EXERCISE # (O-I)

Oxidation number basic examples

1. The oxidation number of phosphorus in PH_4^+, PO_2^{3-}, PO_4^{3-} and PO_3^{3-} are respectively :–

(A) –3, +1, +3, +5 (B) –3, +3, +5, +1 (C) +3, –3, +5, +1 (D) –3, +1, +5, +3

2. The oxidation number of sulphur in S_8, S_2F_2, H_2S respectively are :

(A) 0, +1 & –2 (B) +2, +1 & –2 (C) 0, +1 & +2 (D) –2, +1 & –2

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 oxidation number of phosphorus in $Mg_2P_2O_7$ is

(A) +5 (B) –5 (C) +6 (D) –7

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

(A) –3, + 3 (B) –1,+ 5 (C) –3, + 5 (D) –3, + 1

6. 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) $H_2SO_4 > SO_2 > H_2S > H_2S_2O_8$

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

(A) +2/3 (B) +4/3 (C) +4 (D) – 4/3

8. 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

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

(A) +1 (B) +3 (C) –1 (D) 0

10. 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

Reducing and oxidizing agent type questions

11. Which of the following reactions is a redox reaction ?

(A) $H_2O_2 + KOH \longrightarrow KHO_2 + H_2O$ (B) $Cr_2O_7^{2-} + 2OH^- \longrightarrow 2CrO_4^{2-} + H_2O$

(C) $Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + CO_2 + H_2O$ (D) $H_2O_2 \longrightarrow H_2O + O_2$

12. Which of the following are examples of disproportionation reaction :

(A) $H_2O_2 \longrightarrow H_2O + O_2$ (B) $Cl_2 + OH^- \longrightarrow ClO^- + Cl^- + H_2O$

(C) $KClO_3 \longrightarrow KClO_4 + KCl$ (D) All of these

13. Which reaction does not represent disproportionation :-

(A) $Cl_2 + OH^- \longrightarrow Cl^- + ClO_3^- + H_2O$ (B) $2H_2O_2 \longrightarrow H_2O + O_2$

(C) $2Cu^+ \longrightarrow Cu^{+2} + Cu$ (D) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + 4H_2O$

14. In the following reaction : $Cr(OH)_3 + OH^- + IO_3^- \longrightarrow CrO_4^{2-} + H_2O + I^-$

(A) IO_3^- is oxidising agent (B) $Cr(OH)_3$ is oxidised

(C) $6e^-$ are being taken per iodine atom (D) All of these

15. H_2O_2 acts as a reducing agent in:

(A) $FeCl_2 + HCl + H_2O_2 \longrightarrow FeCl_3 + H_2O$ (B) $Cl_2 + H_2O_2 \longrightarrow HCl + O_2$

(C) $HI + H_2O_2 \longrightarrow I_2 + H_2O$ (D) $H_2SO_3 + H_2O_2 \longrightarrow H_2SO_4 + H_2O$

Balancing of Redox Reactions

16. In the reaction

$xHI + yHNO_3 \longrightarrow NO + I_2 + H_2O$

(A) x = 3, y = 2 (B) x = 2, y = 3 (C) x = 6, y = 2 (D) x = 6, y = 1

17. In the reaction, $xVO + yFe_2O_3 \longrightarrow FeO + V_2O_5$. What is the value of x and y respectively ?

(A) 1, 1 (B) 2, 3 (C) 3, 2 (D) none of these

18. When arsenic sulphide is boiled with NaOH, sodium arsenite and sodium thioarsenite are formed

$x\ As_2S_3 + y\ NaOH \longrightarrow Na_3AsO_3 + x\ Na_3AsS_3 + \frac{y}{2} H_2O$. What are the values of x and y ?

(A) 1, 6 (B) 2, 8 (C) 2, 6 (D) 1, 4

19. CN^- is oxidised by NO_3^- in presence of acid :

$$a\ CN^- + b\ NO_3^- + c\ H^+ \longrightarrow (a + b)\ NO + a\ CO_2 + \frac{c}{2} H_2O$$

What are the whole number values of a, b, c in that order :

(A) 3, 7, 7 (B) 3, 10, 7 (C) 3, 10, 10 (D) 3, 7, 10

20. In the reaction $X^- + XO_3^- + OH^- \longrightarrow X_2 + H_2O$, the molar ratio in which X^- and XO_3^- react is :

(A) 1 : 5 (B) 5 : 1 (C) 2 : 3 (D) 3 : 2

21. Balance the following equation and choose the quantity which is the sum of the coefficients of reactants and products :

$$KMnO_4 + H_2O_2 + H_2SO_4 \longrightarrow MnSO_4 + O_2 + H_2O + K_2SO_4$$

(A) 26 (B) 23 (C) 28 (D) 22

22. The following equations are balanced

(i) $Cr_2O_7^{2-} + 8H^+ + 3H_2O_2 \longrightarrow 2Cr^{3+} + 7H_2O + 3O_2$

(ii) $Cr_2O_7^{2-} + 8H^+ + 5H_2O_2 \longrightarrow 2Cr^{3+} + 9H_2O + 4O_2$

(iii) $Cr_2O_7^{2-} + 8H^+ + 7H_2O_2 \longrightarrow 2Cr^{3+} + 11H_2O + 5O_2$

The precise equation/equations representing the oxidation of H_2O_2 is/are :

(A) (i) only (B) (ii) only (C) (iii) only (D) all the three

Equivalent Weight/n-factor of compound in Redox/Non- Redox/Redox Reaction in Complex Cases

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

(A) 112 (B) 56 (C) 224 (D) 84

24. Equivalent wt. of H_3PO_4 in each of the reaction will be respectively -

$H_3PO_4 + OH^- \rightarrow H_2PO_4^- + H_2O$

$H_3PO_4 + 2OH^- \rightarrow HPO_4^{2-} + 2H_2O$

$H_3PO_4 + 3OH^- \rightarrow PO_4^{3-} + 3H_2O$

(A) 98, 49, 32.67 (B) 49, 98, 32, 67 (C) 98, 32.67, 49 (D) 32.67, 49, 98

25. 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) $\frac{M}{3}$

26. In a redox reaction, the equivalent weight of HNO_2 is found to be 23.5. The reaction products might contain

(A) N_2O (B) NO (C) NH_3 (D) HNO_3

27. Number of moles of electrons taken up when 1 mole of NO_3^- ions is reduced to 1 mole of NH_2OH is

(A) 2 (B) 4 (C) 5 (D) 6

28. A solution of $KMnO_4$ is reduced to MnO_2. The normality of solution is 0.6. The molarity is:

(A) 1.8M (B) 0.6M (C) 0.1M (D) 0.2M

29. Equivalent mass of $Fe_{0.9}O$ in reaction with acidic $K_2Cr_2O_7$ is : (M = Molar mass)

(A) 7 M/10 (B)10 M/7 (C) 7 M/9 (D) 9 M/7

30. When BrO_3^- ion reacts with Br^- ion in acid solution Br_2 is liberated. The equivalent weight of $KBrO_3$ in this reaction is

(A) M/8 (B) M/3 (C) M/5 (D) M/6

31. n-factor of $Ba(SCN)_2$ when it reacts with oxidising agent and forms product, SO_4^{2-}, CO_3^{2-} & NO_3^- is -

(A) 8 (B) 64 (C) 32 (D) 16

Problem on Redox Reaction

32. Calculate the moles of $KMnO_4$ required to oxidise 180 gm $H_2C_2O_4$ in acidic medium. Also calculate moles and volume of (at STP) of $CO_2(g)$ produced.

	Moles of $KMnO_4$	Moles of CO_2	Volume of CO_2 at STP
(A)	2 mol	2	2×22.7 lit
(B)	$\frac{4}{5}$	$\frac{4}{5}$	$\frac{4}{5} \times 22.4$ lit
(C)	$\frac{4}{5}$	4	4×22.4 lit
(D)	$\frac{4}{5}$	4	4×22.7 lit

33. The number of moles of $Cr_2O_7^{2-}$ needed to oxidize 0.132 equivalents of $N_2H_5^+$ by the reaction $N_2H_5^+ + Cr_2O_7^{2-} \rightarrow N_2 + Cr^{3+} + H_2O$ is

(A) 0.132 (B) 0.068 (C) 0.022 (D) 0.044

34. As_2O_3 is oxidised to H_3AsO_4 by $KMnO_4$ in acidic medium. Volume of 0.02M $KMnO_4$ required for this purpose by 1m mol of As_2O_3 will be

(A) 10 mL (B) 20 mL (C) 40 mL (D) 80 mL

35. A solution of $Na_2S_2O_3$ is standardized against 0.167 g of $KBrO_3$. This process requires 45 mL of the $Na_2S_2O_3$ solution. What is the normality of the $Na_2S_2O_3$?

[Molar mass of $KBrO_3$ = 167]

$$KBrO_3 + Na_2S_2O_3 \longrightarrow Br^- + Na_2S_4O_6$$

(A) $\frac{2}{15}$ N (B) $\frac{2}{30}$ N (C) $\frac{1}{30}$ N (D) $\frac{1}{60}$ N

36. Find the number of equivalents of the ion if it absorbs 6×10^{20} electrons.

(A) 0.1 (B) 0.01 (C) 0.001 (D) 0.0001

37. Calculate the moles of $KMnO_4$ required to react completely with 2 moles of $KHC_2O_4.H_2C_2O_4$ in acidic medium

(A) 4/5 (B) 4 (C) 8 (D) 8/5

38. Calculate millimoles moles of compound ($KHC_2O_4 \cdot 2H_2C_2O_4$) required to reduce 3 litre of 2.8 volume H_2O_2 solution.

(A) 100 (B) 250 (C) 500 (D) 200

39. If valence factor (n-factor) of compound $NaHC_2O_4 \cdot 2H_2\ C_2O_4 \cdot 3K_2C_2O_4 \cdot 4Al_2(C_2O_4)_3 \cdot 3FeC_2O_4$ in acid base titration is x and redox titration with $KMnO_4$ is y then value of y/x is –

(A) 8.4 (B) 9 (C) 11.25 (D) 12

40. 1 mole of MnO_4^{-2} disproportionate into MnO_4^- & MnO_2 in acidic medium. % by mass of Mn converted to MnO_4^- (Molar mass of Mn = 55 gm)

(A) 66.67 (B) 33.33 (C) 16.67 (D) 50

41. Volume V_1 mL of 0.1 $MK_2Cr_2O_7$ is needed for complete oxidation of 0.678 g N_2H_4 in acidic medium. The volume of 0.3 M $KMnO_4$ needed for same oxidation in acidic medium will be :-

(A) $\frac{2}{5} V_1$ (B) $\frac{5}{2} V_1$ (C) 113 V_1 (D) can't say

Problems Involving More Than One Step

42. 20 ml of $KMnO_4$ solution completely reacts with 10 ml solution of 1 M FeS_2 and 2M CuS to produce Cu^{+2}, Fe^{+3}, SO_2. Calculate Normality of $KMnO_4$ solution?

(A) 11.5 (B) 15 (C) 5.75 (D) 10

43. x mmol of XeF_4 quantitatively oxidized KI to I_2 and liberated Xe, along with formation of KF. This iodine required 20 ml of decinormal hypo solution for exact titration. The value of x is

(A) 0.5 (B) 1.0 (C) 2.0 (D) 5.0

44. One gram of Na_3AsO_4 is boiled with excess of solid KI in 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

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

calculate the volume of hypo consumed. [Atomic weight of As = 75] .

(A) 48.1 mL (B) 38.4 mL (C) 24.7 mL (D) 30.3 mL

45. If 10 g of V_2O_5 is dissolved in acid and is reduced to V^{2+} by zinc metal, how many mole I_2 could be reduced by the resulting solution if it is further oxidised to VO^{2+} ions ?
[Assume no change in state of Zn^{2+} ions] (V = 51, O = 16, I = 127) :
(A) 0.11 mole of I_2 (B) 0.22 mole of I_2 (C) 0.055 mole of I_2 (D) 0.44 mole of I_2

46. An aqueous solution containing KIO_3 was treated with an excess of KI solution. The solution is acidified with HCl. The liberated iodine consumed 10 ml of 0.1M thiosulphate solution to decolourises the starch iodine complex. Then millimoles of KIO_3 consumed
(A) 1 (B) 1/2 (C) 1/6 (D) 1/3

47. 2 moles of $K_3H(C_2O_4)_2$ and 1 mole of $H_2C_2O_4$ is treated separately with $KMnO_4$ in acidic medium and with $Ba(OH)_2$ having same molarity. Ratio of Volume of $KMnO_4$ to volume of $Ba(OH)_2$ required is.
(A) 3 (B) 1/3 (C) 1 (D) 2

48. An aq. solution of 0.5M $KMnO_4$ is divided into two parts. One part of it requires 125 ml of 1.5M aq. solution of oxalate ions in acidic medium, while another part requires 270 ml of 0.5M aq. solution of iodide ions in neutral medium which are converted into I_2 only. Calculate total volume (mL) of the initial $KMnO_4$ solution.
(A) 240 (B) 120 (C) 300 (D) 480

49. 100 ml of 0.1M $NaAl(OH)_2CO_3$ is neutralised by 0.25 N HCl to form NaCl, $AlCl_3$ and CO_2. Volume of HCl required is
(A) 10 mL (B) 40 mL (C) 100mL (D) 160 mL

50. Dichloroacetic acid ($CHCl_2COOH$) is oxidized to CO_2, H_2O and Cl_2 by 600 meq of an oxidizing agent. Same amount of acid can neutralize how many moles of ammonia to form ammonium dichloroacetate?
(A) 0.0167 (B) 0.1 (C) 0.3 (D) 0.6

Acid – Base titration

51. 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

52. 1 mol each of H_3PO_2, H_3PO_3 and H_3PO_4 will neutralise respectively x mol of NaOH, y mol of $Ca(OH)_2$ and z mol of $Al(OH)_3$ (assuming all as strong electrolytes). x, y, z are in the ratio of :

(A) 3 : 1.5 : 1 (B) 1 : 2 : 3 (C) 3 : 2 : 1 (D) 1 : 1 : 1

53. If 25 mL of a H_2SO_4 solution reacts completely with 1.06 g of pure Na_2CO_3, what is the normality of this acid solution :

(A) 1 N (B) 0.5 N (C) 1.8 N (D) 0.8 N

54. How many milliliters of 0.1N H_2SO_4 solution will be required for complete reaction with a solution containing 0.125 g of pure Na_2CO_3 :

(A) 23.6 mL (B) 32.6 mL (C)26.3 Ml (D) 25.6 ml

Miscellaneous

55. x g of the metal gave y g of its oxide. Hence equivalent weight of the metal

(A) $\frac{y-x}{x}\times 8$ (B) $\frac{x}{(y-x)}\times 8$ (C) $\frac{x}{y}\times 8$ (D) $\frac{x+y}{x}\times 8$

56. 3 g of an oxide of a metal is converted to chloride completely and it yielded 5 g of chloride. Equivalent weight of the metal is :

(A) 33.25 (B) 3.325 (C) 12 (D) 20

57. The equivalent weight of a metal is double that of oxygen. How many times is the weight of its oxide greater than weight of the metal?

(A) 1.5 (B) 2 (C) 0.5 (D) 3

EXERCISE # S-1

Oxidation Number Basic Examples]

Oxidation Number Complex Examples(More Than One Element, Peroxide Etc)

1. Calculate the oxidation number of underlined elements in the following compounds :

(a) $\underline{Cr}O_2Cl_2$ (b) $\underline{Mn}_3O_4$ (c) $Ca(\underline{Cl}O_2)_2$

(d) $\underline{Zn}O_2^{2-}$ (e) $K_4\underline{P}_2O_7$ (f) $\underline{Fe}_{0.93}O$

(g) $K[\underline{Co}(C_2O_4)_2.(NH_3)_2]$

2. Calculate the oxidation number of underlined elements in the following compounds :

(1) $\underline{C}O_2$ (2) $\underline{C}S_2$ (3) $\underline{Fe}_3O_4$ (4) $\underline{Fe}O$

(5) $\underline{Pb}O_2$ (6) $\underline{N}_2O_5$ (7) $\underline{Os}O_4$ (8) $\underline{C}_2H_5OH$

(9) $Ba_2\underline{Xe}O_6$ (10) $(\underline{N}H_4)_2SO_4$ (11) $Ba[H_2\underline{P}O_2]_2$ (12) $CH_3\underline{S}O_3H$

(13) $\underline{Fe}SO_4.(NH_4)_2SO_4.6H_2O$

3. Calculate the oxidation number of underlined elements in the following compounds :

(1) $H_2\underline{S}_2O_3$ (2) $\underline{Cr}O_5$ (3) $Na_2\underline{S}_4O_6$

(4) $Ba(\underline{S}CN)_2$ (5) $H\underline{C}N$ (6) $H\underline{N}C$ (7) $\underline{Fe}S_2$

Balancing of Redox Reactions

4. Write balanced reactions in acidic solution.

(a) $S_4O_6^{2-}(aq) + Al(s) \longrightarrow H_2S(aq) + Al^{3+}(aq) + H_2O$

(b) $S_2O_3^{2-}(aq) + Cr_2O_7^{2-}(aq) \longrightarrow S_4O_6^{2-}(aq) + Cr^{3+}(aq) + H_2O$

(c) $BCl_3 + P_4 + H_2 \longrightarrow BP + HCl$

(d) $IO_3^-(aq) + Re(s) + H_2O \longrightarrow ReO_4^-(aq) + I^-(aq)$

(e) $HSO_4^-(aq) + As_4(s) + Pb_3O_4(s) \longrightarrow PbSO_4(s) + H_2AsO_4^-(aq) + H_2O$

(f) $Ca(OCl)_2 + KI + HCl \longrightarrow I_2 + CaCl_2 + H_2O + KCl + H_2O$

5. Write balanced reactions in basic solution :

(a) $C_4H_4O_6^{2-}(aq) + ClO_3^-(aq) \longrightarrow CO_3^{2-}(aq) + Cl^-(aq) + H_2O$

(b) $C_2H_5OH + MnO_4^- + OH^- \longrightarrow C_2H_3O^- + MnO_2 + H_2O$

(c) $ClO_2 + SbO_2^- + OH^- \longrightarrow ClO_2^- + Sb(OH)_6^- + H_2O$

(d) Tl_2O_3 (s) + NH_2OH (aq) $\longrightarrow$ TlOH (s) + N_2 (g) + H_2O

(e) MnO_4^- + CN^- + H_2O $\longrightarrow$ MnO_2 + CNO^- + OH^-

(f) $Cu(NH_3)_4^{2+}$ (aq) + $S_2O_4^{2-}$ (aq) $\longrightarrow$ SO_3^{2-} (aq) + Cu (s) + NH_3 (aq) + H_2O

Balancing Of Redox Reactions /Complex Examples(More Than One Element)

6. Write balanced reactions

(a) $Cu(NH_3)_4Cl_2$ + KCN + H_2O $\longrightarrow$ $K_2Cu(CN)_3$ + NH_3 + KCNO + NH_4Cl + KCl

(b) ClO_3^- (aq) + As_2S_3 (s) + H_2O $\longrightarrow$ Cl^- (aq) + $H_2AsO_4^-$ (aq) + HSO_4^- (aq) + H^+

(c) Al (s) + $BiONO_3$ (s) + H_2O + OH^- $\longrightarrow$ Bi (s) + NH_3 (aq) + $Al(OH)_4^-$(aq)

7. Write balanced reactions

(a) HNO_2 (aq) $\longrightarrow$ NO_3^- + NO (g) + H^++ H_2O

(b) MnO_4^{2-} + H^+ $\longrightarrow$ MnO_4^- + MnO_2 + H_2O

(c) $Mn(OH)_2$ (s) + MnO_4^- (aq) $\longrightarrow$ MnO_2 (s) + H_2O + OH^-

8. Write balanced reactions

(a) $KMnO_4$ + HCl $\longrightarrow$ $MnCl_2$ + H_2O + Cl_2 + KCl + H_2O

(b) $KMnO_4$ + H_2O_2 + H_2SO_4 $\longrightarrow$ 4 $MnSO_4$ + K_2SO_4 + O_2 + H_2O

(c) H_2O_2 (aq) + Cl_2O_7 (aq) + OH^- $\longrightarrow$ ClO_2^- (aq) + O_2 (g) + H_2O

9. Write balanced reaction

(k) $KMnO_4$ $\longrightarrow$ K_2MnO_4 + MnO_2 + O_2

Equivalent weight/n-factor of compound non redox reactions

Equivalent weight/n-factor of compound in redox reactions

Equivalent weight/n-factor of compound in redox reactions complex cases

10. Determine the equivalent weights of the following salts :

(a) NaCl (b) K_2SO_4 (c) $Ca_3(PO_4)_2$

11. Determine the equivalent weight of the following oxidising and reducing agents :

(a) $KMnO_4$ (reacting in acidic medium $MnO_4^- \longrightarrow Mn^{2+}$)

(b) $KMnO_4$ (reacting in neutral medium $MnO_4^- \longrightarrow MnO_2$)

12. A mixture of CuS (molecular weight = M_1) and Cu_2S (molecular weight = M_2) is oxidised by $KMnO_4$ (molecular weight = M_3) in acidic medium, where the product obtained are Cu^{2+}, Mn^{2+} and SO_2. Find the equivalent weight of CuS, Cu_2S and $KMnO_4$ respectively.

Redox titration

13. Calculate the number of milli moles of SO_2 which will react in the following reaction with 10 ml of 0.1 M $KMnO_4$ solution.

$SO_2 + MnO_4^- \longrightarrow SO_4^{2-} + Mn^{+2}$

14. Calculate the number of millimoles of $K_2Cr_2O_7$ which will completely react with 40 ml 0.1 M KI to produce I_2.

15. Metallic tin in the presence of HCl is oxidized by $K_2Cr_2O_7$ to stannic chloride, $SnCl_4$. What volume of deci-normal dichromate solution would be reduced by 11.9 gm of tin [Sn = 119]

$Sn + Cr_2O_7^{2-} \longrightarrow Sn^{4+} + Cr^{3+}$

16. In neutral of faintly alkaline medium 18 moles permanganate anion quantitatively oxidise thiosulphate anion to product 'X' mole of SO_4^{2-}. Then 'X' is –

17. It required 40 ml of 1 M Ce^{4+} to titrate 20 ml of 1 M Sn^{2+} to Sn^{4+}. What is the oxidation state of cerium in the product.

18. A volume of 10.0 ml of 1 M SeO_2 reacted with exactly 20 ml of 2 M $CrSO_4$. In the reaction, Cr^{2+} was oxidized to Cr^{3+}. To what oxidation state was selenium converted by the reaction.

19. Moles of $K_2Cr_2O_7$ used to oxidise 1 mol $Fe_{0.92}O$ to Fe^{+3} are

20. What volume of 0.1 M H_2O_2 solution will be required to completely reduce 1 litre of 0.1 M $KMnO_4$ in acidic medium.

21. A 1 g sample of H_2O_2 solution containing x% H_2O_2 by mass requires x cm3 of a $KMnO_4$ solution for complete oxidation under acidic condition. Calculate the normality of $KMnO_4$ solution.

$$KMnO_4 + H_2O_2 \longrightarrow Mn^{2+} + H_2O$$

22. How many moles of MnO_4^- will react with 1 mole of ferrous oxalate in acidic medium.

23. How many mL of 0.3M $K_2Cr_2O_7$ (acidic) is required for complete oxidation of 5 mL of 0.2 M SnC_2O_4 solution.

$$K_2Cr_2O_7 + SnC_2O_4 \longrightarrow Sn^{4+} + Cr^{3+} + CO_2$$

24. Calculate the millimoles of Br_2 produced when 10 ml of 0.1 M BrO_3^- reacts with excess of Br^-.

25. 520 gm mixture of Fe_2O_3 and FeO reacts completely with 158 gm $KMnO_4$ in acidic medium Calculate the mole % of Fe_2O_3 in mixture.

26. An equimolar mixture of CuO & Cu_2O is titrated with 100 ml 0.1 M $KMnO_4$ solution in acidic medium. Calculate millimoles of Cu^{2+} in final solution.

27. (a) Calculate volume of 0.4 M $KMnO_4$ required to react with following in acidic medium.

$$KHC_2O_4(1\ mol) + H_2C_2O_4(2\ mol)$$

(b) Calculate volume of 0.2 M $KMnO_4$ required to react with following mixture in acidic medium.

$$KHC_2O_4\ (128\ gm) + H_2C_2O_4\ (180\ gm)$$

28. Potassium acid oxalate $K_2C_2O_4.3H_2C_2O_4.4H_2O$ can be oxidized by MnO_4^- in acid medium. Calculate the volume of 0.1 M $KMnO_4$ reacting in acid solution with 5.08 gm of the acid oxalate.

$$K_2C_2O_4.3H_2C_2O_4.4H_2O + MnO_4^- \longrightarrow Mn^{2+} + CO_2$$

29. Mass of Cl_2 produced by the complete reaction of 230 gm As_2O_5 with 182.5 gm HCl according to reaction is

$$As_2O_5 + HCl \longrightarrow AsCl_3 + Cl_2 + H_2O$$

[Atomic mass of As = 75]

Problems Involving More Than One Step

30. A 100 mL sample of water was treated to convert any iron present to Fe^{2+}. Addition of 25 mL of 0.002 M $K_2Cr_2O_7$ resulted in the reaction :

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

The excess $K_2Cr_2O_7$ was back-titrated with 7.5 mL of 0.01 M Fe^{2+} solution. Calculate the parts per million (ppm) of iron in the water sample.

31. 10 g sample of bleaching powder($CaOCl_2$)was dissolved into water to make the solution one litre. To this solution 35 mL of 1.0 M Mohr salt [$(NH_4)_2SO_4 . FeSO_4 . 6H_2O$]solution was added containing enough H_2SO_4. After the reaction was complete, the excess Mohr salt required 30 mL of 0.1 M $KMnO_4$ for oxidation. The % of available Cl_2 approximately is (mol wt = 71)

32. 5 g of pyrolusite (impure MnO_2) were heated with conc. HCl and Cl_2 evolved was passed through excess of KI solution. The iodine liberated required 40 mL of N/10 hypo solution. Find the % of MnO_2 in the pyrolusite.

Acid – Base titration

33. (a) Calculate volume of 1M H_3PO_4 required to react with 30 ml 2M $Ca(OH)_2$ solution
(b) Calculate volume of 1N H_2SO_4 required to react with 20 ml 1 M $Al(OH)_3$ solution

34. How many litre of 0.1M HCl are required to react completely with 19 gm mixture of Na_2CO_3 and $NaHCO_3$ containing equimolar amounts of two ?

35. H_3PO_4 is a tri basic acid and one of its salts is NaH_2PO_4. What volume in ml of 1 M NaOH solution should be added to 12 g of NaH_2PO_4 to convert it into Na_3PO_4 ?

36. 10 g $CaCO_3$ were dissolved in 250 ml of 1 M HCl. What volume of 2 M KOH would be required to neutralise excess HCl.

37. 50 gm of a sample of $Ca(OH)_2$ is dissolved in 50 ml of 0.5 N HCl solution. The excess of HCl was titrated with 0.3N – NaOH. The volume of NaOH used was 20cc. Calculate % purity of $Ca(OH)_2$

EXERCISE # (O-II)

1. Bleaching powder $Ca(O\overset{I}{Cl})\overset{II}{Cl}$ has important industrial applications. Related to $Ca(O\overset{I}{Cl})\overset{II}{Cl}$ which of the following are correct

(A) Average oxidation number of Cl is '0'

(B) Individual oxidation state of each Cl is zero

(C) Individual oxidation state of $\overset{I}{Cl}$ is (+1) and $\overset{II}{Cl}$ is (–1)

(D) Individual oxidation state of $\overset{I}{Cl}$ is (–1) and $\overset{II}{Cl}$ is (+1)

2. Which among following is/are redox reaction -

(A) $Ca + H_2 \rightarrow CaH_2$

(B) $P_4 \rightarrow PH_3 + H_2PO_2^-$

(C) $FeCl_3 + K_4[Fe(CN)_6] \rightarrow KFe[Fe(CN)_6] + KCl$

(D) $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

3. In which of the following reactions underlined species is/are having n_{factor} equal to one

(A) $\underline{Na_2S_2O_3} + I_2 \rightarrow Na_2S_4O_6 + NaI$

(B) $CuSO_4 + \underline{KI} \rightarrow Cu_2I_2 + I_2 + K_2SO_4$

(C) $KIO_3 + \underline{KI} \xrightarrow{H^+} I_2$

(D) $\underline{H_2PO_4} + NaOH \rightarrow NaH_2PO_4 + H_2O$

4. In the redox reaction

$$Na + 1/2\ H_2 \longrightarrow NaH$$

Choose the correct statement:

(A) Na undergoes reduction (B) Na is oxidising agent

(C) H_2 is reducing agent (D) H_2 undergoes reduction

5. Reaction

(A) $S^{-2} + 4\ H_2O_2 \rightarrow SO_4^{2-} + 4\ H_2O$ (B) $Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$

The incorrect statement regarding the above reactions is :

(A) H_2O_2 acts as reductant in both the reactions.

(B) H_2O_2 acts as oxidant in reaction (A) and reductant in reaction (B).

(C) H_2O_2 acts as an oxidant in both the reactions.

(D) H_2O_2 acts as reductant in reaction (A) and oxidant in reaction (B)

6. For the reaction : $I_2 + NaOH \rightarrow NaIO_3 + NaI + H_2O$. Identify the correct statements (At wt. of Na = 23)

(A) Reaction is an example of disproportionation

(B) Equivalent weight of $I_2 = \frac{3}{5} \times$ (mol. wt of I_2)

(C) Eq. wt of NaOH in the reaction is 6.66

(D) Eq. wt of NaOH in the reaction is 48

7. Choose the incorrect statement(s)-

(A) 1 mole of MnO_4^- ion can oxidized 10 moles of Fe^{2+} ion in acidic medium

(B) 1 mole of $Cr_2O_7^{2-}$ ion can oxidized 12 moles of Fe^{2+} ion in acidic medium

(C) 2 mole of Cu_2S can be oxidized by 2.6 moles of MnO_4^- ion in acidic medium ($Cu_2S \rightarrow Cu^{2+} + SO_2$)

(D) 2 mole of Cu_2S can be oxidized by 2.66 moles of $Cr_2O_7^{2-}$ ion in acidic medium ($Cu_2S \rightarrow Cu^{2+} + SO_2$)

Comprehension # 1

For the reaction:

$$MnBr_2 + PbO_2 + HNO_3 \rightarrow HMnO_4 + Pb(BrO_3)_2 + Pb(NO_3)_2 + H_2O$$

(Atomic masses: $Mn = 55, Br = 80, Pb = 208$)

8. The equivalent weight of $MnBr_2$ is

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

9. The equivalent weight of PbO_2 is

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

10. The equivalent weight of HNO_3 is

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

Comprehension # 2

n-factor is very important in redox as well as non-redox reactions. With the help of n-factor we can predicts the molar ratio of the reactant species taking part in reactions. The reciprocal of n factor's ratio of the reactants is the molar ratio of the reactants.

In general n-factor of acid/base is number of moles of H^+ /OH^- furnished per mole of acid/base.

In redox reactions n-factor of a reactant and product is no. of moles of electrons lost or gained per mole of reactant.

Example 1 :

1. In acidic medium : $KMnO_4$ (n = 5) $\longrightarrow$ Mn^{2+}

2. In neutral medium : $KMnO_4$ (n = 3) $\longrightarrow$ Mn^{2+}

3. In basic medium : $KMnO_4$ (n = 1) $\longrightarrow$ Mn^{6+}

Example 2 : $FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2$

Total no. of moles of e^- lost by 1 mole of FeC_2O_4 = 1 + 1 × 2 ? 3

$\therefore$ n–actor of FeC_2O_4 = 3

11. n–factor of $Ba(MnO_4)_2$ in acidic medium is :

(A) 2 (B) 6 (C) 10 (D) none of these

12. For the reaction,

$H_3PO_2 + NaOH \longrightarrow NaH_2PO_2 + H_2O$

What is the equivalent weight of H_3PO_2 ? (mol. wt. is M)

(A) M (B) M/2 (C) M/3 (D) none of these

13. For the reaction, $Fe_{0.95}O$ (molar mass : M) $\longrightarrow$ Fe_2O_3. What is the eq. wt. of $Fe_{0.95}O$?

(A) $\frac{M}{0.85}$ (B) $\frac{M}{0.95}$ (C) $\frac{M}{0.8075}$ (D) none of these

Comprehension # 3

Some amount of "20V" H_2O_2 is mixed with excess of acidified solution of KI. The iodine so liberated required 200 mL of 0.1 N $Na_2S_2O_3$ for titration.

14. The volume of H_2O_2 solution is :

(A) 11.2 mL (B) 37.2 mL (C) 5.675 mL (D) 22.4 mL

15. The mass of $K_2Cr_2O_7$ needed to oxidise the above volume of H_2O_2 solution is :

(A) 3.6 g (B) 0.8 g (C) 4.2 g (D) 0.98 g

16. The volume of O_2 at 1 atm and 273 K that would be liberated by above H_2O_2 solution on disproportionation is :

(A) 56 mL (B) 113.5 mL (C) 168 mL (D) 224 mL

17. Match List-I (Compounds) with List-II (Oxidation states of nitrogen) and select answer using the codes given below the lists

	List-I		**List-II**
(a)	NaN_3	1.	+5
(b)	N_2H_2	2.	+2
(c)	NO	3.	–1/3
(d)	N_2O_5	4.	–1

Code :	**(a)**	**(b)**	**(c)**	**(d)**
(A)	3	4	2	1
(B)	4	3	2	1
(C)	3	4	1	2
(D)	4	3	1	2

MATCH THE COLUMN

18.

	Column–I (Chemical reactions)		**Column–II ('n' factor of underlined specie in the given chemical redox reactions)**
(A)	$\underline{P_2H_4} \longrightarrow PH_3 + P_4H_2$	(p)	$E = \frac{3M}{4}$
(B)	$\underline{I_2} \longrightarrow I^- + IO_3^-$	(q)	$E = \frac{3M}{5}$
(C)	$MnO_4^- + Mn^{2+} + H_2O \longrightarrow \underline{Mn_3O_4} + H^+$	(r)	$E = \frac{15M}{26}$
(D)	$\underline{H_3PO_2} \longrightarrow PH_3 + H_3PO_3$	(s)	$E = \frac{5M}{6}$

19. Match the column :

Column–I (Chemical reactions)		**Column–II ('n' factor of underlined specie in the given chemical redox reactions)**	
(A)	$H_2\underline{O_2} \rightarrow H_2O + O_2$	(p)	4
(B)	$\underline{Cl}O_3^- + Fe^{2+} \rightarrow Cl^- + Fe^{3+}$	(q)	1
(C)	$Zn^{2+} + \underline{K_4[Fe(CN)_6]} \rightarrow K_2Zn_3[Fe(CN)_6]_2 + K^+$	(r)	3
		(s)	6

EXERCISE # (S-II)

1. A 0.96 gm sample of Fe_2O_3 solid of 50% purity is dissolved in acid and completely reduced by heating the solution with zinc dust. The resultant solution is cooled and made upto 100.0 mL. An aliquot of 25.0 ml of this solution required 30 mL of 0.01 M solution of an oxidising agent for titration. Calculate the number of moles of electrons taken up by I mole of oxidising agent in the reaction of the above titration.

2. A substance of crude copper is boiled in H_2SO_4 till all the copper has reacted. The impurities are inert to the acid. The SO_2 liberated in the action is passed into 100 mL of 0.4 M acidified $KMnO_4$(SO_2 ⍰ SO_4^{-2}) The solution of $KMnO_4$ after passage of SO_2 is allowed to react with oxalic acid and requires 25 mL of 1 M oxalic acid. If the purity of copper is 95.25%, what was the weight of the sample.

3. H_2O_2 is reduced rapidly by Sn^{2+}, the products being Sn^{4+} and water. H_2O_2 decomposes slowly at room temperature to yield O_2 and water. Calculate the volume of O_2 produced at 273 K and 1.00 atm when 200 g of 10.0 % by mass H_2O_2 in water is treated with 88.2 mL of 1 M Sn^{2+} and then the mixture is allowed to stand until no further reaction occurs.

4. 5g sample of brass was dissolved in one litre dil. H_2SO_4. 20 ml of this solution were mixed with KI liberating I_2 and Cu^+ and the I_2 required 20 ml of 0.03 N hypo solution for complete titration. Calculate the percentage of Cu in the alloy.

5. 24 mL of a solution containing HCl was treated with excess of 0.004 M KIO_3 and KI solution of unknown concentration where I_2 liberated is titrated against a standard solution of 0.02 M $Na_2S_2O_3$ solution whose 24 mL were used up. Find the molarity of HCl and volume KIO_3 solution consumed.

6. A 458 g sample containing Mn_3O_4 was dissolved and all manganese was converted to Mn^{2+}. In the presence of fluoride ion, Mn^{2+} is titrated with 3 lit of $KMnO_4$ solution (which was 1.25 N against oxalate in acidic medium), both reactants being converted to a complex of Mn(III) , What was the % of Mn_3O_4 in the sample ?

7. A 2.024 g sample containing $Ba(SCN)_2$ was dissolved in a bicarbonate solution. 50.0 mL of 1 N iodine solution was added, and the mixture was allowed to stand for five minutes. The solution was then acidified, and the excess I_2 was titrated with 26 mL of 1 M sodium thiosulphate. Write a balanced equation for the oxidation of SCN^- into SO_4^{2-} and HCN. Calculate the percent $Ba(SCN)_2$ in sample.

8. A mixture of FeO and Fe_2O_3 is reacted with acidified $KMnO_4$ solution having a concentration of 2/5 M, 100 mL of which was used. The solution was then titrated with Zn dust which converted Fe^{3+} of the solution to Fe^{2+}. The Fe^{2+} required 1000 mL of 2/15 M $K_2Cr_2O_7$ solution. Find the % by mol of FeO and Fe_2O_3.

9. A mixture containing As_2O_3 and As_2O_5 required 20 mL of 0.05 N iodine solution for titration. The resulting solution is then acidified and excess of KI was added. The liberated iodine required 1.116 g hypo ($Na_2S_2O_3.5H_2O$) for complete reaction. Calculate the mass of the mixture. The reactions are:

$$As_2O_3 + 2I_2 + 2H_2O \longrightarrow As_2O_5 + 4H^+ + 4I^-$$

$$As_2O_5 + 4H^+ + 4I^- \longrightarrow As_2O_3 + 2I_2 + 2H_2O$$

(Atomic weight : As = 75)

10. 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 0.12N– $KMnO_4$ 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.

EXERCISE # (JEE-MAINS)

1. Which of the following is a redox **[AIEEE-02]**

(1) $2NaAg(CN)_2 + Zn \longrightarrow Na2Zn\ (CN)_4 + 2\ Ag$

(2) $BaO_2 + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2$

(3) $N_2O_5 + H_2O \longrightarrow 2HNO_3$

(4) $AgNO_3 + KI \longrightarrow AgI + KNO_3$

2. Oxidation number of Cl in $CaOCl_2$ (bleaching powder is) **[AIEEE–02]**

(1) Zero, since it contains Cl_2

(2) –1, since it contains Cl^-

(3) +1, since it contains ClO^-

(4) +1 and –1 since it contains ClO^- and Cl^-

3. MnO_4^- is good oxidising agent in different medium changing to – **[AIEEE–02]**

$$MnO_4^- \longrightarrow Mn^{2+}$$
$$\longrightarrow MnO_4^{2-}$$
$$\longrightarrow MnO_2$$
$$\longrightarrow Mn_2O_3$$

Changes in oxidation number respectively are -

(1) 1, 3, 4, 5 (2) 5, 4, 3, 2 (3) 5, 1, 3, 4 (4) 2, 6, 4, 3

4. In the coordination compound, $K_4[Ni\ (CN)_6]$, the oxidation state of nickel is **[AIEEE-03]**

(1) +1 (2) +2 (3) –1 (4) 0

5. The oxidation state of chromium in the final product formed by the reaction between Kl and acidified potassium dichromate solution is - **[AIEEE-05]**

(1) +6 (2) +4 (3) +3 (4) +2

6. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is – **[AIEEE-05]**

(1) +2 (2) +3 (3) 0 (4) +1

7. Consider the following reaction: **[JEE(Main)-2013]**

$xMnO_4^- + yC_2O_4^{2-} + zH^+ \rightarrow$

$xMn^{2+} + 2yCO_2 + \frac{z}{2} H_2O$

The values of x, y and z in the reaction are respectively :-

(1) 5,2 and 16 (2) 2,5 and 8 (3) 2, 5 and 16 (4) 5,2 and 8

8. Given : **[JEE(Main-online)-2013]**

$X\ Na_2HAsO_3 + Y\ NaBrO_3 + ZHCl \rightarrow NaBr + H_3AsO_4 + NaCl$

The values of X, Y and Z in the above redox reaction are respectively :

(1) 2, 1, 3 (2) 3, 1, 6 (3) 2, 1, 2 (4) 3, 1, 4

9. In which of the following reaction H_2O_2 acts as a reducing agent ?

(a) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$

(b) $H_2O_2 - 2e^- \rightarrow O_2 + 2H^+$

(c) $H_2O_2 + 2e^- \rightarrow 2OH^-$

(d) $H_2O_2 + 2OH^- - 2e^- \rightarrow O_2 + 2H_2O$

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

10. Consider the reaction **[JEE(Main-online)-2014]**

$H_2SO_{3(aq)} + Sn^{4+}_{(aq)} + H_2O_{(l)} \rightarrow + Sn^{2+}_{(aq)} + HSO^-_{4(aq)} + 3H^+_{(aa)}$

Which of the following statements is correct?

(1) H_2SO_3 is the reducing agent because it undergoes oxidation

(2) H_2SO_3 is the reducing agent because it undergoes reduction

(3) Sn^{4+} is the reducing agent because it undergoes oxidation

(4) Sn^{4+} is the oxidizing agent because it undergoes reduction

11. How many electrons are involved in the following redox reaction ? **[JEE(Main-online)-2014]**

$Cr_2O_7^{2-} + Fe^{2+} + C_2O_4^{2-} \rightarrow Cr^{3+} + Fe^{3+} + CO_2$ (Unbalanced)

(1) 3 (2) 4 (3) 5 (4) 6

12. Which of the following reactions is an example of a redox reaction ? **JEE(Main)-2017]**

(1) $XeF_4 + O_2F_2 \rightarrow XeF_6 + O_2$ (2) $XeF_2 + PF_5 \rightarrow [XeF]+PF_6^-$

(3) $XeF_6 + H_2O \rightarrow XeOF_4 + 2HF$ (4) $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$

13. In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is : **[JEE Main– 2019 (Jan.)]**

(A) 10 (B) 5 (C) 1 (D) 2

14. 25 ml of the given HCl solution requires 30 mL of 0.1 M sodium carbonate solution. What is the volume of this HCl solution required to titrate 30 mL of 0.2 M aqueous NaOH solution? **[JEE Main– 2019 (Jan.)]**

(1) 12.5 mL (2) 50 mL (3) 25 mL (4) 75 mL

15. 50 mL of 0.5 M oxalic acid is needed to neutralize 25 mL of sodium hydroxide solution. The amount of NaOH in 50 mL of the given sodium hydroxide solution is: **[JEE Main–2019 (Jan.)]**

(A) 20 g (B) 40 g (C) 80 g (D) 10 g

16. In order to oxidise a mixture of one mole of each of FeC_2O_4, $Fe_2(C_2O_4)_3$ and $Fe_2(SO_4)_3$ in acidic medium, the number of moles of $KMnO_4$ required is : **[JEE Main– 2019 (April)]**

(A) 1 (B) 3 (C) 2 (D) 1.5

17. The correct order of the oxidation states of nitrogen in NO, N_2O, NO_2 and N_2O_3 is: **[JEE Main– 2019 (April)]**

(A) $N_2O < NO < N_2O_3 < NO_2$ (B) $N_2O < N_2O_3 < NO < NO_2$

(C) $NO_2 < NO < N_2O_3 < N2O$ (D) $NO_2 < N_2O_3 < NO < N_2O$

18. An example of a disproportionation reaction is: **[JEE Main– 2019 (April)]**

(A) $2CuBr \rightarrow CuBr_2 + Cu$

(B) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

(C) $2MnO_4^- + 10\ I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H\ O$

(D) $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$

19. A 20.0 mL solution containing 0.2 g impure H_2O_2 reacts completely with 0.316 g of $KMnO_4$ in acid solution. the purity of H_2O_2 (in%) is _____

(mol. wt. of H_2O_2 = 34; mol. wt. of $KMnO_4$ = 158) **[Jee Main, 2020]**

20. $2MnO_4^- + bC_2O_4^{2-} + cH^+ \longrightarrow xMn^{2+} + yCO_2 + zH_2O$

If the above equation is balanced with integer coefficients, the value of c is _____.

(Round off to the Nearest Integer). **[JEE Main, March 2021]**

21. 15 mL of aqueous solution of Fe^{2+} in acidic medium completely reacted with 20 mL of 0.03 M aqueous $Cr_2O_7^{2-}$. The molarity of the Fe^{2+} solution is _____ $\times 10^{-2}$ M.
(Round off to the Nearest Integer)

[JEE Main, March 2021]

22. Which of the following oxoacids of sulphur contains "S" in two different oxidation states?
(A) $H_2S_2O_3$ (B) $H_2S_2O_6$ (C) $H_2S_2O_7$ (D) $H_2S_2O_8$

[JEE Main, June 2022]

23. Which one of the following is an example of disproportionation reaction?

(A) $3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(B) $MnO_4^{2-} + 4H^+ + 4e^- \longrightarrow MnO_2 + 2H_2O$

(C) $10I^- + 2MnO_4^- + 16H^+ \longrightarrow 2Mn^{+2} + 8H_2O + 5I_2$

(D) $8MnO_4^- + 3S_2O_3^{2-} + H_2O \longrightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$

[JEE Main, June 2022]

24. The neutralization occurs when 10 mL of 0.1 M acid 'A' is allowed to react with 30 mL of 0.05 M base $M(OH)_2$. The basicity of the acid 'A' is_____. [M is a metal]

[JEE Main, June 2022]

25. A 2.0 g sample containing MnO_2 is treated with HCl liberating Cl_2. The Cl_2 gas is passed into a solution of KI and 60.0 mL of 0.1 M $Na_2S_2O_3$ is required to titrate the liberated iodine. The percentage of MnO_2 in the sample is _____. (Nearest integer)
[Atomic masses (in u) Mn = 55; Cl = 35.5; O = 16, I = 127, Na = 23, K = 39, S = 32]

[JEE Main, June 2022]

26. 20 mL of 0.02 M hypo solution is used for the titration of 10 mL of copper sulphate solution, in the presence of excess of KI using starch as an indicator. The molarity of Cu^{2+} is found to be _____ $\times 10^{-2}$ M [nearest integer]
Given: $2Cu^{2+} + 4I^- \rightarrow Cu_2I_2 + I_2$

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

[JEE Main, July 2022]

EXERCISE # (JEE-ADVANCED)

1. The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is : **[JEE 1990]**

(A) +3 (B) +2 (C) +1 (D) –1

2. The number of electrons to balance the following equation :– **[JEE 1991]**

$NO_3^- + 4H^+ + e^- \rightarrow 2H_2O + NO$ is

(A) 5 (B) 4 (C) 3 (D) 2

3. The oxidation states of the most electronegative element in the products of the reaction of BaO_2 with dilute H_2SO_4. **[JEE 1991]**

(A) 0 and –1 (B) –1 and –2 (C) –2 and 0 (D) –2 and +2

4. For the redox reaction, **[JEE 1992]**

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

the correct coefficients of the reactants for the balanced reaction are :

	MnO_4^-	$C_2O_4^{2-}$	H^+
(A)	2	5	16
(B)	16	5	2
(C)	5	16	2
(D)	2	16	5

5. A 5.0 cm^3 solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. **[JEE' 1995]**

6. The number of mole of $KMnO_4$ that will need to react completely with one mole ferrous oxalate in acidic solution is : **[JEE 1997]**

(A) 2/5 (B) 3/5 (C) 4/5 (D) 1

7. The number of mole of KMnO4 that will be needed to react with one mole of sulphite ion in acidic solution is : **[JEE 1997]**

(A) 2/5 (B) 3/5 (C) 4/5 (D) 1

8. One litre of a mixture of O_2 and O_3 at STP was allowed to react with an excess of acidified solution of KI. The Iodine liberated required 40 mL of M/10 sodium thiosulphate solution for titration. What is the percent of ozone in the mixture ? Ultraviolet radiation of wavelength 300 nm can decompose ozone. Assuming that one photon can decompose one ozone molecule, how many photons would have been required for the complete decomposition of ozone in the original mixture? **[JEE 1997]**

9. The equivalent mass of $MnSO_4$ is half its molecular mass when it is converted to : **[JEE 1998]**

(A) Mn_2O_3 (B) MnO_2 (C) MnO_4^- (D) MnO_4^{2-}

10. An aqueous solution containing 0.10 g KIO_3 (formula wt. 214.0) was treated with an excess of KI solution. The solution was acidified with HCl. The liberated I_2 consumed 45.0 mL of thiosulphate solution to decolourise the blue starch – iodine complex. Calculate the molarity of the sodium thiosulphate solution. **[JEE 1998]**

11. The oxidation number of sulphur in S_8, S_2F_2 and H_2S respectively are : **[JEE 1999]**

(A) 0, +1 and –2 (B) +2, +1 and –2

(C) 0, +1 and +2 (D) –2, +1 and –2

12. Among the following species in which oxidation state of the element is +6 : **[JEE 2000]**

(A) MnO_4^- (B) $Cr(CN)_6^{3-}$ (C) NiF_6^{2-} (D) CrO_2Cl_2

13. A 3.00 g sample containing Fe_3O_4, Fe_2O_3 and an inert impure substance, is treated with excess of KI solution in presence of dilute H_2SO_4. The entire iron is converted into Fe^{2+} along with the liberation of iodine. The resulting solution is diluted to 100 mL. A 20 mL of the diluted solution require 11 mL of 0.5 M $Na_2S_2O_3$ solution to reduce the iodine present. A 50 mL of diluted solution after complete extraction of the iodine requires 12.80 mL of 0.25 $KMnO_4$ solution in dilute H_2SO_4 medium for the oxidation of Fe^{2+}. Calculate the percentages of Fe_2O_3 and Fe_3O_4 in the original sample. **[JEE 2000]**

14. An aqueous solution of 6.3 g of oxalic acid dihydrate is made upto 250 mL. The volume of 0.1 N NaOH required to completely neutralise 10 mL of this solution is : **[JEE 2001]**

(A) 40 mL (B) 20 mL (C) 10 mL (D) 4 mL

15. 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 $KMnO_4$ solution is just decolorized by 10 mL of $MnSO_4$ in neutral medium simultaneously forming a dark brown precipitate of hydrated MnO_2. The brown precipitate is dissolved in 10 mL of 0.2 M sodium oxalate under boiling condition in the presence of dilute H_2SO_4. Write the balanced equations involved in the reactions and calculate the molarity of H_2O_2. **[JEE 2001]**

16. Reduction of the metal centre in aqueous permanganate ion involves - **[JEE-2011]**

(A) 3 electrons in neutral medium (B) 5 electrons in neutral medium

(C) 3 electrons in alkaline medium (D) 5 electrons in acidic medium

17. Reaction of Br_2 with Na_2CO_3 in aqueous solution gives sodium bromide and sodium bromate with evolution of CO_2 gas. The number of sodium bromide molecules involved in the balanced chemical equation is. **[JEE- 2011]**

18. Which ordering of compounds is according to the decreasing order of the oxidation state of nitrogen– **[JEE- 2012]**

(A) HNO_3, NO, NH_4Cl, N_2 (B) HNO_3, NO, N_2, NH_4Cl

(C) HNO_3, NH_4Cl, NO, N_2 (D) NO, HNO_3, NH_4Cl, N_2

19. 25 mL of household bleach solution was mixed with 30 mL of 0.50 M KI and 10 mL of 4 N acetic acid. In the titration of the liberated iodine, 48 mL of 0.25 N $Na_2S_2O_3$ was used to reach the end point. The molarity of the household bleach solution is **[JEE- 2012]**

(A) 0.48 M (B) 0.96 M (C) 0.24 M (D) 0.024 M

20. For the reaction **[JEE- 2014]**

$I^- + ClO^-_3 + H_2SO_4 \rightarrow Cl^- + HSO^-_4 + I_2$

The correct statement(s) in the balanced equation is / are :

(A) Stoichiometric coefficient of HSO^-_4 is 6

(B) Iodide is oxidized

(C) Sulphur is reduced

(D) H_2O is one of the products

21. In neutral or faintly alkaline solution, 8 moles permanganate anion quantitatively oxidize thiosulphate anions to produce X moles of a sulphur containing product. the magnitude of X is **[JEE- 2016]**

22. To measure the quantity of $MnCl_2$ dissolved in an aqueous solution, it was completely converted to KMnO4 using the reaction,

$MnCl_2 + K_2S_2O_8 + H_2O \longrightarrow KMnO_4 + H_2SO_4 + HCl$ (equation not balanced). Few drops of concentrated HCl were added to this solution and gently warmed. Further, oxalic acid (225 mg) was added in portions till the colour of the permanganate ion disappeared. The quantity of $MnCl_2$ (in mg) present in the initial solution is ___.

(Atomic weights in g mol^{-1}: Mn = 55, Cl = 35.5) **[JEE- 2018]**

23. The amount of water produced (in g) in the oxidation of 1 mole of rhombic sulphur by conc. HNO_3 to a compound with the highest oxidation state of sulphur is ___

(Given data : Molar mass of water = 18 $gmol^{-1}$) **[JEE- 2019]**

24. In the chemical reaction between stoichiometric quantities of $KMnO_4$ and KI in weakly basic solution, what is the number of moles of I_2 released for 4 moles of $KMnO_4$ consumed?

[JEE- 2020]

Question Statement for Questions 25 and 26

A sample (5.6 g) containing iron is completely dissolved in cold dilute HCl to prepare a 250 mL of solution. Titration of 25.0 mL of this solution requires 12.5 mL of 0.03MKMnO4 solution to reach the endpoint. Number of moles of Fe^{2+} present in 250 mL solution is $x \times 10^{-2}$ (consider complete dissolution of FeCl2). The amount of iron present in the sample is y% by weight. (Assume: $KMnO_4$ reacts only with Fe^{2+} in the solution Use: Molar mass of iron as 56 g mol^{-1})

[JEE- 2021]

25. The value of x is

26. The value of y is

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

Exercise # (O-I)

1.	(D)	**2.**	(A)	**3.**	(B)	**4.**	(A)	**5.**	(A)	**6.**	(C)	**7.**	(B)
8.	(C)	**9.**	(D)	**10.**	(B)	**11.**	(D)	**12.**	(D)	**13.**	(D)	**14.**	(D)
15.	(B)	**16.**	(C)	**17.**	(B)	**18.**	(A)	**19.**	(D)	**20.**	(B)	**21.**	(A)
22.	(A)	**23.**	(A)	**24.**	(A)	**25.**	(C)	**26.**	(A, D)	**27.**	(D)	**28.**	(D)
29.	(B)	**30.**	(C)	**31.**	(C)	**32.**	(D)	**33.**	(C)	**34.**	(D)	**35.**	(A)
36.	(C)	**37.**	(D)	**38.**	(B)	**39.**	(B)	**40.**	(A)	**41.**	(A)	**42.**	(A)
43.	(A)	**44.**	(A)	**45.**	(A)	**46.**	(C)	**47.**	(C)	**48.**	(A)	**49.**	(D)
50.	(B)	**51.**	(D)	**52.**	(D)	**53.**	(D)	**54.**	(A)	**55.**	(B)	**56.**	(A)
57.	(A)												

Exercise # (S-I)

1. (a) +6 (b) 8/3 (c) +3 (d) +2
(e) +5 (f) 200/93 (g) +3

2 (1) +4 (2) +4 (3) $+\frac{8}{3}$ (4) +2
(5) +4 (6) +5 (7) +8 (8) –3
(9) +8 (10) -3 (11) +1
(12) +6 (13) +2

3. (1) +4 (2) +5 (3) +2.5
(4) +4 (5) +2 (6) –3 (7) +2

4. (a) $S_4O_6^{2-}(aq) + 6Al\ (s) + 20\ H^+ \longrightarrow 4\ H_2S\ (aq) + 6Al^{3+}\ (aq) + 6H_2O$

(b) $6S_2O_3^{2-}(aq) + Cr_2O_7^{2-}\ (aq) + 14\ H+ \longrightarrow 3\ S_4O_6^{2-}\ (aq) + 2\ Cr^{3+}\ (aq) + 7H_2O$

(c) $4BCl_3 + P_4 + 6H_2 \longrightarrow 4BP + 12HCl$

(d) $7IO_3^-\ (aq) + 6Re\ (s) + 3H_2O \longrightarrow 6\ ReO_4^-\ (aq) + 7I^-\ (aq) + 6H^+$

(e) $30HSO_4^-(aq) + As_4\ (s) + 10\ Pb_3O_4(s) + 26H+ \longrightarrow 30\ PbSO_4\ (s) + 4H_2AsO_4^-\ (aq) + 24H_2O$

(f) $Ca(OCl)_2 + 4KI + 4HCl \longrightarrow 2I_2 + 4KCl + CaCl_2 + 2H_2O$

5. (a) $3C_4H_4O_6^{2-}(aq) + 5ClO_3^-\ (aq) + 18\ OH^- \longrightarrow 12\ CO_3^{2-}\ (aq) + 5\ Cl^-\ (aq) + 15H_2O$

(b) $3C_2H_5OH + 2MnO_4^- + OH^- \longrightarrow 3C_2H_3O^- + 2MnO_2 + 5H_2O$

(c) $2ClO_2 + SbO_2^- + 2OH^- = 2ClO_2^- + Sb(OH)_6^- + 2H_2O$

(d) Tl_2O_3 (s) + $4NH_2OH$ (aq) $\longrightarrow$ 2TlOH (s) + $2N_2$ (g) + $5H_2O$

(e) $2MnO_4^-$ + $3CN^-$ + H_2O $\longrightarrow$ $2MnO_2$ + $3CNO^-$ + $2OH^-$

(f) $Cu(NH_3)_4^{2+}$ (aq) + $S_2O_4^{2-}$ (aq) + $4OH^-$ $\longrightarrow$ $2SO_3^{2-}$ (aq) + Cu (s) + $4NH_3$ (aq) + $2H_2O$

6. (a) $2Cu(NH_3)_4Cl_2 + 7KCN + H_2O = K_2Cu(CN)_3 + 6NH_3 + KCNO + 2NH_4Cl + 2KCl$

(b) $14ClO_3^-$(aq) + $3As_2S_3$(s) + 18 H_2O $\longrightarrow$ 14 Cl^-(aq) + $6H_2AsO_4^-$(aq) + $9HSO_4^-$(aq) + $15H^+$

(c) 11Al (s) + $3BiONO_3$ (s) + $21H_2O$ + $11OH^-$ $\longrightarrow$ 3Bi (s) + $3NH_3$ (aq) + $11Al(OH)_4^-$(aq)

7. (a) $3HNO_2$(aq) $\longrightarrow$ NO_3^- + 2NO (g) + H^+ + H_2O

(b) $3MnO_4^{2-}$ + $4H^+$ $\longrightarrow$ $2MnO_4^-$ + MnO_2 + H_2O

(c) $3Mn(OH)_2$ (s) + $2MnO_4^-$ (aq) $\longrightarrow$ $5MnO_2$ (s) + $2H_2O$ + $2OH^-$

8. (a) $2KMnO_4 + 16HCl \longrightarrow 2MnCl_2 + 5Cl_2 + 2KCl + 8H_2O$

(b) $2KMnO_4 + 5H_2O_2 + 3H_2SO_4 = 2MnSO_4 + K_2SO_4 + 5O_2 + 8H_2O$

(c) $4H_2O_2$ (aq) + Cl_2O_7 (aq) + $2OH^-$ $\longrightarrow$ $2ClO_2^-$ (aq) + $4O_2$ (g) + $5H_2O$

9. (k) $2KMnO_4 = K_2MnO_4 + MnO_2 + O_2$

10. (a) 58.5 (b) 87 (c) 51.67

11. (a) 31.6 (b) 52.67

12. $\frac{M_1}{6}, \frac{M_2}{8}, \frac{M_3}{5}$

13. 2.5

14. 0.667

15. 4 lit

16. 27/2

17. + 3

18. Zero

19. 0.126

20. 2500

21. 0.588 N

22. 0.6

23. 2.22 mL

24. 3

25. 16.66%

26. 75

27. (a) 3L (b) 6 L

28. V = 160 ml

29. 71gm

30. 126 ppm

31. 7.1%

32. 3.48%

33. (a) 40 ml (b) 60 ml

34. V = 3 lit.

35. 200 mL

36. V = 25 mL

37. 1.406%

EXERCISE # (0-II)

1. **(A,C)** **2.** **(A,B,D)** **3.** **(A,C,D)** **4.** **(B,D)** **5.** **(A,C,D)** **6.** **(A,B,D)**

7. **(A,B,C)** **8.** **(C)** **9.** **(A)** **10.** **(B)** **11.** (C) **12.** (A) **13.** (A)

14. (C) **15.** (D) **16.** (B) **17.** (A) **18.** (A) → (s); (B) → (q); (C) → r ; (D) → p

19. (A) → (q); (B) → (t); (C) → (r)

EXERCISE # (S-II)

1. 5 **2.** 5 g **3.** 5.6 L **4.** 38 % **5.** Vol. of KIO_3=20mL, [HCl]=0.02

6. 50 % **7.** 25% ; $SCN^- + I_2 + 4H_2O \longrightarrow HCN + 7H^+ + 6I^-$

8. FeO= 40% and Fe_2O_3= 60%

9. 0.25075 g

10. x:y:z = 1 : 3 : 2 and n = 2.

EXERCISE # (JEE-MAINS)

1. (D) **2.** (D) **3.** (D) **4.** (B) **5.** (C) **6.** (B) **7.** (B)

8. (B) **9.** (A) **10.** (D) **11.** (C) **12.** (B) **13.** (C) **14.** (C)

15. Bonus **16.** (C) **17.** (A) **18.** (A) **19.** (85) **20.** (16) **21.** (24)

22. (A) **23.** (A) **24.** (3) **25.** (13) **26.** (4)

EXERCISE # (JEE-ADVANCED)

1. (C) **2.** (C) **3.** (B) **4.** (A) **5.** (4.48) **6.** (B) **7.** (A)

8. 6.7% O_3 (by weight), 1.2×10^{21} photons **9.** (B) **10.** (0.0626 M)

11. (A) **12. (D)** **13.** Fe_2O_3 = 49.33 %, Fe_3O_4 = 34.8% **14.** (A) **15.** (0.1 M) **16.** (A, C, D)

17. (5) **18.** (B) **19.** (C) **20.** (A, B, D) **21.** (6) **22.** (126)

23. (288) **24.** (6) **25.** (1.875) **26.** (18.75) **27.** (18)