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Paper: C3T: Inorganic Chemistry

Topic : Redox Reaction and Precipitation reaction

Redox Rxn

An oxidation - reduction rxn is called Redox rxn. A redox rxn is that in which oxidation and reduction take place simultaneously i.e. in a redox rxn one substance is oxidise and the other substance is reduce and hence oxidation and reduction process occurs simultaneously.

e.g;

Reduction (Fe: +3 → +2)

i) 2 mole $\overset{+3}{FeCl_3} + \overset{+2}{SnCl_2} = 2\overset{+2}{FeCl_2} + \overset{+4}{SnCl_4}$

Oxidation (Sn: +2 → +4)

reduction (O: 0 → 2−)

ii) $2\overset{0}{Mg} + \overset{0}{O_2} = 2Mg^{2+} + 2O^{2-}$

oxidation (Mg: 0 → 2+)

Oxidising Reagent and Reducing Reagent

An oxidising agent is one that gains electrons and is reduce to a lower oxidation state.

A reducing agent is one that losses electrons and is oxidise to a higher oxidation state.

e.g; In the above eq^n (i) $FeCl_3$ acts as an oxidising agent and $SnCl_2$ acts as a reducing agent.

Oxidation no and Oxidation State

In most of the cases these two terms are used in the same sense. Oxidation no (O.N) of an atom is the appearent charge on the atom in it's compound or in it's ion while oxidation state of an atom is the oxidation no. per atom of that element in a given compound or in an ion.

$K_2Cr_2O_7$ is +12, oxidation state of Cr atom in this molecule is $+12/+2 = +6$.

Actually the O.N or valence no. of an element in a particular compound is a no. which denotes the extent of oxidation or reduction necessary to change the element from the free state into that in the compound.

The oxidation no is given a +ve sign if oxidation is required to effect the change and a -ve sign if reduction is necessary.

- **General Rules for Calculating the oxidation no. and oxidation state.**

Some general rules are given below which can be used to calculate the O.N of the elements.

i) O.N of an element in the free state (i.e elementary state) is zero. e.g; O.N of Cl in Cl_2 is zero.

ii) Oxidation no of an monoatomic ion (e.g; Al^{3+}, Cl^- etc) is equal to the number of positive or negative charges on the ion.

e.g; O.N of Al atom in Al^{3+} ion and of Cl in Cl^- ion are +3 and -1 respectively.

iii) The sum of the oxidation no of all the atoms in a given molecule is zero. This sum is equal to the sum of O.N's of individual atoms.

e.g; In Na_2SO_4 molecule, the sum of oxidation no $= 2 \times (+1) + 1 \times (+6) + 4 \times (-2) = 0$

iv) In polyatomic ions (e.g SO_4^{2-}, NH_4^+ etc) the algebraic sum of O.N of all the constituent atoms is equal to the number of +ve or -ve charges on the polyatomic ion.

e.g; In $Cr_2O_7^{2-}$ ion, the algebric sum of O.N $= 2 \times (+6) + 7 \times (-2) = -2$ which is the charge on $Cr_2O_7^{2-}$ ion.

v) O.N of non metal is negative in it's compound with metals or with hydrogen.

e.g; O.N of N atom in both the molecules (Ca_3N_2 and NH_3) is -3.

vi) O.N of metals of group IA (alkali metals) a. of group IIA (alkali earth metals) is +1 and +2 respectively.

e.g; The O.N of Na and Mg are +1 and +2 respectively.

vii) The O.N of an atom is a variable quantity. Since it may be different in different compounds. The fact is evident from following examples.

1) O.N of H atom is
   a) zero in free H atom or H_2 molecule.
   b) +1 in compounds like NH_3, PH_3, H_2O_2 etc.
   c) −1 in metalic hydrides NaH, $LiAlH_4$ etc.

2) O.N of O atom is
   a) −2 in H_2O, SO_2, Cl_2O. etc
   b) −1 in compounds containing peroxide ion e.g; Na_2O_2, H_2O_2, BaO_2 etc.
   c) −½ in superoxide like KO_2.
   d) +1 in O_2F_2.
   e) +2 in OF_2.

viii) F is the most electronegative element has an oxidation number of −1 in all its compounds.

ix) In all the halides (compounds of HX or MX type, where X is the halogen, M is the metal atom) the O.N of the halogen is −1.

- **Balancing of the Redox Rxn by O.N method**

The use of this method can be understood by considering the following examples.

1) $MnO_4^- + C_2O_4^{=} \longrightarrow Mn^{2+} + CO_2$ (in acid med.)

a) The given eqn is $\overset{+7}{Mn}O_4^- + \overset{+3}{C_2}O_4^{=} \longrightarrow \overset{+2}{Mn^{2+}} + \overset{+4}{C}O_2$

In this rxn MnO_4^- acts as an oxidising agent and $C_2O_4^{=}$ as a reducing agent. This is decreased from +7 to +2 and that of carbon is increased from +3 to +4.

The oxidation no of 'O' remain same.

b) Increase in oxidation number of one carbon atom = (+4) − (+3) = +1

Increase in O.N of two carbon atoms = (+1) × 2 = +2

Decrease in O.N. of one Mn atom = (+7) − (+2) = +5

In order to make the total increase in O.N the oxidising agent should be multiplied by 2 and the reducing agent should be multiplied by 5.

Thus the given equ^n should be written as

$$2MnO_4^- + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2$$

c) In order to balance 'O' atoms, add $8H_2O$ molecules to the R.H.S of the above equ^n and the equ^n becomes -

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

This is the balanced equ^n, since electrical charges on both sides are equal.

2) $As_2S_3 + NO_3^- \longrightarrow H_3AsO_4 + NO + SO_4^{2-}$ (in acid medium)

a) The given eqn is

$$\overset{+3\;-2}{As_2S_3} + \overset{+5}{NO_3^-} \longrightarrow H_3\overset{+5}{As}O_4 + \overset{+2}{N}O + \overset{+6}{S}O_4^{2-}$$

In the given equation NO_3^- acts as an oxidising agent. This is because of the fact that O.N per atom of N is decreased from +5 to +2 and that of As is increased from +3 to +5 and S is increased from −2 to +6. The O.N of 'O' atom remain same.

b) Increase in O.N of one As atom $= (+5) - (+3) = +2$

Increase in O.N of two As atom $= +2 \times 2 = +4$

Increase in O.N of S atom $= (+6) - (-2) = +8$

Increase in O.N of three 'S' atom $= +8 \times 3 = +24$

Therefore total increase of oxidation no of two As atom and three S atom $= +4 + 24 = +28$

Decrease in O.N of one 'N' atom $= (+5) - (+2) = +3$

equal to the total decrease in O.N, the oxidising agent (NO_3^-) should be multiplied by 28 and the reducing agent (As_2S_3) should be multiplied by 3.

Thus the given eqn should be written as

$$3As_2S_3 + 28NO_3^- \longrightarrow 6H_3AsO_4 + 28NO + 9SO_4^{2-}$$

c) In order to balance 'O' atoms add $4H_2O$ molecules to the L.H.S of the above equn and the becomes -

$$3As_2S_3 + 28NO_3^- + 4H_2O \longrightarrow 6H_3AsO_4 + 28NO + 9SO_4^{2-}$$

d) In order to show the acidic medium of the rxn and to balance H atom add $10H^+$ to the L.H.S of the above equation.

$$3As_2S_3 + 28NO_3^- + 10H^+ + 4H_2O = 6H_3AsO_4 + 28NO + 9SO_4^{2-}$$

This is the balanced equation, since the electrical charges on both sides are same.

3) $AsO_3^{3-} + MnO_4^- \longrightarrow AsO_4^{3-} + MnO_2$ (in alkali medium)

a) The given equn is $\overset{+3}{As}O_3^{3-} + \overset{+7}{Mn}O_4^- \rightarrow \overset{+5}{As}O_4^{3-} + \overset{+4}{Mn}O_2$

In the given equn MnO_4^- acts as an oxidising agent and AsO_4^{3-} behave as a reducing agent. This is because of the fact that O.N of Mn is decreased from +7 to +4, and that of As is increased from +3 to +5. The O.N of 'O' atom remain the same.

b) Increased in O.N of As atom = (+5) - (+3) = +2
Decreased in O.N of Mn atom = (+7) - (+4) = +3

In order to make the total increasing in O.N equal to the total decreasing of O.N; the oxidising agent MnO_4^- should be multiplied by 2 and the reducing agent (AsO_3^{3-}) should be multiplied by 3. Thus the given equation becomes -

$$3AsO_3^{3-} + 2MnO_4^- \longrightarrow 3AsO_4^{3-} + 2MnO_2$$

c) One oxygen atom in L.H.S is excess. In order to show alkaline medium of the rxn and to balance O and H atom one H_2O is added L.H.S and two OH^- on R.H.S.

Hence the equn becomes

$$3AsO_3^{3-} + 2MnO_4^- + H_2O = 3AsO_4^{3-} + 2MnO_2 + 2OH^-$$

This is the balanced equation. Since electrical charges on both sides are equal.

- **Balancing of Redox Rxn by ion electron method**

various steps involved in this method are given below —

i) Ascertain the reactants and products and their chemical formulae.

ii) If the unbalanced equation is in the molecular form convert into ionic form and then break this ionic equation into two half reactions (partial eqn). These equation represent the reduction of oxidant and the oxidation of reductant.

iii) Balance both the partial equations in the following way;

a) Balance the no. of atom other than H and O by multiplying the R.H.S or L.H.S of half rxns by a suitable multiple.

b) In order to balance O atoms, add the appropriate number of H_2O molecules to the side defficient in O atom.

c) In order to balance H atoms and to show the acidic medium of the rxn add H^+ ions to the side defficient to the H atoms.

d) If the rxn take place in the basic medium, H^+ ions used in step (c) should be allowed to combine with the equal no of OH^- ion to product, same no of H_2O molecule. Now add the resulted equation, so that H^+ ions are cancelled out from both the equation.

e) Balance the electrical charges on both sides by adding electrons to the side defficient in the negative charges.

f) Multiply one or both half reactions by a suitable number so that by adding the two half rxns the electrons are cancelled out.

iv) The above six steps give both the half rxns in balanced state. Now add the balanced two half rxns and cancelled out the terms which are common the both side.

State what happens when

i) $KMnO_4$ is treated with $FeSO_4$ in acid medium.

ii) $K_2Cr_2O_7$ is treated with KI in acid medium.

iii) $KMnO_4$ is treated with sodium stanite in alkali.

iv) $K_4[Fe(CN)_6]$ is treated with H_2O_2 in acid medium.

Give the balanced equation in each case.

i) $KMnO_4$ is treated with $FeSO_4$ in acid medium.

a) In aqueous acid medium $KMnO_4$ oxidises $FeSO_4$ to $Fe_2(SO_4)_3$ and itself reduces to manganous salt. Hence The molecular unbalanced equation can be written as

$$KMnO_4 + FeSO_4 \rightarrow MnSO_4 + Fe_2(SO_4)_3 + K_2SO_4$$
(in acid medium)

b) In the ionic form this molecular equation can be written as,

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

This ionic equation can be broken into oxidation and reduction half rxns as,

$$MnO_4^- \rightarrow Mn^{2+} \text{ (Reduction)}$$
$$Fe^{2+} \rightarrow Fe^{3+} \text{ (Oxidation)}$$

c) Hence the balance partial equation will be

$$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O \quad \text{—①}$$
and $$2Fe^{2+} \rightarrow 2Fe^{3+} + 2e \quad \text{—②}$$

Multiplying eqn ① by 2 and eqn ② by 5 and adding them, we get,

$$2MnO_4^- + 16H^+ + 10e \rightarrow 2Mn^{2+} + 8H_2O$$
$$10Fe^{2+} \rightarrow 10Fe^{3+} + 10e$$

$$2MnO_4^- + 16H^+ + 10Fe^{2+} \rightarrow 2Mn^{2+} + 8H_2O + 10Fe^{3+}$$

This is the balanced equation

d) The balanced molecular equation will be

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

ii) $K_2Cr_2O_7$ is treated with KI in dilute acid medium.

a) In dilute acid medium $K_2Cr_2O_7$ oxidises KI to I_2 and itself reduces to chromic salt $[Cr_2(SO_4)_3]$. Hence the molecular unbalanced equation can be written as

$$K_2Cr_2O_7 + KI \rightarrow Cr_2(SO_4)_3 + I_2 + K_2SO_4 \text{ (in } H_2SO_4 \text{ med)}$$

b) In the ionic form, This molecular equation can be written as -

$$Cr_2O_7^{2-} + I^- \rightarrow Cr^{3+} + I_2$$

This ionic equation can be broken into oxidation and reduction half rxns as –

$Cr_2O_7^{=} \longrightarrow Cr^{3+}$ (Reduction)

$I^- \longrightarrow I_2$ (oxidation)

c) Hence the balanced partial equation will be

$Cr_2O_7^{=} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$ —— ①

and $2I^- \rightarrow I_2 + 2e$ —— ②

Multiplying equation ① by 1 and equation ② by 3 and adding them we get

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

$6I^- \longrightarrow 3I_2 + 6e$

$Cr_2O_7^{=} + 14H^+ + 6I^- \longrightarrow 2Cr^{3+} + 7H_2O + 3I_2$

This is the balanced equation.

This is the balanced molecular equation will be

d) The balanced molecular equation will be

$K_2Cr_2O_7 + 7H_2SO_4 + 6KI = Cr_2(SO_4)_3 + 7H_2O + 3I_2 + 4K_2SO_4$

iii) KMnO$_4$ is treated with sodium stanite (Na_2SnO_2) in alkaline medium.

⇒ In alkaline medium KMnO$_4$ oxidises Na_2SnO_2 to Na_2SnO_3 and itself reduced to MnO_2. Hence the molecular unbalanced equation will be

$KMnO_4 + Na_2SnO_2 \longrightarrow MnO_2 + Na_2SnO_3$ (in KOH medium)
+KOH

b) In the ionic form, This molecular equation can be written as

$MnO_4^- + SnO_2^{=} \rightarrow MnO_2 + SnO_3^{=}$

This ionic equation can be broken into oxidation and reduction half reactions as

$MnO_4^- \longrightarrow MnO_2$ (Reduction)

$SnO_2^{=} \longrightarrow SnO_3^{=}$ (oxidation)

c) Hence the balanced partial equ^n will be

$2H_2O + MnO_4^- + 3e \longrightarrow MnO_2 + 4OH^-$ —— ①

and $SnO_2^{=} + 2OH^- \longrightarrow SnO_3^{=} + H_2O + 2e$ —— ②

multiplying equ^n ① by 2 and equ^n ② by 3 and adding them we get,

$4H_2O + 2MnO_4^- + 6e \longrightarrow 2MnO_2 + 8OH^-$

$3SnO_2^{=} + 6OH^- \longrightarrow 3SnO_3^{=} + 3H_2O + 6e$

$2MnO_4^- + 3SnO_2^{=} + H_2O \longrightarrow 2MnO_2 + 3SnO_3^{=} + 2OH^-$

iv) $K_4[Fe(CN)_6]$ is treated with H_2O_2 in acid medium.

a) In acid medium $K_4[Fe(CN)_6]$ reduces H_2O_2 to H_2O and itself oxidises to $K_3[Fe(CN)_6]$. Hence the molecular unbalanced equation can be written as,

$$K_4[Fe(CN)_6] + H_2O_2 \rightarrow K_3[Fe(CN)_6] + H_2O \text{ (in } H_2SO_4 \text{ medium)}$$

b) In the ionic form, this molecular equation can be written as

$$[Fe(CN)_6]^{4-} + H_2O_2 \rightarrow [Fe(CN)_6]^{3-} + H_2O$$

This ionic equation can be broken into oxidation and reduction half rxns as -

$$[Fe(CN)_6]^{4-} \rightarrow [Fe(CN)_6]^{3-} \text{ (oxidation)}$$

$$H_2O_2 \rightarrow H_2O \text{ (reduction)}$$

c) Hence the balance partial eqn will be

$$[Fe(CN)_6]^{4-} \rightarrow [Fe(CN)_6]^{3-} + e \quad -①$$

and $H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O \quad —②$

Multiplying equation ① by 2 and eqn ② by 1 and adding them we get

$$2[Fe(CN)_6]^{4} \rightarrow 2[Fe(CN)_6]^{3-} + 2e$$

$$2e + 2H^+ + H_2O_2 \rightarrow 2H_2O$$

$$2[Fe(CN)_6]^{4-} + H_2O_2 + 2H^+ \rightarrow 2[Fe(CN)_6]^{3-} + 2H_2O$$

This is the balanced equation.

d) The balanced molecular equation will be

$$2K_4[Fe(CN)_6] + H_2O_2 + H_2SO_4 = 2K_3[Fe(CN)_6] + 2H_2O + K_2SO_4.$$

• Balance the following equations by ion electron method.

i) $FeCl_3 + SnCl_2 \rightarrow FeCl_2 + SnCl_4$

ii) $P_4 \rightarrow H_2PO_2^- + PH_3$ (in basic medium)

iii) $MnO_4^- + C_2O_4^{2-} \rightarrow Mn^{2+} + CO_2$ (in acid medium)

iv) $I_2 \rightarrow IO_3^- + I^- + H_2O$ (in alkaline medium)

v) XeO_6^{4-} (Per xenate ion) $+ Mn^{2+} + H^+ \rightarrow XeO_3 + MnO_4^- + H_2O$

vi) $BiO_3^- + Mn^{2+} + H^+ \rightarrow Bi^{3+} + MnO_4^- + H_2O$

vii) $Cr_2O_7^{=} + Fe^{2+} + H^+ \rightarrow Cr^{3+} + Fe^{3+} + H_2O$

viii) $MnO_4^- + Fe^{2+} + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$

i) The given equation is $FeCl_3 + SnCl_2 \rightarrow FeCl_2 + SnCl_4$
This is the unbalanced molecular equation.

a) In the ionic form, The above equation can be written as

$$Fe^{3+} + Sn^{2+} \rightarrow Fe^{2+} + Sn^{4+}$$

This ionic equation can be broken into two partial equations as

$$Fe^{3+} \rightarrow Fe^{2+} \text{ (Reduction)} \quad \text{—} ①$$
$$Sn^{2+} \rightarrow Sn^{4+} \text{ (oxidation)} \quad \text{—} ②$$

b) In equation ① The no. of Fe atoms is already balanced. In order to balance the electrical charge adding one electrons to the L.H.S of equ^n ① we get

$$Fe^{3+} + e \rightarrow Fe^{2+} \quad \text{—} ③$$

c) In equation ② The no. of Sn atoms is already balanced. In order to balance the electrical charge adding two electrons to the R.H.S of equ^n ②, we get

$$Sn^{2+} \rightarrow Sn^{4+} + 2e \quad \text{—} ④$$

d) Multiplying equation ③ by 2 and equ^n ④ by 1 and adding Them we get

$$2Fe^{3+} + Sn^{2+} \rightleftharpoons 2Fe^{2+} + Sn^{4+}$$

This is the balanced ionic equation.

e) Converting The above ionic equ^n into The molecular form we get,

$$2FeCl_3 + SnCl_2 = 2FeCl_2 + SnCl_4$$

This is The balanced molecular equation.

ii) The given equ^n is $P_4 \rightarrow H_2PO_2^- + PH_3$ (in basic med.)

a) This equ^n is in The ionic form. In this equation P_4 is oxidised to $H_2PO_2^-$ as well as reduced to PH_3. Thus The given equ^n can be broken into the following partial equations,

$$P_4 \rightarrow H_2PO_2^- \text{ (Oxidation)} \quad \text{—} ①$$
$$P_4 \rightarrow PH_3 \text{ (Reduction)} \quad \text{—} ②$$

b) To balance all the atoms and electrical charge in equ^n ① The following steps are required.

A. $P_4 \rightarrow 4H_2PO_2^-$ (to balance P atom)

B. $P_4 + 8H_2O \rightarrow 4H_2PO_2^-$ (to balance O atom)

C. $P_4 + 8H_2O \rightarrow 4H_2PO_2^- + 8H^+$ (to balance H atom)

D. $P_4 + 8H_2O + 8OH^- \rightarrow 4H_2PO_2^- + 8H^+ + 8\bar{O}H$ (in basic medium)

E. $P_4 + 8\bar{O}H \rightarrow 4H_2PO_2^- + 4e$ (to balance electrical charges) ③

∴ This electrical charge.

c) To balance all the atoms and electrical charges in eqn ② the following steps are required;

A. $P_4 \rightarrow 4PH_3$ (to balance P atom)

B. $P_4 + 12H^+ \rightarrow 4PH_3$ (to balance H atom)

C. $P_4 + 12H^+ + 12OH^- \rightarrow 4PH_3 + 12OH^-$ (in alkaline medium)

D. $P_4 + 12H_2O + 12e \rightarrow 4PH_3 + 12\bar{O}H$ (to balance electrical charges) ④

d) Multiplying eqn ③ by 3 and eqn ④ by 1 and adding them we get

$3P_4 + 24OH^- + P_4 + 12H_2O = 12H_2PO_2^- + 12e + 4PH_3 + 12\bar{O}H$

or $P_4 + 3OH^- + 3H_2O = 3H_2PO_2^- + PH_3$.

This is the balanced ionic equation.

iii) The given eqn is

$MnO_4^- + C_2O_4^= \rightarrow Mn^{2+} + CO_2$ (in acid medium)

a) This eqn is in the ionic form. In this equation MnO_4^- is reduced to Mn^{2+} and $C_2O_4^=$ is oxidised to CO_2. Thus the given eqn can be broken into two partial equations.

$MnO_4^- \rightarrow Mn^{2+}$ (Reduction) —— ①

$C_2O_4^= \rightarrow CO_2$ (oxidation) —— ②

b) The eqn ① can be balanced by using the following steps.

A. $MnO_4^- \rightarrow Mn^{2+} + 4H_2O$ (to balance O atom)

B. $MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$ (to balance H atom)

C. $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$ (to balance the electrical charge)

c) The eqn ② can be balanced by using following steps.

A. $C_2O_4^= \rightarrow 2CO_2$ (to balance C atom)

B. $C_2O_4^= \rightarrow 2CO_2 + 2e$ (to balance electrical charg

d) Multiplying eqn ③ by 2 and eqn ② by 5 and adding them we get,

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

$5C_2O_4^{2-} \longrightarrow 10CO_2 + 10e$

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

This is the balanced equ^n. Since the electrical charges on both side are equal.

iv) The given equation is

$I_2 \longrightarrow IO_3^- + I^- + H_2O$ (in alkaline medium)

a) This equ^n is in the ionic form. In this equ^n I_2 is oxidised to IO_3^- as well as reduced to I^-. Thus the given equ^n can be broken into the following partial equ^n.

$I_2 \longrightarrow IO_3^-$ (Oxidation) —— ①

$I_2 \longrightarrow I^-$ (Reduction) —— ②

b) The equ^n ① can be balanced by following steps.

A. $I_2 \longrightarrow 2IO_3^-$ (to balance I atom)

B. $I_2 + 6H_2O \longrightarrow 2IO_3^-$ (to balance O atom)

C. $I_2 + 6H_2O \longrightarrow 2IO_3^- + 12H^+$ (to balance H atom)

D. $I_2 + 6H_2O + 12OH^- \rightarrow 2IO_3^- + 12H^+ + 12OH^-$ (in basic medium)

E. $I_2 + 12OH^- \rightarrow 2IO_3^- + 6H_2O + 10e$ (to balance the electrical charge) .... ③

c) The equ^n ② can be balanced by using following steps.

A. $I_2 \longrightarrow 2I^-$ (to balance I atom)

B. $I_2 + 2e \longrightarrow 2I^-$ (to balance electrical charges) ..... ④

d) Multiplying equ^n ③ by 1 and equ^n ④ by 5 and adding them we get

$I_2 + 12OH^- + 5I_2 + 10e = 2IO_3^- + 6H_2O + 10e + 10I^-$

or $3I_2 + 6OH^- = IO_3^- + 3H_2O + 5I^-$

This is the balanced ionic equation.

v) The given equ^n is $XeO_6^{4-} + Mn^{2+} + H^+ \rightarrow XeO_3 + MnO_4^- + H_2O$

a) This equ^n is in the ionic form. Since H^+ ions are involved in this equ^n hence this rxn occurs in acid medium. In this equ^n XeO_6^{4-} is reduce to XeO_3 and Mn^{2+} is oxidises to MnO_4^- ion. Thus the given equ^n is broken into two partial equ^{n}s.

$XeO_6^{4-} \longrightarrow XeO_3$ (Reduction) —— ①

$Mn^{2+} \longrightarrow MnO_4^-$ (Oxidation) —— ②

b) To balance all the atoms and electrical charge equation ① the following steps are required.

A. $XeO_6^{4-} \rightarrow XeO_3 + 3H_2O$ (to balance O atoms)

B. $XeO_6^{4-} + 6H^+ \rightarrow XeO_3 + 3H_2O$ (to balance H atoms)

C. $XeO_6^{4-} + 6H^+ + 2e \rightarrow XeO_3 + 3H_2O$ (to balance the electrical charge) ...... ③

c) To balance all the atoms and electrical charges in eqn ② the following steps are required.

A. $Mn^{2+} + 4H_2O \rightarrow MnO_4^-$ (to balance O atoms)

B. $Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+$ (to balance H atoms)

C. $Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e$ (To balance the electrical charges) ...... ④

d) Multiplying eqn ③ by 5 and eqn ② by 2 and adding them we get

$$5XeO_6^{4-} + 30H^+ + 10e \rightarrow 5XeO_3 + 15H_2O$$

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

$$5XeO_6^{4-} + 30H^{\oplus} + 2Mn^{2+} + 8H_2O = 5XeO_3 + 2MnO_4^- + 16H^+ + 15H_2O$$

or, $5XeO_6^{4-} + 2Mn^{2+} + 14H^+ = 5XeO_3 + 2MnO_4^- + 7H_2O$

This is the balanced eqn.