09

Redox Reactions

TOPIC 1

Oxidation, Reduction and Oxidation Number

01 The sum of oxidation states of two silver ions in $[Ag(NH_3)_2][Ag(CN)_2]$ complex is .... **[2021, 1 Sep Shift-II]**

Ans. *(2)*

$[Ag(NH_3)_2][Ag(CN)_2]$ complex dissociates into $[Ag(NH_3)_2]^+$ and $[Ag(CN)_2]$.

Oxidation of Ag in $[Ag(NH_3)_2]^+$

$$Ag + 0 \times 2 = +1$$
$$Ag = +1$$

Oxidation state of Ag in $[Ag(CN)_2]^-$

$$Ag + (-1) \times 2 = -1$$
$$Ag - 2 = -1$$
$$\Rightarrow \quad Ag = +1$$

$\therefore$ Sum of oxidation states of two silver ions in $[Ag(NH_3)_2][Ag(CN)_2]$ complex is 2.

02 Identify the process in which change in the oxidation state is five **[2021, 25 July Shift-II]**

(a) $Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$
(b) $MnO_4^- \longrightarrow Mn^{2+}$
(c) $CrO_4^{2-} \longrightarrow Cr^{3+}$
(d) $C_2O_4^{2-} \longrightarrow 2CO_2$

Ans. *(b)*

Change in oxidation state in different process is as follows :

(a) $Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$
$2x - 14 - 2 = 0$, $x = 6$
$2x = 16$
$x = 8$ $(\therefore 2e^-$ change)

(b) $MnO_4^- \longrightarrow Mn^{2+}$
$x - 8 + 1 = 0$, $x = 2$
$x = 7$ $(\therefore 5\,e^-$ change)

(c) $Cr\,O_4^{2-} \longrightarrow Cr^{3+}$
$x - 8 - 2 = 0$, $x = 3$
$x = 10$ $(\therefore 7\,e^-$ change)

(d) $C_2O_4^{2-} \longrightarrow 2CO_2$
$2x - 8 - 2 = 0$, $x = 4$
$x = 5$
$(\therefore 1\,e^-$ change)

Hence, in the process of MnO_4^- to Mn^{2+} the change in oxidation state is five.

03 Cu^{2+} salt reacts with potassium iodide to give **[2021, 20 July Shift-II]**

(a) Cu_2I_2
(b) Cu_2I_3
(c) CuI
(d) $Cu(I_3)_2$

Ans. *(a)*

Cu^{2+} salt react with potassium iodide to give Cu_2I_2 (white ppt.)

$$2Cu^{2+}(aq) + 4I^-(aq) \longrightarrow \underset{\text{(White ppt.)}}{Cu_2I_2(s)} + I_2$$

In this reaction, Cu^{2+} gets reduced to Cu^+ and I^- gets oxidised to I_2.

04 The species given below that does not show disproportionation reaction is **[2021, 20 July Shift-I]**

(a) BrO_4^-
(b) BrO^-
(c) BrO_2^-
(d) BrO_3^-

Ans. *(a)*

BrO_4^- will not undergo disproportionation because bromine is in its maximum oxidation state, i.e. + 7.

For a species to undergo disproportionation, the oxidation state of the element undergoing disproportionation should lie between its maximum and minimum possible oxidation values.

In option (a), we have the oxidation state of Br = + 7

In option (b), we have oxidation state of Br = + 1

In option (c), we have oxidation state of Br = + 3

In option (d), we have oxidation state of Br = + 5

The maximum and minimum possible oxidation state value for Br are + 7 and – 1 respectively. So, BrO_4^- cannot oxidise further. Hence, it cannot show disproportionation reaction.

05 In basic medium, H_2O_2 exhibits which of the following reactions ?

A. $Mn^{2+} \rightarrow Mn^{4+}$ B. $I_2 \rightarrow I^-$

C. $PbS \rightarrow PbSO_4$

Choose the most appropriate answer from the options given below. **[2021, 18 March Shift-II]**

(a) A and C
(b) Only A
(c) Only B
(d) A and B

Ans. *(d)*

In basic medium, oxidising action of H_2O_2

$$Mn^{2+} + H_2O_2 \longrightarrow Mn^{4+} + 2OH^-$$

In basic medium, reducing action of H_2O_2

$$I_2 + H_2O_2 + 2OH^- \longrightarrow 2I^- + 2H_2O + O_2$$

In acidic medium, oxidising action of H_2O_2

$$PbS(s) + 4H_2O_2(aq) \longrightarrow PbSO_4(s) + 4H_2O(l)$$

Thus, in basic medium H_2O_2 exhibits reaction '*A*' and '*B*'

Hence, correct option is (d).

06 Given below are two statements.

Statement I Potassium permanganate on heating at 573 K forms potassium manganate.

Statement II Both potassium permanganate and potassium manganate are tetrahedral and paramagnetic in nature.

In the light of the above statements, choose the most appropriate answer from the options given below **[2021, 17 March Shift-I]**

(a) Statement I is true but statement II is false.
(b) Both statement I and statement II are true.
(c) Statement I is false but statement II is true.
(d) Both statement I and statement II are false.

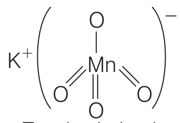
Ans. ***(a)***

Potassium permanganate on heating at 573 K forms potassium manganate.

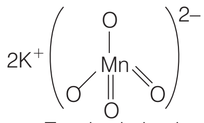
$$\underset{\substack{\text{Potassium}\\\text{permanganate}\\\text{(Diamagnetic)}}}{K\overset{+7}{Mn}O_4} \xrightarrow{573\text{ K}} \underset{\substack{\text{Potassium}\\\text{manganate}\\\text{(Paramagnetic)}}}{K_2\overset{+6}{Mn}O_4} + MnO_2 + O_2$$

Both potassium permanganate and potassium manganate are tetrahedral.

Manganese has four sigma bonds forming tetrahedral structure.



Tetrahedral unit



Tetrahedral unit

$KMnO_4; +1 + x - 8 = 0,$
$x = +7$
$K_2MnO_4; +2 + x - 8 = 0$
$x = +6$

So, Mn is present in $+7$ oxidation state in $KMnO_4$ and $+6$ oxidation state in K_2MnO_4.

$_{25}Mn = [Ar]4s^2\,3d^5$

$Mn^{+7} = [Ar]4s^0\,3d^0$ (Diamagnetic)

$Mn^{+6} = [Ar]4s^1$ (Paramagnetic)

So, potassium permanganate is diamagnetic and potassium manganate is paramagnetic.

Statement I is true but statement II is false.

07 Dichromate ion is treated with base, the oxidation number of Cr in the product formed is .... **[2021, 26 Feb Shift-I]**

Ans. ***(6)***

In basic medium dichromate ion $(Cr_2O_7^{2-})$ changes in chromate ion (CrO_4^{2-}). Oxidation state of Cr in CrO_4^{2-} is +6.

$\Rightarrow \quad CrO_4^{2-} = x + 4(-2) = -2$

or $\quad x = +6.$

Dichromate and chromate equilibrium depends on pH of the medium as

$$\underset{\substack{(aq)\\\text{(Orange)}}}{\overset{+6}{Cr_2}O_7^{2-}} \underset{H^+\,(pH<7)}{\overset{OH^-\,(pH>7)}{\rightleftharpoons}} \underset{\substack{(aq)\\\text{(Yellow)}}}{CrO_4^{2-}}$$

08 Which of the following equation depicts the oxidising nature of H_2O_2? **[2021, 25 Feb Shift-I]**

(a) $KIO_4 + H_2O_2 \longrightarrow KIO_3 + H_2O + O_2$
(b) $I_2 + H_2O_2 + 2OH^- \longrightarrow 2I^- + 2H_2O + O_2$
(c) $2I^- + H_2O_2 + 2H^+ \longrightarrow I_2 + 2H_2O$
(d) $Cl_2 + H_2O_2 \longrightarrow 2HCl + O_2$

Ans. ***(c)***

Oxidation involves increase in oxidation number and reduction involves decrease in oxidation number.

$$2I^- + 2H^+ + \overset{1}{H_2}\overset{-1}{O_2} \longrightarrow \overset{0}{I_2} + 2\overset{+1}{H_2}\overset{-2}{O}$$

In this reaction, H_2O_2 oxidises I^- to I_2 and itself gets reduced to H_2O, so the reaction depicts oxidising nature of H_2O_2. While in other reactions H_2O_2 does not oxidise KIO_4, I_2 and Cl_2.

09 The oxidation states of iron atoms in compounds (A), (B) and (C), respectively, are x, y and z. The sum of x, y and z is

$\underset{(A)}{Na_4[Fe(CN)_5(NOS)]}$, $\underset{(B)}{Na_4[FeO_4]}$, $\underset{(C)}{[Fe_2(CO)_9]}$

[2020, 9 Sep Shift-I]

Ans. ***(6)***

$Na[\underline{Fe}(CN)_5NOS] \Rightarrow 4 \times (+1) + x + 5 \times (-1) + (+1) + (-2) = 0$
$\Rightarrow x = +2$

CN^- $\quad NO^+$ $\quad S^{2-}$

$Na_4[\overset{y}{\underline{Fe}}O_4] \Rightarrow 4(+1) + y + 4 \times (-2) = 0$
$\Rightarrow y = +4$

$[\underline{Fe_2}(CO)_9] \Rightarrow 2 \times z + 9 \times 0 = 0 \Rightarrow z = 0$

So, $x + y + z = (+2) + (+4) + (0) = 6$

10 The oxidation states of transition metal atoms in $K_2Cr_2O_7$, $KMnO_4$ and K_2FeO_4, respectively, are x, y and z. The sum of x, y and z is .... **[2020, 2 Sep Shift-II]**

Ans. ***(19)***

$K_2\overset{x}{Cr_2}O_7 \Rightarrow 2(+1) + 2x + 7 \times (-2) = 0$

$\Rightarrow \quad x = +6$

$K\overset{y}{Mn}O_4 \Rightarrow 1 \times (+1) + x + 4 \times (-2) = 0$

$\Rightarrow \quad y = +7$

$K_2\overset{z}{Fe}O_4 \Rightarrow 2 \times (+1) + z + 4 \times (-2) = 0$

$\Rightarrow \quad z = +6$

So, $\quad (x + y + z) = 6 + 7 + 6 = 19$

11 On heating, lead (II) nitrate gives a brown gas (A). The gas (A) on cooling changes to a colourless solid/liquid (B). (B) on heating with NO changes to a blue solid (C). The oxidation number of nitrogen in solid (C) is **[2020, 4 Sep Shift-I]**

(a) +5 (b) +4
(c) +2 (d) +3

Ans. ***(d)***

On heating lead (II) nitrate following reaction takes place.

$$\underset{\text{(Lead nitrate)}}{Pb(NO_3)_2} \longrightarrow PbO + \underset{\substack{(A)\\\text{Brown gas}}}{2NO_2} + \frac{1}{2}O_2(g)$$

Gas, $NO_2\,(A)$ on cooling gives $N_2O_4\,(B)$.

$$\underset{\text{Brown gas}}{2\ NO_2(g)} \xrightarrow{\text{Cooling}} \underset{(B)}{N_2O_4}$$

Colourless solid/liq. $N_2O_4\,(B)$ on reaction with NO gives N_2O_3.

$$\underset{(B)}{N_2O_4} + 2NO \xrightarrow{\text{D}} \underset{\substack{(C)\\\text{Blue solid}}}{N_2O_3}$$

Oxidation state of N in $N_2O_3\,(C)$.

$N_2O_3 \Rightarrow 2x + 3(-2) = 0$

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

So, oxidation state is + 3.

12 Oxidation number of potassium in K_2O, K_2O_2 and KO_2, respectively, is **[2020, 7 Jan Shift-I]**

(a) +1, +4 and +2 (b) +1, +2 and +4
(c) +1, +1 and +1 (d) +2, +1 and $+\frac{1}{2}$

Ans. ***(c)***

Elements of group 1 (alkali metals) show only one non-zero oxidation number, which is equal to + 1.

K_2O consists of K^+ and O^{2-} ions

K_2O_2 (potassium peroxide) consists of K^+ and O_2^{2-} ions. KO_2 (potassium superoxide) consists of K^+ and O_2^- ions.

Thus, in all the given compounds potassium exhibits +1 oxidation state.

13 The redox reaction among the following is **[2020, 7 Jan Shift-II]**

(a) reaction of H_2SO_4 with NaOH
(b) reaction of $[Co(H_2O)_6]Cl_3$ with $AgNO_3$
(c) combination of dinitrogen with dioxygen at 2000 K
(d) formation of ozone from atmospheric oxygen in the presence of sunlight

Ans. ***(c)***

(a) The given reactions are as follows:

$$\underset{(+6)}{H_2SO_4} + 2\underset{(+1)}{NaOH} \longrightarrow \underset{(+1)\,(+6)}{Na_2SO_4} + 2H_2O$$

(No change in oxidation state, so not a redox reaction).

(b) $$[\underset{(+3)}{Co}(H_2O)_6]Cl_3 + 3\ \underset{(+1)}{AgNO_3} \longrightarrow [\underset{(+3)}{Co}(H_2O)_6](NO_3)_3 + 3\underset{(+1)}{Ag}Cl\downarrow$$

(No change in oxidation state, so not a redox reduction).

(c) $$\underset{(0)}{N_2} + \underset{(0)}{O_2} \xrightarrow{200\ K} \underset{(+2)(-2)}{2NO}$$

(N_2 oxidised from 0 to +2 oxidation state and O_2 reduced from 0 to −2 oxidation state).

∴ This is redox reaction.

(d) $$\underset{(0)}{3O_2} \overset{h\nu}{\rightleftharpoons} \underset{(0)}{2O_3}$$

(No change in oxidation states, so not a redox reaction).

14 The compound that cannot act both as oxidising and reducing agent is **[2020, 9 Jan Shift-II]**

(a) H_2SO_3 (b) H_3PO_4
(c) HNO_2 (d) H_2O_2

Ans. ***(b)***

In H_3PO_4, P is in its highest oxidation state (+5), it can only act as oxidising agent but not as reducing agents, because it can be reduced but not oxidised.

H_2SO_3 : S = +4 can get oxidised or reduced.

HNO_2 : N = +3 can get oxidised or reduced.

H_2O_2 : O = −1 can get oxidised or reduced.

15 An example of a disproportionation reaction is **[2019, 12 April Shift-I]**

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

(b) $2NaBr + Cl_2 \longrightarrow 2NaCl + Br_2$

(c) $2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$

(d) $2CuBr \longrightarrow CuBr_2 + Cu$

Ans. ***(d)***

In disproportionation reactions, same element undergoes oxidation as well as reduction.

e.g.

Reduction

$$2\overset{+1}{Cu}Br \longrightarrow \overset{+2}{Cu}Br_2 + \overset{0}{Cu}$$

Oxidation

Here, CuBr get oxidised to $CuBr_2$ and also it get reduced to Cu. Other given reactions and their types are given below.

Reduction

$$2\overset{+7}{Mn}O_4^- + 10I^- + 16H^+ \longrightarrow 2Mn^{+2} + 5I_2 + 8H_2O$$

Oxidation

In the given reaction, MnO_4^- get oxidised to Mn^{2+} and I^- get reduced to I_2. It is an example of redox reaction. The reaction takes place in acidic medium.

$$2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$$

The given reaction is an example of decomposition reaction. Here, one compound split into two or more simpler compounds, atleast one of which must be in elemental form.

$$2NaBr + Cl_2 \longrightarrow 2NaCl + Br_2$$

The given reaction is an example of displacement reaction. In this reaction, an atom (or ion) replaces the ion (or atom) of another element from a compound.

16 Which of the following reactions is an example of a redox reaction? **[JEE Main 2017]**

(a) $XeF_4 + O_2F_2 \longrightarrow XeF_6 + O_2$

(b) $XeF_2 + PF_5 \longrightarrow [XeF]^+PF_6^-$

(c) $XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$

(d) $XeF_6 + 2H_2O \longrightarrow XeO_2F_2 + 4HF$

Ans. ***(a)***

The reaction in which oxidation and reduction occur simultaneously are termed as redox reaction.

$$(\overset{+4}{X})eF_4 + \overset{+1}{O_2}(F_2) \longrightarrow \overset{+6}{X}eF_6 + \overset{0}{O_2}$$

Since, Xe undergoes oxidation while O undergoes reduction. So, it is an example of redox reaction.

17 In which of the following reactions H_2O_2 acts as a reducing agent? **[JEE Main 2014]**

A. $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$
B. $H_2O_2 - 2e^- \longrightarrow O_2 + 2H^+$
C. $H_2O_2 + 2e^- \longrightarrow 2OH^-$
D. $H_2O_2 + 2OH^- - 2e^- \longrightarrow O_2 + 2H_2O$

(a) A, B (b) C, D
(c) A, C (d) B, D

Ans. ***(d)***

The reducing agent oxidises itself by undergoing oxidation through the loss of electrons. Thus, reducing agent reduces other molecules by supplying electrons to them.

(A) $H_2O_2^{-1} + 2H^+ + 2e^- \longrightarrow 2H_2\overset{-2}{O}$

In this reaction, H_2O_2 undergoes reduction as O shows increase in oxidation number.

(B) $H_2\overset{-1}{O}_2 - 2e^- \longrightarrow \overset{0}{O}_2 + 2H^+$

In this reaction, H_2O_2 undergoes oxidation as it shows decrease in oxidation number. Thus, H_2O_2 acts as a reducing agent.

(C) $H_2\overset{-1}{O}_2 + 2e^- \longrightarrow 2\overset{-2}{O}H^-$

In this reaction, H_2O_2 undergoes reduction.

(D) $H_2\overset{-1}{O}_2 + 2OH^- - 2e^- \longrightarrow \overset{0}{O}_2 + 2H_2O$

In this reaction, H_2O_2 undergoes reduction. Thus, acts as a reducing agent.

18 The metal that cannot be obtained by the electrolysis of an aqueous solution of its salts is **[JEE Main 2014]**

(a) Ag (b) Ca (c) Cu (d) Cr

Ans. ***(b)***

Higher the position of element in the electrochemical series, more difficult is the reduction of its cation. Thus, among all the given elements, only calcium on electrolysis yields H_2 gas at cathode while other yields pure metals at cathode. In case of Ca^{2+} ion, water is reduced in preference to calcium.

For Cr At cathode, $Cr^{3+} + 3e^- \longrightarrow Cr$

For Ag At cathode, $Ag^+ + e^- \longrightarrow Ag$

For Cu At cathode, $Cu^{2+} + 2e^- \longrightarrow Cu$

For Ca^{2+} At cathode,

$$H_2O + e^- \longrightarrow \frac{1}{2}H_2 + OH^-$$

19 Which of the following chemical reactions depicts the oxidising behaviour of H_2SO_4? **[AIEEE 2006]**

(a) $2HI + H_2SO_4 \longrightarrow I_2 + SO_2 + 2H_2O$

(b) $Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

(c) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$

(d) $2PCl_5 + H_2SO_4 \longrightarrow 2POCl_3 + 2HCl + SO_2Cl_2$

Ans. ***(a)***

$$2\overset{-1}{HI} + H_2\overset{+6}{S}O_4 \longrightarrow \overset{0}{I_2} + \overset{+4}{S}O_2 + 2H_2O$$

$\underset{\text{Oxidising agent}}{H_2SO_4}$ — Reduced to $\longrightarrow SO_2$

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

(a) 0 (b) +1 (c) +2 (d) +3

Ans. ***(d)***

$[Cr(NH_3)_4Cl_2]^+$

Let the oxidation state of Cr = x; $NH_3 = 0$; Cl = − 1

Net charge = + 1

$\therefore \quad [Cr(NH_3)_4Cl_2]^+$

$x + 4 \times 0 + 2(-1) = +1 \Rightarrow x = 3$

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

(a) + 3 (b) + 2
(c) + 6 (d) + 4

Ans. ***(a)***

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

$Cr_2O_7^{2-}$ is reduced to Cr^{3+}.

Thus, final state of Cr is + 3.

22 Among the properties (A) reducing, (B) oxidising and (C) complexing, the set of properties shown by CN^- ion towards metal species is **[AIEEE 2004]**

(a) A, B (b) B, C
(c) C, A (d) A, B, C

Ans. ***(c)***

CN^- is a better complexing agent (C) as well as a reducing agent (A).

Thus, properties (A) and (C) are shown

Property (C) :

$$Ni^{2+} + 4CN^- \longrightarrow [Ni(CN)_4]^{2-}$$

Property (A) :

$$\overset{\text{II}}{Cu}Cl_2 + 5KCN \longrightarrow K_3[\overset{\text{I}}{Cu}(CN)_4] + \frac{1}{2}(CN)_2 + 2KCl$$

[CN reduces Cu^{2+} to Cu^+]

23 Oxidation number of Cl in $CaOCl_2$ (bleaching powder) is **[AIEEE 2002]**

(a) zero, since it contains Cl_2
(b) −1, since it contains Cl^-
(c) + 1, since it contains ClO^-
(d) +1 and −1, since it contains ClO^- and Cl^-

Ans. ***(d)***

$CaOCl_2$ is written basically as Ca(OCl)Cl.

$OCl^- \longrightarrow$ Cl has + 1 oxidation state

$Cl^- \longrightarrow$ Cl has − 1 oxidation state

24 MnO_4^- is a good oxidising agent in different medium changing to

$$MnO_4^- \longrightarrow Mn^{2+} \longrightarrow MnO_4^{2-} \longrightarrow MnO_2 \longrightarrow Mn_2O_3$$

Changes in oxidation number respectively, are **[AIEEE 2002]**

(a) 1, 3, 4, 5 (b) 5, 4, 3, 2
(c) 5, 1, 3, 4 (d) 2, 6, 4, 3

Ans. ***(c)***

$\overset{+7}{Mn}O_4^- \longrightarrow Mn^{2+}$ change 5

$\longrightarrow \overset{+6}{Mn}O_4^{2-}$ change 1

$\longrightarrow \overset{+4}{Mn}O_2$ change 3

$\longrightarrow \overset{+3}{Mn_2}O_3$ change 4

25 Which of the following is a redox reaction ? **[AIEEE 2002]**

(a) $NaCl + KNO_3 \longrightarrow NaNO_3 + KCl$
(b) $CaC_2O_4 + 2HCl \longrightarrow CaCl_2 + H_2C_2O_4$
(c) $Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$
(d) $2K[Ag(CN)_2] + Zn \longrightarrow 2Ag + K_2[Zn(CN)_4]$

Ans. ***(d)***

(a) $\overset{+1}{Na}\overset{-1}{Cl} + \overset{+1}{K}\,\overset{+5}{N}\overset{-2}{O_3} \longrightarrow \overset{+1}{Na}\overset{-1}{NO_3} + \overset{+1}{K}\overset{-1}{Cl}$

(b) $\overset{+2}{Ca}C_2\overset{-2}{O_4} + 2\overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+2}{Ca}\overset{-1}{Cl_2} + \overset{+1}{H_2}C_2\overset{-2}{O_4}$

(c) $\overset{+2}{Ca}\overset{-1}{(OH)_2} + 2\overset{-3}{N}\overset{+1}{H_4}\overset{-1}{Cl} \longrightarrow \overset{+2}{Ca}\overset{-1}{Cl_2} + 2\overset{-3}{N}\overset{+1}{H_3} + 2\overset{+1}{H_2}\overset{-2}{O}$

In all these cases during reaction, there is no change in oxidation state of ion or molecule or constituent atom. These are simply ionic reactions.

(d) $2K[Ag(CN)_2] + Zn \rightarrow 2Ag + K_2[Zn(CN)_4]$

$Ag^+ \longrightarrow Ag$ gain of e^-, reduction

$Zn \longrightarrow Zn^{2+}$ loss of e^-, oxidation

TOPIC 2
Balancing of Chemical Equations

26 $2MnO_4^- + bC_2O_4^{2-} + cH^+ \longrightarrow x\,Mn^{2+} + y\,CO_2 + zH_2O$

If the above equation is balanced with integer coefficients, the value of c is .... **[2021, 16 March Shift-I]**

Ans. ***(16)***

Balancing by half-reaction method

$$2\overset{+7}{Mn}O_4^- + b\overset{+3}{C_2}O_4^{2-} + cH^+ \longrightarrow x\overset{+2}{Mn^{+2}} + y\,\overset{+4}{C}O_2 + zH_2O$$

Step 1 Separate two half-reactions

Oxidation half (O.H.) $C_2O_4^{2-} \longrightarrow CO_2$

Reduction half (R.H.) $MnO_4^- \longrightarrow Mn^{2+}$

Step 2 Balance all the atoms except oxygen and 'H'.

O.H. $C_2O_4^{2-} \longrightarrow 2CO_2$

R.H. $MnO_4^- \longrightarrow Mn^{2+}$

Step 3 Balance 'O' by adding H_2O and 'H' by adding H^+.

O.H. $C_2O_4^{2-} \longrightarrow 2CO_2$

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

Step 4 Balance charge by adding electron

O.H $C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$

R.H. $5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$

Step 5 Balance electron by multiplying O.H. by '5' and R.H. by '2'.

O.H. $5C_2O_4^{2-} \longrightarrow 10\,CO_2 + 10e^-$

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

Step 6 Add both half-reaction

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

So, $c = 16$

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

(Rounded off to the nearest integer). **[2021, 25 Feb Shift-I]**

Ans. ***(173)***

Given, Molarity of $CrO_4^{2-}(M_1) = 0.154$ M

Molarity of $S_2O_3^{2-}(M_2) = 0.25$M

Volume of $S_2O_3^{2-}(V_2) = 40$ mL

Volume of $CrO_4^{2-}(V_1) = ?$

$$\overset{+6}{Cr}\overset{2-}{O_4} + \overset{+6}{S_2}\overset{2-}{O_3} \longrightarrow \overset{+6}{S}O_4^{2-} + \overset{+3}{Cr}(OH)_4^-$$

Gram equivalent of CrO_4^{2-} = Gram equivalent of $S_2O_3^{2-}$

$$N_1V_1 = N_2V_2$$

Normality = Molarity × n factor

n for Cr = 6 − 3 = 3

n for S $\Rightarrow S_2O_3^{2-} \longrightarrow 2\,SO_4^{2-} + 8e^-$

$0.154 \times 3 \times V_1 = 0.25 \times 40 \times 8$

$V_1 = 173$ mL

28 The reaction of sulphur in alkaline medium is given below

$$S_8(s) + aOH^-(aq) \longrightarrow bS^{2-}(aq) + cS_2O_3^{2-}(aq) + dH_2O(l)$$

The value of 'a' is .... (Integer answer) **[2021, 24 Feb Shift-I]**

Ans. ***(12)***

The two half reaction, one separately are as follows

$$S_8 + 16e^- \longrightarrow 8S^{2-}$$
(Reduction)

$$S_8 + 12H_2O \longrightarrow 4S_2O_3^{2-} + 24H^+ + 16e^-$$

$$2S_8 + 12H_2O \longrightarrow 8S^{2-} + 4S_2O_3^{2-} + 24H^+$$
(Oxidation)

For balancing in basic medium,

Add an equal number of OH^- that of H^+, we get

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

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

or $S_8 + 12OH^- \longrightarrow 4S^{2-} + 2S_2O_3^{2-} + 6H_2O$ ...(i)

On comparing (i) with

$$S_8 + aOH^-(aq) \longrightarrow bS^{2-}(aq) + cS_2O_3^{2-} + dH_2O$$

We get, $a = 12$; $b = 4$; $c = 2$; $d = 6$

29 Consider the following equations :

$$2Fe^{2+} + H_2O_2 \longrightarrow xA + yB$$
(in basic medium)

$$2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow x'C + y'D + z'E$$
(in acidic medium)

The sum of the stoichiometric coefficients x, y, x', y' and z' for products A, B, C, D and E, respectively, is .... **[2020, 4 Sep Shift-II]**

Ans. ***(19)***

In basic medium

$$[Fe^{2+} \longrightarrow Fe^{3+} + e^-] \times 2$$

$$H_2O_2 + 2e^- \longrightarrow 2HO^-$$

$$2Fe^{2+} + H_2O_2 \longrightarrow \underset{(A)}{2Fe^{3+}} + \underset{(B)}{2HO^-}$$

Hence, $x = 2$ and $y = 2$.

In acidic medium

$$[8H^+ + MnO_4^- + 5e^- \longrightarrow Mn^{2+} + 4H_2O] \times 2$$

$$[H_2O_2 \longrightarrow O_2(g) + 2H^+ + 2e^-] \times 5$$

$$16H^+ + 2MnO_4^- + 5H_2O_2 \longrightarrow \underset{(C)}{2Mn^{2+}} + \underset{(D)}{8H_2O} + \underset{(E)}{5O_2(g)}$$

So, $x' = 2, y' = 8, z' = 5$

So, $x + y + x' + y' + z'$

$\Rightarrow 2 + 2 + 2 + 8 + 5 \Rightarrow 19$

30 In order to oxidise a mixture of one mole of each of FeC_2O_4, $Fe_2(C_2O_4)_3$, $FeSO_4$ and $Fe_2(SO_4)_3$ in acidic medium, the number of moles of $KMnO_4$ required is **[2019, 8 April Shift-I]**

(a) 2 (b) 1 (c) 3 (d) 1.5

Ans. ***(a)***

The oxidation of a mixture of one mole of each of FeC_2O_4, $Fe_2(C_2O_4)_3$ $FeSO_4$ and $Fe_2(SO_4)_3$ in acidic medium with $KMnO_4$ is as follows

$$FeC_2O_4 + KMnO_4 \longrightarrow Fe^{3+} + CO_2 + Mn^{2+} \quad ...(i)$$

$$Fe_2(C_2O_4)_3 + KMnO_4 \longrightarrow Fe^{3+} + CO_2 + Mn^{2+} \quad ...(ii)$$

$$FeSO_4 + KMnO_4 \longrightarrow Fe^{3+} + SO_4^{2-} + Mn^{2+} \quad ...(iii)$$

Change in oxidation number of Mn is 5.
Change in oxidation number of Fe in (i), (ii) and (iii) are +3, +6, +1, respectively.

$$n_{eq}KMnO_4 = n_{eq}[FeC_2O_4 + Fe_2(C_2O_4)_3 + FeSO_4]$$

$$n \times 5 = 1 \times 3 + 1 \times 6 + 1 \times 1 \Rightarrow n = 2$$

31 In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is

(a) 2 (b) 5 (c) 1 (d) 10 **[2019, 10 Jan Shift-II]**

Ans. ***(c)***

Reaction of oxalate with permanganate in acidic medium.

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

n-factor :	$(4-3)\times 2 = 2$	$(7-2) = 5$	
No. of mole	5	2	10

$\Rightarrow 5C_2O_4^{2-}$ ions transfer 10 e^- to produce 10 molecules of CO_2. So, number of electrons involved in producing 10 molecules of CO_2 is 10.

Thus, number of electrons involved in producing 1 molecule of CO_2 is 1.

32 Consider the following reaction,

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

The values of x, y and z in the reaction are, respectively **[AIEEE 2013]**

(a) 5, 2 and 16
(b) 2, 5 and 8
(c) 2, 5 and 16
(d) 5, 2 and 8

Ans. ***(c)***

The half equations of the reaction are

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

$$C_2O_4^{2-} \longrightarrow CO_2$$

The balanced half equations are

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

$$(C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-) \times 5$$

Equating number of electrons, we get

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

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

On adding both the equations, we get

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

Thus, x, y and z are 2, 5 and 16, respectively.