order of electro-vity
F > O > N/Cl > Br > I > S > C > H

Chapter ⇒ 8

Redox Reactions

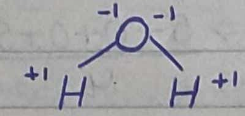
Oxidation State / Oxidation No.

Oxidation state of an atom is the formal charge present on the atom in a specie.

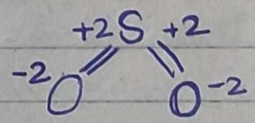
To find the formal charge in a covalent bond, assign (-1) to more electronegative atom & (+1) to more electropositive atom.

e.g. ⇒ ① HCl ⇒ $\overset{+1}{H}—\overset{-1}{Cl}$ (since electro-vity of Cl > H)

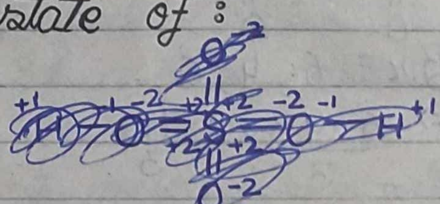
② H_2O ⇒



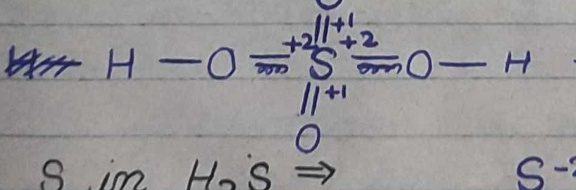
③ SO_2 ⇒



Find the oxidation state of :

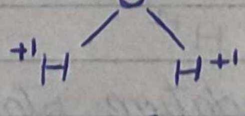


① S in H_2SO_4 ⇒



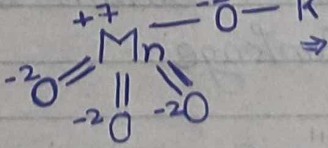
⇒ O.S. of S = +6

② S in H_2S ⇒



⇒ O.S. of S = -2

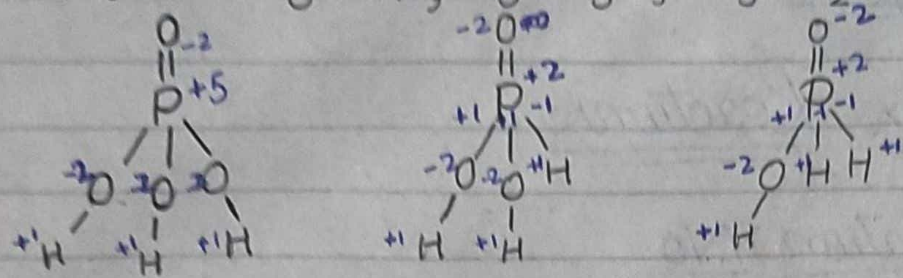
③ Mn in $KMnO_4$ ⇒



⇒ O.S. of Mn = + 7

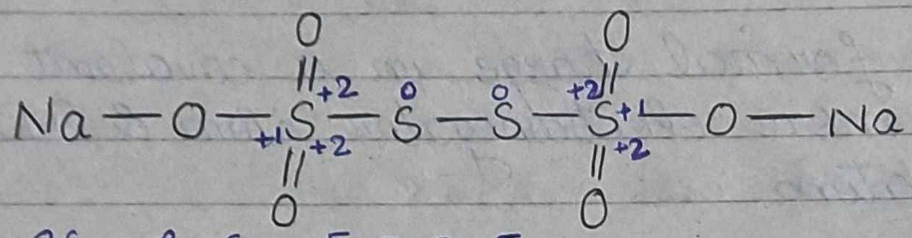
Mn show the highest O.S. in 3d series.

P in H_3PO_4, H_3PO_3, H_3PO_2



$\Rightarrow +5$ $\quad\quad$ $\Rightarrow +3$ $\quad\quad$ $\Rightarrow +1$

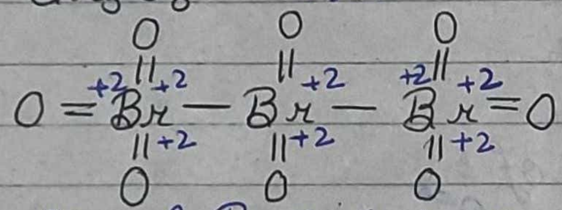
Imp. S in $Na_2S_4O_6 \Rightarrow 5, 0$



$\Rightarrow$ OS of S = 5, 0, 0, 5

Avg. oxidation state $\Rightarrow \frac{5+0+0+5}{4} = \frac{5}{2}$

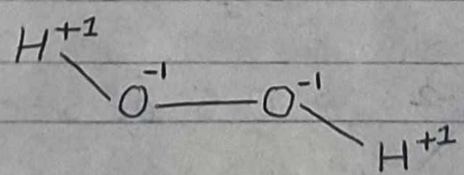
Imp. Br in $Br_3O_8 \Rightarrow 6, 4$



$\Rightarrow$ OS of Br = 6, 4, 6

avg O.S. $\Rightarrow \frac{6+4+6}{3} = \frac{16}{3}$

Imp. O in H_2O_2



When oxygen takes the oxidation state of ~~+2~~ -1 it is called peroxide linkage

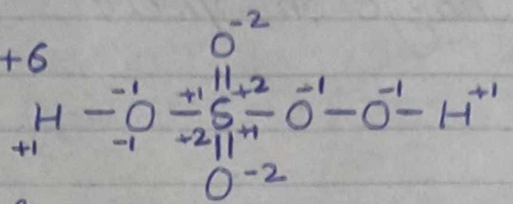
Imp. O in HO_2F

$\overset{+1}{H} - \overset{-1}{O} - \overset{+1}{O} - F \Rightarrow$ O.S. of O $\Rightarrow +1, -1$

$\Rightarrow$ Oxygen can also take OS of -1 in very rare case

Caro's Acid ⇒ H_2SO_5

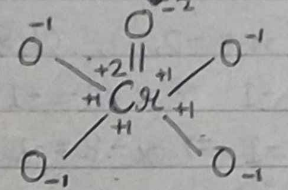
OS of $S = +6$



⇒ O.S. of O ⇒ $-2, -1$

Cr in CrO_5

OS. of $Cr = +6$



+6 is the maximum O.S. of Cr

Calculation of Oxidation State

#1 ⇒ O.S. of Alkalie Metal is +1 (Li, Na, K, Rb, Cs, Fr)

#2 ⇒ O.S. of Alkaline Earth metal is +2 (Be, Mg, Ca, Sr, Ba, Ra)

#3 ⇒ O.S. of Flourine is always -1 & Hydrogen is $+1$.

#4 ⇒ Any atom in elemental state has O.S. = 0

e.g. Cl in Cl_2, Br in Br_2, S in S_8, P in P_4

#5 ⇒ O.S. of O = -2 (in 99% case)

⇒ -1 peroxide linkag

= +1 (in HOOF) & $-\frac{1}{2}$ in KO_2 (in superoxides)

#6 O.S. of Halogen is generally -1
(Cl, Fl, Br, I)

Imp:

P-block elements show variable O.S.

N ($-3 \leftrightarrow +5$) S ($-2 \leftrightarrow +6$) Cl ($-1 \leftrightarrow +7$)

D-block elements also show variable O.S.

for e.g. Fe, Mn

Imp.

⇒ Sum of O.S. of all atoms in a specie = Total charge on specie

Questions

(i) O in H_2O ⟶ $x+2=0 \Rightarrow x=-2 \Rightarrow$ O.S. $\Rightarrow -2$

(ii) ~~C~~ C in CCl_4 ⟶ $x-4=0 \Rightarrow x=4$ O.S $\Rightarrow +4$

(iii) S in SO_3 ⟶ $x+3(-2)=0 \Rightarrow x-6=0 \Rightarrow x=6$ O.S $\Rightarrow +6$

(iv) S in H_2S ⟶ $x+2=0 \Rightarrow x=-2$ O.S. $\Rightarrow -2$

(v) N in NO_3^{-1} ⟶ $x+3(-2)=-1 \Rightarrow x-6=-1 \Rightarrow x=5 \Rightarrow$ O.S $=+5$

(vi) Cl in ClO_4^{-1} ⟶ $x+4(-2)=-1 \Rightarrow x-8=-1 \Rightarrow x=+7 \Rightarrow$ O.S $=+7$

(vii) Mn in $KMnO_4$ ⟶ $x+1+4(-2)=0 \Rightarrow x=7 \Rightarrow$ O.S $=+7$

(viii) S in H_2SO_4 ⟶ $2+x+4(-2)=0 \Rightarrow x=6 \Rightarrow$ O.S. $=+6$

(ix) P in PCl_3, PCl_5, PH_3, H_3PO_2, PO_4^{3-}

1 ⇒ $x-3=0 \Rightarrow x=3 \Rightarrow$ O.S. $=3$ 2. $x-5=0 \Rightarrow x=+5 \Rightarrow$ O.S $=+5$

3 ⇒ $x+3=0 \Rightarrow x=-3 \Rightarrow$ O.S $=-3$ 3. $x+3-4=0 \Rightarrow x=1 \Rightarrow$ O.S $=+1$

4 ⇒ $x+4(-2)=-3 \Rightarrow x-8=-3 \Rightarrow x=5 \Rightarrow$ O.S $=5$

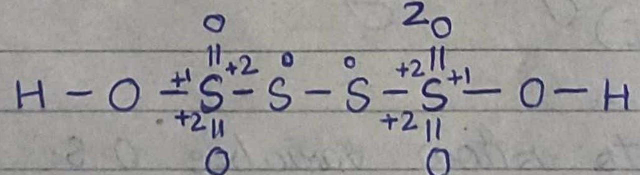
Exception to formula

⇒ When we have to find O.S. of the element whose more than one ~~elements~~ atoms are present in the compound & the O.S comes in fr[action] then the O.S. that the formula gives is the average O.S.

e.g. ① S in $H_2S_4O_6$

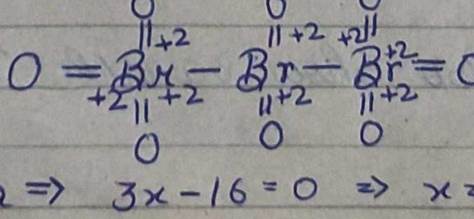
$\Rightarrow 2+4x-12=0 \Rightarrow x=\frac{5}{2}$

$H_2S_4O_6$ ⇒



⇒ O.S. of S ⇒ 5, 0, 0, 5

Br_3O_8 ⇒



⇒ O.S. of Br = 6, 4, 6

by formula ⇒ $3x-16=0 \Rightarrow x=\frac{16}{3}$

⇒ Fe in FeO, Fe_2O_3, Fe_3O_4

⇒ ① Fe in FeO ⇒ $x-2=0$ ⇒ $x=2$ ⇒ O.S. of Fe = +2

② Fe in Fe_2O_3 ⇒ $2x-6=0$ ⇒ $x=3$ O.S. of Fe = +3

③ Fe in Fe_3O_4 ⇒ $3x-8=0$ ⇒ $x=\frac{8}{3}$ O.S of Fe = $+\frac{8}{3}$

This is avg. O.S

⇒ $Fe_3O_4 = FeO \cdot Fe_2O_3$ ⇒ O.S. of Fe = +2, +3

Pb in Pb_3O_4

⇒ $Pb_3O_4 = PbO \cdot Pb_2O_3$

⇒ O.S. of Pb = +2, +3

$$\boxed{\text{Max. O.S.} = \text{Group No.} - 10}$$

Generally No element can have OS ≥ 8

S in Caro's Acid (H_2SO_5)

⇒ $2+x-10=0$ ⇒ $x=+8$ (but the max. O.S. of S = +6)

⇒ Let us assume that there is one peroxide linkage

⇒ $H_2SO_3^{(-2)} \cdot O_2^{(-1)}$ ⇒ $\cancel{2}+x-6-\cancel{2}=0$ ⇒ $x=+6$

⇒ Note ⇒ If in any case the O.S. of the element comes to exceed its max. possible O.S. then we will assume that there is one peroxide linkage between any two O atoms and then use the formula.

N in HNO_4 ⇒ $1+x+4(-2)=0$ ⇒ $x=+7$ (but max O.S. of N = +5)

⇒ Let us assume that there is one peroxide linkage

⇒ $HNO_2^{(-2)} \cdot O_2^{(-1)}$ ⇒ $1+x-4-2$ ⇒ $x=5$

Cr in $CrO_5 \Rightarrow x-10=0 \Rightarrow x=+10$ (but this is not possible

$\Rightarrow$ there is one peroxide linkage

$\Rightarrow$ $CrO_3^{(-2)} \cdot O_2^{(-1)}$

$\Rightarrow x-6-2=0 \Rightarrow x=+8$ (max O.S of Cr = +6)

$\Rightarrow$ there is another peroxide

$CrO^{(-2)}O_4^{(-1)} \Rightarrow x-2-4=0 \Rightarrow \underline{x=+6}$

Redox Reaction

Oxidation	Reduction
$\Rightarrow$ Loss of e^-	$\Rightarrow$ Gain of e^-
$\Rightarrow$ Gain of Oxygen / Loss of Hydrogen	$\Rightarrow$ Gain of Hydrogen / Loss of Oxygen
$\Rightarrow$ Oxidation No. incr.	$\Rightarrow$ Oxidation no. decreases

Q $\Rightarrow$ In the given reaction which element is oxidised & which is reduced

decrease in O.S $\Rightarrow$ reduction

① $Zn^0 + Cu^{2+} \longrightarrow Zn^{2+} + Cu^0$

increase in ~~O.N~~ O.S.
$\Rightarrow$ oxidation

Reduction

Q $\Rightarrow$ $\overset{+6}{Cr_2}O_7^{2-} + Fe^{2+} \longrightarrow Cr^{3+} + Fe^{3+}$

O.S. incr. $\Rightarrow$ oxidation

here O.S. of Cr $\Rightarrow 2x-14=-2 \Rightarrow x=+6$

OS decr. $\Rightarrow$ Reduction

$\Rightarrow$ $\overset{0}{Zn} + \overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+2}{Zn}Cl_2 + \overset{0}{H_2}$

O.S. incr $\Rightarrow$ Oxidation

Oxidizing Agent ⇒ The element of the compound that gains the e^- released by the other element in order to oxidize it.

Reducing Agent ⇒ The element of the compound that looses e^- that are to be taken up by the other element in order to reduce it.

All the reactions of chemistry are not redox reaction.

e.g. $\overset{+1}{Ag}\overset{+5}{N}\overset{-2}{O_3} + \overset{+1}{Na}\overset{-1}{Cl} \longrightarrow \overset{+1}{Ag}\overset{-1}{Cl} + \overset{+1}{Na}\overset{+5}{Na}\overset{-2}{O_3}$

here the O.S. of all the elements are equal to their initial value ⇒ there is no change in O.S.

Types of Redox Reactions

① **Thermal decomposition Redox Reaction**

$\overset{+1}{Ag_2}\overset{-2}{O} \xrightarrow{\Delta} 2\overset{0}{Ag} + \frac{1}{2}\overset{0}{O_2}$

O.S. incr. oxidation

OS decreased ⇒ reduction

Reducing agent ⇒ O
Oxidizing agent ⇒ Ag

Imp.
② **Displacement Redox Reaction**

$\overset{0}{Zn} + \overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+2}{Zn}\overset{-1}{Cl_2} + \overset{0}{H_2}$

O.S decr. ⇒ reduction

O.S. incr. ⇒ oxidation

~~OS decrease~~ Reduction

⇒ Reducing agent ⇒ Zn
⇒ Oxidizing agent ⇒ H

Standard Reduction Potential

Li
K
Ba
Sr
Ca
Na
Mg
Al
Mn
Zn
Cr
Fe
Co
Ni
Pb
H
Cu
~~H~~Hg
Ag
Au
Pt
I_2
Br_2
Cl_2
F_2

Reducing Potential increases
⇓
Tendency to get reduced
⇓
Oxidising Agent

Q ⇒ Which of the given reacⁿ is feasible

ⓐ $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$

ⓑ $Cu + ZnSO_4 \longrightarrow CuSO_4 + Zn$

here

reduction

$$\overset{0}{Zn} + \overset{+2}{Cu}\overset{-2}{SO_4} \longrightarrow \overset{+2}{Zn}\overset{-2}{SO_4} + \overset{0}{Cu}$$

oxidation

since reducing potential of Cu > Zn

⇒ ~~Zn~~ Cu will reduce

⇒ the reacⁿ ⓐ is feasible

Q ⇒ Can we stir a solution of $NiSO_4$ with

ⓐ Zn spoon

ⓑ Ag spoon

since ~~Zn~~ Zn is more reactive than $NiSO_4$

⇒ we can stir the solⁿ with Ag spoon

③ Combination (Synthesis) Redox Reaction

e.g. ⇒ $3\overset{0}{Mg} + \overset{0}{N_2} \longrightarrow \overset{+2}{Mg_3}\overset{-3}{N_2}$

oxidation

reduction

$2\overset{0}{Ca} + \overset{0}{O_2} \longrightarrow 2\overset{+2}{Ca}\overset{-2}{O}$

reduction

oxidation

④ Disproportionation Redox Reaction

e.g. $\overset{0}{P_4} + NaOH \longrightarrow \overset{-3}{P}H_3 + NaH_2\overset{+1}{P}O_2$

Oxidation

reduction

e.g. $\overset{0}{I_2} + KOH \longrightarrow K\overset{-1}{I} + KO\overset{+1}{I} + H_2O$

reduction

Oxidation

⑤ Comproportionation Redox Reaction

$H_2\overset{-2}{S} + \overset{+4}{S}O_2 \longrightarrow \overset{0}{S_2} + H_2O$

reduction

oxidation

Balancing a chemical Equation

① Ion-electron Method

or

Half Reactions Method

Rules ⇒ ① Write the given eq^n in ionic form

② Identify elements undergoing oxidation (charge↑, O.S.↑) & Reduction (charge↓, O.S.↓).

③ Break the eq^n into two halves

(i) Oxidation half ② Reduction half.

④ Balance the half equations

(i) Balance all other atoms except O & H

(ii) Balance O by adding H_2O to the side defecient in O.

(iii) Balance H by adding H^+ ions

(iv) Balance charge by adding e^-.

⑤ Add the two halves such that e^- in two halves gets cancelled.

⇒ Neutral & Acidic medium balanced.

Q ⇒ $Fe^{2+} + \overset{+6}{Cr_2}O_7^{2-} \xrightarrow{acidic} Cr^{3+} + Fe^{3+}$

O.S. decr: reduction

O.S. incr. ⇒ oxidation

Oxidation Half

$Fe^{2+} \longrightarrow Fe^{3+}$

$6\times(Fe^{2+} \longrightarrow Fe^{3+} + e^-)$

$6Fe^{2+} \longrightarrow 6Fe^{3+} + 6e^-$

Reduction Half

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

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + \cancel{7H^+} \longrightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 7H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

adding the two halves

$6Fe^{2+} + Cr_2O_7^{2-} + 7H^+ + \cancel{6e^-} \longrightarrow 6Fe^{3+} + \cancel{6e^-} + 2Cr^{3+} + 7H_2O$

O.S. ↓ ⇒ reduction

Q ⇒ $\overset{+4}{S}O_3^{2-} + \overset{+6}{Cr_2}O_7^{2-} \longrightarrow \overset{+6}{S}O_4^{2-} + Cr^{3+}$

O.S. ↑ ⇒ oxidation

Oxidation half

$SO_3^{2-} \longrightarrow SO_4^{2-}$

$SO_3^{2-} \longrightarrow SO_4^{2-} + H_2O$

$SO_3^{2-} + H^+ \longrightarrow SO_4^{2-} + H_2O$

$SO_3^{2-} + H^+ + e^- \longrightarrow SO_4^{2-} + H_2O$

Reduction half

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

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 7H^+ \longrightarrow 2Cr^{3+} + 7H_2O$

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

adding both halves

⇒ $SO_3^{2-} + H^+ + \cancel{e^-} + Cr_2O_7^{2-} + 7H^+ \longrightarrow 2Cr^{3+} + 7H_2O + \cancel{e^-} + SO_4^{2-} + H_2O$

⇒ $SO_3^{2-} + Cr_2O_7^{2-} + 8H^+ \longrightarrow 2Cr^{3+} + 8H_2O + SO_4^{2-}$

Redox Reactions (Continued)

(ii) $\overset{+4}{S}O_3^{2-} + \overset{+6}{Cr_2}O_7^{2-} \xrightarrow[\text{Acidic}]{\text{reduction}} \overset{+6}{S}O_4^{2-} + Cr^{3+}$

O.S. increases ⇒ oxidation

Oxidation half

$SO_3^{2-} \longrightarrow SO_4^{2-}$

$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-}$

$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+$

$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$

$3\times(SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-)$

Reduction half

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

$Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

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

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

adding ~~bothe~~ the halves

$3SO_3^{2-} + 3H_2O + Cr_2O_7^{2-} + 14H^+ + \cancel{6e^-} \longrightarrow 3SO_4^{2-} + 6H^+ + \cancel{6e^-} + 2Cr^{3+} + 7H_2O$

$3SO_3^{2-} + Cr_2O_7^{2-} + 8H^+ \longrightarrow 3SO_4^{2-} + 2Cr^{3+} + 4H_2O$

H.W ⇒ Balance the following equations

(i) $MnO_4^- + C_2O_4^{2-} \xrightarrow[\text{acidic}]{} Mn^{2+} + CO_2$

(ii) $C_2O_4^{2-} + Cr_2O_7^{2-} \xrightarrow[\text{acidic}]{} Cr^{3+} + CO_2$

Balancing eqn of reaction in basic medium

- The first five rules will be same
- ⑥ For basic medium, add as many OH^- ions to both sides as there are H^+ in one side.

oxidation

(iii) $\overset{+7}{Mn}O_4^- + I^- \xrightarrow{\text{Basic}} \overset{+4}{Mn}O_2 + \overset{0}{I_2}$

reduction

Oxidation half

$I^- \longrightarrow I_2$

$3\times(2I^- \longrightarrow I_2 + 2e^-)$

$6I^- \longrightarrow 3I_2 + 6e^-$

Reduction half

$MnO_4^- + \cancel{e} \longrightarrow MnO_2$

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

$\cancel{2\times(MnO_4^- \longrightarrow MnO_2 + 2H_2O + 8e^-)}$

$\cancel{2MnO_4 \longrightarrow 2MnO_2 + 4H_2O + 2e}$

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

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

$2MnO_4^- + 8H^+ + 6e^- \longrightarrow 2MnO_2 + 4H_2O$

adding both halves

$2MnO_4^- + 8H^+ + \cancel{6e^-} + 6I^- \longrightarrow 3I_2 + \cancel{6e^-} + 2MnO_2 + 4H_2O$

$2MnO_4^- + 8H^+ + 6I^- + 8OH^- \longrightarrow 3I_2 + 2MnO_2 + 4H_2O + 8OH^-$

$2MnO_4^- + 6I^- + 4H_2O \longrightarrow 3I_2 + 2MnO_2 + 8OH^-$

oxidation

(iv) $Br^- + \overset{+7}{Mn}O_4^- \xrightarrow{\text{basic}} \overset{+5}{Br}O_3^- + \overset{+4}{Mn}O_2$

reduction

Oxidation Half

$Br^- \longrightarrow BrO_3^-$

$Br^- \cancel{\ } + 3H_2O \longrightarrow BrO_3^-$

$Br^- + 3H_2O \longrightarrow BrO_3^- + 6H^+$

$Br^- + 3H_2O \longrightarrow BrO_3^- + 6H^+ + \cancel{5e}\ 6e^-$

Reduction Half

$\cancel{Br}$

$MnO_4^- \longrightarrow MnO_2$

$MnO_4^- \longrightarrow MnO_2 + 2H_2O$

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

$2\times(MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

$2MnO_4^- + 8H^+ + 6e^- \rightarrow 2MnO_2 + 4H_2O$

adding both the halves

$2MnO_4^- + 8H^+ + \cancel{6e^-} + Br^- + 3H_2O \longrightarrow BrO_3^- + 6H^+ + \cancel{6e^-} + 2MnO_2 + 4H_2O$

$2MnO_4^- + 2H^+ + Br^- + 2OH^- \longrightarrow BrO_3^- + 2MnO_2 + H_2O + 2OH^-$

$2MnO_4^- + Br^- + H_2O \longrightarrow BrO_3^- + 2MnO_2 + 2OH^-$

H.W.

1. $Zn + NO_3^- \longrightarrow Zn^{2+} + NH_3$
2. $Cr(OH)_3 + IO_3^- \longrightarrow Cr^{3+} + I^-$

Balancing of eq^n that are not written in terms of ions

$$Cu + \underset{\text{(Conc.)}}{HNO_3} \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$$

⇒ Writing the eq^n in terms of ions.

Oxidation

$$\overset{0}{Cu} + \overset{+5}{N}O_3^- \longrightarrow \cancel{Cu(NO_3)_2}\ Cu^{2+} + \overset{+4}{N}O_2$$

reduction

Oxidation half

$Cu \longrightarrow Cu^{2+}$

$Cu \longrightarrow Cu^{2+} + 2e^-$

Reduction halve

$NO_3^- \longrightarrow NO_2$

$NO_3^- \longrightarrow NO_2 + H_2O$

$NO_3^- + 2H^+ \longrightarrow NO_2 + H_2O$

$2 \times (NO_3^- + 2H^+ + e^- \longrightarrow NO_2 + H_2O)$

adding both halves

$Cu + 2NO_3^- + 4H^+ + \cancel{2e^-} \longrightarrow 2NO_2 + 2H_2O + Cu^{2+} + \cancel{2e^-}$

$Cu + 2NO_3^- + 4H^+ + 2NO_3^- \longrightarrow 2NO_2 + 2H_2O + Cu^{2+} + 2NO_3^-$

$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O + 2NO_2$

H.W.

$$Cu + \underset{\text{(dil.)}}{HNO_3} \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

Disproportionation Redox Reaction

$$P_4 + NaOH \longrightarrow PH_3 + NaH_2PO_2$$

~~writing the eq^n in ionic form~~

P_4

$$\overset{0}{P_4} + NaOH \longrightarrow \overset{-3}{P}H_3 + NaH_2\overset{+1}{P}O_2$$

Reduction

Oxidation

converting into ionic form

$$P_4 + OH^- \longrightarrow \overset{-3}{P}H_3 + H_2PO_2^{-1}$$

Oxidation Half

$P_4 \xrightarrow{12H^+} PH_3$

$P_4 + \cancel{3H^+} \longrightarrow 4PH_3$

$P_4 + 12H^+ + 12e^- \longrightarrow 4PH_3$

Reduction Half

$P_4 \cancel{OH} \longrightarrow \cancel{Na} H_2PO_2^{-1}$

$P_4 \longrightarrow 4H_2PO_2^{-1}$

$P_4 + 8H_2O \longrightarrow 4H_2PO_2^{-1}$

$P_4 + 8H_2O \longrightarrow 4H_2PO_2^{-1} + 8H^+$

$P_4 + 8H_2O \longrightarrow 4H_2PO_2^{-1} + 8H^+ + 4e$

$3P_4 + 24H_2O \longrightarrow 12H_2PO_2^{-1} + \cancel{18}\,24H^+ + 12e$

adding

$P_4 + 12H^+ + \cancel{12e} + 3P_4 + 24H_2O \longrightarrow 4PH_3 + 12H_2PO_2^{-1} + 24H^+ + 12e$

$P_4 + 3P_4 + 24H_2O + 12OH^- \longrightarrow 4PH_3 + 12H_2PO_2^{-1} + 12H^+ + 12OH^-$

$4P_4 + 12H_2O + 12OH^- \longrightarrow 4PH_3 + 12H_2O_2^{-1}$

$P_4 + 3H_2O + 3OH^- + 3Na^+ \longrightarrow PH_3 + 3H_2O_2^{-1} + 3Na^+$

$P_4 + 3H_2O + 3NaOH \longrightarrow PH_3 + 3NaH_2O_2$

$I_2 + KOH \longrightarrow KI + KIO_3 + H_2O$

~~Oxidation No. Balancing~~

Balancing of Redox Reaction equations by ~~ion~~ Oxidation No.

Rules

#1 ⇒ Identify the elements (atoms) which undergo oxidation & Reduction. (O.S. Change)
#2 ⇒ Balance atoms undergoing oxidation & reduction
#3 ⇒ Balance charge by cross multiplication
#4 ⇒ Balance all other atoms except O & H
#5 ⇒ To balance O, add H_2O
#6 ⇒ In Basic medium add as many OH^- ions on both sides as no. of H^+ ions on one.

O.S. ↑ ⇒ Oxidation

Q ⇒ $\overset{+3}{Fe}Cl_3 + H_2\overset{-2}{S} \longrightarrow \overset{+2}{Fe}Cl_2 + \overset{0}{S} + HCl$

O.S. ↓ ⇒ Reduction

⇒ $FeCl_3 + H_2S \longrightarrow FeCl_2 + S + HCl$
⇒ $2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + S + 2HCl$

Oxidation

Q ⇒ $\overset{+4}{Mn}O_2 + H\overset{-1}{Cl} \longrightarrow \overset{+2}{Mn}Cl_2 + \overset{0}{Cl_2} + H_2O$

Reduction

⇒ ~~$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$~~
⇒ ~~$MnO_2 + 8HCl \longrightarrow MnCl_2 + 2Cl_2 + 2H_2O$~~

2

$\overset{+4}{Mn}O_2 + 2H\overset{-1}{Cl} \longrightarrow \overset{+2}{Mn}Cl_2 + \overset{0}{Cl_2} + \cancel{H_2O}$

2

On cross multiplying we get

$MnO_2 + 2HCl \longrightarrow MnCl_2 + Cl_2 + \cancel{H_2O}$
$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl + 2H_2O$

Oxidation

(3) $\overset{0}{Zn} + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{Zn}(NO_3)_2 + \overset{-3}{N}H_4NO_3 + H_2O$

Reduction

$\cancel{8}\ 4$

$\overset{0}{Zn} + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{Zn}(NO_3)_2 + \overset{-3}{N}H_4NO_3 + H_2O$

$\cancel{2}\ 1$

$4\overset{0}{Zn} + H\overset{+5}{N}O_3 \longrightarrow 4\overset{+2}{Zn}(NO_3)_2 + \overset{-3}{N}H_4NO_3$

$4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + NH_4NO_3$

$4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$

⇒ The eqn. is balanced.

Oxidation

(4) $\overset{0}{Cu} + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{Cu}(NO_3)_2 + \overset{+4}{N}O_2 + H_2O$

Reduction

2

⇒ $\overset{0}{Cu} + H\overset{+5}{N}O_3 \longrightarrow \overset{+2}{Cu}(NO_3)_2 + \overset{+4}{N}O_2$

1

⇒ $Cu + 2HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2$

$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

⇒ The eqn. is balanced.

Reduction

(5) $K_2\overset{+6}{Cr_2}O_7 + H\overset{-1}{Cl} \longrightarrow KCl + \overset{+3}{Cr}Cl_3 + \overset{0}{Cl_2} + H_2O$

963 Oxidation

$\cancel{2}K_2\overset{+6}{Cr_2}O_7 + 2H\overset{-1}{Cl} \longrightarrow KCl + 2\overset{+3}{Cr}Cl_3 + \overset{0}{Cl_2} + \cancel{H_2O}$

$\cancel{2}\ 1$

$\cancel{2K_2Cr_2O_7 + 18HCl \longrightarrow KCl + 4CrCl_3 + 9Cl_2}$

$\cancel{2K_2Cr_2O_7 + 12HCl \longrightarrow 4KCl + 4CrCl_3 + 6Cl_2}$

$\cancel{2K_2Cr_2O_7 + 48HCl \longrightarrow 48KCl + 4CrCl_3 + 18Cl_2}$

$\overset{6\ 3}{}$

$K_2\overset{+6}{Cr_2}O_7 + 2H\overset{-1}{Cl} \longrightarrow KCl + 2\overset{+3}{Cr}Cl_3 + \overset{0}{Cl_2}$

2

$K_2\overset{+6}{Cr_2}O_7 + 6HCl^{-1} \longrightarrow KCl + 2\overset{+3}{Cr}Cl_3 + 3Cl_2$

$K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 3Cl_2 + 7H_2O$

Reduction

$\overset{+6}{Cr_2}O_7^{2-} + \overset{+4}{S}O_2 + H^+ \longrightarrow Cr^{3+} + H\overset{+6}{S}O_4^- + H_2O$

Oxidation

$\cancel{2}\ 1$

$\Rightarrow Cr_2O_7^{2-} + SO_2 \longrightarrow 2Cr^{3+} + HSO_4^- +$

$\cancel{6}\ 3$

$Cr_2O_7^{-2} + 3SO_2 \longrightarrow 2Cr^{3+} + 3HSO_4^- + H_2O$

$Cr_2O_7^{-2} + 3SO_2 + 5H^+ \longrightarrow 2Cr^{3+} + 3HSO_4^- + H_2O$

Oxidation

(7) $\overset{0}{Cl_2} + \overset{+5}{I}O_3^- + OH^- \longrightarrow \overset{+7}{I}O_4^- + Cl^- + H_2O$

Reduction

2

$\overset{0}{Cl_2} + IO_3^- \longrightarrow IO_4^- + 2Cl^- +$

2

~~$3Cl_2 + 2IO_3^- \longrightarrow 2IO_4^- + 6Cl^-$~~

~~$3Cl_2 + 2IO_3^- + 2H_2O \longrightarrow 2IO_4^- + 6Cl^- + 4H^+$~~

~~$3Cl_2 + 2IO_3^- + 2H_2O + 4OH^- \longrightarrow 2IO_4^- + 6Cl^- + 4H^+ + 4OH^-$~~

~~$3Cl_2 + 2IO_3^- + 2H_2O + 4OH^- \longrightarrow 2IO_4^- + 6Cl^- + 4H_2O$~~

~~$3Cl_2 + 2IO_3^- + 4OH^- \longrightarrow 2IO_4^- + 6Cl^- + 2H_2O$~~

$H_2O + Cl_2 + IO_3^- \longrightarrow IO_4^- + 2Cl^- + 2H^+$

$Cl_2 + IO_3^- + H_2O + 2OH^- \longrightarrow IO_4^- + 2Cl^- + 2H_2O$

$Cl_2 + IO_3^- + 2OH^- \longrightarrow IO_4^- + 2Cl^- + H_2O$

Reduction

(8) $I_2^{0} + NaOH \longrightarrow Na\overset{-1}{I} + Na\overset{+5}{I}O_3 + H_2O$

Oxidation

10→5

$\Rightarrow I_2^{0} + NaOH \longrightarrow 2Na\overset{-1}{I} + 2Na\overset{+5}{I}O_3 + H_2O$

×1

$\Rightarrow 6I_2 + 2NaOH \longrightarrow 10NaI^{-1} + 2NaIO_3 + \cancel{H}$

$6I_2 + \cancel{6}\,12NaOH \longrightarrow 10NaI^{-1} + 2NaIO_3 + 6H_2O$

$3I_2 + 6NaOH \longrightarrow 5NaI^{-1} + NaIO_3 + 3H_2O$

$K_2Cr_2O_7 + FeSO_4 + H_2SO_4 \longrightarrow K_2SO_4 + Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + H_2O$