I. Multiple Choice Questions (Type-I)

1. Which of the following is not an example of redox reaction?
(i). $CuO + H_2 \rightarrow Cu + H_2O$
(ii) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
(iii) $2K + F_2 \rightarrow 2KF$
(iv) $BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$
Solution:
Option (iv) is the answer.

2. The more positive the value of E^o, the greater is the tendency of the species to get reduced. Using the standard electrode potential of redox couples given below to find out which of the following is the strongest oxidising agent.
E^o 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
Solution:
Option (iv) is the answer.

3. E^ovalues of some redox couples is given below. Based on these values choose the correct option.
E^o 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
Solution:
Option (iv) is the answer.

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

E°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+}
Solution:
Option (iv) is the answer.

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

below:
$2S2O3^{2-} + I^2 \rightarrow S4O6^{2-} + 2I^-$
$S2O3^{2-} + 2Br^{2+} 5H2O \rightarrow 2SO4^{2-} + 2Br^- + 10 H^+$
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 a reduction in these reactions.
Solution:
Option (i) is the answer.

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.
Solution:
Option (i) is the answer.

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) N3H
Solution:
Option (ii) is the answer.

8. Which of the following arrangements represent increasing oxidation number of the central atom?
(i) CrO^{2-} , CIO^{-3}, $CrO2^{-4}$, MnO^{-4}
(ii) CIO^{-3}, $CrO2^{-4}$, MnO^{-4} , CrO^{-2}
(iii) $CrO2^{+4}$, MnO^{-4} , CrO^{-2} , CIO^{3-}
(iv) $CrO2^{4-}$, MnO^{4-} , CrO^{2-} , CIO^{3-}
Solution:
Option (i) is the answer.

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 the largest oxidation number?
(i) 3d1 4s2

(ii) 3d3 4s2
(iii) 3d5 4s1
(iv) 3d5 4s2
Solution:
Option (iv) is the answer.

10. Identify disproportionation reaction
(i) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
(ii) $CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$
(iii) $2F_2 + 2OH^- \rightarrow 2F^- + OF_2 + H_2O$
(iv) $2NO_2 + 2OH^- \rightarrow NO^{2-} + NO^{3-} + H_2O$
Solution:
Option (iv) is the answer.

11. Which of the following elements does not show disproportionation tendency?
(i) Cl
(ii) Br
(iii) F
(iv) I
Solution:
Option (iii) is the answer.

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 is undergoing oxidation or reduction
Solution:
Option (i) and (iv) are the answers.

13. identify the correct statement (s) with 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
Solution:
Option (iii) and (iv) are the answers.

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) 3s1
(ii) 3d1 4s2
(iii) 3d2 4s2
(iv) 3s2 3p3
Solution:
Option (iii) and (iv0 are the answers.

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.
Solution:
Option (iii) and (iv) are the answers.

16. Which of the following electrodes will act as anodes, when connected to Standard Hydrogen Electrode?
(i) Al/Al2+ -E\degree = –1.66
(ii) Fe/Fe2+ -E\degree = – 0.44
(iii) Cu/Cu2+ -E\degree= + 0.34
(iv) F2 (g)/2F- (aq) -E\degree= + 2.87
Solution:
Option (i) and (ii) are the answers.

III. Short Answer Type

17. The reaction
$Cl_2 (g) + 2OH^- (aq) \rightarrow ClO^- (aq) + Cl^- (aq) + H_2O (l)$
represents the process of bleaching. Identify and name the species that bleaches the substances due to its oxidising action.
Solution:
Hypochlorite ion is the species that bleaches the substance due to its oxidizing action.

18. MnO_4^{2-} undergoes disproportionation reaction in acidic medium but $MnO_4^–$ does not. Give reason.
Solution:
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 :
$3MnO_4^{2–} + 4H^+ \rightarrow 2MnO_4^– + MnO_2 + 2H_2O$

19. PbO and PbO_2 react with HCl according to the following chemical equations:
$2PbO + 4HCl \rightarrow 2PbCl_2 + 2H_2O$
$PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$

Why do these compounds differ in their reactivity?
Solution:
In reaction (i), none of the atoms changes. Therefore, it is not a redox reaction. It is an acid-base reaction because PbO is a basic oxide which reacts with HCl acid.
The reaction (ii) is a redox reaction in which PbO_2 gets reduced and acts as an oxidizing agent.

20. Nitric acid is an oxidising agent and reacts with PbO but it does not react with PbO_2. Explain why?
Solution:
Nitric acid is an oxidizing agent and reacts with PbO to give a simple acid-base reaction without any change in oxidation state. In PbO_2, Pb is in +4 oxidation state and cannot be oxidized further, hence no reaction takes place between PbO_2 and HNO_3.

21. Write a 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 hydrogen sulphate ion. (Balance by ion-electron method)
(ii) The reaction of liquid hydrazine (N_2H_4) with chlorate ion (ClO_3^-) in basic medium produces nitric oxide gas and chloride ion in the 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)
Solution:
(i) $2MnO_4^- + 5SO_2 + 2H_2O + H^+ \rightarrow 2Mn^{2+} + 5HSO_4^-$
(ii) $N_2H_4 + ClO_3^- \rightarrow Cl^- + NO_2 + 2H_2O$
(iii) $Cl_2O_7 + 4H_2O_2 \rightarrow 2ClO_2^- + 3H_2O + 4O_2 + 2H^+$

22. Calculate the oxidation number of phosphorus in the following species.
(a) HPO_3^{2-} and PO_4^{2-}
Solution:
HPO_3^{2-} x= +3
PO_4^{2-} x=+5
23. . Calculate the oxidation number of phosphorus in the following species.
(a) $Na_2S_2O_3$
(b) $Na_2S_4O_6$
(c) Na_2SO_3
(d) Na_2SO_4
Solution:
$Na_2S_2O_3$ x= +2
$Na_2S_4O_6$ x= +5
Na_2SO_3 x= +4
Na_2SO_4 x= +6

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

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

(ii) I2+ N – O3 → NO2+ I – O3
(iii) I2 + S22– O3 → I– + S42– O
(iv) MnO2 + C2 O2-4→ Mn2+ + CO2
Solution:
(i) 6Fe2+ + Cr2O72- + 14H+ → 6Fe3+ + 2Cr3+ + 7H2O
(ii) I2 + 10NO3- + 8H+ → 2IO3- + 10NO2 +4H2O
(iii) 2S2O3 2- + I2 → S4O62- + 2l-
(iv) C2O402- +MnO2 + 4H+ → 2CO2 +MN2+ +2H2O

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

(i) 3HCI(aq) + HNO3 (aq) → CI2(g) + NOCI (g) + 2H2O(l)
(ii) HgCI2 (aq) + 2KI (aq) → HgI2 (s) + 2KCI (aq)
(iii) Fe2O3 (s) + 3CO(g) → 2Fe (s) + 3CO2(g)
(iv) PCI3 (I) + 3H2O (I) → 3HCI (aq) + H3 Po3 (aq)
(v) 4NH3 + 3O2 (g) → 2N2 (g) + 6H2 O (g)
Solution:
(i) (iii) and (iv) are redox reactions
In (i) Reducing agent: HCl
Oxidizing agent: HNO3
In (iii) Oxidising agent: Fe2O3
Reducing agent: CO
In (iv) Oxidising agent: O2
Reducing agent: NH3

26. Balance the following ionic equations
(i) Cr2O72- + H+ + I-→ Cr3+ + I2 + H2O
(ii) Cr2O2-7 + Fe2+ + H+→ Cr3+ + Fe3+ + H2O
(iii) MnO-4 + SO2-3 + H+→ Mn2+ + SO42- + H2O
(iv) MnO4- + H+ + Br-→ Mn2+ + Br2 + H2O
Solution:
(i) 6I + Cr2O72- + 14H+ → 2Cr3+ + 3I2 + 7H2O
(ii) Cr2O2-7 + 6Fe2+ + 14H+→ 2Cr3+ + 6Fe3+ + 7H2O
(iii) 2MnO-4 + 5SO2-3 + 6H+→ 2Mn2+ + 5SO42- + 3H2O
(iv) 2MnO4- + 16H+ + 10Br-→ 2Mn2+ + 5Br2 + 8H2O

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

Column I	**Column II**	**Column II**
(i) Cr2O72–	**(a) + 3**	**(a) + 3**
(ii) MnO4–	**(b) + 4**	**(b) + 4**
(iii) VO3-	**(c) + 5**	**(c) + 5**
(iv) FeF63–	**(d) + 6**	**(d) + 6**
	(e) + 7	**(e) + 7**

Solution:
(i) is d
(ii) is e
(iii) is c
(iv) a

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

Solution:
(i) is e
(ii) is d
(iii) is c
(iv) is b
(v) is f

V. Assertion and Reason Type
In the following questions, a statement of assertion (A) followed by a statement of the 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.
Solution:
Option (ii) is correct.

30. Assertion (A): In the reaction between potassium permanganate and potassium iodide, permanganate ions act as an 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.
Solution:
Option (iii) is correct.

31. Assertion (A): The decomposition of hydrogen peroxide to form water and oxygen is an example of a disproportionation reaction.
Reason (R): The oxygen of peroxide is in –1 oxidation state and it is converted to zero oxidation state in O2 and –2 oxidation state in H2O.
(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.
Solution:
Option (i) is correct.

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

Assertion (A): Redox couple is the combination of the oxidised and reduced form of a substance involved in an oxidation or reduction half cell.
Reason (R) : In the representation E° Fe3+/fe2+and E°cu2+/cu , Fe3+ / Fe2+ and Cu2+ 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
Solution;
Option (ii) is correct.

VI. Long Answer Type

33. Explain redox reactions based on electron transfer. Give suitable examples.
Solution:
In a redox reaction if one species loses electrons it's considered to be undergoing oxidation reaction and acts as oxidizing agent or oxidant, and for species who accepts electrons is said to undergo reduction and behave as reductant.
For example Zinc and HCl reaction
Zn + 2HCl → ZnCl2 + H2
zinc loses electrons to the electronegative atom Cl with the reaction for oxidation and reduction as follows:
Oxidation: Zn→Zn2+ + 2e-
Reduction: 2H+ + 2e- →H2
Thus the transfer of electrons causes the redox reaction to occur.

34. Based on standard electrode potential values, suggest which of the following reactions would take place? (Consult the book for E\degree value).

(i) Cu + Zn2+→ Cu2+ + Zn
(ii) Mg + Fe2+→ Mg2+ + Fe

(iii) $Br_2 + 2Cl^- \rightarrow Cl_2 + 2Br^-$
(iv) $Fe + Cd^{2+} \rightarrow Cd + Fe^{2+}$
Solution:
(i) $Cu + Zn^{2+} \rightarrow Cu^{2+} + Zn$
Here Cu undergoes oxidation so it acts as anode and Zn acts as the cathode. So from the table
For cathode E°cathode = -0.76 V
For anode E°anode = 0.52 V
E°cell = -0.24V
As the EMF of the cell is negative the given reaction will not occur spontaneously if they were to form a cell placed as electrodes.
(ii) $Mg + Fe^{2+} \rightarrow Mg^{2+} + Fe$
Similarly, we can say that Mg undergoes oxidation and Fe undergoes reduction.
E°cathode = -0.44 V
E°anode = -2.36 V
E°cell = +1.92V
Positive EMF implies that the reaction will give out energy and attain stability, thus it will occur spontaneously. So the given redox reaction will occur.
(iii) $Br_2 + 2Cl^- \rightarrow Cl_2 + 2Br^-$
Here Br undergoes reduction thus acting as cathode and Cl acting as the anode.
For cathode E°cathode = 1.09 V
For anode E°anode = 1.36 V
E°cell = -0.25
The negative potential prevents easy reaction, so the redox reaction will not occur.
(iv) $Fe + Cd^{2+} \rightarrow Cd + Fe^{2+}$
Fe is the cathode and Cd is the anode
For cathode E°cathode = -0.44 V
For anode E°anode = -0.40 V
E°cell = -0.04v
The negative potential prevents easy reaction, so the redox reaction will not occur.

35. Why does fluorine not show disproportionation reaction?
Solution:
Fluorine has the highest electronegativity in the entire periodic table with EN value of 3.98; this means that out of 4 bonded electrons 3.98 fractions of it is shared with fluorine. Thus the ability to attract an electron from other elements is more pronounced than the atom with which it is bonded. And as fluorine has the highest reduction potential (E°cell =2.87) in the spectrochemical series, it cannot undergo oxidation itself. Thus cannot display disproportionation reactions.

36. Write redox couples involved in the reactions (i) to (iv) given in question 34.
Solution:
Redox couple is a reducing element along with its oxidizing form. So for the given example,
(i) Cu^{2+}/Cu and Zn^{2+}/Zn
(ii) Mg^+/Mg and Fe^{2+}/Fe
(iii) Br^-/Br and Cl^-/Cl
(iv) Fe^{2+}/Fe and Cd^{2+}/Cd

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
Solution:
$NaClO_4$ x= +7
$NaClO_3$, x= +5
$NaClO$, x=+1
$KClO_2$, x= +3
Cl_2O_7, x= +7
ClO_3, x= +6
Cl_2O, x=+1
$NaCl$, x=-1
Cl_2, x=0
ClO_2, x= +4
Ascending order of compounds w.r.t their oxidation number is:
$NaCl$ (-1), Cl_2(0), Cl_2O(+1), $KClO_2$(+3), ClO_2(+4), $NaClO_3$(+5), ClO_3(+6), Cl_2O_7=$NaClO_4$(+7).

38. Which method can be used to find out the strength of reductant/oxidant in a solution? Explain with an example.
Strength of a reductant (reducing agent) or oxidant (oxidising agent) can be found out by measuring the relative electrode potential when it's connected in a solution using a cell.
For example, Fe^{3+}/Fe is the element we want to test with the Standard Hydrogen electrode (SHE). The half-cell reaction for Fe and H are given below.
$H^+ + e^- \longrightarrow H_2$ $E^\circ = 0.0V$
$Fe^{3+} + e^- \longrightarrow Fe^{2+}$ $E^\circ = 0.77V$
When any element needs to be evaluated it is placed as an electrode with SHE. The amount of emf it generates in the cell can be considered as the potential of the element.
$E^\circ cell = 0-0.77$
$E^\circ cell = 0.77$
The above-assumed configuration of Fe being anode can be reversed and hence strength Fe as a reductant can be established. Hence the strength of an oxidant can be determined.