Chapter
Redox Reaction

Topic-1: Oxidation and Reduction Reactions

4 Fill in the Blanks

1. Of the halide ions, _____ is the most powerful reducing agent. **[1978]**

5 True / False

2. Cu^+ disproportionates to Cu^{2+} and elemental copper in solution. **[1991 - 1 Mark]**
3. Copper metal reduces Fe^{2+} in an acid medium. **[1982 - 1 Mark]**

7 Match the Following

4. Match the reactions in Columns I with nature of the reactions/type of the products in Column II. Indicate your answer by darkening the appropriate bubbles of the 4×4 matrix given in the ORS. **[2007]**

Column I	Column II
(A) $O_2^- \rightarrow O_2 + O_2^{2-}$	(p) redox reaction
(B) $CrO_4^{2-} + H^+ \rightarrow$	(q) one of the products has trigonal planar structure
(C) $MnO_4^- + NO_2^- + H^+ \rightarrow$	(r) dimeric bridged tetrahedral metal ion
(D) $NO_3^- + H_2SO_4 + Fe^{2+} \rightarrow$	(s) disproportionation

Topic-2: Oxidation Number

1 MCQs with One Correct Answer

1. Consider a titration of potassium dichromate solution with acidified Mohr's salt solution using diphenylamine as indicator. The number of moles of Mohr's salt required per mole of dichromate is **[2007]**
   (a) 3 (b) 4 (c) 5 (d) 6
2. The pair of the compounds in which both the metals are in the highest possible oxidation state is **[2004S]**
   (a) $[Fe(CN)_6]^{3-}, [Co(CN)_6]^{3-}$
   (b) CrO_2Cl_2, MnO_4^-
   (c) TiO_3, MnO_2
   (d) $[Co(CN)_6]^{3-}, MnO_3$
3. The reaction, $3ClO^-(aq) \longrightarrow ClO_3^-(aq) + 2Cl^-(aq)$, is an example of **[2001S]**
   (a) oxidation reaction
   (b) reduction reaction
   (c) disproportionation reaction
   (d) decomposition reaction
4. Amongst the following identify the species with an atom in +6 oxidation state **[2000S]**
   (a) MnO_4^- (b) $Cr(CN)_6^{3-}$
   (c) NiF_6^{2-} (d) CrO_2Cl_2
5. The oxidation number of sulphur in S_8, S_2F_2, H_2S respectively, are **[1999 - 2 Marks]**
   (a) 0, +1 and –2 (b) +2, +1 and –2
   (c) 0, +1 and +2 (d) –2, +1 and –2

6. For the redox reaction : **[1992 - 1 Mark]**

$MnO_4^- + C_2O_4^{2-} + H^+ \rightarrow Mn^{2+} + CO_2 + H_2O$

the correct coefficients of the reactants for the balanced reaction are **[1992 - 1 Mark]**

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

7. The oxidation states of the most electronegative element in the products of the reaction, BaO_2 with dil. H_2SO_4 is **[1991 - 1 Mark]**

(a) 0 and –1 (b) –1 and –2
(c) –2 and 0 (d) –2 and +1

8. The oxidation number of phosphorus in $Ba(H_2PO_2)_2$ is : **[1990 - 1 Mark]**

(a) +3 (b) +2 (c) +1 (d) –1

9. The brown ring complex compound is formulated as $[Fe(H_2O)_5(NO)]SO_4$. The oxidation state of iron is : **[1987 - 1 Mark]**

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

10. The oxidation number of carbon in CH_2O is **[1982 - 1 Mark]**

(a) –2 (b) +2 (c) 0 (d) +4

11. One mole of N_2H_4 loses ten moles of electrons to form a new compound *Y*. Assuming that all the nitrogen appears in the new compound, what is the oxidation state of nitrogen in *Y*? (There is no change in the oxidation state of hydrogen). **[1981 - 1 Mark]**

(a) –1 (b) –3 (c) +3 (d) +5

2 Integer Value Answer

12. Consider the following molecules: Br_3O_8, F_2O, $H_2S_4O_6$, $H_2S_5O_6$, and C_3O_2.
Count the number of atoms existing in their zero oxidation state in each molecule. **[Adv. 2023]**
Their sum is_____.

13. The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is **[2011]**

4 Fill in the Blanks

14. The compound $YBa_2Cu_3O_7$, which shows super-conductivity, has copper in oxidation state....., assume that the rare earth element yttrium is in its usual + 3 oxidation state. **[1994 - 1 Mark]**

6 MCQs with One or More than One Correct Answer

15. For the reaction **[Adv. 2014]**

$I^- + ClO_3^- + H_2SO_4 \rightarrow Cl^- + HSO_4^- + I_2$

The correct statement(s) in the balanced equation is/are

(a) Stoichiometric coefficient of HSO_4^- is 6
(b) Iodide is oxidized
(c) Sulphur is reduced
(d) H_2O is one of the products

10 Subjective Problems

16. Arrange the following in increasing oxidation number of iodine. **[1986 - 1 Mark]**

I_2, HI, HIO_4, ICl

17. Complete and balance the following reactions :

(i) $Ag^+ + AsH_3 \rightarrow H_3AsO_3 + H^+$ **[1986 - 1 Mark]**

(ii) $ClO_3^- + I^- + H_2SO_4 \rightarrow Cl^- + HSO_4^-$ **[1986 - 1 Mark]**

(iii) $S + OH^- \rightarrow S^{2-} + S_2O_3^{2-}$ **[1986 - 1 Mark]**

(iv) $Mn^{2+} + PbO_2 \rightarrow MnO_4^- + H_2O$ **[1986 - 1 Mark]**

(v) $Cl_2 + OH^- \rightarrow Cl^- + ClO^-$ **[1983 - 1 Mark]**

(vi) $Ce^{3+} + S_2O_8^{2-} \rightarrow SO_4^{2-} + Ce^{4+}$ **[1983 - 1 Mark]**

(vii) $HNO_3 + HCl \rightarrow NO + Cl_2$ **[1983 - 1 Mark]**

(viii) $Cr_2O_7^{2-} + C_2H_4O \rightarrow C_2H_4O_2 + Cr^{3+}$ **[1983 - 1 Mark]**

(ix) $Zn + NO_3^- \rightarrow Zn^{2+} + NH_4^+$ **[1983 - 1 Mark]**

18. Balance the following equations.

(i) $Cu_2O + H^+ + NO_3^- \rightarrow Cu^{2+} + NO + H_2O$ **[1981 - 1 Mark]**

(ii) $K_4[Fe(CN)_6] + H_2SO_4 + H_2O \rightarrow K_2SO_4 + FeSO_4 + (NH_4)_2SO_4 + CO$ **[1981 - 1 Mark]**

(iii) $C_2H_5OH + I_2 + OH^- \rightarrow CHI_3 + HCO_3^- + I^- + H_2O$ **[1981 - 1 Mark]**

Answer Key

Topic-1 : Oxidation and Reduction Reactions

1. (I^-) **2.** (True) **3.** (False) **4.** (A - p, s); (B - r); (C - p, q); (D - p).

Topic-2 : Oxidation Number

1. (d) **2.** (b) **3.** (c) **4.** (d) **5.** (a) **6.** (a) **7.** (b) **8.** (c) **9.** (b) **10.** (c)

11. (c) **12.** (6) **13.** (5) **14.** $(+\frac{7}{3})$ **15.** (a,b,d)

Hints & Solutions

Topic-1: Oxidation and Reduction Reactions

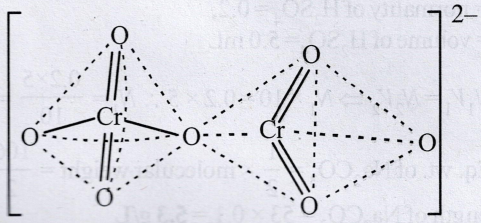
1. I^- ($\because I_2$ is weakest oxidising agent)
2. **True :** Cu^+ is the intermediate oxidation state between Cu^{++} and Cu. If the reduction potential from the intermediate oxidation state to the lower one is more positive than from the higher to the intermediate, then the intermediate state will undergo disproportionation.

$$Cu^{++} \xrightarrow{+0.15V} Cu^+ \xrightarrow{+0.52V} Cu$$

3. **False :** Copper metal does not reduces Fe^{2+} in an acidic medium, because the $E°$ value for Cu is more.
4. **(A - p, s); (B - r); (C - p, q); (D - p).**

A→ p, s; The reaction is redox reaction because the O.N. of O in O_2^- is -0.5 and that in O_2 is zero. In O_2^{2-} is -1.0. It involves reduction oxidation reaction. Since, here a part of molecule is oxidised and a part is reduced, so it is disproportionation.

B → r; The structure of $Cr_2O_7^{2-}$ is given below



[In any solution dichromate ions and chromate ions exist in equilibrium. In alkali solution, dichromate ions are converted into chromate ions and on acidification chromate ions are converted back into dichromate ion.]

C → p, q; The reaction is

$$2MnO_4^- + 6H^+ + 5NO_2^- \rightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$$

In involves change in O.N of Mn from + 7 (in MnO_4^-) to + 2 (in Mn^{2+}). So, Mn is reduced and NO_2^- is oxidised to NO_3^-; it is a redox reaction.

The structure of NO_3^- (one of the products) is **trigonal planar**.

$$3fe^{2+} + NO_3^- + 2H_2SO_4 \rightarrow 3fe^{3+} + NO + 2SO_4^{2-} + 2H_2O$$

D → p, It is a **redox reaction.**

Topic-2 : Oxidation Number

1. **(d)** The following reaction occurs:

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

From the above equation, we find that Mohr's salt ($FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$) and dichromate reacts in 6 : 1 molar ratio.

2. **(b)**

The highest O.S. of an element is equal to the number of its valence electrons

(a) $[Fe(CN)_6]^{3-}$, O.N. of Fe = + 3,
$[Co(CN)_6]^{3-}$, O.N. of Co = + 3

(b) CrO_2Cl_2, O.N. of Cr = +6, (Highest O.S. of Cr)
$[MnO_4]^-$ O.N of Mn = + 7 (Highest O.S. of Mn)

(c) TiO_3, O.N. of Ti = + 6, MnO_2 O.N. of Mn = + 4

(d) $[Co(CN)_6]^{3-}$, O.N. of Co = + 3,
MnO_3, O.N. of Mn = + 6

3. **(c)**

$$\overset{+1}{3ClO^-}(aq) \rightarrow \overset{+5}{ClO_3^-} + 2\overset{-1}{Cl^-}(aq)$$ (i)

It is disproportionation reaction because Cl is both oxidised (+ 1 to + 5) and reduced (+ 1 to – 1) during reaction.

4. **(d)**

Oxidation state of Mn in MnO_4^- = + 7
Oxidation state of Cr in $Cr(CN)_6^{3-}$ = + 3
Oxidation state of Ni in NiF_6^{2-} = + 4
Oxidation state of Cr in CrO_2Cl_2 = + 6

5. **(a)**

O.N. of S in $S_8 = 0$; O.N. of S in $S_2F_2 = +1$;
O.N. of S in $H_2S = -2$;

6. **(a)**

Balance the reaction by ion electron method.

Oxidation reaction : $C_2O_4^{-2} \rightarrow 2CO_2 + 2e^-] \times 5$

Reduction reaction :

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

Net reaction :

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

7. **(b)**

$BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2$

Oxygen is the most electronegative element in the reaction and has the oxidation states of –1 (in H_2O_2) and –2 (in $BaSO_4$). In H_2O_2, peroxo ion is present.

8. **(c)** $2+2(2+x-4)=0$ [$\because$ $Ba(H_2PO_2)_2$ is neutral molecule] or $2x-2=0 \Rightarrow x=+1$

9. **(b)** Sum of oxidation state of all atoms in neutral compound is zero. Let the oxidation state of iron in the complex ion

$[Fe(H_2O)_5(NO)]^{2+}SO_4^{2-}$ be x; then

$x+5\times 0+0=+2$. $\therefore x=+2$

10. **(c)** The sum of oxidation states of all atoms in compound is zero. Calculation of O.S. of C in CH_2O.

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

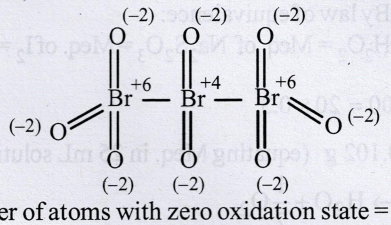
11. **(c)**

$N_2H_4 \rightarrow Y+10e^-$, Calculation of O.S. of N in N_2H_4 :

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

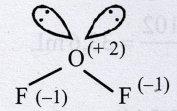
The two nitrogen atoms will balance the charge of 10 *e*. Hence, oxidation state of N will increase by +5, *i.e.* from –2 to +3.

12. **(6)** Br_3O_8



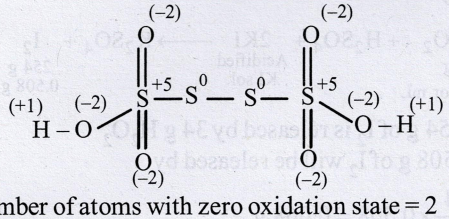
Number of atoms with zero oxidation state = 0

F_2O



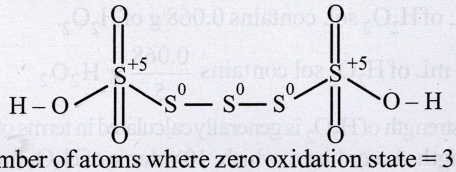
Number of atom with zero oxidation state = 0

$H_2S_4O_6$



Number of atoms with zero oxidation state = 2

$H_2S_5O_6$



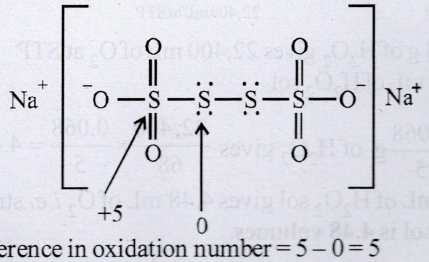
Number of atoms where zero oxidation state = 3

C_3O_2

Number of atoms with zero oxidation state = 1

Sum = 2 + 3 + 1 = 6

13. **(5)**



Difference in oxidation number = 5 – 0 = 5

14. Sum of oxidation states of all atoms (elements) in a neutral compound is zero.

As $YBa_2Cu_3O_7$ is neutral.

$(+3)+2(+2)+3(x)+7(-2)=0$

or $3+4+3x-14=0$; $x=+\frac{7}{3}$

15. **(a, b, d)** Balancing the chemical equation by half-reaction method.

$I^- + ClO_3^- + H_2SO_4 \longrightarrow Cl^- + HSO_4^- + I_2$

$2I^- \longrightarrow I_2 + 2e^- \times 3$

$ClO_3^- + 6H^+ + 6e^- \longrightarrow Cl^- + 3H_2O$

$ClO_3^- + 6I^- + 6H^+ \longrightarrow 3I_2 + Cl^- + 3H_2O$

Adding $6HSO_4^-$ to both sides.

$ClO_3^- + 6I^- + 6H_2SO_4 \longrightarrow 3I_2 + Cl^- + 6HSO_4^- + 3H_2O$

16. $HI < I_2 < ICl < HIO_4$; O.N. of I in $I_2 = 0$, HI = –1, ICl = +1, HIO_4 = +7.

17. Balance the atoms as well as charges by ion electron/ oxidation number method.

(i) $6Ag^+ + AsH_3 + 3H_2O \rightarrow 6Ag + H_3AsO_3 + 6H^+$

(ii) $ClO_3^- + 6I^- + 6H_2SO_4 \rightarrow Cl^- + 6HSO_4^- + 3I_2 + 3H_2O$

(iii) $4S + 6OH^- \rightarrow 2S^{2-} + S_2O_3^{2-} + 3H_2O$

(iv) $2Mn^{2+} + 5PbO_2 + 4H^+ \rightarrow 2MnO_4^- + 2H_2O + 5Pb^{2+}$

(v) $Cl_2 + 2OH^- \longrightarrow Cl^- + ClO^- + H_2O$

(vi) $2Ce^{3+} + S_2O_8^{2-} \longrightarrow 2SO_4^{2-} + 2Ce^{4+}$

(vii) $2HNO_3 + 6HCl \longrightarrow 2NO + 3Cl_2 + 4H_2O$

(viii) $Cr_2O_7^{2-} + 3C_2H_4O + 8H^+$

$\longrightarrow 3C_2H_4O_2 + 2Cr^{3+} + 4H_2O$

(ix) $4Zn + NO_3^- + 10H^+ \longrightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$

18. Balance the reactions by ion electron method.

(i) $Cu_2O + 2H^+ \rightarrow 2Cu^{2+} + H_2O + 2e^-] \times 3$ .....(1)

$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O] \times 2$ .....(2)

$3Cu_2O + 14H^+ + 2NO_3^- \rightarrow 6Cu^{2+} + 2NO + 7H_2O$

(ii) $K_4[Fe(CN)_6] + 6H_2SO_4 + 6H_2O$

$\rightarrow 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO$

(iii) $C_2H_5OH + 4I_2 + 8OH^-$

$\rightarrow CHI_3 + HCO_3^- + 5I^- + 6H_2O$