DAY TWELVE

Redox Reactions

Learning & Revision for the Day

- Electronic Concept of Oxidation and Reduction
- Oxidation Number
- Redox Reactions
- Balancing of Redox Reactions

Redox reactions involve both oxidation and reduction simultaneously. Originally, the term oxidation was used to describe the addition of oxygen to an element and reduction was used to describe the removal of oxygen from an element.

Electronic Concept of Oxidation and Reduction

Loss of electron by an atom is called oxidation or de-electronation, while gain of electron by an atom is called reduction or electronation.

1. **Oxidants or oxidising agents** are the substances which oxidise other and itself, get reduced by gaining electrons (i.e. their oxidation number decreases during a reaction).
2. **Reductants or reducing agents** are the substances which reduce other and itself by get oxidised losing electrons (i.e. their oxidation number increases during a reaction).

Some Important Oxidants

Some important oxidants used in oxidation are given below:

- Molecules of most electronegative elements such as O_2, O_3, halogens.
- Oxides of metals and non-metals such as MgO, CaO, CrO_3, H_2O, CO_2 etc.
- The compounds having either of an element in their highest oxidation state such as $K_2Cr_2O_7$, $KMnO_4$, $HClO_4$, H_2SO_4, HNO_3, $FeCl_3$, $HgCl_2$, $KClO_3$ etc.
- **Permanganate ion** acts as strong oxidising agent and in acidic medium, it always produces 5 electrons per formula unit irrespective of the reducing agent.

Some Important Reductants

Some important reductants used in reduction are given below:

- All metals such as Na, Al, Zn etc. and some non-metals, e.g. C, S, P, H_2 etc.
- Metallic hydrides such as NaH, LiH, KH, CaH_2 and halogen acids such as HCl, HBr, HI.
- The compounds having either of an element in their lowest oxidation state such as $H_2C_2O_4$, $FeSO_4$, Hg_2Cl_2, Cu_2O, $SnCl_2$ etc.

Equivalent Weights of Oxidising Agent (OA) or Reducing Agent (RA)

$$E_{OA/RA} = \frac{\text{Molar mass of OA / RA agent}}{\text{Number of electrons lost or gained per formula unit of RA / OA}}$$

H_2O_2 is both oxidising and reducing agent but its equivalent weight as either oxidising or reducing agents are the same, i.e. 17.

Oxidation Number

The real or imaginary charge, which an atom appears to have in its combined state is called oxidation number of that atom.

Rules for Assigning Oxidation Number

- The oxidation number of an element in its elementary state and a compound is zero. e.g. H in H_2, S in S_8.
- Oxidation number of an ion is equal to the electrical charge present on it.
- Oxidation number of fluorine is always –1 in all of its compounds.
- The oxidation number of alkali metals is always +1 and those of alkaline earth metals is +2.
- Oxidation number of hydrogen is +1 except in ionic hydrides, where it is –1.
- Two oxidation numbers of N are –3 and +3, when it is bonded with less electronegative and more electronegative atoms, respectively.
- Oxidation number of oxygen is –2 except in $OF_2(+2)$, $O_2F_2(+1)$, peroxides (–1) and superoxides (–1/2).
- The oxidation number of halogens is always –1 in metal halides.
- In interhalogen compounds, the more electronegative element out of the two halogens gets the oxidation number of –1.
- Oxidation number of metals in amalgams and carbonyls, e.g. $[Fe(CO)_5]$ is zero.

NOTE Valency of an element is always a whole number. It can neither be zero nor fractional. While oxidation number may be positive or negative. It can be zero or fractional.

Redox Reactions

The reaction, which involves oxidation and reduction as its two half reactions is called redox reaction. A redox change occurs simultaneously.

Redox reactions are of following three types :

1. **Intermolecular redox reactions** are the reactions that involve the reaction between two substances, one of them is oxidant and other is reductant.

e.g. $$\underset{\text{Reductant}}{10FeSO_4} + \underset{\text{Oxidant}}{2KMnO_4} + 8H_2SO_4 \longrightarrow 2\,MnSO_4 + 5Fe_2(SO_4)_3 + K_2SO_4 + 8H_2O$$

These are further divided into two types :

(i) **Combination reactions** in which two atoms or molecules (in their zero oxidation state) combine together and one gets oxidised while the other gets reduced.

$$\underset{\text{Reductant}}{\overset{0}{C}} + \underset{\text{Oxidant}}{\overset{0}{O_2}} \longrightarrow \overset{+4}{C}\overset{-2}{O_2}$$

(ii) **Displacement reactions** in which an atom or ion in a compound is replaced by other atom or ion. These are further divided in two types.

(a) **Metal displacement reactions** in which metal with low reactivity is displaced by metal with high reactivity.

$$\underset{\text{Oxidant}}{CuSO_4} + \underset{\text{Reductant}}{Zn} \longrightarrow Cu + ZnSO_4$$

(b) **Non-metal displacement reactions** in which non-metal is displaced.

$$\underset{\text{Reductant}}{2\,Na} + \underset{\text{Oxidant}}{2H_2O} \longrightarrow 2NaOH + H_2$$

2. **Intramolecular redox reactions** are the reactions that involve oxidation of one element of a compound as well as reduction of other element of the same compound. Decomposition reactions are also called intramolecular redox reactions, but to be a redox reaction, it is essential that one of the products of decomposition must be in the elemental state. e.g.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$$

3. **Auto-redox or disproportionation reactions** are the reactions that involves oxidation and reduction of the same element.

e.g. $$Cl_2 + 2OH^- \longrightarrow ClO^- + Cl^- + H_2O$$

Balancing of Redox Reactions

Following two methods are used to balance the redox reactions:

1. Ion Electron Method

This method involves the following steps :

- Write redox reaction in ionic form.
- Split redox reaction into oxidation half and reduction half reactions.
- Balance atoms of each half reactions by using simple multiples.

- For balancing H and O, if the reaction is carried out in acidic medium add H^+ ion and H_2O to the appropriate sides, similarly for basic medium add OH^- and H_2O to the appropriate sides.
- Balance the charge on both the sides and multiply one or both half reactions by suitable number to equalise number of electrons in both equations.
- Add the two balance half-reactions and cancel common terms.

2. Oxidation Number Method

The method involves the following steps :

- Assign oxidation number to the atoms in the equation and write separate equations for atoms undergoing oxidation and reduction.
- Find the change in oxidation number in each equation and make the change equal in both the equations by multiplying with suitable integers.
- After adding both the equations complete the balancing by balancing H and O.

DAY PRACTICE SESSION 1

FOUNDATION QUESTIONS EXERCISE

1 Which of the following is not a reducing agent?

(a) SO_2 (b) H_2O_2 (c) CO_2 (d) NO_2

2 In which of the following reaction, nitric oxide acts as a reducing agent?

(a) $4NH_3 + 5O_2 \longrightarrow 2NO + 6H_2O$

(b) $2NO + 3I_2 + 4H_2O \longrightarrow 2NO_3^- + 6I^- + 8H^+$

(c) $2NO + H_2SO_3 \longrightarrow N_2O + H_2SO_4$

(d) $2NO + H_2S \longrightarrow N_2O + S + H_2O$

3 Which one of the following cannot function as an oxidising agent? → JEE Main (Online) 2013

(a) I^- (b) $S(s)$ (c) $NO_3^-(aq)$ (d) $Cr_2O_7^{2-}$

4 In which of the following reactions, hydrogen is acting as an oxidising agent ?

(a) With iodine to give hydrogen iodide

(b) With lithium to give lithium hydride

(c) With nitrogen to give ammonia

(d) With sulphur to give hydrogen sulphide

5 The compound that can work both as an oxidising as well as reducing agent is

(a) $KMnO_4$ (b) H_2O_2 (c) $Fe_2(SO_4)_3$ (d) $K_2Cr_2O_7$

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

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

Change in oxidation number respectively, are

(a) 1, 3, 4, 5 (b) 5, 4, 3, 2

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

7. The oxidation numbers of phosphorus in $Ba(H_2PO_2)_2$ and xenon in Na_4XeO_6 respectively are

(a) +3 and +4 (b) +2 and +6 (c) +1 and +8 (d) −1 and −6

8 In which of the following pairs, there is greatest difference in the oxidation number of the underlined elements?

(a) $\underline{N}O_2$ and $\underline{N}_2O_4$ (b) $\underline{P}_2O_5$ and $\underline{P}_4O_{10}$

(c) $\underline{N}_2O$ and $\underline{N}O$ (d) $\underline{S}O_2$ and $\underline{S}O_3$

9 The oxidation number of an element in a compound is evaluated on the basis of certain rules. Which of the following rules is not correct in this respect?

(a) The oxidation number of hydrogen is always +1

(b) The algebraic sum of all the oxidation numbers in a compound is zero

(c) An element in the free or the uncombined state bears oxidation number zero

(d) In all its compounds, the oxidation number of fluorine is −1

10 The oxidation number of sulphur in S_8, S_2F_2 and H_2S respectively are

(a) 0, +1 and −2 (b) +2, +1 and −2

(c) 0, + 1 and + 2 (d) −2, + 1 and − 2

11 In which of the following, the oxidation number of oxygen has been arranged in increasing order?

(a) $BaO_2 < KO_2 < O_3 < OF_2$

(b) $OF_2 < KO_2 < BaO_2 < O_3$

(c) $BaO_2 < O_3 < OF_2 < KO_2$

(d) $KO_2 < OF_2 < O_3 < BaO_2$

12 In the reaction,

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

(a) bromine is oxidised and the carbonate radical is reduced

(b) bromine is reduced and the carbonate radical is oxidised

(c) bromine is neither reduced nor oxidised

(d) bromine is both reduced and oxidised

13 The largest oxidation number exhibited by an element depends on its outer electronic configuration.With which of the following outer electronic configurations, the element will exhibit largest oxidation number?

(a) $3d^1 4s^2$ (b) $3d^3 4s^2$ (c) $3d^5 4s^1$ (d) $3d^5 4s^2$

14 In which of the following compounds, an element exhibits two different oxidation states?

(a) NH_2OH (b) NH_4NO_3
(c) N_2H_4 (d) N_3H

15 When SO_2 is passed through an acidified solution of potassium dichromate, the oxidation state of S changes from

(a) + 4 to 0 (b) + 4 to +2
(c) + 4 to +6 (d) + 6 to +4

16 In which of the compounds does manganese exhibit highest oxidation number?

(a) MnO_2 (b) Mn_3O_4
(c) K_2MnO_4 (d) $MnSO_4$

17 Which order of compounds is according to the decreasing order of the oxidation state of nitrogen?

(a) HNO_3, NO, NH_4Cl, N_2 (b) HNO_3, NO, N_2, NH_4Cl
(c) HNO_3, NH_4Cl, NO, N_2 (d) NO, HNO_3, NH_4Cl, N_2

18 The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is

(a) 4 (b) 5 (c) 6 (d) 7

19 Oxidation states of the metal in the minerals haematite and magnetite, respectively are

(a) II, III in haematite and III in magnetite
(b) II, III in haematite and II in magnetite
(c) II in haematite and II, III in magnetite
(d) III in haematite and II, III in magnetite

20 The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is

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

21 Oxidation state of sulphur in anions SO_3^{2-}, $S_2O_4^{2-}$ and $S_2O_6^{2-}$ increases in the order ➞ JEE Main (Online) 2013

(a) $S_2O_6^{2-} < S_2O_4^{2-} < SO_3^{2-}$ (b) $SO_3^{2-} < S_2O_4^{2-} < S_2O_6^{2-}$
(c) $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-}$ (d) $S_2O_4^{2-} < S_2O_6^{2-} < SO_3^{2-}$

22 Six moles of Cl_2 undergo a loss and gain of 10 moles of electrons to form two oxidation states of Cl in an autoredox change. What are the two oxidation states of Cl in this change?

(a) +5, – 1 (b) +7, – 1
(c) +3, 0 (d) +3, – 1

23 Among the properties A reducing, B oxidising and C complexing, the set of properties shown by CN^- ion towards metal species is

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

24 Which of the following is a redox reaction?

(a) Formation of glucose from CO_2 and water
(b) Reaction of potassium cyanide with silver cyanide
(c) Hydration of rubidium
(d) Reaction of barium chloride with sulphuric acid

25 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) $Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$
(d) $2K[Ag(CN)_2] + Zn \longrightarrow 2Ag + K_2[Zn(CN)_4]$

26 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

27 $C_2H_6(g) + nO_2 \longrightarrow CO_2(g) + H_2O(l)$

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

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

28 Given, $x\,Na_2HAsO_3 + y\,NaBrO_3 + z\,HCl \longrightarrow NaBr + H_3AsO_4 + NaCl$

The value of x, y and z in the above redox reaction respectively are ➞ JEE Main (Online) 2013

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

29 Consider the following reaction,

$$x\,MnO_4^- + y\,C_2O_4^{2-} + z\,H^+ \longrightarrow x\,Mn^{2+} + 2y\,CO_2 + \frac{z}{2}H_2O.$$

The values of x, y and z in the reaction respectively are ➞ JEE Main 2013

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

30 **Assertion** (A) Oxidation number of chromium in CrO_5 is + 6.

Reason (R) Oxidation number of each oxygen atom is –1.

(a) Assertion and Reason both are correct statements and Reason is the correct explanation of the Assertion
(b) Assertion and Reason both are correct statements but Reason is not the correct explanation of the Assertion
(c) Assertion is correct and Reason is incorrect
(d) Both Assertion and Reason are incorrect

DAY PRACTICE SESSION 2

PROGRESSIVE QUESTIONS EXERCISE

1 Which of the following statements is not correct?

(a) The oxidation number of S in $(NH_4)_2S_2O_8$ is +6
(b) The oxidation number of Os in OsO_4 is +8
(c) The oxidation number of S in H_2SO_5 is +8
(d) The oxidation number of O in KO_2 is $-\frac{1}{2}$

2 In a reaction, 4 moles of electrons are transferred to 1 mole of HNO_3. The possible product obtained due to reduction is

(a) 0.5 mole of N_2
(b) 0.5 mole of N_2O
(c) 1 mole of NO_2
(d) 1 mole of NH_3

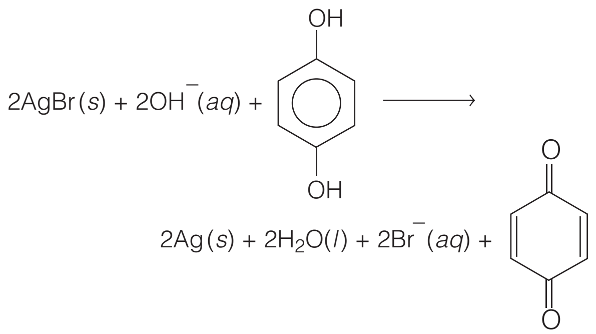
3 When the following half-reaction is balanced

$$CN^- \longrightarrow CNO^-$$

Which of the following statements is true regarding the balance half-reaction?

(a) Carbon is losing two electrons per atom
(b) Oxidation number of carbon increases from +1 to +3
(c) Oxidation number of nitrogen remains constant
(d) Statements (a) and (c) both are true

4 Photographic paper is developed with alkaline hydroquinone



Select the correct statement.

(a) Hydroquinone is the oxidant
(b) Ag^+ is the oxidant
(c) Br^- is the oxidant
(d) Ag^+ is the reductant

5 For the following reaction, consider the following statements

$$2Cr(OH)_3 + 3H_2O_2 + 4OH^- \longrightarrow 2CrO_4^{2-} + 8H_2O$$

I. there is colour change from green precipitate to yellow coloured solution.
II. oxidation number of Cr changes from +3 to +6.
III. oxidation number of O in H_2O_2 changes from –2 to –1.

Select the correct statement(s).

(a) Only I
(b) Both I and II
(c) Only II
(d) Both I and III

6 Oxidation states of X, Y, Z are +2 +5 and –2 respectively. Formula of the compound formed by these will be

(a) X_2YZ_6
(b) XY_2Z_6
(c) XY_5
(d) X_3YZ_4

7 I^- reduces IO_3^- to I_2 and itself oxidised to I_2 in acidic medium. Final reaction is

(a) $I^- + IO_3^- + 6H^+ \longrightarrow I_2 + 3H_2O$
(b) $I^- + IO_3^- \longrightarrow I_2 + O_3$
(c) $5I^- + IO_3^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$
(d) None of the above

8 Thiosulphate reacts differently with iodine and bromine in the reactions given below:

$$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$$

$$S_2O_3^{2-} + 2Br_2 + 5H_2O \longrightarrow 2SO_4^{2-} + 2Br^- + 10H^+$$

Which of the following statements justifies the above dual behaviour of thiosulphate?

(a) Bromine is a stronger oxidant than iodine
(b) Bromine is a weaker oxidant than iodine
(c) Thiosulphate undergoes oxidation by bromine and reduction by iodine in these reactions
(d) Bromine undergoes oxidation and iodine undergoes reduction in these reactions

9 Which has maximum number of equivalent per mole of the oxidant?

(a) $Zn(s) + VO^{2+}(aq) \longrightarrow Zn^{2+}(aq) + V^{3+}(aq)$
(b) $Ag(s) + NO_3^-(aq) \longrightarrow Ag^+(aq) + NO_2(g)$
(c) $Mg(s) + VO_4^{3-}(aq) \longrightarrow Mg^{2+}(aq) + V^{2+}(aq)$
(d) $I^-(aq) + IO_3^-(aq) \longrightarrow I_3^-(aq)$

10 For the reaction between MnO_4^- and $C_2O_4^{2-}$ in basic solution, the unbalanced equation is

$$MnO_4^- + C_2O_4^{2-} \longrightarrow MnO_2 + CO_2$$

In a balanced equation, the number of OH^- ions is

(a) 0
(b) 8 on the right
(c) 4 on the left
(d) 2 on the left

ANSWERS

SESSION 1	**1** (c)	**2** (b)	**3** (a)	**4** (b)	**5** (b)	**6** (c)	**7** (c)	**8** (d)	**9** (a)	**10** (a)
	11 (a)	**12** (d)	**13** (d)	**14** (b)	**15** (c)	**16** (c)	**17** (b)	**18** (b)	**19** (d)	**20** (a)
	21 (c)	**22** (a)	**23** (c)	**24** (a)	**25** (d)	**26** (a)	**27** (b)	**28** (c)	**29** (b)	**30** (c)
SESSION 2	**1** (c)	**2** (b)	**3** (d)	**4** (b)	**5** (b)	**6** (b)	**7** (c)	**8** (a)	**9** (d)	**10** (b)

Hints and Explanations

SESSION 1

1 In CO_2, the oxidation number of C is +4 and is already the maximum. It cannot increase its oxidation number, hence, it does not act as a reducing agent.

2 $2\overset{+2}{N}O + 3I_2 + 4H_2O \longrightarrow 2\overset{+5}{N}O_3^- + 6I^- + 8H^+$

Hence, NO acts as a reducing agent and reduces I_2 to I^- since, the oxidation number of nitrogen changes from +2 in NO to +5 in NO_3^-.

3 In I^-, iodine is present in its lowest possible oxidation state. Further, reduction in oxidation state is not possible. Hence, it cannot function as oxidising agent.

4 $2\overset{0}{Li} + \overset{0}{H_2} \longrightarrow 2\overset{+1}{Li}\overset{-1}{H}$

5 The oxidation number of O in H_2O_2 is -1. It can either increases to zero in O_2 or decreases to -2 in H_2O. Therefore, H_2O_2 can act both as an oxidising as well as reducing agent.

6 $\overset{+7}{Mn}O_4^- \longrightarrow Mn^{2+}$ change in oxidation number 5

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

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

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

7 $\overset{+2}{Ba}(\overset{+1}{H_2}\overset{x}{P}\overset{-2}{O_2})_2$

$\therefore \quad 2 + 2\,[2 \times (+1) + x + 2 \times (-2)] = 0$

or $\quad 2 + 4 + 2x - 8 = 0$ or $x = +1$

and $\overset{+1}{Na_4}\overset{x}{Xe}\overset{-2}{O_6}$

$\therefore\ 4 \times 1 + x + 6 \times (-2) = 0 \quad$ or $\ x = +8$

8 (a) $\overset{+4}{N}O_2$ and $\overset{+4}{N_2}O_4$; Difference = 0

(b) $\overset{+5}{P_2}O_5$ and $\overset{+5}{P_4}O_{10}$; Difference = 0

(c) $\overset{+1}{N_2}O$ and $\overset{+2}{N}O$; Difference $= +2 - 1 = +1$

(d) $\overset{+4}{S}O_2$ and $\overset{+6}{S}O_3$; Difference $= +6 - 4 = +2$

9 Oxidation number of hydrogen is +1 except in ionic hydrides, where it is -1.

10 $\overset{0}{S_8}, \overset{+1}{S_2}\overset{-1}{F_2}, \overset{+1}{H_2}\overset{-2}{S}$

$\therefore$ Oxidation number of S in S_8, S_2F_2 and H_2S respectively are 0, +1, -2.

11 $Ba\overset{-1}{O_2} < K\overset{-0.5}{O_2} < \overset{0}{O_3} < \overset{+2}{O}F_2$

12 $3\overset{0}{Br_2} + 6CO_3^{2-} + 3H_2O \longrightarrow 5\overset{-1}{Br^-} + \overset{+5}{Br}O_3^- + 6HCO_3^-$

Br_2 is reduced to Br^- (oxidation number decreases from zero to -1) and Br_2 is oxidised to BrO_3^- (oxidation number increases from zero to +5).

13 $3d^5 4s^2 = +7$ oxidation number

14 NH_4NO_3 is an ionic compound exist in the form of NH_4^+, NO_3^-

In NH_4^+ ; $x + 4 = +1$ or $x = -3$

In NO_3^- ; $x - 6 = -1$ or $x = +5$

15 $K_2Cr_2O_7 + 4H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3\overset{+6}{S}O_3 + 4H_2O$

Oxidation number of S changes from +4 in SO_2 to +6 in SO_3.

16 Highest oxidation number of Mn in K_2MnO_4 is, $2 + x - 8 = 0$ or $x = +6$, while in all other compounds oxidation number of Mn is lower than 6.

17 Let the oxidation number of N be x

In $HNO_3 \rightarrow +1 + x + 3(-2) = 0$ or $x = +5$

In $NO \rightarrow \quad x - 2 = 0$ or $x = +2$

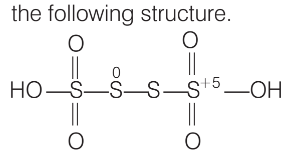
In $N_2 \rightarrow \quad x = 0$

In $NH_4Cl \rightarrow x + 4(1) - 1 = 0$ or $x = -3$

Thus, the order of oxidation states of nitrogen is

$HNO_3 > NO > N_2 > NH_4Cl$.

18 $Na_2S_4O_6$ is a salt of $H_2S_4O_6$, which has the following structure.



$\therefore$ The difference in oxidation number is 5.

19 Haematite is Fe_2O_3, in which oxidation number of iron is (III). Magnetite is Fe_3O_4, which is infact a mixed oxide ($FeO \cdot Fe_2O_3$), hence, iron is present in both (II) and (III) oxidation states.

20 $Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 2Cr^{3+} + 7H_2O + 3I_2$

$Cr_2O_7^{2-}$ is reduced to Cr^{3+}. Thus, final state of Cr is +3.

21 Let the oxidation state of S be x.

$SO_3^{2-} \quad x + (-2) \times 3 = -2$

$x - 6 = -2$

$\therefore \quad x = +4$

$S_2O_4^{2-} \quad 2 \times x + (-2)4 = -2$

$2x - 8 = -2$

$2x = 6$ or $x = +3$

$S_2O_6^{2-} \quad 2x + (-2)6 = -2$

$2x = 10 \Rightarrow x = +5$

$\therefore$ The increasing order of oxidation states is $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-}$.

22 **Oxidation** $Cl_2 \longrightarrow 2\overset{5+}{Cl} + 10e^-$

Reduction $5Cl_2 + 10e^- \longrightarrow 10Cl^-$

Overall redox reaction,

$6Cl_2 \longrightarrow 2\overset{5+}{Cl} + 10Cl^-$

23 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*) :

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

(CN^- reduces Cu^{2+} to Cu^+)

24.
$$\overset{+4}{6CO_2} + 6H_2\overset{-2}{O} \xrightarrow{\text{Sunlight}} \overset{0}{C}_6H_{12}O_6 + 6\overset{0}{O}_2$$
Oxidation

Reduction

Since, oxidation and reduction both occurs simultaneously in the above equation, so it is a redox reaction.

25 (a) $\overset{+1}{Na}\overset{-1}{Cl} + \overset{+1}{K}\overset{-1}{NO_3} \longrightarrow \overset{+1}{Na}\overset{-1}{NO_3} + \overset{+1}{K}\overset{-1}{Cl}$

(b) $\overset{+2}{Ca}\,\overset{-2}{C_2O_4} + 2\overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+2}{Ca}\,\overset{-1}{Cl_2} + \overset{+1}{H_2}\overset{-2}{C_2O_4}$

(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 (i.e. a, b, c) cases during reaction, there is no change in oxidation state of ion or molecule or constituent atom.

∴ These are simply ionic reactions.

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

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

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

26
$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O] \times 2$$
$$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-] \times 5$$
$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Thus, the coefficients of MnO_4^-, $C_2O_4^{2-}$ and H^+ in the above balanced equation respectively are 2, 5, 16.

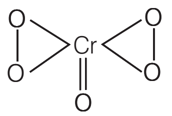
27 The balanced equation is
$$2C_2H_6 + 5O_2 \longrightarrow 4CO_2 + 6H_2O$$
Ratio of the coefficient of CO_2 and H_2O is 4 : 6 or 2 : 3.

28 $3Na_2HAsO_3 + NaBrO_3 + 6HCl \longrightarrow NaBr + 3H_3AsO_4 + 6NaCl$

29 $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10\,CO_2 + 8H_2O$

$x = 2, y = 5, z = 16$

30 In CrO_5, four oxygen atoms are in –1 oxidation state.



$$x + 1(-2) + 4(-1) = 0 \;\Rightarrow\; x = +6$$

Thus, Assertion is true but Reason is false.

SESSION 2

1 (a) $(NH_4)_2S_2O_8^{2-}$

∴ Oxidation state of S = + 6

(Since, $S_2O_8^{2-}$ has one peroxide bond)

(b) Oxidation state of Os = + 8

(c) Oxidation state of S in H_2SO_5 = + 6

(Since, it has one peroxide bond)

(d) $K^+O_2^-$ oxidation state of O = $-\frac{1}{2}$

2 $\underset{+5}{HNO_3} + 4e^- \longrightarrow$ Product has oxidation number = 1

In N_2O oxidation number of N = +1. Thus, 0.5 mole of N_2O are formed by reduction of 1 mole of HNO_3 by 4 moles of electrons.

3 In the given redox reaction, $C^- \equiv N \longrightarrow O^- — C \equiv N$

Oxidation number of nitrogen remains unchanged as – 3. Oxidation number of carbon is increasing from + 2 to + 4. Hence, (a) and (c) are the only correct response. Therefore, option (d) is correct.

4 Ag^+ is reduced hence, it is an oxidant. Hydroquinone is oxidised hence, it is a reductant.

5 (I) $Cr(OH)_3$ (green precipitate) $\longrightarrow CrO_4^{2-}$ (yellow)

(II) Cr(+3) $\longrightarrow$ Cr(+6)

(III) oxidation number of O in H_2O_2 changes from –1 to –2.

Thus, (I) and (II) are true.

6 The oxidation state of *X*, *Y* and *Z* are +2, +5 and –2 respectively.

I. In $X_2YZ_6 = 2 \times 2 + 5 + 6(-2) \neq 0$

II. In $XY_2Z_6 = 2 + 5 \times 2 + 6(-2) = 0$

III. In $XY_5 = 2 + 5 \times 2 \neq 0$

IV. In $X_3YZ_4 = 3 \times 2 + 5 + 4(-2) \neq 0$

Hence, formula of compound is XY_2Z_6.

7 $5I^- + IO_3^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$

8 $2\overset{+2}{S_2}\overset{-2}{O_3^{2-}}(aq) + \overset{0}{I}_2(s) \longrightarrow \overset{2.5}{S_4}O_6^{2-}(aq) + 2I^-(aq)$

$\overset{+2}{S_2}\overset{-2}{O_3^{2-}}(aq) + 2\overset{0}{Br_2}(l) + 5H_2O(l) \longrightarrow 2\overset{+6}{S}\overset{2-}{O_4^{2-}}(aq)$
$+ 4Br^-(aq) + 10H^+(aq)$

Bromine being stronger oxidising agent than I_2, oxidises S of $S_2O_3^{2-}$ to SO_4^{2-}, whereas I_2 oxidises it only into $S_4O_6^{2-}$ ion.

9

	Reaction	Change in oxidation number	Number of equivalent
(a)	$VO^{2+}(aq) \longrightarrow V^{3+}(aq)$; $x-2=+2$, $x=+4$ → +3	1 unit	1
(b)	$NO_3^-(aq) \longrightarrow NO_2(g)$; +5 → +4	1 unit	1
(c)	$VO_4^{3-}(aq) \longrightarrow V^{2+}(aq)$; +5 → +2	3 units	3
(d)	$IO_3^-(aq) \longrightarrow I_3^-(aq)$; +5 → $-\frac{1}{3}$	$\frac{16}{3}$	$\frac{16}{3}$

10 $2MnO_4^- + 3C_2O_4^{2-} + 4H_2O \longrightarrow 2MnO_2 + 6CO_2 + 8OH^-$

∴ The number of OH^- ions is 8 on the right side.