

EQUIVALENT CONCEPT & TITRATIONS

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JEE(Advanced) Syllabus

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions and normality, Law of Equivalence, titration, Application of redox titration, hardness of water, parts per million (PPM), Bleaching powder, Hydrogen peroxide (H_2O_2), Oleum.

JEE(Main) Syllabus

Electronic concepts of oxidation and reduction, redox reactions, oxidation number, rules for assigning oxidation number, balancing of redox reactions, concept of equivalents, titration, hardness of water.

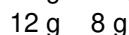
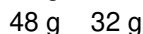
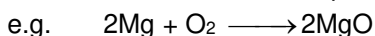


Equivalent Concept & Titrations

Section (A) : Classical Concept of Equivalent weight / Mass, Equivalent weight, n-factor and Normality for Acid, Base and Precipitate

Concept of equivalents :

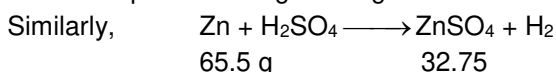
Equivalent mass of element : Number of parts by mass of an element which reacts or displaces from a compound 1.008 parts by mass of hydrogen, 8 parts by mass of oxygen and 35.5 parts by mass of chlorine, is known as the equivalent weight of that element.



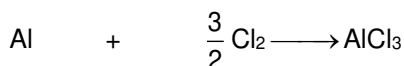
\therefore 32 g of O_2 reacts with 48 g of Mg

\therefore 8 g of $\text{O}_2 = \frac{48 \times 8}{32} = 12 \text{ g}$

\therefore Equivalent weight of Mg = 12



\therefore Equivalent weight of Zn = $\frac{65.5}{2} = 32.75 \text{ g}$



111.5 g chlorine reacts with 27 g of Al.

\therefore 35.5 chlorine reacts with = $\frac{27 \times 35.5}{111.5} = 9.0 \text{ g of Al}$

\therefore Equivalent weight of aluminium = $\frac{27}{3} = 9.0$

As we can see from the above examples that equivalent weight is the ratio of atomic weight and a factor (say n-factor or valency factor) which in the above three cases is their respective valencies.

Equivalent weight (E) :

In general, $\text{Eq. wt. (E)} = \frac{\text{Atomic weight or Molecular weight}}{\text{valency factor (v.f)}} = \frac{\text{Mol. wt.}}{\text{n - factor}} = \frac{M}{x}$

$\text{Number of equivalents} = \frac{\text{mass of species}}{\text{eq. wt. of that species}}$

For a solution, Number of equivalents = N_1V_1 , where N is the normality and V is the volume in litres

- Equivalent mass is a pure number which, when expressed in gram, is called gram equivalent mass.
- The equivalent mass of a substance may have different values under different conditions.
- There is no hard and fast rule that equivalent weight will be always less than the molecular mass.

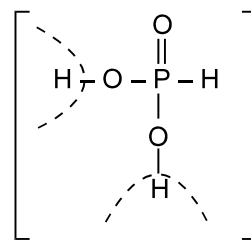
Valency factor calculation :

- **For Elements :** Valency factor = valency of the element.
- **For Acids :** Valency factor = number of replaceable H^+ ions per acid molecule.



Solved Examples

Ex-1 HCl, H₂SO₄, H₃PO₄, H₃PO₃



{see there are only two replaceable H⁺ ions}

Sol. Valency factor → 1 2 3 2
 (Assume 100% dissociation)

Eq. wt. (E) → M/1 M/2 M/3 M/2

○ Replaceable hydrogen atoms are those hydrogen atoms which are attached with the atoms of group VI and group VII i.e. O, S, Se, Te & F, Cl, Br, I.

For Bases :

Valency factor = number of replaceable OH⁻ ions per base molecule.

Solved Examples

Ex-2. NaOH, KOH

Sol. v.f. → 1 1

Eq. wt. → M/1 M/1

○ Bases may be defined as the substances in which OH group is/are directly attached with group I elements (Li, Na, K, Rb, Cs), group II elements (Be, Mg, Ca, Ba) or group III elements (Al, Ga, In, Tl), transition metals, non-metallic cations like PH₄⁺, NH₄⁺ etc.

Acid-base reaction :

In case of acid base reaction, the valence factor is the actual number of H⁺ or OH⁻ replaced in the reaction. The acid or base may contain more number of replaceable H⁺ or OH⁻ than actually replaced in reaction.

○ v.f. for base is the number of H⁺ ion from the acid replaced by each molecule of the base.

Solved Examples

Ex-3. 2NaOH + H₂SO₄ → Na₂SO₄ + 2H₂O

Base Acid

Sol. Valency factor of base = 1

Here, two molecule of NaOH replaced 2H⁺ ion from the H₂SO₄. Therefore, each molecule of NaOH replaced only one H⁺ ion of acid, so v.f. = 1.

○ v.f. for acid is the number of OH⁻ replaced from the base by each molecule of acid.

Solved Examples

Ex-4. NaOH + H₂SO₄ → NaHSO₄ + H₂O

Base Acid

Sol. Valency factor of acid = 1

Here, one of molecule of H₂SO₄ replaced one OH⁻ from NaOH. Therefore, valency factor for H₂SO₄ is one

∴ Eq. wt. of H₂SO₄ = $\frac{\text{Mol. wt}}{1}$





● **Salts :**

(a) In non-reacting condition

- **Valency factor** = Total number of positive charge or negative charge present in the compound.

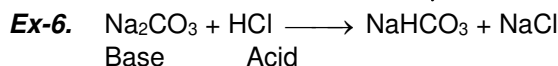
Solved Examples

Ex-5.	Na_2CO_3 ,	$\text{Fe}_2(\text{SO}_4)_3$,	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
Sol.	V.f. 2	$2 \times 3 = 6$	2
	Eq.wt. $M/2$	$M/6$	$M/2$

Note : In case of hydrated salt, positive/negative charge of water molecule is not counted.

(b) In reacting condition

Solved Examples



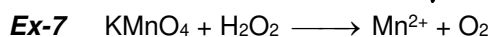
Sol. It is an acid base reaction, therefore valency factor for Na_2CO_3 is one while in non-reacting condition, it will be two.

Section (B) : Equivalent weight, n-factor and Normality for Oxidant and Reductant

(c) Equivalent weight of oxidising / reducing agents in a redox reaction

In case of redox change, **v.f.** = Total change in oxidation number per molecule.

Solved Examples



Sol. Mn in KMnO_4 is going from +7 to +2, so change in oxidation number per molecule of KMnO_4 is 5. So the valency factor of KMnO_4 is 5 and equivalent weight is $\frac{M}{5}$.

Normality :

Normality of a solution is defined as the number of equivalents of solute present in one litre (1000 mL) solution.

Let V mL of a solution is prepared by dissolving W g of solute of equivalent weight E in water.

- Number of equivalents of solute = $\frac{W}{E}$

V mL of solution contain $\frac{W}{E}$ equivalents of solute

∴ 1000 mL solution will contain $\frac{W \times 1000}{E \times V}$ equivalents of solute.

- **Normality (N)** = $\frac{W \times 1000}{E \times V}$

- **Relations between Normality and Molarity :**

Normality (N) = Molarity × Valency factor

or $N \times V \text{ (in mL)} = M \times V \text{ (in mL)} \times n$

or **milliequivalents = millimoles × n**

Solved Examples

Ex-8. Calculate the normality of a solution containing 15.8 g of KMnO_4 in 50 mL acidic solution.

So. **Normality (N)** = $\frac{W \times 1000}{E \times V}$

Here $W = 15.8 \text{ g}$, $V = 50 \text{ mL}$ $E = \frac{\text{molar mass of } \text{KMnO}_4}{\text{Valency factor}} = 158/5 = 31.6$

So, normality = 10 N

Ex-9. Calculate the normality of a solution containing 50 mL of 5 M solution of $\text{K}_2\text{Cr}_2\text{O}_7$ in acidic medium.

Sol. Normality (N) = Molarity × valency factor = $5 \times 6 = 30 \text{ N}$





Section (C) : Equivalent Concept for Acid Base Titration and Precipitation Reactions

Law of Equivalence :

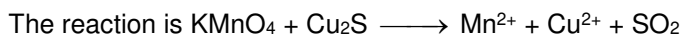
The law states that one equivalent of an element combine with one equivalent of the other. In a chemical reaction, equivalents and milli equivalents of reactants react in equal amount to give same number of equivalents or milli equivalents of products separately.

Accordingly

- (i) $aA + bB \rightarrow mM + nN$; meq of A = meq of B = meq of M = m.eq. of N
 (ii) In a compound M_xN_y ; meq of M_xN_y = meq of M = meq of N

Solved Examples

Ex-10. Find the number of moles of $KMnO_4$ needed to oxidise one mole Cu_2S in acidic medium.



Sol. From law of equivalence,

equivalents of Cu_2S = equivalents of $KMnO_4$

moles of $Cu_2S \times v.f.$ = moles of $KMnO_4 \times v.f.$

$$1 \times 8 = \text{moles of } KMnO_4 \times 5 \quad \Rightarrow \quad \text{moles of } KMnO_4 = 8/5$$

$$(\therefore v.f. \text{ of } Cu_2S = 2(2 - 1) + 1(4 - (-2))) = 8 \text{ and } v.f. \text{ of } KMnO_4 = 1(7 - 2) = 5)$$

Ex-11. The number of moles of oxalate ions oxidized by one mole of MnO_4^- ion in acidic medium are :

- (A) $\frac{5}{2}$ (B) $\frac{2}{5}$ (C) $\frac{3}{5}$ (D) $\frac{5}{3}$

Sol. Equivalents of $C_2O_4^{2-}$ = equivalents of MnO_4^-

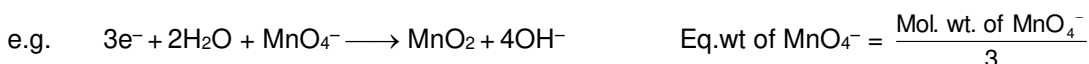
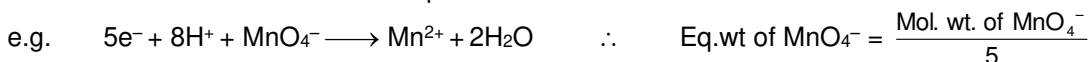
$$x(\text{mole}) \times 2 = 1 \times 5$$

$$(\therefore v.f. \text{ of } C_2O_4^{2-} = 2(4 - 3) = 2 \text{ and } v.f. \text{ of } MnO_4^- = 1(7 - 2) = 5).$$

$$x = \frac{5}{2} \text{ mole of } C_2O_4^{2-} \text{ ions.}$$

Drawbacks of Equivalent concept :

- Since equivalent weight of a substance (for example oxidising or reducing agent) may be variable hence it is better to use mole concept.



Thus, the number of equivalents of MnO_4^- will be different in the above two cases but number of moles will be same.

- Normality of any solution depends on reaction while molarity does not.**

For example : Consider 0.1mol $KMnO_4$ dissolved in water to make 1L solution. Molarity of this solution is 0.1 M. However, its normality is NOT fixed. It will depend upon the reaction in which $KMnO_4$ participates. e.g. if $KMnO_4$ forms Mn^{2+} , normality = $0.1 \times 5 = 0.5$ N. This *same* sample of $KMnO_4$, if employed in a reaction giving MnO_2 as product (Mn in +4 state), will have normality $0.1 \times 3 = 0.3$ N.

- The concept of equivalents is handy, but it should be used with care.** One must never equate equivalents in a sequence which involves same element in more than two oxidation states. Consider an example, KIO_3 reacts with KI to liberate iodine and liberated iodine is titrated with standard hypo solution. The reactions are :



$$\text{meq of hypo} = \text{meq of } I_2 = \text{meq of } IO_3^- = \text{meq of } I^-$$

$$\therefore \text{meq of hypo} = \text{meq of } IO_3^-.$$

This is wrong. Note that I_2 formed by equation (i) has v.f. = 5/3 & in equation (ii) has v.f. = 2.

\therefore v.f. of I_2 in both the equation are different, therefore we cannot equate milli equivalents in sequence. In this type of case, students are advised to use mole concept.



Solved Examples

Ex-12 How many millilitres of 0.02 M KMnO_4 solution would be required to exactly titrate 25 mL of 0.2 M $\text{Fe}(\text{NO}_3)_2$ solution in acidic medium ?

Sol. Method -1 : Mole concept method

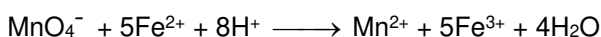
Starting with 25 mL of 0.2 M Fe^{2+} , we can write :

$$\text{Millimoles of } \text{Fe}^{2+} = 25 \times 0.2 \quad \dots\dots(1)$$

and in volume V (in milliliters) of the KMnO_4 ,

$$\text{Millimoles of } \text{MnO}_4^- = V (0.02) \quad \dots\dots(2)$$

The balanced reaction is :



This requires that at the equivalent point,

$$\frac{\text{m.moles of } \text{MnO}_4^-}{1} = \frac{\text{m.moles of } \text{Fe}^{2+}}{5}$$

$$\therefore \frac{V(0.02)}{1} = \frac{(25)(0.2)}{5} \quad (\text{from (1) \& (2)})$$

$$\therefore V = 50 \text{ mL.}$$

Method -2 : Equivalent Method :

At the equivalence point,

milliequivalents of MnO_4^- = milliequivalents of Fe^{2+}

$$M_1 \times v f_1 \times V_1 = M_2 \times v f_2 \times V_2$$

$$0.02 \times 5 \times V_1 = 0.2 \times 1 \times 25 \quad (\because \text{MnO}_4^- \longrightarrow \text{Mn}^{2+}; v.f. = 5, \text{Fe}^{2+} \longrightarrow \text{Fe}^{3+}; v.f. = 1)$$

$$\therefore V_1 = 50 \text{ mL.}$$

Section (D) : Equivalent Concept for Redox reactions, KMnO_4 / $\text{K}_2\text{Cr}_2\text{O}_7$ v/s Reducing Agents & their Redox Titration

Titration :

Titration is a procedure for determining the concentration of a solution by allowing its carefully measured volume to react with a standard solution of another substance, whose concentration is known.

Standard solution - It is a solution whose concentration is known and is taken in burette. It is also called **Titrant**.

There are two type of titrants :

- **Primary titrants/standard** : These reagents can be accurately weighed and their solutions are not to be standardised before use.

Ex : Oxalic acid, $\text{K}_2\text{Cr}_2\text{O}_7$, AgNO_3 , CuSO_4 , ferrous ammonium sulphate, hypo etc.

- **Secondary titrants/standard** : These reagents cannot be accurately weighed and their solutions are to be standardised before use.

Ex : NaOH , KOH , HCl , H_2SO_4 , I_2 , KMnO_4 etc.

Titrate : Solution consisting of substance to be estimated, its generally taken in a beaker .

Equivalence point : It is the point when number of equivalents of titrant added becomes equal to number of equivalents of titrate.

At equivalence point :

$$n_1 V_1 M_1 = n_2 V_2 M_2$$

Indicator : An auxiliary substance added for physical detection of completion of titration at equivalence point. It generally show colour change on completion of titration.



**Type of Titrations :**

- Acid-base titrations (to be studied in Ionic equilibrium)
- Redox Titrations

Some Common Redox Titrations**Table of Redox Titrations : (Excluding Iodometric / Iodimetric titrations)**

S.No.	Estimation of	By titrating with	Reactions	Relation* between OA and RA
1	Fe ²⁺	MnO ₄ ⁻	Fe ²⁺ → Fe ³⁺ + e ⁻ MnO ₄ ⁻ + 8H ⁺ + 5e ⁻ → Mn ²⁺ + 4H ₂ O	5Fe ²⁺ ≡ MnO ₄ ⁻ Eq. wt. of Fe ²⁺ = M/1
2	Fe ²⁺	Cr ₂ O ₇ ²⁻	Fe ²⁺ → Fe ³⁺ + e ⁻ Cr ₂ O ₇ ²⁻ + 14H ⁺ + 6e ⁻ → 2Cr ³⁺ + 7H ₂ O	6Fe ²⁺ ≡ Cr ₂ O ₇ ²⁻ Eq. wt. of Cr ₂ O ₇ ²⁻ = M/6
3	C ₂ O ₄ ²⁻	MnO ₄ ⁻	C ₂ O ₄ ²⁻ → 2CO ₂ + 2e ⁻ MnO ₄ ⁻ + 8H ⁺ + 5e ⁻ → Mn ²⁺ + 4H ₂ O	5C ₂ O ₄ ²⁻ ≡ 2MnO ₄ ⁻ Eq. wt. of C ₂ O ₄ ²⁻ = M/2
4	H ₂ O ₂	MnO ₄ ⁻	H ₂ O ₂ → 2H ⁺ + O ₂ + 2e ⁻ MnO ₄ ⁻ + 8H ⁺ + 5e ⁻ → Mn ²⁺ + 4H ₂ O	5H ₂ O ₂ ≡ 2MnO ₄ ⁻ Eq. wt. of H ₂ O ₂ = M/2
5	As ₂ O ₃	MnO ₄ ⁻	As ₂ O ₃ + 5H ₂ O → 2AsO ₄ ³⁻ + 10H ⁺ + 4e ⁻ MnO ₄ ⁻ + 8H ⁺ + 5e ⁻ → Mn ²⁺ + 4H ₂ O	Eq. wt. of As ₂ O ₃ = M/4
6	AsO ₃ ³⁻	BrO ₃ ⁻	AsO ₃ ³⁻ + H ₂ O → AsO ₄ ³⁻ + 2H ⁺ + 2e ⁻ BrO ₃ ⁻ + 6H ⁺ + 6e ⁻ → Br ⁻ + 3H ₂ O	Eq. wt. of AsO ₃ ³⁻ = M/2 Eq. wt. of BrO ₃ ⁻ = M/6

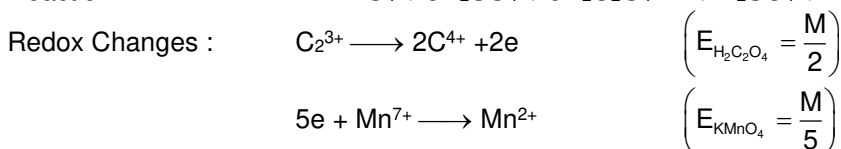
Permanganate Titrations :

- KMnO₄ is generally used as an oxidising agent in acidic medium generally provided by dilute H₂SO₄.
- KMnO₄ works as self indicator persistent pink color is the indication of end point.
- Mainly used for estimation of Fe²⁺, oxalic acid, oxalates, H₂O₂ etc.

Solved Examples

Ex-13 Write the balanced reaction of titration of KMnO₄ Vs oxalic acid in presence of H₂SO₄.

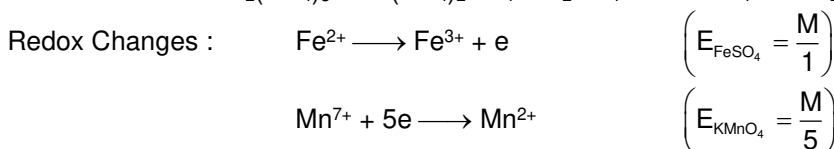
Sol. Reaction : $2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 + 5\text{H}_2\text{C}_2\text{O}_4 \longrightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 8\text{H}_2\text{O} + 10\text{CO}_2$



Indicator : KMnO₄ acts as self indicator.

Ex-14 Write the balanced reaction of titration of KMnO₄ vs ferrous ammonium sulphate in presence of H₂SO₄.

Sol. Reaction : $2\text{KMnO}_4 + 10[\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}] + 8\text{H}_2\text{SO}_4 \longrightarrow 5\text{Fe}_2(\text{SO}_4)_3 + 10(\text{NH}_4)_2\text{SO}_4 + \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 68\text{H}_2\text{O}$



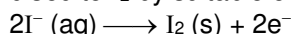
Indicator : KMnO₄ acts as self indicator

Section (E) : Iodometric/Iodimetric Titration, Calculation of Available Chlorine from a sample of bleaching powder

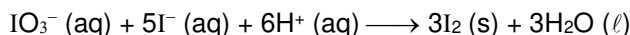
Iodometric/Iodimetric Titrations :

Compound containing iodine are widely used in titrations.

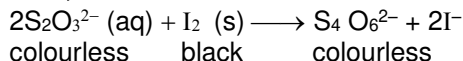
(i) Iodide ions can be oxidised to I₂ by suitable oxidising agent.



(ii) Iodine (V) ions, IO₃⁻, will oxidise I⁻ to I₂.



(iii) Thiosulphate ions, S₂O₃²⁻, can reduce iodine to iodide ions.



Iodometric Titrations (Titration Solution is of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$)

S.No.	Estimation of	Reaction	Relation between O.A. and R.A.
1.	I_2	$\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \longrightarrow 2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6$ or $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \longrightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$	$\text{I}_2 \equiv 2\text{I} \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{Na}_2\text{S}_2\text{O}_3 = \text{M}/1$
2.	CuSO_4	$2\text{CuSO}_4 + 4\text{KI} \longrightarrow 2\text{CuI} + 2\text{K}_2\text{SO}_4 + \text{I}_2$ or $2\text{Cu}^{2+} + 4\text{I}^- \longrightarrow 2\text{CuI} + \text{I}_2$ white ppt	$2\text{CuSO}_4 \equiv \text{I}_2 \equiv 2\text{I} \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{CuSO}_4 = \text{M}/1$
3.	CaOCl_2	$\text{CaOCl}_2 + \text{H}_2\text{O} \longrightarrow \text{Ca(OH)}_2 + \text{Cl}_2$ $\text{Cl}_2 + 2\text{KI} \longrightarrow 2\text{KCl} + \text{I}_2$ $\text{Cl}_2 + 2\text{I}^- \longrightarrow 2\text{Cl}^- + \text{I}_2$	$\text{CaOCl}_2 \equiv \text{Cl}_2 \equiv \text{I}_2 \equiv 2\text{I} \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{CaOCl}_2 = \text{M}/2$
4.	MnO_2	$\text{MnO}_2 + 4\text{HCl}(\text{conc.}) \xrightarrow{\Delta} \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$ $\text{Cl}_2 + 2\text{KI} \longrightarrow 2\text{KCl} + \text{I}_2$ or $\text{MnO}_2 + 4\text{H}^+ + 2\text{Cl}^- \longrightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O} + \text{Cl}_2$ $\text{Cl}_2 + 2\text{I}^- \longrightarrow \text{I}_2 + 2\text{Cl}^-$	$\text{MnO}_2 \equiv \text{Cl}_2 \equiv \text{I}_2 \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{MnO}_2 = \text{M}/2$
5.	IO_3^-	$\text{IO}_3^- + 5\text{I}^- + 6\text{H}^+ \longrightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$	$\text{IO}_3^- \equiv 3\text{I}_2 \equiv 6\text{I} \equiv 6\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{IO}_3^- = \text{M}/6$
6.	H_2O_2	$\text{H}_2\text{O}_2 + 2\text{I}^- + 2\text{H}^+ \longrightarrow \text{I}_2 + 2\text{H}_2\text{O}$	$\text{H}_2\text{O}_2 \equiv \text{I}_2 \equiv 2\text{I} \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{H}_2\text{O}_2 = \text{M}/2$
7.	Cl_2	$\text{Cl}_2 + 2\text{I}^- \longrightarrow 2\text{Cl}^- + \text{I}_2$	$\text{Cl}_2 \equiv \text{I}_2 \equiv 2\text{I} \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{Cl}_2 = \text{M}/2$
8.	O_3	$\text{O}_3 + 6\text{I}^- + 6\text{H}^+ \longrightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$	$\text{O}_3 \equiv 3\text{I}_2 \equiv 6\text{I} \equiv 6\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{O}_3 = \text{M}/6$
9.	ClO^-	$\text{ClO}^- + 2\text{I}^- + 2\text{H}^+ \longrightarrow \text{H}_2\text{O} + \text{Cl}^- + \text{I}_2$	$\text{ClO}^- \equiv \text{I}_2 \equiv 2\text{I} \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{ClO}^- = \text{M}/2$
10.	$\text{Cr}_2\text{O}_7^{2-}$	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{I}^- \longrightarrow 3\text{I}_2 + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	$\text{Cr}_2\text{O}_7^{2-} \equiv 3\text{I}_2 \equiv 6\text{I}$ Eq.wt. of $\text{Cr}_2\text{O}_7^{2-} = \text{M}/6$
11.	MnO_4^-	$2\text{MnO}_4^- + 10\text{I}^- + 16\text{H}^+ \longrightarrow 2\text{Mn}^{2+} + 5\text{I}_2 + 8\text{H}_2\text{O}$	$2\text{MnO}_4^- \equiv 5\text{I}_2 \equiv 10\text{I}$ Eq.wt. of $\text{MnO}_4^- = \text{M}/5$
12.	BrO_3^-	$\text{BrO}_3^- + 6\text{I}^- + 6\text{H}^+ \longrightarrow \text{Br}^- + 3\text{I}_2 + 3\text{H}_2\text{O}$	$\text{BrO}_3^- \equiv 3\text{I}_2 \equiv 6\text{I}$ Eq.wt. of $\text{BrO}_3^- = \text{M}/6$
13.	As(V)	$\text{H}_2\text{AsO}_4 + 2\text{I}^- + 3\text{H}^+ \longrightarrow \text{H}_3\text{AsO}_3 + \text{H}_2\text{O} + \text{I}_2$	$\text{H}_3\text{AsO}_4 \equiv \text{I}_2 \equiv 2\text{I}$ Eq.wt. of $\text{H}_3\text{AsO}_4 = \text{M}/2$
14.	HNO_2	$2\text{HNO}_2 + 2\text{I}^- \longrightarrow \text{I}_2 + 2\text{NO} + \text{H}_2\text{O}$	$2\text{HNO}_2 \equiv \text{I}_2 \equiv 2\text{I}$ Eq.wt. of $\text{HNO}_2 = \text{M}/1$
15.	HClO	$\text{HClO} + 2\text{I}^- + \text{H}^+ \longrightarrow \text{Cl}^- + \text{I}_2 + \text{H}_2\text{O}$	$\text{HClO} \equiv \text{I}_2 \equiv 2\text{Na}_2\text{S}_2\text{O}_3$ Eq.wt. of $\text{HClO} = \text{M}/2$

Iodimetric Titrations

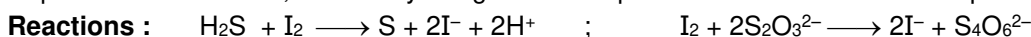
S.No.	Estimation of	Reaction	Relation between O.A. and R.A.
1.	H_2S (in acidic medium)	$\text{H}_2\text{S} + \text{I}_2 \longrightarrow \text{S} + 2\text{I}^- + 2\text{H}^+$	$\text{H}_2\text{S} \equiv \text{I}_2 \equiv 2\text{I}$ Eq.wt. of $\text{H}_2\text{S} = \text{M}/2$
2.	SO_3^{2-} (in acidic medium)	$\text{SO}_3^{2-} + \text{I}_2 + \text{H}_2\text{O} \longrightarrow \text{SO}_4^{2-} + 2\text{I}^- + 2\text{H}^+$	$\text{SO}_3^{2-} \equiv \text{I}_2 \equiv 2\text{I}$ Eq.wt. of $\text{SO}_3^{2-} = \text{M}/2$
3.	Sn^{2+} (in acidic medium)	$\text{Sn}^{2+} + \text{I}_2 \longrightarrow \text{Sn}^{4+} + 2\text{I}^-$	$\text{Sn}^{2+} \equiv \text{I}_2 \equiv 2\text{I}$ Eq.wt. of $\text{Sn}^{2+} = \text{M}/2$
4.	As(III) (at pH 8)	$\text{H}_2\text{AsO}_3^- + \text{I}_2 + \text{H}_2\text{O} \longrightarrow \text{HAsO}_4^{2-} + 2\text{I}^- + 3\text{H}^+$	$\text{H}_2\text{AsO}_3^- \equiv \text{I}_2 \equiv 2\text{I}$ Eq.wt. of $\text{H}_2\text{AsO}_3^- = \text{M}/2$
5.	N_2H_4	$\text{N}_2\text{H}_4 + 2\text{I}_2 \longrightarrow \text{N}_2 + 4\text{H}^+ + 4\text{I}^-$	$\text{N}_2\text{H}_4 \equiv 2\text{I}_2 \equiv 4\text{I}$ Eq.wt. of $\text{N}_2\text{H}_4 = \text{M}/4$





Solved Examples

Ex-15. The sulphur content of a steel sample is determined by converting it to H_2S gas, absorbing the H_2S in 10 mL of 0.005 M I_2 and then back titrating the excess I_2 with 0.002 M $\text{Na}_2\text{S}_2\text{O}_3$. If 10 mL $\text{Na}_2\text{S}_2\text{O}_3$ is required for the titration, how many milligrams of sulphur are contained in the sample?



Sol. Used millimoles of I_2 = (m.moles of I_2 taken initially) – $\frac{\text{m.moles of hypo used}}{2}$

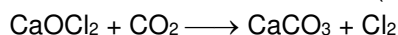
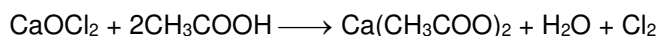
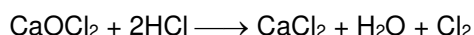
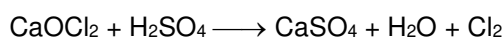
$$= 0.005 \times 10 - 0.002 \times \frac{10}{2}$$

$$= 0.04 = \text{millimoles of } \text{H}_2\text{S}$$

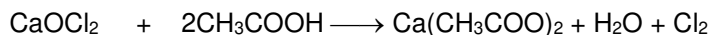
$$\therefore \text{Weight of sulphur} = 0.04 \times 10^{-3} \times 32 \times 10^3 \text{ mg} = 1.28 \text{ mg.}$$

Calculation of available chlorine from a sample of bleaching powder :

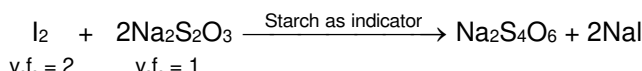
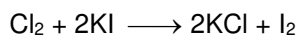
The weight of available Cl_2 released from the given sample of bleaching powder on reaction with dilute acids or CO_2 is called available chlorine.



Method of determination :



(Sample of bleaching powder)



v.f. = 2 v.f. = 1

End point is indicated by disappearance of blue colour.

Let M = Molarity of hypo ($\text{Na}_2\text{S}_2\text{O}_3$) solution

\therefore millimoles of Cl_2 produced = m.moles of I_2 used by hypo

$$= \frac{M \times V}{2} \text{ where } V = \text{vol of hypo solution used in ml.}$$

$$\begin{aligned} \text{mass of } \text{Cl}_2 \text{ produced} &= \frac{M \times V \times 10^{-3}}{2} \times 71 \\ &= 35.5 \times M \times V \times 10^{-3} \end{aligned}$$

$$\therefore \% \text{ of available chlorine} = \frac{35.5 \times M \times V \times 10^{-3}}{W} \times 100$$

where W = amount of bleaching powder taken in g.

$$\text{or } \% \text{ of available } \text{Cl}_2 = \frac{3.55 \times M \times V}{W}$$

Solved Examples

Ex-16 3.55 g sample of bleaching powder suspended in H_2O was treated with enough acetic acid and KI solution. Iodine thus liberated required 80 mL of 0.2 M hypo for titration. Calculate the % of available chlorine.

$$\text{So. } \% \text{ of } \text{Cl}_2 = \frac{3.55 \times 0.2 \times 80}{3.55} = 16\%$$

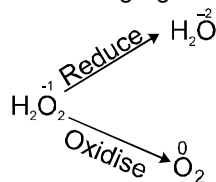




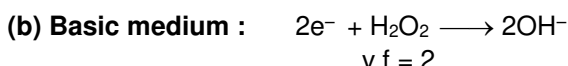
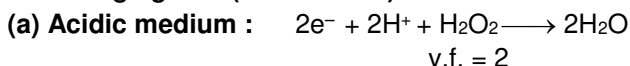
Section (F) : Volume strength of H_2O_2 , Hardness of water

Hydrogen peroxide (H_2O_2)

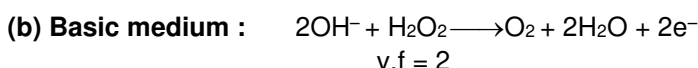
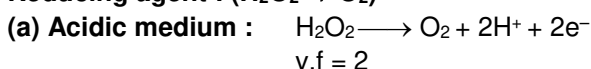
H_2O_2 can behave both like oxidising and reducing agent in both the mediums (acidic and basic).



- **Oxidising agent : ($\text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O}$)**



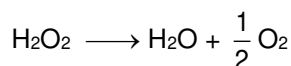
- **Reducing agent : ($\text{H}_2\text{O}_2 \rightarrow \text{O}_2$)**



Volume strength of H_2O_2 : Strength of H_2O_2 is represented as 10V, 20 V, 30 V etc.

20V H_2O_2 means **one litre** of this sample of H_2O_2 on decomposition gives **20L of O_2 gas at STP**.

Decomposition of H_2O_2 is given as :



$$1 \text{ mole} \quad \frac{1}{2} \times 22.4 \text{ L O}_2 \text{ at STP}$$

$$= 34\text{g} \quad = 11.2 \text{ L O}_2 \text{ at STP}$$

- **Molarity of H_2O_2 (M) =**
$$\frac{\text{Volume strength of } \text{H}_2\text{O}_2}{11.2}$$

Strength (in g/L) : Denoted by S

$$\text{Strength} = \text{Molarity} \times \text{Mol. wt} = \text{Molarity} \times 34$$

Hardness of water (Hard water does not give lather with soap)

Temporary hardness - due to bicarbonates of Ca & Mg

Permanent hardness - due to chlorides & sulphates of Ca & Mg. There are some method by which we can soften the water sample.

- (a) By boiling : $2\text{HCO}_3^- \longrightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{CO}_3^{2-}$ **or**
By Slaked lime : $\text{Ca}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \longrightarrow \text{CaCO}_3 + 2\text{H}_2\text{O}$
 $\text{Ca}^{2+} + \text{CO}_3^{2-} \longrightarrow \text{CaCO}_3$
- (b) By Washing Soda : $\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \longrightarrow \text{CaCO}_3 + 2\text{NaCl}$
- (c) By ion exchange resins : $\text{Na}_2\text{R} + \text{Ca}^{2+} \longrightarrow \text{CaR} + 2\text{Na}^+$
- (d) By adding chelating agents like $(\text{PO}_3^-)_3$ etc.

Measurement of Hardness :

Hardness is measured in terms of ppm (parts per million) of CaCO_3 or equivalent to it.

$$\text{Hardness in ppm} = \frac{\text{mass of } \text{CaCO}_3}{\text{Total mass of solution}} \times 10^6$$



Solved Examples

Ex-17 0.00012% MgSO_4 and 0.000111% CaCl_2 is present in water. What is the measured hardness of water and millimoles of washing soda required to purify water 1000 L water ?

Sol. Basis of calculation = 100 g hard water

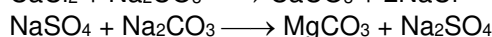
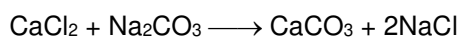
$$\text{MgSO}_4 = 0.00012 \text{ g} = \frac{0.00012}{120} \text{ mole}$$

$$\text{CaCl}_2 = 0.000111 \text{ g} = \frac{0.000111}{111} \text{ mole}$$

$$\therefore \text{equivalent moles of } \text{CaCO}_3 = \left(\frac{0.00012}{120} + \frac{0.000111}{111} \right) \text{ mole}$$

$$\therefore \text{mass of } \text{CaCO}_3 = \left(\frac{0.00012}{120} + \frac{0.000111}{111} \right) \times 100 = 2 \times 10^{-4} \text{ g}$$

$$\text{Hardness (in terms of ppm of } \text{CaCO}_3) = \frac{2 \times 10^{-4}}{100} \times 10^6 = 2 \text{ ppm}$$



$$\therefore \text{Required } \text{Na}_2\text{CO}_3 \text{ for 100g of water} = \left(\frac{0.00012}{120} + \frac{0.000111}{111} \right) \text{ mole}$$

$$= 2 \times 10^{-6} \text{ mole}$$

$$\therefore \text{Required } \text{Na}_2\text{CO}_3 \text{ for 1000 litre water} = \frac{2 \times 10^{-6}}{100} \times 10^6 = \frac{2}{100} \text{ mole } (\because d = 1 \text{ g/mL})$$

$$= \frac{20}{1000} \text{ mole} = 20 \text{ m mole}$$

Strength of Oleum :

Oleum is SO_3 dissolved in 100% H_2SO_4 . Sometimes, oleum is reported as more than 100% by weight, say $y\%$ (where $y > 100$). This means that $(y - 100)$ grams of water, when added to 100 g of given oleum sample, will combine with all the free SO_3 in the oleum to give 100% sulphuric acid.

Hence, weight % of free SO_3 in oleum = $80(y - 100)/18$

Solved Examples

Ex-18 What volume of water is required (in mL) to prepare 1 L of 1 M solution of H_2SO_4 (density = 1.5g/mL) by using 109% oleum and water only (Take density of pure water = 1 g/mL).

Sol. 1 mole H_2SO_4 in 1L solution = 98 g H_2SO_4 in 1500 g solution = 98 g H_2SO_4 in 1402 g water.

Also, in 109% oleum, 9 g H_2O is required to form 109 g pure H_2SO_4 & so, to prepare 98 g H_2SO_4 , water needed is $9/109 \times 98 = 8.09$ g.

Total water needed = $1402 + 8.09 = 1410.09 \text{ g} = 1410.09 \text{ mL}$

MISCELLANEOUS SOLVED PROBLEMS (MSPS)

1. Find the valency factor for following acids

(i) CH_3COOH (ii) NaH_2PO_4 (iii) H_3BO_3

Ans. (i) 1 (ii) 2 (iii) 1

2. Find the valency factor for following bases :

(i) $\text{Ca}(\text{OH})_2$ (ii) CsOH (iii) $\text{Al}(\text{OH})_3$

Ans. (i) 2 (ii) 1 (iii) 3

3. Find the valence factor for following salts :

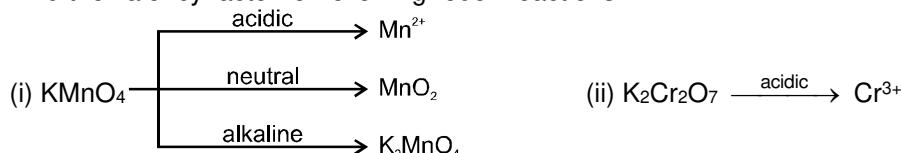
(i) $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (ii) CaCO_3

Ans. (i) 8 (ii) 2





4. Find the valency factor for following redox reactions :



Ans. (iii) $\text{C}_2\text{O}_4^{2-} \longrightarrow \text{CO}_2$ (iv) $\text{Fe}^{2+} \longrightarrow \text{Fe}^{3+}$
 (i) 5, 3, 1; (ii) 6; (iii) 2; (iv) 1

5. Calculate the normality of a solution obtained by mixing 50 mL of 5 M solution of $\text{K}_2\text{Cr}_2\text{O}_7$ and 50 mL of 2 M $\text{K}_2\text{Cr}_2\text{O}_7$ in acidic medium.

Sol. v.f. of $\text{K}_2\text{Cr}_2\text{O}_7 = 6$

$$\text{so } N_f = \frac{N_1V_1 + N_2V_2}{V_1 + V_2} = \frac{5 \times 6 \times 50 + 2 \times 6 \times 50}{50 + 50} = 21 \text{ N}$$

6. Calculate the normality of a solution containing 13.4 g of Sodium oxalate in 100 mL Sol.

Sol. Normality = $\frac{\text{wt. in g / eq. wt}}{\text{vol. of solution in litre}}$

Here, eq. wt. of $\text{Na}_2\text{C}_2\text{O}_4 = 134/2 = 67$

$$\text{so } N = \frac{13.4 / 67}{100 / 1000} = 2 \text{ N}$$

7. The number of moles of ferrous oxalate oxidised by one mole of KMnO_4 in acidic medium is :

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

Sol. Eq. of $\text{FeC}_2\text{O}_4 = \text{Eq. of } \text{KMnO}_4$

moles of $\text{FeC}_2\text{O}_4 \times 3 = \text{moles of } \text{KMnO}_4 \times 5$

so, moles of $\text{FeC}_2\text{O}_4 = 5/3$ **Ans. (D)**

8. How many moles of KMnO_4 are needed to oxidise a mixture of 1 mole of each FeSO_4 & FeC_2O_4 in acidic medium ?

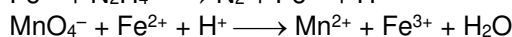
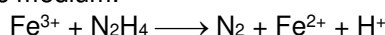
(A) 4/5 (B) 5/4 (C) 3/4 (D) 5/3

Sol. Eq. of $\text{KMnO}_4 = \text{Eq. of } \text{FeSO}_4 + \text{Eq. of } \text{FeC}_2\text{O}_4$

moles of $\text{KMnO}_4 \times 5 = \text{moles of } \text{FeSO}_4 \times 1 + \text{moles of } \text{FeC}_2\text{O}_4 \times 3$

\therefore moles of $\text{KMnO}_4 = 4/5$ **Ans. (A)**

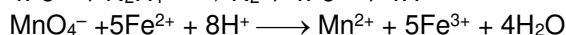
9. A sample of hydrazine sulphate [$\text{N}_2\text{H}_6\text{SO}_4$] was dissolved in 100 mL water. 10 mL of this solution was treated with excess of FeCl_3 Sol. Ferrous ions formed were estimated and it required 20 mL of M/50 KMnO_4 solution in acidic medium.



(a) Write the balanced redox reactions.

(b) Estimate the amount of hydrazine sulphate in one litre of Sol.

Sol. (a) Given $4\text{Fe}^{3+} + \text{N}_2\text{H}_4 \longrightarrow \text{N}_2 + 4\text{Fe}^{2+} + 4\text{H}^+$



(b) In 10 mL solution, eq. of $\text{N}_2\text{H}_6\text{SO}_4 = \text{Eq. of } \text{Fe}^{2+} = \text{Eq. of } \text{KMnO}_4$

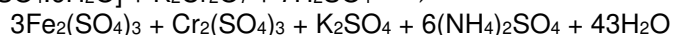
$$= 20 \times \frac{1}{50} \times 5 \times 10^{-3} = 2 \times 10^{-3}$$

v.f. of $\text{N}_2\text{H}_6\text{SO}_4 = 4$

$$\text{so, weight of } \text{N}_2\text{H}_6\text{SO}_4 \text{ in 1 L solution} = \frac{2 \times 10^{-3} \times 1000}{4 \times 10} \times 130 = 6.5 \text{ g.}$$

10. Write the balanced redox reaction and calculate the equivalent weight of oxidising agent and reducing agent for titration of $\text{K}_2\text{Cr}_2\text{O}_7$ Vs Ferrous ammonium sulphate.

Ans. The reaction : $6[\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}] + \text{K}_2\text{Cr}_2\text{O}_7 + 7\text{H}_2\text{SO}_4 \longrightarrow$



Redox changes : $\left(E_{\text{FeSO}_4} = \frac{M}{1} \right) ; \left(E_{\text{K}_2\text{Cr}_2\text{O}_7} = \frac{M}{6} \right)$



11. One litre of acidified KMnO_4 solution containing 15.8 g KMnO_4 is decolorized by passing sufficient SO_2 . If SO_2 is produced by FeS_2 , what is the amount of FeS_2 required to give desired SO_2 ?

Ans. 15 g.

Sol. v.f. of $\text{KMnO}_4 = 5$ & v.f. of $\text{SO}_2 = 2$

Now, Eq. of $\text{KMnO}_4 = \text{Eq. of } \text{SO}_2$

$$\frac{15.8}{158/5} = \text{moles of } \text{SO}_2 \times 2$$

so, moles of $\text{SO}_2 = 1/4$

Now, applying POAC on S, we get :

$$2 \times \text{mole of } \text{FeS}_2 = 1 \times \text{moles of } \text{SO}_2$$

$$\text{so, moles of } \text{FeS}_2 = \frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$$

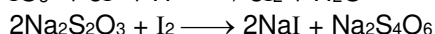
$$\text{so, weight of } \text{FeS}_2 = \frac{1}{8} \times 120 = 15 \text{ g.}$$

12. An aqueous solution containing 0.1 g KIO_3 (formula weight = 214) and an excess of KI was acidified with HCl . The liberated I_2 consumed 45 mL of thiosulphate. The molarity of sodium thiosulphate solution is :

The reaction involved is : $\text{IO}_3^- + \text{I}^- + \text{H}^+ \longrightarrow \text{I}_2 + \text{H}_2\text{O}$

(A) 0.0623 M (B) 0.0313 M (C) 0.126 M (D) 0.252 M

Sol. $\text{IO}_3^- + 5\text{I}^- + \text{H}^+ \longrightarrow 3\text{I}_2 + \text{H}_2\text{O}$



$$\text{Now, Moles of } \text{KIO}_3 = \frac{0.1}{214}$$

$$\text{So, Moles of } \text{I}_2 = 3 \times \frac{0.1}{214}$$

$$\text{Now, Moles of } \text{Na}_2\text{S}_2\text{O}_3 = 2 \times 3 \times \frac{0.1}{214}$$

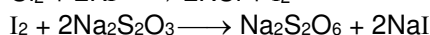
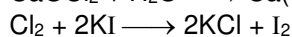
$$\therefore M \times V_L = 2 \times 3 \times \frac{0.1}{214} \quad \therefore M \times \frac{45}{1000} = 2 \times 3 \times \frac{0.1}{214}$$

$$\text{Now, Molarity of hypo solution} = 2 \times 3 \times \frac{0.1}{214} \times \frac{1000}{45} = 0.0623 \text{ M} \quad \text{Ans. (A)}$$

13. Calculate the percentage of available chlorine in a sample of 3.55 g of bleaching powder which was dissolved in 100 mL of water. 25 mL of this solution, on treatment with KI and dilute acid, required 20 mL of 0.125 N sodium thiosulphate Sol.

Ans. 10 %

Sol. $\text{CaOCl}_2 + \text{H}_2\text{O} \longrightarrow \text{Ca(OH)}_2 + \text{Cl}_2$



$$\text{In 25 mL solution, moles of } \text{Na}_2\text{S}_2\text{O}_3 = \frac{20}{1000} \times \frac{0.125}{1} = 25 \times 10^{-4}$$

$$\begin{aligned} \text{So, moles of } \text{I}_2 &= \frac{1}{2} \times \text{moles of } \text{Na}_2\text{S}_2\text{O}_3 \\ &= \frac{1}{2} \times 25 \times 10^{-4} = 12.5 \times 10^{-4} \end{aligned}$$

$$\text{So, in 100 mL solution, moles of } \text{Cl}_2 = 4 \times 12.5 \times 10^{-4} = 50 \times 10^{-4}$$

$$\text{So, weight of } \text{Cl}_2 = 50 \times 10^{-4} \times 71 \text{ g}$$

$$\% \text{ of available } \text{Cl}_2 = \frac{50 \times 10^{-4} \times 71}{3.55} \times 100 = 10\%$$





Exercise-1

✎ Marked questions are recommended for Revision.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Classical Concept of Equivalent weight / Mass, Equivalent weight, n-factor and Normality for Acid, Base and Precipitate

- A-1.** Determine the equivalent weight of the following ions :
 (a) Na^+ (b) Al^{3+} (c) NO^+ (d) Cl^-
 (e) CO_3^{2-} (f) SO_4^{2-} (g) PO_4^{3-}
- A-2.** Determine the equivalent weights of the following salts :
 (a) NaCl (b) K_2SO_4 (c) $\text{Ca}_3(\text{PO}_4)_2$
- A-3. ✎** 1.12 litre dry chlorine gas at STP was passed over a heated metal when 5.56 g of chloride of the metal was formed. What is the equivalent weight of the metal?

Section (B) : Equivalent weight, n-factor and Normality for Oxidant and Reductant

- B-1. ✎** 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.
- B-2.** Determine the equivalent weight of the following oxidising and reducing agents :
 (a) KMnO_4 (reacting in acidic medium $\text{MnO}_4^- \longrightarrow \text{Mn}^{2+}$)
 (b) KMnO_4 (reacting in neutral medium $\text{MnO}_4^- \longrightarrow \text{MnO}_2$)

Section (C) : Equivalent Concept for Acid Base Titration and Precipitation Reactions

- C-1.** 0.98 g of the metal sulphate was dissolved in water and excess of barium chloride was added. The precipitated barium sulphate weighted 0.95 g. Calculate the equivalent weight of the metal.
- C-2.** A dilute solution of H_2SO_4 is made by adding 5 mL of 3N H_2SO_4 to 245 mL of water. Find the normality and molarity of the diluted solution.
- C-3. ✎** What volume at NTP of gaseous ammonia will be required to be passed into 30 cm^3 of 1 N H_2SO_4 solution to bring down the acid strength of the latter to 0.2 N ?

Section (D) : Equivalent Concept for Redox reactions, KMnO_4 / $\text{K}_2\text{Cr}_2\text{O}_7$ v/s Reducing Agents & their Redox Titration

- D-1. ✎** 1.60 g of a metal A and 0.96 g of a metal B when treated with excess of dilute acid, separately, produced the same amount of hydrogen. Calculate the equivalent weight of A if the equivalent weight of B is 12.
- D-2.** It requires 40 mL of 1 M Ce^{4+} to titrate 20 mL of 1M Sn^{2+} to Sn^{4+} . What is the oxidation state of the Cerium in the product ?
- D-3.** 25 mL of a solution of Fe^{2+} ions was titrated with a solution of the oxidizing agent $\text{Cr}_2\text{O}_7^{2-}$. 50 mL of 0.01 M $\text{K}_2\text{Cr}_2\text{O}_7$ solution was required. What is the molarity of the Fe^{2+} solution ?
- D-4. ✎** How many mL of 0.3M $\text{K}_2\text{Cr}_2\text{O}_7$ (acidic) is required for complete oxidation of 5 mL of 0.2 M SnC_2O_4 solution.



Section (E) : Iodometric/Iodimetric Titration, Calculation of Available Chlorine from a sample of Bleaching Powder

- E-1.** 10 g sample of bleaching powder was dissolved into water to make the solution one litre. To this solution 35 mL of 1.0 M Mohr salt 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)
- E-2.** 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 ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$) for complete reaction. Calculate the mass of the mixture. The reactions are:
- $$\text{As}_2\text{O}_3 + 2\text{I}_2 + 2\text{H}_2\text{O} \longrightarrow \text{As}_2\text{O}_5 + 4\text{H}^+ + 4\text{I}^-$$
- $$\text{As}_2\text{O}_5 + 4\text{H}^+ + 4\text{I}^- \longrightarrow \text{As}_2\text{O}_3 + 2\text{I}_2 + 2\text{H}_2\text{O} \quad (\text{Atomic weight : As} = 75)$$

Section (F) : Volume strength of H_2O_2 , Hardness of water

- F-1.** 20 mL of H_2O_2 after acidification with dil H_2SO_4 required 30 mL of $\frac{N}{12}$ KMnO_4 for complete oxidation. Determine the strength of H_2O_2 solution.
- F-2.** A 100 mL sample of water was treated to convert any iron present to Fe^{2+} . Addition of 25 mL of 0.002 M $\text{K}_2\text{Cr}_2\text{O}_7$ resulted in the reaction :
- $$6\text{Fe}^{2+} + \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \longrightarrow 6\text{Fe}^{3+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$$
- The excess $\text{K}_2\text{Cr}_2\text{O}_7$ 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.
- F-3.** By which reason temporary and permanent hardness occur ?
- F-4.** Define two method by which we can soften the water sample.

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Classical Concept of Equivalent weight / Mass, Equivalent weight, n-factor and Normality for Acid, Base and Precipitate

- A-1.** 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) $\frac{x+y}{x} \times 8$
- A-2.** Equivalent wt. of H_3PO_4 in each of the reaction will be respectively -
- $$\text{H}_3\text{PO}_4 + \text{OH}^- \rightarrow \text{H}_2\text{PO}_4^- + \text{H}_2\text{O}$$
- $$\text{H}_3\text{PO}_4 + 2\text{OH}^- \rightarrow \text{HPO}_4^{2-} + 2\text{H}_2\text{O}$$
- $$\text{H}_3\text{PO}_4 + 3\text{OH}^- \rightarrow \text{PO}_4^{3-} + 3\text{H}_2\text{O}$$
- (A) 98, 49, 32.67 (B) 49, 98, 32, 67 (C) 98, 32.67, 49 (D) 32.67, 49, 98
- A-3.** 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

Section (B) : Equivalent weight, n-factor and Normality for Oxidant and Reductant

- B-1.** 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



- B-2.** When N_2 is converted into NH_3 , the equivalent weight of nitrogen will be :
 (A) 1.67 (B) 2.67 (C) 3.67 (D) 4.67
- B-3.** In the ionic equation $2\text{K}^+\text{BrO}_3^- + 12\text{H}^+ + 10\text{e}^- \longrightarrow \text{Br}_2 + 6\text{H}_2\text{O} + 2\text{K}^+$, the equivalent weight of KBrO_3 will be:
 (A) $M/5$ (B) $M/2$ (C) $M/6$ (D) $M/4$
 (where M = molecular weight of KBrO_3)

Section (C) : Equivalent Concept for Acid Base Titration and Precipitation Reactions

- C-1.** If one mole of H_2SO_4 reacts with one mole of NaOH , equivalent weight of H_2SO_4 will be :
 (A) 98 (B) 49 (C) 96 (D) 48
- C-2.** How many millilitres 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) 25.6 mL (C) 26.3 mL (D) 32.6 mL
- C-3.** 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 solution be mixed to obtain a neutral solution?
 (A) 3 : 8 (B) 8 : 3 (C) 15 : 4 (D) 4 : 15

Section (D) : Equivalent Concept for Redox reactions, KMnO_4 / $\text{K}_2\text{Cr}_2\text{O}_7$ v/s Reducing Agents & their Redox Titration

- D-1.** If equal volumes of 0.1 M KMnO_4 and 0.1 M $\text{K}_2\text{Cr}_2\text{O}_7$ solutions are allowed to oxidise Fe^{2+} to Fe^{3+} in acidic medium, then Fe^{2+} oxidised will be :
 (A) more by KMnO_4 (B) more by $\text{K}_2\text{Cr}_2\text{O}_7$
 (C) equal in both cases (D) cannot be determined.
- D-2.** Which of the following solutions will exactly oxidize 25 mL of an acid solution of 0.1 M iron (II) oxalate:
 (A) 25 mL of 0.1 M KMnO_4 (B) 25 mL of 0.2 M KMnO_4
 (C) 25 mL of 0.6 M KMnO_4 (D) 15 mL of 0.1 M KMnO_4
- D-3.** An element A in a compound ABD has oxidation number $-n$. It is oxidised by $\text{Cr}_2\text{O}_7^{2-}$ in acid medium. In the experiment, 1.68×10^{-3} moles of $\text{K}_2\text{Cr}_2\text{O}_7$ were used for 3.36×10^{-3} moles of ABD. The new oxidation number of A after oxidation is :
 (A) 3 (B) $3 - n$ (C) $n - 3$ (D) $+n$
- D-4.** The number of moles of oxalate ions oxidized by one mole of MnO_4^- ion in acidic medium is :
 (A) $5/2$ (B) $2/5$ (C) $3/5$ (D) $5/3$

Section (E) : Iodometric/Iodimetric Titration, Calculation of Available Chlorine from a sample of Bleaching Powder

- E-1.** What can be the maximum percentage of available chlorine possible in a given bleaching powder sample (Take formula of bleaching powder as CaOCl_2) ?
 (A) 52.9% (B) 55.9 % (C) 58% (D) 60%
- E-2.** A 0.2 g sample containing copper (II) was analysed iodometrically, where copper(II) is reduced to copper (I) by iodide ions. $2\text{Cu}^{2+} + 4\text{I}^- \longrightarrow 2\text{CuI} + \text{I}_2$
 If 20 mL of 0.1 M $\text{Na}_2\text{S}_2\text{O}_3$ solution is required for titration of the liberated iodine, then the percentage of copper in the sample will be :
 (A) 31.75 % (B) 63.5 % (C) 53 % (D) 37 %


Section (F) : Volume strength of H_2O_2 , Hardness of water

- F-1.** A substance which participates readily in both acid-base and oxidation-reduction reactions is :
 (A) Na_2CO_3 (B) KOH (C) KMnO_4 (D) $\text{H}_2\text{C}_2\text{O}_4$
- F-2.** A fresh H_2O_2 solution is labeled as 11.2 V. Calculate its concentration in wt/vol percent.
 (A) 3.4 (B) 6.8 (C) 1.7 (D) 13.6
- F-3.** The amount of lime, $\text{Ca}(\text{OH})_2$ required to remove the hardness in 60 L of pond water containing 1.62 mg of calcium bicarbonate per 100 ml of water, will be :
 (A) 4.44 g (B) 0.222 g (C) 2.22 g (D) 0.444 g
- F-4.** What will the concentration of $[\text{Ca}^{+2}]$ in a sample of 1 litre hard water if after treatment with washing soda 10 g insoluble CaCO_3 is precipitated.
 (A) 0.2 M (B) 0.1 M (C) 0.3 M (D) 0.4 M

PART - III : MATCH THE COLUMN

- | 1. Column I | Column II |
|--|--|
| (A) 4.1 g H_2SO_3 | (p) 200 mL of 0.5 N base is used for complete neutralization |
| (B) 4.9 g H_3PO_4 | (q) 200 millimoles of oxygen atoms |
| (C) 4.5 g oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) | (r) Central atom is in its highest oxidation number |
| (D) 5.3 g Na_2CO_3 | (s) May react with an oxidising agent |

Exercise-2

Marked questions are recommended for Revision.

PART - I : ONLY ONE OPTION CORRECT TYPE

1. 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
2. Oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$, reacts with paramagnet ion according to the balanced equation $5\text{H}_2\text{C}_2\text{O}_4 (\text{aq}) + 2\text{MnO}_4^- (\text{aq}) \rightleftharpoons 2\text{Mn}^{2+} (\text{aq}) + 10\text{CO}_2 (\text{g}) + 8\text{H}_2\text{O} (\text{l})$. The volume in mL of 0.0162 M KMnO_4 solution required to react with 25.0 mL of 0.022 M $\text{H}_2\text{C}_2\text{O}_4$ solution is :
 (A) 13.6 (B) 18.5 (C) 33.8 (D) 84.4
3. x mmol of KMnO_4 react completely with y mmol of MnSO_4 in presence of fluoride ions to give MnF_4 quantitatively. Then :
 (A) $x = y$ (B) $4x = y$ (C) $x > y$ (D) $x < y$
4. 1 mol each of H_3PO_2 , H_3PO_3 and H_3PO_4 will neutralise respectively x mol of NaOH , y mol of $\text{Ca}(\text{OH})_2$ and z mol of $\text{Al}(\text{OH})_3$ (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
5. The amount of wet NaOH containing 15% water required to prepare 70 litres of 0.5 N solution is :
 (A) 1.65 kg (B) 1.4 kg (C) 16.5 kg (D) 140 kg
6. $28\text{NO}_3^- + 3\text{As}_2\text{S}_3 + 4\text{H}_2\text{O} \longrightarrow 6\text{AsO}_4^{3-} + 28\text{NO} + 9\text{SO}_4^{2-} + 8\text{H}^+$.
 What will be the equivalent mass of As_2S_3 in above reaction : (Molecular mass of $\text{As}_2\text{S}_3 = M$)
 (A) $\frac{M}{2}$ (B) $\frac{M}{4}$ (C) $\frac{M}{24}$ (D) $\frac{M}{28}$



7. 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
8. 125 mL of 63% (w/v) $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ solution is made to react with 125 mL of a 40% (w/v) NaOH solution. The resulting solution is: (ignoring hydrolysis of ions)
 (A) neutral (B) acidic (C) strongly acidic (D) alkaline
9. 25 mL of a 0.1 M solution of a stable cation of transition metal Z reacts exactly with 25 mL of 0.04 M acidified KMnO_4 solution. Which of the following is most likely to represent the change in oxidation state of Z correctly :
 (A) $\text{Z}^+ \rightarrow \text{Z}^{2+}$ (B) $\text{Z}^{2+} \rightarrow \text{Z}^{3+}$ (C) $\text{Z}^{3+} \rightarrow \text{Z}^{4+}$ (D) $\text{Z}^{2+} \rightarrow \text{Z}^{4+}$
10. How many litres of Cl_2 at STP will be liberated by the oxidation of NaCl with 10 g KMnO_4 in acidic medium: (Atomic weight : Mn = 55 and K = 39)
 (A) 3.54 (B) 7.08 (C) 1.77 (D) None of these
11. 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

$$\text{AsO}_4^{3-} + 2\text{H}^+ + 2\text{I}^- \longrightarrow \text{AsO}_3^{3-} + \text{H}_2\text{O} + \text{I}_2$$
 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
12. If 10 g of V_2O_5 is dissolved in acid and is reduced to V^{2+} by zinc metal, how many mole of 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] (Atomic masses : V = 51, O = 16, I = 127)
 (A) 0.11 (B) 0.22 (C) 0.055 (D) 0.44
13. During the disproportionation of Iodine to iodide and iodate ions, the ratio of iodate and iodide ions formed in alkaline medium is :
 (A) 1 : 5 (B) 5 : 1 (C) 3 : 1 (D) 1 : 3
14. If 1 mL of a KMnO_4 solution react with 0.140 g Fe^{2+} and if 1 mL of $\text{KHC}_2\text{O}_4 \cdot \text{H}_2\text{C}_2\text{O}_4$ solution react with 0.1 mL of previous KMnO_4 solution, how many millilitres of 0.20 M NaOH will react with 1 mL of previous $\text{KHC}_2\text{O}_4 \cdot \text{H}_2\text{C}_2\text{O}_4$ solution in which all the protons (H^+) are ionisable ?
 (A) 15/16 mL (B) 13/16 (C) 11/14 (D) None of these

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. How many equivalents of Mg would have to react in order to liberate 4 N_A electrons? ($\text{Mg} - 2\text{e}^- \rightarrow \text{Mg}^{2+}$)
2. A certain weight of pure CaCO_3 is made to react completely with 20 mL of a HCl solution to give 224 mL of CO_2 gas at STP. The normality of the HCl solution is:
3. The volume of 3 M $\text{Ba}(\text{OH})_2$ solution required to neutralize completely 120 mL of 1.5M H_3PO_4 solution is:
4. In an experiment, 50 mL of 0.1 M solution of a salt reacted with 25 mL of 0.1 M solution of sodium sulphite. The half equation for the oxidation of sulphite ion is :

$$\text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O} \longrightarrow \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+ + 2\text{e}^-$$
 If the oxidation number of metal in the salt was 3, what would be the new oxidation number of metal :
5. When tetracarbonylnickel(0) is heated, it dissociates into its components. If 5 moles of this compound is heated and the resulting gaseous component is absorbed by sufficient amount of I_2O_5 , liberating I_2 . What volume of 4M Hypo solution will be required to react with this I_2 : $\text{Ni}(\text{CO})_4 \xrightarrow{\Delta} \text{Ni} + 4\text{CO}$



6. 1 mole of OH^- ions is obtained from 85 g of hydroxide of a metal. What is the equivalent weight of the metal?
7. An oxide of a metal contains 40% oxygen, by weight. What is the equivalent weight of the metal?
8. In the following reaction, $3\text{Fe} + 4\text{H}_2\text{O} \longrightarrow \text{Fe}_3\text{O}_4 + 4\text{H}_2$, if the atomic weight of iron is 56, then its equivalent weight will be :
9. What volume of 0.05 M $\text{Ca}(\text{OH})_2$ solution is needed for complete conversion of 10 mL of 0.1 M H_3PO_4 into $\text{Ca}(\text{H}_2\text{PO}_4)_2$?
10. Potassium acid oxalate $\text{K}_2\text{C}_2\text{O}_4 \cdot 3\text{H}_2\text{C}_2\text{O}_4 \cdot 4\text{H}_2\text{O}$ can be oxidized by MnO_4^- in acid medium. Calculate the volume of (in mL) 1 M KMnO_4 reacting in acid solution with 5.08 gram of the acid oxalate.
11. In the following reaction, SO_2 acts as a reducing agent :

$$\text{SO}_2 + \text{Cl}_2 + 2\text{H}_2\text{O} \longrightarrow \text{H}_2\text{SO}_4 + 2\text{HCl}$$
 Find the equivalent weight of SO_2 .

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. In the titration of $\text{K}_2\text{Cr}_2\text{O}_7$ and ferrous sulphate, following data is obtained :
 V_1 mL of $\text{K}_2\text{Cr}_2\text{O}_7$ solution of molarity M_1 requires V_2 mL of FeSO_4 solution of molarity M_2 .
 Which of the following relations is/are true for the above titration :
 (A) $6 M_1 V_1 = M_2 V_2$ (B) $M_1 V_1 = 6 M_2 V_2$ (C) $N_1 V_1 = N_2 V_2$ (D) $M_1 V_1 = M_2 V_2$
2. Choose the correct statement(s) :
 (A) 1 mole of MnO_4^- ion can oxidise 5 moles of Fe^{2+} ion in acidic medium.
 (B) 1 mole of $\text{Cr}_2\text{O}_7^{2-}$ ion can oxidise 6 moles of Fe^{2+} ion in acidic medium.
 (C) 1 mole of Cu_2S can be oxidised by 1.6 moles of MnO_4^- ion in acidic medium.
 (D) 1 mole of Cu_2S can be oxidised by 1.33 moles of $\text{Cr}_2\text{O}_7^{2-}$ ion in acidic medium.
3. Which of the following samples of reducing agents is /are chemically equivalent to 25 mL of 0.2 N KMnO_4 to be reduced to Mn^{2+} and water :
 (A) 25 mL of 0.2 M FeSO_4 to be oxidized to Fe^{3+}
 (B) 50 mL of 0.1 M H_3AsO_3 to be oxidized to H_3AsO_4
 (C) 25 mL of 0.1 M H_2O_2 to be oxidized to H^+ and O_2
 (D) 25 mL of 0.1 M SnCl_2 to be oxidized to Sn^{4+}
4. To a 25 ml H_2O_2 solution excess acidified solution of KI was added. The iodine liberated 20 ml of 0.3 N sodium thiosulphate solution. Use these data to choose the correct statements from the following :
 (A) The weight of H_2O_2 present in 25 ml solution is 0.102 g
 (B) The molarity of H_2O_2 solution is 0.12 M
 (C) The weight of H_2O_2 present in 1 L of the solution is 0.816 g
 (D) The volume strength of H_2O_2 is 1.344 L
5. There are two sample of HCl having molarity 1N and 0.25 N. Find volume of these sample taken in order to prepare 0.75 N HCl solution. (Assume no water is used) :
 (A) 20 mL, 10 mL (B) 100 mL, 50 mL (C) 40 mL, 20 mL (D) 50 mL, 25 mL
6. If mass of KHC_2O_4 (potassium acid oxalate) required to reduce 100 mL of 0.02 M KMnO_4 in acidic medium is x g and to neutralise 100 mL of 0.05 M $\text{Ca}(\text{OH})_2$ is y g, then which of the following options may be correct :
 (A) If x is 1 g then y is 2 g (B) If x is 5.5g then y is 11 g
 (C) If x is 2 g then y is 1 g (D) If x is 11 g then y is 5.5 g



PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

Equivalent Mass :

The equivalent mass of a substance is defined as the number of parts by mass of it which combine with or displace 1.0078 parts by mass of hydrogen, 8 parts by mass of oxygen and 35.5 parts by mass of chlorine.

The equivalent mass of a substance expressed in grams is called **gram equivalent mass**.

The equivalent mass of a substance is not constant. It depends upon the reaction in which the substance is participating. A compound may have different equivalent mass in different chemical reactions and under different experimental conditions.

(A) Equivalent mass of an acid : It is the mass of an acid in grams which contains 1.0078 g of replaceable H^+ ions or it is the mass of acid which contains one mole of replaceable H^+ ions. It may be calculated as :

$$\text{Equivalent mass of acid} = \frac{\text{Molecular mass of acid}}{\text{Basicity of acid}}$$

Basicity of acid = number of replaceable hydrogen atoms present in one molecule of acid

(B) Equivalent mass of a base : It is the mass of the base which contains one mole of replaceable OH^- ions in molecule.

$$\text{Equivalent mass of base} = \frac{\text{Molecular mass of base}}{\text{Acidity of base}}$$

Acidity of base = Number of replaceable OH^- ions present in one molecule of the base

Equivalent mass of an oxidising agent :

(a) Electron concept : Equivalent mass of oxidising agent = $\frac{\text{Molecular mass of oxidising agent}}{\text{Number of electrons gained by one molecule}}$

(b) Oxidation number concept : Equivalent mass of oxidising agent = $\frac{\text{Molecular mass of oxidising agent}}{\text{Total change in oxidation number per molecule of oxidising agent}}$

- Equivalent mass of $Ba(MnO_4)_2$ in acidic medium is : (where M stands for molar mass)
(A) $M/5$ (B) $M/6$ (C) $M/10$ (D) $M/2$
- 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) $9 M/7$
- Equivalent weight of oxalic acid salt in following reaction is : (Atomic masses : O = 16, C = 12, K = 39)
 $H_2C_2O_4 + Ca(OH)_2 \longrightarrow CaC_2O_4 + H_2O$
(A) 90 (B) 45 (C) 64 (D) 128

Comprehension # 2

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.

- The volume of H_2O_2 solution is :
(A) 11.2 mL (B) 37.2 mL (C) 5.6 mL (D) 22.4 mL
- 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
- The volume of O_2 at STP that would be liberated by above H_2O_2 solution on disproportionation is :
(A) 56 mL (B) 112 mL (C) 168 mL (D) 224 mL



Comprehension # 3

Answer Q.7, Q.8 and Q.9 by appropriately matching the information given in the three columns of the following table.

Equivalent weight = $\frac{\text{Molecular weight / Atomic weight}}{n\text{-factor}}$ n-factor is very important in redox as well as non-redox reactions. In general n-factor of acid/base is number of moles of H^+/OH^- furnished per mole of acid/base. n-factor of reactions is number of moles of electrons lost or gained per mole of reactant columns 1, 2, 3 contain reactions, n-factor & equivalent weight respectively.					
Column-1		Column-2		Column-3	
(I)	$\text{MnO}_4^- + 2\text{H}_2\text{O} \longrightarrow \text{MnO}_2 + 4\text{OH}^-$	(i)	1	(P)	158
(II)	$\text{MnO}_4^- \longrightarrow \text{MnO}_4^{2-}$	(ii)	$\frac{10}{6}$	(Q)	96
(III)	$\text{Br}_2 + \text{OH}^- \longrightarrow \text{BrO}_3^- + \text{Br}^-$	(iii)	3	(R)	34
(IV)	$\text{H}_2\text{O}_2 \longrightarrow \text{O}_2 + \text{H}_2\text{O}$	(iv)	2	(S)	52.6

7. For KMnO_4 in strong basic medium correct combination is -
 (A) (I) (ii) (R) (B) (II) (i) (P) (C) (II) (iii) (S) (D) (I) (iv) (Q)
8. For KMnO_4 in neutral medium correct combination is -
 (A) (I) (iii) (Q) (B) (II) (i) (R) (C) (I) (iii) (S) (D) (II) (iii) (R)
9. For a disproportionation reaction the only correct combination is -
 (A) (I) (ii) (R) (B) (II) (ii) (Q) (C) (IV) (i) (S) (D) (III) (ii) (Q)

Exercise-3

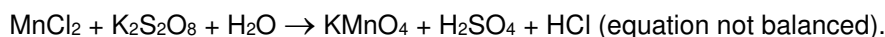
* Marked Questions may have more than one correct option.

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. In basic medium, I^- is oxidised by MnO_4^- . In this process, I^- changes to : [JEE 2004, 3/144]
 (A) IO_3^- (B) I_2 (C) IO_4^- (D) IO^-
2. Consider a titration of potassium dichromate solution with acidified Mohr's salt solution using diphenylamine as indicator. The number of moles of Mohr's salt required per mole of dichromate is : [JEE 2007, 3/162]
 (A) 3 (B) 4 (C) 5 (D) 6
3. 25 mL of household bleach solution was mixed with 30 mL of 0.50 M KI and 10 mL of 4N acetic acid. In the titration of the liberated iodine, 48 mL of 0.25 N $\text{Na}_2\text{S}_2\text{O}_3$ was used to reach the end point. The molarity of the household bleach solution is : [JEE 2012, 3/136]
 (A) 0.48 M (B) 0.96 M (C) 0.24 M (D) 0.024 M
- 4.* For the reaction : $\text{I}^- + \text{ClO}_3^- + \text{H}_2\text{SO}_4 \longrightarrow \text{Cl}^- + \text{HSO}_4^- + \text{I}_2$
 The correct statement(s) in the balanced equation is/are : [JEE (Advanced) 2014, 3/120]
 (A) Stoichiometric coefficient of HSO_4^- is 6. (B) Iodide is oxidized.
 (C) Sulphur is reduced. (D) H_2O is one of the products.



5. To measure the quantity of MnCl_2 dissolved in an aqueous solution, it was completely converted to KMnO_4 using the reaction.



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} : $\text{Mn} = 55$, $\text{Cl} = 35.5$)

[JEE (Advanced) 2018, 3/120]

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

- When KMnO_4 acts as an oxidising agent and ultimately forms MnO_4^{2-} , MnO_2 , Mn_2O_3 and Mn^{2+} , then the number of electrons transferred in each case is : [AIEEE 2002, 3/225]
 (1) 4, 3, 1, 5 (2) 1, 5, 3, 7 (3) 1, 3, 4, 5 (4) 3, 5, 7, 1
- What will happen if the solution of potassium chromate reacts with excess amount of nitric acid
 (1) Cr reduces in the oxidation state +3 from CrO_4^{2-} . [AIEEE 2003, 3/225]
 (2) Cr oxidises in the oxidation state +7 from CrO_4^{2-} .
 (3) Cr^{+3} and $\text{Cr}_2\text{O}_7^{2-}$ will be formed.
 (4) $\text{Cr}_2\text{O}_7^{2-}$ and H_2O will be formed.
- The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is : [AIEEE 2005, 3/225]
 (1) + 4 (2) + 6 (3) + 2 (4) + 3
- Amount of oxalic acid present in a solution can be determined by its titration with KMnO_4 solution in the presence of H_2SO_4 . The titration gives unsatisfactory result when carried out in the presence of HCl , because HCl : [AIEEE 2008, 3/105]
 (1) furnishes H^+ ions in addition to those from oxalic acid.
 (2) reduces permanganate to Mn^{2+} .
 (3) oxidises oxalic acid to carbon dioxide and water.
 (4) gets oxidised by oxalic acid to chlorine.
- 29.5 mg of an organic compound containing nitrogen was digested according to Kjeldahl's method and the evolved ammonia was absorbed in 20 mL of 0.1 M HCl solution. The excess of the acid required 15 mL of 0.1 M NaOH solution for complete neutralization. The percentage of nitrogen in the compound is : [AIEEE 2010, 4/144]
 (1) 59.0 (2) 47.4 (3) 23.7 (4) 29.5
- Consider the following reaction : $x\text{MnO}_4^- + y\text{C}_2\text{O}_4^{2-} + z\text{H}^+ \longrightarrow x\text{Mn}^{2+} + 2y\text{CO}_2 + \frac{z}{2}\text{H}_2\text{O}$
 The values of x, y and z in the reaction are, respectively : [JEE(Main) 2013, 4/120]
 (1) 5, 2 and 16 (2) 2, 5 and 8 (3) 2, 5 and 16 (4) 5, 2 and 8
- For the estimation of nitrogen, 1.4 g of an organic compound was digested by Kjeldahl method and the evolved ammonia was absorbed in 60 mL of $\frac{\text{M}}{10}$ sulphuric acid. The unreacted acid required 20 mL of $\frac{\text{M}}{10}$ sodium hydroxide for complete neutralization. The percentage of nitrogen in the compound is : [JEE(Main) 2014, 4/120]
 (1) 6% (2) 10% (3) 3% (4) 5%



JEE(MAIN) ONLINE PROBLEMS

1. Hydrogen peroxide acts both as an oxidising and as a reducing agent depending upon the nature of the reacting species. In which of the following cases H_2O_2 acts as a reducing agent in acid medium ?
[JEE(Main) 2014 Online (12-04-14), 4/120]
(1) MnO_4^- (2) $\text{Cr}_2\text{O}_7^{2-}$ (3) SO_3^{2-} (4) KI
2. Permanent hardness in water cannot be cured by : [JEE(Main) 2015 Online (10-04-15), 4/120]
(1) Treatment with washing soda (2) Boiling
(3) Ion exchange method (4) Calgon's method
3. 1.4 g of an organic compound was digested according to Kjeldahl's method and the ammonia evolved was absorbed in 60 mL of M/10 H_2SO_4 solution. The excess sulphuric acid required 20 mL of M/10 NaOH solution for neutralization. The percentage of nitrogen in the compound is :
[JEE(Main) 2015 Online (10-04-15), 4/120]
(1) 24 (2) 5 (3) 10 (4) 3
4. The volume of 0.1 N dibasic acid sufficient to neutralize 1 g of a base that furnishes 0.04 mole of OH^- in aqueous solution is : [JEE(Main) 2016 Online (10-04-16), 4/120]
(1) 400 mL (2) 600 mL (3) 200 mL (4) 80 mL
5. For standardizing NaOH solution, which of the following is used as a primary standard ?
[JEE(Main) 2018 Online (16-04-18), 4/120]
(1) Sodium tetraborate (2) Ferrous Ammonium Sulfate
(3) Oxalic acid (4) dil. HCl
6. The temporary hardness of water is due to : [JEE(Main) 2019 Online (09-01-19), 4/120]
(1) CaCl_2 (2) $\text{Ca}(\text{HCO}_3)_2$ (3) NaCl (4) Na_2SO_4
7. 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 Online (10-01-19), 4/120]
(1) 5 (2) 1 (3) 2 (4) 10
8. 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 Online (11-01-19), 4/120]
(1) 12.5 mL (2) 75 mL (3) 50 mL (4) 25 mL
9. The hardness of water sample (in terms of equivalents of CaCO_3) containing 10^{-3} M CaSO_4 is :
(molar mass of $\text{CaSO}_4 = 136 \text{ g mol}^{-1}$) [JEE(Main) 2019 Online (12-01-19), 4/120]
(1) 10 ppm (2) 50 ppm (3) 90 ppm (4) 100 ppm
10. The volume strength of 1M H_2O_2 is: (Molar mass of $\text{H}_2\text{O}_2 = 34 \text{ g mol}^{-1}$)
[JEE(Main) 2019 Online (12-01-19), 4/120]
(1) 11.35 (2) 22.4 (3) 16.8 (4) 5.6



Answers

EXERCISE - 1

PART - I

- A-1.** (a) 23 ; (b) $E = 9$; (c) $E = 30$; (d) $E = \frac{35.5}{1}$; (e) $E = 30$; (f) $E = 48$; (g) $E = 31.67$
- A-2.** (a) $E = 58.5$ or $E = 58.5$; (b) $E = 87$ or $E = 87$; (c) $E = 51.67$ or $E = 51.67$
- A-3.** 20.1 **B-1.** $\frac{M_1}{6}, \frac{M_2}{8}, \frac{M_3}{5}$ **B-2.** (a) 31.6 ; (b) 52.67 **C-1.** 72.61
- C-2.** 0.06 N, 0.03 M **C-3.** 537.6 mL **D-1.** 20 **D-2.** +3
- D-3.** 0.12 M. **D-4.** 2.22 mL. **E-1.** 7.1% **E-2.** 0.25075 g
- F-1.** 2.12 g/L **F-2.** 126 ppm
- F-3.** Temporary hardness - due to bicarbonates of Ca & Mg
Permanent hardness - due to chlorides & sulphates of Ca & Mg.
- F-4.** There are some method by which we can soften the water sample.
(a) By boiling : $2\text{HCO}_3^- \longrightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{CO}_3^{2-}$
or By Slaked lime : $\text{Ca}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \longrightarrow \text{CaCO}_3 + 2\text{H}_2\text{O}$
 $\text{Ca}^{2+} + \text{CO}_3^{2-} \longrightarrow \text{CaCO}_3$
(b) By Washing Soda : $\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \longrightarrow \text{CaCO}_3 + 2\text{NaCl}$
(c) By ion exchange resins : $\text{Na}_2\text{R} + \text{Ca}^{2+} \longrightarrow \text{CaR} + 2\text{Na}^+$
(d) By adding chelating agents like $(\text{PO}_3^-)_3$ etc.

PART - II

- A-1.** (B) **A-2.** (A) **A-3.** (A) **B-1.** (C) **B-2.** (D)
- B-3.** (A) **C-1.** (A) **C-2.** (A) **C-3.** (D) **D-1.** (B)
- D-2.** (D) **D-3.** (B) **D-4.** (A) **E-1.** (B) **E-2.** (B)
- F-1.** (D) **F-2.** (A) **F-3.** (D) **F-4.** (B)

PART - III

1. (A – p,s) ; (B – q,r) ; (C – p,q,s) ; (D – r)

EXERCISE - 2

PART - I

1. (A) 2. (A) 3. (D) 4. (D) 5. (A)
6. (D) 7. (D) 8. (A) 9. (D) 10. (A)
11. (A) 12. (A) 13. (A) 14. (A)

PART - II

1. 4 2. 1 3. 90 4. 2 5. 2
6. 68 7. 12 8. 21 9. 10 mL 10. 16
11. 32

**PART - III**

- | | | | | |
|---------|-----------|----------|----------|-----------|
| 1. (AC) | 2. (ABCD) | 3. (ACD) | 4. (ABD) | 5. (ABCD) |
| 6. (AB) | | | | |

PART - IV

- | | | | | |
|--------|--------|--------|--------|--------|
| 1. (C) | 2. (B) | 3. (C) | 4. (C) | 5. (D) |
| 6. (B) | 7. (B) | 8. (C) | 9. (D) | |

EXERCISE - 3**PART - I**

- | | | | | |
|--------|--------|--------|-----------|-----------|
| 1. (A) | 2. (D) | 3. (C) | 4.* (ABD) | 5. 126 mg |
|--------|--------|--------|-----------|-----------|

PART - II**JEE(MAIN) OFFLINE PROBLEMS**

- | | | | | |
|--------|--------|--------|--------|--------|
| 1. (3) | 2. (4) | 3. (4) | 4. (2) | 5. (3) |
| 6. (3) | 7. (2) | | | |

JEE(MAIN) ONLINE PROBLEMS

- | | | | | |
|--------|--------|--------|--------|---------|
| 1. (4) | 2. (2) | 3. (3) | 4. (3) | 5. (3) |
| 6. (2) | 7. (2) | 8. (4) | 9. (4) | 10. (1) |



Additional Problems for Self Practice (APSP)

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Time : 1 Hr. Max.

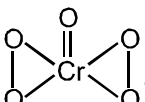
Marks : 120

Important Instructions

1. The test is of **1 hour** duration.
2. The Test Booklet consists of **30** questions. The maximum marks are **120**.
3. Each question is allotted **4 (four)** marks for correct response.
4. Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question. **¼ (one fourth)** marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
5. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

1. In the reaction : $\text{Na}_2\text{S}_2\text{O}_3 + 4\text{Cl}_2 + 5\text{H}_2\text{O} \longrightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{SO}_4 + 8\text{HCl}$,
the equivalent weight of $\text{Na}_2\text{S}_2\text{O}_3$ will be : (M = molecular weight of $\text{Na}_2\text{S}_2\text{O}_3$)
(1) M/4 (2) M/8 (3) M/1 (4) M/2
2. In the reaction, $2\text{CuSO}_4 + 4\text{KI} \longrightarrow 2\text{CuI}_2 + \text{I}_2 + 2\text{K}_2\text{SO}_4$
the equivalent weight of CuSO_4 will be :
(1) 79.75 (2) 159.5 (3) 329 (4) None of these
3. 100 milli moles of dichloroacetic acid (CHCl_2COOH) can neutralize how many moles of ammonia to form ammonium dichloroacetate :
(1) 0.0167 (2) 0.1 (3) 0.3 (4) 0.6
4. The number of moles of ferrous oxalate oxidised by one mole of KMnO_4 in acidic medium is :
(1) 5/2 (2) 2/5 (3) 3/5 (4) 5/3
5. How many moles of KMnO_4 are needed to oxidise a mixture of 1 mole of each FeSO_4 & FeC_2O_4 in acidic medium :
(1) 4/5 (2) 5/4 (3) 3/4 (4) 5/3
6. 22.7 mL of (N/10) Na_2CO_3 solution neutralises 10.2 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.
(1) 490.2 mL (2) 890.2 mL (3) 90.2 mL (4) 290.2 mL
7. HNO_3 oxidises NH_4^+ ions to nitrogen and itself gets reduced to NO_2 . The moles of HNO_3 required by 1 mole of $(\text{NH}_4)_2\text{SO}_4$ is :
(1) 4 (2) 5 (3) 6 (4) 2
8. The mass of oxalic acid crystals ($\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$) required to prepare 50 mL of a 0.2 N solution is :
(1) 4.5 g (2) 6.3 g (3) 0.63 g (4) 0.45 g
9. When HNO_3 is converted into NH_3 , the equivalent weight of HNO_3 will be :
(1) M/2 (2) M/1 (3) M/6 (4) M/8
(M = molecular weight of HNO_3)
10. In the conversion $\text{NH}_2\text{OH} \longrightarrow \text{N}_2\text{O}$, the equivalent weight of NH_2OH will be :
(1) M/4 (2) M/2 (3) M/5 (4) M/1
(M = molecular weight of NH_2OH)
11. Number of moles of CaO required to remove hardness from 1000 litre water having 324 ppm of calcium bicarbonate and 74.5 ppm of potassium chloride is :
(1) 8 (2) 4 (3) 3 (4) 2



12. A 5.0 cm³ solution of H₂O₂ liberates 0.508 g of I₂ from an acidified KI solution. The strength of H₂O₂ solution in terms of volume strength at STP is :
 (1) 2.24 V (2) 1.12 V (3) 4.48 V (4) 8.96 V
13. When hypo solution is added to KMnO₄ solution then
 (1) Na₂S₂O₃ is converted to Na₂SO₄ (2) Na₂S₂O₃ is converted to Na₂S₄O₆
 (3) KMnO₄ is converted to K₂MnO₄ (4) KMnO₄ is converted to MnSO₄
14. Which of the following equations is a balanced one :
 (1) 5BiO₃⁻ + 22H⁺ + Mn²⁺ → 5Bi³⁺ + 7H₂O + MnO₄⁻
 (2) 5BiO₃⁻ + 14H⁺ + 2Mn²⁺ → 5Bi³⁺ + 7H₂O + 2MnO₄⁻
 (3) 2BiO₃⁻ + 4H⁺ + Mn²⁺ → 2Bi³⁺ + 2H₂O + MnO₄⁻
 (4) 6BiO₃⁻ + 12H⁺ + 3Mn²⁺ → 6Bi³⁺ + 6H₂O + 3MnO₄⁻
15. 10 mL of sulphuric acid solution (specific gravity = 1.84) contains 98% by weight of pure acid. Calculate the volume of 2 N NaOH solution required to just neutralize the acid.
 (1) 9.2 mL (2) 92 mL (3) 18.4 mL (4) 184 mL
16. The equivalent mass of MnSO₄ is half its molecular mass when it is converted to :
 (1) Mn₂O₃ (2) MnO₂ (3) MnO₄⁻ (4) MnO₄²⁻
17. 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 :
 (1) 40 mL (2) 20 mL (3) 10 mL (4) 4 mL
18. In the reaction H₂O₂¹⁸ + O₃ → water + oxygen, radioactivity will be shown by which of the product :
 (1) water (2) oxygen (3) both (1) & (2) (4) none of these
19. 1 mole of how many of the following acids neutralize exactly one mol of NaOH, under required favourable conditions? HCl, HNO₃, H₂SO₄, H₂SO₃, H₃PO₄, H₃PO₃, H₃PO₂, H₄P₂O₅, H₃BO₃
 (1) 4 (2) 7 (3) 8 (4) 9
20. CrO₅ has structure as shown 
 The oxidation number of chromium in the above compound is :
 (1) 4 (2) 5 (3) 6 (4) 0
21. The normality of orthophosphoric acid having purity of 70% by weight and specific gravity 1.54 is :
 (1) 11 N (2) 22 N (3) 33 N (4) 44 N
22. The normality of mixture obtained by mixing 100 mL of 0.2 M H₂SO₄ and 200 mL of 0.2 M HCl is :
 (1) 0.0267 (2) 0.2670 (3) 1.0267 (4) 1.1670
23. The reagent commonly used to determine hardness of water titrimetrically is :
 (1) oxalic acid (2) disodium salt of EDTA
 (3) sodium citrate (4) sodium thiosulphate
24. 40 mL of 0.05 M solution of sodium sesquicarbonate (Na₂CO₃·NaHCO₃·2H₂O) is titrated against 0.05 M HCl. When phenolphthalein is used as indicator, x mL HCl is used. In a separate titration of same using methyl orange as indicator, y mL of HCl is used. The value of (y - x) is :
 (1) 80 mL (2) 30 mL (3) 120 mL (4) 180 mL
25. In the following reaction 2MnO₄⁻ + 5H₂O₂¹⁸ + 6H⁺ → 2Mn²⁺ + 8H₂O + 5O₂
 The radioactive oxygen will appear in :
 (1) H₂O (2) O₂
 (3) both (4) above reaction does not take place
26. One gram equimolecular mixture of Na₂CO₃ and NaHCO₃ is reacted with 0.1 N HCl. The milliliters of 0.1 N HCl required to react completely with the above mixture is :
 (1) 15.78 mL (2) 157.8 mL (3) 198.4 mL (4) 295.5 mL



27. Which of the following is not a redox reaction ?
 (1) $\text{KCN} + \text{Fe}(\text{CN})_2 \longrightarrow \text{K}_4[\text{Fe}(\text{CN})_6]$ (2) $\text{Rb} + \text{H}_2\text{O} \longrightarrow \text{RbOH} + \text{H}_2$
 (3) $\text{H}_2\text{O}_2 \longrightarrow \text{H}_2\text{O} + \text{O}$ (4) $\text{CuI}_2 \longrightarrow \text{CuI} + \text{I}_2$
28. Equivalent weight of chlorine molecule in the equation is :
 $3 \text{Cl}_2 + 6 \text{NaOH} \longrightarrow 5 \text{NaCl} + \text{NaClO}_3 + 3 \text{H}_2\text{O}$
 (1) 42.6 (2) 35.5 (3) 59.1 (4) 71
29. $\text{Cr}_2\text{O}_7^{2-} \xrightarrow{\text{H}^+} \text{Cr}^{3+}$, Eq. wt of $\text{Cr}_2\text{O}_7^{2-}$ is :
 (1) mol. wt./6 (2) mol.wt./3 (3) mol.wt./4 (4) mol.wt./1
30. One mole of acidified $\text{K}_2\text{Cr}_2\text{O}_7$ on reaction with excess KI will liberate mole (s) of I_2 .
 (1) 6 (2) 1 (3) 7 (4) 3

Practice Test-1 (IIT-JEE (Main Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25	26	27	28	29	30
Ans.										

PART-II : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. If the equivalent weight of an element is 32, then the percentage of oxygen in its oxide is : [NSEC-2000]
 (A) 16 (B) 40 (C) 32 (D) 20
2. In alkaline medium, KMnO_4 reacts as follows (Atomic weights K = 39.09, Mn = 54.94, O = 16.00)
 $2\text{KMnO}_4 + 2\text{KOH} \rightarrow 2\text{K}_2\text{MnO}_4 + \text{H}_2\text{O} + [\text{O}]$
 Hence, its equivalent weight is : [NSEC-2000]
 (A) 31.6 (B) 63.2 (C) 126.4 (D) 158
3. When 25 g of Na_2SO_4 is dissolved in 10^3 Kg of solution, its concentration will be [NSEC-2000]
 (A) 2.5 ppm (B) 25 ppm (C) 250 ppm (D) 100 ppm
4. Which amongst the following has the highest normality ? [NSEC-2002]
 (A) 16.0 g of NaOH in 200 mL of water (B) 1 N oxalic acid
 (C) 2 M sulphuric acid (D) 1.5 hydrochloric acid
5. The volume of water which must be added to 0.4 dm^3 of 0.25 N oxalic acid in order to make it exactly decinormal is : [NSEC-2002]
 (A) 0.2 dm^3 (B) 0.4 dm^3 (C) 0.6 dm^3 (D) 0.8 dm^3
6. The quantity of electricity required to reduce 0.05 mol of MnO_4^- to Mn^{2+} in acidic medium would be [NSEC-2003]
 (A) 0.01 F (B) 0.05 F (C) 0.15 F (D) 0.25 F
7. You are given a solution of an alkali. In order to estimate its concentration in terms of normality, you need to know [NSEC-2003]
 (A) the volume of the solution, the volume of the alkali present in it and its formula weight
 (B) the mass of the solution, the mass of the alkali present in it and its equivalent weight.
 (C) the volume of the solution, the mass of the alkali present in it and its equivalent weight
 (D) the mass of the solution, the volume of the alkali present in it and its equivalent weight.
8. The normality of '20 volume' H_2O_2 solution is [NSEC-2005]
 (A) 2.0 (B) 2.5 (C) 3.0 (D) 3.5



9. Hydrazine N_2H_4 acts as a reducing agent. To prepare 100 ml of 2 N hydrazine solution, the weight required will be [NSEC-2006]
 (A) 6.4 g (B) 1.6 g (C) 3.2 g (D) 0.8 g
10. For the reaction shown below, which statement is true ? [NSEC-2007]
 $2\text{Fe} + 3\text{CdCl}_2 \rightleftharpoons 2\text{FeCl}_3 + 3\text{Cd}$
 (A) Fe is the oxidizing agent (B) Cd undergoes oxidation
 (C) Cd is the reducing agent (D) Fe undergoes oxidation
11. Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) reacts with permanganate ion according to the balanced equation given below :
 $5\text{H}_2\text{C}_2\text{O}_4(\text{aq}) + 2\text{MnO}_4^- (\text{aq}) + 6\text{H}^+(\text{aq}) \rightarrow 2\text{Mn}^{2+} (\text{aq}) + 10\text{CO}_2(\text{g}) + 8\text{H}_2\text{O}(\text{l})$
 How many mL of 0.0154 M KMnO_4 solution are required to react with 25.0 mL of 0.0208 M $\text{H}_2\text{C}_2\text{O}_4$ solution ? [NSEC-2008]
 (A) 13.5 mL (B) 18.5 mL (C) 33.8 mL (D) 84.4 mL
12. What volume of water should be added to 1600 ml of a 0.205 N solution so that the resulting solution will be 0.2 N ? [NSEC-2008]
 (A) 40 mL (B) 50 mL (C) 100 mL (D) 20 mL
13. Oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$, reacts with permanganate ion according to the balanced equation $5\text{H}_2\text{C}_2\text{O}_4(\text{aq}) + 2\text{MnO}_4^- (\text{aq}) + 6\text{H}^+(\text{aq}) \rightleftharpoons 2\text{Mn}^{2+}(\text{aq}) + 10\text{CO}_2(\text{g}) + 8\text{H}_2\text{O}(\text{l})$. The volume in mL of 0.0162 M KMnO_4 solution required to react with 25.0 mL of 0.022 M $\text{H}_2\text{C}_2\text{O}_4$ solution is [NSEC-2011]
 (A) 13.6 (B) 18.5 (C) 33.8 (D) 84.4
14. A 500 g toothpaste sample has 0.4 g fluoride concentration. The fluoride concentration in terms of ppm will be [NSEC-2012]
 (A) 200 (B) 400 (C) 500 (D) 800
15. The number of moles of KMnO_4 that will be needed to react completely with one mole of ferrous oxalate [$\text{Fe}(\text{C}_2\text{O}_4)$] in acidic solution is [NSEC-2012]
 (A) 1 (B) 2/5 (C) 3/5 (D) 4/5
16. I. $5\text{H}_2\text{O}_2 + 2\text{MnO}_4^- + 6\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 5\text{O}_2 + 8\text{H}_2\text{O}$
 II. $\text{H}_2\text{O}_2 + \text{Ag}_2\text{O} \rightarrow 2\text{Ag} + \text{H}_2\text{O} + \text{O}_2$
 The role of hydrogen peroxide in the above reaction is [NSEC-2014]
 (A) oxidising in I and reducing in II (B) reducing in I and oxidising in II
 (C) reducing in I as well as in II (D) oxidising in I as well as in II
17. A bottle of H_3PO_4 solution contains 70% acid. If the density of the solution is 1.54 g cm^{-3} , the volume of the H_3PO_4 solution required to prepare 1L of 1N solution is. [NSEC-2015]
 (A) 90mL (B) 45mL (C) 30mL (D) 23mL
18. The unbalanced equation for the reaction of P_4S_3 with nitrate in aqueous acidic medium is given below.
 $\text{P}_4\text{S}_3 + \text{NO}_3^- \rightarrow \text{H}_3\text{PO}_4 + \text{SO}_4^{2-} + \text{NO}$
 The number of mol of water required per mol of P_4S_3 is [NSEC-2015]
 (A) 18 (B) 8/3 (C) 8 (D) 28
19. In the redox reaction $2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$, 20 mL of 0.1 M KMnO_4 react quantitatively with [NSEC-2015]
 (A) 20 mL of 0.1 M oxalate (B) 40 mL of 0.1 M oxalate
 (C) 50 mL of 0.25 M oxalate (D) 50 mL of 0.1 M oxalate
20. 1.250 g of metal carbonate (MCO_3) was treated with 500 mL of 0.1 M HCl solution. The unreacted HCl required 50.0 mL of 0.500 M NaOH solution for neutralization. Identify the metal M [NSEC-2016]
 (A) Mg (B) Ca (C) Sr (D) Ba
21. Battery acid (H_2SO_4) has density 1.285 g cm^{-3} . 10.0 cm^3 of this acid is diluted to 1L. 25.0 cm^3 of this diluted solution requires 25.0 cm^3 of 0.1 N sodium hydroxide solution for neutralization. The percentage of sulphuric acid by mass in the battery acid is : [NSEC-2016]
 (A) 98 (B) 38 (C) 19 (D) 49



22. A sample of water from a river was analyzed for the presence of metal ions and the observations were recorded as given below

Reagent added	Observation
dil. HCl	No change
aq. Na_2CO_3	White precipitate
Aq. Na_2SO_4	No change

The water sample is likely to contain

- (A) Ba^{2+} (B) Cu^{2+} (C) Li^+ (D) Mg^{2+}

[NSEC-2018]

23. An ion exchange resin, RH_2 can replace Ca^{2+} in hard water as $\text{RH}_2 + \text{Ca}^{2+} \longrightarrow \text{RCa}^{2+} + 2\text{H}^+$. When a 1.0 L hard water sample was passed through the resin, all H^+ ions were replaced by Ca^{2+} ions and the pH of eluted water was found to be 2.0. The hardness of water (as ppm of Ca^{2+}) in the sample of water treated is

- (A) 50 (B) 100 (C) 125 (D) 200

[NSEC-2018]

PART - III : HIGH LEVEL PROBLEMS (HLP)

SUBJECTIVE QUESTIONS

- A solution contains a mixture of Na_2CO_3 and NaOH . Using phenolphthalein as indicator, 25 mL of mixture required 19.5 mL of 0.995 N HCl for the end point. With methyl orange (MeOH), 25 mL of the solution required 25 mL of the same HCl for the end point. Calculate gram per litre of each substance in the mixture.
- Hydrogen peroxide solution (20 mL) reacts quantitatively with a solution of KMnO_4 (20 mL) acidified with dilute H_2SO_4 . The same volume of the KMnO_4 solution is just decolourised by 10 mL of MnSO_4 in neutral medium simultaneously forming a dark brown precipitate of hydrated MnO_2 . The brown precipitate is dissolved in 10 mL of 0.2 M sodium oxalate under boiling condition in the presence of dilute H_2SO_4 . Write the balanced equations involved in the reactions and calculate the molarity of H_2O_2 .

[JEE 2001, 5/100]

ONLY ONE OPTION CORRECT TYPE

- 0.7 g of $(\text{NH}_4)_2\text{SO}_4$ sample was boiled with 100 mL of 0.2 N NaOH solution till all the NH_3 gas is evolved. The resulting solution was diluted to 250 mL. 25 mL of this solution was neutralized using 10 mL of a 0.1 N H_2SO_4 solution. The percentage purity of the $(\text{NH}_4)_2\text{SO}_4$ sample is :
(A) 94.3 (B) 50.8 (C) 47.4 (D) 79.8
- A mixture of 0.02 mole of KBrO_3 and 0.01 mole of KBr was treated with excess of KI and acidified. The volume of 0.1 M $\text{Na}_2\text{S}_2\text{O}_3$ solution required to consume the liberated iodine will be :
(A) 1000 mL (B) 1200 mL (C) 1500 mL (D) 800 mL
- 10 mL of a H_2SO_4 solution is diluted to 100 mL. 25 mL 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) 11 N (C) 3 N (D) 0.275 N
- Dichloroacetic acid (CHCl_2COOH) is oxidised to CO_2 , H_2O and Cl_2 by 600 meq of an oxidising 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
- 1.2 g of carbon is burnt completely in oxygen (limited supply) to produce CO and CO_2 . This mixture of gases is treated with solid I_2O_5 (to know the amount of CO produced). The liberated iodine required 120 mL of 0.1 M hypo solution for complete titration. The % of carbon converted into CO is :
(A) 60% (B) 100% (C) 50% (D) 30%
- A mixed solution of potassium hydroxide and sodium carbonate required 15 mL of an N/20 HCl solution when titrated with phenolphthalein as an indicator. But the same amount of the solution, when titrated with methyl orange as an indicator, required 25 mL of the same acid. The amount of KOH present in the solution is :
(A) 0.014 g (B) 0.14 g (C) 0.028 g (D) 1.4 g





9. Phenolphthalein is not a good indicator for titrating :
 (A) NaOH against oxalic acid (B) NaOH against HCl
 (C) Ferrous sulphate against KMnO_4 (D) NaOH against H_2SO_4
10. 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 conditions. Calculate the normality of KMnO_4 solution.
 (A) 0.588 N (B) 0.294 N (C) 0.882 N (D) 0.735 N
11. A solution of H_2O_2 labelled as '20 V' was left open. Due to this some, H_2O_2 decomposed and volume strength of the solution decreased. To determine the new volume strength of the H_2O_2 solution, 10 mL of the solution was taken and it was diluted to 100 mL. 10 mL of this diluted solution was titrated against 25 mL of 0.0245 M KMnO_4 solution under acidic condition. Calculate the volume strength of the H_2O_2 solution.
 (A) 15.00 V (B) 17.15 V (C) 20.00 V (D) 12.30 V

SINGLE AND DOUBLE VALUE INTEGER TYPE

12. If a mixture of Na_2CO_3 and NaOH in equimolar quantities when reacts with 0.1 M HCl in presence of phenolphthalein indicator consumes 30 ml of the acid. What will be the volume (in mL) of 0.15 M H_2SO_4 used in the separate titration of same mixture in presence of methyl orange indicator.

PART - IV : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr.

Max. Marks : 66

Important Instructions

A. General :

- The test is of 1 hour duration.
- The Test Booklet consists of 22 questions. The maximum marks are 66.

B. Question Paper Format :

- Each part consists of five sections.
- Section-1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
- Section-2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
- Section 3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
- Section 4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a particular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
- Section 5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

C. Marking Scheme :

- For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
- For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
- For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

**SECTION-1 : (Only One option correct Type)**

This section contains 7 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

- Volume V_1 mL of 0.1M $K_2Cr_2O_7$ 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 not be determined
- $Hg_5(IO_6)_2$ oxidizes KI to I_2 in acid medium and the other product containing iodine is K_2HgI_4 . If the I_2 liberated in the reaction requires 0.004 mole of $Na_2S_2O_3$, the number of moles of $Hg_5(IO_6)_2$ that have reacted is :
 (A) 10^{-3} (B) 10^{-4} (C) 2.5×10^{-4} (D) 2.5×10^{-2}
- 10 mL of 1 N HCl is mixed with 20 mL of 1 M H_2SO_4 and 30 mL of 1 M NaOH. The resultant solution has :
 (A) 20 meq of H^+ ions (B) 20 meq of OH^-
 (C) 0 meq of H^+ or OH^- (D) 30 milli moles of H^+
- 20 mL of H_2O_2 after acidification with dilute H_2SO_4 required 30 mL of N/12 $KMnO_4$ for complete oxidation. The strength of H_2O_2 solution is: [Molar mass of $H_2O_2 = 34$]
 (A) 2 g/L (B) 4 g/L (C) 8 g/L (D) 6 g/L
- x gram of pure As_2S_3 is completely oxidised to respective highest oxidation states by 50 mL of 0.1 M hot acidified $KMnO_4$, then mass of As_2S_3 taken is : (Molar mass of $As_2S_3 = 246$)
 (A) 22.4 g (B) 43.92 g (C) 64.23 g (D) None of these
- During the titration of a mixture of Na_2CO_3 and $NaHCO_3$ against HCl :
 (A) Phenolphthalein is used to detect the first end point
 (B) Phenolphthalein is used to detect the second end point
 (C) Methyl orange is used to detect the first end point
 (D) Phenolphthalein is used to detect the first and second end point
- In the reaction $CrO_5 + H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + H_2O + O_2$, one mole of CrO_5 will liberate how many moles of O_2 :
 (A) $5/2$ (B) $5/4$ (C) $9/2$ (D) $7/4$

Section-2 : (One or More than one options correct Type)

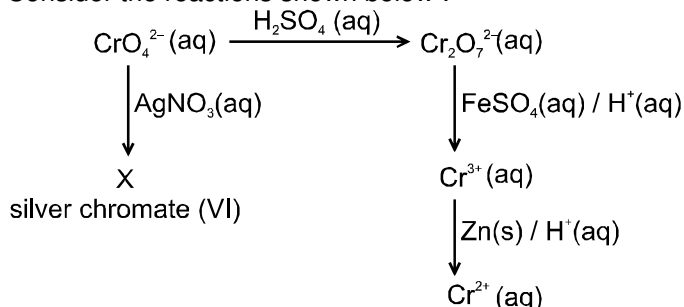
This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

- Consider the redox reaction $2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$:
 (A) $S_2O_3^{2-}$ gets reduced to $S_4O_6^{2-}$ (B) $S_2O_3^{2-}$ gets oxidised to $S_4O_6^{2-}$
 (C) I_2 gets reduced to I^- (D) I_2 gets oxidised to I^-
- Which of the following relations is/are correct for solutions ?
 (A) 3 N $Al_2(SO_4)_3 = 0.5$ M $Al_2(SO_4)_3$
 (B) 3 M $H_2SO_4 = 6$ N H_2SO_4
 (C) 1 M $H_3PO_4 = 1/3$ N H_3PO_4
 (D) 1 M $Al_2(SO_4)_3 = 6$ N $Al_2(SO_4)_3$
- Which of the following statements is/are correct :
 (A) 0.2 moles of $KMnO_4$ will oxidise one mole of ferrous ions to ferric ions in acidic medium.
 (B) 1.5 moles of $KMnO_4$ will oxidise 1 mole of ferrous oxalate to one mole of ferric ion and carbon dioxide in acidic medium in acidic medium.
 (C) 0.6 moles of $KMnO_4$ will oxidise 1 mole of ferrous oxalate to one mole of ferric ion and carbon dioxide in acidic medium.
 (D) 1 mole of $K_2Cr_2O_7$ will oxidise 2 moles of ferrous oxalate to ferric ions and carbon dioxide in acidic medium.



11. $\text{H}_2\text{C}_2\text{O}_4$ and NaHC_2O_4 behave as acids as well as reducing agents. Which are the correct statements?
 (A) equivalent weight of $\text{H}_2\text{C}_2\text{O}_4$ and NaHC_2O_4 are equal to their molecular weights when behaving as reducing agents.
 (B) 100 ml of 1 (N) solution of each is neutralised by equal volume of 1 (M) $\text{Ca}(\text{OH})_2$
 (C) 100 ml of (N) solution $\text{H}_2\text{C}_2\text{O}_4$ is neutralised by equal volumes of 1(N) $\text{Ca}(\text{OH})_2$
 (D) 100 ml of (M) solution of each is oxidised by same volume of 1 (M) KMnO_4

12. Consider the reactions shown below :



Which of the following statements is True : [Atomic Mass of Zinc = 65.4]

- (A) Silver chromate (VI) has the formula Ag_2CrO_4 .
 (B) The minimum mass of zinc required to reduce 0.1 mole of Cr^{3+} to Cr^{2+} is 6.54 g.
 (C) The conversion of CrO_4^{2-} into $\text{Cr}_2\text{O}_7^{2-}$ is not a redox reaction.
 (D) The equation $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Fe}^{2+} \rightarrow 6\text{Fe}^{3+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ correctly describes the reduction of $\text{Cr}_2\text{O}_7^{2-}$ by acidified FeSO_4 .

Section-3 : (One Integer Value Correct Type.)

This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

13. A 3 mole mixture of FeSO_4 and $\text{Fe}_2(\text{SO}_4)_3$ required 100 mL of 2M KMnO_4 solution in acidic medium. Find the mole of FeSO_4 in the mixture.
14. A 7.1 g sample of bleaching powder suspended in H_2O was treated with enough acetic acid and KI solution. Iodine thus liberated required 80 mL of 0.2 N hypo solution for titration. Calculate the % of available chlorine:
15. If the number of N-atoms in 1 molecule of Hyponitrous acid is x and the basicity of Boric acid is y, find the sum (x + y).
16. Find the valency factor (n) for NH_2OH in given reaction :

$$\text{Fe}^{3+} + \text{NH}_2\text{OH} \longrightarrow \text{Fe}^{2+} + \text{N}_2\text{O} + \text{H}^+ + \text{H}_2\text{O}$$
17. A solution of $\text{Na}_2\text{S}_2\text{O}_3$ is standardised iodometrically against 3.34 g of pure KBrO_3 (converted to Br^-), requiring 40 mL $\text{Na}_2\text{S}_2\text{O}_3$ solution. What is the molarity of $\text{Na}_2\text{S}_2\text{O}_3$ solution ? (Molar mass of $\text{KBrO}_3 = 167 \text{ g mol}^{-1}$)
18. 2 moles of a mixture of O_2 and O_3 is reacted with excess of acidified solution of KI. The iodine liberated require 1L of 2M hypo solution for complete reaction. The weight % of O_3 in the initial sample is x. Find $\frac{x}{10}$.

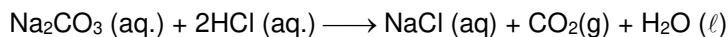
SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)



Paragraph for Questions 19 to 21

The overall equation for the reaction between sodium carbonate solution and dilute hydrochloric acid is



If you had the two solutions of the same concentration, you would have to use double volume of HCl to reach the equivalence point.

Indicators change their colours at the end point of the reaction and hence we are able to know the end points (equivalence points of reactions).

19. How many ml of 1N HCl are required for X milimoles of Na_2CO_3 with methyl orange indicator
(A) X ml (B) 2 X ml (C) 3 X ml (D) 4X ml
20. How many ml of 1N HCl are required for X milimoles of NaOH + Y milimoles of Na_2CO_3 + Z milimoles of NaHCO_3 with methyl orange indicator
(A) $(2X + Y + Z)$ ml (B) $(X + 2 Y + 2 Z)$ ml (C) $(X + 2 Y + 3 Z)$ ml (D) $(X + 2 Y + Z)$ ml
21. 25 ml of Na_2CO_3 solution requires 100ml of 0.1M HCl to reach end point with phenolphthalein indicator. Molarity of HCO_3^- ions in the resulting solution is
(A) 0.008 M (B) 0.04M (C) 0.16M (D) 0.08M

SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct.

22. Match each List-I with an appropriate pair of characteristics from List-II and select the correct answer using the code given below the lists.

	List-I		List-II
(A)	$\text{Sn}^{+2} + \text{MnO}_4^-$ (acidic) 3.5 mole 1.2 mole	(p)	Amount of oxidant available decides the number of electrons transfer
(B)	$\text{H}_2\text{C}_2\text{O}_4 + \text{MnO}_4^-$ (acidic) 8.4 mole 3.6 mole	(q)	Amount of reductant available decides the number of electrons transfer
(C)	$\text{S}_2\text{O}_3^{2-} + \text{I}_2$ 7.2 mole 3.6 mole	(r)	Number of electrons involved per mole of oxidant > Number of electrons involved per mole of reductant
(D)	$\text{Fe}^{+2} + \text{Cr}_2\text{O}_7^{2-}$ (acidic) 9.2 mole 1.6 mole	(s)	Number of electrons involved per mole of oxidant < Number of electrons involved per mole of reductant.

Practice Test-2 (IIT-JEE (ADVANCED Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22								
Ans.		(A)		(B)		(C)		(D)		



APSP Answers

PART - I

1.	(2)	2.	(2)	3.	(2)	4.	(4)	5.	(1)
6.	(1)	7.	(3)	8.	(3)	9.	(4)	10.	(2)
11.	(4)	12.	(3)	13.	(1)	14.	(2)	15.	(4)
16.	(2)	17.	(1)	18.	(2)	19.	(1)	20.	(3)
21.	(3)	22.	(2)	23.	(2)	24.	(1)	25.	(2)
26.	(2)	27.	(1)	28.	(1)	29.	(1)	30.	(4)

PART - II

1.	(D)	2.	(D)	3.	(B)	4.	(C)	5.	(C)
6.	(D)	7.	(C)	8.	(D)	9.	(B)	10.	(D)
11.	(A)	12.	(A)	13.	(A)	14.	(D)	15.	(C)
16.	(C)	17.	(C)	18.	(B)	19.	(D)	20.	(B)
21.	(B)	22.	(D)	23.	(D)				

PART - III

1.	$\text{Na}_2\text{CO}_3 = 23.2 \text{ g/L}$, $\text{NaOH} = 22.28 \text{ g/L}$.					2.	0.1 M		
3.	(A)	4.	(B)	5.	(A)	6.	(B)	7.	(D)
8.	(A)	9.	(C)	10.	(A)	11.	(B)	12.	15

PART - IV

1.	(A)	2.	(C)	3.	(A)	4.	(A)	5.	(D)
6.	(A)	7.	(D)	8.	(BC)	9.	(ABD)	10.	(ACD)
11.	(CD)	12.	(ACD)	13.	1	14.	8	15.	3
16.	2	17.	3	18.	6	19.	(B)	20.	(D)
21.	(D)	22.	(A) – p, r ; (B) – q, r ; (C) – p, q, r ; (D) – q, r.						





APSP Solutions

PART - I

- $$\text{Na}_2\overset{+2}{\text{S}}_2\text{O}_3 \longrightarrow \text{Na}_2\overset{+6}{\text{S}}\text{O}_4$$

the total change in oxidation number = $4 \times 2 = 8$

$$\therefore E_{\text{Na}_2\text{S}_2\text{O}_3} = \frac{\text{mol. wt.}}{\text{V.f.}} = \frac{M}{8}$$
- $$2\text{CuSO}_4 + 4\text{KI} \longrightarrow \text{Cu}_2\text{I}_2 + \text{I}_2 + 2\text{K}_2\text{SO}_4$$

$$\text{Cu}^{2+} + 1\text{e}^- \longrightarrow \text{Cu}^+$$

$$E_{\text{Cu}} = ? \quad \text{V.F.} = 1.$$

$$E_{\text{CuSO}_4} = \frac{159.5}{1} = 159.5$$
- $$\text{eq}_{\text{acid}} = \text{eq}_{\text{base}} \quad (\text{VF} = 1 \text{ for both})$$

$$\text{CHCl}_2\text{COOH} + \text{NH}_3 \longrightarrow \text{CHCl}_2\text{COONH}_4$$

From reaction, m.moles of NH_3 = m.moles of dichloroacetic acid = 100

$$\therefore \text{Moles of } \text{NH}_3 = \frac{100}{1000} = 0.1$$
- Equivalents of FeC_2O_4 = equivalents of KMnO_4

$$x (\text{mole}) \times 3 = 1 \times 5$$

$$x = \frac{5}{3} \text{ mole}$$
- Equivalent of KMnO_4 = equivalent of FeSO_4 + equivalent of FeC_2O_4

$$x \times 5 = 1 \times 1 + 1 \times 3$$

$$x = \frac{4}{5} \text{ mole}$$
- meq of Na_2CO_3 = meq of H_2SO_4

$$\frac{1}{10} \times 22.7 = N \times 10.2$$

Normality = 0.2225 N

$$0.2225 \times 400 = \frac{1}{10} \times V_f$$

or $V_f = 890.2 \text{ mL}$

\therefore Volume of H_2O mixed = $890.2 - 400 = 490.2 \text{ mL}$
- $$\text{HNO}_3 + \text{NH}_4^+ \longrightarrow \text{N}_2 + \text{NO}_2$$

V.F. of $\text{HNO}_3 = (5 - 4) = 1$

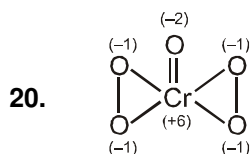
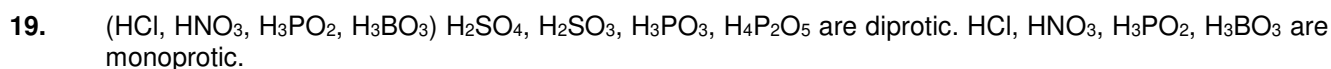
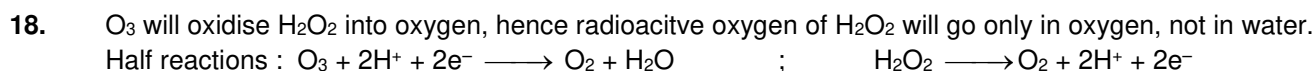
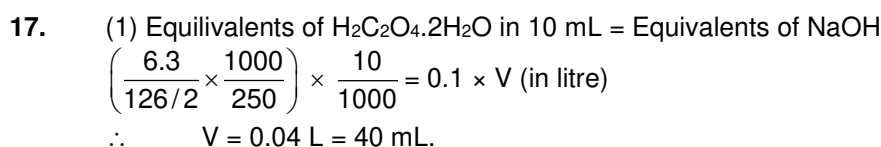
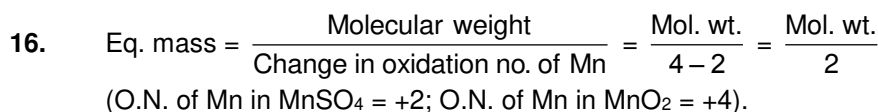
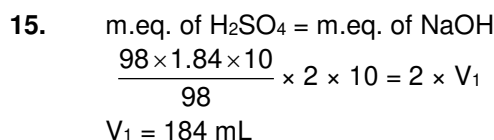
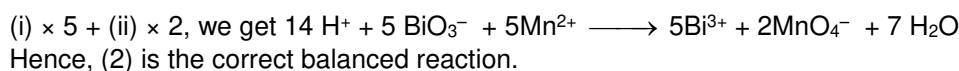
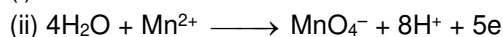
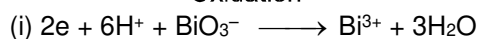
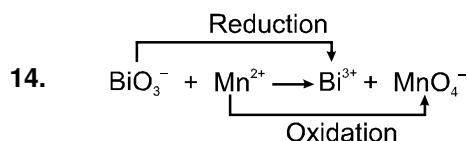
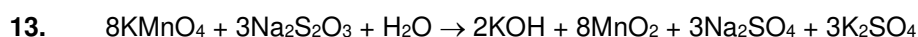
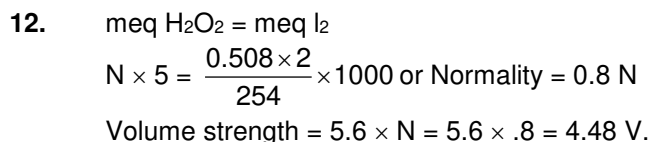
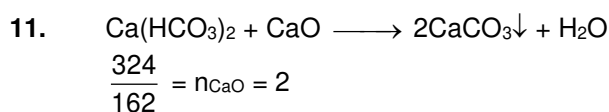
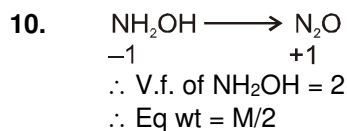
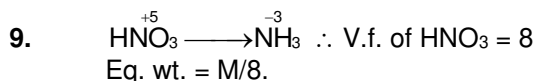
V.F. of $\text{NH}_4^+ = [0 - (-3)] = 3$

so molar ratio of HNO_3 and NH_4^+ is 3 : 1.

1 mole $(\text{NH}_4)_2\text{SO}_4$ is found to contain 2 mole of NH_4^+

So, required moles of HNO_3 is $3 \times 2 = 6 \text{ mole}$.
- $$\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = 2 + 24 + 64 + 36 = 126 \text{ and Equivalent wt.} = \left[\frac{126}{2} \right]$$

$$0.2 = \frac{W \times 1000}{\left(\frac{126}{2} \right) \times 50} \quad \therefore W = 0.63 \text{ g}$$





21. 70% by weight means
70 g of orthophosphoric acid is present in 100 g acid

$$N = \frac{w}{\text{Eq. wt.}} \times \frac{1000}{V_{(\text{cc})}}$$

$$w = 70 \text{ g}$$

$$\text{Eq. wt.} = \frac{\text{mol. mass}}{\text{no. replacable H-atoms}} = \frac{98}{3}$$

$$V = \frac{\text{mass}}{\text{density}} = \frac{100}{1.54}$$

$$N = \frac{70 \times 3 \times 1000 \times 1.54}{98 \times 100} = 33 \text{ N}$$

22. Normality of a mixture (N) = $\frac{N_1 V_1 + N_2 V_2}{V_1 + V_2}$

$$\text{Normality}(N_1) \text{ of } \text{H}_2\text{SO}_4 = \text{molarity} \times \text{basicity} = 0.2 \times 2 = 0.4 \text{ N}$$

$$N_2 = 0.2 \times 1 = 0.2 \text{ N}$$

$$V_1 = 100 \text{ mL}, V_2 = 200 \text{ mL}$$

$$N = \frac{N_1 V_1 + N_2 V_2}{V_1 + V_2} = \frac{40 + 40}{300} = \frac{80}{300} = 0.2670 \text{ N}$$

Normality of mixture of acid and base (N')

$$(N') = \frac{N_1 V_1 \sim N_2 V_2}{V_1 + V_2}$$

23. The hardness of water is estimated by simple titration of ethylene diamine tetra acetate (EDTA) solution. EDTA forms stable complexes with the metal ions present in the hard water since stability constants of calcium and magnesium complexes of EDTA are different, even the selective estimation of these ions is possible.

24. In presence of phenolphthalein,

$$\frac{1}{2} \text{ meq. of } \text{Na}_2\text{CO}_3 = \text{meq. of HCl}$$

$$2 \times 40 \times 0.05 \times \frac{1}{2} = x \times 0.05$$

$$\therefore x = 40 \text{ mL}$$

with M.O.

$$\text{Meq. of } \text{Na}_2\text{CO}_3 + \text{Meq. of } \text{NaHCO}_3 = \text{Meq. of HCl}$$

$$2 \times 40 \times 0.05 + 40 \times 0.05 = y \times 0.05$$

$$y = 120 \text{ mL}$$

$$\therefore (y - x) = 80 \text{ mL}$$

25. During oxidation of H_2O_2 , O–O bond is not broken.

26. Suppose the molecules of Na_2CO_3 and NaHCO_3 in a mixture are 'a'.
milli-equivalent of HCl

$$N_1 V_1 + N_2 V_2 = NV$$

$$a \times 2 \times 1000 + a \times 1 \times 1000 = 0.1 V$$

$$3a = 10^{-4} V \quad \dots\dots(i)$$

$$[\because N = \text{basicity/acidity} \times M]$$

$$\text{wt. of } \text{Na}_2\text{CO}_3 + \text{wt. of } \text{NaHCO}_3 = 1 \text{ g}$$

$$(\therefore \text{wt. of mixture} = 1 \text{ g})$$

$$\Rightarrow a \times 106 + a \times 84 = 1$$

$$a = 5.26 \times 10^{-3} \quad \dots(ii)$$

$$\text{From Eqs. (i) and (ii) we have } 3 \times 5.26 \times 10^{-3} = 10^{-4} V \Rightarrow V = 157.8 \text{ mL}$$



27. $\text{KCN} + \text{Fe}(\text{CN})_2 \longrightarrow \text{K}_4[\text{Fe}(\text{CN})_6]$
This is not redox reaction.
28. $\text{Cl}_2 + \text{OH}^- \longrightarrow \text{Cl}^- + \text{ClO}_3^- + \text{H}_2\text{O}$; $\text{v.f. of Cl}_2 = \frac{2 \times 10}{2 + 10} = \left(\frac{5}{3}\right)$
 $\therefore \text{Eq. wt. of Cl}_2 = \frac{71}{5/3} = 42.6$
29. Valency factor of $\text{Cr}_2\text{O}_7^{2-} = 6$
Equivalent weight = $\frac{\text{molecular weight}}{\text{v.f.}} = \frac{\text{molecular weight}}{6}$
30. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{I}^- \longrightarrow 3\text{I}_2 + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
(v.f.=6) (v.f.=2)
Equivalents of $\text{K}_2\text{Cr}_2\text{O}_7 = \text{equivalents of I}_2$
 $1 \times 6 = \text{moles of I}_2 \times 2$
Moles of $\text{I}_2 = 3$

PART - III

1. At phenolphthalein end point
eq. of $\text{Na}_2\text{CO}_3 + \text{eq. of NaOH} = \text{eq. of HCl used}$
Let x mole of Na_2CO_3 and y mole of NaOH present in 25 mL solution
 $x \times 1 + y \times 1 = 19.5 \times 0.995 \times 10^{-3}$
 $x + y = 19.4 \times 10^{-3}$ (i) (The v.f. of Na_2CO_3 is 1 when phenolphthalein is used)
At Methyl orange (MeOH) end point,
eq. of $\text{Na}_2\text{CO}_3 + \text{eq. of NaOH} = \text{eq. of HCl used}$
 $x \times 2 + y \times 1 = 25 \times 0.995 \times 10^{-3}$
 $2x + y = 24.875 \times 10^{-3}$ (ii) (The v.f. of Na_2CO_3 is 2 when methyl orange (MeOH) is used)
On solving eq. (1) and (2),
 $x = 5.475 \times 10^{-3}$ and $y = 13.925 \times 10^{-3}$
or wt. of Na_2CO_3 in 25 mL = $5.475 \times 10^{-3} \times 106$
wt. of Na_2CO_3 in 1 litre = $\frac{5.475 \times 10^{-3} \times 106}{25} \times 1000 = \mathbf{23.2 \text{ g Ans.}}$
wt. of NaOH in 25 mL solution = $13.925 \times 10^{-3} \times 40$
wt. of NaOH in 1 litre = $\frac{13.925 \times 10^{-3} \times 40}{25} \times 1000 = \mathbf{22.28 \text{ g Ans.}}$
2. $2\text{KMnO}_4 + 5\text{H}_2\text{O}_2 + 3\text{H}_2\text{SO}_4 \longrightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 8\text{H}_2\text{O} + 5\text{O}_2$
 $2\text{KMnO}_4 + 3\text{MnSO}_4 + 2\text{H}_2\text{O} \longrightarrow 5\text{MnO}_2 + 2\text{H}_2\text{SO}_4 + \text{K}_2\text{SO}_4$
 $\text{MnO}_2 + \text{Na}_2\text{C}_2\text{O}_4 + 2\text{H}_2\text{SO}_4 \longrightarrow \text{MnSO}_4 + 2\text{CO}_2 + \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$
 $\therefore \text{meq. of MnO}_2 = \text{meq of Na}_2\text{C}_2\text{O}_4 = 10 \times 0.2 \times 2 = 4$
 $\therefore \text{millimoles of MnO}_2 = \frac{4}{2} = 2$ $\left[\begin{array}{l} \text{Mn}^{4+} + 2\text{e} \rightarrow \text{Mn}^{2+} \\ \therefore \text{Valency factor of MnO}_2 = 2 \end{array} \right]$
Now, $2\text{KMnO}_4 + 3\text{MnSO}_4 + 2\text{H}_2\text{O} \longrightarrow 5\text{MnO}_2 \downarrow + \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
Since MnO_2 is derived from KMnO_4 and MnSO_4 both, thus it is better to proceed by mole concept
millimoles of $\text{KMnO}_4 = \text{millimoles of MnO}_2 \times (2/5) = 4/5$
Also, $5\text{H}_2\text{O}_2 + 2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 \longrightarrow 2\text{MnSO}_4 + \text{K}_2\text{SO}_4 + 8\text{H}_2\text{O} + 5\text{O}_2$
 $\therefore \text{millimoles of H}_2\text{O}_2 = \text{millimoles of KMnO}_4 \times \frac{5}{2} = \frac{4}{5} \times \frac{5}{2} = 2$
 $\therefore \text{M}_{\text{H}_2\text{O}_2} \times 20 = 2 \text{ or } \text{M}_{\text{H}_2\text{O}_2} = \mathbf{0.1 \text{ M}}$



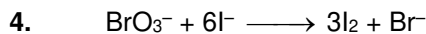
3. $m.\text{eq of } (\text{NH}_4)_2\text{SO}_4 + m.\text{eq of H}_2\text{SO}_4 = m.\text{eq of NaOH}$

$$(m.\text{moles} \times 2) + (0.1 \times 10 \times \frac{250}{25}) = 0.2 \times 100$$

$$\therefore m.\text{mole of } (\text{NH}_4)_2\text{SO}_4 = 5$$

$$\text{wt. of } (\text{NH}_4)_2\text{SO}_4 = \frac{5}{1000} \times 132 = 0.66 \text{ g}$$

$$\therefore \% \text{ of } (\text{NH}_4)_2\text{SO}_4 = \frac{0.66}{0.7} \times 100 = 94.28 \% \approx 94.3 \%$$



$$\text{moles of I}_2 = 3 \times \text{moles of KBrO}_3$$

$$\therefore \text{moles of I}_2 = 0.02 \times 3 = 0.06$$

$$\text{Eq of I}_2 = \text{Eq of Hypo}$$

$$0.06 \times 2 = 0.1 \times V$$

$$V = 1.2 \text{ L} = 1200 \text{ mL.}$$

5. $\text{meq of H}_2\text{SO}_4 = \text{meq of NaOH} + \text{meq of Na}_2\text{CO}_3$

$$N \times 25 = 0.5 \times 50 + \frac{0.265}{106/2} \times 10^3$$

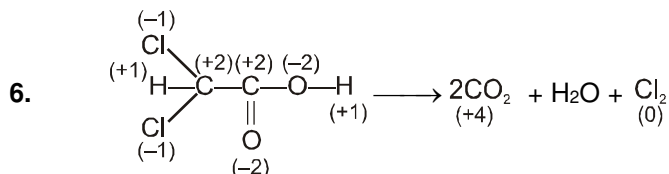
$$\text{or } N = 1.2$$

In original H_2SO_4 solution

$$N_1V_1 = N_2V_2$$

$$\text{or } N_1 \times 10 = 1.2 \times 100$$

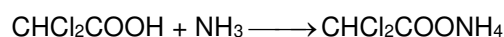
$$\text{or } N_1 = 12 \text{ N}$$



$$\therefore \text{v.f. of dichloroacetic acid} = 2(4 - 2) + 2(0 - (-1)) = 6$$

$$m.\text{eq. of dichloroacetic acid} = m.\text{eq. of oxidising agent} = 600$$

$$\therefore m.\text{moles of dichloroacetic acid} = \frac{600}{6} = 100$$



From reaction, $m.\text{moles of NH}_3 = m.\text{moles of dichloroacetic acid} = 100$

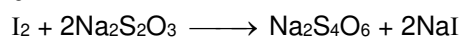
$$\therefore \text{Moles of NH}_3 = \frac{100}{1000} = 0.1$$



$$\begin{array}{l} t = 0 \quad 0.1 \quad \quad \quad - \quad \quad \quad - \\ t = t \quad 0 \quad \quad \quad x \quad \quad \quad (0.1 - x) \end{array}$$



$$\begin{array}{l} t = 0 \quad x \\ t = t \quad 0 \quad \quad \quad x/5 \end{array}$$



$$\therefore \text{moles of I}_2 \text{ liberated} = \frac{1}{2} \times \text{moles of hypo consumed} = \frac{1}{2} \times 120 \times 10^{-3} \times 0.1 = 60 \times 10^{-4}$$

So, $x = 5 \times 60 \times 10^{-4} = 0.03 \text{ moles}$ (from reaction (ii) : $5 \times \text{mole of I}_2 = \text{mole of CO}$)

$$\text{So, \% of C forming CO} = \frac{0.03 \times 12}{1.2} \times 100 = 30\%$$



8. $\text{KOH} + \text{Na}_2\text{CO}_3$
 a m.moles b m.moles
 m.eq. of KOH + m.eq. of Na_2CO_3 (v.f. = 1) = m.eq. of HCl (in presence of phenolphthalein)

$$a \times 1 + b \times 1 = 15 \times \frac{1}{20}$$

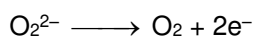
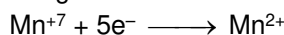
- $\therefore a + b = 0.75$... (i) (in presence of phenolphthalein)
 m.eq. of KOH + m.eq. of Na_2CO_3 (v.f. = 2) = m.eq. of HCl (in presence of methyl orange)

$$1 \times a + 2 \times b = 25 \times \frac{1}{20}$$

- $\therefore a + 2 \times b = 1.25$... (ii) (in presence of methyl orange)
 by solving (i) & (ii), $a = 0.25$ m.moles.

$$\therefore \text{mass of KOH} = \frac{0.25}{1000} \times 56 = 0.014 \text{ g}$$

10. Redox changes are :



$$\therefore \text{Eq. wt. of } \text{H}_2\text{O}_2 = \frac{34}{2}$$

Now m.eq. of KMnO_4 = m.eq. of H_2O_2

$$N.(X) = \frac{X}{100 \times 34/2} \times 1000$$

$$N = 0.588 \text{ N}$$

11. Assuming new normality of original H_2O_2 solution = X

After dilution to 100 mL of 10 mL of this solution, New normality will be (say X_1)

$$\therefore X \times 10 = X_1 \times 100$$

$$X_1 = \frac{X}{10} \quad \dots (i)$$

10 mL of this dilute solution is titrated with 25 mL, 0.0245 M KMnO_4 solution.

So, $N_1V_1 = N_2V_2$

$$\frac{X}{10} \times 10 = 0.0245 \times 5 \times 25$$

$$X = 3.0625 \text{ N}$$

So, volume strength of original H_2O_2 solution = $X \times 5.6 = 3.0625 \times 5.6 = 17.15 \text{ V}$

12. In presence of Hph indicator

m. eq. of HCl = m. eq. of Na_2CO_3 + m.eq. of NaOH

$$30 \times 0.1 = (a \times 1) + (a \times 1)$$

$$\therefore a = 1.5$$

In presence of MeOH indicator

m. eq. of H_2SO_4 = m. eq. of Na_2CO_3 + m. eq. of NaOH

$$0.15 \times 2 \times V = (a \times 2) + (a \times 1)$$

$$V = 15 \text{ ml}$$

PART - IV

1. Equivalent of $\text{K}_2\text{Cr}_2\text{O}_7$ = equivalent of N_2H_4
 also equivalent of KMnO_4 = equivalent of N_2H_4
 So, equivalent of $\text{K}_2\text{Cr}_2\text{O}_7$ = equivalent of KMnO_4
 $0.1 \times 6 \times V_1 = 0.3 \times 5 \times V_2 \quad \therefore \text{so } V_2 = 2/5 V_1$
2. Eq. of $\text{Hg}_5(\text{IO}_6)_2$ = Eq. of I_2 = Eq. of $\text{Na}_2\text{S}_2\text{O}_3$
 $\therefore (\text{moles of } \text{Hg}_5(\text{IO}_6)_2) \times 16 = 0.004 \times 1$
 $\therefore \text{moles of } \text{Hg}_5(\text{IO}_6)_2 = 2.5 \times 10^{-4}$



3. (A) Explanation : No. of meq of H^+ = $10 \times 1 + 20 \times 2 = 50$ [$\therefore H_2SO_4$, $N = 2 M$]
 No. of meq of OH^- = $30 \times 1 = 30$
 No. of meq of H^+ left unreacted = $50 - 30 = 20$ meq
 Hence, (A) is correct, (B), (C) and (D) are ruled out.
4. meq. of $KMnO_4$ = meq of H_2O_2
 $30 \times \frac{1}{12} = 20 \times N' \Rightarrow N' = \frac{30}{12 \times 20} = \frac{1}{8} N$
 \therefore strength = $N' \times$ equivalent mass = $\frac{1}{8} \times 17 = 2.12$ g/L.
5. $5As_2S_3 + 28KMnO_4 + H^+ \longrightarrow 10H_3AsO_4 + 28Mn^{2+} + SO_4^{2-}$
 m.moles of $KMnO_4$ = $50 \times 0.1 = 5$
 28 m.moles of $KMnO_4 \longrightarrow 5$ m.moles of As_2S_3
 \therefore 1 m.mole of $KMnO_4 \longrightarrow \frac{5}{28}$ m.moles of As_2S_3
 \therefore 5 m.mole of $KMnO_4 \longrightarrow \frac{5 \times 5}{28}$ m.moles of As_2S_3
 Mass of As_2S_3 = $x = 246 \times \frac{5 \times 5}{28} \times 10^{-3} = 0.22$ g
7. $4CrO_5 + 6H_2SO_4 \longrightarrow 2Cr_2(SO_4)_3 + 6H_2O + 7O_2$ (Balanced reaction)
 \therefore 1 mole CrO_5 produces $7/4$ moles of O_2 .
8. S undergoes increase in oxidation number from +2 to +2.5, while I undergoes decrease in oxidation number from 0 to -1.
9. Normality = Molarity \times v.f. $\therefore 1M H_3PO_4 = 3N H_3 PO_4$
10. $MnO_4^- + 5e^- + 8 H^+ \longrightarrow Mn^{2+} + 4 H_2O$
 \Rightarrow 1 mole of MnO_4^- accepts 5 mole of e^-
 $1/5$ mole of MnO_4^- accepts 1 mole of e^-
 \Rightarrow 0.2 mole of MnO_4^- accepts 1 mole of e^-
 \Rightarrow 0.6 mole of MnO_4^- accepts 3 mole of e^-
 $Fe^{2+} \longrightarrow Fe^{3+} + e^-$
 \Rightarrow 1 mole of Fe^{2+} will liberate 1 mole of e^-
 $Cr_2O_7^{2-} + 6e^- + 14 H^+ \longrightarrow 2 Cr^{+3} + 7 H_2O$
 \Rightarrow 1 mole of $Cr_2O_7^{2-}$ will accept 6 moles of e^-
 1 mole of $FeC_2O_4 \longrightarrow Fe^{3+} + CO_2 + 3 e^-$
 \Rightarrow 1 moles of ferrous oxalate gives 3 moles of e^-
 \Rightarrow 0.2 moles of $KMnO_4 = 1/5$ moles of $KMnO_4$ oxidises 1 mole of Fe^{2+} ion. (Tallies with statement A)
 0.6 moles of $KMnO_4 = 3/5$ moles of $KMnO_4$ will oxidise 1 mole of ferrous oxalate.
 (Tallies with statement C)
 1 mole of $K_2Cr_2O_7$ will oxidise 2 moles of ferrous oxalate. (Tallies with statement D)
 Hence, (A), (C), (D) are correct while (B) is incorrect.
12. (A) Formula of silver chromate (VI) will be $Ag_2 CrO_4$
 (B) Minimum mass of zinc required for reduction of 0.1 mole of Cr^{3+} to Cr^{2+} = $\frac{0.1}{2}$ moles of Zn
 $(v.f. \text{ of Zn} = 2 \text{ \& } v.f. \text{ of } Cr^{3+} = 1)$
 $= \frac{6.54}{2} \text{ g} = 3.27 \text{ g}$
 (C) $CrO_4^{2-} \rightleftharpoons Cr_2O_7^{2-}$
 in both ions, chromium is in +6 oxidation state.
 (D) Given reaction is correct.



13. Let's mole of $\text{FeSO}_4 = x$
 Now, KMnO_4 oxidises only FeSO_4
 equivalent of $\text{FeSO}_4 = \text{equivalent of } \text{KMnO}_4$

$$x \times 1 = \frac{100}{1000} \times 2 \times 5 \quad \Rightarrow \quad x = 1$$
14. moles of iodine = moles of chlorine = $\frac{80 \times 0.2}{2} \times 10^{-3} = 8 \times 10^{-3}$
 so required % = $\frac{8 \times 71 \times 10^{-3}}{7.1} \times 100\% = 8\%$
15. Hyponitrous acid = $\text{H}_2\text{N}_2\text{O}_2$ $\therefore x = 2$
 Basicity of Boric acid = $y = 1$
 $\therefore x + y = 2 + 1 = 3$.
16. $\text{NH}_2\text{OH} \longrightarrow \text{N}_2\text{O}$
 (-1) (+1) oxidation number of nitrogen.
 $\therefore \text{Vf} = \text{change in oxidation number of nitrogen} = 2$.
17. Necessary equations :
 $\text{KBrO}_3 + \text{KI} \longrightarrow \text{I}_2 + \text{Br}^-$
 $\text{I}_2 + \text{Na}_2\text{S}_2\text{O}_3 \longrightarrow \text{Na}_2\text{S}_4\text{O}_6 + \text{NaI}$
 equivalent of $\text{I}_2 = \text{equivalent of } \text{KBrO}_3 = 12 \times 10^{-2}$
 equivalent of $\text{Na}_2\text{S}_2\text{O}_3 = \text{equivalent of } \text{I}_2$

$$M \times 1 \times \frac{40}{1000} = 12 \times 10^{-2}$$

so molarity = 3 M.
18. $\text{KI} + \text{O}_3 \longrightarrow \text{I}_2 + \text{H}_2\text{O} + \text{O}_2$

$$\begin{array}{ccc} \text{v.f} = 2 & & \text{v.f} = 2 \\ \text{moles} & & \\ = x. & & \end{array}$$

$$\begin{array}{ccc} \text{I}_2 & + & \text{Na}_2\text{S}_2\text{O}_3 \longrightarrow \text{I}^- + \text{Na}_2\text{S}_4\text{O}_6 \\ \text{v.f} = 2 & & \text{M} = 2 \\ & & \text{V} = 1\text{L} \\ & & \text{v.f} = 1 \end{array}$$

 eq of $\text{O}_3 = \text{eq of } \text{I}_2 = \text{eq of hypo}$

$$\Rightarrow 2 \times x = 2$$

$$x = 1 \text{ mole}$$

$$\Rightarrow \text{weight \% of } \text{O}_3 = \frac{1 \times 48}{1 \times 48 + 1 \times 32} \times 100$$

$$= \frac{3}{5} \times 100 = 60\% \quad \text{Ans.} = \frac{60}{10} = 6.$$
19. In presence of MeOH indicator, valence factor of $\text{Na}_2\text{CO}_3 = 2$
 Equivalent of $\text{HCl} = \text{Equivalent of } \text{Na}_2\text{CO}_3$
 $\text{NV} = \text{mole} \times \text{V.F}$
 $1 \text{ V} = x \times 10^{-3} \times 2$
 $\text{V} = 2x \times 10^{-3} \text{ L} = 2x \text{ ml}$
20. Equivalent of $\text{HCl} = \text{Equivalent of } (\text{NaOH} + \text{Na}_2\text{CO}_3 + \text{NaHCO}_3)$
 $1 \times \text{V} = [x \times 10^{-3} \times 1] + [Y \times 10^{-3} \times 2] + [Z \times 10^{-3} \times 1]$
 $\text{V} = [x + 2Y + Z] \times 10^{-3} \text{ L}$
 $\text{V} = [X + 2Y + Z] \text{ ml}$



21. In presence of phenolphthalein indicator valence factor of Hph = 1
 Equivalents of HCl = Equivalent of Na_2CO_3
 $N_1V_1 = N_2V_2$
 For HCl $N_1 = M_1$ and Na_2CO_3 $N_2 = 2$ $M_1 V_1 = M_2V_2$
 $0.1 \times 100 = N_2 \times 25$
 $M_2 = 0.4$
 Reaction is $\text{Na}_2\text{CO}_3 + \text{HCl} \longrightarrow \text{NaHCO}_3 + \text{NaCl}$
 in moles of $\text{Na}_2\text{CO}_3 = MV$
 $= 0.4 \times 0.18 \times 25 \times 10^{-3}$
 $= \text{moles of NaHCO}_3$
 molarity of $\text{HCO}_3^- = \frac{\text{Moles of NaHCO}_3}{\text{Volume}} = \frac{0.4 \times 25 \times 10^{-3} \times 1000}{125} = 0.08$
22. (A) Eq of $\text{Sn}^{2+} = \text{Moles} \times \text{v.f.} = 3.5 \times 2 = 7$.
 Eq of $\text{MnO}_4^- = \text{Moles} \times \text{v.f.} = 1.2 \times 5 = 6$.
 Since MnO_4^- (OA) is the LR, so the amount of oxidant available decides the number of electron transfer.
 Also, electron involved per mole of OA (5) > electron involved per mole of RA (2).
 (B) Eq of $\text{H}_2\text{C}_2\text{O}_4 = \text{Moles} \times \text{v.f.} = 8.4 \times 2 = 16.8$.
 Eq of $\text{MnO}_4^- = \text{Moles} \times \text{v.f.} = 3.6 \times 5 = 18$.
 Since $\text{H}_2\text{C}_2\text{O}_4$ (RA) is the LR, so the amount of reductant available decides the number of electron transfer.
 Also, electron involved per mole of OA (5) > electron per mole of RA (2).
 (C) Eq of $\text{S}_2\text{O}_3^{2-} = \text{Moles} \times \text{v.f.} = 7.2 \times 1 = 7.2$.
 Eq of $\text{I}_2 = \text{Moles} \times \text{v.f.} = 3.6 \times 2 = 7.2$.
 Since $\text{S}_2\text{O}_3^{2-}$ (RA) and I_2 (OA) both completely get consumed, so both the amount of reductant and oxidant decides the number of electron transfer.
 Also, electron involved per mole of OA (2) > electron involved per mole of RA (1).
 (D) Eq of $\text{Fe}^{2+} = \text{Moles} \times \text{v.f.} = 9.2 \times 1 = 9.2$.
 Eq of $\text{Cr}_2\text{O}_7^{2-} = \text{Moles} \times \text{v.f.} = 1.6 \times 6 = 9.6$.
 Since Fe^{2+} (RA) is the LR, so the amount of reductant available decides the number of electron transfer.
 Also, electron involved per mole of OA (6) > electron involved per mole RA (1).