Mole Concept-2

Contents

Syllabus

Mole Concept-2

Oxidation and Reduction, Balancing of Redox Equations, Equivalent Concept and Valency Factor, Law of Equivalence, Hydrogen peroxide, Hardness of water, % strength of oleum, Available chlorine

Name : ______________________________ **Contact No.** ____________________

MOLE CONCEPT-2

Oxidation & Reduction

Let us do a comparative study of oxidation and reduction :

Oxidation	Reduction
1. Addition of Oxygen e.g. $2Mg + O_2 \rightarrow 2MgO$	1. Removal of Oxygen e.g. $CuO + C \rightarrow Cu + CO$
2. Removal of Hydrogen e.g. $H_2S + Cl_2 \rightarrow 2HCl + S$	2. Addition of Hydrogen e.g. $S + H_2 \rightarrow H_2S$
3. Increase in positive charge e.g. $Fe^{2+} \rightarrow Fe^{3+} + e^-$	3. Decrease in positive charge e.g. $Fe^{3+} + e^- \rightarrow Fe^{2+}$
4. Increase in oxidation number e.g. $\overset{(+2)}{SnCl_2} \rightarrow \overset{(+4)}{SnCl_4}$	4. Decrease in oxidation number e.g. $\overset{(+7)}{MnO_4^-} \rightarrow \overset{(+2)}{Mn^{2+}}$
5. Removal of electron e.g. $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$	5. Addition of electron e.g. $Fe^{3+} + e^- \rightarrow Fe^{2+}$

Rules governing oxidation number

- **Fluorine atom :**
  Fluorine is most electronegative atom (known). It always has oxidation number equal to –1 in all its compounds
- **Oxygen atom :**
  In general and as well as in its oxides , oxygen atom has oxidation number equal to –2.

In case of (i) peroxide (e.g. H_2O_2 , Na_2O_2) is –1,
(ii) super oxide (e.g. KO_2) is –1/2
(iii) ozonide (e.g. KO_3) is –1/3
(iv) in OF_2 is + 2 & in O_2F_2 is +1

- **Hydrogen atom :**
  In general, H atom has oxidation number equal to +1. But in metallic hydrides (e.g. NaH, KH), it is –1.
- **Halogen atom :**
  In general, all halogen atoms (Cl, Br , I) have oxidation number equal to –1.
  But if halogen atom is attached with a more electronegative atom than halogen atom, then it will show positive oxidation numbers.

  e.g. $K\overset{+5}{Cl}O_3$, $H\overset{+5}{I}O_3$, $H\overset{+7}{Cl}O_4$, $K\overset{+5}{Br}O_3$

- Oxidation number of an element in free state or in allotropic forms is always zero

  e.g. $\overset{0}{O_2}, \overset{0}{S_8}, \overset{0}{P_4}, \overset{0}{O_3}$

- Sum of the oxidation numbers of atoms of all elements in a molecule is zero.
- Sum of the oxidation numbers of atoms of all elements in an ion is equal to the charge on the ion .
- If the group number of an element in modern periodic table is ***n,*** then its oxidation number may vary from

  (n – 10) to ***(n – 18)*** (but it is mainly applicable for p-block elements)

  e.g. N- atom belongs to 15th group in the periodic table, therefore as per rule, its oxidation number may vary from

  –3 to +5 ($\overset{-3}{N}H_3, \overset{+2}{N}O, \overset{+3}{N_2}O_3, \overset{+4}{N}O_2, \overset{+5}{N_2}O_5$)

Calculation of individual oxidation number

It is important to note that to calculate individual oxidation number of the element in its compound one should know the structure of the compound and use the following guidelines.

1. If there is a bond between similar type of atom and each atom has same type of hybridisation, then bonded pair electrons are equally shared by each element.

2. If there is a bond between different type of atoms :
e.g. A – B (if B is more electronegative than A)
Then after bonding, bonded pair of electrons are counted with B - atom.

Oxidising and reducing agent

- **Oxidising agent or Oxidant :**
  Oxidising agents are those compounds which can oxidise others and reduce itself during the chemical reaction. Those reagents in which for an element, oxidation number decreases or which undergoes gain of electrons in a redox reaction are termed as oxidants.
  e.g. $KMnO_4$, $K_2Cr_2O_7$, HNO_3, conc.H_2SO_4 etc are powerful oxidising agents .

- **Reducing agent or Reductant :**
  Reducing agents are those compounds which can reduce other and oxidise itself during the chemical reaction. Those reagents in which for an element, oxidation number increases or which undergoes loss of electrons in a redox reaction are termed as reductants.
  e.g. KI , $Na_2S_2O_3$ etc are the powerful reducing agents.

Redox reaction

A reaction in which oxidation and reduction simultaneously take place is called a redox reaction
In all redox reactions, the total increase in oxidation number must be equal to the total decrease in oxidation number.

e.g. $10\overset{+2}{Fe}SO_4 + 2K\overset{+5}{Mn}O_4 + 8H_2SO_4 \longrightarrow 5\overset{+3}{Fe_2}(SO_4)_3 + 2\overset{+2}{Mn}SO_4 + K_2SO_4 + 8H_2O$

Disproportionation Reaction :

A redox reaction in which same element present in a particular compound in a definite oxidation state is oxidized as well as reduced simultaneously is a disproportionation reaction.

$$2H_2\overset{-1}{O_2}(aq) \longrightarrow 2H_2\overset{-2}{O}(\ell) + \overset{0}{O_2}(g)$$

List of some important disproportionation reactions

1. $H_2O_2 \longrightarrow H_2O + O_2$
2. $X_2 + OH^-(dil.) \longrightarrow X^- + XO^-$ (X = Cl, Br, I)
3. $X_2 + OH^-(conc.) \longrightarrow X^- + XO_3^-$

F_2 does not undergo disproportionation as it is the most electronegative element.

$F_2 + NaOH(dil.) \longrightarrow F^- + OF_2$

$F_2 + NaOH(conc.) \longrightarrow F^- + O_2$

4. $(CN)_2 + OH^- \longrightarrow CN^- + OCN^-$
5. $P_4 + OH^- \longrightarrow PH_3 + H_2PO_2^-$
6. $S_8 + OH^- \longrightarrow S^{2-} + S_2O_3^{2-}$
7. $MnO_4^{2-} \longrightarrow MnO_4^- + MnO_2$

8. $NH_2OH \longrightarrow N_2O + NH_3$

$NH_2OH \longrightarrow N_2 + NH_3$

9. Oxyacids of Phosphorus (+1, +3 oxidation number)

$H_3PO_2 \longrightarrow PH_3 + H_3PO_3$

$H_3PO_3 \longrightarrow PH_3 + H_3PO_4$

10. Oxyacids of Chlorine(Halogens)(+1, +3, +5 Oxidation number)

$ClO^- \longrightarrow Cl^- + ClO_2^-$

$ClO_2^- \longrightarrow Cl^- + ClO_3^-$

$ClO_3^- \longrightarrow Cl^- + ClO_4^-$

11. $HNO_2 \longrightarrow NO + HNO_3$

- Reverse of disproportionation is called **Comproportionation.** In some of the disproportionation reactions, by changing the medium (from acidic to basic or reverse), the reaction goes in backward direction and can be taken as an example of **Comproportionation reaction.**

$$I^- + IO_3^- + H^+ \longrightarrow I_2 + H_2O$$

Balancing of redox reactions

Ion electron method :

By this method redox equations are balanced in two different medium.

(a) Acidic medium (b) Basic medium

- **Balancing in acidic medium**

  Students are adviced to follow the following steps to balance the redox reactions by Ion electron method in acidic medium

- **Balancing in basic medium :**

  In this case, except step VI, all the steps are same. We can understand it by the following example:

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.

Equivalent weight (E) :

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

Number of Equivalents = $\dfrac{\text{mass of species}}{\text{eq. wt. of that species}}$

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

Valency factor calculation :

- **For Elements :**

  Valency factor = valency of the element.

- **For Acids :**

  Valency factor = number of replaceable H^+ ions per acid molecule

- **For Bases :**
  Valency factor = number of replacable OH^- ions per base molecule.

- **Salts :**

(a) In non-reacting condition

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

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 = $\frac{W}{E}$

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

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

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

  N × V (in mL) = M × V (in mL) × n
  or
- **milliequivalents = millimoles × n**

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

Titrations

Titration is a procedure for determining the concentration of a solution by allowing a 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.**

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

$$n_1V_1M_1 = n_2V_2M_2$$

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 studided in Ionic equilibrium)
- **Redox Titrations**

Some Common Redox Titrations

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

	Estimation of	By titrating with	Reactions	Relation*between OA and RA
1.	Fe^{2+}	MnO_4^-	$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	$5Fe^{2+} \equiv MnO_4^-$ Eq. wt. of Fe^{2+} = M/1
2.	Fe^{2+}	$Cr_2O_7^{2-}$	$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$	$6Fe^{2+} \equiv Cr_2O_7^{2-}$ Eq.wt. of $Cr_2O_7^{2-}$ = M/6
3.	$C_2O_4^{2-}$	MnO_4^-	$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	$5C_2O_4^{2-} \equiv 2MnO_4^-$ Eq. wt. of $C_2O_4^{2-}$ = M/2
4.	H_2O_2	MnO_4^-	$H_2O_2 \longrightarrow 2H^+ + O_2 + 2e^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	$5H_2O_2 \equiv 2MnO_4^-$ Eq.wt. of H_2O_2 = M/2
5.	As_2O_3	MnO_4^-	$As_2O_3 + 5H_2O \longrightarrow 2AsO_4^{3-} + 10H^+ + 4e^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	Eq. wt. of As_2O_3 = M/4
6.	AsO_3^{3-}	BrO_3^-	$AsO_3^{3-} + H_2O \longrightarrow AsO_4^{3-} + 2H^+ + 2e^-$ $BrO_3^- + 6H^+ + 6e^- \longrightarrow Br^- + 3H_2O$	Eq. wt. of AsO_3^{3-} = M/2 Eq.wt. of BrO_3^- = M/6

Permanganate Titrations :

- $KMnO_4$ is generally used as oxidising agent in acidic medium, generally provided by dilute H_2SO_4 .
- $KMnO_4$ works as self indicator persistent pink color is indication of end point.
- Mainly used for estimation of Fe^{2+} , oxalic acid ,oxalates, H_2O_2 etc.

Iodometric/Iodimetric Titrations :

Compound containing iodine are widely used in titrations.

(i) Iodide ions can be oxidised to I_2 by suitable oxidising agent

$$2I^- \text{ (aq)} \longrightarrow I_2 \text{ (s)} + 2e^-$$

(ii) Iodine (V) ions, IO_3^- , will oxidise I^- to I_2

$$IO_3^- \text{ (aq)} + 5I^- \text{ (aq)} + 6H^+ \text{ (aq)} \longrightarrow 3I_2 \text{ (s)} + 3H_2O \ (\ell)$$

(iii) Thiosulphate ions, $S_2O_3^{2-}$, can reduce iodine to iodide ions.

$$2S_2O_3^{2-} \text{ (aq)} + I_2 \text{ (s)} \longrightarrow S_4O_6^{2-} + 2I^-$$

colourless black colourless

Iodometric Titrations (Titration Solution is of $Na_2S_2O_3 . 5H_2O$)

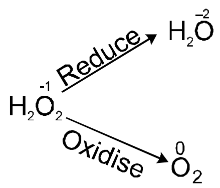
S.No.	Estimation of	Reaction	Relation between O.A. and R.A.
1.	I_2	$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$ or $I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$	$I_2 \equiv 2I \equiv 2Na_2S_2O_3$ Eq.wt. of $Na_2S_2O_3$ = M/1
2.	$CuSO_4$	$2CuSO_4 + 4KI \longrightarrow 2CuI + 2K_2SO_4 + I_2$ or $2Cu^{2+} + 4I^- \longrightarrow 2CuI + I_2$ white ppt	$2CuSO_4 \equiv I_2 \equiv 2I = 2Na_2S_2O_3$ Eq.wt.of $CuSO_4$ = M/1
3.	$CaOCl_2$	$CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$ $Cl_2 + 2KI \longrightarrow 2KCl + I_2$ $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$	$CaOCl_2 \equiv Cl_2 \equiv I_2 \equiv 2I \equiv$ $2Na_2S_2O_3$ Eq.wt. of $CaOCl_2$ = M/2
4.	MnO_2	$MnO_2 + 4HCl(conc.) \xrightarrow{\Delta} MnCl_2 + Cl_2 + 2H_2O$ $Cl_2 + 2KI \longrightarrow 2KCl + I_2$ or $MnO_2 + 4H^+ + 2Cl^- \longrightarrow Mn^{2+} + 2H_2O + Cl_2$ $Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$	$MnO_2 \equiv Cl_2 \equiv I_2 \equiv 2Na_2S_2O_3$ Eq.wt. of MnO_2 = M/2
5.	IO_3^-	$IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$	$IO_3^- \equiv 3I_2 \equiv 6I \equiv 6Na_2S_2O_3$ Eq.wt. of IO_3^- = M/6
6.	H_2O_2	$H_2O_2 + 2I^- + 2H^+ \longrightarrow I_2 + 2H_2O$	$H_2O_2 \equiv I_2 \equiv 2I \equiv 2Na_2S_2O_3$ Eq.wt. of H_2O_2 = M/2
7.	Cl_2	$Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$	$Cl_2 \equiv I_2 \equiv 2I \equiv 2Na_2S_2O_3$ Eq.wt. of Cl_2 = M/2
8.	O_3	$O_3 + 6I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$	$O_3 \equiv 3I_2 \equiv 6I \equiv 6Na_2S_2O_3$ Eq.wt. of O_3 = M/6
9.	ClO^-	$ClO^- + 2I^- + 2H^+ \longrightarrow H_2O + Cl^- + I_2$	$ClO^- \equiv I_2 \equiv 2I \equiv 2Na_2S_2O_3$ Eq.wt. of OCl^- = M/2
10.	$Cr_2O_7^{2-}$	$Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 3I_2 + 2Cr^{3+} + 7H_2O$	$Cr_2O_7^{2-} \equiv 3I_2 \equiv 6I$ Eq.wt. of $Cr_2O_7^{2-}$ = M/6
11.	MnO_4^-	$2MnO_4^- + 10I^- + 16H^+ \longrightarrow 2MnO_4^- + 5I_2 + 8H_2O$	$2MnO_4^- \equiv 5I_2 \equiv 10I$ Eq.wt. of MnO_4^- = M/5
12.	BrO_3^-	$BrO_3^- + 6I^- + 6H^+ \longrightarrow Br^- + 3I_2 + 3H_2O$	$BrO_3^- \equiv 3I_2 \equiv 6I$ Eq.wt. of BrO_3^- = M/6
13.	As(V)	$H_2AsO_4 + 2I^- + 3H^+ \longrightarrow H_3AsO_3 + H_2O + I_2$	$H_3AsO_4 \equiv I_2 \equiv 2I$ Eq.wt. of H_3AsO_4 = M/2
14.	HNO_2	$2HNO_2 + 2I^- \longrightarrow I_2 + 2NO + H_2O$	$2HNO_2 \equiv I_2 \equiv 2I$ Eq.wt. of HNO_2 = M/1
15.	HClO	$HClO + 2I^- + H^+ \longrightarrow Cl^- + I_2 + H_2O$	$HClO \equiv I_2 \equiv 2Na_2S_2O_3$ Eq.wt. of HClO = M/2

Iodimetric Titrations

S.No.	Estimation of	Reaction	Relation between O.A. and R.A.
1.	H_2S (in acidic medium)	$H_2S + I_2 \longrightarrow S + 2I^- + 2H^+$	$H_2S \equiv I_2 \equiv 2I$ Eq.wt. of H_2S = M/2
2.	SO_3^{2-} (in acidic medium)	$SO_3^{2-} + I_2 + H_2O \longrightarrow SO_4^{2-} + 2I^- + 2H^+$	$SO_3^{2-} \equiv I_2 \equiv 2I$ Eq.wt. of SO_3^{2-} = M/2
3.	Sn^{2+} (in acidic medium)	$Sn^{2+} + I_2 \longrightarrow Sn^{4+} + 2I^-$	$Sn^{2+} \equiv I_2 \equiv 2I$ Eq.wt. of Sn^{2+} = M/2
4.	As(III) (at pH 8)	$H_2AsO_3^- + I_2 + H_2O \longrightarrow HAsO_4^{2-} + 2I^- + 3H^+$	$H_2AsO_3^- \equiv I_2 \equiv 2I$ Eq.wt. of $H_2AsO_3^-$ = M/2
5.	N_2H_4	$N_2H_4 + 2I_2 \longrightarrow N_2 + 4H^+ + 4I^-$	$N_2H_4 = 2I_2 \equiv 4I$ Eq.wt. of N_2H_4 = M/4

Hydrogen peroxide (H_2O_2)

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



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.**

- **Normality of H_2O_2 (N) =** $\dfrac{\text{Volume strength of } H_2O_2}{5.6}$
- **Molarity of H_2O_2 (M) =** $\dfrac{\text{Volume strength of } H_2O_2}{11.2}$

Strength (in g/L) : Denoted by S
Strength = Molarity × Mol. wt = Molarity × 34
Strength = Normality × Eq. weight = Normality × 17

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.

By boiling : $2HCO_3^- \longrightarrow H_2O + CO_2 + CO_3^{2-}$ **or**

By Slaked lime : $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow CaCO_3 + 2H_2O$

$Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_3$

Parts Per Million (ppm)

When the solute is present in very less amount, then this concentration term is used. It is defined as the number of parts of the solute present in every 1 million parts of the solution.

$$ppm_A = \frac{\text{mass of A}}{\text{Total mass}} \times 10^6 = \text{mass fraction} \times 10^6$$

Measurement of Hardness :

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

$$\text{Hardness in ppm} = \frac{\text{mass of } CaCO_3}{\text{Total mass of solution}} \times 10^6$$

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

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.

$$CaOCl_2 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + Cl_2$$

$$CaOCl_2 + 2HCl \longrightarrow CaCl_2 + H_2O + Cl_2$$

Method of determination :

$$CaOCl_2 + 2CH_3COOH \longrightarrow Ca(CH_3COO)_2 + H_2O + Cl_2$$

(Sample of bleaching powder)

$$Cl_2 + 2KI \longrightarrow 2KCl + I_2$$

$$\underset{v.f. = 2}{I_2} + \underset{v.f. = 1}{2Na_2S_2O_3} \xrightarrow{\text{Starch as indicator}} Na_2S_4O_6 + 2NaI$$

M = Molarity of hypo ($Na_2S_2O_3$) solution

V = vol of hypo solution used in ml.

or **% of available Cl_2 =** $\mathbf{\frac{3.55 \times M \times V}{W}}$

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

*** Marked Questions are having more than one correct option.**

Section (A) : Oxidation and Reduction

A-1. According to modern concept, oxidation is -
(A) Electronation (B) Deelectronation
(C) Addition of oxygen (D) Addition of electronegative element

A-2. Oxidation takes place with -
(A) Gain of electrons (B) Loss of electrons
(C) Increase in the valency of negative part (D) Decrease in the valency of positive part

A-3. The reaction,
$2K_2MnO_4 + Cl_2 \rightarrow 2KMnO_4 + 2KCl$
is an example of -
(A) Oxidation (B) Reduction (C) Redox (D) Chlorination

A-4. In the reaction,
$3Br_2 + 6CO_3^{2-} + 3H_2O \rightarrow 5Br^- + BrO_3^- + 6HCO_3^-$
(A) Bromine is oxidised and carbonate is reduced
(B) Bromine is oxidised as well as reduced
(C) Bromine is reduced and water is oxidised
(D) Br_2 is neither oxidised nor reduced

A-5. Oxidation state of hydrogen in CaH_2 is -
(A) +1 (B) –1 (C) + 2 (D) 0

A-6. Oxidation number of C in CH_2Cl_2 is -
(A) +2 (B) + 4 (C) – 4 (D) 0

A-7. The oxidation number of P is + 3 in -
(A) H_3PO_3 (B) H_3PO_4 (C) HPO_3 (D) $H_4P_2O_7$

A-8. Which one of the following is a redox reaction ?
(A) $H_2 + Br_2 = 2HBr$ (B) $2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$
(C) $HCl + AgNO_3 = AgCl + HNO_3$ (D) $NaOH + HCl = NaCl + H_2O$

A-9. Fluorine does not show positive oxidation state due to the -
(A) Absence of s-orbitals (B) Absence of p-orbitals
(C) Absence of d-orbitals (D) Highest electronegativity

A-10. The oxidation number of Oxygen in Na_2O_2 is :
(A) + 1 (B) + 2 (C) – 2 (D) – 1

A-11. In $FeCr_2O_4$, the oxidation numbers of Fe and Cr are :
(A) + 2 and + 3 (B) 0 and + 2 (C) + 2 and + 6 (D) + 3 and + 6

A-12. The oxidation number of Phosphorus in $Mg_2P_2O_7$ is :
(A) + 3 (B) + 2 (C) + 5 (D) – 3

A-13. The oxidation states of Sulphur in the anions SO_3^{2-}, $S_2O_4^{2-}$ and $S_2O_6^{2-}$ follow the order :
(A) $S_2O_6^{2-} < S_2O_4^{2} < SO_3^{2-}$ (B) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-}$
(C) $SO_3^{2-} < S_2O_4^{2-} < S_2O_6^{2-}$ (D) $S_2O_4^{2} < S_2O_6^{2-} < SO_3^{2-}$

A-14. Match List-I (Compounds) with List-II (Oxidation states of Nitrogen) and select answer using the codes given below the lists :

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

(Code) :

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

A-15. The oxidation number of carbon in $C_{12}H_{22}O_{11}$ is -
(A) 0 (B) – 6 (C) + 6 (D) + 2

A-16. When SO_2 is passed through acidified $K_2Cr_2O_7$ solution, $Cr_2(SO_4)_3$ is formed. The change in Oxidation number of Cr is –
(A) + 4 to + 2 (B) + 5 to + 3 (C) + 6 to + 3 (D) + 7 to + 1

A-17. In the reaction $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$, the oxidation state of S is -
(A) Increased (B) Decreased (C) Remains same (D) None

A-18. White P reacts with caustic soda forming PH_3 and NaH_2PO_2. The reaction is -
(A) Redox (B) Oxidation (C) Reduction (D) Neutralisation

A-19. The reaction $Co(s) + Cu^{2+}(aq) \rightarrow Co^{2+}(aq) + Cu(s)$ is -
(A) Oxidation (B) Reduction (C) Redox (D) Hydrolysis

A-20. A redox reaction is -
(A) Proton transfer reaction (B) Electron transfer reaction
(C) Ion combination reaction (D) A reaction in a solution

A-21. In the rusting of iron, iron has been-
(A) Oxidised (B) Reduced (C) Vapourised (D) Decomposed

A-22. The conversion of sugar $C_{12}H_{22}O_{11} \longrightarrow CO_2$ is-
(A) Oxidation (B) Reduction
(C) Neither oxidation nor reduction (D) Both oxidation and reduction

A-23. In acidic medium, reaction $MnO_4^- \rightleftharpoons Mn^{2+}$ is an example of -
(A) Oxidation by three electrons (B) Reduction by three electrons
(C) Oxidation by five electrons (D) Reduction by five electrons

A-24. In the reaction $MnO_4^- + SO_3^{2-} + H^+ \longrightarrow SO_4^{2-} + Mn^{2+} + H_2O$
(A) MnO_4^- and H^+ both are reduced (B) MnO_4^- is reduced and H^+ is oxidised
(C) MnO_4^- is reduced and SO_3^{2-} is oxidised (D) MnO_4^- is oxidised and SO_3^{2-} is reduced

A-25. In a reaction between zinc and iodine, zinc iodide is formed, what is being oxidised-
(A) Zinc ions (B) Iodide ions (C) Zinc atom (D) Iodine

A-26. The charge on cobalt in $[Co(CN)_6]^{3-}$ is-
(A) – 6 (B) – 3 (C) + 3 (D) + 6

A-27. Which of following is not a redox change ?
(A) $2H_2S + SO_2 = 2H_2O + 3S$ (B) $2BaO + O_2 = 2BaO_2$
(C) $BaO_2 + H_2SO_4 = BaSO_4 + H_2O$ (D) $2KClO_3 = 2KCl + 3O_2$

A-28. Which of the following halogens always shows only one oxidation state-
(A) Cl (B) F (C) Br (D) I

A-29. In which of the following reactions, the underlined element has decreased its oxidation number during the reaction ?
(A) $\underline{Fe} + CuSO_4 \rightarrow Cu + FeSO_4$ (B) $\underline{H_2} + Cl_2 \rightarrow 2HCl$
(C) $\underline{C} + H_2O \rightarrow CO + H_2$ (D) $\underline{Mn}O_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

A-30. The compound in which oxidation state of metal is zero-
(A) $Fe_2(CO)_9$ (B) $Ni\ (CO)_4$ (C) $Fe_3(CO)_9$ (D) All the above

A-31. When potassium permanganate is added to acidulated solution of ferrous sulphate-
(A) Potassium ion is reduced (B) Manganese ions is oxidised
(C) Ferrous ion is oxidised (D) Acid is neutralised

A-32. Which of the following examples does not represent disproportionation ?
(A) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$ (B) $2H_2O_2 \rightarrow 2H_2O + O_2$
(C) $4KClO_3 \rightarrow 3KClO_4 + KCl$ (D) $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

A-33. Which of the following is a disproportionation reaction ?
(A) $Cu_2O + 2H^+ \rightarrow Cu + Cu^{2+} + H_2O$ (B) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$
(C) $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + H_2O + CO_2$ (D) $Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

A-34. In which of the following compounds, the oxidation state of I-atom is highest-
(A) KI_3 (B) KIO_4 (C) KIO_3 (D) IF_5

A-35. The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is-
(A) + 3 (B) + 2 (C) + 1 (D) – 1

A-36. Oxidation number of Ni in $Ni(CO)_4$ is-
(A) 0 (B) 4 (C) 8 (D) 2

A-37. $H_2O_2 + H_2O_2 \longrightarrow 2H_2O + O_2$ is an example of disproportionation because-
(A) O.N. of oxygen only decreases
(B) O.N. of oxygen only increases
(C) O.N. of oxygen decreases as well as increases
(D) O.N. of oxygen neither decreases nor increases

A-38. In a reaction, $H_2O + C \rightarrow CO + H_2$
(A) H_2O is the reducing agent (B) H_2O is the oxidising agent
(C) carbon is the oxidising agent (D) oxidation-reduction does not occur

A-39. The oxidation number of nitrogen in NH_2OH is-

(A) + 1 (B) – 1 (C) – 3 (D) – 2

A-40. If H_2S gas is passed through a solution of $K_2Cr_2O_7$, the colour of the solution will-

(A) Remain unchanged (B) Become deep red

(C) Become green (D) Become deep gray

A-41. In the following reaction

$4P + 3KOH + 3H_2O \longrightarrow 3KH_2PO_2 + PH_3$

(A) Only phosphorus is oxidised (B) Only phosphorous is reduced

(C) Phosphorus is both oxidised and reduced (D) Phosphorus is neither oxidised nor reduced

A-42. Oxygen has the oxidation state of + 2 in-

(A) SO_2 (B) CO_2 (C) H_2O_2 (D) OF_2

A-43. The oxidation number of chlorine in HOCl is-

(A) – 1 (B) 0 (C) + 1 (D) 2

A-44. O.N. of hydrogen in KH, MgH_2 and NaH respectively would be-

(A) –1, – 1 and –1 (B) +1, + 1, and + 1 (C) +2, +1 and –2 (D) –2, –3 and –1

A-45. Oxidation number of nitrogen can be-

(A) From + 5 to – 3 (B) From – 5 to – 3

(C) From – 5 to + 3 (D) From + 10 to + 6

A-46. Oxidation Number of Mn can be-

(A) +2 to +6 (B) +2, +3 (C) +2 to +7 (D) +2, +8

A-47. Maximum & minimum oxidation number of elements are given which one is in currect match-

Elements	***Min O.N.***	***Max O.N.***
(A) P	– 3	+ 5
(B) Cr	+ 2	+ 6
(C) Cl	– 1	+ 7
(D) e	– 4	+ 4

A-48. Oxidation number of iodine varies from

(A) –1 to +1 (B) –1 to +7 (C) +3 to +5 (D) –1 to +5

Section (B) : Balancing of Redox Equations

B-1. A reducing agent is a substance :

(A) in which an element undergoes increase in oxidation number.

(B) in which an element undergoes decrease in oxidation number.

(C) which gains electron(s)

(D) which shares electron(s)

B-2. In the reaction $2Ag + 2H_2SO_4 \longrightarrow Ag_2SO_4 + 2H_2O + SO_2$,

sulphuric acid acts as:

(A) an oxidizing agent (B) a reducing agent

(C) a catalyst (D) an acid as well as an oxidant

B-3. Consider the following reaction :

$3Br_2 + 6CO_3^{2-} + 3H_2O \longrightarrow 5Br^- + BrO_3^- + 6HCO_3^-$

Which of the following statements is true regarding this reaction:

(A) Bromine is oxidized and the carbonate radical is reduced.
(B) Bromine is reduced and the carbonate radical is oxidized.
(C) Bromine is neither reduced nor oxidized.
(D) Bromine is both reduced and oxidized.

B-4. Which of the following is a redox reaction:

(A) $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ (B) $CuSO_4 + 4NH_3 \rightarrow [Cu(NH_3)_4]SO_4$
(C) $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$ (D) $Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

B-5. In which of the following reactions is there a change in the oxidation number of nitrogen atom:

(A) $2NO_2 \longrightarrow N_2O_4$ (B) $NH_3 + H_2O \longrightarrow NH_4^+ + OH^-$
(C) $N_2O_5 + H_2O \longrightarrow 2HNO_3$ (D) None of these

B-6. Which reaction does not represent auto redox or disproportionation reaction :

(A) $Cl_2 + OH^- \longrightarrow Cl^- + ClO_3^- + H_2O$ (B) $2H_2O_2 \longrightarrow H_2O + O_2$
(C) $2Cu^+ \longrightarrow Cu^{2+} + Cu$ (D) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + 4H_2O$

B-7. In the reaction $xHI + yHNO_3 \longrightarrow NO + I_2 + H_2O$:

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

B-8. For the redox reaction $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$,
the correct stoichiometric coefficients of MnO_4^-, $C_2O_4^{2-}$ and H^+ are respectively:

(A) 2, 5, 16 (B) 16, 5, 2 (C) 5, 16, 2 (D) 2, 16, 5

B-9. For the redox reaction $xP_4 + yHNO_3 \longrightarrow H_3PO_4 + NO_2 + H_2O$:

(A) x = 1, y = 5 (B) x = 2, y = 10 (C) x = 1, y = 20 (D) x = 1, y = 15

B-10. CN^- is oxidised by NO_3^- in presence of acid :

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

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

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

B-11.* In the following reaction : $Cr(OH)_3 + OH^- + IO_3^- \rightarrow CrO_4^{2-} + H_2O + I^-$

(A) IO_3^- is oxidising agent (B) $Cr(OH)_3$ is oxidised
(C) $6e^-$ are being taken per iodine atom (D) None of these

B-12.* Which of the following reactions do not involve oxidation or reduction :

(A) $2Rb + 2H_2O \longrightarrow 2RbOH + H_2$ (B) $2CuI_2 \longrightarrow 2CuI + I_2$
(C) $NH_4Cl + NaOH \longrightarrow NaCl + NH_3 + H_2O$ (D) $4KCN + Fe(CN)_2 \longrightarrow K_4[Fe(CN)_6]$.

B-13.* Which of the following can act both as an oxidising as well as reducing agent :

(A) HNO_2 (B) H_2O_2 (C) H_2S (D) SO_2

B-14.* Which of the following represent redox reactions :

(A) $Cr_2O_7^{2-} + 2OH^- \longrightarrow CrO_4^{2-} + H_2O$ (B) $SO_5^{2-} + I^- \longrightarrow I_2 + SO_4^{2-}$
(C) $Ca(OH)_2 + Cl_2 \longrightarrow Ca(OCl)_2 + CaCl_2$ (D) $PCl_5 \longrightarrow PCl_3 + Cl_2$

B-15.* Which of the following is/are not the redox reaction(s) :

(A) $NaBr + HCl \longrightarrow NaCl + HBr$ (B) $HBr + AgNO_3 \longrightarrow AgBr + HNO_3$
(C) $H_2 + Br_2 \longrightarrow 2HBr$ (D) $Na_2O + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

B-16. For the redox reaction $MnO_4^- + C_2O_4^{--} + H^+ \rightarrow Mn^{2+} + CO_2 + H_2O$ the correct coefficients for the balanced reaction are –

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

B-17. For the redox reaction $MnO_4^- + Fe^{++} + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$ in the balanced equation, correct coefficient are –

	MnO_4^-	Fe^{2+}	H^+
(A)	1	5	8
(B)	16	5	2
(C)	5	16	2
(D)	2	16	5

B-18. In the chemical reaction, $K_2Cr_2O_7 + XH_2SO_4 + YSO_2 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + ZH_2O$
X, Y and Z are –
(A) 1, 3, 1 (B) 4, 1, 4 (C) 3, 2, 3 (D) 2, 1, 2

B-19. What will be the value of x, y and z in the following equation –
$H_2C_2O_4 + xH_2O_2 \rightarrow yCO_2 + zH_2O$
(A) 2, 1, 2 (B) 1, 2, 2 (C) 2, 2, 1 (D) None

B-20. What will be the value of x, y and z in the following equation –
$xI_2 + yOH^- \rightarrow IO_3^- + zI^- + 3H_2O$
(A) 3, 5, 6 (B) 5, 6, 3 (C) 3, 6, 5 (D) 6, 3, 5

B-21. $Cu + X \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$. Here X is-
(A) $4HNO_3$ (B) $2HNO_3$ (C) $4HNO_2$ (D) $6HNO_3$

B-22. In the redox reaction –
$10FeC_2O_4 + x\,KMnO_4 + 24H_2SO_4 \rightarrow 5Fe_2(SO_4)_3 + 20CO_2 + y\,MnSO_4 + 3\,K_2SO_4 + 24H_2O$.
The values of x and y are respectively –
(A) 6, 3 (B) 3, 6 (C) 3, 3 (D) 6, 6

B-23. Which of the following equations is a balanced one-
(A) $5\,BiO_3^- + 22H^+ + Mn^{2+} \rightarrow 5Bi^{3+} + 7H_2O + MnO_4^-$
(B) $5\,BiO_3^- + 14H^+ + 2Mn^{2+} \rightarrow 5Bi^{3+} + 7H_2O + 2MnO_4^-$
(C) $2\,BiO_3^- + 4H^+ + Mn^{2+} \rightarrow 2Bi^{3+} + 2H_2O + MnO_4^-$
(D) $6\,BiO_3^- + 12H^+ + 3Mn^{2+} \rightarrow 6Bi^{3+} + 6H_2O + 3MnO_4^-$

B-24. In the reaction : $A^{-n_2} + xe \rightarrow A^{-n_1}$
Here x will be –
(A) $n_1 + n_2$ (B) $n_2 - n_1$ (C) $n_1 - n_2$ (D) $n_1.n_2$

Section (C) : Equivalent Concept and Valency Factor :

C-1. When $KMnO_4$ is titrated against $FeSO_4.(NH_4)_2SO_4.6H_2O$ the equivalent mass of $KMnO_4$ is –
(A) Molecular mass / 10 (B) Molecular mass / 5
(C) Molecular mass / 2 (D) Molecular mass

C-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

C-3. When HNO_3 is converted into NH_3, the equivalent weight of HNO_3 will be :
(M = molecular weight of HNO_3)
(A) M/2 (B) M/1 (C) M/6 (D) M/8

C-4. In the conversion $NH_2OH \longrightarrow N_2O$, the equivalent weight of NH_2OH will be :
(M = molecular weight of NH_2OH)
(A) M/4 (B) M/2 (C) M/5 (D) M/1

C-5. In the ionic equation $2K^+BrO_3^- + 12H^+ + 10e^- \longrightarrow Br_2 + 6H_2O + 2K^+$,
the equivalent weight of $KBrO_3$ will be : (where M = molecular weight of $KBrO_3$)
(A) M/5 (B) M/2 (C) M/6 (D) M/4

C-6. Which of the following relations is incorrect 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 $Al_2(SO_4)_3$

C-7. In acidic medium, equivalent weight of $K_2Cr_2O_7$ (Mol. wt. = M) is-
(A) M / 3 (B) M / 4 (C) M / 6 (D) M / 2

C-8. The equivalent weight of $Na_2S_2O_3$ (Mol. wt = M) in the reaction $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$ is –
(A) M/4 (B) M/3 (C) M/2 (D) M

C-9. In the following unbalanced redox reaction : $Cu_3P + Cr_2O_7^{2-} \longrightarrow Cu^{2+} + H_3PO_4 + Cr^{3+}$ Equivalent weight of H_3PO_4 is -
(A) $\frac{M}{3}$ (B) $\frac{M}{6}$ (C) $\frac{M}{7}$ (D) $\frac{M}{8}$

C-10. What is the equivalent weight of NH_3 in the given reaction ?
$3CuO + 2NH_3 = 3Cu + N_2 + 3H_2O$
(A) 17 (B) $\frac{17}{4}$ (C) $\frac{17}{2}$ (D) $\frac{17}{3}$

C-11. What is the equivalent weight of $C_{12}H_{22}O_{11}$ in the following reaction ?
$C_{12}H_{22}O_{11} + 36HNO_3 = 6H_2C_2O_4 + 36NO_2 + 23\ H_2O$
(A) $\frac{342}{36}$ (B) $\frac{342}{12}$ (C) $\frac{342}{22}$ (D) $\frac{342}{3}$

C-12. What is the equivalent weight of P_4 in the following reaction ?
$P_4 + NaOH \longrightarrow NaH_2PO_2 + PH_3$
(A) $\frac{31}{4}$ (B) $\frac{31}{3}$ (C) $\frac{31}{2}$ (D) 31 × 4/3

C-13. Equivalent weight of H_3PO_2 when it disproportionates into PH_3 and H_3PO_3 is (mol. wt. of H_3PO_2 = M)
(A) M (B) $\frac{3M}{4}$ (C) $\frac{M}{2}$ (D) $\frac{M}{4}$

C-14. $N_2 + 3H_2 \longrightarrow 2NH_3$
Molecular weight of NH_3 and N_2 are x_1 and x_2, their equivalent weight are y_1 and y_2. Then $(y_1 - y_2)$ is-
(A) $\left(\frac{2x_1 - x_2}{6}\right)$ (B) $(x_1 - x_2)$ (C) $(3x_1 - x_2)$ (D) $(x_1 - 3x_2)$

Section (D) : Law of Equivalence

D-1. 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

D-2. 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

D-3. The mass of oxalic acid crystals ($H_2C_2O_4 . 2H_2O$) required to prepare 50 mL of a 0.2 N solution is :
(A) 4.5 g (B) 6.3 g (C) 0.63 g (D) 0.45 g

D-4. 125 mL of 63% (w/v) $H_2C_2O_4 . 2H_2O$ 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

D-5. A certain weight of pure $CaCO_3$ is made to react completely with 200 mL of a HCl solution to give 224 mL of CO_2 gas at STP. The normality of the HCl solution is:
(A) 0.05N (B) 0.1 N (C) 1.0 N (D) 0.2 N

D-6. The volume of 1.5M H_3PO_4 solution required to neutralize exactly 90 mL of a 0.5 M $Ba(OH)_2$ solution is:
(A) 10 mL (B) 30 mL (C) 20 mL (D) 60 mL

D-7. 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

D-8. If equal volumes of 0.1 M $KMnO_4$ and 0.1 M $K_2Cr_2O_7$ 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 $K_2Cr_2O_7$
(C) equal in both cases (D) cannot be determined.

D-9. 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-10. An element A in a compound ABD has oxidation number –n. It is oxidised by $Cr_2O_7^{2-}$ in acid medium. In the experiment, 1.68×10^{-3} moles of $K_2Cr_2O_7$ 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-11. The number of milli equivalents of acid in 100 ml of 0.5 N HCl solution is -
(A) 50 (B) 100 (C) 25 (D) 200

D-12. For preparation of one litre of N/10 H_2SO_4 solution we need H_2SO_4 equal to -
(A) 98 gm (B) 4.9 gm (C) 10 gm (D) 2.45 gm

D-13. 100 c.c. of 0.5 N NaOH solution is added to 10 c.c. of 3N H_2SO_4 solution and 20 c.c. of 1N HCl solution. The solution will be -
(A) Strongly acidic (B) Alkaline (C) Neutral (D) Fairly acidic

D-14. The normality of a solution obtained by mixing 100 ml of 0.2 N HCl and 500 ml of 0.12 M H_2SO_4 is-
(A) 0.233 N (B) 0.466 N (C) 0.116 N (D) 2.33 N

D-15. The amount of water required to be added to 200 c.c. of a semi-normal solution of NaOH to make it exactly decinormal is -
(A) 200 c.c. (B) 400 c.c. (C) 800 c.c. (D) 100 c.c.

D-16. The amount of water to be added to 100 c.c. of normal HCl solution to make it decinormal is -
(A) 900 c.c. (B) 850 c.c. (C) 400 c.c. (D) 600 c.c.

D-17. The amount of $CuSO_4$. $5H_2O$ required to prepare 500 c.c. of 0.5 N solution is -
(Mol.wt. of $CuSO_4.5H_2O$ = 249.5)
(A) 249.5 (B) 249.5/2 (C) 249.5/8 (D) 249.5/3

D-18. 100 c.c. of 0.6 N H_2SO_4 and 200 c.c. of 0.3 N HCl were mixed together. The normality of the resulting solution will be -
(A) 0.2 N (B) 0.4 N (C) 0.8 N (D) 0.6 N

D-19. How many gram of $KMnO_4$ are contained in 4 litres of 0.05 N solution? The $KMnO_4$ is to be used as an oxidant in acid medium. (Mol. wt. of $KMnO_4$ = 158)
(A) 1.58 g (B) 15.8 g (C) 6.32 g (D) 31.6 g

D-20. If 250 ml of 0.25 M NaCl solution is diluted with water to a volume of 500 ml, the new concentration of the solution is -
(A) 0.167 M (B) 0.125 M (C) 0.0833 M (D) 0.0167 M

D-21. 100 ml of 0.3 N HCl is mixed with 200 ml of 0.6N H_2SO_4. The final normality of the resulting solution will be -
(A) 0.1 N (B) 0.2 N (C) 0.3 N (D) 0.5 N

D-22. What is the normality of a 1 M solution of H_3PO_4 ?
(A) 0.5 N (B) 1.0 N (C) 2.0 N (D) 3.0 N

D-23. 9.8 g of H_2SO_4 is present in 2 litres of a solution. The molarity of the solution is -
(A) 1 M (B) 0.05 M (C) 0.02 M (D) 2 M

D-24. 10 ml. of N-HCl, 20 ml of N/2 H_2SO_4 and 30 ml of N/3 HNO_3 are mixed together and volume made to one litre. The normality of the resulting solution is -
(A) 3N/100 (B) N/10 (C) N/20 (D) N/40

D-25. How many moles of $K_2Cr_2O_7$ are reduced by 1 mole of formic acid –
(A) 1/3 mole (B) 1 mole (C) 2/3 mole (D) 5/3 mole

D-26. The mililitres of 0.2M $KMnO_4$ required for the complete oxidation of 0.1 mol Fe^{2+} in acidic medium is-
(A) 200 ml (B) 100 ml (C) 400 ml (D) 50 ml

D-27. 1 mol of MnO_4^- will oxidise x mol of ferric oxalate in acidic medium, x is -
(A) $\frac{5}{6}$ (B) $\frac{6}{5}$ (C) 5 (D) 6

D-28. In the following redox reaction $Cu(OH)_2(s) + N_2H_4(aq) \longrightarrow Cu(s) + N_2(g)$ number of mol of $Cu(OH)_2$ reduced by one mol of N_2H_4 is -
(A) 1 (B) 2 (C) 3 (D) 4

D-29. NH_3 is oxidised to NO by O_2 (air) in basic medium. Number of equivalent of NH_3 oxidised by 1 mol of O_2 is -
(A) 4 (B) 5 (C) 6 (D) 7

D-30. 5 Lit of $KMnO_4$ solution contain 0.01 equiv of $KMnO_4$. 50 ml of the given solution contains how many moles of $KMnO_4$?
$KMnO_4 \longrightarrow MnO_2$
(A) $\frac{10^{-6}}{4}$ (B) $\frac{10^{-4}}{3}$ (C) 3×10^{-5} (D) 10^{-5}

Section (E) : Hydrogen peroxide, Hardness of water, % strength of oleum, Available chlorine

E-1. The volume strength of 1.5 N H_2O_2 solution is :
(A) 4.8 V (B) 8.4 V (C) 3 V (D) 8 V

E-2. Find the volume strength of H_2O_2 solution prepared by mixing of 250 mL of 3N H_2O_2 & 750 mL of 1N H_2O_2 solution :
(A) 1.5 V (B) 8.4 V (C) 5.6 V (D) 11.2 V

E-3. Bottle (A) contain 320 mL of H_2O_2 solution and labelled with "10 V H_2O_2" and Bottle (B) contain 80 mL H_2O_2 having normality 5N. Content of bottle (A) and bottle (B) are mixed and solution is filled in bottle (C). Select the correct label for bottle (C) in term of volume strength and g/litre.
(A) 13.6 "V" & 41.286 g / L (B) 11.2 "V" & 0.68 g / L
(C) 5.6 "V" & 0.68 g / L (D) 5.6 "V" & 41.286 g / L

E-4. Hydrogen peroxide in aqueous solution decomposes on warming to give oxygen according to the equation :

$$2H_2O_2(aq) \longrightarrow 2H_2O(\ell) + O_2(g)$$

under conditions where 1 mole of gas occupies 24 dm^3. 100 cm^3 of X M solution of H_2O_2 produces 3 dm^3 of O_2. Thus, X is :
(A) 2.5 (B) 1 (C) 0.5 (D) 0.25

E-5. Temporary hardness is due to bicarbonates of Mg^{2+} and Ca^{2+}. It is removed by addition of CaO as follows :

$$Ca(HCO_3)_2 + CaO \longrightarrow 2CaCO_3 + H_2O$$

Mass of CaO required to precipitate 2 g $CaCO_3$ is :
(A) 2 g (B) 0.56 g (C) 0.28 g (D) 1.12 g

E-6. In the reaction $X^- + XO_3^- + H^+ \longrightarrow X_2 + H_2O$, the molar ratio in which X^- and XO_3^- react is :
(A) 1 : 5 (B) 5 : 1 (C) 2 : 3 (D) 3 : 2

E-7.* 25 mL of 0.5 M H_2O_2 solution is added to 50 mL of 0.2 M $KMnO_4$ in acid solution. Which of the following statements is false :
(A) 0.010 mole of oxygen gas is liberated. (B) 0.005 mole of $KMnO_4$ is left.
(C) 0.030 g of oxygen gas is evolved. (D) 0.0025 mole H_2O_2 does not react with $KMnO_4$.

PART - II : MISCELLANEOUS QUESTIONS

COMPREHENSIONS TYPE

Comprehension # 1

Read the following passage carefully and answer the questions.

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 :

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.

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

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 = $\frac{\text{Molecular mass of oxidising agent}}{\text{Total change in oxidation number per molecule of oxidising agent}}$

1. 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

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

3. 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

4. Which of the following is not a disproportionation reaction :
(A) $P_4 + NaOH \longrightarrow NaH_2PO_2 + PH_3$
(B) $BaC_2 + N_2 \longrightarrow Ba(CN)_2$
(C) $Hg_2I_2 \longrightarrow HgI_2 + Hg$
(D) $Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$

5. When NO_2 is dissolved in water solution become acidic. Equivalent weight of NO_2 in this reaction is :
(A) 28 (B) 46 (C) 92 (D) 14

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.

6. The volume of H_2O_2 solution is :
(A) 11.2 mL (B) 37.2 mL (C) 5.6 mL (D) 22.4 mL

7. 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

8. The volume of O_2 at STP that would be liberated by above H_2O_2 solution is :
(A) 56 mL (B) 112 mL (C) 168 mL (D) 224 mL

MATCH THE COLUMN

9. **Column I** — **Column II**

Column I		Column II	
(A)	$KMnO_4$	(p)	oxidising agent
(B)	$K_2Cr_2O_7$	(q)	reducing agent
(C)	H_2O_2	(r)	sp^3 hybridisation of central atom
(D)	$Na_2S_2O_3$	(s)	ionic compound

10. **Column I** — **Column II**

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 ($H_2C_2O_4$)	(r) Central atom is in its highest oxidation number
(D) 5.3 g Na_2CO_3	(s) May react with an oxidising agent

11. **Column I** — **Column II**

Column I	Column II
(A) Sn^{+2} + MnO_4^- (acidic) 3.5 mole 1.2 mole	(p) Amount of oxidant available decides the number of electrons transfer
(B) $H_2C_2O_4$ + MnO_4^- (acidic) 8.4 mole 3.6 mole	(q) Amount of reductant available decides the number of electrons transfer
(C) $S_2O_3^{-2}$ + 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) Fe^{+2} + $Cr_2O_7^{-2}$ (acidic) 9.2 mole 1.6 mole	(s) Number of electrons involved per mole of oxidant < Number of electrons involved per mole of reductant.

ASSERTION / REASONING

DIRECTIONS :

Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.
(E) Statement-1 and Statement-2 both are False.

12. **Statement-1 :** Oxidation involves loss of electrons and reduction involves gain of electrons.
Statement-2 : The overall reaction in which oxidation and reduction occur simultaneously, is called redox reaction.

13. **Statement-1 :** H_2SO_4 cannot act as reducing agent.
Statement-2 : Sulphur cannot increase its oxidation number beyond + 6.

14. **Statement-1 :** The oxidation state of oxygen in superoxide ion in KO_2, CsO_2 and RbO_2 is – 1/2.
Statement-2 : Since the oxidation state of an alkali metal in any compound is always +1, the oxidation state of oxygen is – 1/2 in the O_2^- ion.

15. **Statement-1 :** In the redox reaction $8\ H^+ (aq) + 4\ NO_3^- + 6\ Cl^- + Sn(s) \longrightarrow SnCl_6^{2-} + 4\ NO_2 + 4\ H_2O$, the reducing agent is Sn(s).

Statement-2 : In balancing half reaction, $S_2O_3^{2-} \longrightarrow S(s)$, the number of electrons added on the left is 4.

16. **Statement-1 :** Among Br^-, O_2^{2-}, H^- and NO_3^-, the ions that cannot act as oxidising agents are Br^- and H^-.
Statement-2 : Br^- and H^- cannot be reduced.

17. **Statement-1 :** In the reaction, $MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$, MnO_4^- acts as oxidising agent.
Statement-2 : : In the above reaction, Fe^{2+} is converted to Fe^{3+}.

18. **Statement-1 :** If 200 mL of 0.1N NaOH is added to 200 mL of 0.1N H_2SO_4 solution, then the resulting solution is acidic.
Statement-2 : If milliequivalents of acid is greater than milliequivalents of base, then upon mixing the solution is acidic.

19. **Statement-1 :** Equivalent weight of FeC_2O_4 in the reaction,

$$FeC_2O_4 + \text{Oxidising agent} \longrightarrow Fe^{3+} + CO_2$$

is M/3, where M is molar mass of FeC_2O_4.
Statement-2 : In the above reaction total two moles of electrons are given up by 1 mole of FeC_2O_4 to the oxidising agent.

TRUE / FALSE

20. In a compound, all the atoms of a particular element have the same oxidation number.

21. In H_2O_2, both oxygen atoms have same oxidation number but in $Na_2S_2O_3$, the two S-atoms do not have same oxidation number.

22. In the reaction :

$$3\ Cl_2 + 6\ NaOH \longrightarrow 5\ NaCl + NaClO_3 + 3\ H_2O$$, Cl_2 acts purely as an oxidizing agent.

23. In a redox reaction, the oxidation number of an element can either increase or decrease but both cannot happen simultaneously.

24. In $CaOCl_2$, both the chlorine atom are in same oxidation state.

FILL IN THE BLANKS

25. Oxidizing agent (or oxidant) is a substance in which oxidation number of one of the atoms _____.

26. Reducing agent (or reductant) is a substance which __________ electrons.

27. In the reaction $2\ H_2O_2 \longrightarrow 2\ H_2O + O_2$, hydrogen peroxide is _________.

28. In the reaction $2\ KClO_3 \longrightarrow 2\ KCl + 3\ O_2$, the element which has been oxidised is _________ and the element which has been reduced is ________.

29. In HCN, oxidation number of carbon is ___________.

30. The following reaction $Cl_2 + 2OH^- \longrightarrow Cl^- + ClO^- + H_2O$ ______________ disproportionation reaction.

31. The reaction $NH_4NO_2 \longrightarrow N_2 + 2H_2O$ ______________ disproportionation reaction.

EXERCISE # 2

PART - I : MIXED OBJECTIVE

Single Choice Type

1. If in a reaction HNO_3 is reduced to NO, the mass of HNO_3 absorbing one mole of electrons would be -
(A) 12.6 g (B) 21.0 g (C) 31.5 g (D) 63.0 g

2. If in a given reaction NO_3^- is reduced to NH_4^+, the mass of NO_3^- absorbing one mole of electrons would be-
(A) 31.0 g (B) 12.4 g (C) 6.29 g (D) 7.75 g

3. For the reaction $Br_2 + OH^- \rightarrow Br^- + BrO_3^- + H_2O$ what is the equivalent weight of Br_2
(A) M/8 (B) M/5 (C) 3M/5 (D) 5M/8.

4. For the reaction, $M^{x+} + MnO_4^- \rightarrow MO_3^- + Mn^{2+}$ if one mole of MnO_4^- oxidises 1.67 moles of M^{x+} to MO_3^-, then the value of x in the reaction is -
(A) 5 (B) 3 (C) 2 (D) 1

5. Amount of oxalic acid required to prepare 250 mL of N/10 solution (Mol. mass of oxalic acid = 126) is :
(A) 1.5759 g (B) 3.15 g (C) 15.75 g (D) 63.0 g

6. The equivalent mass of phosphoric acid (H_3PO_4) is 49. It behaves as ... acid.
(A) monobasic (B) dibasic (C) tribasic (D) tetrabasic

7. 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

8. 1 mole of N_2H_4 loses ten moles of electrons to form a new compound Y. Assuming that all the nitrogen appears in the new compound, what is the oxidation state of nitrogen in Y ? (There is no change in the oxidation state of hydrogen).
(A) – 1 (B) – 3 (C) + 3 (D) + 5

9. 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 :

$$SO_3^{2-}(aq) + H_2O \longrightarrow SO_4^{2-}(aq) + 2H^+ + 2e^-$$

If the oxidation number of metal in the salt was 3, what would be the new oxidation number of metal :
(A) 0 (B) 1 (C) 2 (D) 4

10. 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 $(NH_4)_2SO_4$ is :
(A) 4 (B) 5 (C) 6 (D) 2

11. 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) $Z^+ \rightarrow Z^{2+}$ (B) $Z^{2+} \rightarrow Z^{3+}$ (C) $Z^{3+} \rightarrow Z^{4+}$ (D) $Z^{2+} \rightarrow Z^{4+}$

12. 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

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. $28\ NO_3^- + 3As_2S_3 + 4H_2O \longrightarrow 6AsO_4^{3-} + 28NO + 9SO_4^{2-} + 8H^+$.
What will be the equivalent mass of As_2S_3 in above reaction : (Molecular mass of As_2S_3 = M)
(A) $\frac{M}{2}$ (B) $\frac{M}{4}$ (C) $\frac{M}{24}$ (D) $\frac{M}{28}$

15. When ZnS is boiled with strong nitric acid, the products are zinc nitrate, sulphuric acid and nitrogen dioxide. What are the changes in the oxidation numbers of Zn, S and N :
(A) + 2, + 4, – 1 (B) + 2, + 6, – 2 (C) 0, + 4, – 2 (D) 0, + 8, – 1

16. When arsenic sulphide is boiled with NaOH, sodium arsenite and sodium thioarsenite are formed according to reactions :

$x\ As_2S_3 + y\ NaOH \longrightarrow x\ Na_3AsO_3 + x\ Na_3AsS_3 + \frac{y}{2}\ H_2O$. What are the values of x and y?
(A) 1, 6 (B) 2, 8 (C) 2, 6 (D) 1, 4

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

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

calculate the volume of hypo consumed. [Atomic weight of As = 75]
(A) 48.1 mL (B) 38.4 mL (C) 24.7 mL (D) 30.3 mL

18. The following equations are balanced atomwise and chargewise.
(i) $Cr_2O_7^{2-} + 8H^+ + 3H_2O_2 \longrightarrow 2Cr^{3+} + 7H_2O + 3O_2$
(ii) $Cr_2O_7^{2-} + 8H^+ + 5H_2O_2 \longrightarrow 2Cr^{3+} + 9H_2O + 4O_2$
(iii) $Cr_2O_7^{2-} + 8H^+ + 7H_2O_2 \longrightarrow 2Cr^{3+} + 11H_2O + 5O_2$
The precise equation/equations representing the oxidation of H_2O_2 is/are :
(A) (i) only (B) (ii) only (C) (iii) only (D) all the three

19. 35 mL sample of hydrogen peroxide gives off 500 mL of O_2 at 27ºC and 1 atm pressure. Volume strength of H_2O_2 sample will be :
(A) 10 V (B) 13 V (C) 11 V (D) 12 V

20. 4.9 g of $K_2Cr_2O_7$ is taken to prepare 0.1 L of the solution. 10 mL of this solution is further taken to oxidise Sn^{2+} ion into Sn^{4+} ion. If Sn^{4+} so produced is used in 2nd reaction to prepare Fe^{3+} ion from Fe^{2+}, then the millimoles of Fe^{3+} ion formed will be : (assume all other components are in sufficient amount) [Molar mass of $K_2Cr_2O_7$ = 294]
(A) 5 (B) 20 (C) 10 (D) none of these

21. 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 $Na_2S_2O_3$ solution required to consume the liberated iodine will be :
(A) 1000 mL (B) 1200 mL (C) 1500 mL (D) 800 mL

22. $Hg_5(IO_6)_2$ 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}

23. 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

24. 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

Multiplce Choice Type

25. The incorrect order of decreasing oxidation number of S in compounds is :

(A) $H_2S_2O_7 > Na_2S_4O_6 > Na_2S_2O_3 > S_8$ (B) $H_2SO_5 > H_2SO_3 > SCl_2 > H_2S$

(C) $SO_3 > SO_2 > H_2S > S_8$ (D) $H_2SO_4 > SO_2 > H_2S > H_2S_2O_8$

26. 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+}

27. In the titration of $K_2Cr_2O_7$ and ferrous sulphate , following data is obtained :

V_1 mL of $K_2Cr_2O_7$ 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) $6\ M_1V_1 = M_2V_2$ (B) $M_1V_1 = 6\ M_2V_2$ (C) $N_1V_1 = N_2V_2$ (D) $M_1V_1 = M_2V_2$

28. 0.1 M solution of KI reacts with excess of H_2SO_4 and KIO_3 solutions, according to equation

$5I^- + IO_3^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$; which of the following statements is/are correct :

(A) 200 mL of the KI solution react with 0.004 mole KIO_3.

(B) 100 mL of the KI solution reacts with 0.006 mole of H_2SO_4.

(C) 0.5 litre of the KI solution produced 0.005 mole of I_2.

(D) Equivalent weight of KIO_3 is equal to $\left(\frac{\text{Molecular Weight}}{5}\right)$.

PART - II : SUBJECTIVE QUESTIONS

1. Calculate oxidation number of underlined element :

(a) $Na_2\underline{S}_2O_3$ **(b)** $Na_2\underline{S}_4O_6$

2. Calculate individual oxidation number of each S-atom in $Na_2S_2O_3$ (sodium thiosulphate) with the help of its structure .

3. Balance the following redox reaction :

$FeSO_4 + KMnO_4 + H_2SO_4 \longrightarrow Fe_2(SO_4)_3 + MnSO_4 + H_2O + K_2SO_4$

4. Balance the following redox reaction in basic medium :

$ClO^- + CrO_2^- + OH^- \longrightarrow Cl^- + CrO_4^{2-} + H_2O$

5. Calculate the normality of a solution containing 15.8 g of $KMnO_4$ in 50 mL acidic solution.

6. Calculate the normality of a solution containing 50 mL of 5 M solution of $K_2Cr_2O_7$ in acidic medium.

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

The reaction is $KMnO_4 + Cu_2S \longrightarrow Mn^{2+} + Cu^{2+} + SO_2$

8. How many millilitres of 0.02 M $KMnO_4$ solution would be required to exactly titrate 25 mL of 0.2 M $Fe(NO_3)_2$ solution in acidic medium ?

9. Write the balanced reaction of titration of $KMnO_4$ Vs oxalic acid in presence of H_2SO_4.

10. Write the balanced reaction of titration of $KMnO_4$ Vs ferrous ammonium sulphate in presence of H_2SO_4.

11. 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 $Na_2S_2O_3$. If 10 mL $Na_2S_2O_3$ is required for the titration, how many milligrams of sulphur are contained in the sample?

Reactions :

$H_2S + I_2 \longrightarrow S + 2I^- + 2H^+$; $I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$

12. 20 mL of H_2O_2 after acidification with dilute H_2SO_4 required 30 mL of $\frac{N}{12}$ $KMnO_4$ for complete oxidation. Final the strength of H_2O_2 solution. [Molar mass of H_2O_2 = 34]

13. 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 ?

14. 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).

15. 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.

16. Calculate individual oxidation number of each S-atom in $Na_2S_4O_6$ (sodium tetrathionate) with the help of its structure .

17. Find the average and individual oxidation number of Fe & Pb in Fe_3O_4 & Pb_3O_4, which are mixed oxides.

18. Balance the following equations :

(a) $H_2O_2 + MnO_4^- \longrightarrow Mn^{+2} + O_2$ (acidic medium) (अम्लीय माध्यम)

(b) $Zn + HNO_3(dil) \longrightarrow Zn(NO_3)_2 + H_2O + NH_4NO_3$

(c) $CrI_3 + KOH + Cl_2 \longrightarrow K_2CrO_4 + KIO_4 + KCl + H_2O$.

(d) $P_2H_4 \longrightarrow PH_3 + P_4$

(e) $Ca_3(PO_4)_2 + SiO_2 + C \longrightarrow CaSiO_3 + P_4 + CO$

19. Find the valency factor for following acids

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

20. Find the valency factor for following bases :

(i) $Ca(OH)_2$ (ii) CsOH (iii) $Al(OH)_3$

21. Find the valence factor for following salts :

(i) $K_2SO_4.Al_2(SO_4)_3.24H_2O$ (ii) $CaCO_3$

22. **Find the valency factor for following redox reactions :**

(i) $KMnO_4 \xrightarrow{\text{acidic}} Mn^{2+}$

$KMnO_4 \xrightarrow{\text{neutral}} MnO_2$

$KMnO_4 \xrightarrow{\text{alkaline}} K_2MnO_4$

(ii) $K_2Cr_2O_7 \xrightarrow{\text{acidic}} Cr^{3+}$

(iii) $C_2O_4^{2-} \longrightarrow CO_2$

(iv) $Fe^{2+} \longrightarrow Fe^{3+}$

23. Calculate the normality of a solution obtained by mixing 50 mL of 5 M solution of $K_2Cr_2O_7$ and 50 mL of 2 M $K_2Cr_2O_7$ in acidic medium.

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

25. A sample of hydrazine sulphate [$N_2H_6SO_4$] 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.

$$Fe^{3+} + N_2H_4 \longrightarrow N_2 + Fe^{2+} + H^+$$
$$MnO_4^- + Fe^{2+} + H^+ \longrightarrow Mn^{2+} + Fe^{3+} + H_2O$$

(a) Write the balanced redox reactions.
(b) Estimate the amount of hydrazine sulphate in one litre of Sol.

26. Write the balanced redox reaction and calculate the equivalent weight of oxidising agent and reducing agent for titration of $K_2Cr_2O_7$ Vs Ferrous ammonium sulphate.

27. 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 ?

28. 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.

EXERCISE # 3

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

Marked Questions are having more than one correct option.

1. The equivalent mass of $MnSO_4$ is half its molecular mass when it is converted to : **[JEE 1998, 2]**
(A) Mn_2O_3 (B) MnO_2 (C) MnO_4^- (D) MnO_4^{2-}

2. The oxidation number of sulphur in S_8, S_2F_2 and H_2S respectively are : **[JEE 1999, 2/80]**
(A) 0, + 1 and – 2 (B) + 2, + 1 and – 2 (C) 0, + 1 and + 2 (D) – 2, + 1 and – 2

3. The normality of 0.3 M phosphorus acid (H_3PO_3) is : **[JEE 1999, 2/80]**
(A) 0.1 (B) 0.9 (C) 0.3 (D) 0.6

4. Among the following, the species in which oxidation state of an element is + 6, is : **[JEE 2000, 1/35]**
(A) MnO_4^- (B) $Cr(CN)_6^{3-}$ (C) NiF_6^{2-} (D) CrO_2Cl_2

5. Oxidation number of iron in $Na_2[Fe(CN)_5(NO^+)]$ is : **[JEE 2001, 1/35]**
(A) + 2 (B) + 3 (C) +8/3 (D) none of the three

6. An aqueous solution of 6.3 g of oxalic acid dihydrate is made upto 250 mL. The volume of 0.1 N NaOH required to completely neutralise 10 mL of this solution is : **[JEE 2001, 1/35]**
(A) 40 mL (B) 20 mL (C) 10 mL (D) 4 mL

7. Hydrogen peroxide solution (20 mL) reacts quantitatively with a solution of $KMnO_4$(20mL) 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]**

8. In basic medium, I^- is oxidised by MnO_4^-. In this process, I^- changes to : **[JEE 2004, 3/84]**
(A) IO_3^- (B) I_2 (C) IO_4^- (D) IO^-

9. Amongst the following, the pair having both the metals in their highest oxidation state is : **[JEE 2004, 3/84]**
(A) $[Fe(CN)_6]^{3-}$ and $[Co(CN)_6]^{3-}$ (B) CrO_2Cl_2 and MnO_4^-
(C) TiO_2 and MnO_2 (D) $[MnCl_4]^{2-}$ and $[NiF_6]^{2-}$

10. O_3 does not oxidise : **[JEE 2005, 3/84]**
(A) KI (B) $FeSO_4$ (C) $KMnO_4$ (D) K_2MnO_4

11. 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

12. The reagent (s) used for softening the temporary hardness of water is (are) : **[JEE 2010, 3/163]**
(A) $Ca_3(PO_4)_2$ (B) $Ca(OH)_2$ (C) Na_2CO_3 (D) NaOCl

13. A student performs a titration with different burettes and finds titre values of 25.2 mL, 25.25 mL, and 25.0 mL. The number of significant figures in the average titre value is : **[JEE 2010, 3/163]**

14. Among the following, the number of elements showing only one non-zero oxidation state is : **[JEE 2010, 3/163]**
O, Cl, F, N, P, Sn, Tl, Na, Ti

15. The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is. **[JEE - 2011, P-1]**

16. Reaction of Br_2 with Na_2CO_3 in aqueous solution gives sodium bromide and sodium bromate with evolution of CO_2 gas. The number of sodium bromide molecules involved in the balanced chemical equation is **[JEE - 2011, P-1]**

17. Reduction of the metal centre in aqueous permanganate ion involves **[JEE 2011, P-2]**
(A) 3 electron in neutral medium (B) 5 electrons in neutral medium
(C) 3 electrons in alkaline medium (D) 5 electrons in acidic medium

PART - II : AIEEE PROBLEMS (PREVIOUS YEARS)

1. 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]**
(1) 4, 3, 1, 5 (2) 1, 5, 3, 7 (3) 1, 3, 4, 5 (4) 3, 5, 7, 1

2. Which of the following is a redox reaction : **[AIEEE 2002]**
(1) $NaCl + KNO_3 \longrightarrow NaNO_3 + KCl$
(2) $CaC_2O_4 + 2HCl \longrightarrow CaCl_2 + H_2C_2O_4$
(3) $Mg(OH)_2 + 2NH_4Cl \longrightarrow MgCl_2 + 2NH_4OH$
(4) $Zn + 2AgCN \longrightarrow 2Ag + Zn(CN)_2$

3. What will happen if the solution of potassium chromate reacts with excess amount of nitric acid **[AIEEE 2003]**

(1) Cr reduces in the oxidation state +3 from CrO_4^{2-}.

(2) Cr oxidises in the oxidation state +7 from CrO_4^{2-}.

(3) Cr^{+3} and $Cr_2O_7^{2-}$ will be formed.

(4) $Cr_2O_7^{2-}$ and H_2O will be formed.

4. What volume of hydrogen gas at 273 K and 1 atm pressure will be consumed in obtaining 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen : **[AIEEE 2003]**

(1) 44.8 L (2) 22.4 L (3) 89.6 L (4) 67.2 L

5. $CuSO_4$ reacts with excess amount of KI, followed by solution of $Na_2S_2O_3$. In this process which of following statement is incorrect : **[AIEEE 2004]**

(1) CuI will be formed (2) Evolved I_2 will be reduced

(3) $Na_2S_2O_3$ will be oxidised (4) CuI_2 will be formed

6. The oxidation state of Cr in $[Cr(NH_3)_4Cl_2]^+$ is : **[AIEEE 2005]**

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

7. The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is : **[AIEEE 2005]**

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

8. Which of the following chemical reactions depicts the oxidizing behaviour of H_2SO_4? **[AIEEE 2006]**

(1) $2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$ (2) $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

(3) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$ (4) $2PCl_5 + H_2SO_4 \rightarrow 2POCl_3 + 2HCl + SO_2Cl_2$

9. 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.

10. 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

11. Consider the following reaction :

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

The values of x, y and z in the reaction are, respectively : **[JEE Mains_2013]**

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

12. Experimentally it was found that a metal oxide has formula $M_{0.98}O$. Metal M is present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be : **[JEE Mains_2013]**

(1) 7.01 % (2) 4.08 % (3) 6.05 % (4) 5.08 %

EXERCISE # 4

NCERT QUESTIONS

1. Assign oxidation number to the underlined elements in each of the followingspecies :

(a) $NaH_2\underline{P}O_4$ (b) $NaH\underline{S}O_4$ (c) $H_4\underline{P}_2O_7$ (d) $K_2\underline{Mn}O_4$

(e) $Ca\underline{O}_2$ (f) $Na\underline{B}H_4$ (g) $H_2\underline{S}_2O_7$ (h) $KAl(\underline{S}O_4)_2.12\ H_2O$

2. What are the oxidation number of the underlined elements in each of thefollowing and how do you rationalise your results ?

(a) $K\underline{I}_3$ (b) $H_2\underline{S}_4O_6$ (c) $\underline{Fe}_3O_4$ (d) $\underline{C}H_3\underline{C}H_2OH$ (e) $\underline{C}H_3\underline{C}OOH$

3. Justify that the following reactions are redox reactions :

(a) $CuO(s) + H_2(g) \longrightarrow Cu(s) + H_2O(g)$

(b) $Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$

(c) $4BCl_3(g) + 3LiAlH_4(s) \longrightarrow 2B_2H_6(g) + 3LiCl(s) + 3\ AlCl_3(s)$

(d) $2K(s) + F_2(g) \longrightarrow 2K^+F^-(s)$

(e) $4\ NH_3(g) + 5\ O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

4. Fluorine reacts with ice and results in the change :

$H_2O(s) + F_2(g) \longrightarrow HF(g) + HOF(g)$

Justify that this reaction is a redox reaction.

5. Calculate the oxidation number of sulphur, chromium and nitrogen in H_2SO_5,$Cr_2O_7^{2-}$ and NO_3^-. Suggest structure of these compounds. Count for the fallacy.

6. Write formulas for the following compounds :

(a) Mercury(II) chloride (b) Nickel(II) sulphate

(c) Tin(IV) oxide (d) Thallium(I) sulphate

(e) Iron(III) sulphate (f) Chromium(III) oxide

7. Suggest a list of the substances where carbon can exhibit oxidation states from – 4 to + 4 and nitrogen from – 3 to + 5.

8. While sulphur dioxide and hydrogen peroxide can act as oxidising as well asreducing agents in their reactions, ozone and nitric acid act only as oxidants.Why ?

9. Consider the reactions :

(a) $6\,CO_2(g) + 6H_2O(l) \longrightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

(b) $O_3(g) + H_2O_2(l) \longrightarrow H_2O(l) + 2O_2(g)$

Why it is more appropriate to write these reactions as :

(a) $6CO_2(g) + 12H_2O(l) \longrightarrow C_6H_{12}O_6(aq) + 6H_2O(l) + 6O_2(g)$

(b) $O_3(g) + H_2O_2(l) \longrightarrow H_2O(l) + O_2(g) + O_2(g)$

Also suggest a technique to investigate the path of the above (a) and (b) redox reactions.

10. The compound AgF_2 is unstable compound. However, if formed, the compoundacts as a very strong oxidising agent. Why ?

11. Whenever a reaction between an oxidising agent and a reducing agent is carriedout, a compound of lower oxidation state is formed if the reducing agent is inexcess and a compound of higher oxidation state is formed if the oxidising agentis in excess. Justify this statement giving three illustrations.

12. How do you count for the following observations ?

(a) Though alkaline potassium permanganate and acidic potassiumpermanganate both are used as oxidants, yet in the manufacture of benzoicacid from toluene we use alcoholic potassium permanganate as an oxidant.Why ? Write a balanced redox equation for the reaction.

(b) When concentrated sulphuric acid is added to an inorganic mixturecontaining chloride, we get colourless pungent smelling gas HCl, but if themixture contains bromide then we get red vapour of bromine. Why ?

13. Identify the substance oxidised reduced, oxidising agent and reducing agent foreach of the following reactions:

(a) $2AgBr(s) + C_6H_6O_2(aq) \longrightarrow 2Ag(s) + 2HBr(aq) + C_6H_4O_2(aq)$

(b) $HCHO(l) + 2[Ag(NH_3)_2]^+(aq) + 3OH^-(aq) \longrightarrow 2Ag(s) + HCOO^-(aq) + 4NH_3(aq) + 2H_2O(l)$

(c) $HCHO(l) + 2\,Cu^{2+}(aq) + 5\,OH^-(aq) \longrightarrow Cu_2O(s) + HCOO^-(aq) + 3H_2O(l)$

(d) $N_2H_4(l) + 2H_2O_2(l) \longrightarrow N_2(g) + 4H_2O(l)$

(e) $Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \longrightarrow 2PbSO_4(s) + 2H_2O(l)$

14. Consider the reactions :

$2\,S_2O_3^{2-}(aq) + I_2(s) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

$S_2O_3^{2-}(aq) + 2Br_2(l) + 5\,H_2O(l) \longrightarrow 2SO_4^{2-}(aq) + 4Br^-(aq) + 10H^+(aq)$

Why does the same reductant, thiosulphate react differently with iodine andbromine ?

15. Justify giving reactions that among halogens, fluorine is the best oxidant andamong hydrohalic compounds, hydroiodic acid is the best reductant.

16. Why does the following reaction occur ?

$XeO_6^{4-}(aq) + 2F^-(aq) + 6H^+(aq) \longrightarrow XeO_3(g) + F_2(g) + 3H_2O(l)$

What conclusion about the compound Na_4XeO_6 (of which XeO_6^{4-} is a part) can bedrawn from the reaction.

17. Consider the reactions:

(a) $H_3PO_2(aq) + 4\,AgNO_3(aq) + 2\,H_2O(l) \longrightarrow H_3PO_4(aq) + 4Ag(s) + 4HNO_3(aq)$

(b) $H_3PO_2(aq) + 2CuSO_4(aq) + 2\,H_2O(l) \longrightarrow H_3PO_4(aq) + 2Cu(s) + H_2SO_4(aq)$

(c) $C_6H_5CHO(l) + 2[Ag\,(NH_3)_2]^+(aq) + 3OH^-(aq) \longrightarrow C_6H_5COO^-(aq) + 2Ag(s) + 4NH_3\,(aq) + 2\,H_2O(l)$

(d) $C_6H_5CHO(l) + 2Cu^{2+}(aq) + 5OH^-(aq) \longrightarrow$ No change observed.

18. Balance the following redox reactions by ion – electron method :

(a) $MnO_4^-\,(aq) + I^-\,(aq) \longrightarrow MnO_2\,(s) + I_2(s)$ (in basic medium)

(b) $MnO_4^-\,(aq) + SO_2\,(g) \longrightarrow Mn^{2+}\,(aq) + HSO_4^-\,(aq)$ (in acidic solution)

(c) $H_2O_2\,(aq) + Fe^{2+}\,(aq) \longrightarrow Fe^{3+}(aq) + H_2O\,(l)$ (in acidic solution)

(d) $Cr_2O_7^{2-} + SO_2(g) \longrightarrow Cr^{3+}\,(aq) + SO_4^{2-}\,(aq)$ (in acidic solution)

19. Balance the following equations in basic medium by ion-electron method andoxidation number methods and identify the oxidising agent and the reducingagent.

(a) $P_4(s) + OH^-(aq) \longrightarrow PH_3(g) + HPO_2^-\,(aq)$

(b) $N_2H_4(l) + ClO_3^-(aq) \longrightarrow NO(g) + Cl^-(g)$

(c) $Cl_2O_7\,(g) + H_2O_2(aq) \longrightarrow ClO_2^-(aq) + O_2(g) + H^+$

20. What sorts of informations can you draw from the following reaction ?

$(CN)_2(g) + 2OH^-(aq) \longrightarrow CN^-(aq) + CNO^-(aq) + H_2O(l)$

21. The Mn^{3+} ion is unstable in solution and undergoes disproportionation to give Mn^{2+}, MnO_2 and H^+ ion. Write a balanced ionic equation for the reaction.

22. Consider the elements :

Cs, Ne, I and F

(a) Identify the element that exhibits only negative oxidation state.

(b) Identify the element that exhibits only postive oxidation state.

(c) Identify the element that exhibits both positive and negative oxidation states.

(d) Identify the element which exhibits neither the negative nor does the positiveoxidation state.

23. Chlorine is used to purify drinking water. Excess of chlorine is harmful. Theexcess of chlorine is removed by treating with sulphur dioxide. Present a balancedequation for this redox change taking place in water.

24. In Ostwald's process for the manufacture of nitric acid, the first step involvesthe oxidation of ammonia gas by oxygen gas to give nitric oxide gas and steam.What is the maximum weight of nitric oxide that can be obtained starting onlywith 10.00 g. of ammonia and 20.00 g of oxygen ?

ANSWERS

EXERCISE # 1

PART # I

A-1.	(B)	**A-2.**	(B)	**A-3.**	(C)	**A-4.**	(B)	**A-5.**	(B)	**A-6.**	(D)	**A-7.**	(A)
A-8.	(A)	**A-9.**	(D)	**A-10.**	(D)	**A-11.**	(A)	**A-12.**	(C)	**A-13.**	(B)	**A-14.**	(A)
A-15.	(A)	**A-16.**	(C)	**A-17.**	(A)	**A-18.**	(A)	**A-19.**	(C)	**A-20.**	(B)	**A-21.**	(A)
A-22.	(A)	**A-23.**	(A)	**A-24.**	(C)	**A-25.**	(C)	**A-26.**	(C)	**A-27.**	(C)	**A-28.**	(B)
A-29.	(D)	**A-30.**	(D)	**A-31.**	(C)	**A-32.**	(A)	**A-33.**	(A)	**A-34.**	(B)	**A-35.**	(C)
A-36.	(A)	**A-37.**	(C)	**A-38.**	(B)	**A-39.**	(B)	**A-40.**	(C)	**A-41.**	(C)	**A-42.**	(D)
A-43.	(C)	**A-44.**	(A)	**A-45.**	(A)	**A-46.**	(C)	**A-47.**	(B)	**A-48.**	(B)	**B-1.**	(A)
B-2.	(D)	**B-3.**	(D)	**B-4.**	(C)	**B-5.**	(D)	**B-6.**	(D)	**B-7.**	(C)	**B-8.**	(A)
B-9.	(C)	**B-10.**	(D)	**B-11.***	(ABC)	**B-12.***	(CD)	**B-13.***	(ABD)	**B-14.***	(BCD)		
B-15.*	(ABD)	**B-16.**	(A)	**B-17.**	(A)	**B-18.**	(A)	**B-19.**	(B)	**B-20.**	(C)	**B-21.**	(A)
B-22.	(D)	**B-23.**	(B)	**B-24.**	(C)	**C-1.**	(B)	**C-2.**	(D)	**C-3.**	(D)	**C-4.**	(B)
C-5.	(A)	**C-6.**	(C)	**C-7.**	(D)	**C-8.**	(D)	**C-9.**	(D)	**C-10.**	(D)	**C-11.**	(A)
C-12.	(D)	**C-13.**	(B)	**C-14.**	(A)	**D-1.**	(A)	**D-2.**	(D)	**D-3.**	(C)	**D-4.**	(A)
D-5.	(B)	**D-6.**	(C)	**D-7.**	(A)	**D-8.**	(B)	**D-9.**	(D)	**D-10.**	(B)	**D-11.**	(A)
D-12.	(B)	**D-13.**	(C)	**D-14.**	(A)	**D-15.**	(C)	**D-16.**	(A)	**D-17.**	(C)	**D-18.**	(B)
D-19.	(C)	**D-20.**	(B)	**D-21.**	(D)	**D-22.**	(D)	**D-23.**	(B)	**D-24.**	(A)	**D-25.**	(A)
D-26.	(B)	**D-27.**	(A)	**D-28.**	(B)	**D-29.**	(A)	**D-30.**	(B)	**E-1.**	(B)	**E-2.**	(B)
E-3.	(A)	**E-4.**	(A)	**E-5.**	(B)	**E-6.**	(B)	**E-7.***	(ACD)				

PART # II

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

8. (B) **9.** (A) - p, r, s ; (B) - p, r, s ; (C) - p, q, r ; (D) - q, r, s

10. (A) – p,s ; (B) – q,r ; (C) p,q,s ; (D) – r **11.** (A) – p, r ; (B) – q, r ; (C) – p, q, r ; (D) – q, r.

12.	(B)	**13.**	(A)	**14.**	(A)	**15.**	(B)	**16.**	(A)	**17.**	(A)	**18.**	(D)
19.	(C)	**20.**	F	**21.**	T	**22.**	F						

23. F **24.** F **25.** decreases **26.** loses **27.** oxidized as well as reduced

28. Oxygen, Chlorine **29.** +2 **30.** is an example of **31.** is not

EXERCISE # 2

PART # I

1.	(B)	**2.**	(D)	**3.**	(C)	**4.**	(C)	**5.**	(A)	**6.**	(B)	**7.**	(A)
8.	(C)	**9.**	(C)	**10.**	(C)	**11.**	(D)	**12.**	(A)	**13.**	(A)	**14.**	(D)
15.	(D)	**16.**	(A)	**17.**	(A)	**18.**	(A)	**19.**	(B)	**20.**	(C)	**21.**	(B)
22.	(C)	**23.**	(A)	**24.**	(D)	**25.**	(CD)	**26.**	(ACD)	**27.**	(AC)		
28.	(ABD)												

PART # II

1. **(a)** Let oxidation number of S-atom is x. Now work accordingly with the rules given before .

$(+1) \times 2 + (x) \times 2 + (-2) \times 3 = 0$

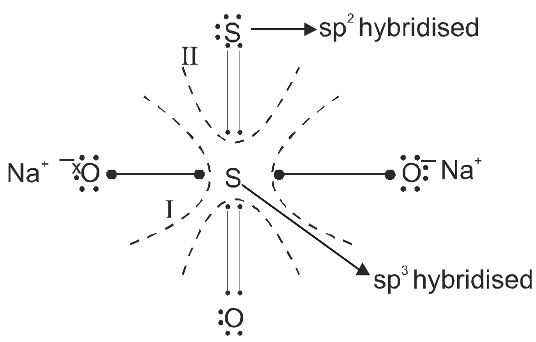
$x = +2$

(b) Let oxidation number of S-atom is x

$\therefore \quad (+1) \times 2 + (x) \times 4 + (-2) \times 6 = 0$

$x = +2.5$

2. ***Structure :***



3. **Step–I** Assign the oxidation number to each element present in the reaction.

$$\overset{+2}{Fe}\overset{+6}{S}\overset{-2}{O_4} + \overset{+1}{K}\overset{+7}{Mn}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{+6}{S}\overset{-2}{O_4} \longrightarrow \overset{+3}{Fe_2}(\overset{+6}{S}\overset{-2}{O_4})_3 + \overset{+2}{Mn}\overset{+6}{S}\overset{-2}{O_4} + \overset{+1}{H_2}\overset{-2}{O}$$

Step II :

Now convert the reaction in Ionic form by eliminating the elements or species, which are not undergoing either oxidation or reduction.

$$Fe^{2+} + \overset{+7}{Mn}O_4^- \longrightarrow Fe^{3+} + Mn^{2+}$$

Step III :

Now identify the oxidation / reduction occuring in the reaction

undergoes reduction.

$$Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$$

undergoes oxidation.

Step IV : Spilt the Ionic reaction in two half, one for oxidation and other for reduction.

$$Fe^{2+} \xrightarrow{\text{oxidation}} Fe^{3+} \quad \Big| \quad MnO_4^- \xrightarrow{\text{Reduction}} Mn^{2+}$$

Step V :

Balance the atom other than oxygen and hydrogen atom in both half reactions

$$Fe^{2+} \longrightarrow Fe^{3+} \quad \Big| \quad MnO_4^- \longrightarrow Mn^{2+}$$

Fe & Mn atoms are balanced on both side.

Step VI :

Now balance O & H atom by H_2O & H^+ respectively by the following way : For one excess oxygen atom, add one H_2O on the other side and two H^+ on the same side.

$Fe^{2+} \longrightarrow Fe^{3+}$ (no oxygen atom) ....(i)

$8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ ....(ii)

Step VII :

Equation (i) & (ii) are balanced atomwise. Now balance both equations chargewise. To balance the charge, add electrons to the electrically positive side.

$Fe^{2+} \xrightarrow{\text{oxidation}} Fe^{3+} + e^-$ ....(1)

$5e^- + 8H^+ + MnO_4^- \xrightarrow{\text{Reduction}} Mn^{2+} + 4H_2O$ ....(2)

Step VIII :
The number of electrons gained and lost in each half -reaction are equalised by multiplying both the half reactions with a suitable factor and finally the half reactions are added to give the overall balanced reaction. Here, we multiply equation (1) by 5 and (2) by 1 and add them :

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ ....(1) × 5

$5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ ....(2)×1

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

(Here, at his stage, you will get balanced redox reaction in Ionic form)

Step IX :
Now convert the Ionic reaction into molecular form by adding the elements or species, which are removed in step (2).
Now, by some manipulation, you will get :

$$5\,FeSO_4 + KMnO_4 + 4H_2SO_4 \longrightarrow \frac{5}{2}\,Fe_2(SO_4)_3 + MnSO_4 + 4H_2O + \frac{1}{2}\,K_2SO_4 \quad \text{or}$$

$$10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \longrightarrow 5Fe_2(SO_4)_3 + 2MnSO_4 + 8H_2O + K_2SO_4.$$

4. By using upto step V, we will get :

$\overset{+1}{Cl}O^- \xrightarrow{\text{Reduction}} Cl^-$ | $\overset{+3}{Cr}O_2^- \xrightarrow{\text{Oxidation}} \overset{+6}{Cr}O_4^{2-}$

Now, students are advised to follow step VI to balance 'O' and 'H' atom.
$2H^+ + ClO^- \longrightarrow Cl^- + H_2O$ | $2H_2O + CrO_2^- \longrightarrow CrO_4^{2-} + 4H^+$

➢ Now, since we are balancing in basic medium, therefore add as many as OH^- on both side of equation as there are H^+ ions in the equation.

$2OH^- + 2H^+ + ClO^- \longrightarrow Cl^- + H_2O + 2OH^-$ | $4OH^- + 2H_2O + CrO_2^- \longrightarrow CrO_4^{2-} + 4H^+ + 4OH^-$

Finally you will get | Finally you will get

$H_2O + ClO^- \longrightarrow Cl^- + 2OH^-$ ....(i) | $4OH^- + CrO_2^- \longrightarrow CrO_4^{2-} + 2H_2O$ .... (ii)

Now see equation (i) and (ii) in which O and H atoms are balanced by OH^- and H_2O
Now from step VIII

$2e^- + H_2O + ClO^- \longrightarrow Cl^- + 2OH^-$ .... (i) ×3

$4OH^- + CrO_2^- \longrightarrow CrO_4^{2-} + 2H_2O + 3e^-$ .... (ii) ×2

Adding : $3ClO^- + 2CrO_2^- + 2OH^- \longrightarrow 3Cl^- + 2CrO_4^{2-} + H_2O$

5. normality = 10 N

6. Normality (N) = 30 N

7. From law of equivalence,
equivalents of Cu_2S = equivalents of $KMnO_4$
moles of Cu_2S × v.f. = moles of $kMnO_4$ × v.f.
1 × 8 = moles of $KMnO_4$ × 5 ⇒ moles of $KMnO_4$ **= 8/5**
($\because$ v.f. of Cu_2S = 2 (2 – 1) + 1 (4 – (–2))) = 8 and v.f. of $KMnO_4$ = 1 (7 –2) = 5)

8. **Method -1 : Mole concept method**
Starting with 25 mL of 0.2 M Fe^{2+}, we can write :
Millimoles of Fe^{2+} = 25 x 0.2 ....(1)
and in volume V (in milliliters) of the $KMnO_4$,
Millimoles of MnO_4^- = V (0.02) ....(2)
The balanced reaction is :

$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$
This requires that at the equivalent point,

$$\frac{\text{m.moles of } MnO_4^-}{1} = \frac{\text{m.moles of } Fe^{2+}}{5}$$

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

$\therefore \quad V = 50$ mL.

Method -2 : Equivalent Method :

At the equivalence point,

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

$M_1 \times vf_1 \times V_1 = M_2 \times vf_2 \times V_2$

$0.02 \times 5 \times V_1 = 0.2 \times 1 \times 25$ $(\because MnO_4^- \longrightarrow Mn^{2+}$; v.f. = 5, $Fe^{2+} \longrightarrow Fe^{3+}$; v.f. = 1)

$\therefore \quad V_1 = 50$ mL.

9. Reaction : $2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 10CO_2$

Redox Changes : $C_2^{3+} \longrightarrow 2C^{4+} + 2e$ $\left(E_{H_2C_2O_4} = \frac{M}{2}\right)$

$5e + Mn^{7+} \longrightarrow Mn^{2+}$ $\left(E_{KMnO_4} = \frac{M}{5}\right)$

Indicator : $KMnO_4$ acts as self indicator.

10. Reaction : $2KMnO_4 + 10[FeSO_4(NH_4)_2SO_4 . 6H_2O] + 8H_2SO_4 \longrightarrow$

$5Fe_2(SO_4)_3 + 10(NH_4)_2SO_4 + K_2SO_4 + 2MnSO_4 + 68H_2O$

Redox Changes : $Fe^{2+} \longrightarrow Fe^{3+} + e$ $\left(E_{FeSO_4} = \frac{M}{1}\right)$

$Mn^{7+} + 5e \longrightarrow Mn^{2+}$ $\left(E_{KMnO_4} = \frac{M}{5}\right)$

Indicator : $KMnO_4$ acts as self indicator

11. 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 = millimoles of H_2S

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

12. meq. of $KMnO_4$ = meq. of H_2O_2

$30 \times \frac{1}{12} = 20 \times N'$

$N' = \frac{30}{12 \times 20} = \frac{1}{8} N$

$\therefore$ strength = N′ × equivalent mass $= \frac{1}{8} \times 17 = 2.12$ g/L.

13. Basis of calculation = 100 g hard water

$MgSO_4 = 0.00012g = \frac{0.00012}{120}$ mole

$CaCl_2 = 0.000111g = \frac{0.000111}{111}$ mole

$\therefore$ equivalent moles of $CaCO_3 = \left(\frac{0.00012}{120} + \frac{0.000111}{111}\right)$ mole

$\therefore$ mass of $CaCO_3 = \left(\frac{0.00012}{120} + \frac{0.000111}{111}\right) \times 100 = 2 \times 10^{-4}$ g

Hardness (in terms of ppm of $CaCO_3$) = $\frac{2 \times 10^{-4}}{100} \times 10^6 = 2$ ppm

$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$

$NaSO_4 + Na_2CO_3 \longrightarrow MgCO_3 + Na_2SO_4$

$\therefore$ Required Na_2CO_3 for 100g of water = $\left(\frac{0.00012}{120} + \frac{0.000111}{111}\right)$ mole

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

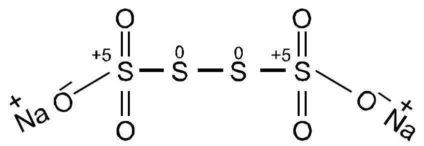
$\therefore$ Required Na_2CO_3 for 1000 litre water = $\frac{2 \times 10^{-6}}{100} \times 10^6 = \frac{2}{100}$ mole ($\because$ d = 1g/mL)

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

14. 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 × 98 = 8.09 g.
Total water needed = 1402 + 8.09 = 1410.09 g = **1410.09 mL**

15. % of $Cl_2 = \frac{3.55 \times 0.2 \times 80}{3.55} = 16\%$

16.



17. (i) Fe_3O_4 is mixture of FeO & Fe_2O_3 in 1 : 1 ratio
so, individual oxidation number of Fe = +2 & +3

& average oxidation number = $\frac{1(+2) + 2(+3)}{3} = 8/3$

(ii) Pb_3O_4 is a mixture of PbO & PbO_2 in 2 : 1 molar ratio
so, individual oxidation number of Pb are +2 & +4

& average oxidation number of Pb = $\frac{2(+2) + 1(+4)}{3} = 8/3$

18. (a) $6H^+ + 5H_2O_2 + 2MnO_4^- \longrightarrow 2Mn^{+2} + 5O_2 + 8H_2O$

(b) $4Zn + 10HNO_3(dil) \longrightarrow 4Zn(NO_3)_2 + 3H_2O + NH_4NO_3$

(c) $2CrI_3 + 64KOH + 27Cl_2 \longrightarrow 2K_2CrO_4 + 6KIO_4 + 54KCl + 32H_2O$.

(d) $6P_2H_4 \longrightarrow 8PH_3 + P_4$

(e) $2Ca_3(PO_4)_2 + 6SiO_2 + 10C \longrightarrow 6CaSiO_3 + P_4 + 10CO$

19. (i) 1 (ii) 2 (iii) 1
20. (i) 2 (ii) 1 (iii) 3
21. (i) 8 (ii) 2
22. (i) 5, 3, 1; (ii) 6 ; (iii) 2 ; (iv) 1
23. v.f. of $K_2Cr_2O_7 = 6$

so $N_f = \dfrac{N_1V_1 + N_2V_2}{V_1 + V_2}$

$= \dfrac{5 \times 6 \times 50 + 2 \times 6 \times 50}{50 + 50} = 21$ N

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

Here, eq. wt. of $Na_2C_2O_4 = 134/2 = 67$

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

25. (a) Given $4Fe^{3+} + N_2H_4 \longrightarrow N_2 + 4Fe^{2+} + 4H^+$

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

(b) In 10 mL solution, eq. of $N_2H_6SO_4$ = Eq. of Fe^{2+} = Eq. of $KMnO_4$

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

v.f. of $N_2H_6SO_4 = 4$

so, weight of $N_2H_6SO_4$ in 1 L solution $= \dfrac{2 \times 10^{-3} \times 1000}{4 \times 10} \times 130 = 6.5$ g.

26. The reaction : $6[FeSO_4(NH_4)_2SO_4 \cdot 6H_2O] + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow$
$3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + K_2SO_4 + 6(NH_4)_2SO_4 + 43H_2O$

Redox changes : $\left(E_{FeSO_4} = \dfrac{M}{1}\right)$; $\left(E_{K_2Cr_2O_7} = \dfrac{M}{6}\right)$

27. 15 g. **28.** 10 %

EXERCISE # 3

PART # I

1.	(B)	**2.**	(A)	**3.**	(D)	**4.**	(D)	**5.**	(A)	**6.**	(A)	**7.**	0.1 M
8.	(A)	**9.**	(B)	**10.**	(C)	**11.**	(D)	**12.**	(B)	**13.**	3	**14.**	2
15.	5	**16.**	5	**17.**	(A,D or A,C,D)								

PART # II

1.	(3)	**2.**	(4)	**3.**	(4)	**4.**	(4)	**5.**	(4)	**6.**	(1)	**7.**	(4)
8.	(1)	**9.**	(2)	**10.**	(3)	**11.**	(3)	**12.**	(2)				