Redox Reactions

Numerical

Q.1 In mildly alkaline medium, thiosulphate ion is oxidized by MnO_4^- to "A". The oxidation state of sulphur in "A" is _____.
26th Feb Evening Shift 2021

Q.2 Dichromate ion is treated with base, the oxidation number of Cr in the product formed is _____.
26th Feb Morning Shift 2021

Numerical Answer Key

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1. Ans. (6)
2. Ans. (6)

Numerical Explanation

Ans 1.

$$MnO_4^- + S_2O_3^{2-} \rightarrow \overset{+4}{\underset{(A)}{MnO_2}} + SO_4^{2-}$$

Oxidation state of 'S' in SO^{2-}_4

= +6

Ans 2.

$$Cr_2O_7^{2-} + 2OH^- \rightleftharpoons 2CrO_4^{2-} + H_2O$$

Let Oxidation state of Cr in CrO_4^{2-} is = x.

$\therefore$ x + (−2 × 4) = −2

$\Rightarrow$ x = 6

MCQ (Single Correct Answer)

Q.1 In the given chemical reaction, colors of the Fe^{2+} and Fe^{3+} ions, are respectively :

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$$

A Yellow, Orange

B Yellow, Green

C Green, Orange

D Green, Yellow

1st Sept Evening Shift 2021

Q.2 Experimentally reducing a functional group cannot be done by which one of the following reagents?

A $Pt\text{-}C/H_2$

B Na/H_2

C $Pd\text{-}C/H_2$

D Zn/H_2O

1st Sept Evening Shift 2021

Q.3 In which one of the following sets all species show disproportionation reaction?

A ClO_2^-, F_2, MnO_4^- and $Cr_2O_7^{2-}$

B $Cr_2O_7^{2-}$, MnO_4^-, ClO_2^- and Cl_2

C MnO_4^-, ClO_2^-, Cl_2 and Mn^{3+}

D ClO_4^-, MnO_4^-, ClO_2^- and F_2

31st Aug Evening Shift 2021

Q.4 Potassium permanganate on heating at 513 K gives a product which is :

A paramagnetic and colourless

B diamagnetic and green

C diamagnetic and colourless

D paramagnetic and green

27th Aug Evening Shift 2021

Q.5 The nature of oxides V_2O_3 and CrO is indexed as 'X' and 'Y' type respectively. The correct set of X and Y is :

A. X = basic, Y = amphoteric

B. X = amphoteric, Y = basic

C. X = acidic, Y = acidic

D. X = basic, Y = basic

27th Aug Morning Shift 2021

Q.6 The incorrect statement is :

A. Cl_2 is more reactive than ClF.

B. F_2 is more reactive than ClF.

C. On hydrolysis ClF forms HOCl and HF.

D. F_2 is a stronger oxidizing agent than Cl_2 in aqueous solution.

26th Aug Morning Shift 2021

Q.7 Match List - I with List - II :

	List - I		**List - II**
(a)	NaOH	(i)	Acidic
(b)	$Be(OH)_2$	(ii)	Basic
(c)	$Ca(OH)_2$	(iii)	Amphoteric
(d)	$B(OH)_3$		
(e)	$Al(OH)_3$		

Choose the most appropriate answer from the options given below

A (a)-(ii), (b)-(ii), (c)-(iii), (d)-(ii), (e)-(iii)

B (a)-(ii), (b)-(iii), (c)-(ii), (d)-(i), (e)-(iii)

C (a)-(ii), (b)-(ii), (c)-(iii), (d)-(i), (e)-(iii)

D (a)-(ii), (b)-(i), (c)-(ii), (d)-(iii), (e)-(iii)

27th July Morning Shift 2021

Q.8 The oxidation states of 'P' in $H_4P_2O_7$, $H_4P_2O_5$ and $H_4P_2O_6$, respectively, are :

A 7, 5 and 6

B 5, 4 and 3

C 5, 3 and 4

D 6, 4 and 5

27th July Morning Shift 2021

Q.9 Identify the process in which change in the oxidation state is five :

A $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

B $MnO_4^- \rightarrow Mn^{2+}$

C $CrO_4^{2-} \rightarrow Cr^{3+}$

D $C_2O_4^{2-} \rightarrow 2CO_2$

25th July Evening Shift 2021

Q.10 The oxidation states of nitrogen in NO, NO_2, N_2O and NO−3 are in the order of :

A $N_2O > NO_2 > NO > NO_3^-$

B $NO > NO_2 > N_2O > NO_3^-$

C $NO_2 > NO_3^- > NO > N_2O$

D $NO_3^- > NO_2 > NO > N_2O$

18th March Evening Shift 2021

Q.11 The set that represents the pair of neutral oxides of nitrogen is :

A NO and N_2O

B N_2O and NO_2

C NO and NO_2

D N_2O and N_2O_3

17th March Evening Shift 2021

Q.12 Statement I : Sodium hydride can be used as an oxidising agent.
Statement II : The lone pair of electrons on nitrogen in pyridine makes it basic.
Choose the CORRECT answer from the options given below :

A Statement I is false but statement II is true

B Both statement I and statement II are true

C Statement I is true but statement II is false

D Both statement I and statement II are false

16th March Evening Shift 2021

Q.13 Compound A used as a strong oxidizing agent is amphoteric in nature. It is the part of lead storage batteries. Compound A is :

A PbO

B PbO_2

C $PbSO_4$

D Pb_3O_4

26th Feb Morning Shift 2021

Q.14 Which of the following equation depicts the oxidizing nature of H_2O_2?

A $CL_2 + H_2O_2 \rightarrow 2HCl + O_2$

B $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$

C $2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$

D $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

25th Feb Morning Slot 2021

Q.15 The incorrect statement among the following is :

A RuO_4 is an oxidizing agent

B Cr_2O_3 is an amphoteric oxide.

C $VOSO_4$ is a reducing agent

D Red colour of ruby is due to the presence of Co^{3+}

24th Feb Evening Slot 2021

Q.16 (A) $HOCl + H_2O_2 \rightarrow H_3O^+ + Cl^- + O_2$
(B) $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$
Choose the correct option.

A H_2O_2 acts as reducing and oxidising agent respectively in equations (A) and (B).

B H_2O_2 act as oxidizing and reducing agent respectively in equations (A) and (B).

C H_2O_2 acts as oxidising agent in equations (A) and (B).

D H_2O_2 acts as reducing agent in equations (A) and (B).

24th Feb Morning Slot 2021

MCQ Answer Key

1. **Ans. (D)**
2. **Ans. (B)**
3. **Ans. (C)**
4. **Ans. (D)**
5. **Ans. (D)**
6. **Ans. (A)**
7. **Ans. (B)**
8. **Ans. (C)**
9. **Ans. (B)**
10. **Ans. (D)**
11. **Ans. (A)**
12. **Ans. (A)**
13. **Ans. (B)**
14. **Ans. (C)**
15. **Ans. (D)**
16. **Ans. (D)**

MCQ Explanation

Ans 1. Colour of Fe^{2+} is observed green and Fe^{3+} is yellow.

Ans 2. Na in presence of H_2, will not release electron which are required for reduction.
H_2 gas also not get adsorbed on Na. Hence Na/H_2 cannot be used as a reducing agent.

Ans 3. No option contains all species that show disproportionation reaction. So question is bonus.

MnO_4^-, ClO_4^-, $Cr_2O_7^{2-}$ - Cl, Mn, Cr in these anions are present in highest oxidation state. These will not undergo disproportionation.

Ans 4.

$$2KMnO_4 \xrightarrow[200^\circ C]{\Delta} \underset{Green}{K_2MnO_4} + \underset{Black}{MnO_2} + O_2$$

In K_2MnO_4, manganese oxidation state is +6 and hence it has one unpaired e^-.

Ans 5.

V_2O_3 basic

CrO basic

Ans 6. (i) Reactivity order :

F_2 > ClF (inter halogen) > Cl_2

(ii) ClF + H_2O → HOCl + HF

(iii) Oxidizing power is aqueous solution

$F_2 > Cl_2 > Br_2 > I_2$

Ans 7. NaOH → Basic

$Be(OH)_2$ → Amphoteric

$Ca(OH)_2$ → Basic

$B(OH)_3$ → Acidic

$Al(OH)_3$ → Amphoteric

Ans 8. Oxidation state of P in $H_4P_2O_7$, $H_4P_2O_5$ and $H_4P_2O_6$ is 5, 3 & 4 respectively

$H_4P_2O_7$

2x + 4(+ 1) + 7 (−2) = 0

x = + 5

$H_4\underline{P_2}O_5$

2x + 4(+ 1) + 5 (−2) = 0

x = + 3

$H_4\underline{P_2}O_6$

2x + 4 (+ 1) + 6(−2) = 0

x = +4

Ans 9.

$$MnO_4^- + 5e \rightarrow Mn^{+2}$$

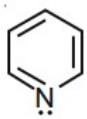
Ans 10. The oxidation states of Nitrogen in following molecules are as follows

$NO_3^- \rightarrow +5$

$NO_2 \rightarrow +4$
$NO \rightarrow +2$
$N_2O \rightarrow +1$

Ans 11. NO and N_2O are neutral oxides and N_2O_3 , NO_2 and N_2O_5 are acidic oxides.

Ans 12. NaH is a strong H^- (hydride) donor. Hence cannot be used as an oxidising agent.



Pyridine

In Pyridine, the lone pair of 'N' is localised, makes it basic.

Ans 13. PbO_2 is strong oxidizing agent because Pb^{+4} is not stable and can be easily reduced to Pb^{+2}.
PbO_2 is used in lead storage batteries. It is also amphoteric in nature.

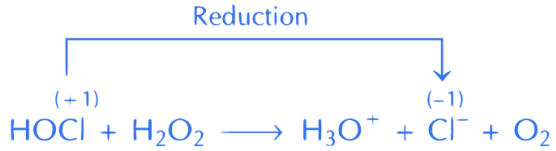
Ans 14.

$$2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$$

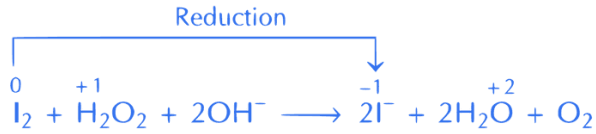
Oxygen reduces from –1 to –2.
So, its reduction will takes place. Hence it will behave as oxidising agent or it shows oxidising nature.
While in other option it change from (–1) to 0.

Ans 15. Red colour of ruby is due to presence of Cr^{3+} ions in Al_2O_3. Chromium is the trace element that causes ruby's red colour, which ranges from an orange red to a publish red. The strength of ruby's red depends on how much chromium is present.

Ans 16. In equation (A), HOCl undergoes reduction in presence of H_2O_2.



Here, oxidation state of Cl changes from +1 to –1 (i.e. reduces)
∴ H_2O_2 act as reducing agent I_2 reduces to I^- in presence of H_2O_2.
In equation (B),



Here oxidation state of iodine decreases (from 0 to –1)
∴ H_2O_2 act as reducing agent in both the equations.

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)]**

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

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

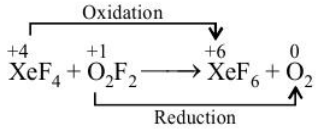
2. **(d)** $N_2 + O_2 \rightarrow 2NO$ (Redox reaction)

$3O_2 \rightarrow 2O_3$ (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



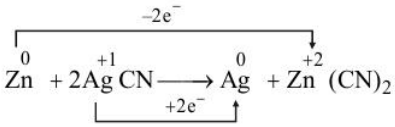
4. **(b)** Copper when exposed to moist air having CO_2. It gets superficially coated with a green layer of basic carbonate $CuCO_3$. $Cu(OH)_2$.

5. **(c)** $\overset{-1}{2HI} + \overset{+6}{H_2SO_4} \longrightarrow \overset{0}{I_2} + \overset{+4}{SO_2} + 2H_2O$

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)**



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)** $\overset{+}{CuBr} \longrightarrow \overset{0}{Cu} + \overset{2+}{CuBr_2}$

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:

$\overset{+3}{C_2}O_4^{2-} \longrightarrow 2\overset{+4}{C}O_2 + 2e^-$

Oxidation number of C-atom increased.

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

24. **(d)**

(a) $\overset{+1}{H}O\overset{-1}{Cl} + H_2\overset{-1}{O_2} \longrightarrow H_3O^+ + \overset{-1}{Cl}^- + \overset{0}{O_2}$ (Oxidation; Reduction)

(b) $\overset{0}{I_2} + H_2\overset{-1}{O_2} + 2OH^- \longrightarrow \overset{-1}{2I}^- + 2H_2O + \overset{0}{O_2}$ (Oxidation; Reduction)

(c) $\overset{+7}{2MnO_4^-} + 3H_2\overset{-1}{O_2} \longrightarrow \overset{+2}{2MnO_2} + 3\overset{0}{O_2} + 2H_2O + 2\,OH^-$ (Oxidation; Reduction)

(d) $\overset{-2}{PbS} + 4H_2\overset{-1}{O_2} \longrightarrow \overset{+6}{PbSO_4} + 4\overset{-2}{H_2O}$ (Reduction; Oxidation)

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)** $H_2SO_3(aq) + Sn^{4+}(aq) + H_2O(l) \longrightarrow Sn^{2+}(aq) + \overset{+6}{H}SO_4^-(aq) + 3H^+$

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^-