Chapter 8

Redox Reactions and Volumetric Analysis

1. The mass of potassium dichromate crystals required to oxidise 750 cm^3 of 0.6 M Mohr's salt solution is: (Given molar mass : potassium dichromate = 294, Mohr's salt = 392) **[AIEEE-2011]**
   (1) 2.2 g
   (2) 0.49 g
   (3) 0.45 g
   (4) 22.05 g

2. Consider the following reaction:

$$xMnO_4^- + yC_2O_4^{2-} + zH^+ \longrightarrow xMn^{2+} + 2yCO_2 + \frac{z}{2}H_2O$$

   The values of x, y and z in the reaction are, respectively **[JEE (Main)-2013]**
   (1) 5, 2 and 16
   (2) 2, 5 and 8
   (3) 2, 5 and 16
   (4) 5, 2 and 8

3. The chemical nature of hydrogen peroxide is **[JEE (Main)-2019]**
   (1) Oxidising and reducing agent in both acidic and basic medium
   (2) Oxidising and reducing agent in acidic medium, but not in basic medium
   (3) Reducing agent in basic medium, but not in acidic medium
   (4) Oxidising agent in acidic medium, but not in basic medium

4. Consider the following reduction processes:

   $Zn^{2+} + 2e^- \rightarrow Zn(s)$; $E^o = -0.76$ V

   $Ca^{2+} + 2e^- \rightarrow Ca(s)$; $E^o = -2.87$ V

   $Mg^{2+} + 2e^- \rightarrow Mg(s)$; $E^o = -2.36$ V

   $Ni^{2+} + 2e^- \rightarrow Ni(s)$; $E^o = -0.25$ V

   The reducing power of the metals increases in the order : **[JEE (Main)-2019]**
   (1) Ca < Mg < Zn < Ni
   (2) Ni < Zn < Mg < Ca
   (3) Ca < Zn < Mg < Ni
   (4) Zn < Mg < Ni < Ca

5. 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]**
   (1) 1
   (2) 10
   (3) 2
   (4) 5

6. A 10 mg effervescent tablet containing sodium bicarbonate and oxalic acid releases 0.25 ml of CO_2 at T = 298.15 K and p = 1 bar. If molar volume of CO_2 is 25.0 L under such condition, what is the percentage of sodium bicarbonate in each tablet?
   [Molar mass of $NaHCO_3$ = 84 g mol^{-1}] **[JEE (Main)-2019]**
   (1) 33.6
   (2) 8.4
   (3) 0.84
   (4) 16.8

7. 25 ml of the given HCl solution requires 30 mL of 0.1 M sodium carbonate solution. What is the volume of this HCl solution required to titrate 30 mL of 0.2 M aqueous NaOH solution **[JEE (Main)-2019]**
   (1) 25 mL
   (2) 12.5 mL
   (3) 50 mL
   (4) 75 mL

8. 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]**
   (1) 10 g
   (2) 4 g
   (3) 20 g
   (4) 80 g

9. In order to oxidise a mixture of one mole of each of FeC_2O_4, $Fe_2(C_2O_4)_3$, $FeSO_4$ and $Fe_2(SO_4)_3$ in acidic medium, the number of moles of $KMnO_4$ required is **[JEE (Main)-2019]**
   (1) 1.5
   (2) 2
   (3) 3
   (4) 1

10. An example of a disproportionation reaction is: **[JEE (Main)-2019]**

(1) $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

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

(3) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

(4) $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$

11. Oxidation number of potassium in K_2O, K_2O_2 and KO_2, respectively, is **[JEE (Main)-2020]**

(1) +1, +2 and +4

(2) +2, +1 and $+\frac{1}{2}$

(3) +1, +4 and +2

(4) +1, +1 and +1

12. The redox reaction among the following is **[JEE (Main)-2020]**

(1) Reaction of $[Co(H_2O)_6]Cl_3$ with $AgNO_3$

(2) Formation of ozone from atmospheric oxygen in the presence of sunlight.

(3) Combination of dinitrogen with dioxygen at 2000 K

(4) Reaction of H_2SO_4 with NaOH

13. While titrating dilute HCl solution with aqueous NaOH, which of the following will not be required? **[JEE (Main)-2020]**

(1) Pipette and distilled water

(2) Clamp and phenolphthalein

(3) Burette and porcelain tile

(4) Bunsen burner and measuring cylinder

14. The oxidation states of transition metal atoms in $K_2Cr_2O_7$, $KMnO_4$ and K_2FeO_4, respectively, are x, y and z. The sum of x, y and z is _______. **[JEE (Main)-2020]**

15. 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]**

16. Consider the following equations :

$2Fe^{2+} + H_2O_2 \rightarrow xA + yB$

(in basic medium)

$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow x'C + y'D + z'E$

(in acidic medium)

The sum of the stoichiometric coefficients

$x, y,, x', y'$ and z' for products A, B, C, D and E, respectively, is ______. **[JEE (Main)-2020]**

17. The volume (in mL) of 0.1 N NaOH required to neutralise 10 mL of 0.1 N phosphinic acid is ______. **[JEE (Main)-2020]**

18. A 100 mL solution was made by adding 1.43 g of $Na_2CO_3 \cdot xH_2O$. The normality of the solution is 0.1 N. The value of x is _____. **[JEE (Main)-2020]**

(The atomic mass of Na is 23 g/mol)

19. The volume, in mL, of 0.02 M $K_2Cr_2O_7$ solution required to react with 0.288 g of ferrous oxalate in acidic medium is _______.

(Molar mass of Fe = 56 g mol^{-1})

[JEE (Main)-2020]

20. The ammonia (NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide (NaOH) can be neutralized by **[JEE (Main)-2020]**

(1) 200 ml of 0.4 N HCl

(2) 100 ml of 0.1 N HCl

(3) 200 ml of 0.2 N HCl

(4) 100 ml of 0.2 N HCl

21. The reaction of sulphur in alkaline medium is given below:

$$S_{8(s)} + a\,OH^-_{(aq)} \longrightarrow b\,S^{2-}_{(aq)} + c\,S_2O_3^{2-}{}_{(aq)} + d\,H_2O_{(l)}$$

The value of 'a' is ______. (Integer answer)

[JEE (Main)-2021]

22. 0.4 g mixture of NaOH, Na_2CO_3 and some inert impurities was first titrated with $\frac{N}{10}$ HCl using phenolphthalein as an indicator, 17.5 mL of HCl was required at the end point. After this methyl orange was added and titrated. 1.5 mL of same HCl was required for the next end point. The weight percentage of Na_2CO_3 in the mixture is _________. (Rounded-off to the nearest integer)

[JEE (Main)-2021]

23. In basic medium CrO_4^{2-} oxidises $S_2O_3^{2-}$ to form SO_4^{2-} and itself changes into $Cr(OH)_4^-$. The volume of 0.154 M CrO_4^{2-} required to react with 40 mL of 0.25 M $S_2O_3^{2-}$ is ________ mL. (Rounded-off to the nearest integer)

[JEE (Main)-2021]

24. Consider titration of NaOH solution versus 1.25 M oxalic acid solution. At the end point following burette readings were obtained. **[JEE (Main)-2021]**

(i) 4.5 mL (ii) 4.5 mL

(iii) 4.4 mL (iv) 4.4 mL

(v) 4.4 mL

If the volume of oxalic acid taken was 10.0 mL then the molarity of the NaOH solution is ____ M. (Rounded-off to the nearest integer)

25. $2MnO_4^- + bC_2O_4^{2-} + cH^+ \rightarrow x\,Mn^{2+} + yCO_2 + z\,H_2O$

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

[JEE (Main)-2021]

26. The exact volumes of 1 M NaOH solution required to neutralise 50 mL of 1 M H_3PO_3 solution and 100 mL of 2 M H_3PO_2 solution, respectively, are:

[JEE (Main)-2021]

(1) 100 mL and 100 mL

(2) 50 mL and 50 mL

(3) 100 mL and 200 mL

(4) 100 mL and 50 mL

27. 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)-2021]

28. The oxidation states of nitrogen in NO, NO_2, N_2O and NO_3^- are in the order of : **[JEE (Main)-2021]**

(1) $NO_2 > NO_3^- > NO > N_2O$

(2) $NO_3^- > NO_2 > NO > N_2O$

(3) $N_2O > NO_2 > NO > NO_3^-$

(4) $NO > NO_2 > N_2O > NO_3^-$

29. 10.0 mL of Na_2CO_3 solution is titrated against 0.2 M HCl solution. The following titre values were obtained in 5 readings: **[JEE (Main)-2021]**

4.8 mL, 4.9 mL, 5.0 mL, 5.0 mL and 5.0 mL

Based on these readings and convention of titrimetric estimation the concentration of Na_2CO_3 solution is _______ mM

(Round off the Nearest integer).

30. The species given below that does NOT show disproportionation reaction is **[JEE (Main)-2021]**

(1) BrO_3^- (2) BrO^-

(3) BrO_2^- (4) BrO_4^-

31. 4 g equimolar mixture of NaOH and Na_2CO_3 contains x g of NaOH and y g of Na_2CO_3. The value of x is ___________g. **[JEE (Main)-2021]**

(Nearest integer)

32. When 10 mL of an aqueous solution of Fe^{2+} ions was titrated in the presence of dil H_2SO_4 using diphenylamine indicator, 15 mL of 0.02 M solution of $K_2Cr_2O_7$ was required to get the end point. The molarity of the solution containing Fe^{2+} ions is $x \times 10^{-2}$ M. The value of x is ______. (Nearest integer) **[JEE (Main)-2021]**

33. Identify the process in which change in the oxidation state is five : **[JEE (Main)-2021]**

(1) $C_2O_4^{2-} \rightarrow 2CO_2$

(2) $MnO_4^- \rightarrow Mn^{2+}$

(3) $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

(4) $CrO_4^{2-} \rightarrow Cr^{3+}$

34. The oxidation states of 'P' in $H_4P_2O_7$, $H_4P_2O_5$ and $H_4P_2O_6$, respectively are **[JEE (Main)-2021]**

(1) 5, 4 and 3 (2) 7, 5 and 6

(3) 6, 4 and 5 (4) 5, 3 and 4

35. 10.0 mL of 0.05 M $KMnO_4$ solution was consumed in a titration with 10.0 mL of given oxalic acid dihydrate solution. The strength of given oxalic acid solution is ________ $\times 10^{-2}$ g/L.

(Round off to the Nearest Integer).

[JEE (Main)-2021]

36. When 10 mL of an aqueous solution of $KMnO_4$ was titrated in acidic medium, equal volume of 0.1 M of an aqueous solution of ferrous sulphate was required for complete discharge of colour. The strength of $KMnO_4$ in grams per litre is _______ $\times 10^{-2}$. (Nearest integer)

[Atomic mass of K = 39, Mn = 55, O = 16]

[JEE (Main)-2021]

37. In which one of the following sets all species show disproportionation reaction? [JEE (Main)-2021]

(1) $ClO_4^-, MnO_4^-, ClO_2^-$ and F_2

(2) ClO_2^-, F_2, MnO_4^- and $Cr_2O_7^{2-}$

(3) MnO_4^-, ClO_2^-, Cl_2 and Mn^{3+}

(4) $Cr_2O_7^{2-}, MnO_4^-, ClO_2^-$ and Cl_2

38. 1 L aqueous solution of H_2SO_4 contains 0.02 m mol H_2SO_4. 50% of this solution is diluted with deionized water to give 1 L solution (A). In solution (A), 0.01 m mol of H_2SO_4 are added. Total m mols of H_2SO_4 in the final solution is ______ × 10^3 m mols.

[JEE (Main)-2022]

39. The neutralization occurs when 10 mL of 0.1M 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)-2022]

40. Which one of the following is an example of disproportionation reaction? [JEE (Main)-2022]

(1) $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(2) $MnO_4^- + 4H^+ + 4e^- \rightarrow MnO_2 + 2H_2O$

(3) $10I^- + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5I_2$

(4) $8MnO_4^- + 3S_2O_3^{2-} + H_2O \rightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$

41. 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)-2022]

42. 0.01 M $KMnO_4$ solution was added to 20.0 mL of 0.05 M Mohr's salt solution through a burette. The initial reading of 50 mL burette is zero. The volume of $KMnO_4$ solution left in burette after the end point is _____ml. [nearest integer] [JEE (Main)-2022]

43. SO_2Cl_2 on reaction with excess of water results into acidic mixture

$$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$$

16 moles of NaOH is required for the complete neutralisation of the resultant acidic mixture. The number of moles of SO_2Cl_2 used is

[JEE (Main)-2022]

(1) 16 (2) 8

(3) 4 (4) 2

44. Which of the given reactions is not an example of disproportionation reaction? [JEE (Main)-2022]

(1) $2H_2O_2 \rightarrow 2H_2O + O_2$

(2) $2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

(3) $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

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

45. The dark purple colour of $KMnO_4$ disappears in the titration with oxalic acid in acidic medium. The overall change in the oxidation number of manganese in the reaction is : [JEE (Main)-2022]

(1) 5 (2) 1

(3) 7 (4) 2

46. 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 ________ × 10^{-2} M. [nearest integer]

Given : $2\,Cu^{2+} + 4\,I^- \rightarrow Cu_2I_2 + I_2$

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ [JEE (Main)-2022]

47. 20 mL of 0.02 M $K_2Cr_2O_7$ solution is used for the titration of 10 mL of Fe^{2+} solution in the acidic medium. The molarity of Fe^{2+} solution is _______$\times 10^{-2}$ M. (Nearest integer)

[JEE (Main)-2022]

48. Given below are two statements: One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A: Permanganate titrations are not performed in presence of hydrochloric acid.

Reason R: Chlorine is formed as a consequence of oxidation of hydrochloric acid.

In the light of the above statements, choose the ***correct*** answer from the options given below.

[JEE (Main)-2022]

(1) Both **A** and **R** are true and **R** is the correct explanation of **A**

(2) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**

(3) **A** is true but **R** is false

(4) **A** is false but **R** is true

49. In neutral or faintly alkaline medium, $KMnO_4$ being a powerful oxidant can oxidize, thiosulphate almost quantitatively, to sulphate. In this reaction overall change in oxidation state of manganese will be **[JEE (Main)-2022]**

(1) 5 (2) 1

(3) 0 (4) 3

50. The normality of H_2SO_4 in the solution obtained on mixing 100 mL of 0.1 M H_2SO_4 with 50 mL of 0.1 M NaOH is ________ $\times 10^{-1}$ N. (Nearest Integer)

[JEE (Main)-2022]

51. In the titration of $KMnO_4$ and oxalic acid in acidic medium, the change in oxidation number of carbon at the end point is _____ **[JEE (Main)-2022]**

❑ ❑ ❑

Chapter 8

Redox Reactions and Volumetric Analysis

1. Answer (4)

$K_2Cr_2O_7$ Oxidation Number of Cr = 6

Weight of $K_2Cr_2O_7 = \dfrac{0.75\times0.6\times294}{6} = 22.05$ g

2. Answer (3)

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} \rightarrow 10CO_2 + 8H_2O$$

3. Answer (1)

H_2O_2 can act as both oxidising as well as reducing agent in both acidic as well as basic medium.

4. Answer (2)

As $E^\circ_{M/M^{2+}}$ increases, reducing power increases.

$E^\circ_{Zn/Zn^{2+}}$ = 0.76 V

$E^\circ_{Ca/Ca^{2+}}$ = 2.87 V

$E^\circ_{Mg/Mg^{2+}}$ = 2.36 V

$E^\circ_{Ni/Ni^{2+}}$ = 0.25 V

Ca > Mg > Zn > Ni

5. Answer (1)

$$\overset{+3}{C_2}O_4^{2-} \longrightarrow 2\overset{+4}{C}O_2 \quad +2e^-$$

O.N. of one C-atom ↑ by 1

∴ No. of electrons involved in producing one mole of CO_2 is 1.

6. Answer (2)

Moles of CO_2 evolved $= \dfrac{0.25}{25\times10^3} = 10^{-5}$

∴ moles of $NaHCO_3 = 10^{-5}$

∴ mass of $NaHCO_3 = 84 \times 10^{-5}$ g

$= 0.84 \times 10^{-3}$ g

= 0.84 mg

∴ % by weight $= \dfrac{0.84}{10}\times100$

= 8.4 %

7. Answer (1)

25 mL of HCl solution required 30 mL of 0.1 M Na_2CO_3 solution

∴ 25 × M × 1 = 30 × 0.1 × 2

⇒ $M = \dfrac{6}{25} = 0.24$ M

Now, HCl solution is titrated with NaOH solution.

∴ V × 0.24 × 1 = 30 × 0.2 × 1

⇒ V = 25 mL

8. Answer (2)

2 × 50 × 0.5 = 25 × M

⇒ M = 2

∴ Moles of NaOH in 50 mL $= \dfrac{2\times50}{1000}$

$= \dfrac{2}{20} = \dfrac{1}{10}$

∴ Weight = 4 grams

9. Answer (2)

$$5e + MnO_4^- \longrightarrow Mn^{+2}$$

(i) $FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2 + 3e$

1 mole of FeC_2O_4 react with $\dfrac{3}{5}$ moles of acidified $KMnO_4$.

(ii) $Fe_2(C_2O_4)_3 \longrightarrow Fe^{3+} + CO_2 + 6e$

1 mole of $Fe_2(C_2O_4)_3$ react with $\dfrac{6}{5}$ moles of $KMnO_4$

(iii) $FeSO_4 \longrightarrow Fe^{3+} + e$

1 mole of $FeSO_4$ react with $\frac{1}{5}$ moles of $KMnO_4$

$\therefore$ Total moles required $= \frac{3}{5} + \frac{6}{5} + \frac{1}{5} = 2$

10. Answer (2)

$$\underset{Cu^{+}}{CuBr} \longrightarrow \underset{Cu^{0}}{Cu} + \underset{Cu^{2+}}{CuBr_2}$$

It is an example of disproportionation reaction.

11. Answer (4)

Alkali metals show an oxidation state of +1 in their compounds.

12. Answer (3)

The redox reaction is

$$N_2 + O_2 \xrightleftharpoons{2000\text{ K}} 2NO$$

Nitrogen is oxidised while oxygen is reduced.

Reaction of $[CO(H_2O)_6]Cl_3$ with $AgNO_3$ is not redox reaction. It is a precipitation reaction.

13. Answer (4)

Bunsen Burner and measuring cylinder is not required for titration.

14. Answer (19)

$\overset{+1}{K}_2\overset{x}{Cr}_2\overset{-2}{O}_7$ $\quad 2 + 2x - 14 = 0 \quad \Rightarrow x = +6$

$\overset{+1}{K}\overset{y}{Mn}\overset{-2}{O}_4$ $\quad 1 + y - 8 = 0 \quad \Rightarrow y = +7$

$\overset{+1}{K}_2\overset{z}{Fe}\overset{-2}{O}_4$ $\quad 2 + z - 8 = 0 \quad \Rightarrow z = +6$

$x + y + z = 6 + 7 + 6 = 19$

15. Answer (85)

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

Moles of $KMnO_4 = \frac{0.316}{158} = 2 \times 10^{-3}$

Equivalents of H_2O_2 = Equivalent of $KMnO_4$

$= 2 \times 10^{-3} \times 5 = 0.01$

Moles of H_2O_2 $= \frac{0.01}{2} = 0.005$

Mass of pure H_2O_2 $= 0.005 \times 34 = 0.170$ gm

Percentage purity $= \frac{0.17}{0.2} \times 100 = 85\%$

16. Answer (19.00)

$2Fe^{2+} + H_2O_2 \rightarrow 2Fe^{3+} + 2OH^-$

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

$\therefore$ $x + y + x' + y' + z' = 19$

17. Answer (10.00)

Phosphinic acid is H_3PO_2

$NaOH + H_3PO_2 \rightarrow NaH_2PO_2 + H_2O$

milliequivalents of NaOH = milliequivalents of H_3PO_2

$V \times 0.1 = 10 \times 0.1$

$V = 10$ mL

18. Answer (10.00)

$$\text{Normality} = \frac{\text{No. of equivalents of solute}}{\text{Volume of solution (in L)}}$$

$$0.1 = \frac{1.43}{\frac{(106 + 18x)}{2} \times 0.1}$$

$$\Rightarrow \frac{106 + 18x}{2} = 143$$

$\Rightarrow$ $18x = 286 - 106 = 180$

$x = 10$

19. Answer (50.00)

m. eq. of $K_2Cr_2O_7$ = m. eq. of FeC_2O_4

$FeC_2O_4 + Cr_2O_7^{2-} \rightarrow Fe^{3+} + CO_2 + Cr^{3+}$

$$\Rightarrow V \times 0.02 \times 6 = \frac{0.288 \times 3 \times 1000}{144}$$

$V = 50$ mL

20. Answer (4)

$$NH_2-\overset{\overset{O}{\|}}{C}-NH_2 \xrightarrow{NaOH} 2NH_3$$

2 moles of NH_3 will react with 2 mole of HCl.

0.6 g of urea give $= \frac{0.6}{60}\times 2 = 0.02$ mol of NH_3

100 × 0.2 N HCl = 0.02 mol of HCl

21. Answer (12)

$$S_{8(s)} + a\,OH^-_{(aq)} \longrightarrow b\,S^{2-}_{(aq)} + c\,S_2O^{2-}_{3\,(aq)} + d\,H_2O_{(l)}$$

$$S_{8(s)} + 16\,e^- \longrightarrow 8\,S^{2-}_{(aq)}$$

$$S_{8(s)} \longrightarrow 4\,S_2^{+4} + 16e^-$$

$$2S_8 \longrightarrow 8\,S^{2-} + 4S_2O_3^{2-}$$

$$\Rightarrow\ 2S_8 + 24OH^- \longrightarrow 8S^{2-} + 4S_2O_3^{2-} + 12H_2O$$

$$\Rightarrow\ S_8 + 12OH^- \longrightarrow 4S^{2-} + 2S_2O_3^{2-} + 6H_2O$$

$\therefore$ a = 12

22. Answer (4)

0.4 g mixture of NaOH + Na_2CO_3 + inert impurity

Assume : no. of moles of NaOH = a m. moles

: no. of moles of Na_2CO_3 = b m. moles

When phenolphthalein is used as indicator:

NaOH will react with HCl and convert into NaCl and H_2O.

Na_2CO_3 will react with HCl and convert into $NaHCO_3$ and NaCl.

Using law of equivalence :

$$a \times 1 + b \times 1 = 17.5 \times \frac{1}{10} = 1.75$$

a + b = 1.75

When methyl orange is added as indicator in the same solution.

$NaHCO_3$ will convert into H_2CO_3 and NaCl

using law of equivalence

$$b \times 1 = 1.5 \times \frac{1}{10} = 0.15$$

$$W_{Na_2CO_3} \text{ in the mixture} = \frac{0.15}{1000}\times 106$$

$$\simeq 0.016\,g$$

$$\text{weight \% of } Na_2CO_3 = \frac{0.016}{0.4}\times 100 = 4\%$$

23. Answer (173)

$$CrO_4^{2-} + S_2O_3^{2-} \rightarrow Cr(OH)_4^- + SO_4^{2-}$$

using law of equivalence

m. equivalents of CrO_4^{2-} used = m. equivalents of $S_2O_3^{2-}$ used

n-factor of CrO_4^{2-} = 3

n-factor of $S_2O_3^{2-}$ = 4×2 = 8

$\therefore$ 0.154 × V × 3 = 0.25 × 40 × 8

$\Rightarrow V = 173.16$ mL

≈ 173 mL

24. Answer (6)

Average volume of NaOH solution used at end point = 4.44 mL

At the end point, Equivalents of NaOH = Equivalents of oxalic acid

$N_1V_1 = N_2V_2$

N_1 × 4.44 = (1.25 × 2) × 10

$$N_1 = \frac{1.25\times 2\times 10}{4.44} = 5.63 \simeq 6$$

Molarity of NaOH = 6 M

25. Answer (16)

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

b = 5

c = 16

x = 2

y = 10

z = 8

26. Answer (3)

H_3PO_3 – diprotic acid

H_3PO_2 – monoprotic acid

Using Law of equivalence:

m.equivalents of H_3PO_3 = m.equivalents of NaOH

$\Rightarrow$ 50 × 1 × 2 = V × 1 × 1

$\Rightarrow$ V = 100 mL

Similarly,

m.equivalents of H_3PO_2 = m.equivalents of NaOH

$\Rightarrow$ 100 × 2 × 1 = V × 1 × 1

$\Rightarrow$ V = 200 mL

27. Answer (24)

$$\underset{n=1}{6Fe^{2+}} + \underset{n=6}{Cr_2O_7^{2-}} + 14H^+ \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

milliequivalents of Fe^{2+} = milliequivalents of $Cr_2O_7^{2-}$

If M is the molarity of Fe^{2+} ion solution

1 × M × 15 = 0.03 × 6 × 20

M = 0.24 = 24 × 10^{-2}

28. Answer (2)

	O.S of N
NO_3^-	+5
NO_2	+4
NO	+2
N_2O	+1

29. Answer (50)

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

equivalents of Na_2CO_3 = equivalents of HCl

2 × M × 10 = 1 × 0.2 × 5

$$M = \frac{0.2 \times 5}{20} = 0.05\ M$$

= 5 × 10^{-2} M

= 50 × 10^{-3} M = 50 mM

30. Answer (4)

BrO_4^- is in maximum oxidation state *i.e.*, + 7 so it can only reduce.

31. Answer (1)

Mass of NaOH = x

$$\text{Moles of NaOH} = \frac{x}{40}$$

Mass of Na_2CO_3 = y

$$\text{Moles of } Na_2CO_3 = \frac{y}{106}$$

$$\frac{x}{40} = \frac{y}{106}$$

x + y = 4

x = 1.1, y = 2.9

x = 1.1 ≈ 1 (nearest integer)

32. Answer (18)

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

At equivalence point

(Number of gram equivalents)$_{OA}$

= (Number of gram equivalents)$_{RA}$

$$(15 \times 0.02 \times 6)_{K_2Cr_2O_7} = (10 \times M \times 1)_{Fe^{2+}}$$

M = 18 × 10^{-2} M

33. Answer (2)

$$\underset{\text{O.S. } +3}{C_2O_4^{2-}} \longrightarrow \underset{+4}{CO_2}$$

$$\underset{\text{O.S. } +7}{MnO_4^-} \longrightarrow \underset{+2}{Mn^{2+}}$$

$$\underset{\text{O.S. } +6}{Cr_2O_7^{2-}} \longrightarrow \underset{+3}{2Cr^{3+}}$$

$$\underset{\text{O.S. } +6}{CrO_4^{2-}} \longrightarrow \underset{+3}{Cr^{3+}}$$

34. Answer (4)

	$H_4P_2O_7$	$H_4P_2O_5$	$H_4P_2O_6$
Oxidation state of 'P'	+5	+3	+4

35. Answer (1575)

At equivalence point

(Number of gram equivalence)$_{OA}$

= (Number of gram equivalence)$_{RA}$

(10 × 0.05 × 5) $KMnO_4$ = (10 × M × 2) $H_2C_2O_4 \cdot 2H_2O$

M = 0.125 Molar

Strength of solution = molarity × molar mass (gL^{-1})

= 0.125 × 126

= 1575 × 10^{-2} gL^{-1}

36. Answer (316)

$$FeSO_4 + MnO_4^- + H^+ \rightarrow (Fe)_2(SO_4)_3 + Mn^{2+} + H_2O$$

n = 1 n = 5

Equivalents of $KMnO_4$ = Equivalents of $FeSO_4$

$$= \frac{0.1 \times 1 \times 10}{1000} = 10^{-3}$$

Moles of $KMnO_4$ in 10 mL $= \frac{10^{-3}}{5} = 2 \times 10^{-4}$

Moles of $KMnO_4$ In 1 L $= 2 \times 10^{-4} \times 100 = 0.02$

Mass of $KMnO_4$ in 1 L = 158 × 0.02 = 316 × 10^{-2} g/L

37. Answer (Bonus)

$ClO_4^-, MnO_4^-, Cr_2O_7^{2-}$ – Cl, Mn, Cr in these anions are present in highest oxidation state. These will not undergo disproportionation.

38. Answer (0.02 × 10^{-3})

Initially one litre contains 0.02 mole

∴ 50% of this solution will contains 0.01 m mol

After adding 0.01 mol, final solution will contain 0.02 m mol of H_2SO_4

= 0.02 m mol

Correct answer should 0.02 × 10^{-3}

39. Answer (3)

Millieq of acid A = Millieq of base $M(OH)_2$

$$(M \times V \times n - Factor)_A = (M \times V \times n - Factor)_{M(OH)_2}$$

[n-Factor of $M(OH)_2$ = 2]

0.1 × 10 × n-Factor = 0.05 × 30 × 2

(n-Factor)$_A$ = 3

Hence basicity of acid A is 3.

40. Answer (1)

$$\overset{+6}{Mn}O_4^{-2} \rightarrow \overset{+7}{Mn}O_4^-$$

$$\overset{+6}{Mn}O_4^{-2} \rightarrow \overset{+4}{Mn}O_2$$

MnO_4^{-2} is an intermediate oxidation state and is converted into compounds having higher and lower oxidation states.

41. Answer (13)

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$$

$$Cl_2 + KI \longrightarrow Cl^- + I_2$$

$$\Big\downarrow 2Na_2S_2O_3$$

$$Na_2S_4O_6 + 2NaI$$

Equivalent of MnO_2 = HCl = Cl_2 = I_2 = $Na_2S_2O_3$

2 × number of moles of MnO_2 = 1 × number of moles of $Na_2S_2O_3$

Moles of MnO_2 $= \frac{60 \times 0.1 \times 10^{-3}}{2}$

= 3 × 10^{-3} mole

Mass of MnO_2 = 0.261 g

% of MnO_2 $= \frac{0.261}{2} \times 100 \simeq 13\%$

42. Answer (30)

Meq of oxidising agent = Meq of reducing agent

$$(M \times V \times n_F)_{KMnO_4} = (M \times V \times n_F)_{Mohr's\ salt}$$

$$0.01 \times 20 \times 5 = 0.05 \times V \times 1$$

Volume required = 20 ml

Since initial volume of $KMnO_4$ in burette is 50 ml. Hence volume of $KMnO_4$ left in the burette after end point is 30 ml.

43. Answer (3)

$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

Moles of NaOH required for complete neutralisation of resultant acidic mixture = 16 moles

And 1 mole of SO_2Cl_2 produced 4 moles of H^+.

$\therefore$ Moles of SO_2Cl_2 used will be $= \frac{16}{4} = 4$ moles

44. Answer (3)

$$\overset{+7}{Mn}O_4^- + 4H^+ + 3e^- \longrightarrow \overset{+4}{Mn}O_2 + 2H_2O$$

The above reaction involves the reduction of MnO_4^- to MnO_2.

45. Answer (1)

$$2K\overset{+7}{Mn}O_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow$$

$$K_2SO_4 + 2\overset{+2}{Mn}SO_4 + 10CO_2 + 8H_2O$$

Change in oxidation state of Mn is 5.

46. Answer (4)

$2Cu^{2+} + 4I^- \rightarrow Cu_2I_2 + I_2$

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

Milliequivalents of hypo solution = 0.02 × 20 = 0.4

Milliequivalents of Cu^{2+} in 10 mL solution =

Milliequivalents of I_2 = Milliequivalents of hypo

= 0.4

Millimoles of Cu^{2+} ions in 10 mL = 0.4

Molarity of Cu^{2+} ions $= \frac{0.4}{10} = 0.04$ M

$= 4 \times 10^{-2}$ M

47. Answer (24)

Applying the law of equivalence,

milliequivalents of Fe^{2+} = milliequivalents of $K_2Cr_2O_7$

$10 \times 1 \times M = 20 \times 6 \times .02$

$M = 24 \times 10^{-2}$ M

$\therefore$ Answer will be 24

48. Answer (1)

HCl is not used in the process of titration because it reacts with the ($KMnO_4$) that is used in the process and gets oxidized.

49. Answer (4)

In neutral or Faintly alkaline medium, thiosulphate is oxidised almost quantitatively to sulphate ion according to reaction given below,

$$8MnO_4^- + 3S_2O_3^{2-} + H_2O \rightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$$

Here the Mn changes from Mn^{+7} to Mn^{+4}

Thus overall change in its oxidation number would be of 3.

50. Answer (01.00)

	H_2SO_4	+ 2NaOH ⟶	Na_2SO_4	+ H_2O
Initial millimoles	10	5	–	–
Final millimoles	7.5	–	2.5	–

Molarity of $H_2SO_4 = \frac{7.5}{150} = \frac{1}{20}$M

Normality of $H_2SO_4 = \frac{1}{20} \times 2 = 0.1$ N

$= 1 \times 10^{-1}$ N

51. Answer (1)

$$16H^+ + 2MnO_4^- + 5C_2O_4^{2-} \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$

During titration of oxalic acid by $KMnO_4$, oxalic acid converts into CO_2.

$\therefore$ Change in oxidation state of carbon = 1

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