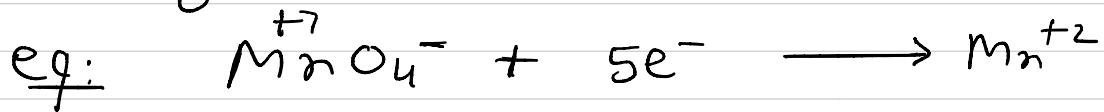
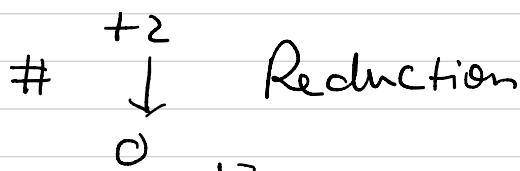
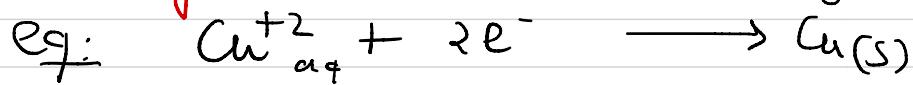
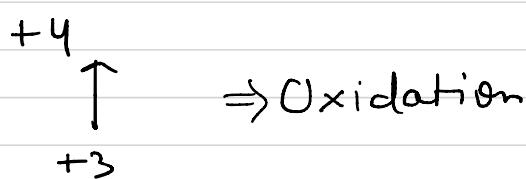


Oxidation and Reduction:-

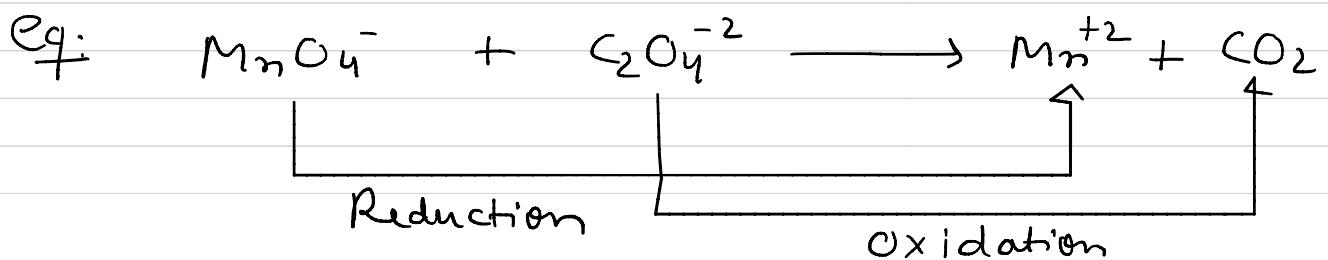
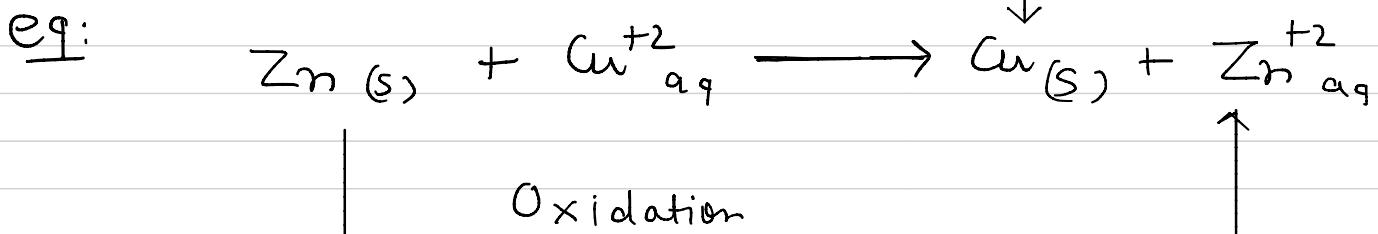
Process of electronation is called Reduction



Process of deelectronation is called Oxidation

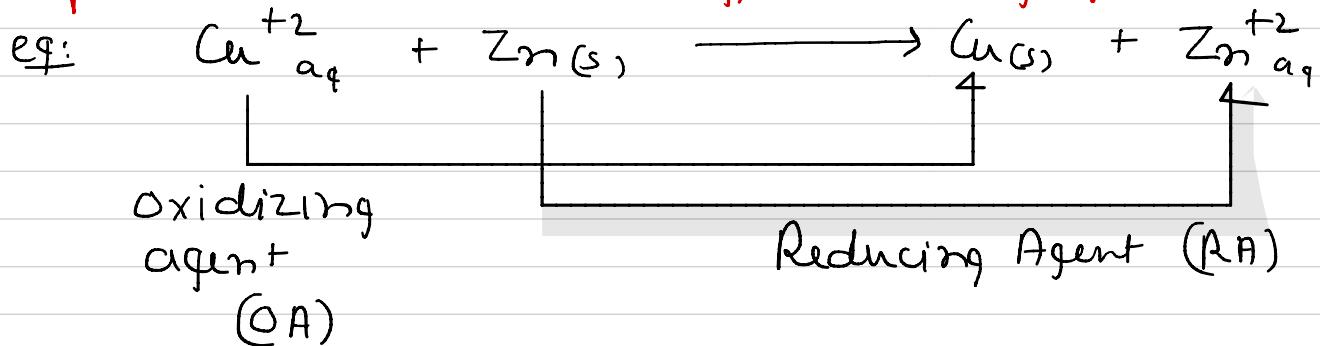


Redox rxn :- Rxn having Oxidation and reduction are Reduction called Redox rxn

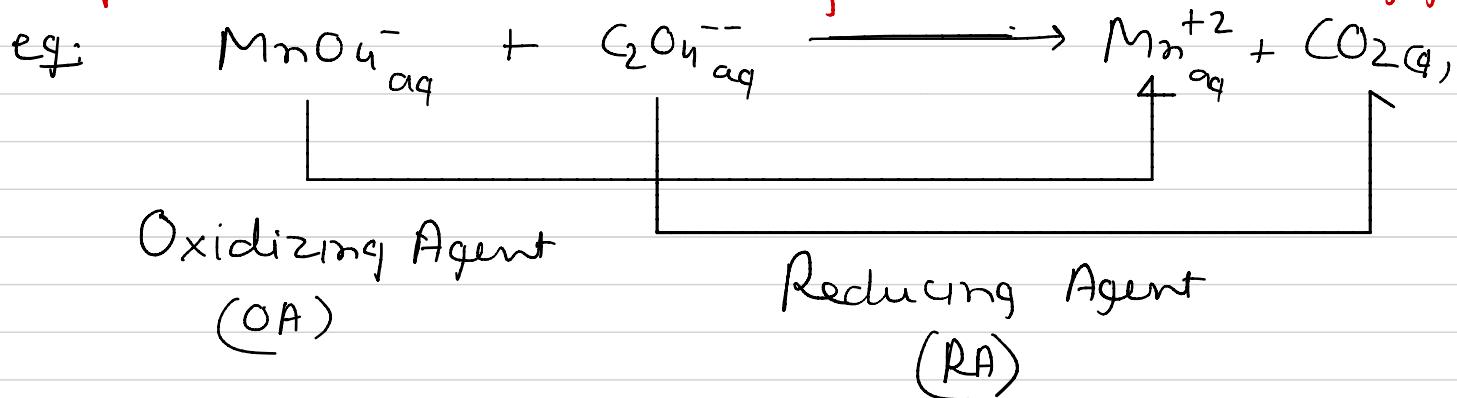


Redox Titrations TOV TLV 21-22(4)

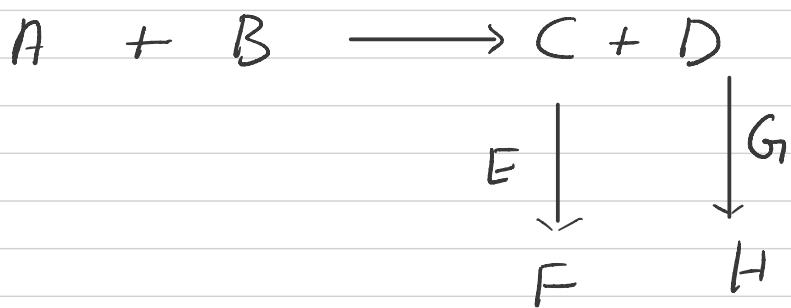
Component which is oxidizing, is reducing agent



≠ Component which is reducing is called Oxidizing Agent



Law of Equivalence :



Equal no of equivalent of each component, involve in rxn, take part in rxn.

$$\begin{aligned}
 \text{Eq of A} &= \text{Eq of B} = \text{Eq of C} = \text{Eq of D} \\
 &= \text{Eq of E} = \text{Eq of G} \\
 &= \text{Eq of F} = \text{Eq of H}
 \end{aligned}$$

Equivalent (or gram equivalent) :

$$\begin{aligned}
 \text{Equivalent} &= \left(\frac{m}{E} \right) \\
 &= \left(\frac{m}{M} \right) \times n\text{-factor}
 \end{aligned}$$

$\text{Equivalent} = \text{mole} \times n\text{-factor}$

$$\begin{aligned}
 E &= \text{Equivalent mass} \\
 &= \left(\frac{M}{n\text{-factor}} \right)
 \end{aligned}$$

M = molar mass

m = mass of substance in gram.

Normality (N) :

No of equivalent of solute, present in 1 lit sol³

or

No of milli equivalent of solute present in 1 ml sol³
is called as normality.

$$\Rightarrow N = \frac{\text{No of Eq}}{V(\text{lit})} = \frac{\text{No of m Eq}}{V(m)}$$

$$N = \frac{\text{mole} \times \text{n-factor}}{V(\text{lit})}$$

$$N = M \times \text{n-factor}$$

where M = molarity
 V = volume of sol³

#

$$\begin{aligned}\text{No of Eq} &= N \times V_{\text{lit}} \\ \text{No of m Eq} &= N \times V(m)\end{aligned}$$

Calculation of n-factor :-

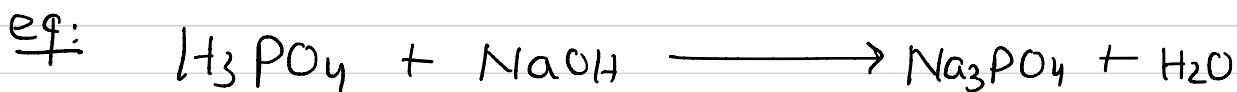
① Acid/Base rxn :-

No of mole of H^+ given / No of mole e pair taken for Acid

No of mole of OH^- given / No of mole of e pair given / No of mole of H^+ taken for Base



n-factor = 2. 1



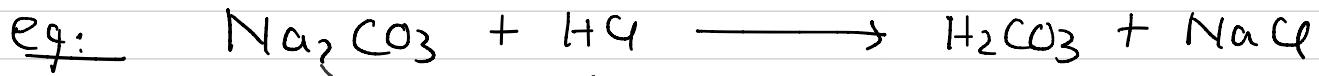
n-factor = 3 1



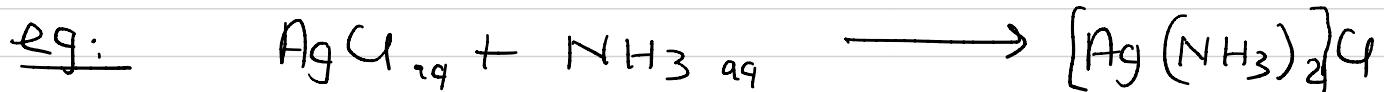
n-factor = 1 1



n-factor = 1 1



n-factor = 2 1



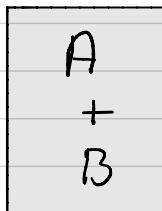
n-factor = 2 1

Note :-

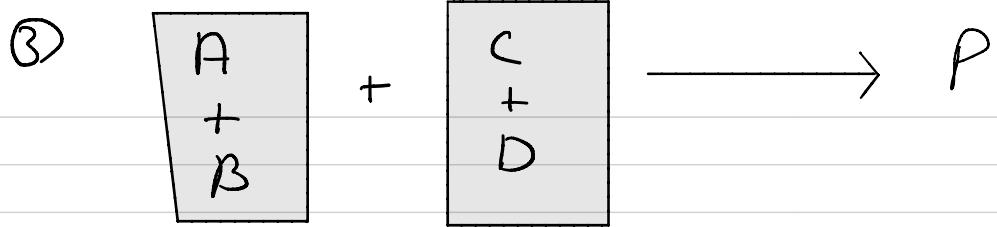


$$\text{Eq of A} = \text{Eq of B}$$

②



$$\text{Eq of A} + \text{Eq of B} = \text{Eq of C}$$



$$\sum q \text{ of } A + \sum q \text{ of } B = \sum q \text{ of } C + \sum q \text{ of } D$$

If 25 mL of a H_2SO_4 solution reacts completely with 1.06 g of pure Na_2CO_3 , what is the normality of this acid solution :

D

5 ml of N -HCl, 20 ml of $\frac{N}{2}$ H_2SO_4 and 30 ml of $\frac{N}{2}$

HNO_3 are mixed together and the volume made upto 1 litre. What is the weight of pure NaOH required to neutralize the solution?

- (a) 1 gm
 (b) 0.5 gm
 (c) 0.1 gm
 (d) 21.8 gm

A

$$\text{Eq of H}_2\text{SO}_4 = \text{Eq of Na}_2\text{CO}_3$$

$$\frac{N \times 25}{1000} = \left(\frac{1.06}{106}\right) \times 2$$

$N = 0.8 \text{ normal}$

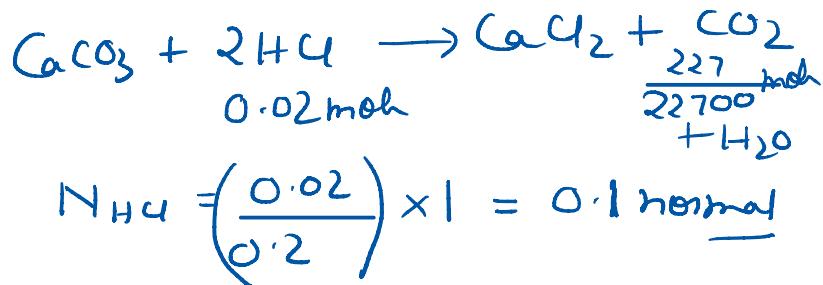
4.3 gm of an alkane is burnt in sufficient oxygen. The CO_2 formed reacts completely with 300 mL, 2*N* NaOH solution producing Na_2CO_3 . The alkane should be :

- (a) C_3H_8 (b) $\text{C}_{12}\text{H}_{26}$
 (c) C_6H_{14} (d) C_2H_6

A certain weight of pure CaCO_3 is made to react completely with 200 mL of a HCl solution to give 227 mL of CO_2 gas at STP. The normality of the HCl solution is :

- (a) $0.05 N$ (b) $0.1 N$
 (c) $1.0 N$ (d) $0.2 N$

B



A 25 mL HCl solution containing 3.65 g HCl/L is neutralized by 50 mL of NaOH solution. Again, 25 mL of the same NaOH solution neutralized by 50 mL of an H_2SO_4 solution of unknown strength. The normality of the H_2SO_4 solution is :

- (a) $0.25 N$ (b) $0.025 N$
 (c) $0.05 N$ (d) $0.50 N$

B

$$\begin{aligned}
 \text{meq of HCl} &= \text{meq of NaOH} \\
 \frac{\left(\frac{3.65}{36.5}\right) \times 1 \times 25}{N_1 \times 50} &= N_1 \times 50 - \text{①} \\
 \text{meq of H}_2\text{SO}_4 &= \text{meq of NaOH} \\
 N \times 50 &= N_1 \times 25 - \text{②} \\
 N &= 0.025 \text{ normal}
 \end{aligned}$$

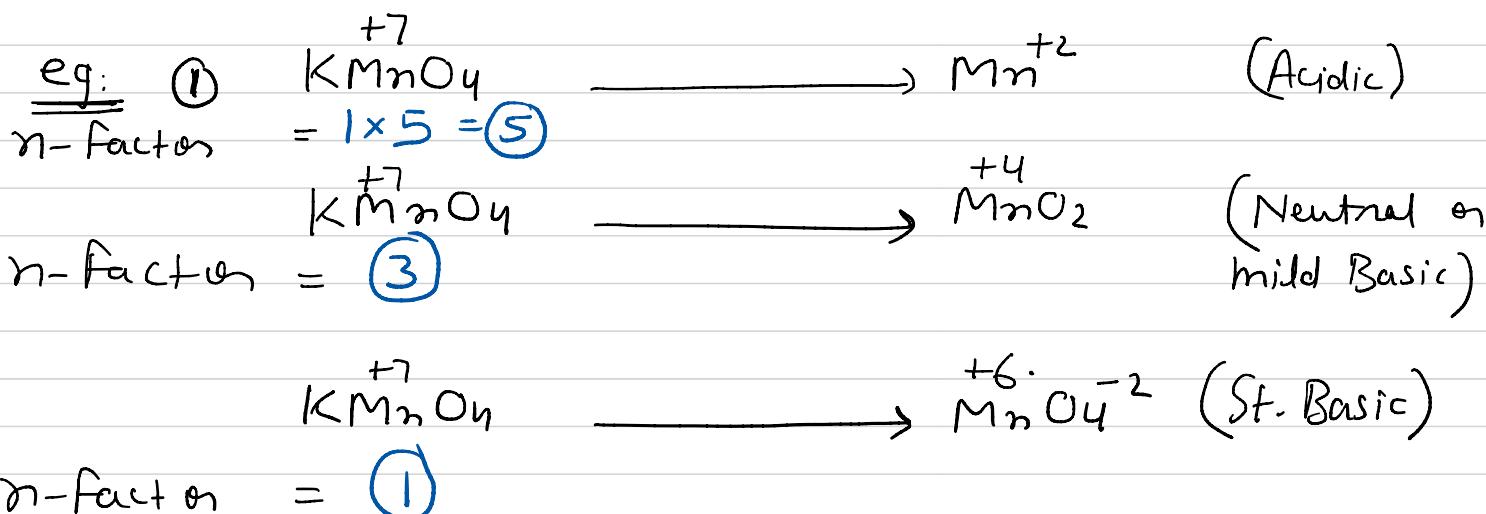
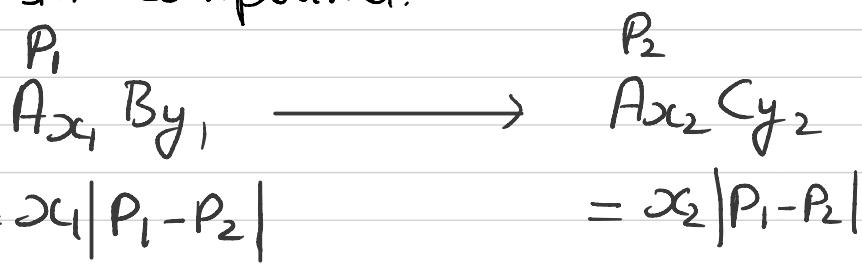
Redox Titrations TOV_TLV 21-22

② Redox rxn :-

Net charge of e^- per mole of component is called n-factor.

Case-1

When O.N. of only one element is changing in compound.

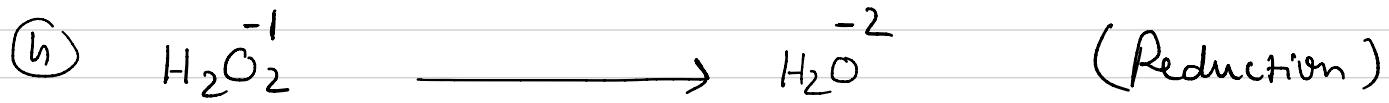




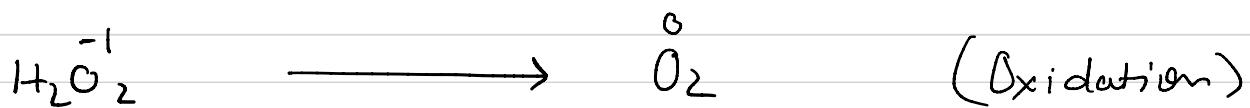
$$n\text{-factor} = 2 \times 3 = \textcircled{6}$$



$$n\text{-factor} = 2 \times 1 = \textcircled{2}$$



$$n\text{-factor} = \textcircled{2}$$



$$n\text{-factor} = \textcircled{2}$$



$$n\text{-Factor} = 2 \times 0.5 = 1$$



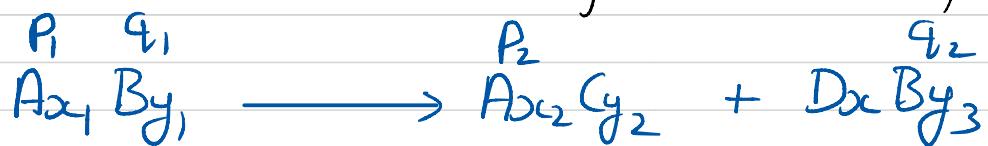
$$n\text{-factor} = \textcircled{6}$$



$$n\text{-factor} = \textcircled{2}$$

Case-2 When ON. of more than one elements are changing,

All are either oxidizing or reducing.



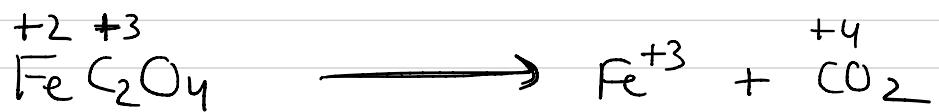
$$n\text{-factor} = x_1|P_1 - P_2| + y_1|Q_1 - Q_2|$$

Given : $P_1 > P_2$ and $Q_1 > Q_2$

Or $P_1 < P_2$ and $Q_1 < Q_2$



n -factor: $2 \times 1 + 6 = 8$



n -factor = $1 + 2 \times 1 = 3$



n -factor = $1 + 2 \times 5 = 11$

Illus 1. Calculate the number of moles of KMnO_4 which will react with 180 gm $\text{H}_2\text{C}_2\text{O}_4$ according to given reaction



and also calculate the volume of CO_2 produced at STP.

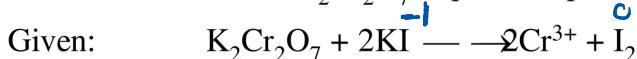
[Ans. $n = 4/5$, $V = 90.8$]

$$\begin{aligned}\text{Eq of } \text{KMnO}_4 &= \text{Eq of } \text{H}_2\text{C}_2\text{O}_4 = \text{Eq of } \text{CO}_2 \\ n \times 5 &= \left(\frac{180}{90}\right) \times 2 = n_{\text{CO}_2} \times 1\end{aligned}$$

$$n = \frac{4}{5} \text{ mol}$$

$$\begin{aligned}n_{\text{CO}_2} &= 4 \text{ mol} \\ V_{\text{CO}_2} &= 4 \times 22.7 = 90.8 \text{ lit}\end{aligned}$$

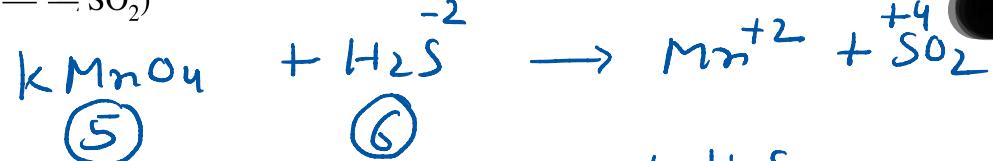
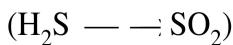
Illus 2. Calculate the mass of $\text{K}_2\text{Cr}_2\text{O}_7$ required to produce 254 gm I_2 from KI solution ($M=294$, 127)



[Ans. 98gm]

$$\begin{aligned}\text{Eq of } \text{K}_2\text{Cr}_2\text{O}_7 &= \text{Eq of } \text{I}_2 \\ \left(\frac{m}{294}\right) \times 6^3 &= \left(\frac{254}{254}\right) \times 2 \Rightarrow m = 98 \text{ gm}\end{aligned}$$

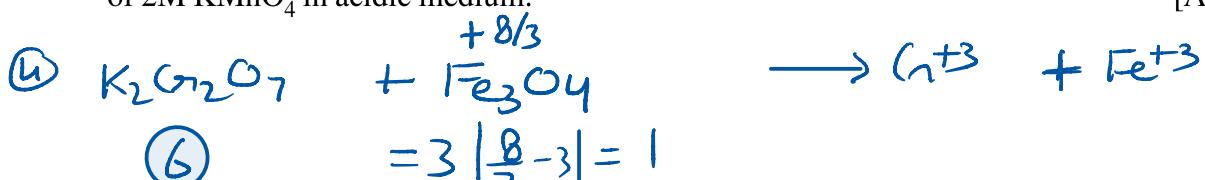
Illus 3. Calculate volume of 0.05M KMnO_4 which will react with 50 ml of 0.1M H_2S in acidic medium



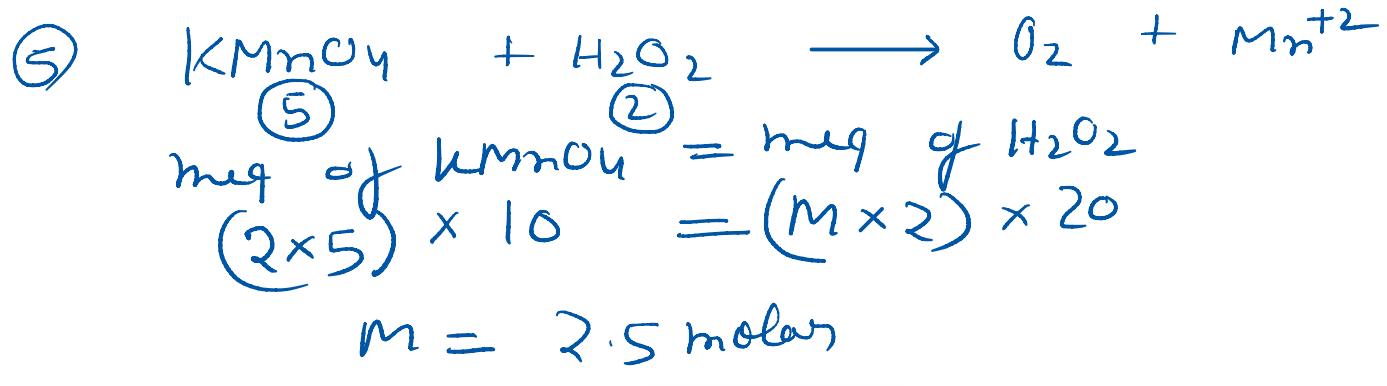
$$\begin{aligned}\text{Eq of } \text{KMnO}_4 &= \text{Eq of } \text{H}_2\text{S} \\ (0.05 \times 5) \times V_{\text{ml}} &= (0.1 \times 6) \times 50 \text{ ml} \\ V_{\text{ml}} &= \frac{6}{0.05} = 120 \text{ ml}\end{aligned}$$

Illus 4. Calculate mass of Fe_3O_4 if it reacts completely with 25 ml of 0.3 M $\text{K}_2\text{Cr}_2\text{O}_7$ ($M=232$). [Ans 10.44gm]

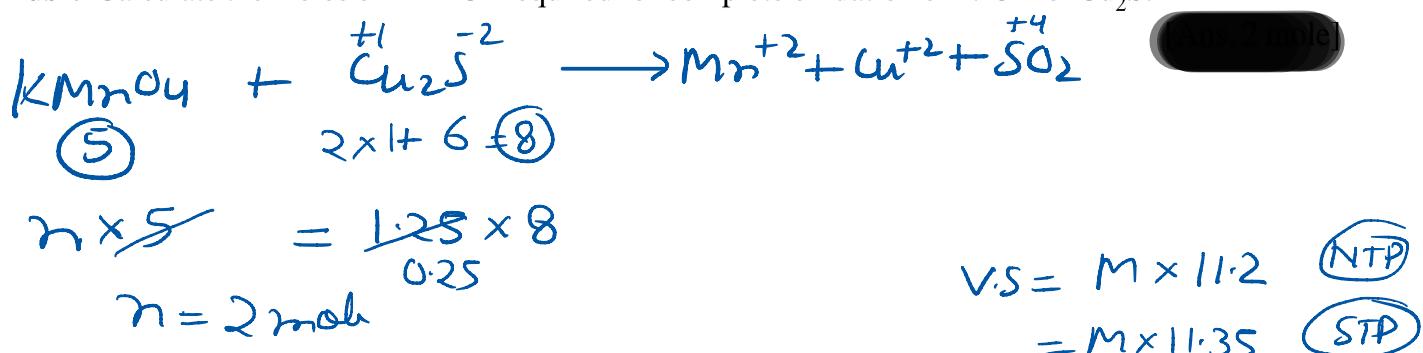
Illus 5. Calculate the concentration of H_2O_2 solution if 20 ml of H_2O_2 solution reacts completely with 10 ml of 2M KMnO_4 in acidic medium. [Ans. 2.5 M]



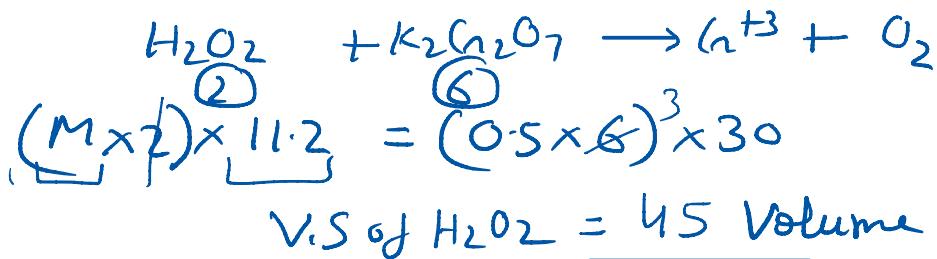
$$\begin{aligned}\text{Eq of } \text{K}_2\text{Cr}_2\text{O}_7 &= \text{Eq of } \text{Fe}_3\text{O}_4 \\ (0.3 \times 6) \times 25 \times \frac{1}{1000} &= \left(\frac{m}{232} \right) \times 1 \Rightarrow m = 10.44 \text{ gm}\end{aligned}$$



Illus7. Calculate the moles of KMnO₄ required for complete oxidation of 1.25 mol Cu₂S.

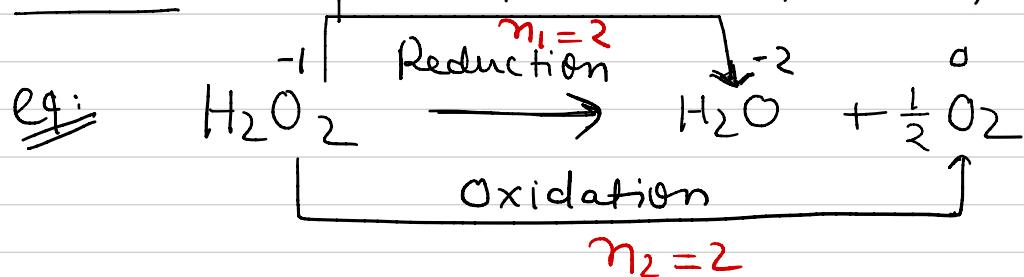


Illus8. Calculate volume strength of H₂O₂ of its 11.2 ml requires 30 ml of 0.5 M K₂Cr₂O₇

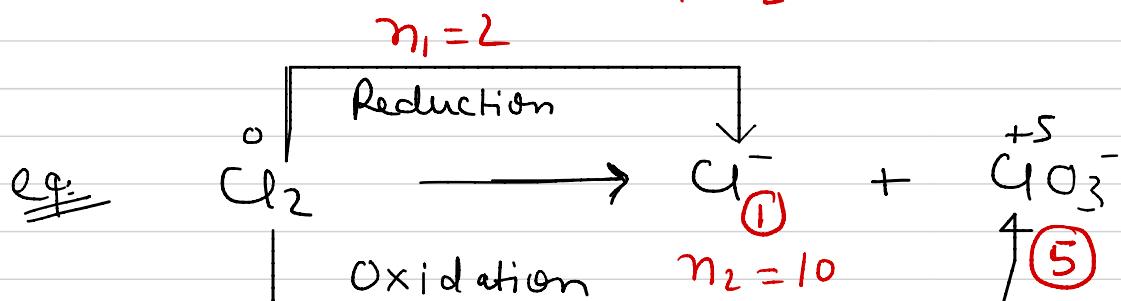


Redox Titrations TOV_TLV 21-22(1)

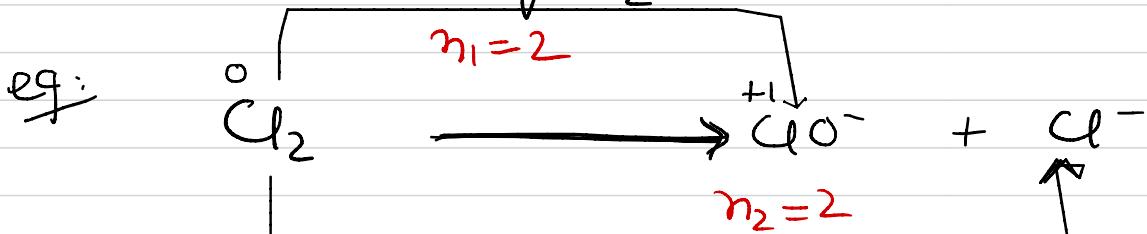
Case-3 Disproportionation Rxn



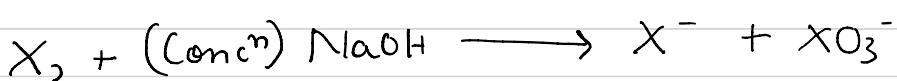
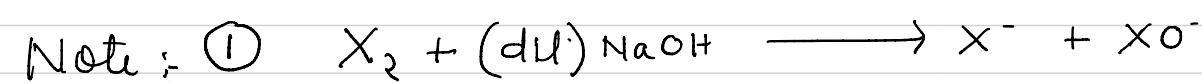
$$n\text{-factor of H}_2\text{O}_2 = \frac{n_1 n_2}{n_1 + n_2} = \frac{2 \times 2}{2+2} = 1$$



$$n\text{-factor of Cl}_2 = \frac{2 \times 10}{2+10} = \frac{20}{12} = (5/3)$$

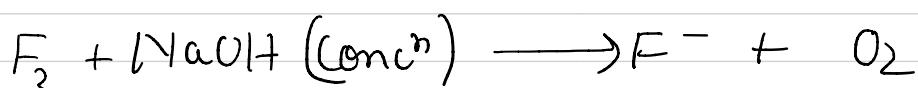
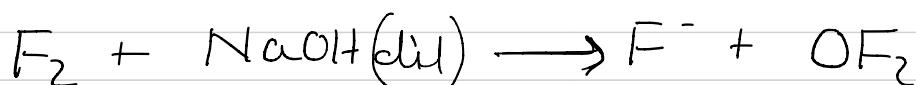


$$n\text{-factor of Cl}_2 = \frac{2 \times 2}{2+2} = 1$$

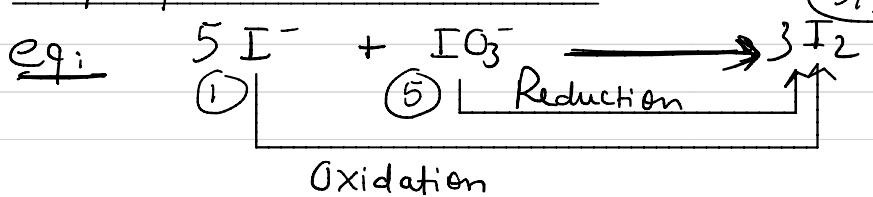


②

exception :-



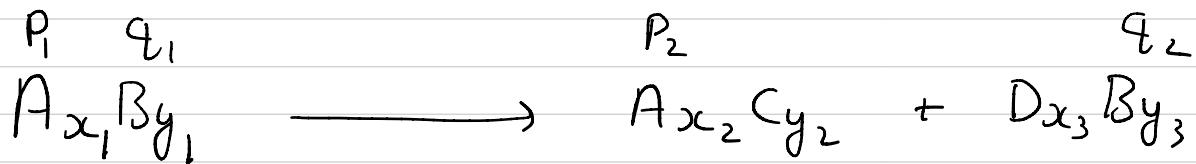
③ Comproportionation Rxn :



(5/3)

Case-4 When some elements are oxidizing and some are reducing in compound

(a) When e^- released in Oxidation are equal to e^- accepted in reduction



$$\text{given } P_1 > P_2 \quad \& \quad q_1 < q_2$$

$$\text{or } P_1 < P_2 \quad \& \quad q_1 > q_2$$

$$q_j \quad x_1 | P_1 - P_2 | = y_1 | q_1 - q_2 |$$

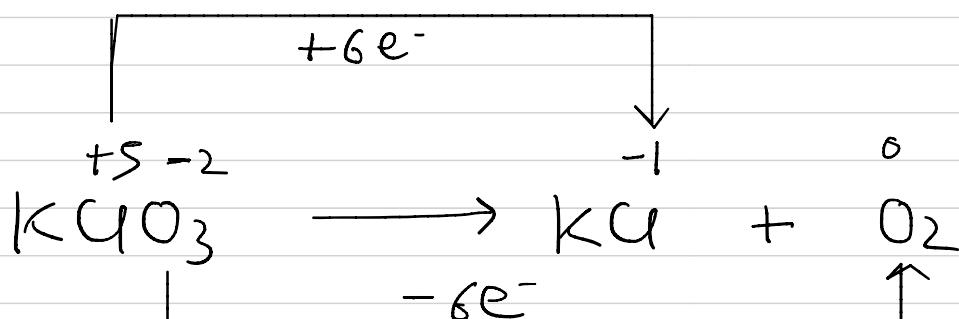
$$n\text{-Factor } A_{x_1}B_{y_1} = x_1 | P_1 - P_2 | = y_1 | q_1 - q_2 |$$

(b) When e^- released in oxidation are not equal to e^- accepted in reduction

$$q_j \quad x_1 | P_1 - P_2 | \neq y_1 | q_1 - q_2 |$$

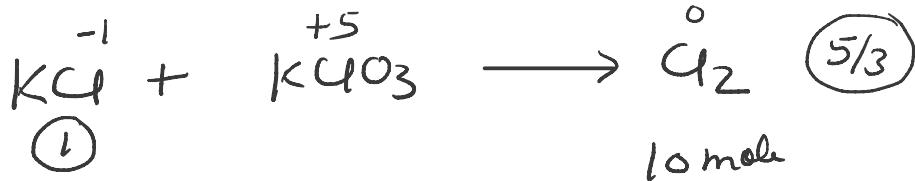
$$n\text{-Factor of } A_{x_1}B_{y_1} = | x_1 | P_1 - P_2 | - y_1 | q_1 - q_2 |$$

eg:



$$n\text{-Factor of KClO}_3 = 6$$

Illus6. Calculate the moles of KCl required to produce 10 mol Cl₂ by the reaction with KClO₃.



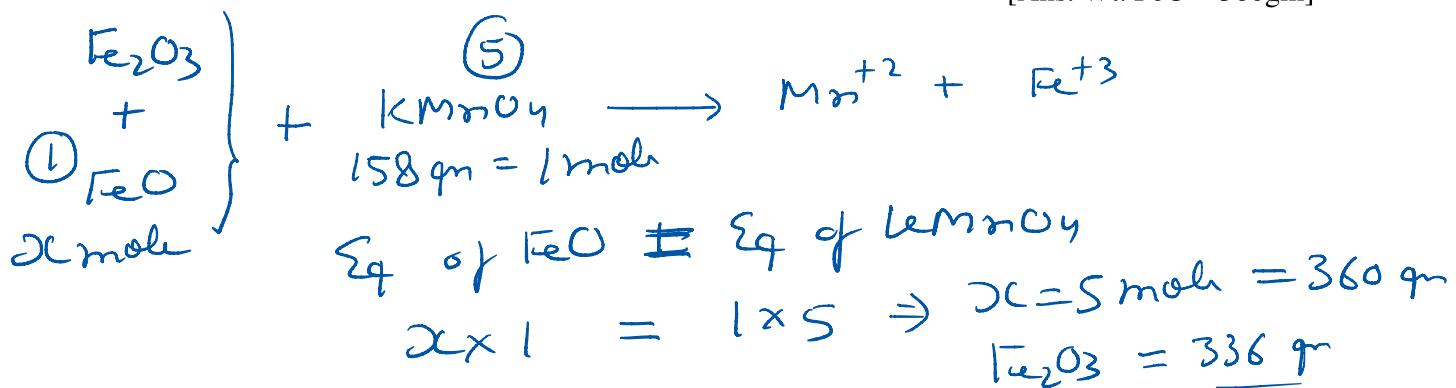
$$\text{Eq of KC}\text{l} = \text{Eq of C}\text{l}_2$$

$$n \times 1 = 10 \times \frac{5}{3} \Rightarrow n = \frac{50}{3} \text{ mole}$$

[Ans. 10.00 mole]

Illus9. 696 gm mixture of Fe₂O₃ & FeO reacts completely with 158 gm KMnO₄ in acidic medium. Calculate the composition of the mixture by moles.(M=72,160)

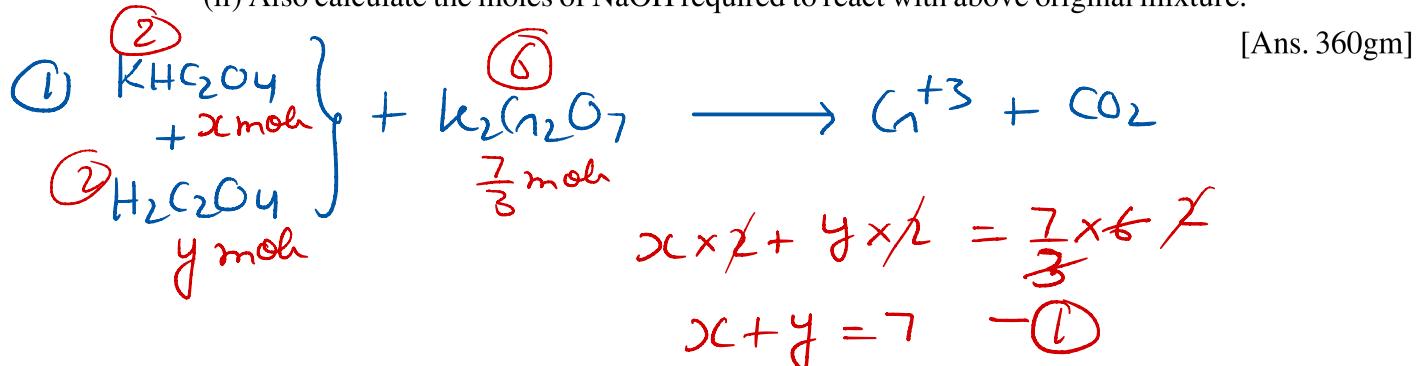
[Ans. Wt. FeO = 360gm]



Illus10.(i) 820 gm mixture of KHC₂O₄ and H₂C₂O₄ reacts completely with 7/3 moles of K₂Cr₂O₇, calculate moles of each in mixture.(M=90,128)

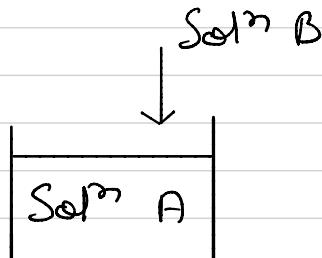
[Ans. 640, 180] gm

(ii) Also calculate the moles of NaOH required to react with above original mixture.

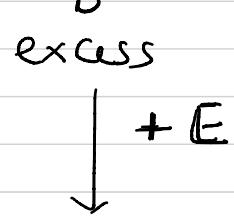


[Ans. 360gm]

Different type of titration:-



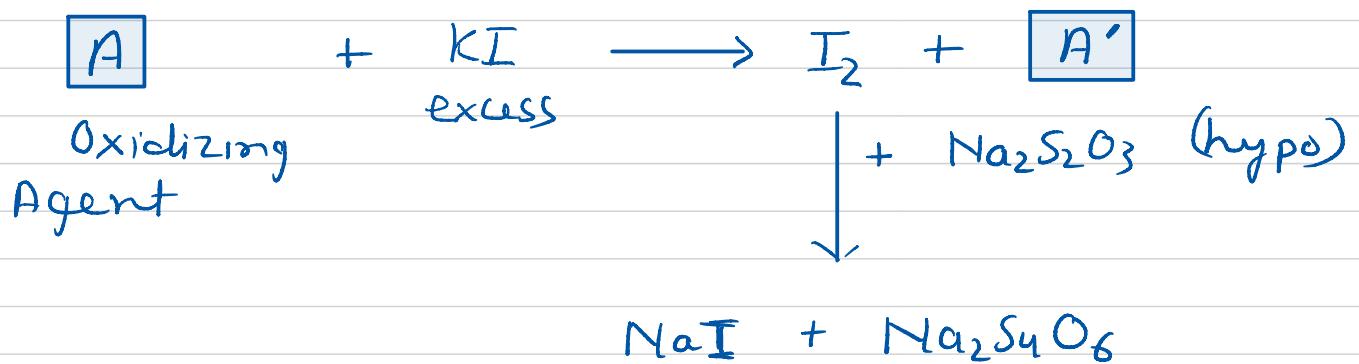
① Back titration:-



$$\begin{aligned}\text{Eq of } A &= \text{Eq of } B(\text{Used}) \\ &= \text{Eq of } B - \text{Eq of } B(\text{remain})\end{aligned}$$

$$\text{Product Eq of } A = \text{Eq of } B - \text{Eq of } E$$

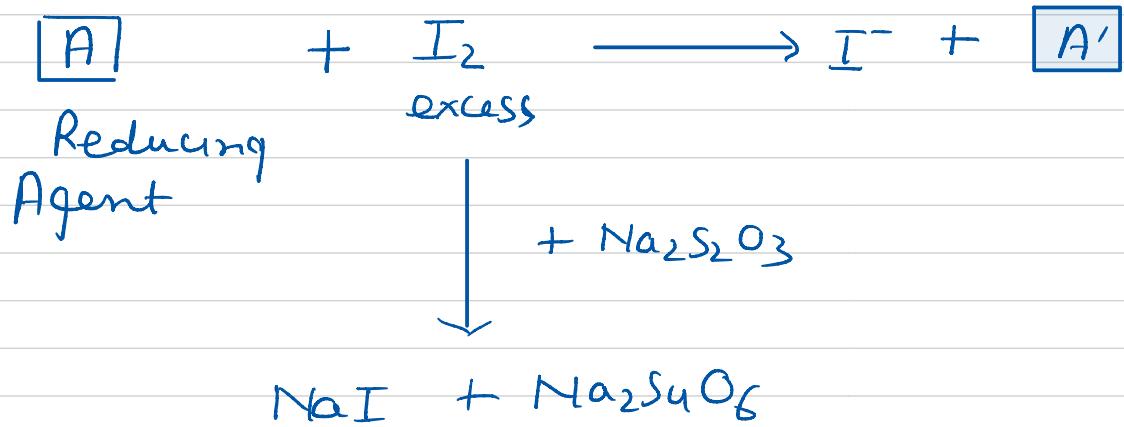
② Iodometric titration:-



$$\text{Eq of } A = \text{Eq of } KI(\text{Used}) = \text{Eq of } I_2 = \text{Eq of } Na_2S_2O_3$$

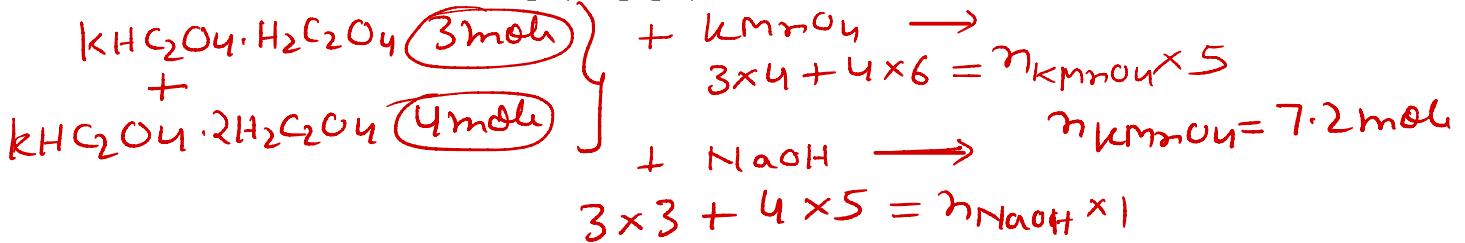
$$\Rightarrow \text{Eq of } A = \text{Eq of } Na_2S_2O_3 (\text{hypo})$$

③ Iodimetric titration :-



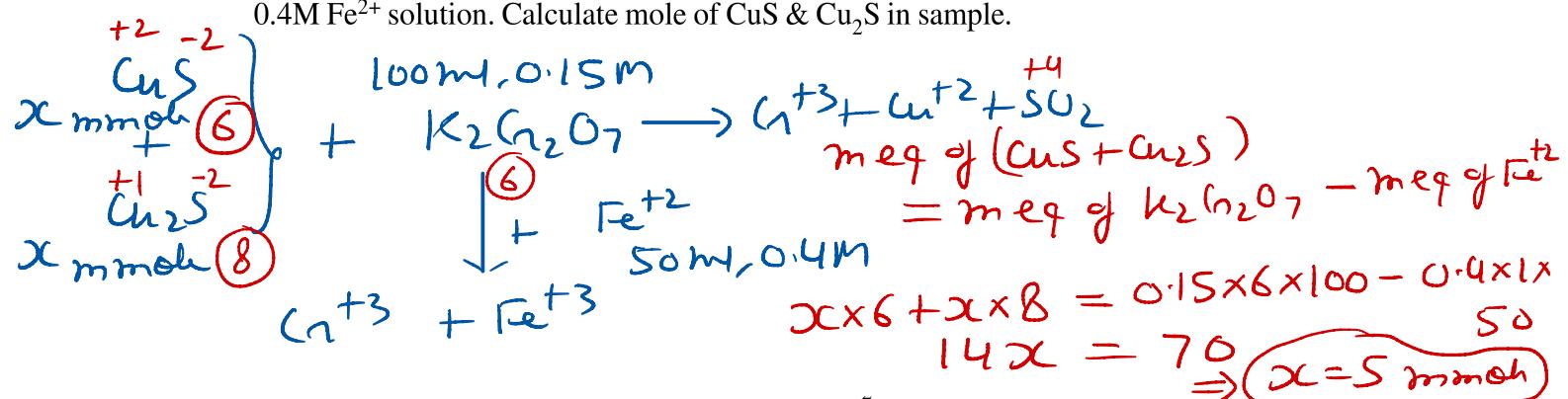
$$\text{Eq of A} = \text{Eq of I}_2 - \text{Eq of Na}_2\text{S}_2\text{O}_3$$

Illus11. Calculate the moles of KMnO_4 & NaOH required to react with a mixture of 3 mol $\text{KHC}_2\text{O}_4 \cdot \text{H}_2\text{C}_2\text{O}_4$ & 4 mol $\text{KHC}_2\text{O}_4 \cdot 2\text{H}_2\text{C}_2\text{O}_4$. ans: 7.2 mole, 29 mole

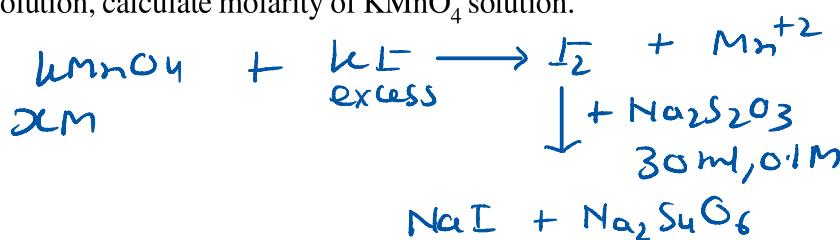


Illus12. A mixture of FeO and Fe_2O_3 is reacted with acidified KMnO_4 solution having a concentration of 0.2M, 100ml of which was used. The solution was then titrated with Zn dust which converted Fe^{3+} of the solution of Fe^{2+} . The Fe^{2+} required 1000 ml of 0.1 M $\text{K}_2\text{Cr}_2\text{O}_7$ solution. Find the % of FeO & Fe_2O_3 . Ans: x=100 mmole, y=250 mmole

Illus13. A mixture containing equal moles of CuS and Cu_2S was treated with 100mL of 0.15 M $\text{K}_2\text{Cr}_2\text{O}_7$. The products obtained were Cr^{3+} , Cu^{2+} and SO_2 . The excess oxidant was reacted with 50 mL of 0.4M Fe^{2+} solution. Calculate mole of CuS & Cu_2S in sample.



Illus14. 50 ml KMnO_4 is mixed completely with excess KI. The I_2 liberated required 30 ml of 0.1M $\text{Na}_2\text{S}_2\text{O}_3$ solution, calculate molarity of KMnO_4 solution.



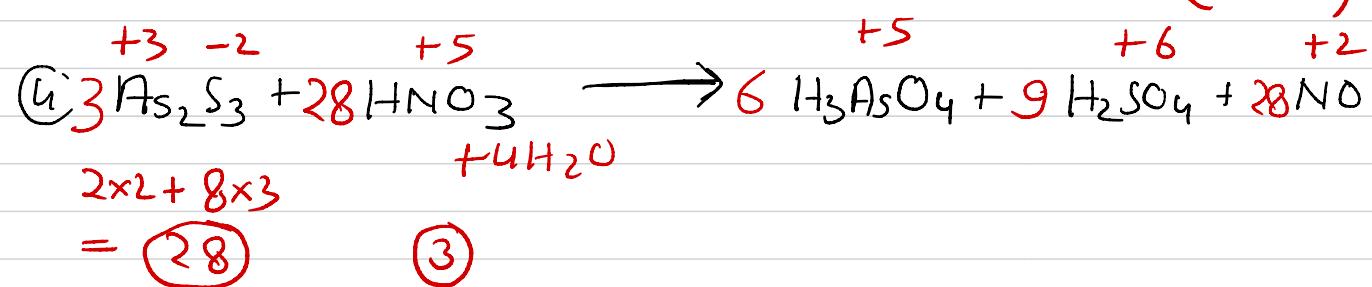
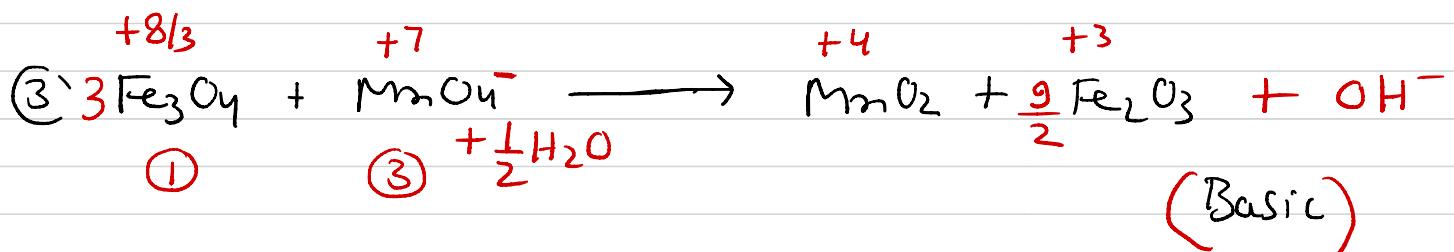
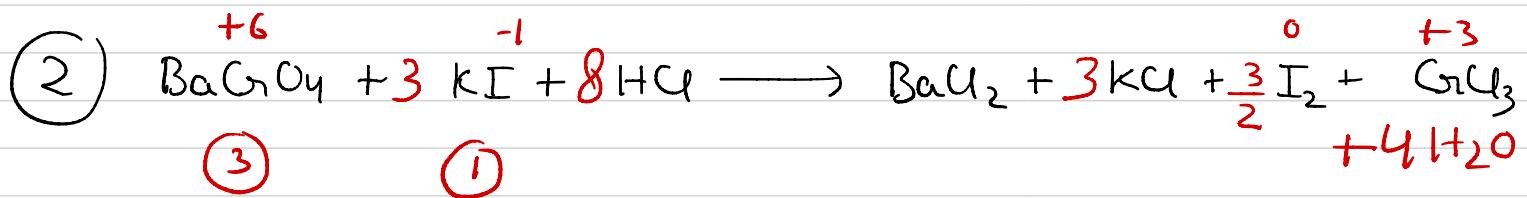
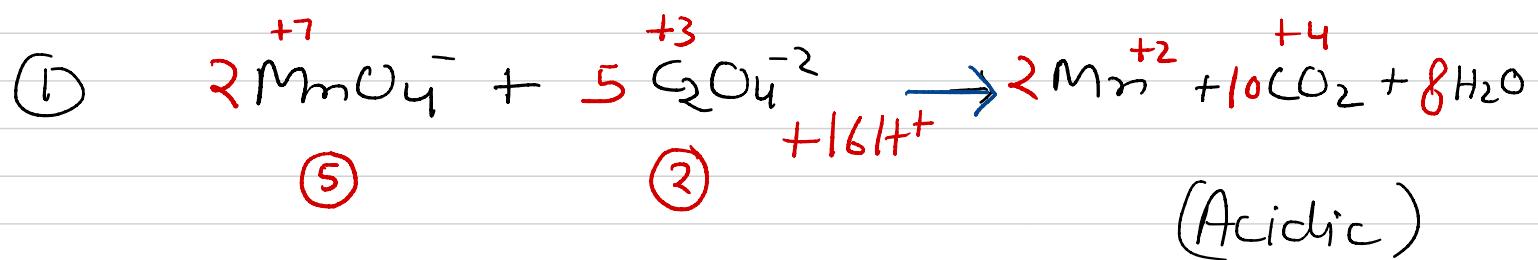
$$\begin{aligned} x \times 5 \times 50 &= 0.1 \times 1 \times 30 \\ x &= \frac{3}{250} \text{ M} \\ &= 0.012 \text{ M} \end{aligned}$$

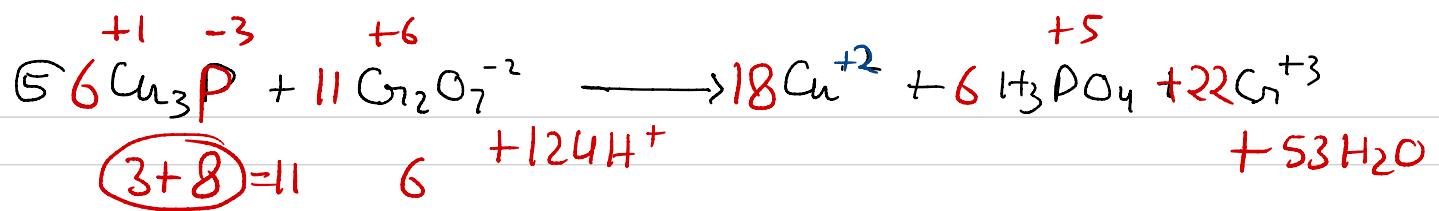
Illus15. Certain amount of KIO_3 was mixed with excess KI solution. The liberated I_2 was titrated with 50 ml, 0.2M $\text{Na}_2\text{S}_2\text{O}_3$ solution, calculate moles of KIO_3 mixed.

Redox Titrations TOV_TLV 21-22(2)

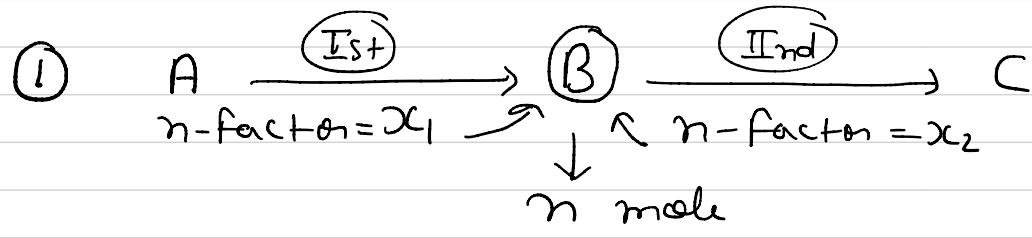
Balancing of Redox rxn :

- Identify the components oxidizing and Reducing.
- Calculate No of moles of e^- exchanged by these components
- Equate No of e^- exchanged by components by multiplying some coeff.
- Balance element involve in oxidation/reduction on product side.
- Balance other elements using observation.
- Balance charge using H^+ in acidic medium, using OH^- in basic medium.
- Balance H and O using H_2O





Limitation of Law of Equivalence :-



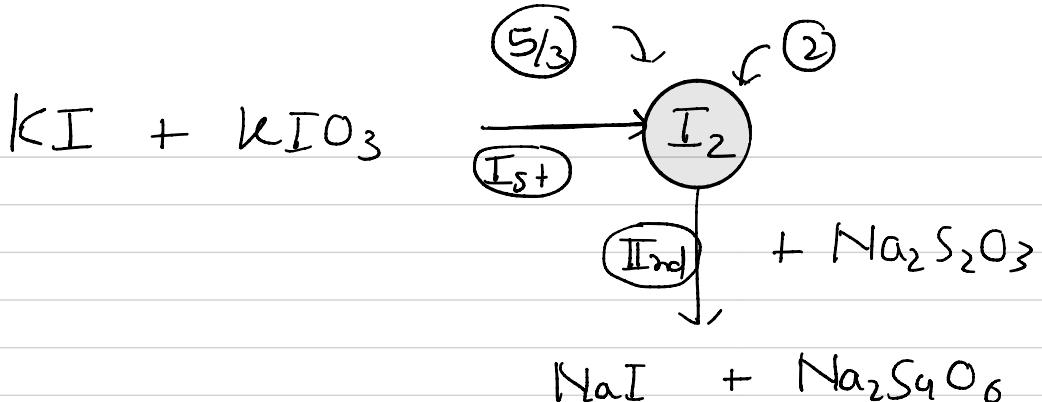
$$\text{Eq of A} = \text{Eq of B} = \text{Eq of C} \quad \times$$

$$\text{Eq of B} = n \times x_1 \neq n \times x_2$$

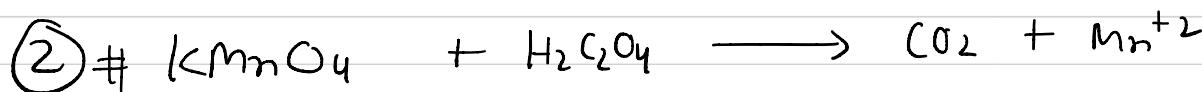
(a) $\text{Eq of A} = \text{Eq of B} \quad \checkmark$
 $= n \times x_1$

(b) $\text{Eq of B} = \text{Eq of C} \quad \checkmark$
 $n \times x_2 =$

eq:



$$\text{Eq of } KI = \text{Eq of } I_2 = \text{Eq of } Na_2S_2O_3 \times$$



Acid

$x N$ (given)

$$y_m \times 5 = x_N \Rightarrow y = \left(\frac{x}{5}\right) M$$



$x N \times$

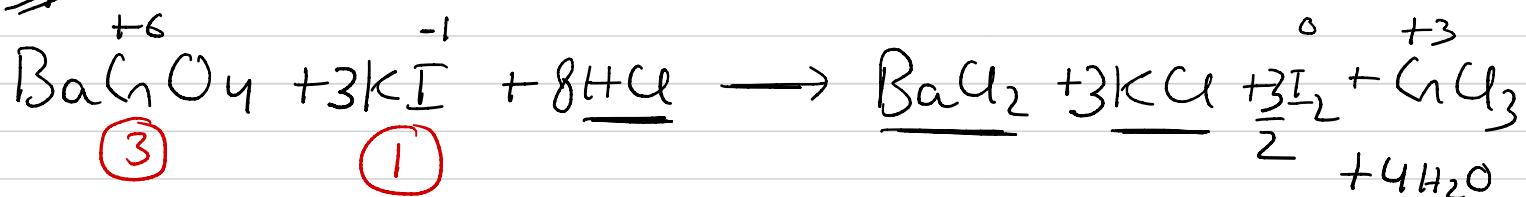
Neutral

$$y_m = \left(\frac{x}{5}\right) M \checkmark$$

$$\text{Normality} = \frac{3x}{5} N \checkmark$$

Case-5 n-factor of non-Redox components in Redox rxn.

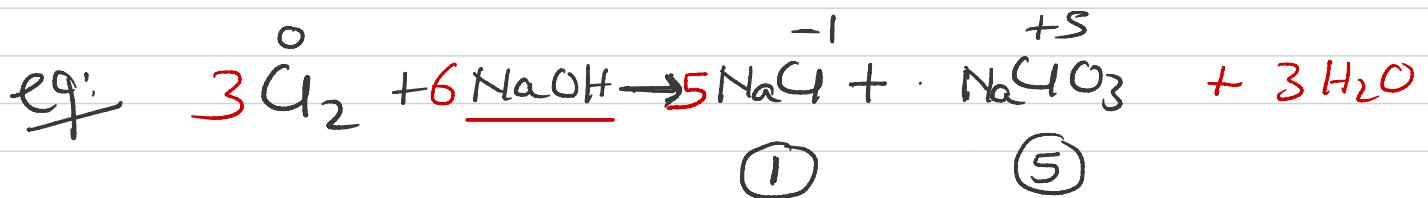
eg:



$$\text{Eq of Ba}(\text{CrO}_4) = \text{Eq of KI} = \text{Eq of HCl}$$

$$1 \times 3 = 3 \times 1 = 8 \times \text{n-factor}$$

$$\text{n-factor (HCl)} = (3/8)$$

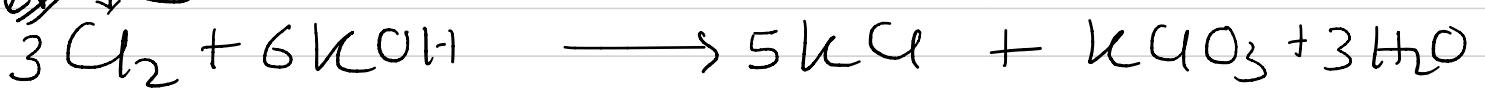


$$\text{Eq of Cr}_2 = \text{Eq of NaOH} = \text{Eq of NaCl}$$

$$3 \times \frac{5}{3} = 6 \times \text{n-factor} = 5 \times 1$$

$$\text{n-factor (NaOH)} = (5/6)$$

eg: ↓ $\text{Cr}_2^{\textcircled{5/3}}$

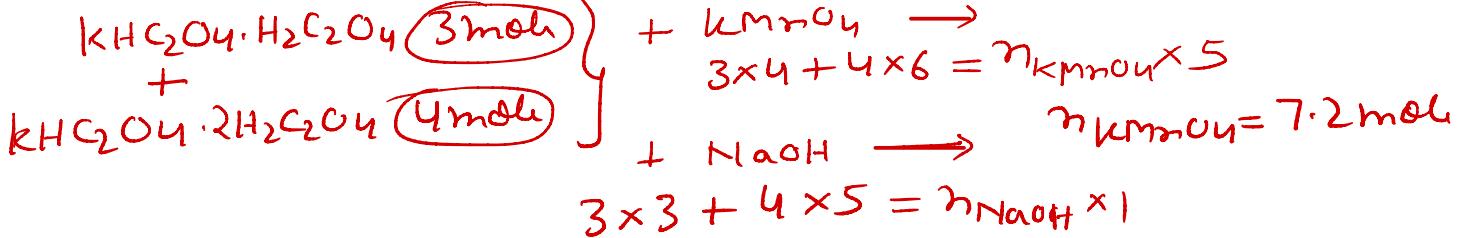


$$3 \times \left(\frac{5}{3}\right) = 6 \times \text{n-factor of KOH} = 5 \times 1 = 1 \times 5 = 3 \times \text{n-factor}$$

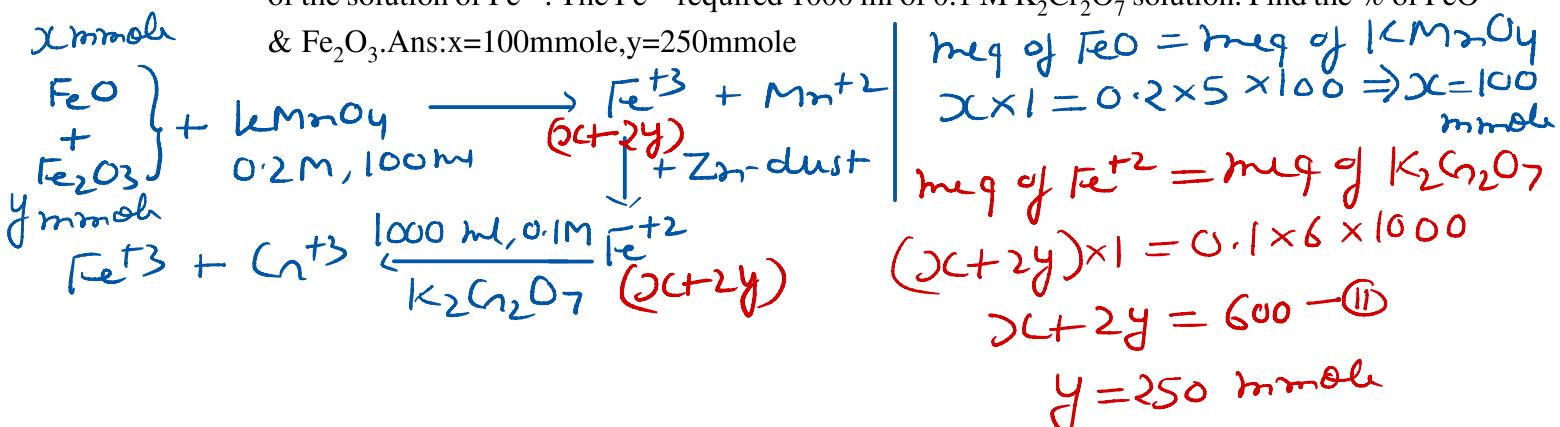
Redox Titrations TOV_TLV 21-22(3)

Illus11. Calculate the moles of KMnO_4 & NaOH required to react with a mixture of 3 mol $\text{KHC}_2\text{O}_4 \cdot \text{H}_2\text{C}_2\text{O}_4$

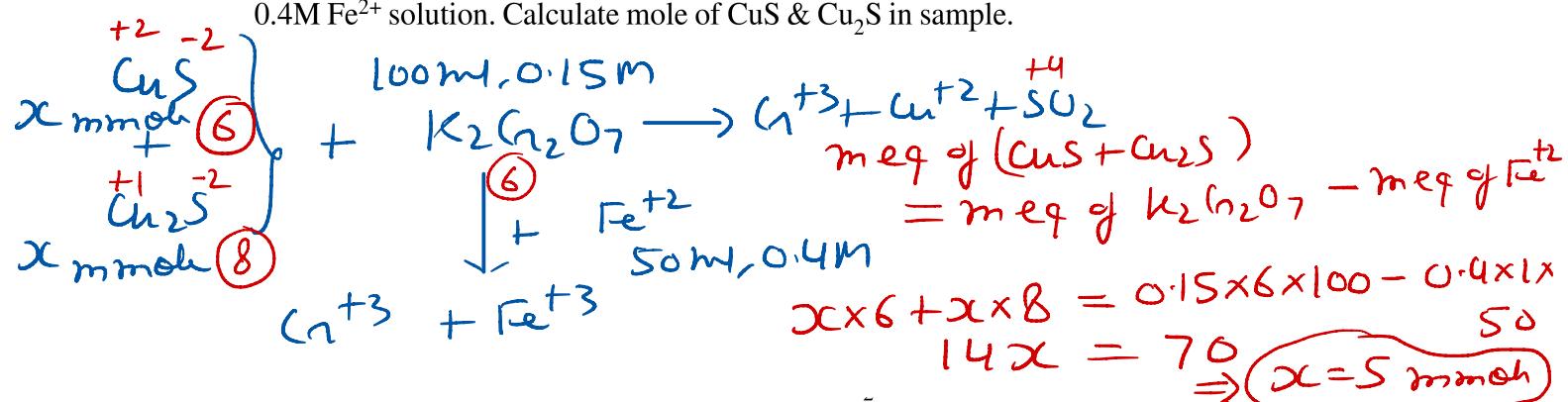
& 4 mol $\text{KHC}_2\text{O}_4 \cdot 2\text{H}_2\text{C}_2\text{O}_4$. Ans: 7.2 mole, 29 mole



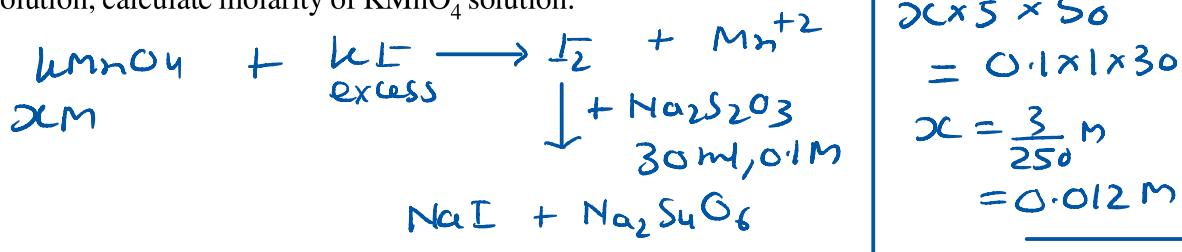
Illus12. A mixture of FeO and Fe_2O_3 is reacted with acidified KMnO_4 solution having a concentration of 0.2M, 100ml of which was used. The solution was then titrated with Zn dust which converted Fe^{3+} of the solution of Fe^{2+} . The Fe^{2+} required 1000 ml of 0.1 M $\text{K}_2\text{Cr}_2\text{O}_7$ solution. Find the % of FeO & Fe_2O_3 . Ans: $x=100$ mmole, $y=250$ mmole



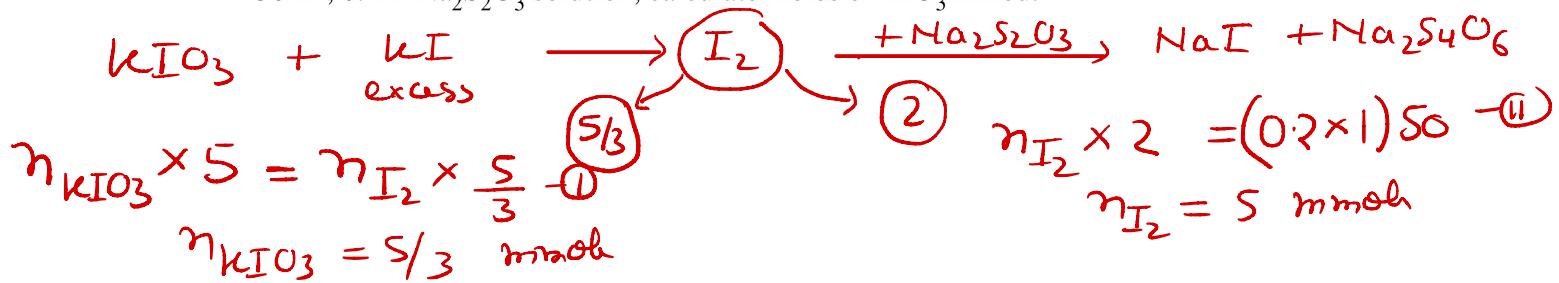
Illus13. A mixture containing equal moles of CuS and Cu_2S was treated with 100mL of 0.15 M $\text{K}_2\text{Cr}_2\text{O}_7$. The products obtained were Cr^{3+} , Cu^{2+} and SO_2 . The excess oxidant was reacted with 50 mL of 0.4M Fe^{2+} solution. Calculate mole of CuS & Cu_2S in sample.



Illus14. 50 ml KMnO_4 is mixed completely with excess KI. The I_2 liberated required 30 ml of 0.1M $\text{Na}_2\text{S}_2\text{O}_3$ solution, calculate molarity of KMnO_4 solution.



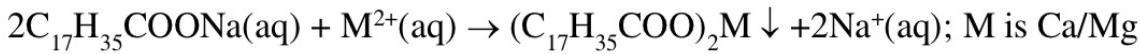
Illus15. Certain amount of KIO_3 was mixed with excess KI solution. The liberated I_2 was titrated with 50 ml, 0.2M $\text{Na}_2\text{S}_2\text{O}_3$ solution, calculate moles of KIO_3 mixed.



Hardness of water :

Hard water does not give lather with soap. Water free from soluble salts of calcium and magnesium is called **Soft water**. It gives lather with soap easily.

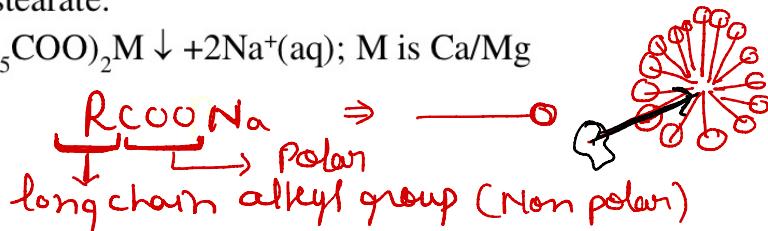
Hard water forms scum/precipitate with soap. Soap containing sodium stearate ($C_{17}H_{35}COONa$) reacts with hard water to precipitate out Ca/Mg stearate.



Hardness of water is of two types

(a) Temporary Hardness

(b) Permanent Hardness

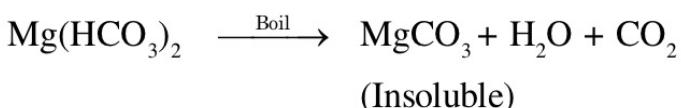
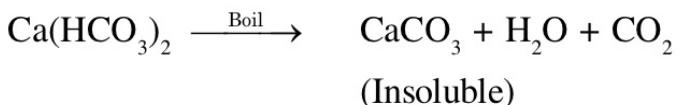


Temporary Hardness :- This is due to presence of bicarbonate of calcium and magnesium. Rain water dissolves a small quantities of CO_2 from the atmosphere forming a very dilute solution of carbonic acid.

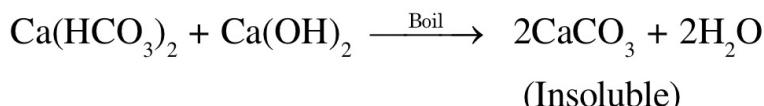
This water attacks Ca and Mg carbonate in any rock



Temporary hardness in water is easily removed by boiling, as the bicarbonates decomposes readily and the insoluble carbonates are precipitated.

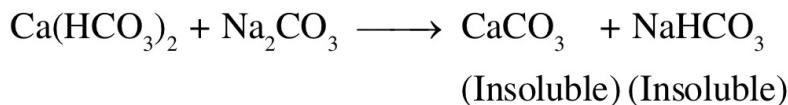


Temporarily hardness can also be removed by clark's process which involves the addition of slaked lime $Ca(OH)_2$



Permanent Hardness :- Permanent hardness is due to presence of sulphates and chlorides of both calcium and magnesium. This type of hardness cannot be removed by boiling or by $Ca(OH)_2$; Substance used to remove the hardness of water are known as water softener. These various water softeners are -

(i) **Washing soda** :- It removes both the temporary and permanent hardness by converting soluble Ca and Mg compounds into insoluble Carbonates.



(ii) **Permutit:** Permutit is technical name given to certain hydrated silicates of aluminium and sodium or sodium alumunium orthosilicate or sodium zeolite.

Example : $\text{Na}_2\text{Al}_2\text{Si}_2\text{O}_8 \times \text{H}_2\text{O}$ or Na_2Z

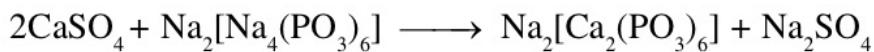


These ions can be re-exchanged by treating it with brine (NaCl) solution.



This method is useful for the removal of both temporary and permanent hardness of water.

(iii) **CALGON:** Tlie complex salt of metaphosphoric acid, sodium hexametaphosphate ($\text{Na}_4(\text{PO}_3)_6$) is called Calgon. It is represented as $\text{Na}_2[\text{Na}_4(\text{PO}_3)_6]$.



(iv) **Ion exchange Resins:-** Ion exchange resins are the most popular water softener thease days. This resins are synthetic substance. The cation exchanger consists of granular insoluble organic acid resins having giant molecules with $-\text{SO}_3\text{H}$ or $-\text{COOH}$ groups while the anion exchanges contains giant organic molecules with basic groups derived from amine. Ion exchange resins removes all soluble mineral from water.

Hard water \longrightarrow [] \longrightarrow [] \longrightarrow Pure water

Cation exchanger

Remove cation like

Na^+ , Mg^{2+} or Ca^{2+}

and furnish H^+

Anion

Cation exchanger

Remove anion like

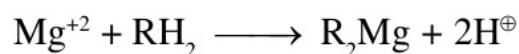
SO_4^{2-} , Cl^- or NO_3^+

and furnish OH^-

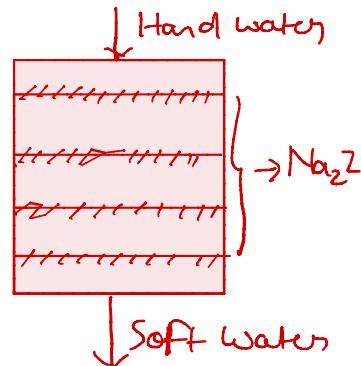


The water coming from cation exchanger is acidic due to H^{\oplus} . This water is then passed through another bed containing anion exchanger. This exchanger removes anion like Cl^- , SO_4^{2-} , NO_3^- by exchanging with OH^- ions.

Reaction at Cation exchanger :



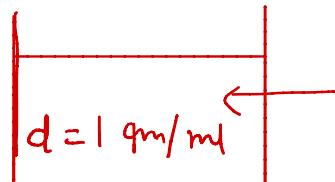
Reaction at Anion exchanger :



Degree of Hardness :-

PPM of CaCO_3

Eq:



$$\text{Ca}(\text{HCO}_3)_2 = 2 \times 10^{-3} \text{ mole} = n_{\text{Ca}^{+2}}$$

$$\text{MgSO}_4 = 5 \times 10^{-3} \text{ mole} = n_{\text{Mg}^{+2}}$$

Eq of Ca Salt + Eq of Mg Salt = Eq of CaCO_3

$n_{\text{Ca}^{+2}} + n_{\text{Mg}^{+2}} \equiv n_{\text{CaCO}_3}$

$$\Rightarrow n_{\text{CaCO}_3} = 7 \times 10^{-3} \text{ mole} \equiv 0.7 \text{ gm}$$

$$\Rightarrow 5 \text{ lit water} \equiv 5000 \text{ gm}$$

PPM of $\text{CaCO}_3 = \frac{0.7}{5000} \times 10^6 = \frac{700}{5} = 140 \text{ ppm}$

$$\Rightarrow \text{Degree of Hardness} = \underline{140}$$