaNO_2$ is limiting reactant.

Mol of N_2 formed = mol of NH_4NO_2 formed = 0.5
Volume of N_2(STP) = 0.5 × 22.4 = 11.2 L ; mass of N_2 = 0.5 × 28 = 14g

5. (a,b,d) $2CO + O_2 \rightarrow 2CO_2$ The residual gas is CO.
Volume of CO oxidised = 2 × 30 = 60 ml ; Volume of CO = 60 + 10 = 70 ml
Volume of CO_2 initially present in the mixture = 100 – 70 = 30 ml
Volume of CO_2 formed = 60 ml ; Volume of CO_2 absorbed by KOH = 30 + 60 = 90 ml

6. (a,b,d) $CO_{2(g)} + C_{(s)} \rightarrow 2CO_{(g)}$;
Volume of CO_2 = x ml, volume of CO = 100 – x
Final volume = 100 – x + 2x = 160 $\Rightarrow x$ = 60ml ;
Volume of CO = 100 – 60 = 40ml

Mole fraction of CO = $\frac{40}{100} = 0.4$;

Mol % of CO_2 = 60

7. (b,c) $CaSO_{3(s)} + H_2O_{(\ell)} + SO_{2(g)} \rightarrow Ca(HSO_3)_2$
(soluble)
mol of SO_2 required = mol of $CaSO_3$

$= \frac{12}{120} = 0.1$; mass of SO_2 = $0.1 \times 64 = 6.4g$

8. (c,d) $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
(neutralization)
mol of NaOH = 100 × 10^{-3} × 1 = 0.1 ; mol of H_2SO_4

required = $\frac{0.1}{2} = 0.05$

mass of H_2SO_4 required in 100 ml = 0.05 × 98 = 4.9g
mass of H_2SO_4 per litre of solution

$= \frac{4.9 \times 1000}{100} = 49g$

9. (a,c) H_3PO_3 is a dibasic acid. Equivalent mass = molar mass / 2

10. (b,c) $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$;
$H_2SO_4 + Ba(OH)_2 \rightarrow BaSO_4 + 2H_2O$
mol of NaOH required = 2 × 1.5 = 3
mol of $Ba(OH)_2$ required = 1.5

11. (d) Volume of 100g of solution = 100/1.09 ml

Hence, molarity = $\frac{17 \times 1000}{82 \times \frac{100}{1.09}} = 2.26$

12. (a,b) The hard water sample contains HCO_3^- ion and can be titrated with dil HCl as also with dil NaOH.
$HCO_3^- + HCl \rightarrow H_2O + CO_2 + Cl^-$
$HCO_3^- + NaOH \rightarrow Na^+ + CO_3^{2-} + H_2O$

13. (c,d) Mole ratio of iodine : oxygen = $\frac{254}{127} : \frac{112}{16} = 2 : 7$

The oxide is I_2O_7.

When dissolved in water it can produce HIO_4 or H_5IO_6

$I_2O_7 + H_2O \longrightarrow 2HIO_4$

$I_2O_7 + 5H_2O \longrightarrow 2H_5IO_6$

14. (a,b,c) Volume strength of an H_2O_2 solution is the volume of O_2 in litres at NTP produced by 1 L of the solution.

$2H_2O_2 \longrightarrow 2H_2O + O_2$
68 g   22.4 L at NTP
∴ Volume produced by 17g H_2O_2 (present in 1 L

solution) $= \frac{22.4}{68} \times 17 = 5.6$ L at NTP

So the volume strength is 5.6.
The volume of O_2 given out at NTP by 1 L of solution = 5.6 L
∴ Volume of O_2 given out at NTP by 1 ml of solution = 5.6 mL
Converting this volume to volume at 2 atmosphere pressure and 273 K temperature, we get

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ or volume $= \frac{5.6}{2} = 2.8$ ml

Moles of H_2O_2 present in 1 L solution = $\frac{17}{34}$
= 0.5 moles
[Mol wt = 34]
∴ Molarity of given solution = 0.5 M

15. (b) Weight of solute present in 500 g of solution

$= \frac{30 \times 500}{100} = 150g$

Weight of solvent in 500 g of solution
= [500 – 150g] = 350g
Weight of solute left after cooling
= (150 – 50g) = 100 g
Total weight of solution after cooling
= (350 + 100) g = 450g
Now 450 g of solution contains solute 'X' = 100 g
∴ 100 g of solution contains solute 'X'

$= \frac{100}{450} \times 100 = 22.2\%$

16. (c) Let the hydrocarbon be C_xH_y. The reaction that occurs can be represented as

$$C_xH_y + \left(x + \frac{y}{4}\right) O_2 \longrightarrow x\,CO_2 + \frac{y}{2}\,H_2O$$

10 ml   10(x + y/4) ml   10x ml
1 mole of hydrocarbon reacts with (x + y/4) moles of O_2(g) to produce x mole of CO_2 and y/2 moles of H_2O.
Volume of CO_2 produced from 10 ml of hydrocarbon = 10x ml
Volume of O_2 consumed by 10 ml of hydrocarbon = 10x (x + y/4) ml

At a pressure of 1 atm and room temperature water vapour is condensed to liquid state. The residual gases are CO_2 and unreacted O_2.
Hence, volume of CO_2 and left out O_2 = 180 ml
On passing the mixture of gases through aqueous KOH, CO_2 is absorbed leaving behind O_2.
Hence volume of unreacted O_2 = 100 ml (given)

Volume of O_2 reacted = 200 – 100 = 100 ml
Volume of CO_2 produced = 180 – 100 = 80 ml
Then, we have
$10x = 80$ or $x = 8$
And $10 \times (x + y/4) = 100$
or $8 + y/4 = 10 \Rightarrow y = 8$
Thus the hydrocarbon is C_8H_8

E MATRIX-MATCH TYPE

1. A - s; B - r; C - p; D - q

Moles of A needed to react completely with 1 mole of B $= \frac{2}{3}$ (Hence B is limiting reagent)

Moles of A left unreacted $= 2 - \frac{2}{3} = \frac{4}{3}$

Moles of X formed $= \frac{1}{3}$; Mole of Y formed $= \frac{2}{3}$

2. A - r; B - s; C - q; D - p, s

(A) $H_2C_2O_4 + NaOH \longrightarrow NaHC_2O_4(\text{acid salt}) + H_2O$

(B) H_3PO_2 (monobasic acid)

$+KOH \longrightarrow KH_2PO_2$ (normal salt) $+ H_2O$

(C) $Ca(OH_2) + HCl \longrightarrow Ca(OH)Cl$ (Basic salt) $+ H_2O$

(D) CHOHCOOH | CHOHCOOH $+ KOH + NaOH \longrightarrow$ CHOHCOOK | CHOHCOONa (Mixed salt) $+2H_2O$

3. A - r; B - s; C - q; D - p

$FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2 + 3e^- \times 5$

$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O \times 3$

$$5FeC_2O_4 + 3MnO_4^- + 24H^+ \longrightarrow 5Fe^{3+} + 3Mn^{2+} + 10CO_2 + 12H_2O$$

4. A - s; B - r; C - q; D - p

Water gas $\longrightarrow CO + H_2$ (1 : 1 mixture by volume)

$CO(1.0\,L) + H_2(1.0\,L) + O_2 \longrightarrow CO_2(1.0\,L) + H_2O_{(\ell)}$

Volume of CO_2 formed = 1.0 L (absorbed by $KOH_{(aq)}$)
Volume of O_2 used = 1.0 L

Volume of O_2 present in 8.0 L of air $= 8 \times \frac{1}{5} = 1.6\,L$

Volume of O_2 left $= 1.6 - 1.0 = 0.6\,L$ (absorbed by pyrogallol)

Volume of residual gas (N_2) $= 8.0 - 1.6 = 6.4\,L$

5. A - p, q; B - p; C - p, q, r; D - s

1.5 mole of $CO_2\,(g) = 1.5 \times 22400$ mL at NTP
= 33600 ml at NTP
Total number of atoms in one molecule of $CO_2 = 1 + 2 = 3$
Total number of atoms in 1.5 mole of $CO_2 = 1.5 \times 3 \times N_A = 4.5 \times N_A$

3.0 g of $H_2 = \frac{3}{2} \times 22400$ mL of H_2 at NTP = 33600 ml at NTP

Number of mole of H_2 in 3.0 g $H_2 = \frac{3}{2}$ or 1.5 moles

Number of atoms in 1 molecule of $H_2 = 2$
Number of atoms in 1.5 mole $H_2 = 2 \times 1.5 \times N_A = 3.0 \times N_A$
Volume of 1.5 moles of ozone at NTP = 22400 × 1.5 ml = 33600 ml
Number of atoms in one molecule of $O_3 = 3$
Total number of atoms in 1.5 mole of $O_3 = 3 \times 1.5 \times N_A = 4.5 \times N_A$
Weight of 1 mole of $O_3 = 48\,g$
Weight of 1.5 mole of $O_3 = 48 \times 1.5$ g $= 72\,g$
Weight of 1 mole of oxygen (O_2) = 32g

6. A - p, r; B - q, r; C - q, s; D - q, r

% of age of heavier isotope

In (A) $= \frac{Z-(Z-1)}{(Z+3)-(Z-1)} \times 100$

[% by mole $= \frac{M_{Avg} - M_1}{M_2 - M_1} \times 100$]

$= \frac{Z - Z + 1}{Z + 3 - Z + 1} \times 100 = \frac{1}{4} \times 100$ or 25%

In (B) $= \frac{(Z+2)-(Z+1)}{(Z+3)-(Z+1)} \times 100$

$= \frac{Z+2-Z-1}{Z+3-Z-1} = \frac{1}{2} \times 100$ or 50%

In (C) $= \frac{2Z-(Z)}{3Z-Z} \times 100 = \frac{Z}{2Z} \times 100$ or 50%

In (D) $= \frac{Z-(Z-1)}{(Z+1)-(Z-1)} \times 100$

$= \frac{Z-Z+1}{Z+1-Z+1} \times 100 = \frac{1}{2} \times 100$ or 50%

% age of mass of heavier isotope in (A) $= \frac{25 \times (Z+3)}{Z}$

[% by mass of heavier isotope $= \frac{\%\text{by moles} \times \text{Mass of heavier isotope}}{\text{Average mass}}$]

$= \frac{25Z+75}{Z}$

Thus % age by mass of heavier isotope depends on Z.

In (B) $= \frac{50\times(Z+3)}{(Z+2)}$ or $\frac{50Z+150}{Z+2}$ [depends on Z]

In (C) $= \frac{50\times(3Z)}{2Z}$ or $\frac{150}{2}$ i.e. 75% [It does not depend on Z]

in (D) $= \frac{50\times(Z+1)}{Z}$ or $\frac{50Z+50}{Z}$ i.e. it depends on Z

F NUMERIC/INTEGER ANSWER TYPE

1. Ans : 20

Let a and b cm^3 be the volumes of CO and CH_4 respectively in the mixture.

$$CO_{(g)} + \frac{1}{2}O_{2(g)} \longrightarrow CO_{2(g)}$$

1 vol   1/2vol   1 vol
a cm^3 $a/2$ cm^3 a cm^3

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$$

1 vol   2 vol   1 vol
b cm^3 $2b$ cm^3 b cm^3

Reactions show that volume contraction after the reaction is due only to the consumption of oxygen.

Volume contraction after reaction, $\frac{a}{2} + 2b = 13$ .... (i)

When treated with aqueous KOH, CO_2 is absorbed.
Hence $a + b = 14$ ....(ii)
Solving equation (i) and (ii), $a = 10$, $b = 4$
% of CO = 50; % of CH_4 = **20**; % of He = 30;

2. Ans : 4

$$\underset{a\ \text{moles}}{HCOOH} \xrightarrow{H_2SO_4} H_2O + \underset{a\ \text{moles}}{CO}$$

$$\underset{b\ \text{moles}}{H_2C_2O_4} \xrightarrow{H_2SO_4} H_2O + \underset{b\ \text{moles}}{CO} + \underset{b\ \text{moles}}{CO_2}$$

Total number of moles of gases formed = $a + 2b$
Moles of gas (CO_2) absorbed by KOH = b

Hence, $b = \frac{1}{6}(a+2b)$ [Volume ∝ moles]

$a/b = 4$

3. Ans : 21.7

(a) $MCO_3 \xrightarrow{\Delta} MO + CO_{2(g)}$

(b) $M'CO_3 \xrightarrow{\Delta} M'O + CO_{2(g)}$

1 mole of CO_2 (44 g) ≡ 1 mole of CO_3^{2-} ion (60 g)

1.233g of $CO_2 \equiv \frac{60\times1.233}{44} = 1.68$g of CO_3^{2-}ion

Percentage of CO_3^{2-} ion $= \frac{1.68\times100}{2.58} = 65.12$

Percentage of one of the metals = 13.2

Percentage of the other metal = 100 – 65.12 (total CO_3^{2-}) – 13.20 = 21.68.

4. Ans : 51.7

Pressure (P) of mixture $= \frac{10^{-3}}{760}$ atm

Number of moles of gaseous mixture

$$n = \frac{PV}{RT} = \frac{10^{-3}\times2}{760\times0.082\times300} = 1.069\times10^{-7}$$

Moles of N_2 $= \frac{3}{8}\times1.069\times10^{-7} = 4.008\times10^{-8}$

Moles of water vapour $= \frac{5}{8}\times1.069\times10^{-7} = 6.668\times10^{-8}$

Weight of N_2 gas = $4.008 \times 10^{-8} \times 28 = 11.22 \times 10^{-7}$g
Weight of water vapour = $6.668 \times 10^{-8} \times 18 = 12.00 \times 10^{-7}$g
Total weight of the mixture = $(11.22 + 12.00) \times 10^{-7}$
= 23.22×10^{-7} g

At – 50°C water vapour will condense to solid (ice) and hence the only gas available at that temperature would be nitrogen.

Percent loss of mass of the mixture on cooling to – 50°C

$$= \frac{12.00\times10^{-7}\times100}{23.22\times10^{-7}} = 51.68.$$

5. Ans : 0.167

$$C_6H_{6(g)} + 3H_{2(g)} \longrightarrow C_6H_{12(g)}$$

Let x and y be the partial pressures (initial) of gaseous benzene and hydrogen in the vessel.
Then, $x + y = 60$ .... (i)
After the reaction, whole of benzene is converted to cyclohexane.
Partial pressure of cyclohexane = x mm
Partial pressure of hydrogen left unreacted = $y - 3x$
Total pressure of the system after the reaction,
$x + y - 3x = y - 2x = 30$ .... (ii)
Solving (i) and (ii), $x = 10$ mm
Number of moles ∝ pressure ; Volume ∝ number of moles
Hence, fraction of benzene by volume in the original

mixture $= \frac{10}{60} = \frac{1}{6} = 0.167$.

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