Unit

8

REDOX REACTIONS

I. Multiple Choice Questions (Type-I)

1. Which of the following is **not** an example of redox reaction?

(i) $CuO + H_2 \longrightarrow Cu + H_2O$

(ii) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

(iii) $2K + F_2 \longrightarrow 2KF$

(iv) $BaCl_2 + H_2SO_4 \longrightarrow BaSO_4 + 2HCl$

2. The more positive the value of $E^{\ominus}$, the greater is the tendency of the species to get reduced. Using the standard electrode potential of redox couples given below find out which of the following is the strongest oxidising agent.

$E^{\ominus}$ values: $Fe^{3+}/Fe^{2+} = +0.77$; $I_2(s)/I^- = +0.54$;

$Cu^{2+}/Cu = +0.34$; $Ag^+/Ag = +0.80V$

(i) Fe^{3+}

(ii) $I_2(s)$

(iii) Cu^{2+}

(iv) Ag^+

3. $E^{\ominus}$ values of some redox couples are given below. On the basis of these values choose the correct option.

$E^{\ominus}$ values : $Br_2/Br^- = +1.90$; $Ag^+/Ag(s) = +0.80$

$Cu^{2+}/Cu(s) = +0.34$; $I_2(s)/I^- = +0.54$

(i) Cu will reduce Br^-

(ii) Cu will reduce Ag

(iii) Cu will reduce I^-

(iv) Cu will reduce Br_2

4. Using the standard electrode potential, find out the pair between which redox reaction is **not** feasible.

$E^{\ominus}$ values : $Fe^{3+}/Fe^{2+} = +0.77$; $I_2/I^- = +0.54$;

$Cu^{2+}/Cu = +0.34$; $Ag^+/Ag = +0.80$ V

(i) Fe^{3+} and I^-

(ii) Ag^+ and Cu

(iii) Fe^{3+} and Cu

(iv) Ag and Fe^{3+}

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

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$
$$S_2O_3^{2-} + 2Br_2 + 5H_2O \rightarrow 2SO_4^{2-} + 2Br^- + 10\,H^+$$

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

(i) Bromine is a stronger oxidant than iodine.

(ii) Bromine is a weaker oxidant than iodine.

(iii) Thiosulphate undergoes oxidation by bromine and reduction by iodine in these reactions.

(iv) Bromine undergoes oxidation and iodine undergoes reduction in these reactions.

6. 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?

(i) The oxidation number of hydrogen is always +1.

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

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

(iv) In all its compounds, the oxidation number of fluorine is – 1.

7. In which of the following compounds, an element exhibits two different oxidation states.

(i) NH_2OH

(ii) NH_4NO_3

(iii) N_2H_4

(iv) N_3H

8. Which of the following arrangements represent increasing oxidation number of the central atom?

(i) CrO_2^-, ClO_3^-, CrO_4^{2-}, MnO_4^-

(ii) ClO_3^-, CrO_4^{2-}, MnO_4^-, CrO_2^-

(iii) CrO_2^- , ClO_3^- , MnO_4^- , CrO_4^{2-}

(iv) CrO_4^{2-}, MnO_4^-, CrO_2^- , ClO_3^-

9. 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?

(i) $3d^1 4s^2$

(ii) $3d^3 4s^2$

(iii) $3d^5 4s^1$

(iv) $3d^5 4s^2$

10. Identify disproportionation reaction

(i) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

(ii) $CH_4 + 4Cl_2 \longrightarrow CCl_4 + 4HCl$

(iii) $2F_2 + 2OH^- \longrightarrow 2F^- + OF_2 + H_2O$

(iv) $2NO_2 + 2OH^- \longrightarrow NO_2^- + NO_3^- + H_2O$

11. Which of the following elements does **not** show disproportionation tendency?

(i) Cl

(ii) Br

(iii) F

(iv) I

II. Multiple Choice Questions (Type-II)

In the following questions two or more options may be correct.

12. Which of the following statement(s) is/are **not** true about the following decomposition reaction.

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

(i) Potassium is undergoing oxidation

(ii) Chlorine is undergoing oxidation

(iii) Oxygen is reduced

(iv) None of the species are undergoing oxidation or reduction

13. Identify the correct statement (s) in relation to the following reaction:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

(i) Zinc is acting as an oxidant

(ii) Chlorine is acting as a reductant

(iii) Hydrogen ion is acting as an oxidant

(iv) Zinc is acting as a reductant

14. The exhibition of various oxidation states by an element is also related to the outer orbital electronic configuration of its atom. Atom(s) having which of the following outermost electronic configurations will exhibit more than one oxidation state in its compounds.

(i) $3s^1$

(ii) $3d^1 4s^2$

(iii) $3d^2 4s^2$

(iv) $3s^2 3p^3$

15. Identify the correct statements with reference to the given reaction

$$P_4 + 3OH^- + 3H_2O \rightarrow PH_3 + 3H_2PO_2^-$$

(i) Phosphorus is undergoing reduction only.

(ii) Phosphorus is undergoing oxidation only.

(iii) Phosphorus is undergoing oxidation as well as reduction.

(iv) Hydrogen is undergoing neither oxidation nor reduction.

16. Which of the following electrodes will act as anodes, when connected to Standard Hydrogen Electrode?

(i) Al/Al^{3+} $E^{\ominus} = -1.66$

(ii) Fe/Fe^{2+} $E^{\ominus} = -0.44$

(iii) Cu/Cu^{2+} $E^{\ominus} = +0.34$

(iv) $F_2\,(g)/2F^-\,(aq)$ $E^{\ominus} = +2.87$

III. Short Answer Type

17. The reaction

$$Cl_2\,(g) + 2OH^-\,(aq) \longrightarrow ClO^-\,(aq) + Cl^-\,(aq) + H_2O\,(l)$$

represents the process of bleaching. Identify and name the species that bleaches the substances due to its oxidising action.

18. MnO_4^{2-} undergoes disproportionation reaction in acidic medium but MnO_4^- does not. Give reason.

19. PbO and PbO_2 react with HCl according to following chemical equations :

$$2PbO + 4HCl \longrightarrow 2PbCl_2 + 2H_2O$$

$$PbO_2 + 4HCl \longrightarrow PbCl_2 + Cl_2 + 2H_2O$$

Why do these compounds differ in their reactivity?

20. Nitric acid is an oxidising agent and reacts with PbO but it does not react with PbO_2. Explain why?

21. Write balanced chemical equation for the following reactions:

(i) Permanganate ion (MnO_4^-) reacts with sulphur dioxide gas in acidic medium to produce Mn^{2+} and hydrogensulphate ion.

(Balance by ion electron method)

(ii) Reaction of liquid hydrazine (N_2H_4) with chlorate ion (ClO_3^-) in basic medium produces nitric oxide gas and chloride ion in gaseous state.

(Balance by oxidation number method)

(iii) Dichlorine heptaoxide (Cl_2O_7) in gaseous state combines with an aqueous solution of hydrogen peroxide in acidic medium to give chlorite ion (ClO_2^-) and oxygen gas.

(Balance by ion electron method)

22. Calculate the oxidation number of phosphorus in the following species.

(a) HPO_3^{2-} and (b) PO_4^{3-}

23. Calculate the oxidation number of each sulphur atom in the following compounds:

(a) $Na_2S_2O_3$ (b) $Na_2S_4O_6$ (c) Na_2SO_3 (d) Na_2SO_4

24. Balance the following equations by the oxidation number method.

(i) $Fe^{2+} + H^+ + Cr_2O_7^{2-} \longrightarrow Cr^{3+} + Fe^{3+} + H_2O$

(ii) $I_2 + NO_3^- \longrightarrow NO_2 + IO_3^-$

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

(iv) $MnO_2 + C_2O_4^{2-} \longrightarrow Mn^{2+} + CO_2$

25. Identify the redox reactions out of the following reactions and identify the oxidising and reducing agents in them.

(i) $3HCl(aq) + HNO_3(aq) \longrightarrow Cl_2(g) + NOCl(g) + 2H_2O(l)$

(ii) $HgCl_2(aq) + 2KI(aq) \longrightarrow HgI_2(s) + 2KCl(aq)$

(iii) $Fe_2O_3(s) + 3CO(g) \xrightarrow{\Delta} 2Fe(s) + 3CO_2(g)$

(iv) $PCl_3(l) + 3H_2O(l) \longrightarrow 3HCl(aq) + H_3PO_3(aq)$

(v) $4NH_3 + 3O_2(g) \longrightarrow 2N_2(g) + 6H_2O(g)$

26. Balance the following ionic equations

(i) $Cr_2O_7^{2-} + H^+ + I^- \longrightarrow Cr^{3+} + I_2 + H_2O$

(ii) $Cr_2O_7^{2-} + Fe^{2+} + H^+ \longrightarrow Cr^{3+} + Fe^{3+} + H_2O$

(iii) $MnO_4^- + SO_3^{2-} + H^+ \longrightarrow Mn^{2+} + SO_4^{2-} + H_2O$

(iv) $MnO_4^- + H^+ + Br^- \longrightarrow Mn^{2+} + Br_2 + H_2O$

IV. Matching Type

27. Match Column I with Column II for the oxidation states of the central atoms.

	Column I		Column II
(i)	$Cr_2O_7^{2-}$	(a)	+ 3
(ii)	MnO_4^-	(b)	+ 4
(iii)	VO_3^-	(c)	+ 5
(iv)	FeF_6^{3-}	(d)	+ 6
		(e)	+ 7

28. Match the items in Column I with relevant items in Column II.

	Column I		Column II
(i)	Ions having positive charge	(a)	+7
(ii)	The sum of oxidation number	(b)	–1
	of all atoms in a neutral molecule	(c)	+1
(iii)	Oxidation number of hydrogen ion (H^+)	(d)	0
(iv)	Oxidation number of fluorine in NaF	(e)	Cation
(v)	Ions having negative charge	(f)	Anion

V. Assertion and Reason Type

In the following questions a statement of assertion (A) followed by a statement of reason (R) is given. Choose the correct option out of the choices given below each question.

29. ***Assertion (A) :*** Among halogens fluorine is the best oxidant.

Reason (R) : Fluorine is the most electronegative atom.

(i) Both A and R are true and R is the correct explanation of A.
(ii) Both A and R are true but R is not the correct explanation of A.
(iii) A is true but R is false.
(iv) Both A and R are false.

30. ***Assertion (A):*** In the reaction between potassium permanganate and potassium iodide, permanganate ions act as oxidising agent.

Reason (R) : Oxidation state of manganese changes from +2 to +7 during the reaction.

(i) Both A and R are true and R is the correct explanation of A.
(ii) Both A and R are true but R is not the correct explanation of A.
(iii) A is true but R is false.
(iv) Both A and R are false.

31. ***Assertion (A) :*** The decomposition of hydrogen peroxide to form water and oxygen is an example of disproportionation reaction.

Reason (R) : The oxygen of peroxide is in –1 oxidation state and it is converted to zero oxidation state in O_2 and –2 oxidation state in H_2O.

(i) Both A and R are true and R is the correct explanation of A.

(ii) Both A and R are true but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) Both A and R are false.

32. ***Assertion (A) :*** Redox couple is the combination of oxidised and reduced form of a substance involved in an oxidation or reduction half cell.

Reason (R) : In the representation $E^{\ominus}_{Fe^{3+}/Fe^{2+}}$ and $E^{\ominus}_{Cu^{2+}/Cu}$, Fe^{3+}/Fe^{2+} and Cu^{2+}/Cu are redox couples.

(i) Both A and R are true and R is the correct explanation of A.

(ii) Both A and R are true but R is not the correct explanation of A.

(iii) A is true but R is false.

(iv) Both A and R are false.

VI. Long Answer Type

33. Explain redox reactions on the basis of electron transfer. Give suitable examples.

34. On the basis of standard electrode potential values, suggest which of the following reactions would take place? (Consult the book for $E^{\ominus}$ value).

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

(ii) $Mg + Fe^{2+} \longrightarrow Mg^{2+} + Fe$

(iii) $Br_2 + 2Cl^- \longrightarrow Cl_2 + 2Br^-$

(iv) $Fe + Cd^{2+} \longrightarrow Cd + Fe^{2+}$

35. Why does fluorine not show disporportionation reaction?

36. Write redox couples involved in the reactions (i) to (iv) given in question 34.

37. Find out the oxidation number of chlorine in the following compounds and arrange them in increasing order of oxidation number of chlorine.

$NaClO_4$, $NaClO_3$, $NaClO$, $KClO_2$, Cl_2O_7, ClO_3, Cl_2O, $NaCl$, Cl_2, ClO_2.

Which oxidation state is not present in any of the above compounds?

38. Which method can be used to find out strength of reductant/oxidant in a solution? Explain with an example.

ANSWERS

I. Multiple Choice Questions (Type-I)

1. (iv)	2. (iv)	3. (iv)	4. (iv)	5. (i)	6. (i)
7. (ii)	8. (i)	9. (iv)	10. (iv)	11. (iii)	

II. Multiple Choice Questions (Type-II)

12. (i), (iv)	13. (iii), (iv)	14. (iii), (iv)
15. (iii), (iv)	16. (i), (ii)	

III. Short Answer Type

17. Hypochlorite ion

18. In MnO_4^-, Mn is in the highest oxidation state i.e. +7. Therefore, it does not undergo disproportionation. MnO_4^{2-} undergoes disproportionation as follows :

$$3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$$

19. $2PbO + 4HCl \longrightarrow 2PbCl_2 + 2H_2O$ (Acid base reaction)

$PbO_2 + 4HCl \longrightarrow PbCl_2 + Cl_2 + 2H_2O$ (Redox reaction)

(***Hint :*** Note the oxidation number of lead in the oxides)

20. PbO is a basic oxide and simple acid base reaction takes place between PbO and HNO_3. On the other hand in PbO_2 lead is in + 4 oxidation state and cannot be oxidised further. Therefore no reaction takes place. Thus, PbO_2 is passive, only PbO reacts with HNO_3.

$$2PbO + 4HNO_3 \longrightarrow 2Pb(NO_3)_2 + 2H_2O \quad \text{(Acid base reaction)}$$

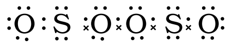
22. (a) +3, (b) +5

23. (a) +2 (b) +5, 0, 0, +5 (c) +4 (d) +6

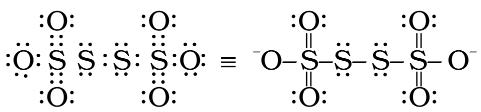
Justification :

Write Lewis structure of each ion then assign electron pair shared between atoms of different electronegativity to more electronegative atom and distribute the electron pair shared between atoms of same element equally. Now count the number of electrons possessed by each atom. Find out the difference in number of electrons possessed by neutral atom and that possessed by atom in the compound. This difference is the oxidation number. If atom present in the compound possesses more electrons than the neutral atom, the oxidation number is negative. If it possesses less electrons then oxidation number is positive.

(i) Lewis structure of $S_2O_4^{2-}$ can be written as follows :



Electron pair shared between sulphur and oxygen is assigned to oxygen atoms because of more electronegativity of oxygen. Thus each sulphur atom is deficient of two electrons with respect to neutral sulphur atom hence, each sulphur atom is in +2 oxidation state. Each oxygen atom gets two excess electrons hence, it is in –2 oxidation state. Lewis structure of $S_4O_6^{2-}$ can be written as follows :



To find out oxidation state of each atom we distribute electrons of electron pair shared between two sulphur atoms equally (i.e. one electron is assigned to each sulphur atom). Both the electrons of electron pair shared between sulphur and oxygen atom are assigned to oxygen as oxygen is more electronegative. Thus we find that each of the central sulphur atoms obtain six electrons. This number is same as that in the outer shell of neutral sulphur atom hence oxidation state of central sulphur atoms is zero. Each of the sulphur atoms attached to oxygen atoms obtain only one electron as its share. This number is less by five electrons in comparison to the neutral sulphur atom. So, outer sulphur atoms are in +5 oxidation state. Therefore average oxidation state of sulphur atoms is :

$$\frac{5+0+0+5}{4} = \frac{10}{4} = 2.5$$

By using the formula we obtain average oxidation state of the particular type of atoms. Real oxidation state can be obtained only by writing the complete structural formula. Similarly we can see that each oxygen atom is in – 2 oxidation state.

In the same way one can find out the oxidation state of each atom in SO_3^{2-} and SO_4^{2-} ions. Oxidation state of metal atoms will be +1 as these will lose one electron in each case.

IV. Matching Type

27. (i)→ (d) (ii)→ (e) (iii) → (c) (iv)→(a)

28. (i)→ (e) (ii) → (d) (iii) → (c) (iv) → (b) (v) → (f)

V. Assertion and Reason Type

29. (ii) 30. (iii) 31. (i) 32. (ii)