8

Redox Reactions

TOPIC 1 Oxidation and Reduction Reactions

1. The compound that cannot act both as oxidising and reducing agent is: **[Jan. 09, 2020 (I)]**

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

2. The redox reaction among the following is: **[Jan. 07, 2020 (II)]**

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

3. Which of the following reactions is an example of a redox reaction? **[2017]**

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

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

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

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

4. Copper becomes green when exposed to moist air for a long period. This is due to: **[Online April 12, 2014]**

(a) the formation of a layer of cupric oxide on the surface of copper.
(b) the formation of a layer of basic carbonate of copper on the surface of copper.
(c) the formation of a layer of cupric hydroxide on the surface of copper.
(d) the formation of basic copper sulphate layer on the surface of the metal.

5. Which of the following chemical reactions depict the oxidizing beahviour of H_2SO_4? **[2006]**

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

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

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

(d) $Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O$

6. Several blocks of magnesium are fixed to the bottom of a ship to **[2003]**

(a) make the ship lighter
(b) prevent action of water and salt
(c) prevent puncturing by under-sea rocks
(d) keep away the sharks

7. Which of the following is a redox reaction? **[2002]**

(a) $NaCl + KNO_3 \rightarrow NaNO_3 + KCl$
(b) $CaC_2O_4 + 2HCl \rightarrow CaCl_2 + H_2C_2O_4$
(c) $Mg(OH)_2 + 2NH_4Cl \rightarrow MgCl_2 + 2NH_4OH$
(d) $Zn + 2AgCN \rightarrow 2Ag + Zn(CN)_2$.

TOPIC 2 Oxidation Number

8. 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 ________. **[NV, Sep. 02, 2020 (I)]**

$Na_4[Fe(CN)_5(NOS)]$	$Na_4[FeO_4]$	$[Fe_2(CO)_9]$
(A)	(B)	(C)

9. 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 _______. **[NV, Sep. 02, 2020 (II)]**

10. Oxidation number of potassium in K_2O, K_2O_2 and KO_2, respectively, is: **[Jan. 07, 2020 (I)]**

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

11. The oxidation states of Cr in $[Cr(H_2O)_6]Cl_3$, $[Cr(C_6H_6)_2]$, and $K_2[Cr(CN)_2(O)_2(O_2)(NH_3)]$ respectively are : **[2018]**

(a) +3, +4, and +6 (b) +3, +2, and +4
(c) +3, 0, and +6 (d) +3, 0, and +4

12. Amongst the following, identify the species with an atom in + 6 oxidation state: **[Online April 19, 2014]**

(a) $[MnO_4]^-$ (b) $[Cr(CN)_6]^{3-}$

(c) Cr_2O_3 (d) CrO_2Cl_2

13. Oxidation state of sulphur in anions SO_3^{2-}, $S_2O_4^{2-}$ and $S_2O_6^{2-}$ increases in the orders : **[Online April 22, 2013]**

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

(b) $SO_6^{2-} < S_2O_4^{2-} < S_2O_6^{2-}$

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

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

TOPIC 3 Disproportionation and Balancing of Redox Reactions

14. Consider the following equations :

$$2Fe^{2+} + H_2O_2 \rightarrow xA + yB$$

(in basic medium)

$$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow x'C + y'D + z'E$$

(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 ___________. **[NV, Sep. 04, 2020 (II)]**

15. An example of a disproportionation reaction is: **[April 12, 2019 (I)]**

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

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

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

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

16. 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 : **[April 8, 2019 (I)]**

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

17. How many electrons are involved in the following redox reaction? **[Online April 19, 2014]**

$$Cr_2O_7^{2-} + Fe^{2+} + C_2O_4^{2-} \rightarrow Cr^{3+} + Fe^{3+} + CO_2 \text{ (Unbalanced)}$$

(a) 3 (b) 4 (c) 6 (d) 5

18. Given :

$$XNa_2HAsO_3 + YNaBrO_3 + ZHCl \rightarrow NaBr + H_3AsO_4 + NaCl$$

The values of X, Y and Z in the above redox reaction are respectively : **[Online April 9, 2013]**

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

19. In the following balanced reaction,

$$XMnO_4^- + YC_2O_4^{2-} + ZH^+ \rightleftharpoons XMn^{2+} + 2YCO_2 + \frac{Z}{2}H_2O$$

values of X, Y and Z respectively are **[Online May 12, 2012; 2013]**

(a) 2, 5, 16 (b) 8, 2, 5 (c) 5, 2, 16 (d) 5, 8, 4

TOPIC 4 Electrode Potential and Oxidising, Reducing Agents

20. Given :

$Co^{3+} + e^- \rightarrow Co^{2+}$; $E^o = +1.81$ V

$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$; $E^o = +1.67$ V

$Ce^{4+} + e^- \rightarrow Ce^{3+}$; $E^o = +1.61$ V

$Bi^{3+} + 3e^- \rightarrow Bi$; $E^o = +0.20$ V

oxidizing power of the species will increase in the order: **[April 12, 2019 (I)]**

(a) $Ce^{4+} < Pb^{4+} < Bi^{3+} < Co^{3+}$

(b) $Bi^{3+} < Ce^{4+} < Pb^{4+} < Co^{3+}$

(c) $Co^{3+} < Ce^{4+} < Bi^{3+} < Pb^{4+}$

(d) $Co^{3+} < Pb^{4+} < Ce^{4+} < Bi^{3+}$

21. Given that $E^\circ_{O_2/H_2O} = +1.23V$;

$E^\circ_{S_2O_8^{2-}/SO_4^{2-}} = 2.05V$

$E^\circ_{Br_2/Br^-} = +1.09V$

$E^\circ_{Au^{3+}/Au} = +1.4V$ **[April 8, 2019 (I)]**

The strongest oxidising agent is :

(a) Au^{3+} (b) O_2 (c) $S_2O_8^{2-}$ (d) Br_2

22. Consider the following reduction processes: **[Jan. 10, 2019 (I)]**

$Zn^{2+} + 2e^- \rightarrow Zn(s)$; $E^\circ = -0.76$ V

$Ca^{2+} + 2e^- \rightarrow Ca(s)$; $E^\circ = -2.87$ V

$Mg^{2+} + 2e^- \rightarrow Mg(s)$; $E^\circ = -2.36$ V

$Ni^{2+} + 2e^- \rightarrow Ni(s)$; $E^\circ = -0.25$ V

The reducing power of the metals increases in the order:

(a) Ca < Zn < Mg < Ni (b) Ni < Zn < Mg < Ca

(c) Zn < Mg < Ni < Ca (d) Ca < Mg < Zn < Ni

23. In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is: **[Jan. 10, 2019 (II)]**

(a) 1 (b) 10 (c) 2 (d) 5

24. In which of the following reactions, hydrogen peroxide acts as an oxidizing agent ? **[Online April 8, 2017]**

(a) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$

(b) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

(c) $2MnO_4^- + 3H_2O_2 \rightarrow 2MnO_2 + 3O_2 + 2H_2O + 2OH^-$

(d) $PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$

25. Consider the reaction:

$$H_2SO_3(aq) + Sn^{4+}(aq) + H_2O(l) \rightarrow Sn^{2+}(aq) + HSO_4^-(aq) + 3H^+(aq)$$

Which of the following statements is correct? **[Online April 19, 2014]**

(a) Sn^{4+} is the oxidizing agent because it undergoes oxidation

(b) Sn^{4+} is the reducing agent because it undergoes oxidation

(c) H_2SO_3 is the reducing agent because it undergoes oxidation

(d) H_2SO_3 is the reducing agent because it undergoes reduction

26. Which one of the following cannot function as an oxidising agent ? **[Online April 25, 2013]**

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

Hints & Solutions

1. **(a)** In H_3PO_4 oxidation state of P is +5, which cannot be oxidised further to a higher oxidation state.
   Hence, it cannot act as reducing agent.

2. **(d)** $N_2 + O_2 \rightarrow 2NO$ (Redox reaction)

   $3O_2 \rightarrow 2O_3$ (Photochemical reaction)

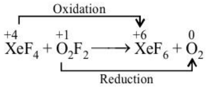
   $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

   (Neutralisation reaction)

   $[Co(H_2O)_6]Cl_3 + 3AgNO_3 \rightarrow [CO(H_2O)_6](NO_3)_3 + 3AgCl$

   (Neutralisation reaction)

3. **(a)** In the reaction



$$\overset{+4}{Xe}F_4 + \overset{+1}{O_2}F_2 \longrightarrow \overset{+6}{Xe}F_6 + \overset{0}{O_2}$$

Oxidation

Reduction

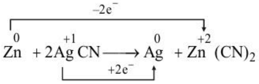
4. **(b)** Copper when exposed to moist air having CO_2. It gets superficially coated with a green layer of basic carbonate $CuCO_3 . Cu(OH)_2$.

5. **(c)** $2\overset{-1}{HI} + H_2\overset{+6}{S}O_4 \longrightarrow \overset{0}{I_2} + \overset{+4}{S}O_2 + 2H_2O$

   in this reaction oxidation number of S is decreasing from + 6 to +4 hence undergoing reduction and for HI oxidation number of I is increasing from –1 to 0 hence underegoing oxidation, therefore H_2SO_4 is acting as oxidising agent.

6. **(b)** Magnesium provides cathodic protection and prevents rusting or corrosion.

7. **(d)**



$$\overset{0}{Zn} + 2\overset{+1}{Ag}CN \longrightarrow \overset{0}{Ag} + \overset{+2}{Zn}(CN)_2$$

$-2e^-$

$+2e^-$

   The oxidation state shows a change only in (d)

8. **(6)**

   The oxidation states of iron in these compounds will be -

   In A, $x + 5(-1) + (-1) = -4 \Rightarrow x = +2$

   In B, $y + 4(-2) = -4 \Rightarrow y = +4$

   In C, $z = 0$

   The sum of oxidation states will be $= 4 + 2 + 0 = 6$.

9. **(19)**

	Compound	**Oxidation state of transition element**
(i)	$K_2Cr_2O_7$	$x = +6$
(ii)	$KMnO_4$	$y = +7$
(iii)	K_2FeO_4	$z = +6$

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

10. **(b)** $K_2O : 2x - 2 = 0 \Rightarrow x = +1$

    $K_2O_2 : 2x - 2 = 0 \Rightarrow x = +1$

    $KO_2 : x - 1 = 0 \Rightarrow x = +1$

    Thus, potassium shows +1 state in all its oxides, superoxides and peroxides.

11. **(c)** $[Cr(H_2O)_6]Cl_3$

    $\Rightarrow x + 6 \times 0 + (-1) \times 3 = 0$

    $\Rightarrow x = +3$

    $[Cr(C_6H_6)_2]$

    $x + 2 \times 0 = 0 ; x = 0$

    $K_2[Cr(CN)_2(O)_2(O_2)(NH_3)]$

    [Here $(O)_2$ is OXO, $(2x - 2)$ and

    (O_2) is per OXO, $(1x - 2)$]

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

    $x = +6$

12. **(d)** CrO_2Cl_2

    Let O. No. of Cr $= x$

    $\therefore \quad x + 2(-2) + 2(-1) = 0$

    $x - 4 - 2 = 0$

    $\therefore \quad x = +6$

13. **(c)** In SO_3^{2-}

    $x + 3(-2) = -2; x = +4$

    In $S_2O_4^{2-}$

    $2x + 4(-2) = -2$

    $2x - 8 = -2$

    $2x = 6; \quad x = +3$

    In $S_2O_6^{2-}$

    $2x + 6(-2) = -2$

    $2x = 10; \quad x = +5$

    hence the correct order is

    $S_2O_4^{2-} < SO_3^{2-} < S_2O_6^{2-}$

14. **(19)**

    $2Fe^{2+} + H_2O_2 \longrightarrow 2Fe^{3+} + 2OH^-$

    $2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$

    $\because x = 2, y = 2, x' = 2, y' = 8, z' = 5$

    $\therefore x + y + x' + y' + z' = 19$

15. **(d)** $\overset{+}{Cu}Br \longrightarrow \overset{0}{Cu} + \overset{2+}{Cu}Br_2$

    It is an example of disproportionation reaction, as Cu undergoes both oxidation and reduction.

16. **(a)** $MnO^-_4 + 5e^- \longrightarrow Mn^{2+}$

(i) $FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2 + 3e^-$

1 mole of FeC_2O_4 reacts with $\frac{3}{5}$ mole of acidified $KMnO_4$

(ii) $Fe_2(C_2O_4)_3 \longrightarrow Fe^{3+} + CO_2 + 6e^-$

1 mole of $Fe_2(C_2O_4)_3$ reacts with $\frac{6}{5}$ moles of $KMnO_4$

(iii) $FeSO_4 \longrightarrow Fe^{3+} + e^-$

1 mole of $FeSO_4$ react with $\frac{1}{5}$ moles of $KMnO_4$

(iv) $Fe_2\,(SO_4)_3$ does not oxidise

$\therefore$ Total moles required $= \frac{3}{6} + \frac{6}{5} + \frac{1}{5} = 2$

17. **(a)** The reaction given is

$Cr_2O_7^{2-} + Fe^{2+} + C_2O_4^{2-} \longrightarrow Cr^{3+} + Fe^{3+} + CO_2$

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$

On balancing

$14H^+ + Cr_2O_7^{2-} + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$ ......(i)

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ ......(ii)

$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$ ....(iii)

On adding all three equations, we get

$$Cr_2O_7^{2-} + Fe^{2+} + C_2O_4^{2-} + 14H^+ + 3e^- \longrightarrow 2Cr^{3+} + Fe^{3+} + 2CO_2 + 7H_2O$$

Hence the total no. of electrons involved in the reaction = 3

18. **(c)** On balancing the given reaction, we find

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

19. **(a)** $X\,MnO_4^- + Y\,C_2O_4^{2-} + ZH^+ \rightleftharpoons$

$$X\,Mn^{+2} + 2Y\,CO_2 + \frac{Z}{2}H_2O$$

First half reaction $MnO_4^- \longrightarrow Mn^{2+}$ .... (i)

On balancing

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

Second half reaction

$C_2O_4^{2-} \longrightarrow 2CO_2$ .... (iii)

On balancing

$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e^-$ .... (iv)

On multiplying eqn. (ii) by 5 and (iv) by 2 and then adding we get

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

20. **(b)** Higher the reduction potential, higher will be oxidising power. So,

$$Bi^{3+} < Ce^{4+} < Pb^{4+} < Co^{3+}$$

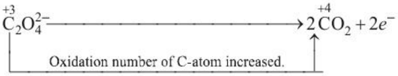
21. **(c)** More positive is the reduction potential stronger is the oxidising agent.

Reduction potential is maximum for $S_2O_8^{2-}$, therefore, it is the strongest oxidising agent amongst the given species.

22. **(b)** Higher the oxidation potential, higher will be the reducing power. So, the order of reducing behaviour is:

$$Ca > Mg > Zn > Ni$$

23. **(a)** Reaction involved:

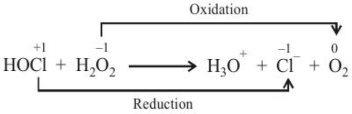


$$\overset{+3}{C}_2O_4^{2-} \longrightarrow 2\overset{+4}{C}O_2 + 2e^-$$

$\therefore$ The number of electrons involved in producing one mole of CO_2 is 1.

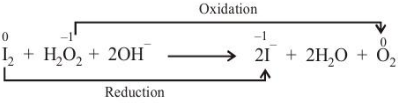
24. **(d)**

(a)



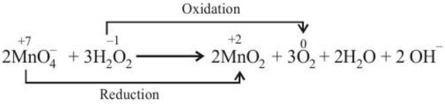
$$HO\overset{+1}{Cl} + H_2\overset{-1}{O}_2 \longrightarrow H_3O^+ + \overset{-1}{Cl^-} + \overset{0}{O}_2$$

(b)



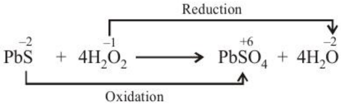
$$\overset{0}{I}_2 + H_2\overset{-1}{O}_2 + 2OH^- \longrightarrow 2\overset{-1}{I^-} + 2H_2O + \overset{0}{O}_2$$

(c)



$$2\overset{+7}{Mn}O_4^- + 3H_2\overset{-1}{O}_2 \longrightarrow 2\overset{+2}{Mn}O_2 + 3\overset{0}{O}_2 + 2H_2O + 2\,OH^-$$

(d)



$$Pb\overset{-2}{S} + 4H_2\overset{-1}{O}_2 \longrightarrow Pb\overset{+6}{S}O_4 + 4H_2\overset{-2}{O}$$

Notice that the oxidation state of oxygen goes from –1 on the H_2O_2 to –2 on the H_2O means H_2O_2 is being reduced. On the other hand the oxidation state of sulfur is going from –2 on the PbS to +6 on the $PbSO_4$. i.e Sulfur is being oxidised.

25. **(c)** $H_2\overset{+4}{S}O_3(aq) + Sn^{4+}(aq) + H_2O(l) \longrightarrow$

$$Sn^{2+}(aq) + H\overset{+6}{S}O_4^-(aq) + 3H^+$$

Hence H_2SO_3 is the reducing agent because it undergoes oxidation.

26. **(a)** If an electronegative element is in its lowest possible oxidation state in a compound or in free state. It can function as a powerful reducing agent. e.g. I^-