6 Redox Reactions

QUICK LOOK

Redox Reaction: Redox reactions may be regarded as electron transfer reactions in which the electrons are transferred from one reactant to the other. As the result substance which losses electrons is called a reducing agent or reducctant while another which accepts the electrons is called an oxidizaing agent or oxidant.

Oxidation

$$\underset{\text{(Reducing agent)}}{Zn(s)} + 2H^{+}(aq) \longrightarrow Zn^{2+}(aq) + H_2(g)$$

Oxidation

$$\underset{\text{(Reducing agent)}}{Al} + \underset{\text{(Reducing agent)}}{Fe_2O_3} \longrightarrow Al_2O_3 + 2Fe$$

Reduction

Types of Redox Reaction

- **Direct redox reaction:** The reactions in which oxidation and reduction takes place in the same vessel are called direct redox reactions.
- **Indirect redox reaction:** The reactions in which oxidation and reduction takes place in different vessels are called indirect redox reactions. Indirect redox reactions are the basis of electro-chemical cells.
- **Intermolecular redox reactions:** In which one substance is oxidised while the other is reduced.

  For example, $2Al + Fe_2O_3 \longrightarrow Al_2O_3 + 2Fe$

  Here, Al is oxidised to Al_2O_3 while Fe_2O_3 is reduced to Fe.
- **Intramolecular redox reactions:** In which one element of a compound is oxidised while the other is reduced.

  For example, $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

  Here, Cl^{+5} in $KClO_3$ is reduced to Cl^{-1} in KCl while O^{2-} in $KClO_3$ is oxidised to O_2^0.
- **Molecular equations:** When the reactants and products involved in a chemical change are written in molecular forms in the chemical equation, it is termed as molecular equation.

  For example, $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

  In above example the reactants and products have been written in molecular forms, thus the equation is termed as molecular equation.
- **Ionic equations:** When the reactants and products involved in a chemical change are ionic compounds, these will be present in the form of ions in the solution. The chemical change is written in ionic forms in chemical equation, it is termed as ionic equation.

  Example

  $MnO_2 + 4H^{+} + 4Cl^{-} \longrightarrow Mn^{2+} + 2Cl^{-} + 2H_2O + Cl_2$

  In above example the reactants and products have been written in ionic forms, thus the equation is termed as ionic equation.
- **Spectator ions:** In ionic equations, the ions which do not undergo any change and equal in number in both reactants and products are termed as spectator ions and are not included in the final balanced equations.

  Example

  $Zn + 2H^{+} + 2Cl^{-} \longrightarrow Zn^{2+} + H_2 + 2Cl^{-}$ (Ionic equation)

  $Zn + 2H^{+} \longrightarrow Zn^{2+} + H_2$ (Final ionic equation)

  In above example, the Cl^{-} ions are the spectator ions and hence are not included in the final ionic balanced equation.

Redox Titrations: These involve the titration of an oxidizing agent against a reducing agent or vice-versa.

- The most important fact for solving the problems of redox changes is to evaluate equivalent weight of redox correctly using the formula: Eq. wt. of reductant or oxidant

  $$= \frac{\text{Mol. weight of reductant or oxidant}}{\text{No. of electrons lost or gained by one molecule}}$$
- Calculate the Meq. of desired substance and then calculate its weight by: $\text{Meq.} = \frac{\text{Wt.}}{\text{Eq. wt.}} \times 1000$. This equation gives weight of substance whose Eq. wt. is substituted.
- Be careful in deciding equivalent weights. First write redox change for each and then derive no. of electrons lost or gained by one molecule of reductant or oxidant.
- In case balanced equation is given, it is always advised to proceed with mole concept to avoid complications in equivalent weight determination.

Note: Sometimes a reaction is slow to go to completion and a sharp end point cannot be obtained.

Indicators: The process of determining the strength of a solution of an acid by titration against standard solution of alkali is called acidimetry. Similarly, the process of determing the strength of an alkali by titrating it against a standard acid solution is called alkalimetry. Titration of a weak acid H_3PO_4 with NaOH can be made in different stages using different indicators as:

Step (i): Bromocresol green an indicator is used for neutralization of H_3PO_4 upto $H_2PO_4^-$

Step (ii): Thymophthalein is used for neutralization of H_3PO_4 upto HPO_4^{2-}.

Note

- **Saponification value:** It is the amount of KOH in mg required to neutralize a fatty acid obtained by the hydrolysis of 1 g of oil.
- Trace concentrations are usually expressed in small units such as parts per thousand (ppt), parts per million (ppm) or parts per billion (ppb).

$$\text{ppt}(w/w) = \frac{\text{mass of solute}(g)}{\text{mass of sample}(g)} \times 10^3$$

$$\text{ppm}(w/w) = \frac{\text{mass of solute}(g)}{\text{mass of sample}(g)} \times 10^6$$

$$\text{ppb}(w/w) = \frac{\text{mass of solute}(g)}{\text{mass of sample}(g)} \times 10^9$$

$$\text{Part per trillion} = \frac{\text{mass of solute}(g)}{\text{mass of sample}(g)} \times 10^{12}$$

Oxidation-Reduction

- Oxidation is a process which liberates electrons, *i.e,* de-electro-nation.
- Reduction is a process which gains electrons, *i.e.,* electro-nation.

Oxidation	**Reduction**
$M \longrightarrow M^{+n} + ne$	$M^{+n} + ne \longrightarrow M$
$A^{-n} \longrightarrow A + ne$	$A + ne \longrightarrow A^{-n}$
$n_2 > n_1$ $M^{+n_1} \longrightarrow M^{+n_2} + (n_2 - n_1)e$	$M^{+n_2} + (n_2 - n_1)e \longrightarrow M^{+n_1}$
$n_1 > n_2$ $A^{-n_1} \longrightarrow A^{-n_2} + (n_1 - n_2)e$	$A^{-n_2} + (n_1 - n_2)e \longrightarrow A^{-n_1}$

- Oxidants are substance which
  (a) oxidize other.
  (b) are reduced themselves
  (c) show electronation
  (d) show a decrease in oxidation no. during a redox change.
  (e) has higher oxidation no. in a conjugate pair of redox.
- Reductants are substances which:
  (a) reduce other
  (b) are oxidized themselves
  (c) show de-electronation
  (d) show an increase in oxidation no. during a redox change
  (e) has lower oxidation no. in a conjugate pair of redox.
- A redox change is one in which a reductant is oxidized to liberate electrons, which are then used up by an oxidant to get itself reduced.

$M_1 \longrightarrow M_2^{+n} + ne$	Oxidation
$M_2^{+n} + ne \longrightarrow M_2$	Reduction
$M_1 + M_2^{+n} \longrightarrow M_1^{+n} + M_2$	Redox reaction

- A redox change occurs simultaneously.

Oxidation Number

- Oxidation no. of an element in a particular compound represents the no. of electrons lost or gained by an element during its change from free-state into that compound.

or Oxidation no. of an element in a particular compound represents the extent of oxidation or reduction of an element during its change from free state into that compound.

- Oxidation no. is given positive sign if electrons are lost. Oxidation no. is given negative sign if electrons are gained.
- Oxidation no. represents real change in case of ionic compounds. However, in covalent compounds it represents imaginary charge.
- Loss of electrons (also known as de-electro-nation)

$$\overset{-4}{M}\quad \overset{-3}{M}\quad \overset{-2}{M}\quad \overset{-1}{M}\quad \overset{0}{M}\quad \overset{+1}{M}\quad \overset{+2}{M}\quad \overset{+3}{M}\quad \overset{+4}{M}$$

$$-e^-\quad -e^-\quad -e^-\quad -e^-\quad -e^-\quad -e^-\quad -e^-\quad -e^-\quad -e^- \longrightarrow$$

Loss of electrons

(a) $H^0 \longrightarrow H^+ + e^-$ (Formation of proton)

(b) $MnO_4^{2-} \longrightarrow MnO_4^- + e^-$ (De-electro-nation of MnO_4^{2-}

(c) $2Fe^0 \longrightarrow 2Fe^{3+} + 6e^-$ (De-electro-nation of iron)

- Increase in oxidation number

(a) $Mg^0 \longrightarrow Mg^{2+}$ (From 0 to +2)

(b) $[Fe^{+2}(CN)\ ]^{4-} \longrightarrow [Fe^{+3}(CN)_6]^{3-}$ (From +2 to +3)

(c) $2Cl^- \longrightarrow Cl_2^0$ (From –1 to 0)

Rules of Deriving Oxidation Number: Following rules have been arbitrarily adopted to decide oxidation no. of elements on the basis of their periodic properties.

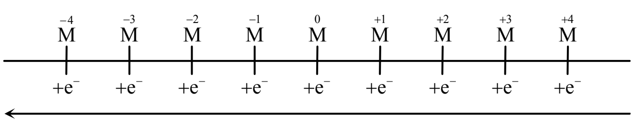
- In uncombined state or free-state, oxidation no. of an element is zero.

- In combined state oxidation no. of ……
  (a) …… F is always –1.
  (b) ……O is –2. In peroxides it is –1. However in F_2O it is +2.
  (c) …… H is +1. In ionic hydrides it is –1. (*i.e.,* IA, IIA and IIIA metals)
  (d) …… halogens as halide is always –1.
  (e) …… sulphur as sulphide is always –2.
  (f) …… metals is always + ve.
  (g) …… alkali metals (*i.e.,* I A group – Li, Na, K, Rb, Cs, Fr) is always +1.
  (h) ……alkaline earth metals (*i.e.,* II A group -Be, Mg, Ca, Sr, Ba, Ra) is always +2.
- The algebraic sum of all the oxidation no. of elements in a compound is equal to zero, *e.g.,* $KMnO_4$.
- The algebraic sum of all the oxidation no. of elements in a radical is equal to the net charge on the radical, *e.g.,* CO_3^{-2}
  Oxidation no. of $C + 3\times$(Oxidation no. of O) $= -2$
- Oxidation number can be $\text{zero}, +\text{ve}, -\text{ve}$ (integer or fraction)
- Maximum oxidation no. of an element is = Group no. (Except O and F)
  Minimum oxidation no. of an element is = Group no. –8 (Except metals)

Oxidation State: It is defined as oxidation no. per atom. *e.g.,* in $KMnO_4$
Oxidation no. of Mn is + 7
Oxidation state of Mn is $= Mn^{+7}$

Reduction: Reduction is just reverse of oxidation. Reduction is a process which involves; removal of oxygen, addition of hydrogen, removal of non-metal, addition of metal, decrease in +*ve* valency, gain of electrons and decrease in oxidation number.

- Removal of oxygen: $CuO + C \longrightarrow Cu + CO$
- Addition of hydrogen: $Cl_2 + H_2 \longrightarrow 2HCl$
- Removal of non-metal
  $2HgCl_2 + SnCl_2 \longrightarrow Hg_2Cl_2 + SnCl_4$
- Addition of metal: $HgCl_2 + Hg \longrightarrow Hg_2Cl_2$
- Decrease in +ve valency
  (a) $Fe^{3+} \longrightarrow Fe^{2+}$ (+ve valency decreases)
  (b) $[Fe(CN)_6]^{3-} \longrightarrow [Fe(CN)_6]^{4-}$ (–ve valency increases)
- Gain of electrons (also known as electronation)



Gain of electrons
(a) $Zn^{2+}(aq) + 2e^- \longrightarrow Zn(S)$ (Electronation of Zn^{2+})
(b) $Pb^{2+} + 2e^- \longrightarrow Pb^0$ (Electronation of Pb^{2+})
(c) $[Fe(CN)_6]^{3-} + e^- \longrightarrow [Fe(CN)_6]^{4-}$
(Electronation of $[Fe(CN)_6]^{3-}$)

- Decrease in oxidation number
  (a) $Mg^{2+} \longrightarrow Mg^0$ (From +2 to 0)
  (b) $[Fe(CN)_6]^{3-} \longrightarrow [Fe(CN)_6]^{4-}$ (From +3 to +2)
  (c) $Cl_2^0 \longrightarrow 2Cl^-$ (From 0 to –1)

Balancing of Redox Equations: Two methods are commonly used for this purpose.

Ion Electrons Method: It involves three sets of rules depending upon the nature of medium (*i.e.,* neutral, acid or alkaline) in which reactions occurs.

Neutral Medium
e.g., $H_2C_2O_4 + KMnO_4 \longrightarrow CO_2 + K_2O + MnO + H_2O$
Step (i): Select the oxidant, reductant atoms and write their half reactions, one representing oxidation and other reduction.
i.e., $C_2^{+3} \longrightarrow 2C^{+4} + 2e$, $5e + Mn^{+7} \longrightarrow Mn^{+2}$
Step (ii): Balance the no. of electrons and add the two equations.

$$5C_2^{+3} \longrightarrow 10C^{+4} + 10e$$
$$10e + 2Mn^{+7} \longrightarrow 2Mn^{+2}$$
$$\overline{5C_2^{+3} + 2Mn^{+7} \longrightarrow 10C^{+4} + 2Mn^{+2}}$$

Step (iii): Write complete molecule of the reductant and oxidant from which respective redox atoms were obtained.

$$5H_2 + C_2O_4 + 2KMnO_4 \longrightarrow 10CO_2 + 2MnO$$

Step (iv): Balance other atoms if any (except H and O). In above example K is unbalanced, therefore,

$$5H_2C_2O_4 + 2KMnO_4 \longrightarrow 10CO_2 + 2MnO + K_2O$$

(mentioned as product)
Step (v): Balance O atom using H_2O on desired side.

$$5H_2C_2O_4 + 2KMnO_4 \longrightarrow 10CO_2 + 2MnO + K_2O + 5H_2O$$

Acidic Medium:
e.g., $NO_3^- + H_2S \xrightarrow{H^+} HSO_4^- + NH_4^+$.
Proceed like neutral medium for Step 1 to 4.
Step (i): $8e + N^{+5} \longrightarrow N^{-3}$, $S^{-2} \longrightarrow S^{+6} + 8e$
Step (ii): $N^{+5} + S^{-2} \longrightarrow N^{-3}S^{+6}$
Step (iii): $NO_3^- + H_2S \longrightarrow NH_4^+ + HSO_4^-$

Step (iv): No other atom (except H and O) is unbalanced and thus, no need for this step.

Step (v): Balance O atom: Balancing of O atoms is made by using H_2O and H^+ ions. Add desired molecules of H_2O on the side deficient with O atom and double H^+ on opposite side. Therefore,

$$H_2O + NO_3^- + H_2S \longrightarrow NH_4^+ + HSO_4^- + 2H^+$$

Step (vi): Balance charge by H^+ :

$$3H^+ + H_2O + NO_3^- + H_2S \longrightarrow NH_4^+ + HSO_4^- + 2H^+$$

$\therefore$ Finally balanced equation is, $H^+ + H_2O + NO_3^- + H_2S \longrightarrow NH_4^+ + HSO_4^-$

Alkaline Medium

e.g., $Fe + N_2H_4 \xrightarrow{OH^-} Fe(OH)_2 + NH_3$.

Proceed like neutral medium for step 1 to step 4.

Step (i): $Fe \longrightarrow Fe^{+2} + 2e$, $2e + N_2^{-2} \longrightarrow 2N^{-3}$

Step (ii): $Fe + N_2^{-2} \longrightarrow Fe^{+2} + 2N^{-3}$

Step (iii): $Fe + N_2H_4 \longrightarrow Fe(OH)_2 + 2NH_3$

Step (iv): No other atom (except H and O) is unbalanced and thus, no need for this step.

Step (v): Balancing of O atom is made by using H_2O and OH^- ions.

Step (vi): Balancing charge by H^+ : $4OH^- + 4H^+ + Fe + N_2H_4 \longrightarrow Fe(OH)_2 + 2NH_3 + 2H_2O$

$\therefore$ Finally balanced equation is, $2H_2O + Fe + N_2H_4 \longrightarrow Fe(OH)_2 + +NH_3$

Oxidation State Method

e.g., $KMnO_4 + H_2C_2O_4 \longrightarrow CO_2 + K_2O + MnO + H_2O$

The initial step I should be written as

Step (i): $Mn^{+7} \longrightarrow Mn^{+2}$ *i.e.,* change in oxidation no. of $Mn\ (+7 \longrightarrow +2) = 5$ units

$C_2^{+3} \longrightarrow 2C^{+4}$ *i.e.,* change in oxidation no. of C $(+6 \longrightarrow +8) =$ 2 units

Step (ii): Proceed from step II last step for neutral, acidic or alkaline medium as in ion electrons method.

Balancing of Half Reactions

Example: $I_2 \longrightarrow IO_3^-$ (Acid medium)

Step (i): Balance atoms other than O and H if needed *i.e.,* $I_2 \longrightarrow 2IO_3^-$

Step (ii): Balance O atoms using H^+ and H_2O as reported earlier.

$$I_2 + 6H_2O \longrightarrow 2IO_3^- + 12H^+$$

Step (iii): Balance charge by electrons.

$$I_2 + 6H_2O \longrightarrow 2IO_3^- + 12H^+ + 10e\ .$$

This is balanced half reaction.

Example

$$S_2O_3^{-2} \longrightarrow SO_2 \text{ (Basic medium)}$$

Step (i): As above $S_2O_3^{-2} \longrightarrow 2SO_2$

Step (ii): Balance O atom by H_2O and OH^- as reported earlier

$$2OH^- + S_2O_3^{-2} \longrightarrow 2SO_2 + H_2O$$

Step (iii): Balance charge by electron

$$2OH^- + S_2O_3^{-2} \longrightarrow 2SO_2 + H_2O + 4e$$

This is balanced half reaction.

Autoxidation

- Turpentine and numerous other olefinic compounds, phosphorus and certain metals like Zn and Pb can absorb oxygen from the air in presence of water. The water is oxidised to hydrogen peroxide. This phenomenon of formation of H_2O_2 by the oxidation of H_2O is known as autoxidation. The substance such as turpentine or phosphorus or lead which can activate the oxygen is called activator. The activator is supposed to first combine with oxygen to form an addition compound, which acts as an autoxidator and reacts with water or some other acceptor so as to oxidise the latter. For example;

$$\underset{(\text{activator})}{Pb} + O_2 \rightarrow \underset{(\text{autoxidator})}{PbO_2}\ ;\ PbO_2 + \underset{(\text{acceptor})}{H_2O} \rightarrow PbO + H_2O_2$$

- The turpentine or other unsaturated compounds which act as activators are supposed to take up oxygen molecule at the double bond position to form unstable peroxide called moloxide, which then gives up the oxygen to water molecule or any other acceptor.
- The concept of autoxidation help to explain the phenomenon of induced oxidation. Na_2SO_3 solution is oxidised by air but Na_3AsO_3 solution is not oxidised by air. If a mixture of both is taken, it is observed both are oxidised.

Disproportionation

One and the same substance may act simultaneously as an oxidising agent and as a reducing agent with the result that a part of it gets oxidised to a higher state and rest of it is reduced to lower state of oxidation. Such a reaction, in which a substance undergoes simultaneous oxidation and reduction, is called disproportionation and the substance is said to disproportionate.

MULTIPLE CHOICE QUESTIONS

Oxidation Reduction

1. $2CuI \longrightarrow Cu + CuI_2$ the reaction is:
   a. Redox **b.** Neutralisation
   c. Oxidation **d.** Reduction

2. H_2S reacts with halogens, the halogens:
   a. Form sulphur halides **b.** Are oxidised
   c. Are reduced **d.** None of these

3. H_2O_2 reduces $K_4Fe(CN)_6$:
   a. In neutral solution **b.** In acidic solution
   c. In non-polar solvent **d.** In alkaline solution

4. Which halide is not oxidised by MnO_2 ?
   a. F **b.** Cl
   c. Br **d.** I

5. When Fe^{2+} changes to Fe^{3+} in a reaction?
   a. It loses an electron **b.** It gains an electron
   c. It loses a proton **d.** It gains a proton

6. In acid solution, the reaction $MnO_4^- \longrightarrow Mn^{2+}$ involves:
   a. Oxidation by 3 electrons
   b. Reduction by 3 electrons
   c. Oxidation by 5 electrons
   d. Reduction by 5 electrons

7. When iron or zinc is added to $CuSO_4$ solution, copper is precipitated. It is due to?
   a. Oxidation of Cu^{+2} **b.** Reduction of Cu^{+2}
   c. Hydrolysis of $CuSO_4$ **d.** Ionization of $CuSO_4$

8. The reaction $H_2S + H_2O_2 \longrightarrow 2H_2O + S$ shows:
   a. Oxidizing action of H_2O_2
   b. Reducing action of H_2O_2
   c. Alkaline nature of H_2O_2
   d. Acidic nature of H_2O_2

9. Which of the following is not a reducing agent?
   a. $NaNO_2$ **b.** $NaNO_3$
   c. HI **d.** $SnCl_2$

10. Oxidation number of N in HNO_3 is:
   a. – 3.5 **b.** + 3.5
   c. – 3, +5 **d.** + 5

11. The oxidation number of Mn in MnO_4^{-1} is:
   a. + 7 **b.** – 5
   c. + 6 **d.** + 5

12. Sn^{++} loses two electrons in a reaction. What will be the oxidation number of tin after the reaction?
   a. + 2 **b.** Zero **c.** + 4 **d.** – 2

13. $2MnO_4^- + 5H_2O_2 + 6H^+ \longrightarrow 2\ Z + 5O_2 + 8H_2O.$
   In this reaction Z is:
   a. Mn^{+2} **b.** Mn^{+4}
   c. MnO_2 **d.** Mn

14. What is '*A*' in the following reaction?
   $2Fe^{3+}_{(aq)} + Sn^{2+}_{(aq)} \longrightarrow 2Fe^{2+}_{(aq)} + A\ ?$
   a. $Sn^{3+}_{(aq)}$ **b.** $Sn^{4+}_{(aq)}$
   c. $Sn^{2+}_{(aq)}$ **d.** Sn

15. For the redox reaction
   $MnO_4^- + C_2O_4^{-2} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$
   The correct coefficients of the reactants for the balanced reaction are:

	MnO_4^-	$C_2O_4^{2-}$	H^+
a.	2	5	16
b.	16	5	2
c.	5	16	2
d.	2	16	5

16. Which of the following is a redox reaction?
   a. $NaCl + KNO_3 \longrightarrow NaNO_3 + KCl$
   b. $CaC_2O_4 + 2HCl \longrightarrow CaCl_2 + H_2C_2O_4$
   c. $Mg(OH)_2 + 2NH_4Cl \longrightarrow MgCl_2 + 2NH_4OH$
   d. $Zn + 2AgCN \longrightarrow 2Ag + Zn(CN)_2$

17. In the reaction $H_2S + NO_2 \longrightarrow H_2O + NO + S.$ H_2S is:
   a. Oxidised **b.** Reduced
   c. Precipitated **d.** None of these

18. In the course of a chemical reaction an oxidant:
   a. Loses electrons
   b. Gains electrons
   c. Both loses and gains electron
   d. Electron change takes place

19. H_2O_2 Reduces $K_4Fe\ (CN)_6$:
   a. In neutral solution **b.** In acidic solution
   c. In non-polar solvent **d.** In alkaline solution

20. $SnCl_2$ gives a precipitate with a solution of $HgCl_2$. In this process $HgCl_2$is:
   a. Reduced
   b. Oxidised
   c. Converted into a complex compound containing both Sn and Hg
   d. Converted into a chloro complex of Hg

21. In a reaction between zinc and iodine, in which zinc iodide is formed, what is being oxidised?
a. Zinc ions **b.** Iodide ions
c. Zinc atom **d.** Iodine

22. Which of the following is redox reaction?
a. H_2SO_4 with NaOH
b. In atmosphere, O_3 from O_2 by lightning
c. Evaporation of H_2O
d. Nitrogen oxides form nitrogen and oxygen by lightning

Disproportionation

23. For decolourization of 1 mole of $KMnO_4$, the moles of H_2O_2 required is:
a. 1/2 **b.** 3/2
c. 5/2 **d.** 7/2

24. In the reaction $I_2 + 2S_2O_3^{--} \longrightarrow 2I^- + S_4O_6^{--}$ equivalent weight of iodine will be equal to:
a. 1/2 of molecular weight
b. Molecular weight
c. 1/4 of molecular weight
d. None

25. The equivalent weight of KIO_3 in the reaction
$2Cr(OH)_3 + 4OH + KIO_3 \longrightarrow 2CrO_4^{2-} + 5H_2O + KI$ is:
a. Mole wt. **b.** $\frac{\text{Mol. wt.}}{6}$
c. $\frac{\text{Mol. wt.}}{2}$ **d.** $\frac{\text{Mol. wt.}}{3}$

26. In alkaline medium ClO_2 oxidize H_2O_2 in O_2 and reduced itself in Cl^- then how many mole of H_2O_2 will oxidize by one mole of ClO_2:
a. 1.0 **b.** 1.5
c. 2.5 **d.** 3.5

Oxidizing and Reducing Agent

27. Equation $H_2S + H_2O_2 \longrightarrow S + 2H_2O$ represents:
a. Acidic nature of H_2O_2
b. Basic nature of H_2O_2
c. Oxidising nature of H_2O_2
d. Reducing nature of H_2O_2

28. A reducing agent is a substance which can:
a. Accept electron **b.** Donate electrons
c. Accept protons **d.** Donate protons

29. A solution of sulphur dioxide in water reacts with H_2S precipitating sulphur. Here sulphur dioxide acts as:
a. As oxidising agent **b.** A reducing agent
c. An acid **d.** A catalyst

30. In which of the following reactions H_2O_2 is a reducing agent?
a. $2FeCl_2 + 2HCl + H_2O_2 \longrightarrow 2FeCl_3 + 2H_2O$
b. $Cl_2 + H_2O_2 \longrightarrow 2HCl + O_2$
c. $2HI + H_2O_2 \longrightarrow 2H_2O + I_2$
d. $H_2SO_3 + H_2O_2 \longrightarrow H_2SO_4 + H_2O$

31. Which is the best description of the behaviour of bromine in the reaction given below?
$H_2O + Br_2 \longrightarrow HOBr + HBr$
a. Oxidised only
b. Reduced only
c. Proton acceptor only
d. Both oxidised and reduced

32. In the reaction $HAsO_2 + Sn^{2+} \longrightarrow As + Sn^{4+} + H_2O$ oxidising agent is:
a. Sn^{2+} **b.** Sn^{4+}
c. *As* **d.** $HAsO_2$

33. HNO_2 acts both as reductant and oxidant, while HNO_3 acts only as oxidant. It is due to their:
a. Solubility ability
b. Maximum oxidation number
c. Minimum oxidation number
d. Minimum number of valence electrons

34. Oxidation state of chlorine in perchloric acid is:
a. – 1 **b.** 0
c. – 7 **d.** + 7

35. Oxidation number of carbon in $H_2C_2O_4$ is:
a. + 4 **b.** + 3
c. + 2 **d.** – 2

36. The oxidation number of Fe and S in iron pyrites are:
a. 4, – 2 **b.** 2, – 1
c. 3, – 1.5 **d.** 3, – 1

37. The oxidation states of the most electronegative element in the products of the reaction of BaO_2 with dilute H_2SO_4 are:
a. 0 and – 1 **b.** – 1 and – 2
c. – 2 and 0 **d.** – 2 and + 1

38. The oxidation number of Cr in $K_2Cr_2O_7$ is:

a. +6 **b.** – 7

c. +2 **d.** – 2

39. The oxidation state of nitrogen is highest in:

a. N_3H **b.** NH_2OH

c. N_2H_4 **d.** NH_3

40. The oxidation number and covalency of sulphur in the sulphur molecule (S_8) are respectively:

a. 0 and 2 **b.** 6 and 8

c. 0 and 8 **d.** 6 and 2

41. When $KMnO_4$ is reduced with oxalic acid in acidic solution, the oxidation number of Mn changes from?

a. 7 to 4 **b.** 6 to 4

c. 7 to 2 **d.** 4 to 2

42. What is the net charge on ferrous ion?

a. + 2 **b.** + 3

c. + 4 **d.** + 5

43. Oxidation number of nitrogen in $NaNO_2$ is:

a. + 2 **b.** + 3

c. + 4 **d.** – 3

Oxidation Number and Oxidation State

44. Oxidation number of cobalt in $K[Co(CO)_4]$ is:

a. + 1 **b.** + 3

c. – 1 **d.** – 3

45. In which compound, oxidation state of nitrogen is 1?

a. NO **b.** N_2O

c. NH_2OH **d.** N_2H_4

46. The oxidation state of Mn in K_2MnO_4:

a. + 2 **b.** + 7

c. – 2 **d.** + 6

47. In which of the following compound transition metal has zero oxidation state?

a. CrO_5 **b.** $NH_2.NH_2$

c. $NOClO_4$ **d.** $[Fe(CO)_5]$

48. The oxidation state of nitrogen in N_3H is:

a. $+\frac{1}{3}$ **b.** + 3

c. -1 **d.** $-\frac{1}{3}$

49. Sulphur has highest oxidation state in:

a. SO_2 **b.** H_2SO_4

c. $Na_2S_2O_3$ **d.** $Na_2S_4O_6$

50. An element which never has a positive oxidation number in any of its compounds:

a. Boron **b.** Oxygen

c. Chlorine **d.** Fluorine

Redox Reaction and Method for Balancing Redox Reaction

51. $C_2H_6(g) + nO_2 \longrightarrow CO_2(g) + H_2O(l)$

In this equation, the ratio of the coefficients of CO_2 and H_2O is:

a. 1 : 1 **b.** 2 : 3

c. 3 : 2 **d.** 1 : 3

52. Starch paper is used to test for the presence of:

a. Iodine **b.** Oxidising agent

c. Iodide ion **d.** Reducing agent

53. In the balanced chemical reaction,

$IO_3^- + a\,I^- + b\,H^+ \longrightarrow c\,H_2O + d\,I_2$

a, b, c and *d* respectively correspond to:

a. 5, 6, 3, 3 **b.** 5, 3, 6, 3

c. 3, 5, 3, 6 **d.** 5, 6, 5, 5

54. $2MnO_4^- + 5H_2O_2 + 6H^+ \longrightarrow 2\,Z + 5O_2 + 8H_2O$.

In this reaction *Z* is:

a. Mn^{+2} **b.** Mn^{+4}

c. MnO_2 **d.** Mn

Auto Oxidation and Disproportionation

55. In the equation $H_2S + 2HNO_3 \longrightarrow 2H_2O + 2NO_2 + S$

The equivalent weight of hydrogen sulphide is:

a. 16 **b.** 68

c. 34 **d.** 17

56. The metal used in galvanizing of iron is:

a. Pb **b.** Zn

c. A*l* **d.** Sn

57. The equivalent weight of phosphoric acid (H_3PO_4) in the reaction $NaOH + H_3PO_4 \longrightarrow NaH_2PO_4 + H_2O$ is:

a. 25 **b.** 49

c. 59 **d.** 98

58. What is the equivalent mass of IO_4^- when it is converted into I_2 in acid medium?

a. M/6 **b.** M/7

c. M/5 **d.** M/4

59. Which one of the following nitrates will leave behind a metal on strong heating?

a. Ferric nitrate **b.** Copper nitrate
c. Manganese nitrate **d.** Silver nitrate

60. To prevent rancidification of food material, which of the following is added?

a. Reducing agent **b.** Anti-oxidant
c. Oxidising agent **d.** None of these

NCERT EXEMPLAR PROBLEMS

More than One Answer

61. 15 g of $KMnO_4$ in acidic medium is equal to:

a. 0.09493 moles
b. 0.4446 g equivalents
c. 9.492 L of 0.05 N $KMnO_4$
d. 10 mL of 0.05 M $KMnO_4$

62. Choose the correct option(s):

a. $KClO_4$ and $KMnO_4$ are isomorphous in nature
b. Equivalent weight of $Fe_{0.9}O$ when it is converted to FeO is 332. (At wt. of Fe =56)
c. Molar volume of water at STP is 22.4 litre
d. When 'w' g $Na_2SO_4 \cdot 10H_2O$ is added in X g of water, molality of SO_2^{4-} is $\frac{1000}{332X}$

63. Which of the following reactions represent disproportionation?

a. $F_2 + NaOH \longrightarrow NaF + H_2O + O_2$
b. $2Cu^+ \longrightarrow Cu^{+2} + Cu(s)$
c. $2H_2O_2(l) \longrightarrow 2H_2O(l) + O_2(g)$
d. $Cl_2 + H_2O \longrightarrow HCl + HOCl$

64. For the balanced redox reaction

$aNO_3^- + bAs_2S_3 + 4H_2O \longrightarrow xAsO_4^{3-} + yNO + zSO_4^{2-} + 8H^+$

Which of the following statements are correct?

a. Equivalent weight of As_2S_3 is M/24 where 'M' is molecular weight of As_2S_3
b. The value of $a : b = 8 : 1$
c. The value of $\frac{b+2b}{x+y}$ is 1
d. The value of $\frac{z-x}{3}$ is 1

65. The oxidation number of Mn is +2 in:

a. Manganese oxide
b. Manganese chloride
c. Manganese sulphate
d. Potassium permanganate

66. Oxygen has an oxidation state of –1 in:

a. H_2O_2 **b.** BaO_2
c. OF_2 **d.** $H_2S_2O_8$

67. Which of the following reactions do not involve oxidation 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. $4KCN + Fe(CN_2) \longrightarrow K_4[Fe(CN)_6]$

68. Oxidation numbers of carbon is correctly given for:

Compound	O. No.
a. $HN \equiv C$	$+2$
b. $H-C \equiv N$	$+4$
c. CCl_4	$+4$
d. $C_6H_{12}O_6$	0

69. When Cl_2 is passed through NaOH in cold, the oxidation number of Cl changes from:

a. 0 to –1 **b.** 0 to +1
c. 0 to –2 **d.** 0 to +2

70. H_2S acts only as a reducing agent while SO_2 can act both as a reducing and oxidizing agent because:

a. S in H_2S has –2 oxidation state
b. S in SO_2 has oxidation state $+4$
c. Hydrogen in H_2S more +ve than oxygen
d. Oxygen is more – ve in SO_2

71. $K_4[Fe(CN)_6] + H_2SO_4 + H_2O \longrightarrow K_2SO_4 + FeSO_4 + (NH_4)_2SO_4 + CO_2$

For the above reaction which statement is/are correct?

a. Oxidation number of C changes from $+2$ to $+4$
b. The above reaction is called acidic hydrolysis.
c. The above reaction is called disproportionation reaction.
d. n-factor for $K_4[Fe(CN)_6]$ is 12.

72. $Cu_2S \longrightarrow Cu + SO_2$; Equivalent weight of $Cu_2S = x_1$

$Cu_2S \longrightarrow Cu\overset{+6}{S}O_4$; Equivalent weight of $Cu_2S = x_2$

$Cu_2S \longrightarrow Cu^+ + S$; Equivalent weight of $Cu_2S = x_3$

a. $x_1 > x_2$ **b.** $x_2 > x_3$
c. $x_3 > x_1$ **d.** $x_3 > x_2$

73. The compound(s) behaving both oxidizing as well as reducing agent is/are:

a. H_2O_2 **b.** SO_2

c. HNO_2 **d.** HNO_3

74. The compound in which the same element possesses two different oxidation states is/are:

a. bleaching powder

b. hypo

c. perdisulphuric acid

d. potassium permanganate

75. Which of the following cannot work as oxidising agent?

a. O_2 **b.** $KMnO_4$

c. I_2 **d.** None of these

Assertion and Reason

Note: Read the Assertion (A) and Reason (R) carefully to mark the correct option out of the options given below:

a. If both assertion and reason are true and the reason is the correct explanation of the assertion.

b. If both assertion and reason are true but reason is not the correct explanation of the assertion.

c. If assertion is true but reason is false.

d. If the assertion and reason both are false.

e. If assertion is false but reason is true.

76. **Assertion:** The oxidation numbers are artificial; they are useful as a 'book-keeping' device of electrons in reactions.

Reason: The oxidation numbers do not usually represent real charges on atoms, they are simply conventions that indicate what the maximum charge could possibly be on an atom in a molecule.

77. **Assertion:** H_2SO_4 cannot act as reducing agent.

Reason: Sulphur cannot increase its oxidation number beyond $+6$.

78. **Assertion:** Equivalent weight of NH_3 in the reaction $N_2 \longrightarrow NH_3$ is 17/3 while that of N_2 is 28/6.

Reason: Equivalent weight $= \dfrac{\text{Molecular weight}}{\text{number of } e^- \text{ lost or gained}}$

79. **Assertion:** SO_2 and Cl_2 both are bleaching agents.

Reason: Both are reducing agents.

80. **Assertion:** Fluorine exists only in -1 oxidation state.

Reason: Fluorine has $2s^2 2p^5$ configuration.

81. **Assertion:** Stannous chloride is a powerful oxidising agent which oxidises mercuric chloride to mercury.

Reason: Stannous chloride gives grey precipitate with mercuric chloride, but stannic chloride does not do so.

82. **Assertion:** $HClO_4$ is a stronger acid than $HClO_3$.

Reason: Oxidation state of Cl in $HClO_4$ is +VII and in $HClO_3$ $+V$.

83. **Assertion:** In a reaction $Zn(s) + CuSO_4(aq) \longrightarrow ZnSO_4(aq) + Cu(s)$, Zn is a reductant but itself get oxidized.

Reason: In a redox reaction, oxidant is reduced by accepting electrons and reductant is oxidized by losing electrons.

84. **Assertion:** Oxidation number of carbon in CH_2O is zero.

Reason: CH_2O formaldehyde, is a covalent compound.

85. **Assertion:** A reaction between Fe and I_2 occurs, but a reaction between Fe^{2+} and I^- does not occur.

Reason: Fe is a better reducing agent than I^-.

Comprehension Based

Paragraph–I

Consider the following unbalanced redox reaction:

$$H_2O + AX + BY \longrightarrow HA + OY + X_2B$$

The oxidation number of X is -2, and neither X nor water is involved in the redox process.

86. The element(s) undergoing oxidation is/are:

a. A **b.** B

c. Y **d.** B or Y or both

87. The possible oxidation state of B and Y in BY are, respectively:

a. $+1, -1$ **b.** $+2, -2$

c. $+3, -3$ **d.** All of these

88. If the above reaction is balanced with smallest whole number coefficients, the sum of the stoichiometric coefficients of all the compounds is:

a. 9 **b.** 8

c. 7 **d.** 6

Paragraph–II

Oxidation reaction involves loss of electrons, and reduction reaction involves gain of electrons. The reaction in which a species disproportionate into two oxidation states (lower and higher) is called disproportionation reaction

89. Which of the following statements is wrong?

a. A acidified $K_2Cr_2O_7$ paper on being exposed to SO_2 turns green.

b. Mercuric chloride and stannous chloride cannot exist as such.
c. Iron turning on addition to $CuSO_4$ solution decolourises the blue colour.
d. $[CuI_4]^{2-}$ is formed but $[CuCl_4]^{2-}$ is not.

90. Which of the following statements is wrong?
a. Accidified $KMnO_4$ solution decolourieses on the addition of sodium oxalate.
b. In the reaction between Br_2 and CsI, Br_2 is an oxidising agent and CsI is a reducing agent.
c. In the reaction $2K_2S_2O_3 + I_2 \longrightarrow 2KI + K_2S_4O_6$, the change in the oxidation number of S is 0.5
d. C has the same oxidation number in both CH_4 and CO_2

91. Which of the following statements is correct?
a. An element in the lowest oxidation state acts only as a reducing agent.
b. An element in the highest oxidation sate acts only as a reducing agent.
c. The oxidation number of V in $Rb_4K(HV_{10}O_{28})$ is +4.
d. The oxidation number and valency of Hg in calomel is +1

92. Which of the following statements is wrong?
a. The algebraic sum of the oxidation numbers of all atoms in an ion is zero
b. The oxidation number is an arbitrary number. It can have positive, negative, zero, or fractional values.
c. When a negative ion changes to neutral species, the process is oxidation.
d. The oxidation number of phosphorous can very form –3 to +5.

93. Which of the following is not a disproportionation reaction?
a. $OH^- + Br_2 \longrightarrow Br^- + BrO_3^-$
b. $Cu_2O + 2H^+ \longrightarrow Cu + Cu^{2+} + H_2O$
c. $(CN)^- \longrightarrow CO_3^{2-} + NO_3^-$
d. $(CN)_2 + 2OH^- \longrightarrow CN^- + CNO^- + H_2O$

Match the Column

94. Match the statement of Column with those in Column II:

Column I (Compound)	Column II (Oxidation state of N)
(A) NO_2	**1.** +5
(B) HNO	**2.** −3
(C) NH_3	**3.** +4
(D) N_2O_5	**4.** +1

a. A→ 2; B→ 3; C→ 4; D→ 1
b. A→ 3; B→ 1; C→ 2; D→ 4
c. A→ 3; B→ 4; C→ 2; D→ 1
d. A→ 2; B→ 3; C→ 1; D→ 4

95. Match the statement of Column with those in Column II:

Column I (Reaction)	Column II (Number of elect –rons lost or gained)
(A) $MN(OH)_2 + H_2O_2 \longrightarrow MnO_2$	**1.** 8
(B) $AlCl_2 + 3K \longrightarrow Al + 3KCl$	**2.** 2
(C) $3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$	**3.** 3
(D) $H_2S + NO_3^- \longrightarrow S + NO$	**4.** 6

a. A→ 2; B→ 3; C→ 1; D→ 4
b. A→ 3; B→ 1; C→ 2; D→ 4
c. A→ 1; B→ 2; C→ 3; D→ 4
d. A→ 2; B→ 3; C→ 4; D→ 1

Integer

96. Find out the value of n in
$MnO_4^- + 8H^+ + ne \longrightarrow Mn^{+2} + 4H_2O$

97. One mole of N_2H_4 loses 10 mole electrons to form a new compound Y. Assuming that all the N_2 appears in new compound, what is oxidation state of N in Y? There is no change in oxidation state of H.

98. The equivalent weight of HNO_3 (molecular weight $=63$) in the following reaction is
$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

99. In the following reaction
$xZn + yHNO_3(dil) \longrightarrow aZn(NO_3)_2 + bH_2O + cNH_4NO_3$
What is the sum of the coefficients $(a+b+c)$?

100. CN^- ion is oxidized by a powerful oxidising agent of NO_3^- and CO_2 or CO_3^{2-} depending on the acidity of the reaction mixture
$CN^- \longrightarrow CO_2 + NO_3^- + H^+ + ne^-$
What is the number (n) of electrons involved in the process, divided by 10?

ANSWER

1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
a	c	b	a	a	d	b	a	b	d
11.	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**
a	c	a	b	a	d	a	b	b	a
21.	**22.**	**23.**	**24.**	**25.**	**26.**	**27.**	**28.**	**29.**	**30.**
c	d	c	a	d	c	c	b	a	b
31.	**32.**	**33.**	**34.**	**35.**	**36.**	**37.**	**38.**	**39.**	**40.**
d	d	b	d	b	a	b	a	a	a
41.	**42.**	**43.**	**44.**	**45.**	**46.**	**47.**	**48.**	**49.**	**50.**
c	a	b	c	b	d	d	d	b	d
51.	**52.**	**53.**	**54.**	**55.**	**56.**	**57.**	**58.**	**59.**	**60.**
b	a	a	a	d	b	d	b	d	b
61.	**62.**	**63.**	**64.**	**65.**	**66.**	**67.**	**68.**	**69.**	**70.**
a,c	a,b	b,c,d	c,d	a,b,c	a,b,d	c,d	c,d	a,b	a,b
71.	**72.**	**73.**	**74.**	**75.**	**76.**	**77.**	**78.**	**79.**	**80.**
a,c	a,c,d	a,b,d	a,b,c	c	a	a	a	c	b
81.	**82.**	**83.**	**84.**	**85.**	**86.**	**87.**	**88.**	**89.**	**90.**
e	b	a	b	a	d	d	b	d	d
91.	**92.**	**93.**	**94.**	**95.**	**96.**	**97.**	**98.**	**99.**	**100.**
a	a	c	c	a	5	3	84	8	3

SOLUTION

Multiple Choice Questions

1. **(a)** $2\overset{+1}{Cu}I \longrightarrow \overset{0}{Cu} + \overset{+2}{Cu}I_2$. Oxidation and Reduction both occur so the reaction is redox.

2. **(c)** $H_2S + X_2 (Cl, Br, I = X) \longrightarrow 2HX + S.$
Here the halogen are reduced.

3. **(b)** When H_2O_2 reduces with $K_4[Fe(CN)_6]$.
It is present in acidic solution.
$$2K_4[Fe(CN)_6 + H_2SO_4 + H_2O_2 \longrightarrow 2K_3[Fe(CN)_6] + K_2SO_4 + 2H_2O$$

4. **(a)** Fluorine has highest E^o – value and more reactive than MnO_2.

5. **(a)** $Fe^{2+} \longrightarrow Fe^{3+} + e^-$ oxidation.

6. **(d)** $MnO_4^- \longrightarrow Mn^{2+}$. In this reaction $5e^-$ are needed for the reduction of Mn^{2+} as: $MnO_4^- + 5e^- \longrightarrow Mn^{2+}$.

7. **(b)**
$$\overbrace{\overset{0}{Zn} + \overset{+2}{Cu}SO_4 \rightarrow ZnSO_4 + \overset{0}{Cu}}^{\text{Oxidation}}$$
Reduction

In this reaction Cu^{2+} change in Cu^o, hence it is called as reduction reaction.

8. **(a)** In this reaction H_2O_2 acts as a oxidizing agent.

9. **(b)** $NaNO_2$, $SnCl_2$ and HI have reducing and oxidizing properties but $NaNO_3$ have only oxidizing property.

10. **(d)** $H\overset{*}{N}O_3;\ 1 + x - 6 = 0;\ x = +5.$

11. **(a)** Mn shows +7 oxidation state in MnO_4^{-1}

$\overset{*}{Mn}O_4^{-1}$
$x + (-2 \times 4) = -1$
$x - 8 = -1$
$x = -1 + 8 = +7.$

12. **(c)** $Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$

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

14. **(b)**
Reduction
$$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$$
Oxidation

15. **(a)** $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O \times 2$
$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^- \times 5$$
$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$
Thus, the coefficient of MnO_4^-, $C_2O_4^{2-}$ and H^+ in the above balanced equation respectively are 2, 5, 16.

16. **(d)** $\overset{0}{Zn} + 2\overset{+1}{Ag}CN \longrightarrow 2\overset{0}{Ag} + \overset{+2}{Zn}(CN)_2$
Reduction
Oxidation

17. **(a)** In this reaction H_2S is oxidised because the oxidation state of 'S' change from – 2 to 0.

18. **(b)** Any substance which is capable of oxidising other substances and is capable of accepting/gaining electron during oxidation is called oxidising agent or oxidant.

19. **(b)** When H_2O_2 reduces with $K_4[Fe(CN)_6]$. It is present in acidic solution.
$$2K_4[Fe(CN)_6 + H_2SO_4 + H_2O_2 \longrightarrow 2K_3[Fe(CN)_6] + K_2SO_4 + 2H_2O$$

20. **(a)** $\overset{+2}{Sn}Cl_2 + 2\overset{+1}{Hg}Cl_2 \longrightarrow \overset{+4}{Sn}Cl_4 + Hg_2Cl_2(s)$
In this reaction $HgCl_2$ is reduced in Hg.

21. **(c)** $\overset{o}{Zn} + \overset{o}{I_2} \longrightarrow \overset{+2\ -1}{ZnI_2}$

In this reaction Znatom oxidised to Zn^{2+} ion and iodine reduced to I^-.

22. **(d)** $2\overset{0}{N_2}+\overset{0}{O_2}\longrightarrow 2\overset{+2}{N}\overset{-2}{O}$

Here O.N. of N increases from O in N_2 to +2 in NO, 2– and that of decreased from O in O_2 to –2 in O, therefore, it is a redox reaction.

23. **(c)** $2KMnO_4+3H_2SO_4\longrightarrow K_2SO_4+2MnSO_4+3H_2O+5O$

$5H_2O_2+5O\longrightarrow 5H_2O+5O_2$

$$2KMnO_4+3H_2SO_4+5H_2O_2\longrightarrow K_2SO_4+2MnSO_4+8H_2O+5O_2$$

24. **(a)** $\frac{\text{Molecular weight}}{2}$ = Equivalent weight of Iodine.

25. **(d)** $\frac{\text{Molecular weight}}{3}$

Because in KIO_3 effective oxidation number is 3.

26. **(c)** $ClO_2\longrightarrow Cl^-$

$ClO_2+2H_2O+5e\longrightarrow Cl^-+4OH^-$

$H_2O_2\longrightarrow O_2$

$H_2O_2+2OH^-\longrightarrow O_2+2H_2O+2e$

$ClO_2+2H_2O+5e\longrightarrow Cl^-+4OH^-]\times 2$

$H_2O_2+2OH^-\longrightarrow O_2+2H_2O+2e]\times 2$

$2ClO_2+5H_2O_2+2OH^-\longrightarrow 2Cl^-+5O_2+5H_2O$

$2ClO_2\equiv 5H_2O_2$

$\therefore$ $ClO_2=2.5H_2O_2$

27. **(c)** $H_2\overset{-2}{S}+H_2O_2\longrightarrow\overset{0}{S}+2H_2O$

Oxidation

The oxidation of S shows oxidising nature of H_2O_2.

28. **(b)** A substance which is capable of reducing other substances and is capable of donating electrons during reduction is called a reducing agent or reductant.

29. **(a)** When sulphur dioxide is react with H_2S here SO_2 act as an oxidising agent and H_2S act as reducing agent.

30. **(b)** $\overset{0}{Cl_2}+H_2O_2\longrightarrow 2H\overset{-1}{Cl}+O_2$. In this reaction chlorine reduced from zero to – 1 oxidation state.

31. **(d)** $H_2O+\underset{0}{Br_2}\longrightarrow \underset{+1}{HOBr}+\underset{-1}{HBr}$

In the above reaction the oxidation number of Br_2 increases from zero (in Br_2) to +1 (in $HOBr$) and decrease from zero (Br_2) to – 1 (in HBr). Thus Br_2 is oxidised as well as reduced & hence it is a redox reaction.

32. **(d)** Oxidizing agent itself, undergoes reduction during a redox reaction

$H\overset{+3}{As}O_2+\overset{+2}{Sn}\longrightarrow\overset{0}{As}+\overset{2+}{Sn}+H_2O$

Hence, here $HAsO_2$ is acting as oxidizing agent.

Oxidation number and Oxidation state

33. **(b)** In $H\overset{*}{N}O_2$ oxidation number of N = + 3

In $H\overset{*}{N}O_3$ oxidation number of N = + 5.

34. **(d)** $H\overset{*}{Cl}O_4$

$1+x-2\times 4=0;\ 1+x-8=0$

$x=8-1=+7$ oxidation state.

35. **(b)** $H_2\overset{*}{C}_2O_4$

$2+2x-2\times 4=0$;

$2x=8-2=6$

$x=\frac{6}{2}=+3.$

36. **(a)** $\overset{*}{Fe}S_2$ $\qquad$ $Fe\overset{*}{S}_2$

$x-4=0 \quad 4+2x=0$

$x=+4 \quad 2x=-4$

$x=\frac{-4}{2}=-2$.

37. **(b)** In H_2O_2 oxygen shows = – 1 (peroxide) oxidation state and in $BaSO_4$ oxygen shows = – 2 oxidation state.

38. **(a)** $K_2\overset{*}{Cr}_2O_7$

$2+2x-2\times 7=0$

$2x-14+2=0$

$2x=12$; $x=\frac{12}{2}=+6.$

39. **(a)** $3\times x+1(1)=0$

$3x+1=0$

$3x=-1,\Rightarrow x=-\frac{1}{3}$ in N_3H

$x+2(+1)+1(-2)+1(1)=0$

$x=-1$ in NH_2OH

$x\times 2+4(1)=0$ $x=-\frac{4}{2}=-2$ in N_2H_4

$x+3(1)=0$ $x=-3$ in NH_3

Hence, highest in N_3H.

40. **(a)** The oxidation number of sulphur in the sulphur molecule (S_8) is 0 and 2.

41. **(c)** $5\begin{array}{l}COOH\\ | \\ COOH\end{array}+2K\overset{+7}{Mn}O_4+3H_2SO_4\longrightarrow$

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

In this reaction oxidation state of Mn change from + 7 to + 2.

42. **(a)** $_{26}Fe\longrightarrow[Ar]3d^6 4S^2$

$Fe^{++}\longrightarrow[Ar]3d^6\,4S^0$

$Fe^{+++}\longrightarrow[Ar]3d^5 4S^0$

In +2 state Fe is called Ferrous and in +3 state as ferric.

43. **(b)** Let the oxidation number of N in $NaNO_2$ be

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

$1+x-4=0;\;\; x=+3$

44. **(c)** $K[\overset{*}{Co}(CO)_4]$

$1+x+0=0;\; x=-1.$

45. **(b)** In N_2O nitrogen have +1 oxidation state.

46. **(d)** $K_2\overset{*}{Mn}O_4$

$2+x-2\times 4=0$

$x=8-2=+6$.

47. **(d)** In $[Fe(CO)_5]$, transition metal Fe has zero oxidation state.

48. **(d)** In hydrazoic acid (N_3H) nitrogen shows $-\frac{1}{3}$ oxidation state.

$\overset{*}{N}_3H$

$3x+1=0$,

$3x=-1$,

$x=-\frac{1}{3}$.

49. **(b)** $\overset{*}{S}O_2=+4$

$H_2\overset{*}{S}O_4=+6$

$Na_2\overset{*}{S}_2O_3=+2$

$Na_2\overset{*}{S}_4O_6=+\frac{5}{2}$.

50. **(d)** Fluorine always shows – 1 oxidation state.

51. **(b)** The balanced equation is

$2C_2H_6+7O_2\longrightarrow 4CO_2+6H_2O$.

Ratio of the coefficients of CO_2 and H_2O is 4 : 6 or 2 : 3.

52. **(a)** Starch paper are used for iodine test

as: I^- + oxidant $\longrightarrow I_2$

I_2 + starch $\longrightarrow$ blue colour

53. **(a)** $IO_3^- + aI^- + bH^+ \longrightarrow cH_2O + dI_2$

Step (i) : $I^{-1}\rightarrow I_2$ (oxidation)

$IO_3^-\rightarrow I_2$ (reduction)

Step (ii): $2IO_3^- + 12H^+ \longrightarrow I_2 + 6H_2O$

Step (iii): $2IO_3^- + 12H^+ + 10e \longrightarrow I_2 + 6H_2O$

$2I^-\rightarrow I_2 + 2e$

Step (iv): $2IO_3^- + 12H^+ + 10e^- \longrightarrow I_2 + 6H_2O$

$[2I^-\rightarrow I_2 + 2e]5$

Step (v): $2IO_3^- + 10I^- + 12H^+ \longrightarrow 6I_2 + 6H_2O$

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

On comparing, a = 5, b = 6, c = 3, d = 3

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

55. **(d)** $H_2S\longrightarrow\overset{0}{S}+2e$

Equivalent wt. = $\frac{\text{Mol. wt.}}{2}=\frac{34}{2}=17$.

56. **(b)** $Zn^{2+}/Zn.E^o=-0.76\,V$

$Al^{3+}/Al\quad E^o=-1.662$

$Sn^{2+}/Sn\quad E^o=-0.136$

$Pb^{2+}/Pb\quad E^o=-0.126$

In galvanizing action Zn is coated over iron.

57. **(d)** Molecular weight of H_3PO_4 is 98 and change in its valency = 1 equivalent wt. of H_3PO_4

$=\frac{\text{Molecular weight}}{\text{Change in valency}}$

$=\frac{98}{1}=98$.

58. **(b)** Equivalent mass

$=\frac{\text{Molecular weight}}{\text{Change in oxidation number per mole}}$

Suppose molecular weight is M

Oxidation number of I_2 in IO_4^- in

Acidic medium *i.e.,* $I\times(-8)+1e^-=+7$

So eq. wt. = M / 7.

59. **(d)** $2AgNO_3\xrightarrow{\Delta}2Ag+2NO_2+O_2$.

60. **(b)** To prevent rancidification of food material we add anti-oxidant which are called oxidation inhibitor.

NCERT Exemplar Problems

More than One Answer

61. **(a, c)** 0.09493 moles, 9.492 L of 0.05 N $KMnO_4$

62. **(a, b)** $KClO_4$ and $KMnO_4$ are isomorphous in nature, Equivalent weight of $Fe_{0.9}O$ when it is converted to FeO is 332. (At wt. of Fe =56)

63. **(b, c, d)** $2Cu^{+} \longrightarrow Cu^{+2} + Cu(s)$,

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

$Cl_2 + H_2O \longrightarrow HCl + HOCl$

64. **(c, d)** The value of $\frac{b+2b}{x+y}$ is 1, The value of $\frac{z-x}{3}$ is 1

65. **(a, b, c)** Manganese oxide, Manganese chloride, Manganese sulphate

66. **(a, b, d)** H_2O_2, BaO_2, $H_2S_2O_8$

67. **(c, d)** $NH_4Cl + NaOH \longrightarrow NaCl + NH_3 + H_2O$,

$4KCN + Fe(CN_2) \longrightarrow K_4[Fe(CN)_6]$

68. **(c, d)** $CCl_4 \quad +4, C_6H_{12}O_6 \quad 0$

69. **(a, b)** 0 to –1, 0 to +1

70. **(a, b)** In H_2S sulphur shows –2 oxidation state and in SO_2 shows+4 oxidation state. Hence SO_2 shows both oxidising and reducing properties.

71. **(a, c)** Oxidation number of C changes from +2 to +4, The above reaction is called disproportionation reaction

72. **(a, c, d)** $x_1 > x_2,\ x_3 > x_1, x_3 > x_2$

73. **(a, b, d)** H_2O_2,SO_2,HNO_3

74. **(a, b,c)** bleaching powder, hypo, perdisulphuric acid

75. **(c)** Because I_2 is a reducing agent.

Assertion and Reason

76. **(a)** Both assertion and reason are true and reason is the correct explanation of assertion.

77. **(a)** Both assertion and reason are true and reason is the correct explanation of assertion. Maximum oxidation state of S is +6, it cannot exceed it. Therefore it can't be further oxidised as S^{-2} can't be reduced further.

78. **(a)** Both assertion and reason are true and reason is the correct explanation of assertion. $\overset{0}{N_2} + 6e^- \longrightarrow 2N^{3-}$

$\therefore$ equivalent weight of $NH_3 = \frac{14+3}{3} = \frac{17}{3}$ (M. wt. ofNH_3)

While for $N_2 = \frac{14\times 2}{6} = \frac{28}{6}$

79. **(c)** It is true that SO_2 and Cl_2 both are bleaching agents. But Cl_2 is an oxidising agent while SO_2 is a reducing agent. Therefore, in this question assertion is true while reason is false.

80. **(b)** It is correct that fluorine exists only in –1 oxidation state because it has $1s^2\ 2p^5$ electronic configuration and thus shows only –1 oxidation state in order to complete its octet. Hence, both assertion and reason are true and reason is not a correct explanation of assertion.

81. **(e)** Here, assertion is false, because stannous chloiride is a strong reducing agent not strong oxidising agent. Stannous chlorides gives Grey precipitate with mercuric chloride. Hence, reason is true.

82. **(b)** Both assertion and reason are true but reason is not the correct explanation of assertion. Greater the number of negative atoms present in the oxy-acid make the acid stronger. In general, the strengths of acids that have general formula $(HO)_mZO_n$ can be related to the value of n. As the value of *n* increases, acidic character also increases. The negative atoms draw electrons away from the Z-atom and make it more positive. The Z-atom, therefore, becomes more effective in with drawing electron density away from the oxygen atom that bonded to hydrogen. in turn, the electrons of H—O bond are drawn more strongly away from the H-atom. The net effect makes it easier from the proton release and increases the acid strength.

83. **(a)** Both assertion and reason are true and reason is the correct explanation of assertion.

Oxidation loss of 2e

$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$

Reduction gain of 2e

84. **(b)** Both assertion and reason are true but reason is not the correct explanation of assertion. Oxidation number can be calculated using some rules. H is assigned +1 oxidation state and 0 has oxidation number –2

$\therefore$ O. No. of C in CH_2O: O. no. of C + 2 (+1) + (–2) = 0

$\therefore$ O. No. of C = 0

85. **(a)** Both assertion and reason are correct and reason is the correct explanation for assertion.

$I_2 + Fe \longrightarrow Fe^{2+} + 2I^-$

$I^- + Fe^{2+} \longrightarrow$ No reaction

The oxidation potential of Fe/Fe^{2+} is greater than the oxidation potential of $2I^-/I_2$.

Comprehension Based

86. **(d)** Oxidation state of $X = -2$ $\qquad \overset{+2}{A}\overset{-2}{X}$

Oxidation state of $O = -2$ $\qquad \overset{-2}{O}\overset{+2}{Y}$

Oxidation state of $X = -2$ $\qquad \overset{-2\times 2}{X_2}\overset{+4}{B}$

$\therefore \quad \overset{+2}{A}\overset{-2}{X} + BY + H_2O \longrightarrow \overset{+1}{H}\overset{-1}{A} + \overset{-2}{O}\overset{+2}{Y} + \overset{-2\times 2}{X_2}\overset{+4}{B}$

$e^- + A^{2+} \longrightarrow A^{1-}$ (reduction)

$\overset{+a}{B}\overset{-a}{Y} \longrightarrow B^{4+} + Y^{2+}$ (oxidation)

Therefore, B or Y or both might have been oxidized.

87. **(d)** In BY, the oxidation state of $B \le +4$

Oxidation state of

If the oxidation state of B is +1 and that Y is –1, then both will be oxidised.

If the oxidation state of B is +2 and that of Y is –2, then both will be oxidised.

If the oxidation state of B is +3 and that of Y is –3 then both will be oxidised.

88. **(b)** $A^{2+} + H^+ + 3e^- \longrightarrow HA] \times 2$

$BY + H_2O \longrightarrow B^{4+} + OY + 2H^+ + 6e^-$

$2A^{2+} + BY + H_2O \longrightarrow 2HA + B^{4+} + OY$

or $\quad \frac{2AX}{2} + \frac{BY}{2} + \frac{H_2O}{1} \longrightarrow \frac{2HA}{2} + \frac{BX_2}{2} + \frac{OY}{2} = 8$

The sum of all the coefficients is 8.

89. **(d)** (a) $Cr_2O_7^{2-}$ (orange red) oxidizes SO_2 to SO_4^{2-} and is itself reduced to Cr^{+3}(green)

$$\underset{\text{(Orange)}}{Cr_2O_7^{2-}} + 3H^+ + 3SO_2 \longrightarrow \underset{\text{(Green)}}{2Cr^{3+}} + 3SO_4^{2-} + 4H_2O$$

(b) Both reacts together

$$\overset{+2}{Hg}Cl_2 + \overset{+2}{Sn}Cl_2 \longrightarrow \overset{+1}{Hg_2}Cl_2 \downarrow + \overset{+4}{Sn}Cl_2 \text{ (White ppt)}$$

$$\overset{+1}{Hg_2}Cl_2 + \overset{+2}{Sn}Cl_2 \longrightarrow 2Hg \downarrow + \overset{+4}{Sn}Cl_2 \text{ (Grey)}$$

(c) $\overset{0}{Fe} + \underset{\text{(Blue)}}{\overset{+2}{Cu}\overset{2}{SO_4}} \longrightarrow Fe^{2+} + \overset{0}{Cu}$

(d) $[CuCl_4]^{2-}$ is formed but $[CuI_4]^{2-}$ is not. I^-ion reduces Cu^{+2} to CuI and itself undergoes oxidation to form I_2. However, Cl^- does not reduce Cu^{+2}

90. **(d)** (a) The purple colour of $KMnO_4$ is decolourised due to the reduction of MnO_4^- to Mn^{2+} and $C_2O_4^{2-}$ is oxidized to CO_2 is acidic medium.

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

(b) $Br_2 + 2I^- \longrightarrow 2Br^+ + I_2$

Reduction

Oxidation

(c) $2S_2O_3^{2-} \longrightarrow S_4O_6^{2-}$

$4x - 12 = -4 \qquad 4x - 12 = -2$

$4x = 8 \qquad 4x = 10$

$10 - 8 = 2$

Change in oxidation number of each $N = \frac{2}{4} = 0.5$

(d) $\underline{C}H_4 : x + 4 = 0,\ x = -4$

$\underline{C}O_2 : x - 4 = 0,\ x = 4$

91. **(a)** (a) An element in the lowest oxidation state can only attain higher oxidation state. So it is a reductant and undergoes oxidation.

(b) An element in the highest oxidation state can only attain lower oxidation state. So it is an oxidant and undergoes reduction

(c) The oxidation state of Rb and K is +1 (first group element) $\overset{-1\times 4}{Rb_4}\overset{+1}{K}[HV_{10}O_{28}]^{-5}$

$HV_{10}O_{28}^{-5} = +10x - 2 \times 28 = -5$

$\therefore$ Oxidation state of V(x) =5

(d) Calomel is $\overset{+1\times 2}{Hg_2}\overset{-1\times 2}{Cl_2}$

The oxidation number of Hg is +1 and valency is 2.

92. **(a)** (a) Wrong: The algebraic sum of the oxidation numbers of all the atoms in an ion equals the charge present on the ion.

(b) True statement

(c) True $(2Cl^- \longrightarrow Cl_2 + 2e^-)$ (oxidation)

(d) True

93. **(c)** (a) Disproportionation reaction: $\overset{0}{Br_2} \longrightarrow 2\overset{-1}{Br^+}$

(Oxidation state of Br_2 decreases form 0 to –1)

$\overset{0}{Br_2} \longrightarrow BrO_3^+$

(Oxidation state of Br_2 increases form 0 to +5.)

$x - 6 = -1, x = 5$

(b) Disproportionation reaction: $\overset{+1}{Cu_2}O \longrightarrow \overset{0}{Cu}$

(Oxidation state of Cu decreases form +1 to 0)

Cu^{+2} (Oxidation state of Cu increasing from +1 to +2)

(c) Oxidation: $\overset{+2}{C}N^- \longrightarrow \overset{+2}{C}O_3^{2-} + 2e^-$

$x - 3 = -1 \qquad x - 6 = -2$

$x = 2 \qquad x = 4$

$CN^- \longrightarrow NO_3^- + 8e^-$

(oxidation state of N = –3) $x - 6 = -1, x = 5$
Both are oxidation.
(d) Disproportionation reaction:
$(CN)_2$ gets simultaneously oxidized to CNO^- (cyanate ion) and reduced to CN^-.
The oxidation number of N in $(CN)_2$ is –3, in CN^- is +2, and in CNO^- is –5.

Match the Column

94. **(c)** A→ 3; B→ 4; C→ 2; D→ 1

(A) $\overset{*}{N}O_2$; $x - 4 = 0,\ x = +4$

(B) $H\overset{*}{N}O$; $1 + x - 2 = 0, x = +1$

(C) $\overset{*}{N}H_3$; $x + 3 = 0,\ x = -3$

(D) $\overset{*}{N}_2O_5$; $2x - 10 = 0, 2x = 10, x = \frac{10}{2},\ x = 5$

95. **(a)** A→ 2; B→ 3; C→ 1; D→ 4

(A) $Mn^{2+} \longrightarrow Mn^{4+} + 2e^-$ (Oxidation)

$2e^- + H_2O_2 \longrightarrow 2H_2O$ (Reduction)

(B) $3K \longrightarrow 3K^+ + 3e^-$ (Oxidation)

$3e^- + Al^{3+} \longrightarrow Al$ (Reduction)

(C) $3\overset{0}{Fe} \longrightarrow Fe_3O_4 + 8e^-$ (Oxidation)

$3x = 0 \qquad 3x - 8 = 0, 3x = 8$

$8e^- + 4H_2O \longrightarrow 4H_2$ (Reduction)

$8x - 8 = 0 \qquad 8x = 0$

$8x = 8$

(D) $3H_2S \longrightarrow 3S + 6e^-$

$2 + x = 0 \qquad x = 0$

$x = -2$

$6e^- + 2NO_3^- \longrightarrow 2NO$

$x - 6 = -1 \qquad x - 2 = 0$

$x = 5 \qquad x = 2$

Integer

96. **(5)** Total charge on L.H.S. = Total charges on R.H.S.

$(-1) + 8 + (-n) = +2$

$\therefore$ $n = 5$

97. **(3)** $N_2H_4 \longrightarrow (Y) + 10e$

$\because$ Y contains all N atoms

$\therefore$ $N_2^{-2} \longrightarrow (2N)^a + 10e$

Therefore, $2a - (-4) = 10$; $a = +3$

98. **(84)** In this case only 2 mole of NO_3^- undergo reduction.

$3e^- + NO_3^- \longrightarrow NO\ (x = 3)_2$

$x - 6 = -1 \qquad x - 2 = 0$

$x = 5 \qquad x = 2$

6 mol of HNO_3 are not changing so $6NO_3^-$ are added in the reaction to get 3 mol of $Cu(NO_3)_2$

$\therefore$ $Ew = M + \frac{M}{3} = \frac{4M}{3} = \frac{4 \times 63}{3}$

99. **(8)** Balance the equation by any method.

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

$\therefore$ $a + b + c = 4 + 3 + 1 = 8$

100. **(3)** Balance the equation.

$15H_2O + 3CN^- \longrightarrow 3CO_2 + 3NO_3^- + 30H^+ + 30e^-$

$\therefore$ Number of e^-'s $= \frac{30}{10} = 3$

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