CHAPTER 2

Equivalent Concept

EXERCISE I (JEE MAIN)

Oxidation–Reduction

1. A compound contains X, Y and Z atoms. The oxidation states of X are $+a$, Y is $-b$ and Z is $-c$. The molecular formula of the compound is $X_mY_nZ_r$. Therefore, among the given relations, which one is correct?

(a) $am + bn + cr = 0$ (b) $am + bn = cr$
(c) $am + cr = bn$ (d) $bn + cr = am$

2. What is the oxidation state of Xe in Ba_2XeO_6?

(a) 0 (b) +4
(c) +6 (d) +8

3. When $K_2Cr_2O_7$ is converted into K_2CrO_4, the change in oxidation number of Cr is

(a) 0 (b) 6
(c) 4 (d) 3

4. The formula of brown ring complex is $[Fe(H_2O)_5(NO)]SO_4$. The oxidation state of iron is

(a) +1 (b) +2
(c) +3 (d) 0

5. In the reaction: $3Br_2 + 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + BrO_3^- + 6HCO_3^-$

(a) Bromine is oxidized and carbonate is reduced.
(b) Bromine is oxidized and water is reduced.
(c) Bromine is both oxidized and reduced.
(d) Bromine is neither oxidized nor reduced.

6. In which of the following compound, the oxidation state of sulphur is +7?

(a) $Na_2S_2O_8$ (b) $H_2S_2O_7$
(c) H_2SO_4 (d) None of these

7. In which of the following compound, iron has the lowest oxidation state?

(a) $Fe(CO)_5$
(b) Fe_2O_3
(c) $K_4[Fe(CN)_6]$
(d) $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$

8. Which of the following have been arranged in the order of decreasing oxidation number of sulphur?

(a) $H_2S_2O_7 > Na_2S_4O_6 > Na_2S_2O_3 > S_8$
(b) $SO^{2+} > SO_4^{2-} > SO_3^{2-} > HSO_4^-$
(c) $H_2SO_5 > H_2SO_3 > SCl_2 > H_2S$
(d) $H_2SO_4 > SO_2 > H_2S > H_2S_2O_8$

9. The oxidation state of iron in oxygenated haemoglobin is

(a) +1 (b) +2
(c) +3 (d) Zero

10. The oxidation numbers of C in HCN and HNC, respectively, are

(a) +2, +2 (b) +2, +4
(c) +4, +4 (d) −2, −2

11. The oxidation number of carbon in carbon suboxide (C_3O_2) is

(a) +2/3 (b) +4/3
(c) +4 (d) −4/3

12. The oxidation states of the most electronegative element in the products of the reaction, BaO_2 with dil. H_2SO_4 are

(a) 0 and −1 (b) −1 and −2
(c) −2 and 0 (d) −2 and +1

13. The pair of compounds having metals in their highest oxidation state is

(a) MnO_2, $FeCl_3$
(b) $[MnO_4]^-$, CrO_2Cl_2
(c) $[Fe(CN)_6]^{3-}$, $[Co(CN)_3]$
(d) $[NiCl_4]^{2-}$, $[CoCl_4]^-$

14. The oxidation number of phosphorus in $Mg_2P_2O_7$ is

(a) +5 (b) −5
(c) +6 (d) −7

15. The sum of oxidation states of all carbon atoms in toluene molecule is

(a) −1 (b) −7/8
(c) −8/7 (d) −8

16. The oxidation number of K in KO_2 is

(a) +4 (b) +1
(c) +1/2 (d) −1/2

17. The oxidation state of chromium is +6 in

(a) K_3CrO_8 (b) Cr_2O_3
(c) $Cr_2(SO_4)_3$ (d) CrO_5

18. The oxidation states of N in aniline and nitrobenzene are, respectively,

(a) −3, +3 (b) −1, +5
(c) −3, +5 (d) −3, +1

19. Which of the following statements is true about oxidation state of S in $Na_2S_4O_6$?

(a) All S–atoms are in +2.5 state.
(b) All S–atoms are in +2 state.
(c) Two S–atoms are in 0 state and other two is in +5 state.
(d) Two S–atoms are in −1 state and other two is in +6 state.

20. The oxidation state of C in $C_6H_{12}O_6$ is equal to the oxidation state of C in

(a) HCOOH (b) HCHO
(c) CH_4 (d) CO

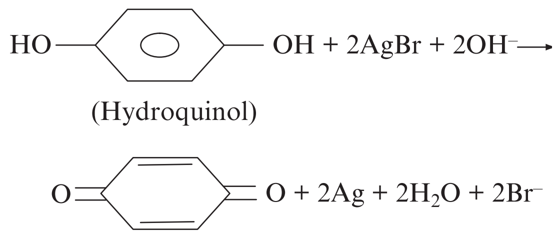
21. An oxide of iron contains 30% oxygen by mass. The oxidation state of iron in this oxide is (Fe =56)

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

22. The strongest reducing agent is

(a) H_2S (b) H_2O
(c) H_2Se (d) H_2Te

23. During developing of an exposed camera film, one step involves in the following reaction.



Which of the following best describes the role of hydroquinol?

(a) It acts as an acid.
(b) It acts as a reducing agent.
(c) It acts as an oxidant.
(d) It acts as a base.

24. A redox reaction is

(a) exothermic.
(b) endothermic.
(c) neither exothermic nor endothermic.
(d) either exothermic or endothermic.

25. The decomposition of $KClO_3$ to KCl and O_2 on heating is an example of

(a) intermolecular redox change
(b) intramolecular redox change
(c) disproportionation or auto redox change
(d) All the above

26. Which of the following reaction is non-redox?

(a) $2NaNO_3 \rightarrow 2NaNO_2 + O_2$
(b) $CaO + SiO_2 \rightarrow CaSiO_3$
(c) $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$
(d) $4Ag + 8CN^- + O_2 + 2H_2O \rightarrow 4[Ag(CN)_2]^- + 4OH^-$

27. Which of the following reaction is not a disproportionation reaction?

(a) $Br_2 + CO_3^{2-} + H_2O \rightarrow Br^- + BrO_3^- + HCO_3^-$

(b) $P_4 + OH^- + H_2O \rightarrow PH_3 + H_2PO_2^-$

(c) $H_2S + SO_2 \rightarrow S + H_2O$

(d) $H_2O_2 \rightarrow H_2O + O_2$

28. Which of the following reaction is an example of comproportionation reaction?

(a) $Cl_2 + OH^- \rightarrow Cl^- + ClO_3^- + H_2O$

(b) $CH_4 + O_2 \rightarrow CO_2 + H_2O$

(c) $H_2S + SO_2 \rightarrow S + H_2O$

(d) $NaOH + HCl \rightarrow NaCl + H_2O$

29. An oxide, X_2O_3 is oxidized to XO_4^- by $Cr_2O_7^{2-}$ in acid medium. The number of moles of X_2O_3 oxidized per mole of $Cr_2O_7^{2-}$ is

(a) 3/4 (b) 3

(c) 3/2 (d) 2/3

30. The number of electrons involved in the reduction of nitrate ion to hydrazine is

(a) 8 (b) 7

(c) 5 (d) 3

31. In the disproportionation reaction (unbalanced),

$$Br_2 + OH^- \rightarrow Br^- + BrO_3^- + H_2O,$$

the ratio of Br_2 molecules undergoing oxidation and reduction is

(a) 5:1 (b) 1:5

(c) 2:3 (d) 3:2

32. For the process, $NO_3^- \rightarrow N_2O$, the number of H_2O molecules needed for balancing in acid medium and the side in which it should be added are

(a) 2, right (b) 2, left

(c) 5, right (d) 5, left

33. In the process, $NO_2^- \rightarrow NH_3$, the number of OH^- ions and the side in which they should be added in balancing are

(a) 7, right (b) 7, left

(c) 4, left (d) 5, right

34. For the redox reaction,

$Zn + NO_3^- \rightarrow Zn^{2+} + NH_4^+$

in basic medium, the coefficients of Zn, NO_3^- and OH^- in the balanced equation, respectively, are

(a) 4, 1, 7 (b) 7, 4, 1

(c) 4, 1, 10 (d) 1, 4, 10

35. The ratio of coefficients of HNO_3, $Fe(NO_3)_2$ and NH_4NO_3 in the following redox reaction,

$$Fe + HNO_3 \rightarrow Fe(NO_3)_2 + NH_4NO_3 + H_2O$$

respectively

(a) 10 : 1 : 4 (b) 10 : 4 : 1

(c) 4 : 10 : 1 (d) 4 : 1 : 10

Equivalent Concept

36. An oxide of metal have 20% oxygen, the equivalent weight of oxide is

(a) 32 (b) 48

(c) 40 (d) 52

37. On heating in contact with tin, sulphurated hydrogen (V.D. = 17) is converted into hydrogen without change in volume. The equivalent weight of sulphur is

(a) 32 (b) 16

(c) 24 (d) 34

38. An element (X) having equivalent mass *E* forms an oxide X_mO_n. The atomic mass of element should be

(a) $\frac{2En}{m}$ (b) $2mEn$

(c) $\frac{E}{n}$ (d) En

39. Equivalent weight of a metal is 18.67. When it reacts with chlorine, the mass of metal which will form 162.52 g of metal chloride is

(a) 143.83 g (b) 56 g

(c) 14.4 g (d) 5.6 g

40. How many grams of Mg would have to react in order to liberate 4 N_A electrons?

(a) 12 g (b) 24 g

(c) 48 g (d) 96 g

41. Equivalent weight of K_2CrO_4 when it reacts with $AgNO_3$ to give Ag_2CrO_4 is

(a) infinite (b) M
(c) $\frac{M}{2}$ (d) $\frac{M}{3}$

42. The equivalent weight of $NaHC_2O_4$ in reaction with NaOH is

(a) 112 (b) 56
(c) 224 (d) 84

43. The equivalent weight of $NaHC_2O_4$ in reaction with HCl is

(a) 112 (b) 56
(c) 224 (d) 8

44. In a reaction, calcium phosphate is producing calcium hydrogen phosphate. The equivalent weight of calcium phosphate in this process is (Ca = 40, P = 31)

(a) 310 (b) 155
(c) 103.33 (d) 51.67

45. The equivalent weight of $MnSO_4$ is half of its molecular weight when it is converted to

(a) Mn_2O_3 (b) MnO_2
(c) MnO_4^- (d) MnO_4^{2-}

46. Equivalent weight of MnO_4^- in acidic, basic, neutral medium is in the ratio of

(a) 3 : 5 : 15 (b) 5 : 3 : 1
(c) 5 : 1 : 3 (d) 3 : 15 : 5

47. In the following reaction (unbalanced), equivalent weight of As_2S_3 is related to its molecular weight, M, by

$$As_2S_3 + H^+ + NO_3^- \rightarrow NO + H_2O + AsO_4^{3-} + SO_4^{2-}$$

(a) $M/2$ (b) $M/4$
(c) $M/28$ (d) $M/24$

48. In the following redox reactions, NH_3 appears either in reactant or product. In which case, the equivalent weight of NH_3 is maximum?

(a) $N_2 + 3H_2 \rightarrow 2NH_3$
(b) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
(c) $2NH_3 + 2Na \rightarrow 2NaNH_2 + H_2$
(d) Equal in all cases

49. In the following unbalanced redox reaction,

$Cu_3P + Cr_2O_7^{2-} \rightarrow Cu^{2+} + H_3PO_4 + Cr^{3+}$,

the equivalent weight of H_3PO_4 is

(a) M/3 (b) M/6
(c) M/7 (d) M/8

50. The equivalent weight of Cl_2 acting as oxidizing agent is

(a) 72 (b) 35.5
(c) 7.1 (d) 23.67

51. H_2O_2 disproportionates into H_2O and O_2. The equivalent weight of H_2O_2 in this reaction is

(a) 34 (b) 17
(c) 68 (d) 8.5

52. The equivalent weight of H_2SO_4 in the reaction:

$$2KMnO_4 + 3H_2SO_4 + 10HCl \rightarrow 2MnSO_4 + K_2SO_4 + 5Cl_2 + 8H_2O, \text{ is}$$

(a) $\frac{M}{2}$ (b) M
(c) $\frac{3M}{10}$ (d) $\frac{3M}{5}$

53. What would be the equivalent weight of reductant in the reaction? (Fe = 56)

$$2[Fe(CN)_6]^{-3} + H_2O_2 + 2OH^- \rightarrow 2[Fe(CN)_6]^{4-} + 2H_2O + O_2$$

(a) 17 (b) 212
(c) 34 (d) 32

54. In the Haber's process, the equivalent weight of ammonia is

(a) M (b) M/3
(c) 2M/3 (d) 3M

55. Equivalent mass of a bivalent metal is 32.7. Molecular mass of its chloride is

(a) 68.2 (b) 103.7
(c) 136.4 (d) 166.3

56. In the reaction,

$Zn + HNO_3 \rightarrow Zn(NO_3)_2 + NO + H_2O$,

the equivalent weight of HNO_3 is

(a) M (b) $4M/3$
(c) $8M/3$ (d) $2M/3$

57. Equivalent weight of H_2SO_4 in the reaction
$Mg + 2H_2SO_4 \rightarrow MgSO_4 + SO_2 + 2H_2O$, is

(a) 98 (b) 49
(c) 196 (d) 32.67

58. A metal carbonate on heating is converted to metal oxide and is reduced to 60% of its original weight. The equivalent weight of the metal is

(a) 5 (b) 25
(c) 60 (d) 70

59. A quantity of 0.298 g of the chloride of a metal yielded 0.348 g of the sulphate of the same metal. The equivalent weight of the metal is

(a) 12 (b) 20
(c) 39 (d) 41.5

60. NH_3 is oxidized to NO by O_2 in basic medium. The number of equivalents of NH_3 oxidized by 1 mole of O_2 is

(a) 4 (b) 5
(c) 6 (d) 7

61. The number of moles of $Cr_2O_7^{2-}$ needed to oxidize 0.136 equivalent of $N_2H_5^+$ through the reaction

$$N_2H_5^+ + Cr_2O_7^{2-} \rightarrow N_2 + Cr^{3+} + H_2O \text{ is}$$

(a) 0.023 (b) 0.091
(c) 0.136 (d) 0.816

62. A certain amount of a reducing agent reduces x mole of $KMnO_4$ and y mole of $K_2Cr_2O_7$ in different experiments in acidic medium. If the change in oxidation state in reducing agent is same in both experiments, $x : y$ is

(a) 5 : 3 (b) 3 : 5
(c) 5 : 6 (d) 6 : 5

63. When a metal carbonate is treated with excess of dilute sulphuric acid, the weight of metal sulphate formed is 1.43 times the weight of carbonate reacted. What is the equivalent weight of metal?

(a) 23 (b) 20
(c) 39 (d) 12

64. How many grams of H_2S will react with 6.32 g $KMnO_4$ to produce K_2SO_4 and MnO_2? (K = 39, Mn = 55)

(a) 4.08 g (b) 0.85 g
(c) 0.51 g (d) 2.04 g

65. The oxide of a metal contains 52.91% of the metal. If the formula of the metal oxide is M_2O_3, then what is the atomic mass of the metal?

(a) 8.99 (b) 26.96
(c) 17.97 (d) 53.93

66. The equivalent weight of an element is 25. If its specific heat is 0.085 cal/K-g, its exact atomic mass should be

(a) 75.29 (b) 75
(c) 50 (d) 50.8

67. The vapour density of metal chloride is 77. If its equivalent weight is 3, its atomic mass will be

(a) 3 (b) 6
(c) 9 (d) 12

68. One gram of the acid $C_6H_{10}O_4$ requires 0.768 g of KOH for complete neutralization. How many neutralizable hydrogen atoms are in this molecule?

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

69. A quantity of 1.878 g of a metal bromide when heated in a stream of hydrogen chloride gas is completely converted to the chloride weighing 1.00 g. The specific heat of the metal is 0.14 cal/°c-g. What is the molecular weight of the bromide? (Br = 80, Cl = 35.5)

(a) 45.54 (b) 125.54
(c) 285.54 (d) 205.54

70. Potassium sulphate is isomorphous with potassium chromate which contains 26.79% by mass of chromium. The atomic mass of chromium is

(a) 24 (b) 32
(c) 51.96 (d) 53.2

Volumetric Analysis

71. Equal volumes of 10% (w/v) H_2SO_4 solution and 10% (w/v) NaOH solution are mixed. The nature of the resulting solution will be

(a) neutral (b) acidic
(c) basic (d) unpredictable

72. A quantity of 0.62 g of $Na_2CO_3 \cdot H_2O$ is added to 100 ml of 0.1 N-H_2SO_4 solution. The resulting solution would be

(a) acidic (b) alkaline
(c) neutral (d) buffer

73. The volume of 0.10 M-$AgNO_3$ should be added to 10.0 ml of 0.09 M-K_2CrO_4 to precipitate all the chromate as Ag_2CrO_4 is

(a) 18 ml (b) 9 ml
(c) 27 ml (d) 36 ml

74. What volume of 0.18 N-$KMnO_4$ solution would be needed for complete reaction with 25 ml of 0.21 N-KNO_2 in acidic medium?

(a) 57.29 ml (b) 11.67 ml
(c) 29.17 ml (d) 22.92 ml

75. A 0.1 M-$KMnO_4$ solution is used for the following titration. What volume of the solution will be required to react with 0.158 g of $Na_2S_2O_3$?

$$S_2O_3^{2-} + MnO_4^- + H_2O \rightarrow MnO_2(s) + SO_4^{2-} + OH^-$$

(a) 80 ml (b) 26.67 ml
(c) 13.33 ml (d) 16 ml

76. One litre of a solution contains 18.9 g of HNO_3 and one litre of another solution contains 3.2 g of NaOH. In what volume ratio must these solutions be mixed to obtain a neutral solution?

(a) 3:8 (b) 8:3
(c) 15:4 (d) 4:15

77. What volume of gaseous NH_3 at 0°C and 1 atm will be required to be passed into 30 ml of N–H_2SO_4 solution to bring down the acid strength of this solution to 0.2 N?

(a) 537.6 ml (b) 268.8 ml
(c) 1075.2 ml (d) 371.3 ml

78. A 26 ml of N-Na_2CO_3 solution is neutralized by the solutions of acids A and B in different experiments. The volumes of the acids A and B required were 10 ml and 40 ml, respectively. How many volumes of A and B are to be mixed in order to prepare 1 litre of normal acid solution?

(a) 179.4, 820.6 (b) 820.6, 179.4
(c) 500, 500 (d) 474.3, 525.7

79. A sample of an alloy of silver weighing 0.50 g and containing 90% silver was dissolved in conc. HNO_3 and silver was analysed by Volhard method. A volume of 25 ml of a KCNS solution was required for complete precipitation. The normality of KCNS solution is (Ag = 108)

(a) 4.167 (b) 0.167
(c) 3.136 (d) 0.125

80. A 0.5 g sample of KH_2PO_4 is titrated with 0.1 M NaOH. The volume of base required to do this is 25.0 ml. The reaction is represented as

$$H_2PO_4^- + OH^- \rightarrow HPO_4^{2-} + H_2O.$$

The percentage purity of KH_2PO_4 is (K = 39, P = 31)

(a) 68% (b) 34%
(c) 85% (d) 51%

81. A solution of H_2O_2 is titrated with a solution of $KMnO_4$. The reaction is

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

It requires 50 ml of 0.1 M-$KMnO_4$ to oxidize 10 ml of H_2O_2. The strength of H_2O_2 solution is

(a) 4.25% (w/v) (b) 8.5% (w/v)
(c) 0.85% (w/v) (d) 1.7% (w/v)

82. For the standardization of $Ba(OH)_2$ solution, 0.204 g of potassium acid phthalate was weighed which was then titrated with $Ba(OH)_2$ solution. The titration indicated equivalence at 25.0 ml of $Ba(OH)_2$ solution. The reaction involved is

$$KHC_8H_4O_4 + Ba(OH)_2 \rightarrow H_2O + K^+ + Ba^{2+} + C_8H_4O_4^{2-}$$

The molarity of the base solution is (K = 39)

(a) 0.04 M (b) 0.03 M
(c) 0.02 M (d) 0.01 M

83. A volume of 12.5 ml of 0.05 M selenium dioxide, SeO_2, reacted with exactly 25.0 ml of 0.1 M – $CrSO_4$. In this reaction, Cr^{2+} is converted to Cr^{3+}. To what oxidation state the selenium is converted by the reaction?

(a) 0 (b) +1
(c) +2 (d) +4

84. The chromate ion may be present in waste water from a chrome planting plant. It is reduced to insoluble chromium hydroxide, $Cr(OH)_3$ by dithionation, in basic solution:

$$S_2O_4^{2-} + CrO_4^{2-} + H_2O + OH^- \rightarrow SO_3^{2-} + Cr(OH)_3$$

100 litre of water requires 522 g of $Na_2S_2O_4$. The molarity of CrO_4^{2-} in waste water is

(a) 0.04 (b) 0.03
(c) 0.02 (d) 2.0

85. Calcium oxalate is insoluble in water. This property has been used to determine the amount of calcium ion in fluids such as blood. The calcium oxalate isolated from blood is dissolved in acid and titrated against a standard $KMnO_4$ solution. In one test, it is found that the calcium oxalate isolated from a 10 ml sample of blood requires 25 ml of 0.001 M-$KMnO_4$ for titration. The number of milligram of calcium per litre of blood is

(a) 0.25 (b) 0.50
(c) 0.80 (d) 0.40

86. How many grams of $KMnO_4$ will react with 50 ml of 0.2 M-$H_2C_2O_4$ solution in the presence of H_2SO_4?

(a) 1.58 g (b) 3.16 g
(c) 0.632 g (d) 0.79 g

87. What volume of 0.05 M-$Ca(OH)_2$ solution is needed for complete conversion of 10 ml of 0.1 M-H_3PO_4 into $Ca(H_2PO_4)_2$?

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

88. How many grams of oxalic acid crystals, $H_2C_2O_4 \cdot 2H_2O$ is needed to react completely with 100 ml of 0.4 M-$KMnO_4$ in the presence of H_2SO_4?

(a) 2.52 g (b) 12.6 g
(c) 25.2 g (d) 9.0 g

89. Borax has the formula $Na_2B_4O_7 \cdot 10H_2O$. It is a strong base in aqueous solution because OH^- ions are produced by reaction with water.

$(B_4O_7^{2-} + 7H_2O \rightarrow 4H_3BO_3 + 2OH^-)$.

How many grams of borax is necessary to neutralize 25 ml of 0.2 M solution of hydrochloric acid? (B = 10.8)

(a) 0.4765 g (b) 0.953 g
(c) 9.53 g (d) 1.906 g

90. A volume of 50 ml of 0.1 M metal salt reacts completely with 25 ml of 0.1 M sodium sulphite. In the reaction, SO_3^{2-} is oxidized to SO_4^{2-}. If the oxidation number of metal in the salt is +3, then what is its new oxidation number?

(a) 0 (b) +1
(c) 2 (d) 4

91. A 1 g sample of hydrogen peroxide solution containing $x\%$ of H_2O_2 by weight requires x ml of $KMnO_4$ solution for complete oxidation under acidic conditions. What is the normality of $KMnO_4$ solution?

(a) 5.88 N (b) 58.8 N
(c) 0.0588 N (d) 0.588 N

92. One gram of ferrous oxalate dissolved in dil. H_2SO_4 is treated with $KMnO_4$ solution added in drops till a faint pink colour persists in the solution. If 60 ml of $KMnO_4$ solution is consumed, then calculate its molarity (Fe = 56).

(a) 0.694 M (b) 0.0694 M
(c) 0.294 M (d) 0.0294 M

93. Magnesium hydroxide is the white milky substance in milk of magnesia. What mass of $Mg(OH)_2$ is formed when 15 ml of 0.2 M-NaOH is combined with 12 ml of 0.15 M-$MgCl_2$?

(a) 0.087 g (b) 0.079 g
(c) 0.1044 g (d) 0.522 g

94. The formula weight of an acid is 82 amu. In a titration, 100 cm^3 of a solution of this acid containing 39.0 g of the acid per litre was completely neutralized by 95 cm^3 of aqueous solution of NaOH containing 40 g of NaOH in 1 L of solution. What is the basicity of the acid?

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

95. A quantity of 20 g of H_3PO_4 is dissolved in water and made up to 1 L. What is the normality of the solution, if titration against NaOH is carried only up to the second stage of neutralization?

(a) 0.408 (b) 0.204
(c) 0.612 (d) 0.102

96. A volume of 25 ml of 0.017 M-HSO_3^- in strongly acidic solution required the addition of 16.9 ml of 0.01 M-MnO_4^- for its complete oxidation. In neutral solution, 28.6 ml is required. Assign oxidation numbers of Mn in each of the products.

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

97. A quantity of 0.84 g of an acid (molecular mass = 150) was dissolved in water and the volume was made up to 100 ml. Twenty five millilitres of this solution required 28 ml of (N/10) NaOH solution for neutralization. The equivalent weight and basicity of the acid is

(a) 75, 2 (b) 150, 1
(c) 75, 4 (d) 150, 2

98. A quantity of 0.70 g of a sample of $Na_2CO_3 \cdot xH_2O$ was dissolved in water and the volume was made to 100 ml. Twenty millilitres of this solution required 19.8 ml of N/10 HCl for complete neutralization. The value of x is

(a) 2 (b) 1
(c) 4 (d) 10

99. The specific gravity of a given H_2SO_4 solution is 1.76. A quantity of 3.5 ml of the acid is diluted to 1.0 L and 25 ml of this diluted acid required 25.6 ml of N/10 (f = 0.95) NaOH solution for complete neutralization. The percentage strength (by mass) of the original acid solution is

(a) 61.6% (b) 77.38%
(c) 50% (d) 47.66%

100. A volume of 25 ml of (N/10)-Na_2CO_3 solution neutralizes 10 ml of a dilute H_2SO_4 solution. The volume of water that must be added to 400 ml of this H_2SO_4 solution in order to make it exactly N/10 is

(a) 1000 ml (b) 600 ml
(c) 500 ml (d) 400 ml

101. A volume of 10 ml of a H_2SO_4 solution is diluted to 100 ml. Twenty five millilitres of this diluted solution is mixed with 50 ml of 0.5 N-NaOH solution. The resulting solution requires 0.265 g Na_2CO_3 for complete neutralization. The normality of original H_2SO_4 solution is

(a) 12 N (b) 1.2 N
(c) 3 N (d) 0.275 N

102. The normality of a solution of a mixture containing HCl and H_2SO_4 is N/5. Twenty millilitres of this solution reacts with excess of $AgNO_3$ solution to give 0.287 g of silver chloride. The percentage of HCl in the mixture by mass is (Ag = 108)

(a) 42.69% (b) 57.31%
(c) 40% (d) 33.18%

103. A quantity of 0.10 g of anhydrous organic acid requires 25 ml of 0.10 N-NaOH for neutralization. A quantity of 0.245 g of the hydrated acid requires 50 ml of the same alkali. The number of moles of water of crystallization per equivalent of the anhydrous acid is

(a) 1.0 (b) 2.0
(c) 0.5 (d) 4.0

104. A volume of 100 ml of H_2O_2 is oxidized by 100 ml of 1 M-$KMnO_4$ in acidic medium (MnO_4^- reduced to Mn^{2+}). A volume of 100 ml of same H_2O_2 is oxidized by 'V' ml of 1 M-$KMnO_4$ in basic medium (MnO_4^- reduced to MnO_2). The value of 'V' is

(a) 500 (b) 100
(c) 33.33 (d) 166.67

105. A quantity of 1 g of metal carbonate was dissolved in 25 ml of normal HCl. The resulting liquid requires 50 ml of N/10 caustic soda solution to neutralize it completely. The equivalent weight of metal carbonate is

(a) 10 (b) 20
(c) 100 (d) 50

106. When 0.91 g of a mixture of Na_2SO_4 and $(NH_4)_2SO_4$ was boiled with 80 ml of 0.1 N-NaOH until no more NH_3 is evolved, the excess of NaOH required is 11.6 ml of 0.1 N-HCl. How many grams of Na_2SO_4 is present in the mixture?

(a) 0.594 g (b) 0.459 g
(c) 0.549 g (d) 0.945 g

107. A quantity of 10 g of a sample of silver, which is contaminated with silver sulphide, gave 11.2 ml of hydrogen sulphide at 0°C and 1 atm, on treatment with excess of hydrochloride acid. The amount of silver sulphide in the sample is (Ag = 108)

(a) 1.24 g (b) 124 mg
(c) 5×10^{-3} mol (d) 62 mg

108. A 0.2 g sample of iron wire containing 98% iron is dissolved in acid to form ferrous ion. The solution requires 30 ml of $K_2Cr_2O_7$ solution for complete reaction. What is the normality of $K_2Cr_2O_7$ solution? (Fe = 56)

(a) 0.1167 N (b) 0.2333 N
(c) 0.0583 N (d) 0.167 N

109. One litre of a mixture of O_2 and O_3 at 0°C and 1 atm was allowed to react with an excess of acidified solution of KI. The iodine liberated requires 40 ml of $M/10$ sodium thiosulphate solution for titration. What is the mass percent of ozone in the mixture?

(a) 6.575% (b) 9.6%
(c) 93.425% (d) 90.4%

110. A 71 ml (specific gravity 1.1) of chlorine water is treated with an excess of KI. The liberated iodine requires 26 ml of 0.11 N-$Na_2S_2O_3$ (sodium thiosulphate or hypo) solution. What is the percentage of Cl_2 (by mass) in the chlorine water? Chlorine water is a solution of free chlorine in water.

(a) 0.26% (b) 0.13%
(c) 0.065% (d) 1.3%

111. Household bleach contains hypochlorite ion, which is formed when chlorine dissolves in water. To determine the concentration of hypochlorite in the bleach, the solution is first treated with a KI solution. The iodine liberated can be determined by titration with a standard thiosulphate solution. A 25 ml of certain household bleach requires 17.4 ml of a 0.02 M-$Na_2S_2O_3$ solution for titration. The mass of chlorine dissolved in one litre of the bleach solution is

(a) 0.1392 g (b) 0.494 g
(c) 9.88 g (d) 0.278 g

112. One gram of Na_3AsO_4 is boiled with excess of solid KI in the presence of strong HCl. The iodine evolved is absorbed in KI solution and titrated against 0.2 N hypo solution. Assuming the reaction to be

$$AsO_4^{3-} + 2H^+ + 2I^- \rightarrow AsO_3^{3-} + H_2O + I_2$$

The volume of thiosulphate hypo consumed is (As = 75)

(a) 48.1 ml (b) 38.4 ml
(c) 24.7 ml (d) 30.3 ml

113. $S_2O_3^{2-}$ ion is oxidized by $S_2O_8^{2-}$ ion, the products are $S_4O_6^{2-}$ and SO_4^{2-} ions. What volume of 0.25 M thiosulphate solution would be needed to reduce 1 g of $K_2S_2O_8$? (K = 39)

(a) 36.92 ml (b) 32.69 ml
(c) 29.63 ml (d) 62.93 ml

114. V_1 ml of permanganate solution of molarity M_1 reacts exactly with V_2 ml of ferrous sulphate solution of molarity M_2, then

(a) $V_1M_1 = V_2M_2$ (b) $5V_1M_1 = V_2M_2$
(c) $V_1M_1 = 5V_1M_2$ (d) None of these

115. x g of KHC_2O_4 requires 100 ml of 0.02 M-$KMnO_4$ in acidic medium. In another experiment, y g of KHC_2O_4 requires 100 ml of 0.05 M-$Ca(OH)_2$. The ratio of x and y is

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

116. In the mixture of $NaHCO_3$ and Na_2CO_3, the volume of a given HCl required is x ml with phenolphthalein indicator and further y ml is required with methyl orange indicator. Hence, the volume of HCl for complete reaction of $NaHCO_3$ present in the original mixture is

(a) $2x$ (b) y
(c) $x/2$ (d) $(y - x)$

117. A volume of 25 ml of 0.107 M-H_3PO_4 was titrated with 0.115 M solution of NaOH to the end point identified by indicator bromocresol green. This requires 23.1 ml. The titration was repeated using phenolphthalein as indicator. This time 25 ml of 0.107 M-H_3PO_4 requires 46.2 ml of the 0.115 M-NaOH. What is the coefficient n in the following reaction?

$$H_3PO_4 + nOH^- \rightarrow [H_{3-n}PO_4]^{n-} + nH_2O$$

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

118. Calculate the temporary and permanent hardness of water sample having the following constituents per litre.

$Ca(HCO_3)_2 = 162$ mg, $MgCl_2 = 95$ mg

$NaCl = 585$ mg, $Mg(HCO_3)_2 = 73$ mg

$CaSO_4 = 136$ mg

(a) 200 ppm, 150 ppm
(b) 100 ppm, 150 ppm
(c) 150 ppm, 200 ppm
(d) 150 ppm, 150 ppm

119. A volume of 100 L of hard water requires 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

120. RH_2 (ion exchange resin) can replace Ca^{2+} in hard water as follows.

$RH_2 + Ca^{2+} \rightarrow RCa + 2H^+$.

One litre of hard water after passing through RH_2 has pH = 2. Hence, hardness in ppm of Ca^{2+} is

(a) 200 (b) 100
(c) 50 (d) 125

EXERCISE II (JEE ADVANCED)

Section A (Only one Correct)

1. Which of the following process is reduction?

(a) $CH_2 = CH_2 \rightarrow CH_2(OH) - CH_2(OH)$

(b) $CH_3CH_2CH{=}CH - CH_2 - CHO \rightarrow CH_3CH_2CH{=}CH - CH_2 - CH_2OH$

(c) $CH_3CHO \rightarrow CCl_3CHO$

(d) $Ag^+ + 2NH_3 \rightarrow [Ag(NH_3)_2]^+$

2. The oxidation number of sodium in sodium amalgam is

(a) +2 (b) +1
(c) −2 (d) zero

3. The oxidation state of molybdenum in its oxocomplex $[Mo_2O_4(C_2H_4)_2(H_2O)_2]^{2-}$ is

(a) +2 (b) +3
(c) +4 (d) +5

4. The oxidation state of boron in potassium tetrafluoroborate is

(a) +2 (b) +3
(c) +4 (d) −3

5. The oxidation state of bismuth in lithium bismuthate is

(a) +5 (b) +3
(c) +2 (d) +4

6. The compound of Xe and F is found to have 53.5% Xe. What is the oxidation number of Xe in this compound? (Xe = 131, F = 19)

(a) −4 (b) 0
(c) +4 (d) +6

7. The oxidation number of S in $(CH_3)_2SO$ is

(a) zero (b) +1
(c) +2 (d) +3

8. Sulphide ions react with $Na_4[Fe(NO)(CN)_5]$ to form a purple-coloured compound $Na_4[Fe(CN)_5(NOS)]$. In the reaction, the oxidation state of iron

(a) changes from +2 to +3.
(b) changes from +2 to +4.
(c) changes from +3 to +2.
(d) does not change.

9. The oxidation number of cobalt in $K[Co(CO)_4]$ is

(a) +1 (b) +3
(c) −1 (d) 0

10. Phosphorus has oxidation state of +3 in

(a) phosphorus acid
(b) orthophosphoric acid
(c) metaphosphoric acid
(d) pyrophosphoric acid

11. One gas bleaches the colour of the flowers by reduction while the other by oxidation. The gases are

(a) CO, Cl_2 (b) H_2S, Br_2
(c) SO_2, Cl_2 (d) NH_3, SO_3

12. In a reaction, HNO_3 is behaving as reducing agent. What should be its expected product?

(a) H_2 (b) NO_2
(c) N_2O (d) O_2

13. Which of these substance is a good reducing agent?

(a) HI (b) KBr
(c) $FeCl_3$ (d) $KClO_3$

14. Which of the following ion cannot act as an oxidizing agent?

(a) MnO_4^- (b) CrO_4^{2-}
(c) I^- (d) Fe^{3+}

15. Which of the following reaction is redox?

(a) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

(b) $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

(c) $Ca(OCl)Cl + H_2O \rightarrow Ca(OH)_2 + Cl_2$

(d) $PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$

16. During the oxidation of Mn^{2+} to MnO_4^- by PbO_2 in acid medium, the number of moles of acid consumed per mole of Mn^{2+} ion is

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

17. During the oxidation of arsenite ion AsO_3^{3-} to arsenate ion AsO_4^{3-} in alkaline medium, the number of moles of hydroxide ions consumed per mole of arsenite ion is

(a) 2 (b) 3
(c) 2/3 (d) 3/2

18. $Cr(OH)_3 + ClO^- + OH^- \rightarrow ... + Cl^- + H_2O$. The missing ion is

(a) $Cr_2O_7^{2-}$ (b) Cr^{3+}
(c) CrO_4^{2-} (d) Cr_2O_3

19. In a reaction, 4 moles of electrons is transferred to one mole of HNO_3. The possible product obtained due to reduction is

(a) 0.5 mole of N_2.
(b) 0.5 mole of N_2O.
(c) 1 mole of NO_2.
(d) 1 mole of N_2O.

20. The number of electrons lost per mole of ethanol in its oxidation into acetic acid is

(a) $4N_A$ (b) $2N_A$
(c) $6N_A$ (d) $8N_A$

21. For the process $CH_3CH_2OH \rightarrow CH_3COOH$, the number of H^+ ions needed for balancing and the side in which it should be added are, respectively

(a) 4, left (b) 4, right
(c) 2, Left (d) 2, right

22. In basic medium, Cl_2 disproportionates into Cl^- and ClO_x^-. If there is loss and gain of one mole of electron per mole of Cl_2, then the value of x is

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

23. An amount of 0.2 mole of AO_3^- gains 1.2 mole of electron in a process. Assuming that there is no change in oxidation state of oxygen, determine the oxidation state of 'A' in product.

(a) +1 (b) −1
(c) 0 (d) +6

24. The equivalent weights of an element of variable valency are 21 and 14. The atomic mass of the element may be

(a) 35 (b) 42
(c) 70 (d) 126

25. When copper oxide is strongly heated with hydrogen, it reduces to copper. The loss in its weight is 14.9 g and the weight of water formed was 16.78 g. What is the equivalent weight of oxygen, taking the equivalent weight of hydrogen as 1.008?

(a) 8.000 (b) 7.989
(c) 8.064 (d) 16.00

26. A quantity of 1 g of metal ion, M^{2+} was discharged by the passage of 1.81×10^{22} electrons. The atomic mass of the metal is

(a) 33.27 (b) 99.81
(c) 66.54 (d) 133.08

27. Phosphoric acid has minimum equivalent weight when 1 mole of it reacts with

(a) 1 mole of NaOH (b) 2 moles of NaOH
(c) 3 moles of NaOH (d) 4 moles of NaOH

28. Equivalent weight of water in a neutralization reaction between dibasic acid and triacidic base is

(a) 9 (b) 18
(c) 6 (d) 3

29. Acetic acid on chlorination yields trichloroacetic acid. Its equivalent weight will be

(a) 60 (b) 40
(c) 20 (d) 10

30. Molecular masses of NH_3 and N_2 are x_1 and x_2, respectively. In the reaction,

$N_2 + 3H_2 \rightarrow 2NH_3$,

their equivalent weights are y_1 and y_2. Then $(y_1 - y_2)$ is

(a) $\left(\frac{2x_1 - x_2}{6}\right)$ (b) $(x_1 - x_2)$
(c) $(3x_1 - x_2)$ (d) $(x_1 - 3x_2)$

31. In the reaction,

$P_4 + NaOH + H_2O \rightarrow PH_3 + NaH_2PO_2$,

the equivalent weight of P_4 is

(a) M (b) $M/3$
(c) $M/6$ (d) $2M/3$

32. In the reaction,

$Pb + PbO_2 + H_2SO_4 \rightarrow PbSO_4 + H_2O$,

the equivalent weight of H_2SO_4 is

(a) M (b) $M/2$
(c) $2M$ (d) $M/4$

33. In the reaction,

$Cl_2 + NaOH \rightarrow NaCl + NaClO_3 + H_2O$,

the equivalent weight of H_2O is

(a) M (b) $3M/5$
(c) $6M/5$ (d) $M/2$

34. The equivalent weight of ozone behaving as an oxidizing agent is

(a) 48 (b) 24
(c) 16 (d) 32

35. In the reaction,

$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$,

the equivalent weight of HCl is

(a) M (b) $M/2$
(c) $2M$ (d) $M/4$

36. In an acidic solution, I^- changes to I_2. How many grams of I_2 is produced if, in the same process, 1.5×10^{22} electrons are used up to reduce H_3AsO_4 to H_3AsO_3? ($I = 128$, $N_A = 6 \times 10^{23}$)

(a) 1.6 g (b) 6.4 g
(c) 4.8 g (d) 3.2 g

37. An ion is reduced to the element when it absorbs 6×10^{20} electrons. The number of equivalents of the ion is

(a) 0.1 (b) 0.01
(c) 0.001 (d) 0.0001

38. In which of the following reactions, 1 g equivalent of H_3PO_4 reacts with 3 g equivalents of NaOH?

(a) $H_3PO_4 + NaOH \rightarrow NaH_2PO_4 + H_2O$
(b) $H_3PO_4 + 2NaOH \rightarrow Na_2HPO_4 + 2H_2O$
(c) $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$
(d) None of the above

39. A quantity of 8.6 g of an oxide of a metal reacts completely with hydrogen gas to yield 1.8 g of water. The equivalent weight of the metal is

(a) 23 (b) 37
(c) 78 (d) 35

40. A quantity of 20 g of an acid furnished 0.5 moles of H_3O^+ ions in its aqueous solution. The mass of 1 g equivalent of the acid will be

(a) 40 g (b) 20 g
(c) 10 g (d) 100 g

41. A quantity of 1.0 g of an acid when completely acted upon by magnesium gave 1.301 g of the anhydrous magnesium salt. The equivalent weight of the acid is

(a) 35.54 (b) 36.54
(c) 48 (d) 49

42. A quantity of 3.7 g of an oxide of a metal was heated with charcoal, and CO_2 so produced was absorbed in caustic soda solution whose weight increased by 1.0 g. The equivalent weight of the metal is

(a) 11 (b) 40.7
(c) 32.7 (d) 73.4

43. Which has the maximum number of equivalent per mole of the oxidant?

(a) $Zn(s) + VO^{2+}(aq) \rightarrow Zn^{2+}(aq) + V^{3+}(aq)$
(b) $Ag(s) + NO_2^-(aq) \rightarrow Ag^+(aq) + NO_2(g)$
(c) $Mg(s) + V^{4+}(aq) \rightarrow Mg^{2+}(aq) + V^{2+}(aq)$
(d) $I^-(aq) + IO_3^-(aq) \rightarrow I_3^-(aq)$

44. The number of moles of $KMnO_4$ that will be needed to react completely with one mole of ferrous oxalate in acidic solution is

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

45. The number of moles of $KMnO_4$ that will be needed to react completely with one mole of sulphite ion in acidic solution is

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

46. A certain amount of a reducing agent reduces x mole of MnO_2 and y mole of K_2CrO_4 in different reactions in acidic medium. If the changes in oxidation states of reducing agent in the reactions are in 1 : 2 ratio, respectively, then the ratio of x and y is

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

47. Dichloroacetic acid ($CHCl_2CO_2H$) is oxidized to CO_2, H_2O and Cl_2 by 1.2 equivalents of an oxidizing agent. Same amount of the acid can neutralize 'X' moles of NH_3 to give ammonium dichloroacetate. The value of 'X' is

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

48. Two acids H_2SO_4 and H_3PO_4 are neutralized separately by the same amount of an alkali when sulphate and dihydrogen orthophosphate are formed, respectively. Find the ratio of the masses of H_2SO_4 and H_3PO_4.

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

49. A metal exhibits the valencies of 2 and 3. Its equivalent weight is 28 when it forms a metal oxide of formula MO. What mass of H_2SO_4 is needed for complete reaction with 4.8 g of M_2O_3?

(a) 8.82 g (b) 4.41 g
(c) 13.23 g (d) 11.03 g

50. The specific heat of a metal is 0.26. The chloride of the metal (always monomer) has its molecular mass 95. The volume of hydrogen gas that 1.2 g of the metal will evolve at $0^{o}C$ and 1 atm, if it is allowed to react with excess of an acid, is

(a) 2.24 L (b) 1.12 L
(c) 0.56 L (d) 5.611 L

51. The vapour density of a volatile chloride of a metal is 74.6. If the specific heat of the metal is 0.55, then the atomic mass of the metal is

(a) 7.2 (b) 7.46
(c) 11.63 (d) 10

52. A quantity of 3 g of impure marble was treated with 200 ml of dil. HCl. After completion of the reaction a small quantity of the residue was left and 560 ml of a gas was evolved at $0^{o}C$ and 1 atm. The normality of acid solution is

(a) 0.3 N (b) 0.125 N
(c) 0.25 N (d) 0.5 N

53. What will be present in the solution when 50 ml of 0.1M-HCl is mixed with 50 ml of 0.1 M-NaOH solution?

(a) 4.5 millimoles of H^+
(b) 0.05 millimoles of OH^-
(c) 0.1 M-NaCl
(d) 10^{-7} M of H^+ ion

54. A quantity of 5.88 g of $FeSO_4 \cdot (NH_4)_2SO_4 \cdot xH_2O$ was dissolved in 250 ml of its solution. Twenty millilitres of this solution requires 20 ml of $KMnO_4$ solution containing 3.16 g of 75% pure $KMnO_4$ dissolved per litre. The value of '*x*' is (K = 39, Mn = 55, Fe = 56)

(a) 3 (b) 4
(c) 6 (d) 7

55. The ratio of amounts of H_2S needed to precipitate all the metal ions from 100 ml of 1 M-$AgNO_3$ and 100 ml of 1 M-$CuSO_4$ is

(a) 1:2 (b) 2:1
(c) zero (d) infinite

56. A volume of 100 ml of 0.1 M-$NaAl(OH)_2CO_3$ is neutralized by 0.25 N-HCl to form NaCl, $AlCl_3$ and CO_2. The volume of HCl required is

(a) 10 ml (b) 40 ml
(c) 100 ml (d) 160 ml

57. Purple of Cassius is prepared by reducing $AuCl_3$ to colloidal gold by $SnCl_2$. A 1 L solution containing 1.97 mg of gold per ml is prepared from 0.05 M solution of $AuCl_3$ by reduction with appropriate amount of 0.05 M-$SnCl_2$ solution, the resulting solution being diluted to 1 L with water. The volume of stannous chloride solution required, if its oxidation product is $SnCl_4$(aq), is (Au = 197)

(a) 300 ml (b) 500 ml
(c) 800 ml (d) 100 ml

58. The iodide content of a solution was determined by titration with cerium (IV) sulphate in the presence of HCl, in which I^- is converted to ICl. A 250 ml sample of the solution required 20 ml of 0.05 N-Ce^{4+} solution. What is the iodide concentration in the original solution in g/L? (I = 127)

(a) 0.508 (b) 0.254
(c) 0.762 (d) 0.127

59. A chemist is preparing to analyse samples that will contain no more than 0.5 g of uranium. His procedure calls for preparing the uranium as U^{4+} ion and oxidizing it by MnO_4^- in the following acid solution.

$$U^{4+} + MnO_4^- + H_2O \rightarrow UO_2^{2+} + Mn^{2+} + H_3O^+$$

If he wants to react the total U^{4+} sample with a maximum of 50 ml of $KMnO_4$ solution, then what concentration does he choose? (U = 238)

(a) 0.0336 M (b) 0.0168 M
(c) 0.168 M (d) 0.0672 M

60. KIO_3 reacts with oxalic acid in solution to yield $K_2C_2O_4$, CO_2 and I_2. How many grams of oxalic acid will be required to react with one gram of KIO_3? (K = 39, I = 127)

(a) 1.262 g (b) 1.622 g
(c) 1.747 g (d) 1.022 g

61. What is the mass of oxalic acid, $H_2C_2O_4$, which can be oxidized to CO_2 by 100 ml of MnO_4^- solution, 10 ml of which is capable of oxidizing 50 ml of 1.00 N – I^- to I_2?

(a) 2.25 g (b) 52.2 g
(c) 25.2 g (d) 22.5 g

62. What volume of 0.2 M-$KMnO_4$ solution is needed for complete reaction with 26.56 gm $Fe_{0.9}O_{1.0}$, in acidic medium? (Fe = 56)

(a) 280 ml (b) $\frac{280}{9}$ ml
(c) $\frac{2800}{9}$ ml (d) 560 ml

63. A volume of 20 ml of M-$KMnO_4$ solution is diluted to 150 ml. In this solution, 50 ml of 10 M H_2SO_4 is added. 25 ml of this mixture is titrated with 20 ml of FeC_2O_4 solution. The molarity of FeC_2O_4 solution is

(a) 0.0416 (b) 0.208
(c) 0.625 (d) 0.125

64. A volume of 20 ml of M-$K_2Cr_2O_7$ solution is diluted to 200 ml. Twenty five millilitres of diluted solution is mixed with 50 ml of 4 M-H_2SO_4 solution. Thirty millilitres of this mixture is diluted to 150 ml. How many millilitres of 0.02 M-H_2O_2 solution is needed to titrate 15 ml of the diluted solution?

(a) 14 ml (b) 15 ml
(c) 30 ml (d) 45 ml

65. A polyvalent metal weighing 0.1 g and having atomic mass 51 reacted with dilute H_2SO_4 to give 43.9 ml of hydrogen at 0°C and 1 atm. The solution containing the metal in this lower oxidation state was found to require 58.8 ml of 0.1 N–permanganate for complete oxidation. What are the valencies of the metal?

(a) 2, 5 (b) 2, 4
(c) 3, 5 (d) 4, 5

66. A solution of $Na_2S_2O_3$ is standardized iodometrically against 0.1336 g of $KBrO_3$. This process required 40 ml of the $Na_2S_2O_3$ solution. What is the strength of the $Na_2S_2O_3$? (K = 39, Br = 80)

(a) 0.04 M (b) 0.02 M
(c) 0.05 M (d) 0.01 M

67. A sample of a metal carbonate MCO_3 was neutralized by 10 ml of 0.1 N-HCl and the resulting chloride gave 0.0517 g of phosphate, $M_3(PO_4)_2$. The equivalent weight of M is

(a) 20.03 (b) 40.06
(c) 51.7 (d) 8.62

68. A small amount of $CaCO_3$ completely neutralizes 525 ml of 0.1 N-HCl and no acid is left at the end. After converting all calcium chloride to $CaSO_4$, how much plaster of Paris can be obtained?

(a) 1.916 g (b) 5.827 g
(c) 3.57 g (d) 3.81 g

69. What volume of 0.40 M-$Na_2S_2O_3$ would be required to react with the I_2 liberated by adding excess of KI to 50 ml of 0.20 M $CuSO_4$?

(a) 12.5 ml (b) 25 ml
(c) 50 ml (d) 2.5 ml

70. To a 25 ml H_2O_2 solution, excess of acidified solution of potassium iodide was added. The iodine liberated required 20 ml of 0.3 N-$Na_2S_2O_3$ solution. The volume strength of H_2O_2 solution is

(a) 1.362 (b) 0.681
(c) 2.724 (d) 0.908

71. An unknown composition of a mixture of carbon disulphide and hydrogen sulphide was burnt in sufficient amount of oxygen. The resulting gases found to exert a pressure of 1.97 atm in a 20 l vessel at 400 K. The gaseous mixture required 2.8 M iodine solution and 250 ml of it was required to reach the end point forming I^-. Calculate the mole fraction of CS_2 in the original mixture.

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

72. One gram of a sample of $CaCO_3$ was strongly heated and the CO_2 liberated absorbed in 100 ml of 0.5 M-NaOH. Assuming 90% purity for the sample, how much ml of 0.5 M-HCl would be required to react with the solution of the alkali for the phenolphthalein end point?

(a) 73 ml (b) 41 ml
(c) 82 ml (d) 97 ml

73. A volume of 40 ml of 0.05 M solution of sodium sesquicarbonate ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$) is titrated against 0.05 M-HCl solution. x ml of HCl solution is used when phenolphthalein is the indicator and y ml of HCl is used when methyl orange is the indicator in two separate titrations. Hence, $(y - x)$ is

(a) 80 ml (b) 30 ml
(c) 120 ml (d) 40 ml

74. A 100 ml mixture of Na_2CO_3 and $NaHCO_3$ is titrated against 1 M-HCl. If V_1 L and V_2 L are consumed when phenolphthalein and methyl orange are used as indicators, respectively, in two separate titrations, which of the following is true for molarities in the original solution?

(a) Molarity of $Na_2CO_3 = 20V_1$
(b) Molarity of $NaHCO_3 = 10(V_2 - 2V_1)$
(c) Molarity of $Na_2CO_3 = 10(V_2 + V_1)$
(d) Molarity of $NaHCO_3 = 10(V_2 - V_1)$

75. In the mysterious deserts of Egypt, large deposits of 'Trona' ($Na_2CO_3 \cdot NaHCO_3$) are found. If a sample of 'Trona' (containing same inert impurities) is dissolved in water and titration against 0.1 M-HCl, then which of the following readings are possible when x and y ml of HCl are required for titration against equal volumes of this solution, one using phenolphthalein and the other using methyl orange respectively as indicators?

(a) $x = 20, y = 20$ (b) $x = 10, y = 30$
(c) $x = 20, y = 40$ (d) $x = 20, y = 10$

Section B (One or More than one Correct)

1. In the compound $NOClO_4$, the oxidation state of

(a) nitrogen is +1 (b) nitrogen is +3
(c) chlorine is +5 (d) chlorine is +7

2. Which of the following is/are peroxide(s)?

(a) PbO_2 (b) H_2O_2
(c) SrO_2 (d) BaO_2

3. Which of the following is a non-redox process?

(a) $SO_4^{2-} \rightarrow SO_3$ (b) $Cr_2O_7^{2-} \rightarrow CrO_4^{2-}$
(c) $PO_4^{3-} \rightarrow P_2O_7^{4-}$ (d) $C_2O_4^{2-} \rightarrow CO_2$

4. Which of the following compound does not decolourized an acidified solution of $KMnO_4$?

(a) SO_2 (b) $FeCl_3$
(c) H_2O_2 (d) $FeSO_4$

5. Which of the following statement(s) is/are true regarding the change $CN^- \rightarrow CNO^-$?

(a) Carbon is losing two electrons per atom.
(b) The oxidation state of carbon changes from +2 to +4.
(c) Oxidation state of nitrogen is not changing.
(d) Oxidation state of nitrogen changes from −3 to −1.

6. Substances which may be oxidized as well as reduced are

(a) HCl (b) HClO
(c) $HClO_3$ (d) $HClO_4$

7. A quantity of 15.8 g of $KMnO_4$ can be decolourized in acidic medium by (K = 39, Mn = 55, Fe = 56)

(a) 18.25 g HCl (b) 22.5 g $H_2C_2O_4$
(c) 32 g SO_2 (d) 38 g $FeSO_4$

8. When copper is treated with a certain concentration of nitric acid, nitric oxide and nitrogen dioxide are liberated in equal volumes according to the following equation.

$$X Cu + Y HNO_3 \rightarrow Cu(NO_3)_2 + NO + NO_2 + H_2O$$

The coefficients of X and Y are, respectively,

(a) 2 and 3 (b) 2 and 6
(c) 1 and 3 (d) 3 and 8

9. The equivalent volume of a gaseous substance is 5.6 L at 0°C and 1 atm. The substance may be

(a) CH_4 gas in combustion.
(b) O_3 gas as oxidizing agent.
(c) H_2S gas as reducing agent.
(d) CO_2 formed from carbon.

10. A quantity of 0.5 g of a metal nitrate gave 0.43 g of metal sulphate.

(a) The equivalent weight of the metal is 38.
(b) The equivalent weight of the metal is 76.
(c) The atomic weight of metal may be 76.
(d) The atomic weight of metal may be 19.

11. A metal (M) forms a hydrated sulphate, isomorphous with $ZnSO_4 \cdot 7H_2O$. If the sulphate contains 20% metal, by weight, which of the following is/are correct for the metal?

(a) The atomic weight of metal is 24.
(b) The equivalent weight of the metal is 27.75.
(c) The metal is bivalent.
(d) The anhydrous metal sulphate contains 36.6% metal, by mass.

12. A metal forms two oxides. The higher oxide contains 20% oxygen, while 4.29 g of the lower oxide when converted to higher oxide, become 4.77 g. The equivalent weight of metal in

(a) lower oxide is 32.
(b) lower oxide is 64.4.
(c) higher oxide is 64.4.
(d) higher oxide is 32.

13. The specific heat of a metal is found to be 0.03. 10 g of the metal on treatment with nitric acid gave 18.9 g of pure dry nitrate. The correct statement(s) is/are

(a) The equivalent weight of the metal is 69.66.
(b) The atomic weight of the metal is 209.
(c) The metal is trivalent.
(d) The metal is an alkali metal.

14. A 100 ml mixture of Na_2CO_3 and $NaHCO_3$ is titrated against 1 M-HCl. If V_1 L and V_2 L are consumed when phenolphthalein and methyl orange are used as indicators, respectively, in two separate titrations, which of the following is true for molarities in the original solution?

(a) Molarity of $Na_2CO_3 = 20V_1$
(b) Molarity of $NaHCO_3 = 10\,(V_2 - 2V_1)$
(c) Molarity of $Na_2CO_3 = 10\,(V_2 + V_1)$
(d) Molarity of $NaHCO_3 = 10\,(V_2 - V_1)$

15. A volume of 20 ml of an aqueous solution of hydrated oxalic acid ($H_2C_2O_4 \cdot xH_2O$) containing 6.3 g per litre requires 40 ml of 0.05 M-NaOH solution for complete neutralization. Which of the following statement about the acid solution is/are correct?

(a) The value of x is 2.
(b) The equivalent weight of anhydrous acid is 63.
(c) The molarity of acid solution is 0.1 M.
(d) 100 ml of the same acid solution requires 40 ml of 0.05 M-$KMnO_4$ solution for complete oxidation in the presence of H_2SO_4.

16. A bottle of oleum is labelled as 109%. Which of the following statement is/are correct for this oleum sample?

(a) It contains 40% of free SO_3 by weight.
(b) 1.0 g of this sample approximately requires 22.25 ml of 0.5 M-NaOH solution for complete neutralization.
(c) 0.5 g of this sample approximately requires 11.12 ml of 0.1 N-$Ba(OH)_2$ solution for complete neutralization.
(d) When 500 g water is added to 100 g of this sample, the resulting solution becomes $\left(\frac{109}{49}\right)$ m in H_2SO_4.

17. A quantity of 5.68 g of pure P_4O_{10} is dissolved completely in sufficient water and the solution is diluted to 250 ml. Which of the following statement(s) is/are correct? (P = 31)

(a) The diluted solution has molarity 0.32 with respect to H_3PO_4.
(b) 25 ml of the diluted solution exactly requires 48 ml of 0.5 M-NaOH solution for complete neutralization.
(c) 15 ml of the diluted solution exactly requires 36 ml of 0.2 M-$BaCl_2$ solution for complete precipitation of phosphate.
(d) 40 ml of the diluted solution exactly requires 48 ml of 0.8 N-KOH solution for the first equivalent point.

18. An amount of 0.01 mole of SO_2Cl_2 is hydrolysed completely in sufficient water (no gas is allowed to escape out) and the solution is diluted to 200 ml. Which of the following statement is/are correct? (Ag = 108)

(a) The solution is 0.05 M in H_2SO_4.
(b) The solution is 0.1 M in HCl.
(c) A volume of 20 ml of the solution exactly requires 20 ml of 0.2 M NaOH solution for complete neutralization.
(d) When 100 ml of the solution is treated with excess of $AgNO_3$ solution, 1.435 g of AgCl will precipitate out.

19. A definite mass of H_2O_2 is oxidized by excess of acidified $KMnO_4$ and acidified $K_2Cr_2O_7$ in separate experiments. Which of the following is/are correct statements? (K = 39, Cr = 52, Mn = 55)

(a) Mass of $K_2Cr_2O_7$ used up will be greater than that of $KMnO_4$.

(b) Moles of $KMnO_4$ used up will be greater than that of $K_2Cr_2O_7$.

(c) Equal mass of oxygen gas is evolved in both the experiments.

(d) If equal volumes of both the solutions are used for complete reaction, then the molarities of $KMnO_4$ and $K_2Cr_2O_7$ solutions are in 6 : 5 ratio.

20. A quantity of 8.0 g of solid sulphur is first oxidized to SO_2 and then it is divided into two equal parts. One part is sufficient for complete decolourization of 200 ml of acidified $KMnO_4$ solution. Another part is oxidized to SO_3 and the SO_3 formed is sufficient for complete precipitation of all $BaCl_2$ present in 100 ml solution as $BaSO_4$. Which of the following statements is/are correct? (S = 32, Ba = 138)

(a) The molarity of $KMnO_4$ solution is 0.25.

(b) The molarity of $BaCl_2$ solution is 0.25.

(c) The weight of $BaSO_4$ precipitated out is 29.25 g.

(d) The same equivalents of $KMnO_4$ and $BaCl_2$ are reacted.

Section C (Comprehensions)

Comprehension I

For the reaction: $MnBr_2 + PbO_2 + HNO_3 \rightarrow HMnO_4 + Pb(BrO_3)_2 + Pb(NO_3)_2 + H_2O$ (Atomic masses: Mn = 55, Br = 80, Pb = 208)

1. The equivalent weight of $MnBr_2$ is

(a) 107.5 (b) 215
(c) 12.65 (d) 19.55

2. The equivalent weight of PbO_2 is

(a) 120 (b) 240
(c) 14.11 (d) 21.82

3. The equivalent weight of HNO_3 is

(a) 63 (b) 55.6
(c) 31.5 (d) 111.18

Comprehension II

It was found that 100 g of silver combined with all the chlorine in 56 g of arsenious chloride. The vapour density of arsenious chloride is 6.25 (air = 1). The specific heat of arsenic is 0.08. Given that one litre of air at 0°C and 1 atm weighs 1.3 g (Ag = 108).

4. What is the exact atomic weight of arsenic?

(a) 74.94 (b) 24.98
(c) 80.00 (d) 182.47

5. What is the equivalent weight of arsenic in the arsenious chloride?

(a) 74.94 (b) 24.98
(c) 14.49 (d) 49.96

6. What is the molecular formula of arsenious chloride?

(a) $AsCl_3$ (b) As_2Cl_6
(c) As_2Cl_5 (d) $AsCl_5$

Comprehension III

A quantity of 0.4 g of oxygen and 4.0 g of a halogen combine separately with the same amount of metal.

7. What is the equivalent weight of halogen if the element exhibits the same valency in both compounds?

(a) 40 (b) 80
(c) 20 (d) 160

8. What is the equivalent weight of halogen if the valency of element in the halide is twice that in oxide?

(a) 40 (b) 80
(c) 20 (d) 160

9. The atomic weight of the halogen can never have the value

(a) 40 (b) 80
(c) 20 (d) 160

Comprehension IV

$KMnO_4$ oxidizes X^{n+} ion to XO_3^- in acid solution. 2.5×10^{-3} mole of X^{n+} requires 1.5×10^{-3} mole of MnO_4^-.

10. What is the value of n?

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

11. What is the atomic mass of X, if the mass of 1 g-equivalent of XCl_n in this reaction is 56? XCl_n is the molecular form of x^{+n}. Assume no change in oxidation state of chlorine.

(a) 71 (b) 112
(c) 97 (d) 41

12. How many mole of $KMnO_4$ is needed per mole of X^{n+} to oxidize it to XO_3^- in strong basic medium?

(a) 1 (b) 3
(c) 0.6 (d) 2

Comprehension V

One gram of a moist sample of a mixture of potassium chloride and potassium chlorate was dissolved in water and made up to 250 ml. Twenty-five millilitres of this solution was treated with SO_2 to reduce the chlorate to chloride and excess SO_2 was removed by boiling. The total chloride was precipitated as silver chloride. The weight of the precipitate was 0.1435 g. In another experiment, 25 ml of the original solution was heated with 30 ml of 0.2 N solution of ferrous sulphate and unreacted ferrous sulphate required 37.5 ml of 0.08 N solution of an oxidizing agent for complete oxidation. (K = 39, Ag = 108)

13. What is the molar ratio of the chlorate to chloride in the given mixture?

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

14. What is the mass percent of moisture present in the moist sample?

(a) 1.0% (b) 1.5%
(c) 1.75% (d) 3.5%

15. What is the mass percent of potassium chloride in the moist sample?

(a) 37.25% (b) 61.25%
(c) 3.725% (d) 74.5%

Comprehension VI

A forensic chemist needed to determine the concentration of HCN in the blood of a suspected homicide victim and decided to titrate a dilute sample of the blood with iodine using the following reaction.

$$HCN(aq) + I_3^-(aq) \rightarrow ICN(aq) + 2I^-(aq) + H^+(aq)$$

A diluted blood sample of volume 15.0 ml was titrated to the stoichiometric point with 5.0 ml of an I_3^- solution. The molar concentration of the I_3^- solution was determined by titrating it against arsenic (III) oxide, As_4O_6, which in solution forms arsenious acid, H_3AsO_3. A volume of 10.0 ml of the triiodide solution was needed to reach the stoichiometric point on a 0.1188 g sample of As_4O_6 in the following reaction.

$$H_3AsO_3(aq) + I_3^-(aq) + H_2O(l) \rightarrow H_3AsO_4(aq) + 3I^-(aq) + 2H^+(aq)$$

(Atomic mass of As = 75)

16. What is the molar concentration of the triiodide solution?

(a) 0.03 M (b) 0.12 M
(c) 0.06 M (d) 0.00012 M

17. What is the molar concentration of HCN in the blood sample?

(a) 0.04 M (b) 0.03 M
(c) 0.12 M (d) 0.36 M

18. How many grams of HCN is present in the blood of victim if the total volume of blood present in the victim is 6.0 l?

(a) 0.24 g (b) 6.48 g
(c) 3.24 g (d) 2.16 g

Comprehension VII

In the presence of fluoride ion, Mn^{2+} can be titrated with MnO_4^-, where both reactants being converted to a complex of Mn(III). A 0.458 g of sample containing Mn_3O_4 was dissolved and all manganese was converted to Mn^{2+}. Titration in the presence of fluoride ion consumed 30.0 ml of $KMnO_4$ that was 0.125 N against oxalate. (Mn = 55)

19. The correct balanced reaction, assuming that the complex is MnF_4^-, is

(a) $Mn^{2+} + MnO_4^- + H^+ + F^- \rightarrow MnF_4^- + H_2O$
(b) $4Mn^{2+} + MnO_4^- + 8H^+ \rightarrow 5Mn^{3+} + 4H_2O$
(c) $4Mn^{2+} + MnO_4^- + 8H^+ + 20F^- \rightarrow 5MnF_4^- + 4H_2O$
(d) $Mn^{2+} + MnO_4^- + H^+ \rightarrow MnF_4^- + H_2O$

20. What is the percentage of Mn_3O_4 in the sample?

(a) 50.00% (b) 40.00%
(c) 62.50% (d) 75.00%

21. What is the normality of $KMnO_4$ solution against Mn^{2+}?

(a) 0.125 N (b) 0.1 N
(c) 0.01 N (d) 0.156 N

Comprehension VIII

Chromium exists as $FeCr_2O_4$ in the nature and it contains $Fe_{0.95}O_{1.00}$ as an impurity. To obtain pure chromium from $FeCr_2O_4$, the ore is fused with KOH and oxygen is passed through the mixture when K_2CrO_4 and Fe_2O_3 are produced. A quantity of 2 g of ore required 280 ml of O_2 at 0^oC and 1 atm for complete oxidation of ore. K_2CrO_4 is then precipitated as $BaCrO_4$ after addition of Barium salt. To the remaining solution, 10 ml of 1 M-$K_4Fe(CN)_6$ is added when Fe^{3+} ions reacts with it to form KFe[Fe(CN)$_6$], after called 'Prussian Blue'. To determine excess of $K_4Fe(CN)_6$ in solution, 6 ml of 0.4 N-Fe^{2+} is added when all the $K_4Fe(CN)_6$ is precipitated as $K_2Fe[Fe(CN)_6]$. (Fe = 56)

22. What is the percentage of $Fe_{0.95}O_{1.00}$ in the ore?

(a) 6.92% (b) 3.46%
(c) 13.84% (d) 93.08%

23. What per cent of total iron present in the ore is in +2 state?

(a) 77.53% (b) 97.73%
(c) 78.41% (d) 87.9%

24. How many millimoles of Prussian blue is formed?

(a) 8.9 (b) 8.8
(c) 0.0088 (d) 7.85

Comprehension IX

Chile saltpeter, a source of $NaNO_3$ also contains $NaIO_3$. The $NaIO_3$ can be used as a source of iodine, produced in the following reactions.

$$IO_3^- + 3HSO_3^- \rightarrow I^- + 3H^+ + 3SO_4^{2-}$$

and

$$5I^- + IO_3^- + 6H+ \rightarrow 3I_2 + 3H_2O$$

One litre of Chile saltpeter solution containing 5.94 g $NaIO_3$ is treated with stoichiometric quantity of $NaHSO_3$. Now an additional amount of the same solution is added to the reaction mixture to bring about the second reaction. (I = 127)

25. How many grams of $NaHSO_3$ is required in step I for complete reaction?

(a) 9.36 g (b) 3.12 g
(c) 6.24 g (d) 14.04 g

26. What additional volume of Chile saltpeter must be added in step II to bring in complete conversion of I^- to I_2?

(a) 1000 ml (b) 200 ml
(c) 5000 ml (d) 400 ml

27. How many grams of I_2 can be produced per litre of Chile saltpeter?

(a) 4.572 g (b) 2.286 g
(c) 5.486 g (d) 3.810 g

Comprehension X

A volume of 50 ml of solution containing 1 g each of Na_2CO_3, $NaHCO_3$ and NaOH was treated with N-HCl.

28. What will be the titre reading if only phenolphthalein is used as an indicator?

(a) 43.8 ml (b) 21.9 ml
(c) 34.4 ml (d) 57.9 ml

29. What will be the titre reading if only methyl orange is used as indicator from the very beginning?

(a) 67.7 ml (b) 55.8 ml
(c) 46.3 ml (d) 23.5 ml

30. What will be the titre reading if methyl orange is added after the first end point with phenolphthalein?

(a) 30.8 ml (b) 21.3 ml
(c) 33.2 ml (d) 51.9 ml

Section D (Assertion–Reason)

The following questions consist of two statements. Mark the answer as follows.

(a) If both statements are CORRECT, and **Statement II** is the CORRECT explanation of **Statement I**.

(b) If both statements are CORRECT, and **Statement II** is NOT the CORRECT explanation of **Statement I**.

(c) If **Statement I** is CORRECT, but **Statement II** is INCORRECT.

(d) If **Statement I** is INCORRECT, but **Statement II** is CORRECT.

1. **Statement I:** I^- can never act as an oxidizing agent.

Statement II: Oxidizing agent undergoes reduction.

2. **Statement I:** In propane, all carbon atoms are in the same oxidation state.

Statement II: The oxidation state is −8/3 per carbon atom.

3. **Statement I:** When O_3 reacts with KI, O_3 is reduced into O_2.

Statement II: There is no change in oxidation state of oxygen in this reaction.

4. **Statement I:** In ClF_3, chlorine has the oxidation number −1.

Statement II: Electron affinity of chlorine is greater than that of fluorine.

5. **Statement I:** The equivalent weight of any substance is its molecular weight divided by some factor, depending on the nature of the substance.

Statement II: The equivalent weight of any substance is always less than its molecular weight.

6. **Statement I:** The molecular weight of any substance is unique but the equivalent weight is not unique.

Statement II: Equivalent weight of any substance depends on its nature in the chemical reaction concerned.

7. **Statement I:** Equivalent weight of any element represents the parts by weight of the element which combines with or displaces 1 part by weight of hydrogen or 8 parts by weight of oxygen or 35.5 parts by weight of chlorine.

Statement II: The atomic weights of hydrogen, oxygen or chlorine are taken as reference for the determination of equivalent weights of all other elements.

8. **Statement I:** The number of g-equivalents of all the reactants reacted in any chemical reaction is always the same.

Statement II: In any chemical reaction, the total mass of reactants reacted is always equal to the total mass of products formed.

9. **Statement I:** Equal volumes of 0.3 M-H_2SO_4 solution and 0.2M–H_3PO_4 solution will require the same volume of the same NaOH solution for complete neutralization.

Statement II: H_2SO_4 is dibasic and H_3PO_4 is a tribasic acid.

10. **Statement I:** When a solution of Na_2CO_3 is titrated with HCl solution, the volume of acid solution required for the end point in case of methyl orange indicator is double than that required in case of phenolphthalein indicator.

Statement II: In case of phenolphthalein indicator, the sudden change in colour is observed when Na_2CO_3 is completely converted into H_2CO_3.

11. **Statement I:** When 10 ml of 0.5 M–$NaHCO_3$ solution is titrated with 0.25 M–HCl solution using phenolphthalein indicator, 20 ml of acid solution is consumed at the end point.

Statement II: End point cannot be detected when $NaHCO_3$ solution is titrated with HCl solution using phenolphthalein indicator.

12. **Statement I:** Equal volumes of 1 M–HCl solution and 1 M–NaOH solution is required for complete reaction with the same mass of KHC_2O_4.

Statement II: KHC_2O_4 is amphoteric and it can lose or gain one proton.

13. **Statement I:** The number of g-equivalents in the same mass of $KMnO_4$ is in 5 : 3 : 1 ratio in acid, neutral and strong basic medium, respectively.

Statement II: The oxidation state of Mn changes from +7 state to +2, +4 and +6 states, respectively, in acid, neutral and strong basic medium.

14. **Statement I:** When 20 ml of 0.5 M-$CuSO_4$ solution is treated with excess of KI solution, the liberated I_2 exactly requires 20 ml of 0.5 M-$Na_2S_2O_3$ solution for titration.

Statement II: For both the solutions ($CuSO_4$ and $Na_2S_2O_3$), their molarity and normality are equal.

15. **Statement I:** For the sequential reactions: A $\rightarrow$ B and B $\rightarrow$ C (both occurring completely), the number of g-equivalents of A and C must be equal.

Statement II: The relation between the number of g-equivalents of A and C depends on the equivalent weight of B in both the reactions.

Section E (Column Match)

1. In **Column I**, some reactions are given and in **Column II**, the type of some reactions on the basis of oxidation and reduction processes are given. Match the reactions with their correct type.

Column I	Column II
(A) $3CaO + 2P_2O_5 \rightarrow Ca_3(PO_4)_2$	(P) Disproportionation
(B) $2Cu^+ \rightarrow Cu + Cu^{2+}$	(Q) Comproportionation
(C) $NH_4NO_2 \rightarrow N_2 + 2H_2O$	(R) Non-redox
(D) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	(S) Combustion
	(T) Redox

2. Some compounds are given in **Column I**. Match them correctly with the terms given in **Column II**.

Column I	Column II
(A) SO_2	(P) Oxidizing agent
(B) SO_3	(Q) Reducing agent
(C) H_2O_2	(R) Undergoes disproportionation in air
(D) NaF	(S) Neither an oxidizing nor a reducing agent

3. Match the columns.

Column I (Oxidation number of underlined element)	Column II (Oxidation number)
(A) $\underline{N}H_4\underline{N}O_3$	(P) 0
(B) $\underline{C}H_2O$	(Q) −2
(C) $\underline{Ni}(\underline{C}\,\underline{O})_4$	(R) +2
(D) $\underline{Cl}_2O_5$	(S) +5
	(T) −3

4. In **Column I**, one mole of some oxidizing agents is given. Match them with the moles of the reducing agents needed for complete reaction, given in **Column II**.

Column I	Column II
(A) $KMnO_4$ (H^+)	(P) 3.0 mole of $FeSO_4$
(B) $KMnO_4$ (OH^-)	(Q) 0.5 mole of I_2 to HIO_3
(C) MnO_2 (H^+)	(R) 1.0 mole of $K_2C_2O_4$
(D) K_2CrO_4 (H^+)	(S) 1.5 mole of K_2SO_3

5. Some redox reactions are given in **Column I**. Match them with the correct mole ratio of oxidizing to reducing agents given in **Column II**.

Column I	Column II
(A) $MnO_4^- + C_2O_4^{2-} \rightarrow MnO_2 + CO_2$	(P) 2 : 1
(B) $ClO^- + Fe(OH)_3 \rightarrow Cl^- + FeO_4^{2-}$	(Q) 3 : 1
(C) $HO_2^- + Cr(OH)_3^- \rightarrow CrO_4^{2-} + HO^-$	(R) 2 : 3
(D) $N_2H_4 + Cu(OH)_2 \rightarrow N_2O + Cu$	(S) 3 : 2

6. Match the columns.

Column I	Column II
(A) Equivalent volume of Cl_2 gas	(P) 5.6 L at 0°C and 1 atm
(B) Volume of O_2 needed for complete combustion of 5.6 L methane at 0°C and 1 atm	(Q) 11.2 L at 0°C and 1 atm
(C) Equivalent volume of O_2 gas	(R) 22.4 L at 0°C and 0.5 atm
(D) Equivalent volume of SO_2 gas as oxidizing agent	(S) 11.2 L at 0°C and 0.5 atm

7. Match the columns.

Column I (Process)	Column II (Equivalent weight of Cl_2)
(A) $Cl_2 \rightarrow Cl^-$	(P) 71
(B) $Cl_2 \rightarrow ClO_3^-$	(Q) 35.5
(C) $Cl_2 \rightarrow Cl^- + ClO_3^-$	(R) 42.6
(D) $Cl_2 \rightarrow Cl^- + ClO^-$	(S) 7.1

8. Match the columns.

Column I (Equivalent weight of HCl)	Column II (Chemical change)
(A) Greater than its molecular weight	(P) Neutralization reaction
(B) Equal to molecular weight	(Q) $MnO_2 + HCl \rightarrow MnCl_2 + Cl_2 + H_2O$
(C) Less than molecular weight	(R) $HClO \rightarrow HCl$
	(S) $HCl \rightarrow HClO_3$
	(T) $Cu + HCl \rightarrow H_2[CuCl_4] + H_2$

9. Match the columns.

Column I	Column II (Solution needed for complete reaction)
(A) 100 ml of 0.3 M – $H_2C_2O_4$ solution	(P) 100 ml of 0.3 M – KOH solution
(B) 50 ml of 0.6 M – KHC_2O_4 solution	(Q) 120 ml of 0.1 M – $KMnO_4$ solution in the presence of H_2SO_4
(C) 50 ml of 0.6 M – HCl solution	(R) 60 ml of 0.1 M – $KMnO_4$ solution in the presence of H_2SO_4
(D) 100 ml of 0.2 M – H_3PO_4 solution	(S) 100 ml of 0.6 M – KOH solution

10. Match the columns.

Column I	Column II (Solution needed for complete reaction)
(A) 50 ml of 0.5 M-Na_2CO_3 solution using methyl orange indicator.	(P) 50 ml of 0.5 M-H_2SO_4 solution
(B) 50 ml of 0.5 M-Na_2CO_3 solution using phenolphthalein indicator.	(Q) 50 ml of 0.5 M-HCl solution
(C) 50 ml of 0.5 M-$NaHCO_3$ solution using methyl orange indicator.	(R) 25 ml of 0.5 M-H_2SO_4 solution
(D) 50 ml of 0.5 M-NaOH solution using phenolphthalein indicator.	(S) 50 ml of 1.0 M-HCl solution

Section F (Subjective)

Single-digit Integer Type

1. The value of n in the following processes: $AO_4^{n-} + 2e \rightarrow HAO_n^{2-}$ is

2. AO_2 disproportionates into AO_4^- and A^{n+} ion. If the mole ratio of AO_2 undergone oxidation and reduction is 2 : 3, the value of n is

3. A volume of 1.12 L dry chlorine gas at 0°C and 1 atm was passed over a heated metal when 5.55 g of chloride of the metal was formed. If the atomic mass of the metal is 40, then its valency is

4. The equivalent weight of Br_2 is 96 in the following disproportionation reaction.

   $Br_2 + OH^- \rightarrow Br^- + H_2O + ?$ (Oxidized product)

   The oxidation state of Br in the oxidized product is (Br = 80)

5. HCHO disproportionates to $HCOO^-$ and CH_3OH in the presence of OH^- (Cannizzaro's reaction).

   $$2HCHO + OH^- \rightarrow HCOO^- + CH_3OH$$

   If the equivalent weight of HCHO is E, then the value of $\frac{E}{10}$ is

6. When a solid element is reacted with chlorine, a gaseous chloride of vapour density 68.75 is formed. If this reaction is performed at constant temperature and pressure, the volume of the system reduces by one third. If the equivalent weight of the solid element is E, then the value of $\left(\frac{12}{31} \times E\right)$ is

7. V litre of SO_2 at 0°C and 1 atm is required to reduce 16.9 g of $HClO_3$ to HCl. The number of moles in '5 V' litre of SO_2 at 273°C and 2 atm is

8. The approximate mass (in g) of N_2H_4 can be oxidized by 24 g of K_2CrO_4 is (Cr = 52)

   $$3N_2H_4 + 4CrO_4^{2-} + 4H_2O \rightarrow 3N_2 + Cr(OH)_4^- + 4OH^-$$

9. A sample of pure $KHC_2O_4.H_2C_2O_4.2H_2O$ requires 30 mol of NaOH for titration. How many moles of $KMnO_4$ will the same sample react with, in acid medium?

10. The basic solution of Na_4XeO_6 is powerful oxidants. How many millimoles of $Mn(NO_3)_2 \cdot 6H_2O$ reacts with 62.5 ml of a 0.04 M basic solution of Na_4XeO_6 that contains an excess of sodium hydroxide if the products include Xe and a solution of sodium permanganate? (Mn = 55)

11. A newly developed method for water treatment uses chlorine dioxide ClO_2 rather than Cl_2 itself. ClO_2 can be obtained by passing $Cl_2(g)$ into concentrated solution of sodium chlorite $NaClO_2$. NaCl is the other product. If this reaction has a 90% yield, then how many moles of ClO_2 are produced from 5 L of 2.0 M-$NaClO_2$?

12. A quantity of 1.245 g of $CuSO_4 \cdot xH_2O$ was dissolved in water and H_2S was passed into it till CuS was completely precipitated. The H_2SO_4 produced in the filtrate required 10 ml of M-NaOH solution. Calculate the value of x. (Cu = 63.5)

13. A mixture of CS_2 and H_2S when oxidized yields a mixture of CO_2, SO_2 and $H_2O(g)$, which exerts a pressure of 7.2 atm, when collected in 82.1 L vessel at 327°C. To oxidize SO_2 in the mixture, 7 L of 2 N – iodine was required. Moles of CS_2 in the mixture is

14. A mixture of Xe and F_2 was heated. A sample of white solid thus formed reacted with hydrogen to give 56 ml of Xe at 0°C and 1 atm and HF formed required 60 ml of 0.25 M-NaOH for complete neutralization. If the molecular formula of the solid formed is XeF_x, then the value of x is

15. One litre of a sample of ozonized oxygen at 0°C and 1 atm on passing through a KI solution, liberated iodine which required 9 ml of a thiosulphate solution. A volume of 12 ml of a '5.675 volume' hydrogen peroxide solution liberated iodine from another iodide solution, which required 24 ml of the same thiosulphate solution. The volume percent of ozone in the ozonized oxygen sample is approximately

16. A certain mass of anhydrous oxalic acid is converted into H_2O, CO_2 and CO, on heating in the presence of H_2SO_4. The CO formed reacts completely with iodine pentoxide to liberate iodine. The iodine thus liberated required 200 ml of 0.2 N thiosulphate. The mass (in g) of oxalic acid taken was

17. When ammonium vanadate is heated with oxalic acid solution, a substance Z is formed. A sample of Z was treated with $KMnO_4$ solution in hot acidic solution. The resulting liquid was reduced with SO_2, the excess SO_2 boiled off and the liquid again titrated with same $KMnO_4$. The ratio of the volumes of $KMnO_4$ used in the two titrations was 5 : 1. What is the oxidation state of vanadium in substance Z? Given that $KMnO_4$ oxidizes all oxidation state of vanadium to vanadium (+5) and SO_2 reduces V (+5) to V (+4).

18. A solution of 0.2 g of a compound containing Cu^{2+} and $C_2O_4^{2-}$ ions on titration with 0.02 M-$KMnO_4$ in the presence of H_2SO_4 consumes 22.6 ml of the oxidant. The resultant solution is neutralized with Na_2CO_3 acidified with dilute acetic acid and treated with excess KI. The liberated iodine requires 11.3 ml of 0.05 M-$Na_2S_2O_3$ for complete reduction. If the molar ratio of Cu^{2+} to $C_2O_4^{2-}$ in the compound is 1 : *x*, then the value of *x* is

19. A quantity of 1.0 g sample of Fe_2O_3 solid of 55.2 per cent purity is dissolved in acid and reduced by heating the solution with zinc dust. The resultant solution is cooled and made up to 100 ml. An aliquot of 25 ml of this solution requires 17 ml of 0.0167 M solution of an oxidant for titration. The number of electrons taken up by the oxidant in the reaction of the above titration is

20. A quantity of 1.16 g $CH_3(CH_2)_nCOOH$ was burnt in excess of air and the resultant gases (CO_2 and H_2O) were passed through excess NaOH solution. The resulting solution was divided into two equal parts. One part requires 50 ml of N-HCl for neutralization using phenolphthalein indicator. Another part required 80 ml of N-HCl for neutralization using methyl orange indicator. The value of *n* is

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Four-digit Integer Type

1. A transition metal X forms an oxide of formula X_2O_3. It is found that only 50% of X atoms in this compound are in the +3 oxidation state. The only other stable oxidation states of X are +2 and +5. What percentage of X atoms is in the +2 oxidation state in this compound?

2. An amount of 0.1 moles of OH^- ions is obtained from 8.50 g of hydroxide of a metal. What is the equivalent weight of the metal?

3. A quantity of 2.7 g of an alloy of copper and silver was dissolved in moderately conc. HNO_3 and excess of HCl was added to this solution when 2.87 g of a dry precipitate is formed. Calculate the percentage of copper in the alloy. (Cu = 63.5, Ag = 108)

4. Peroxides like oxides are basic. They form hydrogen peroxide upon treatment with an acid. What volume (in ml) of 0.25 M-H_2SO_4 solution is required to neutralize a solution that contains 7.2 g of CaO_2?

5. A volume of 30 ml of a solution containing 9.15 g per litre of an oxalate $K_xH_y(C_2O_4)_z.nH_2O$ is required for titrating 27 ml of 0.12 N-NaOH and 36 ml of 0.12 N – $KMnO_4$ separately. Assume all H-atoms are replaceable and *x*, *y* and *z* are in the simple ratio of g-atoms. The value of *xyzn* is

6. A solution is made by mixing 200 ml of 0.1 M-$FeSO_4$, 200 ml of 0.1 M-$KMnO_4$ and 600 ml of 1 M-$HClO_4$. A reaction occurs in which Fe^{2+} and MnO_4^- convert to Fe^{3+} and Mn^{2+}. If the molarity of H^+ ion in the final solution is '*x*' M, then the value of 1000*x* is

7. The saponification number of fat or oil is defined as the number of mg of KOH required to saponify 1 g oil or fat. A sample of peanut oil weighing 1.5 g is added to 25.0 ml of 0.4 M-KOH. After saponification is complete, 8.0 ml of 0.25 M-H_2SO_4 is needed to neutralize excess of KOH. What is the saponification number of peanut oil?

8. A quantity of 1.6 g of pyrolusite ore was treated with 50 ml of 1.0 N-oxalic acid and some sulphuric acid. The oxalic acid left undecomposed was raised to 250 ml in a flask. A volume of 25 ml of this solution when titrated with 0.1 N-$KMnO_4$ required 32 ml of the solution. The percentage of available oxygen in the ore is

9. Calculate the amount (in mg) of SeO_3^{2-} in solution, where 20 ml of M/40 solution of $KBrO_3$ was added to a definite volume of SeO_3^{2-} solution. The bromine evolved was removed by boiling and excess of $KBrO_3$ was back titrated with 7.5 ml of M/25 solution of $NaAsO_2$. The reactions are (Se = 79)

$$SeO_3^{2-} + BrO_3^- + H^+ \rightarrow SeO_4^{2-} + Br_2 + H_2O$$

$$BrO_3^- + AsO_2^- + H_2O \rightarrow Br^- + AsO_4^{3-} + H^+$$

10. If 91 g of V_2O_5 is dissolved in acid and reduced to V^{2+} by treatment with zinc metal, then how many grams of I_2 could be reduced by the resulting V^{2+} solution, as it is oxidized to V^{4+}? (V = 51, I = 127)

$$V_2O_5 + 10H^+ + 6e^- \rightarrow 2V^{2+} + 5H_2O$$

$$V^{2+} + I_2 + H_2O \rightarrow 2I^- + VO^{2+} + 2H^+$$

11. A 200 ml sample of a citrus fruit drinks containing ascorbic acid (vitamin C) was acidified with H_2SO_4 and 10 ml of 0.025 M-I_2 was added. Some of the I_2 was reduced by the ascorbic acid to I^-. The excess of I_2 required 2.5 ml of 0.01 M-$Na_2S_2O_3$ for reduction. What was the vitamin C content of the drink in microgram vitamin per ml drink?

$$C_6H_8O_6 + I_2 \rightarrow C_6H_6O_6 + 2HI$$

$$5H_2O + S_2O_3^{2-} + 4I_2 \rightarrow 2SO_4^{2-} + 8I^- + 10H^+$$

12. A 0.2 g sample of chromite was fused with excess of Na_2O_2 and brought into solution according to the following reaction.

$$2Fe(CrO_2)_2 + 7Na_2O_2 \rightarrow 2NaFeO_2 + 4Na_2CrO_4 + 2Na_2O$$

The solution was acidified with dil. HCl and 1.96 g Mohr's salt (molar mass = 392 g/mol) was added. The excess of Fe^{2+} required 40 ml of 0.05 N-$K_2Cr_2O_7$ for titration. What is the percent of Cr in sample? (Cr = 52, Fe = 56)

13. A 10 g mixture of Cu_2S and CuS was treated with 400 ml of 0.4 M – MnO_4^- in acid solution producing SO_2, Cu^{2+} and Mn^{2+}. The SO_2 was boiled off and the excess of MnO_4^- was titrated with 200 ml of 1 M – Fe^{2+} solution. The percentage of CuS in original mixture is (Cu = 64)

14. A mixture containing As_2S_3 and As_2S_5 requires 20 ml of 0.05 N iodine for titration. The resulting solution is then acidified and excess of KI was added. The liberated iodine required 1.24 g hypo, $Na_2S_2O_3 \cdot 5H_2O$, for complete reaction. The reactions are as follows.

$$As_2S_3 + 2I_2 + 2H_2S \rightarrow As_2S_5 + 4H^+ + 4I^-$$

$$As_2S_5 + 4H^+ + 2I^- \rightarrow As_2S_3 + 2I_2 + 2H_2S$$

The mole percent of As_2S_3 in the original mixture is (As = 75)

15. The element Se dispersed in 2 ml sample of detergent for dandruff control was determined by suspending it in the warm ammonical solution that contained 45 ml of 0.02 M-$AgNO_3$.

$$6Ag^+ + 3Se(s) + 6NH_3 + 3H_2O \rightarrow 2Ag_2Se(s) + Ag_2SeO_3(s) + 6NH_4^+$$

The mixture was now treated with excess nitric acid which dissolved the Ag_2SeO_3 but not Ag_2Se. The Ag^+ from Ag_2SeO_3 and the excess of $AgNO_3$ consumed 10 ml of 0.01 N-KSCN in Volhard titration. How many milligrams of Se was contained per ml of sample? (Se = 80)

16. 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 is titrated with M/10-KIO_3 solution in the presence of 6 M-HCl till all iodide ions are converted into ICl. It requires 50 ml of M/10-KIO_3 solution. A 20 ml of the same stock solution of KI requires 30 ml of M/10-KIO_3 under similar conditions. The percentage of $AgNO_3$ in the sample is (Ag = 108)

Reaction: $KIO_3 + 2KI + 6HCl \rightarrow 3ICl + KCl + 3H_2O$

17. A 4.0 g sample containing Fe_3O_4, Fe_2O_3 and an inert impure substance is treated with excess of KI solution in the presence of dilute H_2SO_4. The entire iron is converted to Fe^{2+} along with the liberation of iodine. The resulting solution is diluted to 100 ml. A 20 ml of dilute solution requires 11.2 ml of 0.5 M – $Na_2S_2O_3$ solution to reduce the iodine present. A 50 ml of the diluted solution, after complete extraction of iodine, requires 12.80 ml of 0.25 M – $KMnO_4$ solution in dilute H_2SO_4 medium for the oxidation of Fe^{2+}. The percentage of Fe_2O_3 in the original sample is

18. An aqueous solution containing 1.07 g KIO_3 was treated with an excess of KI solution. The solution was acidified with HCl. The liberated I_2 consumed 50 ml of thiosulphate solution to decolourize the blue starch-iodine complex. The molarity of the sodium thiosulphate solution is x M, then the value of $1000x$ is (K = 39, I = 127)

19. 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 decolourized 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. The strength of H_2O_2 solution in mg per 100 ml solution is

20. If 20 ml of 0.1 M solution of sodium sesquicarbonate ($Na_2CO_3 \cdot NaHCO_3$) is titrated against 0.05 M – HCl, using (i) phenolphthalein and (ii) methyl orange as indicators, then what difference in titre values (in ml) would be recorded?

Answer Keys — Exercise I

Oxidation–Reduction

1. (d)	2. (d)	3. (a)	4. (a)	5. (c)	6. (d)	7. (a)	8. (a)	9. (c)	10. (a)
11. (b)	12. (b)	13. (b)	14. (a)	15. (d)	16. (b)	17. (d)	18. (a)	19. (c)	20. (b)
21. (c)	22. (d)	23. (b)	24. (d)	25. (b)	26. (b)	27. (c)	28. (c)	29. (a)	30. (b)
31. (b)	32. (c)	33. (a)	34. (c)	35. (b)					

Equivalent Concept

36. (c)	37. (b)	38. (a)	39. (b)	40. (c)	41. (c)	42. (a)	43. (a)	44. (b)	45. (b)
46. (d)	47. (c)	48. (c)	49. (d)	50. (b)	51. (a)	52. (c)	53. (a)	54. (b)	55. (c)
56. (b)	57. (a)	58. (b)	59. (c)	60. (a)	61. (a)	62. (d)	63. (d)	64. (c)	65. (b)
66. (b)	67. (d)	68. (c)	69. (c)	70. (c)					

Volumetric Analysis

71. (c)	72. (c)	73. (a)	74. (c)	75. (b)	76. (d)	77. (a)	78. (a)	79. (b)	80. (a)
81. (a)	82. (c)	83. (a)	84. (c)	85. (a)	86. (c)	87. (a)	88. (b)	89. (b)	90. (c)
91. (d)	92. (b)	93. (a)	94. (b)	95. (a)	96. (a)	97. (a)	98. (a)	99. (b)	100. (b)
101. (a)	102. (d)	103. (c)	104. (d)	105. (d)	106. (b)	107. (b)	108. (a)	109. (a)	110. (b)
111. (b)	112. (a)	113. (c)	114. (b)	115. (b)	116. (d)	117. (a)	118. (c)	119. (b)	120. (a)

Answer Keys — Exercise II

Section A (Only one Correct)

1. (b)	2. (d)	3. (b)	4. (b)	5. (b)	6. (d)	7. (a)	8. (d)	9. (c)	10. (a)
11. (c)	12. (d)	13. (a)	14. (c)	15. (c)	16. (c)	17. (a)	18. (c)	19. (b)	20. (a)
21. (b)	22. (b)	23. (b)	24. (b)	25. (b)	26. (c)	27. (c)	28. (b)	29. (d)	30. (a)
31. (b)	32. (a)	33. (b)	34. (b)	35. (c)	36. (d)	37. (c)	38. (d)	39. (d)	40. (a)
41. (b)	42. (c)	43. (d)	44. (a)	45. (b)	46. (c)	47. (c)	48. (b)	49. (a)	50. (b)
51. (a)	52. (c)	53. (d)	54. (c)	55. (c)	56. (d)	57. (a)	58. (b)	59. (b)	60. (a)
61. (d)	62. (a)	63. (b)	64. (b)	65. (a)	66. (b)	67. (a)	68. (d)	69. (b)	70. (a)
71. (b)	72. (c)	73. (a)	74. (b)	75. (b)					

Section B (One or More than one Correct)

1. (b), (d)
2. (b), (c), (d)
3. (a), (b), (c)
4. (b)
5. (a), (b), (c)
6. (b), (c)
7. (a), (b)
8. (b)
9. (d)
10. (a), (c)
11. (b), (c), (d)
12. (b), (d)
13. (a), (b), (c)
14. (b)
15. (a), (d)
16. (a)
17. (a), (b), (c)
18. (a), (b), (c), (d)
19. (a), (b), (c), (d)
20. (a), (c), (d)

Section C

Comprehension I

1. (c) 2. (a) 3. (b)

Comprehension II

4. (a) 5. (b) 6. (b)

Comprehension III

7. (b) 8. (a) 9. (c)

Comprehension IV

10. (b) 11. (c) 12. (b)

Comprehension V

13. (a) 14. (b) 15. (a)

Comprehension VI

16. (b) 17. (a) 18. (b)

Comprehension VII

19. (c) 20. (a) 21. (b)

Comprehension VIII

22. (a) 23. (b) 24. (b)

Comprehension IX

25. (a) 26. (b) 27. (d)

Comprehension X

28. (c) 29. (b) 30. (b)

Section D (Assertion – Reason)

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

Section E (Column Match)

1. A $\rightarrow$ R; B $\rightarrow$ P, T; C $\rightarrow$ Q, T; D $\rightarrow$ S, T
2. A $\rightarrow$ P, Q; B $\rightarrow$ P; C $\rightarrow$ P, Q, R; D $\rightarrow$ S
3. A $\rightarrow$ S, T; B $\rightarrow$ P, Q; C $\rightarrow$ P, Q, R; D $\rightarrow$ Q, S
4. A $\rightarrow$ Q; B $\rightarrow$ P, S; C $\rightarrow$ R; D $\rightarrow$ P, S
5. A $\rightarrow$ R; B $\rightarrow$ S; C $\rightarrow$ P; D $\rightarrow$ Q
6. A $\rightarrow$ Q, R; B $\rightarrow$ Q, R; C $\rightarrow$ P, S; D $\rightarrow$ P, S
7. A $\rightarrow$ Q; B $\rightarrow$ S; C $\rightarrow$ R; D $\rightarrow$ P
8. A $\rightarrow$ Q, T; B $\rightarrow$ P; C $\rightarrow$ R, S
9. A $\rightarrow$ Q, S; B $\rightarrow$ P, Q; C $\rightarrow$ P, R; D $\rightarrow$ S
10. A $\rightarrow$ P, S; B $\rightarrow$ Q, R; C $\rightarrow$ Q, R; D $\rightarrow$ Q,R

Section F (Subjective)

Single-digit Integer Type

1. (3) 2. (2) 3. (2) 4. (5) 5. (3) 6. (4) 7. (3) 8. (3) 9. (8) 10. (4)
11. (9) 12. (5) 13. (2) 14. (6) 15. (9) 16. (9) 17. (0) 18. (2) 19. (6) 20. (4)

Four-digit Integer Type

1. (0033) 2. (0068) 3. (0020) 4. (0400) 5. (1322)
6. (0568) 7. (0224) 8. (0009) 9. (0127) 10. (0254)
11. (0132) 12. (0026) 13. (0080) 14. (0020) 15. (0024)
16. (0085) 17. (0040) 18. (0600) 19. (0340) 20. (0080)

HINTS AND EXPLANATIONS

EXERCISE I (JEE MAIN)

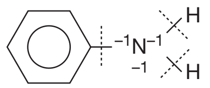
Oxidation–Reduction

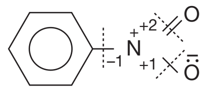
1. $m \times (+a) + n \times (-b) + r \times (-c) = 0 \Rightarrow ma = bn + cr.$
2. $2(+2) + x + 6(-2) = 0 \Rightarrow x = +8.$
3. Oxidation state of Cr in both compounds is +6.
4. In this compound, NO is present as NO^+.
5. Oxidation state of Br in Br_2, Br^- and BrO_3^- is 0, –1 and +5, respectively.
6. The maximum oxidation state of S in any of its compound is +6.
7. The oxidation state of Fe in $Fe(CO)_5$, Fe_2O_3, $K_4[Fe(CN)_6]$ and $FeSO_4.(NH_4)_2SO_4.6H_2O$ are 0, +3, +2 and +2, respectively.
8. (a) $H_2\overset{+6}{S_2}O_7$, $Na_2\overset{+2.5}{S_4}O_6$, $Na_2\overset{+2}{S_4}O_3$, $\overset{0}{S_8}$

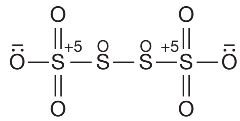
   (b) $\overset{+4}{S}O^{2+}$, $\overset{+6}{S}O_4^{2-}$, $\overset{+4}{S}O_3^{2-}$, $H\overset{+4}{S}O_4^-$

   (c) $H_2\overset{+6}{S}O_5$, $H_2\overset{+4}{S}O_3$, $\overset{+2}{S}C_2$, $H_2\overset{-2}{S}$

   (d) $H_2\overset{+6}{S}O_4$, $\overset{+4}{S}O_2$, $H_2\overset{-2}{S}$, $H_2\overset{+6}{S_2}O_8$
9. On oxygenation, Fe^{2+} present in haemoglobin oxidizes to Fe^{3+}.
10. $H^{+1}—{}^{-1}C^{+3}\equiv{}^{-3}N$ $\quad$ $H^{+1}—{}^{-1}\overset{+}{N}{}^{-3}\equiv{}^{+3}\bar{\bar{C}}$

    Oxidation state of C = +2 $\quad$ Oxidation state of C = +2
11. $3x + 2(-2) = 0 \Rightarrow x = +\frac{4}{3}.$
12. $H_2SO_4 + BaO_2 \rightarrow BaSO_4^{-2} + H_2O_2^{-1}$
13. $\overset{+7}{Mn}O_4^-$, $\overset{+6}{Cr}O_2Cl_2$ These are highest oxidation states of Mn and Cr, respectively.
14. $2(+2) + 2x + 7(-2) = 0 \Rightarrow x = +5.$
15. Toluene $= C_7H_8 \Rightarrow 7x + 8(+1) = 0 \Rightarrow 7x = -8.$
16. Oxidation state of K in all of its compound is +1.
17. Oxidation state of Cr in K_3CrO_8 is +5. In CrO_5, it is +6. K_3CrO_8 has four peroxide (O_2^{2-}) linkage while CrO_5 has only two peroxide linkage.
18. 

    Oxidation state of N = –3 $\quad$ Oxidation state of N = +3
19. 

20. Empirical formula of $C_6H_{12}O_6$ and HCHO is same.
21. $\frac{N_{Fe}}{N_O} = \frac{\frac{70}{56}}{\frac{30}{16}} = \frac{2}{3} \Rightarrow$ Formula $= Fe_2O_3$

    $\therefore$ Oxidation state of Fe = +3.
22. The reducing power of non-metal hydrides increase from top to bottom in a group
23. Hydroquinol undergoes removal of hydrogen, i.e., oxidation and hence, it acts as a reducing agent.
24. Redox reactions may involve absorption or release of heat.
25. Oxidation and reduction is occurring due to different elements and hence, it is not a disproportionation.
26. $\underset{Base}{CaO} + \underset{Acid}{\overset{+4}{Si}O_2} \rightarrow \underset{Salt}{Ca\overset{+4}{Si}O_3}$
27. $H_2S + SO_2 \rightarrow S + H_2O$

    Same element but belonging to different molecule undergoes oxidation and reduction and hence, it is not disproportionation. In fact, it is comproportionation.
28. Referer Question No. 27.

29. $3X_2O_3 + 4Cr_2O_7^{2-} + 26H^+ \rightarrow$
$6XO_4^- + 8Cr^{3+} + 13H_2O$

Method II: (After equivalent concept)

n_{eq} of $X_2O_3 = n_{eq}Cr_2O_7^{-2}$

or $n \times 8 = 1 \times 6 \Rightarrow n_{X_2O_3} = \frac{3}{4}$

30. $2NO_3^- + 16H^+ + 14e^- \rightarrow N_2H_4 + 6H_2O$

$\therefore$ Number of e^- per NO_3^- ion $= \frac{14}{2} = 7.$

Method II: Oxidation state of N changes from +5 to –2 and hence, there is a gain of $7e^-$ per NO_3^- ion.

31. Oxidation: $Br_2 + 12OH^- \rightarrow 2BrO_3^- + 6H_2O + 10e^-$

Reduction: $Br_2 + 2e^- \rightarrow 2Br^- 1 \times 5$

Net reaction:
$6Br_2 + 12OH^- \rightarrow 2BrO_3^- + 10Br^- + 6H_2O$

32. $2NO_3^- + 10H^+ + 8e^- \rightarrow N_2O + 5H_2O$

33. $NO_2^- + 5H_2O + 6e^- \rightarrow NH_3 + 7OH^-$

34. $4Zn + NO_3^- + 7H_2O \rightarrow 4Zn^{2+} + NH_4^+ + 10OH^-$

35. $4Fe + 10HNO_3 \rightarrow 4Fe(NO_3)_2 + NH_4NO_3 + 3H_2O$

Equivalent Concept

36. n_{eq} of oxygen = n_{eq} of oxide

or $\frac{20}{8} = \frac{100}{E} \Rightarrow E = 40.$

37. Sulphurated hydrogen (g) $+ Sn(S) \rightarrow$ Tin Sulphide$(s) + H_2(g)$

x mole $\qquad$ x mole

$= x \times 34$ g $\qquad$ $= x \times 2$ g

No change in volume means no change in mole of gases.

Mass of sulphur combined with $2x$ gm hydrogen $= 34x - 2x = 32x$ g.

$\therefore E_{sulphur} = \frac{32x}{2x} \times 1 = 16$

38. Atomic mass = Equivalent mass × Valency

$$= E \times \frac{n}{m} \times 2$$

39. n_{eq} metal = n_{eq} metal chloride

or $\frac{w}{18.67} = \frac{162.52}{18.67 + 35.5} \Rightarrow w = 56$ g.

40. $4N_A$ electrons means 4 equivalents. Hence, mass of Mg needed $= 4 \times 12 = 48$ gm

41. K_2CrO_4 is behaving as salt and hence, $E = \frac{M}{2}.$

42. $NaHC_2O_4$ is behaving as acid and hence, $E = \frac{M}{1}.$

43. $NaHC_2O_4$ is behaving as base and hence, $E = \frac{M}{1}.$

44. $Ca_3(PO_4)_2 + 2H^+ \rightarrow 2CaHPO_4 + Ca^{2+}$

Equivalent weight of $Ca_3(PO_4)_2 = \frac{M}{2}.$

45. Change in oxidation state of Mn should be 2 units.

46. $E_1 : E_2 : E_3 = \frac{M}{5} : \frac{M}{1} : \frac{M}{3} = 3 : 15 : 5$

47. $As_2S_3 + 20H_2O + 28e^- \rightarrow 2AsO_4^{3-} + 3SO_4^{2-} + 40H^+$

48. (a) $E = \frac{M}{3}$ $\qquad$ (b) $E = \frac{M}{5}$ $\qquad$ (c) $E = \frac{M}{1}$

49. $Cu_2P^{-3} \rightarrow H_3\overset{+5}{P}O_4$

50. $Cl_2 \rightarrow Cl^-$

51. $H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$

The reaction is balanced on the loss and gain of one electron per H_2O_2 molecule.

52. Reaction is balanced on the loss or gain of $10e^-$.

53. H_2O_2 is acting as reductant. Its equivalent weight is $\frac{34}{2} = 17.$

54. $N_2 + 3H_2 \rightarrow 2NH_3$

Reaction is balanced by the loss or gain of $6e^-$.

55. $MCl_2 = 32.7 \times 2 + 35.5 \times 2 = 136.4$

56. $3Zn + 8HNO_3 \rightarrow 3Zn(NO_3)_2 + 2NO + 4H_2O$

Reaction is balanced by the loss or gain of $6e^-$.

57. Reaction is balanced by the loss or gain of $2e^-$.

58. n_{eq} metal carbonate $= n_{eq}$ metal oxide

or $\frac{100}{E+30} = \frac{60}{E+8} \Rightarrow E = 25$

59. n_{eq} metal chloride $= n_{eq}$ metal sulphate

or $\frac{0.298}{E+35.5} = \frac{0.348}{E+48} \Rightarrow E = 39$

60. $n_{eq} NH_3 = n_{eq} O_2 = 1 \times 4 = 4$

61. $n_{eq} Cr_2O_7^{2-} = n_{eq} N_2H_5^+$

$\Rightarrow n \times 6 = 0.136$

$\Rightarrow n = 0.0226$

62. $x \times 5 = y \times 6 \Rightarrow x : y = 6 : 5$

63. n_{eq} metal carbonate $= n_{eq}$ metal sulphate

or $\frac{w}{E+30} = \frac{1.43w}{E+48}$

$\therefore$ E = 11.86

64. $n_{eq} H_2S = n_{eq} KMnO_4$

or $\frac{w}{34} \times 8 = \frac{6.32 \times 3}{158} \Rightarrow w = 0.51$ g

65. n_{eq} metal $= n_{eq}$ oxygen

or $\frac{52.91}{E} = \frac{47.09}{8} \Rightarrow E = 8.99$

$\therefore$ Atomic mass of metal $= 8.99 \times 3 = 26.97$

66. Approximate atomic mass $= \frac{6.4}{0.085} = 75.29$

Now, Valency $= \frac{\text{Atomic mass}}{\text{Equivalent mass}} \approx \frac{75.29}{25}$

≈ 3(integer)

$\therefore$ Exact atomic mass $= 25 \times 3 = 75$.

67. Valency $= \frac{2 \times \text{V.D.}}{E + 35.5} = \frac{2 \times 77}{3 + 35.5} = 4$

$\therefore$ Atomic mass $= 3 \times 4 = 12$

68. $n_{eq} C_6H_{10}O_4 = n_{eq} KOH$

or $\frac{1}{146} \times \text{Basicity} = \frac{0.768}{56} \times 1$

$\Rightarrow$ Basicity of $C_6H_{10}O_4 = 2$

69. n_{eq} metal bromide $= n_{eq}$ metal chloride

or $\frac{1.878}{E+80} = \frac{1.00}{E+35.5} \Rightarrow$ Equivalent mass of metal, $E = 15.18$.

Now, approximate atomic mass of metal $= \frac{6.4}{0.14} = 45.71$

$\therefore$ Valency $= \frac{45.71}{15.18} = 3$ (Integer)

$\therefore$ Exact atomic mass of metal bromide
$= 15.18 \times 3 = 45.54$

$\therefore$ Molecular mass of metal bromide
$= 45.54 + 3 \times 80 = 285.54$

70. The chemical formula of potassium sulphate is K_2SO_4 and hence, potassium chromate is K_2CrO_4.

Molecular mass $= 2 \times 39 + A + 4 \times 16 = 142 + A$

From question, $(142 + A) \times \frac{26.79}{100} = A \Rightarrow A = 51.96$.

Volumetric Analysis

71. n_{eq} of H_2SO_4 in V ml solution $= \frac{V \times \frac{10}{100}}{49} = x$

n_{eq} of NaOH in V ml solution $= \frac{V \times \frac{10}{100}}{40} = y$

As $y > x$, the resulting solution should be basic.

72. n_{eq} of $Na_2CO_3.H_2O = \frac{0.62}{124} \times 2 = 0.01$

and n_{eq} of $H_2SO_4 = \frac{100 \times 0.1}{1000} = 0.01$.

Hence, 0.01 eq. of Na_2SO_4 will form and the resulting solution will be neutral.

73. $n_{eq} AgNO_3 = n_{eq} K_2CrO_4$

or $\frac{V \times 0.1}{1000} \times 1 = \frac{10 \times 0.09}{1000} \times 2 \Rightarrow V = 18$ ml

74. $n_{eq} KMnO_4 = n_{eq} KNO_2$

or $\frac{V \times 0.18}{1000} = \frac{25 \times 0.21}{1000} \Rightarrow V = 29.17$ ml

75. $n_{eq}\ KMnO_4 = n_{eq} Na_2S_2O_3$

or $\frac{V \times 0.1}{1000} \times 3 = \frac{0.158}{158} \times 8 \Rightarrow V = 26.67$ ml

76. $n_{eq}\ HNO_3 = n_{eq} NaOH$

or $\frac{V_1 \times 18.9}{63} \times 1 = \frac{V_2 \times 3.2}{40} \times 1 \Rightarrow V_1 : V_2 = 4 : 15$

77. $n_{eq}\ NH_3 = n_{eq} H_2SO_4$

or $\frac{V}{22400} \times 1 = \frac{30 \times (1-0.2)}{1000} \Rightarrow V = 537.6$ ml

78. $n_{eq}\ Na_2CO_3 = n_{eq}$ acid 'A'

or $\frac{26 \times 1}{1000} = \frac{10 \times N_A}{1000} \Rightarrow N_A = 2.6$ N

and $n_{eq}\ Na_2CO_3 = n_{eq}$ acid 'B'

or $\frac{26 \times 1}{1000} = \frac{40 \times N_B}{1000} \Rightarrow N_B = 0.65$ N

Now, $VN = V_A N_A + V_B N_B$

or $1000 \times 1 = V_A \times 2.6 + (1000 - V_A) \times 0.65$

$\Rightarrow V_A = 179.49$ ml.

79. $n_{eq}\ Ag = n_{eq} KCNS$

or $\frac{0.5 \times \frac{90}{100}}{108} = \frac{25 \times N}{1000} \Rightarrow N = 0.167$

80. $n_{eq} KH_2PO_4 = n_{eq} OH^-$

or $\frac{w}{136} \times 1 = \frac{25 \times 0.1}{1000} \Rightarrow w = 0.34$ g

$\therefore$ % Purity $= \frac{0.34}{0.5} \times 100 = 68\%$

81. $n_{eq} KMnO_4 = n_{eq} H_2O_2$

or $\frac{50 \times 0.1}{1000} \times 5 = \frac{w}{34} \times 2 \Rightarrow w = 0.425$ g

$\therefore$ Strength $= \frac{0.425}{10} \times 100 = 4.25\% \left({}^{w}\!/_{v}\right)$

82. $n_{eq}\ KHC_8H_4O_4 = n_{eq} Ba(OH)_2$

or $\frac{0.204}{204} \times 1 = \frac{25 \times M}{1000} \times 2 \Rightarrow M = 0.02$

83. $n_{eq} SeO_2 = n_{eq} Cr^{2+}$

or $\frac{12.5 \times 0.05}{1000} \times (4 - x) = \frac{25 \times 0.1}{1000} \times 1 \Rightarrow x = 0$

84. $n_{eq} CrO_4^{-2} = n_{eq} S_2O_4^{2-}$

or $100 \times M \times 3 = \frac{522}{179} \times 2 \Rightarrow M = 0.02$

85. $n_{eq} CaC_2O_4 = n_{eq} KMnO_4$

or $n \times 2 = \frac{25 \times 0.001}{1000} \times 5$

$\therefore$ Moles of Ca = Moles of $CaC_2O_4 = 62.5 \times 10^{-6}$ in 10 ml of blood.

$\therefore$ Milligram of Ca per litre blood

$= \frac{62.5 \times 10^{-6} \times 40}{10} \times 1000 = 0.25$

86. $n_{eq} KMnO_4 = n_{eq} H_2C_2O_4$

or $\frac{w}{158} \times 5 = \frac{50 \times 0.2}{1000} \times 2 \Rightarrow w = 0.632$ g

87. $n_{eq} Ca(OH)_2 = n_{eq} H_3PO_4$

or $\frac{V \times 0.05}{1000} \times 2 = \frac{10 \times 0.1}{1000} \times 1 \Rightarrow V = 10$ ml

88. $n_{eq} H_2C_2O_4 \cdot 2H_2O = n_{eq} KMnO_4$

or $\frac{w}{126} \times 2 = \frac{100 \times 0.4}{1000} \times 5 \Rightarrow w = 12.6$ g

89. $n_{eq} Na_2B_4O_7.10H_2O = n_{eq} HCl$

or $\frac{w}{381.2} \times 2 = \frac{25 \times 0.2}{1000} \Rightarrow w = 0.953$ g

90. n_{eq} metal salt $= n_{eq} Na_2SO_3$

or $\frac{50 \times 0.1}{1000} \times (3 - x) = \frac{25 \times 0.1}{1000} \times 2 \Rightarrow x = 2$

91. $n_{eq} H_2O_2 = n_{eq} KMnO_4$

or $\frac{1 \times \frac{x}{100}}{34} \times 2 = \frac{x \times N}{1000} \Rightarrow N = 0.588$

92. $n_{eq} FeC_2O_4 = n_{eq} KMnO_4$

or $\frac{1}{144} \times 3 = \frac{60 \times M}{1000} \times 5 \Rightarrow M = 0.0694$

93. n_{eq} of NaOH $= \frac{15 \times 0.2}{1000} \times 1 = 3 \times 10^{-3}$

n_{eq} of $MgCl_2 = \frac{12 \times 0.15}{1000} \times 2 = 3.6 \times 10^{-3}$

Hence, NaOH is a limiting reagent.

Now, the mass of $Mg(OH)_2$ formed $= 3 \times 10^{-3} \times 29 = 0.087$ g.

94. n_{eq} acid $= n_{eq}$ NaOH

or $\dfrac{\frac{39}{1000}\times 100}{82}\times n = \dfrac{\frac{40}{1000}\times 95}{40}\times 1 \Rightarrow n = 1.997 \simeq 2$

95. Normality $= \dfrac{20}{98}\times 2 = 0.408$ N

96. **Acidic solution:**

$\dfrac{25\times 0.017}{1000}\times 2 = \dfrac{16.9\times 0.01}{1000}\times (7-x) \Rightarrow x = 2$

Neutral Solution:

$\dfrac{25\times 0.017}{1000}\times 2 = \dfrac{28.6\times 0.01}{1000}\times (7-y) \Rightarrow y = 4$

97. n_{eq}acid $= n_{eq}$NaOH

or $\dfrac{0.84}{150}\times n = \dfrac{\left(\frac{28}{25}\times 100\right)\times \frac{1}{10}}{1000} \Rightarrow$ Basicity, $N = 2$

and equivalent weight of acid $= \dfrac{150}{2} = 75$

98. $n_{eq}Na_2CO_3 \cdot xH_2O = n_{eq}HCl$

or $\dfrac{0.70}{106+18x}\times 2 = \dfrac{\left(\frac{19.8}{20}\times 100\right)\times \frac{1}{10}}{1000} \Rightarrow x = 2$

99. $n_{eq}H_2SO_4 = n_{eq}NaOH$

or $\dfrac{w}{98}\times 2 = \dfrac{\left(\frac{25.6}{25}\times 1000\right)\times \frac{1}{10}\times 0.95}{1000}$

$\Rightarrow w = 4.77$ g

$\therefore$ % Strength of acid $= \dfrac{w}{3.5\times 1.76}\times 100 = 77.38\%$

100. $n_{eq}Na_2CO_3 = n_{eq}H_2SO_4$

or $\dfrac{25\times \frac{1}{10}}{1000} = \dfrac{10\times N}{1000} \Rightarrow N = 0.25$

Now, for dilution, $400\times 0.25 = V\times 0.1$
$\Rightarrow V = 1000$ ml.

$\therefore$ Volume of water added $= 1000 - 400 = 600$ ml.

101. $n_{eq}H_2SO_4 = n_{eq}NaOH + n_{eq}Na_2CO_3$

or $\dfrac{25\times N}{1000} = \dfrac{50\times 0.5}{1000} + \dfrac{0.265}{106}\times 2$

$\therefore$ Normality of diluted solution, $N = 1.2$

Now, $V_1N_1 = V_2N_2 \Rightarrow 10\times N_1 = 100\times 1.2$
$\Rightarrow N_1 = 12N$

102. $n_{eq}HCl = n_{eq}AgCl$

or $\dfrac{25\times N}{1000} = \dfrac{0.287}{143.5}\times 1 \Rightarrow N_{HCl} = 0.08$

and $N_{H_2SO_4} = 0.2 - 0.08 = 0.12.$

$\therefore$ Mass per cent of

$HCl = \dfrac{0.08\times 36.5}{0.08\times 36.5 + 0.12\times 49}\times 100 = 33.18\%$

103. n_{eq} anhydrous acid $= n_{eq}$ NaOH

or $\dfrac{0.10}{E} = \dfrac{25\times 0.1}{1000} \Rightarrow E = 40$

and n_{eq} hydrated acid $= n_{eq}$NaOH

or $\dfrac{0.245}{E+18x} = \dfrac{50\times 0.1}{1000} \Rightarrow x = 0.5$

104. $\dfrac{100\times 1}{1000}\times 5 = \dfrac{V\times 1}{1000}\times 3 \Rightarrow V = 166.67$ ml

105. $n_{eq}HCl = n_{eq}$metal carbonate $+ n_{eq}$caustic soda

or $\dfrac{25\times 1}{1000} = \dfrac{1}{E} + \dfrac{50\times \frac{1}{10}}{1000} \Rightarrow E = 50$

106. $n_{eq}NaOH = n_{eq}(NH_4)_2SO_4 + n_{eq}HCl$

or $\dfrac{80\times 0.1}{1000} = \dfrac{w}{132}\times 2 + \dfrac{11.6\times 0.1}{1000} \Rightarrow w = 0.451$ g

$\therefore$ Mass of $Na_2SO_4 = 0.91 - 0.451 = 0.459$ g

107. $n_{eq}Ag_2S = n_{eq}H_2S$

or $\dfrac{w}{248}\times 2 = \dfrac{11.2}{22400}\times 2 \Rightarrow w = 0.124$ g

108. $n_{eq}Fe^{2+} = n_{eq}K_2Cr_2O_7$

or $\dfrac{0.2\times \frac{98}{100}}{56}\times 1 = \dfrac{30\times N}{1000} \Rightarrow N = 0.1167$

109. $n_{eq}\, O_3 = n_{eq}I_2 = n_{eq}Na_2S_2O_3$

or $n\times 2 = \dfrac{40\times \frac{1}{10}}{1000}\times 1 \Rightarrow n_{O_3} = 2\times 10^{-3}$

and total moles of gases $= \dfrac{1}{22.4} = 4.46\times 10^{-2}$

$\therefore$ Moles of $O_2 = 4.46\times 10^{-2} - 2\times 10^{-3} = 4.26\times 10^{-2}$

$\therefore$ Mass percent of

$O_3 = \dfrac{2\times 10^{-3}\times 48}{2\times 10^{-3}\times 48 + 4.26\times 10^{-2}\times 32}\times 100 = 6.575\%$

110. $n_{eq}\,Cl_2 = n_{eq}I_2 = n_{eq}Na_2S_2O_3$

or $\frac{w}{71}\times 2 = \frac{26\times 0.15}{1000} \Rightarrow w = \frac{35.5\times 26\times 0.11}{1000}$ g

$\therefore$ Mass percent of $Cl_2 = \frac{w}{71\times 1.1}\times 100 = 0.13\%$

111. $n_{eq}HClO = n_{eq}I_2 = n_{eq}Na_2S_2O_3$

or $n\times 2 = \frac{17.4\times 0.02}{1000}\times 1 \Rightarrow n = \frac{0.174}{1000}$.

$Cl_2 + H_2O \rightarrow HCl + HClO$

$\therefore$ Mass of Cl_2 per litre $= \left(\frac{n}{25}\times 1000\right)\times 71 = 0.494$ g

112. $n_{eq}Na_3AsO_4 = n_{eq}I_2 = n_{eq}$hypo

or $\frac{1}{208}\times 2 = \frac{V\times 0.2}{1000} \Rightarrow V = 48.1$ ml

113. $n_{eq}S_2O_3^{2-} = n_{eq}K_2S_2O_8$

or $\frac{V\times 0.25}{1000}\times 1 = \frac{1}{270}\times 2 \Rightarrow v = 29.63$ ml

114. $n_{eq}MnO_4^- = n_{eq}FeSO_4$

or $\frac{V_1\times M_1}{1000}\times 5 = \frac{V_2\times M_2}{1000}\times 1 \Rightarrow 5V_1M_1 = V_2M_2$

115. $n_{eq}KHC_2O_4 = n_{eq}KMnO_4$

or $\frac{x}{M}\times 2 = \frac{100\times 0.02}{1000}\times 5$ (1)

$n_{eq}KHC_2O_4 = n_{eq}Ca(OH)_2$

or $\frac{y}{M}\times 1 = \frac{100\times 0.5}{1000}\times 2$ (2)

$\therefore \frac{x}{y} = \frac{1}{2}$

116. Let $NaHCO_3 = a$ mole, $Na_2CO_3 = 6$ mole.

In the presence of phenolphthalein, $n_{eq}HCl = n_{eq}Na_2CO_3$

or $\frac{x\times N}{1000} = b\times 1$ (1)

In the presence of methyl orange,

$n_{eq}HCl = n_{eq}NaHCO_3$ (original) +

$n_{eq}NaHCO_3$ (formed)

or $\frac{y\times N}{1000} = a\times 1 + b\times 1$ (2)

From (1) and (2), we get:

V_{HCl} only forms $NaHCO_3$ (original) $= (y-x)$ ml.

117. Bromocresol green:

$\frac{25\times 0.107}{1000}\times n = \frac{23.1\times 0.115}{1000}\times 1 \Rightarrow n \simeq 1$

Phenolphthalein:

$\frac{25\times 0.107}{1000}\times n = \frac{46.2\times 0.115}{1000}\times 1 \Rightarrow n \simeq 2$

118. Temporary hardness is due to $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$.

$n_{eq}CaCO_3 = n_{eq}Ca(HCO_3)_2 + n_{eq}Mg(HCO_3)_2$

or $\frac{w}{100}\times 2 = \frac{162\times 10^{-3}}{162}\times 2 + \frac{73\times 10^{-3}}{146}\times 2$

$\Rightarrow w = 150\times 10^{-3}$ g

$\therefore$ Temporary hardness $= \frac{150\times 10^{-3}}{1000}\times 10^6$

$= 150$ ppm.

Permanent hardness is due to $MgCl_2$ and $CaSO_4$.

$n_{eq}CaCO_3 = n_{eq}MgCl_2 + n_{eq}CaSO_4$

or $\frac{w}{100}\times 2 = \frac{95\times 10^{-3}}{95}\times 2 + \frac{136\times 10^{-3}}{136}\times 2$

$\Rightarrow w = 200\times 10^{-3}$ g.

$\therefore$ Permanent hardness $= \frac{200\times 10^{-3}}{1000}\times 10^6$

$= 200$ ppm.

119. Temporary hardness $= \left(\frac{\frac{5.6}{100}\times 1000}{56}\right)\times 200$

$= 100$ ppm.

120. $(Ca^{2+}) = \frac{10^2}{2} = 5\times 10^{-3}$ M

$\therefore$ Hardness $= \left(\frac{5\times 10^{-3}}{1000}\times 10^6\right)\times 40 = 200$ ppm

EXERCISE II (JEE ADVANCED)

Section A (Only one Correct)

1. Addition of hydrogen is reduction.

2. Sodium amalgam is an alloy (mixture of sodium and mercury).

3. $2x + 4(-2) + 2\times 0 + 2\times 0 = -2 \Rightarrow x = +3$

4. $KBF_4 : (+1) + x + 4(-1) = 0 \Rightarrow x = +3$

5. $LiBiO_2 : (+1) + x + 2(-2) = 0 \Rightarrow x = +3$

6. $N_{Xe} : N_F = \frac{53.5}{131} : \frac{46.5}{19} = 1:6 \Rightarrow XeF_6$

$\therefore$ Oxidation state of $Xe = +6$.

7. $H_3C{-}\overset{O}{\overset{\|}{S}}{-}CH_3$ S is more E_N than C, but less E_N than O.

8. Oxidation state of Fe is +2 in both as NO^- and NOS^- are the ligands.

9. CO is a neutral oxide.

10. Phosphorus acid: H_3PO_3, oxidation state of P = +3.

Orthophosphoric acid: H_3PO_4, oxidation state of P = +5.

Metaphosphoric acid: HPO_3, oxidation state of P = +5.

Pyrophosphoric acid: $H_4P_2O_7$, oxidation state of P = +5.

11. Informative

12. Reducing agent undergoes oxidation. In HNO_3, H and N are in their maximum oxidation state and hence, oxidation is possible only for 'O'.

13. I^- is a strong reducing agent.

14. Oxidizing agent must undergo reduction. I^- can never be reduced.

15. In $Ca(OCl)Cl$, the oxidation state of 'Cl' is +1 and –1 but in the product Cl_2, it becomes zero.

16. $2Mn^{2+} + 5PbO_2 + 4H^+ \rightarrow 2MnO_4^- + 5Pb^{2+} + 2H_2O$

17. $AsO_3^{3-} + 2OH^- \rightarrow AsO_4^{3-} + H_2O + 2e^-$

18. 'Cr' should be in +6 oxidation state in the product. For basic medium, the product should be CrO_4^{2-}.

19. $\overset{+5}{N}O_3^- + 4e^- \rightarrow$ Oxidation state of N in the product should be +1.

20. $CH_3CH_2OH + H_2O \Rightarrow CH_3COOH + 4H^+ + 4e^-$

21. $CH_3CH_2OH + H_2O \Rightarrow CH_3COOH + 4H^+ + 4e^-$

22. The oxidation state of 'Cr' in ClO_x^- must be +1 and hence, $x = 1$.

23. 1 mole of AO_3^- should gain 6 moles of electron.

$AO_3^- + 6H^+ + 6e^- \rightarrow A^{x+} + 3H_2O$

From charge conservation, (–1) + (+6) + (–6) = $+x$ $\Rightarrow x = -1$.

24. $E = \frac{A}{V} \Rightarrow A = 21\,V_1 = 14\,V_2$

As V_1 and V_2 must be integer, A should be 42, 84, 126, etc.

25. Mass of oxygen present = 14.9 g and mass of hydrogen combined with oxygen to form water = 16.78 – 14.9 = 1.88 g.

$\therefore$ Equivalent weight of oxygen $= \frac{14.9}{1.88} \times 1.008 = 7.989$

26. $\underset{A\text{ gm}}{M^{2+}} + \underset{2N_A e^-}{2e^-} \rightarrow M$

$\therefore\ 1\,g \rightarrow \frac{2N_A}{A} \times 1 = 1.81 \times 10^{22} \Rightarrow A = 66.54.$

27. For minimum equivalent weight, the basicity of acid should be maximum.

28. In the neutralization reactions, one mole of H_2O is formed from 1 mole of H^+ and 1 mole of OH^- ions and hence, equivalent weight of water = 18.

29. $CH_3COOH + 3Cl^- \rightarrow CCl_3COOH + 3H^+ + 6e^-$

$\therefore\ E_{CH_3COOH} = \frac{60}{6} = 10$

30. $\underset{n-factor=6}{N_2} + \underset{2}{3H_2} \rightarrow \underset{3}{2NH_3}$ (No. of e^- involved = 6)

$\therefore\ E_{NH_3} = \frac{x_1}{3}$ and $E_{N_2} = \frac{x_2}{6}$.

31. $P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$

The reaction is balanced by the loss and gain of 3 moles of electron per mole of P_4 and hence,

$E_{P_4} = \frac{M}{3}$.

32. $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

The reaction is balanced by the loss and gain of 2 moles of electron per mole of Pb and hence,

$E_{H_2SO_4} = \frac{2M}{2} = M$.

33. $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

The reaction is balanced by the loss and gain of 5 moles of electron per mole of $NaClO_3$ and hence,

$E_{H_2O} = \frac{3M}{5}$.

34. $O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O$

$\therefore\ E_{O_3} = \frac{48}{2} = 24$.

35. The reaction is balanced by the loss and gain of 2 moles of electron per mole of MnO_2 and hence,

$E_{HCl} = \frac{4M}{2} = 2M$.

36. $n_{eq}\ I_2 = n_{eq} H_3AsO_4$

or $\frac{w}{254} \times 2 = \frac{1.5 \times 10^{22}}{6 \times 10^{23}} \Rightarrow w = 3.175\,g$.

37. $n_{eq} = \frac{6 \times 10^{20}}{6 \times 10^{23}} = 0.001$

38. 1 g equivalent always reacts with 1 g equivalent of other substance.

39. n_{eq} metal oxide = n_{eq} water

or $\frac{8.6}{E_M + 8} = \frac{1.8}{18} \times 2 \Rightarrow E_M = 35$

40. Mass of acid $= \frac{20}{0.5} \times 1 = 40\,g$

41. Let the acid be H_nA.

n_{eq} acid = n_{eq} magnesium salt

or $\frac{1.0}{1 + E_{A^{n-}}} = \frac{1.301}{12 + E_{A^{n-}}} \Rightarrow E_{A^{n-}} = 35.54$

$\therefore$ Equivalent weight of acid = 1 + 35.54 = 36.54.

42. n_{eq} metal oxide = $n_{eq}\ CO_2$

or $\frac{3.7}{E_M + 8} = \frac{1.0}{44} \times 4$ $\left(\overset{\circ}{C} \rightarrow \overset{+4}{C}O_2\right)$

$\therefore\ E_M = 32.7$

43. $n_{eq} = n \times n$-factor and n-factor is maximum for IO_3^- $\left(+5 \text{ to } -\frac{1}{3}\right)$.

44. $n_{eq}\ KMnO_4 = n_{eq} FeC_2O_4$

$(FeC_2O_4 \rightarrow Fe^{3+} + CO_2)$

or $n \times 5 = 1 \times 3 \Rightarrow n = \frac{3}{5}$.

45. $n_{eq}\ KMnO_4 = n_{eq}\ SO_3^{2-}$ $\left(SO_3^{2-} \rightarrow SO_4^{2-}\right)$

or $n \times 5 = 1 \times 2 \Rightarrow n = \frac{2}{5}$.

46. $n_{eq}R.A. = n_{eq}MnO_2 \Rightarrow n \times 1 = x \times 2$

and $n_{eq}R.A. = n_{eq}K_2CrO_4 \Rightarrow n \times 2 = y \times 3$.

$\therefore\ x : y = 3 : 4$

47. $CHCl_2COOH + 3H_2O \rightarrow$

$2CO_2 + H_2O + Cl_2 + 6H^+ + 6e^-$

$n_{eq}CHCl_2COOH = n_{eq}O.A.$

or $n \times 6 = 1.2 \Rightarrow n = 0.2$.

Now, $n_{eq}CHCl_2COOH = n_{eq}NH_3$

or $0.2 \times 1 = x \times 1 \Rightarrow x = 0.2$.

48. $M_{H_2SO_4} : M_{H_3PO_4} = E_{H_2SO_4} : E_{H_3PO_4} = \frac{98}{2} : \frac{98}{1} = 1:2$

49. $28 = \frac{A_M}{2} \Rightarrow$ Atomic mass of metal, $A_M = 56$.

Now, $n_{eq}H_2SO_4 = n_{eq}M_2O_3$

or $\frac{w}{98} \times 2 = \frac{4.8}{160} \times 6 \Rightarrow w = 8.82$ g

50. Approximate atomic mass of metal $= \frac{6.4}{0.26} = 24.62$.

Let the metal chloride be MCl_V.

$24.62 + V \times 35.5 \approx 95 \Rightarrow V \simeq 2$

$\therefore$ Exact atomic mass of metal $= 95 - 2 \times 35.5 = 24$.

Now, n_{eq} metal $= n_{eq}\ H_2$

or $\frac{1.2}{24} \times 2 = \frac{V_{H_2}}{22.4\ L} \times 2 \Rightarrow V_{H_2} = 1.12$ L

51. Approximate atomic mass of metal $= \frac{6.4}{0.55} = 11.63$.

Let the metal chloride be MCl_V. Then,

$2 \times 74.6 \simeq 11.63 + V \times 35.5 \Rightarrow V \approx 4$.

Again, $2 \times 74.6 = A + 4 \times 35.5 \Rightarrow A = 7.2$.

52. $n_{eq}HCl = n_{eq}CO_2$

or $\frac{200 \times N}{1000} = \frac{560}{22400} \times 2 \Rightarrow N_{HCL} = 0.25\ N$

53. The resulting solution becomes neutral.

54. $n_{eq}FeSO_4 \cdot (NH_4)_2 SO_4 \cdot xH_2O = n_{eq}\ KMnO_4$

or $\frac{5.88}{284 + 18x} \times 1 = \frac{\left(\frac{20}{25} \times 250\right) \times \frac{3.16}{1000} \times \frac{75}{100}}{158} \times 5$

$\Rightarrow x = 6$.

55. $2Ag^+ + H_2S \rightarrow Ag_2S \downarrow + 2H^+$

$Cu^{2+} + H_2S \rightarrow CuS \downarrow + 2H$

$\therefore$ Ratio of amount of $H_2S = 1:2$

56. $NaAl(OH)_2 CO_3 + 4HCl \rightarrow$

$NaCl + AlCl_3 + CO_2 + 3H_2O$

$n_{eq}NaAl(OH)_2 CO_3 = n_{eq}HCl$

or $\frac{100 \times 0.1}{1000} \times 4 = \frac{V \times 0.25}{1000} \Rightarrow V = 160\ ml$

57. $n_{eq}Au = n_{eq}SnCl_2$

or $\frac{1.97}{197} \times 3 = \frac{V \times 0.05}{1000} \times 2 \Rightarrow V = 300\ ml$

58. $n_{eq}\ I^- = n_{eq}Ce^{4+}$

or $\frac{250 \times M}{1000} \times 2 = \frac{20 \times 0.05}{1000} \Rightarrow M_{I^-} = \frac{1}{500} M$

$\therefore$ Concentration in $\frac{g}{L} = \frac{1}{500} \times 127 = 0.254$

59. $n_{eq}U^{4+} = n_{eq}KMnO_4$

or $\frac{0.5}{238} \times 2 = \frac{50 \times M}{1000} \times 5 \Rightarrow M = 0.0168$

60. $2IO_3^- + 6H_2C_2O_4 \rightarrow C_2O_4^{2-} + 10CO_2 + I_2 + 6H_2O$

$\frac{n_{KIO_3}}{2} = \frac{n_{H_2C_2O_4}}{6} \Rightarrow \frac{1}{214} = \frac{1}{3} \times \frac{w}{90} \Rightarrow w = 1.262\ g$

61. $n_{eq}H_2C_2O_4 = n_{eq}MnO_4^- = n_{eq}I^-$

or $\frac{w}{90} \times 2 = \frac{500 \times 1.0}{1000} \Rightarrow w = 22.5\ g$

62. $n_{eq}Fe_{0.9}O = n_{eq}KMnO_4$

or $\frac{26.56}{66.4} \times 0.7 = \frac{V \times 0.2}{1000} \times 5 \Rightarrow V = 280\ ml$

63. $n_{eq}KMnO_4 = n_{eq}FeC_2O_4$

or $\frac{25 \times \left(\frac{20 \times 1}{200}\right)}{1000} \times 5 = \frac{20 \times M}{1000} \times 3$

$\Rightarrow M_{FeC_2O_4} = 0.208\ M$

64. $20 \times 1 = 200 \times M_1 \Rightarrow M_1 = 0.1\ M$

$20 \times 0.1 = 75 \times M_2 \Rightarrow M_2 = \frac{0.1}{3} M$

$30 \times \frac{0.1}{3} = 150 \times M_3 \Rightarrow M_3 = \frac{1}{150} M$

Now, $n_{eq}K_2Cr_2O_7 = n_{eq}H_2O_2$

or $\frac{15 \times \frac{1}{150}}{1000} \times 6 = \frac{V \times 0.02}{1000} \times 2 \Rightarrow V_{H_2O_2} = 15\ ml$

65. n_{eq} metal $= n_{eq}\ H_2$

or $\frac{0.1}{51} \times x = \frac{43.9}{22400} \times 2 \Rightarrow x \simeq 2$

Now, $n_{eq}M^{x+} = n_{eq}MnO_4^-$

or $\frac{0.1}{51} \times (y - x) = \frac{58.8 \times 0.1}{1000} \Rightarrow y \simeq 5$

66. $n_{eq}Na_2S_2O_3 = n_{eq}K\,BrO_3$

or $\frac{40 \times M}{1000} \times 1 = \frac{0.1336}{167} \Rightarrow M_{Na_2S_2O_3} = 0.02\ M$

67. $n_{eq}HCl = n_{eq}M_3(PO_4)_2$

or $\frac{10 \times 0.1}{1000} = \frac{0.0517}{E_M + 31.67} \Rightarrow E_M = 20.03$

68. $n_{eq}HCl = n_{eq}CaSO_4 \cdot \frac{1}{2}H_2O$

or $\frac{525 \times 0.1}{1000} = \frac{w}{145} \times 2 \Rightarrow w = 3.81\ g$

69. $Cu^{2+} + I^- \rightarrow Cu^+ + I_2$

$n_{eq}Na_2S_2O_3 = n_{eq}I_2 = n_{eq}Cu^{2+}$

or $\frac{V \times 0.4}{1000} \times 1 = \frac{50 \times 0.2}{1000} \times 1 \Rightarrow V_{Na_2S_2O_3} = 25\ ml$

70. $n_{eq} H_2O_2 = n_{eq} I_2 = n_{eq} Na_2S_2O_3$

or $\frac{25 \times M}{1000} \times 2 = \frac{20 \times 0.3}{1000} \Rightarrow M_{H_2O_2} = \frac{6}{50} M$

$\therefore$ Volume strength $= \frac{6}{50} \times 11.35 = 1.362$

71. $\underset{x \text{ mole}}{CS_2} + 3O_2 \rightarrow \underset{x \text{ mole}}{CO_2} + \underset{2x \text{ mole}}{2SO_2}$

$\underset{y \text{ mole}}{H_2S} + \frac{3}{2} O_2 \rightarrow \underset{y \text{ mole}}{H_2O} + \underset{y \text{ mole}}{SO_2}$

$3x + 2y = \frac{1.97 \times 20}{0.082 \times 400} = 1.2$ (1)

Now, $n_{eq} SO_2 = n_{eq} I_2$

or $(2x + y) \times 2 = \frac{250 \times 2.8}{1000} \times 2 \Rightarrow 2x + y = 0.7$ (2)

From (1) and (2), $x = 0.2$; $y = 0.3$

Now, $X_{CS_2} = \frac{x}{x+y} = 0.4$

72. n_{CO_2} formed $= \frac{0.9}{100} = 9 \times 10^{-3}$

$n_{NaOH} = \frac{100 \times 0.5}{1000} = 50 \times 10^{-3}$

$\underset{18 \times 10^{-3}}{2NaOH} + \underset{9 \times 10^{-3}}{CO_2} \rightarrow \underset{9 \times 10^{-3}}{Na_2CO_3} + H_2O$

$\therefore$ Final solution contains NaOH = (50 – 18) × $10^{-3} = 32 \times 10^{-3}$ mole and $Na_2Co_3 = 9 \times 10^{-3}$ mole.

Now, n_{eq} HCl $= n_{eq}$ NaOH $+ n_{eq} Na_2CO_3$

or $\frac{V \times 0.5}{1000} \times 1 = 32 \times 10^{-3} \times 1 + 9 \times 10^{-3} \times 1$

$\Rightarrow V_{HCl} = 82$ ml

73. Phenolphthalein:

$\frac{x \times 0.05}{1000} \times 1 = \frac{40 \times 0.05}{1000} \times 1 \Rightarrow x = 40$

Methyl orange:

$\frac{y \times 0.05}{1000} \times 1 = \frac{40 \times 0.05}{1000} \times 3 \Rightarrow y = 120$

74. Let $M_{Na_2CO_3} = x$M ; $M_{NaHCO_3} = y$M

Now, $V_1 \times 1 \times 1 = \frac{100 \times x}{1000} \times 1$ (Phenolphthalein)

and $V_2 \times 1 \times 1 = \frac{100 \times x}{1000} \times 2 + \frac{100 \times y}{1000} \times 1$ (Methyl orange)

$\therefore$ $x = 10V_1$ and $y = 10(V_2 - 2V_1)$

75. In presence of phenolphthalein, n-factor = 1.

In presence of methyl orange, n-factor = 3.

Section B (One or More than one Correct)

1. NO^+ and ClO_4^- ⇒, Oxidation state of N = +3, Cl = +7.

2. PbO_2 is an oxide.

3. (a) Oxidation state of S = +6 in both.

(b) Oxidation state of Cr = +6 in both.

(c) Oxidation state of P = +5 in both.

4. As $KMnO_4$ reduces, the compound must oxidize. Fe^{+3} cannot oxidize.

5. $\bar{C} \equiv \dot{N}$ Oxidation state of C = +2, N = –3

$:\ddot{O}=C=\ddot{N}:^- \longleftrightarrow :\ddot{\underset{..}{O}}^- - C \equiv N$

O.S. of C= +4, O = –2, N = –3

6. 'Cl' should be in intermediate oxidation state.

7. $KMnO_4 = \frac{15.8}{158} \times 5 = 0.5$ eq

$HCl = \frac{18.25}{36.5} \times 1 = 0.5$ eq

$H_2C_2O_4 = \frac{22.5}{90} \times 2 = 0.5$ eq

$SO_2 = \frac{32}{69} \times 2 = 1.0$ eq

$FeSO_4 = \frac{38}{152} \times 1 = 0.25$ eq

8. $2Cu + 6HNO_3 \rightarrow$
$2Cu(NO_3)_2 + NO + NO_2 + 3H_2O$

9. Equivalent volume is the volume occupied by 1g-equivalent of the gas.

(a) 1g-equivalent of $CH_4 = \frac{1}{8}$ mole $= \frac{1}{8} \times 22.4$ L
$= 2.8$ L

(b) 1g-equivalent of $O_3 = \frac{1}{2}$ mole $= 11.2$ L

(c) 1g-equivalent of $H_2S = \frac{1}{2}$ mole $= 11.2$ L

(d) 1g-equivalent of $CO_2 = \frac{1}{4}$ mole $= 5.6$ L

10. n_{eq} metal nitrate $= n_{eq}$ metal sulphate

or $\frac{0.5}{E_M + 62} = \frac{0.43}{E_M + 48} \Rightarrow E_M = 38$

11. The chemical formula of sulphate is $MSO_4 \cdot 7H_2O$.

$(A + 222) \times \frac{20}{100} = A \Rightarrow A = 55.5$

As the valency of metal is 2, the equivalent weight $= \frac{55.5}{2} = 27.75$

12. Higher oxide: $\frac{80}{E_M} = \frac{20}{8} \Rightarrow E_M = 32.$

Lower oxide (4.29 g) $\rightarrow$ Higher oxide (4.77 g)

Mass of metal $= 4.77 \times \frac{80}{100} = 3.816$ g

Mass of oxygen $= 4.29 - 3.816$

$= 0.474$ g

Lower oxide: $\frac{3.816}{E_M} = \frac{0.474}{8} \Rightarrow E_M = 64.4$

13. Atomic weight (approx.) $= \frac{6.4}{0.03} = 213.33$

Now, $\frac{10}{E_M} = \frac{18.9}{E_M + 62} \Rightarrow E_M = 69.66$

Now, Valency $\approx \frac{213.33}{69.66} \approx 3$ (Integer value)

$\therefore$ Atomic weight (exactly) $= 69.66 \times 3 = 208.98$

14. Let molarities of Na_2CO_3 and $NaHCO_3$ be xM and yM, respectively.

Phenolphthalein:

$\frac{100 \times x}{1000} \times 1 = V_1 \times 1 \times 1 \Rightarrow x = 10V_1$

Methyl orange:

$\frac{100 \times x}{1000} \times 2 + \frac{100 \times y}{1000} \times 1 = (V_2 \times 1) \times 1$

$\Rightarrow y = 10(V_2 - 2V_1)$

15. Molarity of oxalic acid solution $= \frac{6.3}{90 + 18x}$

Now, $\frac{20 \times \left(\frac{6.3}{90 + 18x}\right)}{1000} \times 2 = \frac{40 \times 0.05}{1000} \times 1 \Rightarrow x = 2$

$E_{H_2C_2O_4.2H_2O} = \frac{126}{2} = 63$ but $E_{H_2C_2O_4} = \frac{90}{2} = 45$

Molarity $= \frac{6.3}{126} = 0.05$ M

Now, n_{eq} acid $= n_{eq}$ $KMnO_4$

or $\frac{100 \times 0.05}{1000} \times 2 = \frac{V \times 0.05}{1000} \times 5 \Rightarrow V = 40$ ml.

16. (a) 109% oleum means 100 g oleum ($H_2SO_4 + SO_3$) exactly requires 9 g water to produce exactly 109 g of pure H_2SO_4.

$$\underset{18\,g}{H_2O} + \underset{80\,g}{SO_3} \rightarrow H_2SO_4$$

$\therefore$ 9 g $\rightarrow$ 40 g

$\therefore$ Percentage of free $SO_3 = 40\%$

(b) 1 g of oleum contains 0.4 g of SO_3 and hence, 0.6 g of H_2SO_4.

Now, $n_{eq}SO_3 + n_{eq}H_2SO_4 = n_{eq}NaOH$

or $\frac{0.4}{80} \times 2 + \frac{0.6}{98} \times 2 = \frac{V \times 0.5}{1000} \times 1 \Rightarrow V = 44.49$ ml

(c) n_{eq} $SO_3 + n_{eq}H_2SO_4 = n_{eq}Ba(OH)_2$

or $\frac{2.0}{80} \times 2 + \frac{3.0}{98} \times 2 = \frac{V \times 0.1}{1000} \Rightarrow V = 111.22$ ml

(d) 100 g of oleum requires 9g of water to give 109 g of H_2SO_4. Hence, the final solution contains 109 g of H_2SO_4 and 491 g of water.

$\therefore$ Molality $= \frac{109/98}{491} \times 1000 = 2.265$ m.

17. (a) Moles of $P_4O_{10} = \frac{5.68}{284} = 0.02$

$$P_4O_{10} \xrightarrow{\text{aqueous}} 4H_3PO_4$$

$\therefore$ Molarity of H_3PO_4 solution

$= \frac{0.02 \times 4}{250} \times 1000 = 0.32$ M

(b) $\frac{25 \times 0.32}{1000} \times 3 = \frac{V \times 0.5}{1000} \times 1 \Rightarrow V = 48$ ml

(c) $\frac{15\times0.32}{1000}\times3=\frac{V\times0.2}{1000}\times2\Rightarrow V=36\text{ ml}$

(d) $\frac{40\times0.32}{1000}\times1=\frac{V\times0.8}{1000}\Rightarrow V=16\text{ ml}$

18. $\underset{0.01\text{mole}}{SO_2Cl_2}+2H_2O\rightarrow\underset{0.01\text{mole}}{H_2SO_4}+\underset{0.02\text{mole}}{2HCl}$

(a) $[H_2SO_4]=\frac{0.01}{200}\times1000=0.05\text{ M}$

(b) $[HCl]=\frac{0.02}{200}\times1000=0.1\text{ M}$

(c) $\frac{20\times0.05}{1000}\times2+\frac{20\times0.1}{1000}\times1=\frac{V\times0.2}{1000}\times1$

$\Rightarrow V_{NaOH}=20\text{ ml.}$

(d) $\frac{100\times0.1}{1000}=\frac{w}{143.5}\Rightarrow W_{AgCl}=1.435\text{ g}$

19. $n_{eq}H_2O_2=n_{eq}KMnO_4=n_{eq}K_2Cr_2O_7=n_{eq}O_2$

or $n_{KMnO_4}\times5=n_{K_2Cr_2O_7}\times6$

$\Rightarrow n_{KMnO_4}>n_{K_2Cr_2O_7}$

or $\frac{W_{KMnO_4}}{158}\times5=\frac{W_{K_2Cr_2O_7}}{294}\times6$

$\Rightarrow W_{KMnO_4}<W_{K_2Cr_2O_7}$

or $\frac{V\times M_{KMnO_4}}{1000}\times5=\frac{V\times M_{K_2Cr_2O_7}}{1000}\times6$

$\Rightarrow\frac{M_{KMnO_4}}{M_{K_2Cr_2O_7}}=\frac{6}{5}$

20. Moles of $S=\frac{8.0}{32}=0.25$

(a) $\frac{0.25}{2}\times2=\frac{200\times M}{1000}\times5\Rightarrow M_{KMnO_4}=0.25\text{ M}$

(b) $M_{BaCl_2}=\frac{0.25/2}{100}\times1000=1.25\text{ M}$

(c) $M_{BaSO_4}=\frac{0.25}{2}\times234=29.25\text{ g}$

Section C (Comprehensions)

Comprehension I

1. $E_{MnBr_2}=\frac{215}{17}\simeq12.65$

2. $E_{PbO_2}=\frac{240}{2}=120$

3. $2MnBr_2+17PbO_2+30HNO_3\rightarrow$
$2HMnO_4+2Pb(BrO_3)_2+15Pb(NO_3)_2+14H_2O$

The reaction is balanced by the loss or gain of 34 electrons. Hence,

$E_{HNO_3}=\frac{30\times63}{34}=55.6$

Comprehension II

4. Atomic weight (approx.) $=\frac{6.4}{0.08}=80$

$n_{eq}Ag=n_{eq}$ arsenious chloride

or $\frac{100}{108}\times1=\frac{56}{E_{As}+35.5}\Rightarrow E_{AS}=24.98$

Now, Valency $=\frac{80}{24.98}\simeq3$

$\therefore$ Exact atomic mass = 24.98 × 3 = 74.94

5. $E_{As}=24.98$

6. Molecular mass of arsenious chloride = 6.25 × (22.4 × 1.3) = 182.

Let the formula be $(AsCl_3)_x$.

$x(74.94+3\times35.5)=182\Rightarrow x=1.0$

$\therefore$ Molecular formula $=AsCl_3$

Comprehension III

Let the oxide be M_2O_x and the halide be MX_y.

For oxide: $\frac{0.4}{8} = \frac{w}{A} \times x$ (1)

For halide: $\frac{4.0}{E} = \frac{w}{A} \times y$ (2)

From (1) and (2), we get: $\frac{E}{80} = \frac{x}{y}$

7. $x = y \Rightarrow E = 80$

8. $y = 2x \Rightarrow E = 40$

9. $A = E.n \Rightarrow$ As valency should be an integer, A must be an integer multiple of 40.

Comprehension IV

10. $n_{eq}KMnO_4 = n_{eq}X^{n+}$

or $1.5 \times 10^{-3} \times 5 = 2.5 \times 10^{-3} \times (5 - n) \Rightarrow n = 2.$

11. $E = \frac{M}{n\text{-factor}}$

$\therefore M = 56 \times (5 - n) = 168$

Hence, atomic mass of $X = 168 - 2 \times 35.5 = 97.$

12. $n_{eq}KMnO_4 = n_{eq}X^{n+}$

or $n \times 1 = 1 \times 3 \Rightarrow n = 3$

Comprehension V

Let the sample contains x mole KCl and y mole $KClO_3$.

$$\underset{\frac{y}{10}\text{mole}}{KClO_3} \xrightarrow{SO_2} \underset{\frac{y}{10}\text{mole}}{KCl}$$

Now, mole of AgCl formed,

$\frac{x}{10} + \frac{y}{10} = \frac{0.1435}{143.5} \Rightarrow x + y = 0.01$ (1)

For second experiment,

$n_{eq}KClO_3 + n_{eq}O.A. = n_{eq}FeSO_4$

or $\frac{y}{10} \times 6 + \frac{37.5 \times 0.08}{1000} = \frac{30 \times 0.2}{1000} \Rightarrow y = 5 \times 10^{-3}$

From Equation (1), we get: $x = 5 \times 10^{-3}$

13. $n_{KClO_3} : n_{Kcl} = y : x = 1 : 1$

14. $m_{KCl} = x \times 74.5 = 0.3725$ g

$m_{KClO_3} = y \times 122.5 = 0.6125$ g

$\therefore m_{moisture} = 1 - (0.3725 + 0.6125) = 0.015$ g,

i.e., 1.5%

15. Mass percent of $KCl = \frac{0.3725}{1} \times 100 = 37.25\%$

Comprehension VI

16. $n_{eq}As_4O_6 = n_{eq}I_3^-$

or $\frac{0.1188}{396} \times 8 = \frac{10 \times M}{1000} \times 2 \Rightarrow M_{I_3^-} = 0.12$ M

17. $n_{HCN} = n I_3^-$

or $\frac{15 \times M}{1000} = \frac{5 \times 0.12}{1000} \Rightarrow M_{HCN} = 0.04$ M

18. Mass of $HCN = (6 \times 0.04) \times 27 = 6.48$ g

Comprehension VII

19. $4Mn^{2+} + MnO_4^- + 20F^- + 8H^+ \rightarrow 5MnF_4^- + 4H_2O$

20. Let the moles of $Mn_3O_4 = x$. Hence, moles of Mn^{2+} formed $= 3x$.

Now, for $KMnO_4$ solution, molarity $= \frac{0.125}{5} = 0.025$ M.

Now, $n_{eq}KMnO_4 = n_{eq}Mn^{2+}$

or $\frac{30 \times 0.025}{1000} \times 4 = 3x \times 1 \Rightarrow x = 10^{-3}$

Now, mass of $Mn_3O_4 = x \times 229 = 0.229$ g

$\therefore$ Percentage of $Mn_3O_4 = \frac{0.229}{0.458} \times 100 = 50\%$

21. Normality $= 0.025 \times 4 = 0.1$N

Comprehension VIII

Let the ore contains x mole of $FeCr_2O_4$ and y mole of $Fe_{0.95}O_{1.00}$.

Now, $n_{eq}FeCr_2O_4 + n_{eq}Fe_{0.95}O_{1.00} = n_{eq}O_2$

or $x \times 7 + y \times 0.85 = \frac{280}{22400} \times 4 \Rightarrow 7x + 0.85y = 0.05$ (1)

Now,

Moles of $K_4[Fe(CN)_6]$ taken $= \frac{10 \times 1}{1000} = 0.01$

$n_{eq}Fe^{2+} = n_{eq}K_4[Fe(CN)_6]$

or $\frac{6 \times 0.4}{1000} = n = 2 \Rightarrow n = 0.0012$.

$\therefore$ Moles of $K_4[Fe(CN)_6]$ reacted with

$Fe^{3+} = 0.01 - 0.0012 = 0.0088$

Now, $n_{eq}Fe^{3+} = n_{eq}K_4[Fe(CN)_6]$

or $(x + 0.95y) \times 3 = 0.0088 \times 3 \Rightarrow x + 0.95y = 0.0088$ (2)

From (1) and (2), we get:

$$y = 2 \times 10^{-3}, \ x = 6.9 \times 10^{-3}$$

22. Mass per cent of

$Fe_{0.95}O_{1.00} = \frac{2 \times 10^{-3} \times 69.2}{2} \times 100 = 6.92\%$

23. Let in $Fe_{0.95}O_{1.00}$, 'z' Fe-atom are in +2 state.

$z \times (+2) + (0.95 - z) \times (+3) = 2.00 \Rightarrow z = 0.85$

Hence, per cent of total iron in +2 state

$= \frac{x + y \times 0.85}{x + 0.95y} \times 100$

$= 97.73\%$

24. Moles of Prussian blue = moles of Fe^{3+}

$= x + 0.95y = 8.8 \times 10^{-3}$

Comprehension IX

25. Moles of $NaHSO_3$ needed = 3× moles of $NaIO_3$

$= 3 \times \frac{5.94}{198} = 0.09$

$\therefore$ Mass of $NaHSO_3$ needed $= 0.09 \times 104 = 9.36$ g.

26. Moles of SO_3^- needed in 2nd reaction.

$= \frac{1}{5} \times$ moles of I^- formed in 1st reaction

$= \frac{1}{5} \times \frac{5.94}{198} = 6 \times 10^{-3}$

$\therefore$ Volume of solution required $= \frac{6 \times 10^{-3}}{5.94/198} = 0.2$ L

27. Mass of I_2 produced $= 6 \times 10^{-3} \times 3 \times 254 = 4.572$ g

$\therefore$ Mass of I_2 produced per litre of solution

$= \frac{4.572}{(1 + 0.2)} = 3.81$ g

Comprehension X

28. $n_{eq}HCl = n_{eq}Na_2CO_3 + n_{eq}NaOH$

or $\frac{V \times 1}{1000} = \frac{1}{106} \times 1 + \frac{1}{40} \times 1 \Rightarrow V_{HCl} = 34.43$ ml

29. $n_{eq}HCl = n_{eq}Na_2CO_3 + n_{eq}NaHCO_3 + n_{eq}NaOH$

or $\frac{V \times 1}{1000} = \frac{1}{106} \times 2 + \frac{1}{84} \times 1 + \frac{1}{40} \times 1$

$\Rightarrow V_{HCl} = 55.77$ ml

30. $n_{eq}HCl = n_{eq}NaHCO_3$ formed $+ n_{eq}NaHCO_3$, present initially.

or $\frac{V \times 1}{1000} = \frac{1}{106} \times 1 + \frac{1}{84} \times 1 \Rightarrow V_{HCl} = 21.34$ ml

Section D (Assertion–Reason)

1. I^- can never be reduced.

2. The oxidation state of terminal C-atoms are –3 and middle C-atoms are –2.

3. I^- can not be reduced and hence, reduction of O_3 occurs.

$$O_3 + 2H^+ + 2e^- \rightarrow O_2 + H_2O$$

4. Oxidation state of $Cl = +3$

5. n-factor may be fractional.

9. $V \times 0.3 \times 2 = V \times 0.2 \times 3$

10. In the presence of methyl orange, the colour change appears when Na_2CO_3 converts completely in H_2CO_3.

14. Copper converts from Cu^{2+} to Cu^+.

15. $n_{eq}A = n_{eq}C$ only when n-factor of B is same in both reactions.

Section E (Column Match)

4.

Column I	Column II
(A) $n_{eq} = 1 \times 5$	(P) $n_{eq} = 3 \times 1$
(B) $n_{eq} = 1 \times 3$	(Q) $n_{eq} = 0.5 \times 10$
(C) $n_{eq} = 1 \times 2$	(R) $n_{eq} = 1 \times 2$
(D) $n_{eq} = 1 \times 3$	(S) $n_{eq} = 1.5 \times 2$

5.

Column I	Column II
(A) $n_{eq}\underset{(O.A.)}{MnO_4^-} = n_{eq}\underset{(R.A.)}{C_2O_4^{2-}} \Rightarrow$ $n_1 \times 3 = n_2 \times 2 \Rightarrow n_1 : n_2 = 2:3$	
(B) $n_{eq}\underset{(O.A.)}{ClO^-} = n_{eq}\underset{(R.A.)}{Fe(OH)_3} \Rightarrow$ $n_1 \times 2 = n_2 \times 3 \Rightarrow n_1 : n_2 = 3:2$	
(C) $n_{eq}\underset{(O.A.)}{HO_2^-} = n_{eq}\underset{(R.A.)}{Cr(OH)_3} \Rightarrow$ $n_1 \times 2 = n_2 \times 4 \Rightarrow n_1 : n_2 = 2:1$	
(D) $n_{eq}\underset{(R.A.)}{N_2H_4} = n_{eq}\underset{(O.A.)}{Cr(OH)_2} \Rightarrow$ $n_1 \times 6 = n_2 \times 2 \Rightarrow n_2 : n_1 = 3:1$	

6. Equivalent volume is the volume of gas corresponding to 1 g-equivalent of the gas.

7.

(A) n-factor $= 2$
(B) n-factor $= 10$
(C) n-factor $= \frac{2 \times 10}{2 + 10} = \frac{5}{3}$
(D) n-factor $= \frac{2 \times 2}{2 + 2} = 1$

8.

	(P) n-factor $= 1$
	(Q) n-factor $= \frac{1}{2}$
	(R) n-factor $= 2$
	(S) n-factor $= 6$
	(T) n-factor $= \frac{1}{2}$

9. Milliequivalents:

Column I	Column II
(A) $100 \times 0.3 \times 2 = 60$ for P, Q, R, S	(P) $100 \times 0.3 \times 1 = 30$
(B) $50 \times 0.6 \times 1 = 30$ for P, S $50 \times 0.6 \times 2 = 60$ for Q, R	(Q) $120 \times 0.1 \times 5 = 60$
(C) $50 \times 0.6 \times 1 = 30$ for P, Q, R, S	(R) $60 \times 0.1 \times 5 = 30$
(D) $100 \times 0.2 \times 3 = 60$ for P, Q, S	(S) $100 \times 0.6 \times 1 = 60$

10. Milliequivalents:

Column I	Column II
(A) $50 \times 0.5 \times 2 = 50$	(P) $50 \times 0.5 \times 2 = 50$
(B) $50 \times 0.5 \times 1 = 25$	(Q) $50 \times 0.5 \times 1 = 25$
(C) $50 \times 0.5 \times 1 = 25$	(R) $25 \times 0.5 \times 2 = 25$
(D) $50 \times 0.5 \times 1 = 25$	(S) $50 \times 1.0 \times 1 = 50$

Section F (Subjective)

Single-digit Integer Type

1. $AO_4^{n-} + (9-2n)H^+ + 2e^- \rightarrow HAO_n^{2-} + (4-n)H_2O$

From charge conservation,

$(-n)+(9-2n)+(-2) = -2 \Rightarrow n = 3.$

2. $5AO_2 + 4H^+ \rightarrow 2AO_4^- + 3A^{n+} + 2H_2O$

From charge conservation,

$(+4) = (-2) + 3n \Rightarrow n = 2.$

3. $n_{eq}Cl_2 = n_{eq}$ metal chloride

or $\frac{1.12}{22.4} \times 2 = \frac{5.55}{E+35.5} \Rightarrow$ Equivalent weight of metal, $E = 20$

$\therefore$ Valency $= \frac{A}{E} = \frac{40}{20} = 20$

4. $\frac{160}{96} = \frac{2 \times n}{2+n} \Rightarrow n = 10 \Rightarrow$ Oxidation state of Br in unknown product = 5

5. $E = \frac{30}{\left(\frac{2 \times 2}{2+2}\right)} = 30$

6. $M(s) + Cl_2(g) \rightarrow \text{Chloride}(g)$

As the volume reduced by one-third, moles of chloride formed $= \frac{2}{3} \times$ Moles of Cl_2 reacted.

Mass of chorine used $= n \times 71$ g.

Mass of chloride formed

$= \frac{2}{3} n \times 68.75 \times 2 = \frac{275}{3} n$ g

$\therefore$ Mass of element used $= \frac{275}{3} n - 71n = \frac{62}{3} n$ g

Now, equivalent weight of element,

$E = \frac{62n/3}{71n} \times 35.5 = \frac{31}{3}$

7. $n_{eq}SO_2 = n_{eq}HClO_3$

or $\frac{V}{22.4} \times 2 = \frac{16.9}{84.5} \times 6 \Rightarrow V = 13.44$ L

Now $n = \frac{PV}{RT} = \frac{2 \times (5 \times 13.44)}{0.0821 \times 546} = 3$

8. $n_{eq}N_2H_4 = n_{eq}K_2CrO_4$

or $\frac{w}{32} \times 4 = \frac{24}{194} \times 3 \Rightarrow w = 2.97 \text{ g} \simeq 3$ g

9. $n_{eq}KHC_2O_4 \cdot H_2C_2O_4 \cdot 2H_2O = n_{eq}NaOH$

or $n \times 3 = 30 \times 1 \Rightarrow n = 10$

Now, $n_{eq}KHC_2O_4 \cdot H_2C_2O_4 \cdot 2H_2O = n_{eq}KMnO_4$

or $10 \times 4 = n \times 5 \Rightarrow n = 8$

10. $n_{eq}Mn(NO_3) \cdot 6H_2O = n_{eq}Na_4XeO_6$

or $n \times 5 = \frac{62.5 \times 0.04}{1000} \times 8 \Rightarrow n = 4 \times 10^{-3}$

11. $Cl_2 + 2NaClO_2 \Rightarrow 2ClO_2 + 2NaCl$

$$n_{eq} NaClO_2 \times \frac{90}{100} = n_{eq} ClO_2$$

or $5 \times 2 \times \frac{90}{100} = n \Rightarrow n = 9$

12. $n_{eq} CuSO_4 \cdot xH_2O = n_{eq} H_2SO_4 = n_{eq} NaOH$

or $\frac{1.245}{159.5 + 18x} \times 2 = \frac{10 \times 1}{1000} \times 1 \Rightarrow x = 4.97 \simeq 5$

13. $\underset{x\,\text{mole}}{CS_2} + O_2 \rightarrow \underset{x\,\text{mole}}{CO_2} + \underset{2x\,\text{mole}}{2SO_2}$

$$\underset{y\,\text{mole}}{H_2S} + \frac{3}{2}O_2 \rightarrow \underset{y\,\text{mole}}{H_2O(g)} + \underset{y\,\text{mole}}{SO_2}$$

From the question, $3x + 2y = \frac{7.2 \times 82.1}{0.0821 \times 600} = 12$

and $(2x + y) \times 2 = 75 \times 2$

Hence, $x = 2$ and $y = 3$.

14. $XeF_x + \frac{x}{2}H_2 \rightarrow \underset{a\,\text{mole}}{Xe} + \underset{a\,x\,\text{mole}}{xHF}$

$$a = \frac{56}{22400}$$

and $ax \times 1 = \frac{60 \times 0.25}{1000} \times 1 \Rightarrow x = 6$

15. $n_{eq} H_2O_2 = n_{eq} I_2 = n_{eq} Na_2S_2O_3$

or $\frac{12 \times \frac{5.675}{11.35}}{1000} \times 2 = \frac{24 \times M}{1000} \times 1 \Rightarrow M = 0.5$

Now, $n_{eq} O_3 = n_{eq} I_2 = n_{eq} Na_2S_2O_3$

or $\frac{V}{22.4} \times 2 = \frac{9 \times 0.5}{1000} \times 1 \Rightarrow V = 0.504$ L

$\therefore$ Percentage of $O_3 = \frac{0.0504}{1} \times 100 = 5.04\% \simeq 5\%$

16. $\underset{x\,\text{mole}}{H_2C_2O_4} \rightarrow H_2O + \underset{x\,\text{mole}}{CO} + CO_2$

$$\underset{x\,\text{mole}}{5CO} + I_2O_5 \rightarrow 5CO_2 + \underset{\frac{x}{5}\text{mole}}{I_2}$$

$n_{eq}\ I_2 = n_{eq} Na_2S_2O_3$

or $\frac{x}{5} \times 2 = \frac{200 \times 0.2}{1000} \Rightarrow x = 0.1$

$\therefore$ Mass of $H_2C_2O_4 = 0.1 \times 90 = 9$ g

17. Ammonium Vanadate $\xrightarrow[\text{acid}]{\text{oxalic}} \underset{\left(\overset{x+}{V}\right)}{Z} \xrightarrow{KMnO_4}$

$$\overset{+5}{V} \xrightarrow{SO_2} \overset{+4}{V} \xrightarrow{KMnO_4} \overset{+5}{V}$$

$n_{eq}\ Z = n_{eq}\ KMnO_4 \Rightarrow n \times (5 - x) = V_1 \times N$

$n_{eq} V^{4+} = n_{eq} KMnO_4 \Rightarrow n \times 1 = V_2 \times N$

From question, $\frac{V_1}{V_2} = \frac{5}{1} \Rightarrow x = 0$

18. Let $Cu^{2+} = a$ mole and $C_2O_4^{2-} = b$ mole.

$n_{eq} C_2O_4^{2-} = n_{eq} MnO_4^- \Rightarrow b \times 2 = \frac{22.6 \times 0.02}{1000} \times 5$

$n_{eq} Cu^{2+} = n_{eq} I_2 = n_{eq} Na_2S_2O_3 \Rightarrow$

$a \times 1 = \frac{11.3 \times 0.05}{1000} \times 1$

$\therefore a : b = 1 : 2$

19. Moles of $Fe_2O_3 = \frac{0.552}{160} \Rightarrow$

Moles of Fe^{2+} formed $= 2 \times \frac{0.552}{160}$

Now, $n_{eq} Fe^{2+} = n_{eq}$ Oxidizing agent

or $\frac{2 \times 0.552}{160} \times 1 = \frac{\left(\frac{17}{25} \times 100\right) \times 0.0167}{1000} \times n_f$

$\Rightarrow$ n-factor, $n_f \simeq 6$

20. $\underset{a\,\text{mole}}{CH_3(CH_2)_nCOOH} \rightarrow \underset{a(n+2)\text{mole}}{(n+2)CO_2} \xrightarrow[\text{excess}]{NaOH}$

$\underset{a(n+2)\text{mole}}{(n+2)Na_2CO_3}$ + x mole NaOH left

In presence of phenolphthalein:

$$x \times 1 + \frac{a(n+2)}{2} \times 1 = \frac{50 \times 1}{1000} \quad (1)$$

In presence of methyl orange:

$$x \times 1 + \frac{a(n+2)}{2} \times 2 = \frac{80 \times 1}{1000} \quad (2)$$

From (1) and (2), $\frac{a(n+2)}{2} = 0.03$ and $a = \frac{1.16}{60 + 14n}$

$\therefore n = 4$

Four-digit Integer Type

1. $1(+3)+x(+2)+1(1-x)(+5)+3\times(-2)=0$

$\Rightarrow x=\frac{2}{3}$

$\therefore$ Percentage of 'x' in +2 state $=\frac{\frac{2}{3}}{2}\times 100\% = 33.33\%$

2. $n_{eq}OH^- = n_{eq}$ Metal hydroxide

or $0.1\times 1=\frac{8.50}{E+17}\Rightarrow E=68$

3. $n_{eq}Ag = n_{eq}AgCl$

or $\frac{w}{108}\times 1=\frac{2.87}{143.5}\times 1\Rightarrow w=2.16$ g

$\therefore$ Mass of $Cu = 2.7-2.16=0.54$ g

$\therefore$ Percentage of $Cu=\frac{0.54}{2.7}\times 100=20\%$

4. $n_{eq}H_2SO_4 = n_{eq}CaO_2$

or $\frac{V\times 0.25}{1000}\times 2=\frac{7.2}{72}\times 2\Rightarrow V=400$ ml

5. $n_{eq}NaOH = n_{eq}$ Oxalate

or $\frac{27\times 0.12}{1000}=\frac{30\times\frac{9.15}{M}}{1000}\times y$ (1)

$n_{eq}KMnO_4 = n_{eq}$ Oxalate

or $\frac{36\times 0.12}{1000}=\frac{30\times\frac{9.15}{M}}{1000}\times 2z$ (2)

From charge conservation,

$x+y=2z$ (3)

and molar mass, $M=39x+y+88z+18n$ (4)

Solving (1), (2), (3) and (4), we get: $x:y:z=1:3:2$ and $n=2$.

6.

$$\underset{\frac{200\times 0.1}{1000}M}{5Fe^{2+}}+\underset{\frac{200\times 0.1}{1000}M}{MnO_4^-}+\underset{\frac{600\times 1.0}{1000}M}{8H^+}\rightarrow 5Fe^{3+}+Mn^{2+}+4H_2O$$

$$\left[H^+\right]_{final}=\frac{600}{1000}-\frac{8}{5}\times\frac{20}{1000}=\frac{568}{1000}M$$

7. Moles of KOH used in saponification

$=\frac{25\times 0.4}{1000}-\frac{8.0\times 0.25}{1000}\times 2=6\times 10^{-3}$

$\therefore$ Mass of KOH used $=6\times 10^{-3}\times 56=0.336$ g

$\therefore$ Saponification number $=\frac{0.336\times 10^3}{1.5}=224$

8. n_{eq} Oxalic acid $=n_{eq}MnO_2+n_{eq}KMnO_4$

or $\frac{50\times 1.0}{1000}=n_{MnO_2}\times 2+\frac{320\times 0.1}{1000}$

$\Rightarrow n_{MnO_2}=9\times 10^{-3}$

$MnO_2\rightarrow MnO+\underset{\text{available oxygen}}{\text{'O'}}$

$\therefore$ Percentage of available oxygen

$=\frac{9\times 10^{-3}\times 16}{1.6}\times 100=9\%$

9. $n_{eq}SeO_3^{2-}=n_{eq}BrO_3^-\Rightarrow n\times 2=\frac{V_1\times 1/40}{1000}\times 5$ (1)

$n_{eq}AsO_2^-=n_{eq}BrO_3^-$

$\Rightarrow\frac{7.5\times\frac{1}{25}}{1000}\times 2=\frac{V_2\times\frac{1}{40}}{1000}\times 6$ (2)

and $V_1+V_2=20$ (3)

From (1), (2) and (3), we get:

$n=10^{-3}$

$\therefore$ Mass of $SeO_3^{2-}=10^{-3}\times 127$ g $=127$ mg

10. Moles of $V_2O_5=\frac{91}{182}=0.5$

$\therefore$ Moles of V^{2+} formed $=0.5\times 2=1.0$

Now, $n_{eq}V^{2+}=n_{eq}I_2$

or $1.0\times 2=\frac{2}{254}\times 2\Rightarrow w=254$ g

11. $n_{eq}I_2=n_{eq}C_6H_8O_6+n_{eq}Na_2S_2O_3$

or $\frac{10\times 0.025}{1000}\times 2=\frac{w}{176}\times 2+\frac{2.5\times 0.01}{1000}\times 8$

$\Rightarrow w=0.0264$

$\therefore$ Vitamin C content $=\frac{0.0264}{200}\times 10^6=132$ mg/mL

12. n_{eq} Mohr salt $= n_{eq}Na_2CrO_4 + n_{eq}K_2Cr_2O_7$

or $\frac{1.96}{392}\times 1 = 2a\times 3 + \frac{40\times 0.05}{1000}$

$\therefore$ Moles of $Fe(CrO_2)_2 = a = 5\times 10^{-4}$

$\therefore$ Mass of Cr – present $= \frac{2a\times 52}{0.2}\times 100\% = 26\%$

13. $n_{eq}CuS + n_{eq}Cu_2S + n_{eq}Fe^{2+} = n_{eq}MnO_4^-$

or $\frac{x}{96}\times 6 + \frac{10-x}{160}\times 8 + \frac{200\times 1}{1000}\times 1 = \frac{900\times 0.4}{1000}\times 5$

$\therefore x = 8.$

$\therefore$ Percentage of $CuS = \frac{x}{10}\times 100 = 80\%$

14. Let the mixture contains x moles of As_2S_3 and y moles of As_2S_5.

$n_{eq}As_2S_3 = n_{eq}I_2$

or $x\times 4 = \frac{20\times 0.05}{1000} \Rightarrow x = 2.5\times 10^{-4}$

Now, $n_{eq}As_2S_5 = n_{eq}I_2 = n_{eq}Na_2S_2O_3\cdot 5H_2O$

or $(x+y)\times 4 = \frac{1.24}{248}\times 1 \Rightarrow y = 1.0\times 10^{-3}$

$\therefore$ Mole percent of $As_2S_3 = \frac{x}{x+y}\times 100 = 20\%$

15.

$3Se(s) +$	$6Ag^+ + 6NH_3 + 3H_2O \rightarrow 2Ag_2Se +$		$Ag_2SeO_3 + 6NH_4^+$
x mole	$\frac{45\times 0.02}{1000}$ $= 9\times 10^{-4}$ mole	0	0
0	$(9\times 10^{-4} - 2x)$ mole	$\frac{2x}{3}$ mole	$\frac{x}{3}$ mole

From the question, $(9\times 10^{-4} - 2x) + 2\times\frac{x}{3} = \frac{10\times 0.01}{1000}$ $\left(n_{Ag^+} = n_{SCN^-}\right)$

$\therefore\ x = 6\times 10^{-4}$

$\therefore$ Mass of Se per ml $\frac{6\times 10^{-4}\times 80}{2}$ gm = 24 mg

16. $n_{eq}KI = n_{eq}KIO_3$

or $\frac{20\times M}{1000}\times 2 = \frac{30\times\frac{1}{10}}{1000}\times 4$

$\Rightarrow$ Molarity of KI solution = 0.3 M

Now, moles of KI taken $= \frac{50\times 0.3}{1000} = 15\times 10^{-3}$

and moles of KI reacted with

$KIO_3 = 2\times\frac{50\times\frac{1}{10}}{1000} = 10\times 10^{-3}$

$\therefore$ Moles of KI reacted with

$AgNO_3 = 15\times 10^{-3} - 10\times 10^{-3} = 5\times 10^{-3}$

= Moles of $AgNO_3$ present

$\therefore$ Percentage of $AgNO_3 = \frac{5\times 10^{-3}\times 170}{1}\times 100 = 85$

17. Let the original sample contains x moles of Fe_3O_4 and y mole of Fe_2O_3.

As, $n_{eq}Fe_3O_4 + n_{eq}Fe_2O_3 = n_{eq}I_2 = n_{eq}Na_2S_2O_3$

or $x\times 2 + y\times 2 = \frac{\left(\frac{11.2}{20}\times 100\right)\times 0.5}{1000}\times 1$

$\Rightarrow 2x + 2y = 28\times 10^{-3}$ (1)

Now, moles of Fe^{2+} formed $= 3x + 2y$

As, $n_{eq}Fe^{2+} = n_{eq}KMnO_4$

$$\text{or } (3x+2y)\times 1=\frac{\left(\frac{12.8}{50}\times 100\right)\times 0.25}{1000}\times 5 \qquad (2)$$

$$\Rightarrow 3x+2y=32\times 10^{-3}$$

From (1) and (2), we get:

$x=4\times 10^{-3}$ and $y=10\times 10^{-3}$.

Now, the percentage of Fe_2O_3 in sample $=\frac{y\times 160}{4}\times 100=40\%$

18. $$\underset{\frac{1.07}{214}=5\times 10^{-3}\text{ mole}}{IO_3^-}+5I^-+6H^+\rightarrow \underset{15\times 10^{-3}\text{ mole}}{3I_2}+3H_2O$$

Now, $n_{eq}I_2=n_{eq}Na_2S_2O_3$

$$\text{or } 15\times 10^{-3}\times 2=\frac{50\times M}{1000}\times 1\Rightarrow M=0.6$$

19. $$\underset{\frac{10\times 0.2}{1000}=2\times 10^{-3}\text{ mole}}{C_2O_4^{2-}}+\underset{2\times 10-3\text{ mole}}{MnO_2}+4H^+\rightarrow 2CO_2+Mn^{2+}+2H_2O$$

$$\underset{\frac{2}{5}\times 2\times 10^{-3}\text{ mole}=0.8\times 10^{-3}\text{ mole}}{2MnO_4^-}+3Mn^{2+}+2H_2O\rightarrow \underset{2\times 10^{-3}\text{ mole}}{5MnO_2}+4H^+$$

$$\underset{0.8\times 10^{-3}\text{ mole}}{2MnO_4^-}+6H^++\underset{\frac{5}{2}\times 0.8\times 10^{-3}\text{ mole}=2\times 10^{-3}\text{ mole}=2\times 10^{-3}\times 34\text{ g}}{5H_2O_2}\rightarrow 2Mn^{2+}+8H_2O+5O_2$$

$\therefore$ Mass of H_2O_2 per 100 ml of solution

$$=\frac{68\times 10^{-3}}{20}\times 100\text{ g}=340\text{ mg}$$

20. In the presence of phenolphthalein,

$$\frac{20\times 0.1}{1000}\times 1=\frac{V_1\times 0.05}{1000}\times 1\Rightarrow V_1=40\text{ ml}$$

In the presence of methyl orange,

$$\frac{20\times 0.1}{1000}\times 3=\frac{V_2\times 0.05}{1000}\times 1\Rightarrow V_2=120\text{ ml}$$

$$\therefore V_2-V_1=80\text{ ml}$$