Experiment - 3

* Experiment on softening of hard water using Lime Soda process.

→ Objective :- To estimate amount of lime and soda required to soften the given hard water sample and to check for the removal of hardness in given sample.

→ Principle :- The lime soda process involves the chemical conversion of all the soluble hardness causing salts by addition of soda [Na_2CO_3] & lime [$Ca(OH)_2$] into insoluble precipitates which can be easily removed by settling & filtration. As lime in the form of lime water is added to hard water, the pH of water sample is raised & equilibrium of carbonate species present in water is shifted. Dissolved CO_2 is changed into HCO_3^- and then CO_2^{3-}. This causes calcium carbonate to precipitate because it exceeds the solubility product. Additionally Magnesium can be precipitated as Magnesium Hydroxide in a double displacement reaction.

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In this process both the Calcium as well as Calcium added with lime are precipitated. The chemical reactions involved in lime soda process are :

(i) Lime for removal of temporary hardness

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O$

$Mg(HCO_3)_2 + 2Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + 2CaCO_3 + 2H_2O$

(ii) Lime for removal of permanent Magnesium hardness

$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaCl_2$

$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaSO_4$

(iii) Lime for removal of dissolved CO_2

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 \downarrow + H_2O$

(iv) Soda for removal of complete Calcium permanent hardness

$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + NaCl$

$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + NaSO_4$

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→ Observations & Calculations

100 parts by mass of $CaCO_3$ are equivalent to:

i) 74 part of $Ca(OH)_2$
ii) 106 part of Na_2CO_3

↝ Lime required for softening

$$= \frac{74}{100}\left[Ca^{+2} + 2 \times \text{Temp } Mg^{2+} + \text{Perm } (Mg^{+2} + Fe^{+2} + Al^{+3}) + CO_2 + H^+ (HCl \text{ or } H_2SO_4) - NaAlO_2 + HCO_3^-\right]$$

↝ Soda required for softening

$$= \frac{106}{100}\left[\text{Perm.}\ (Ca^{+2} + Mg^{+2} + Fe^{+2} + Al^{+3}) + H^+ - HCO_3^-\right]$$

→ Hardness of sample before treatment

Sr. No	Vol of H_2O (ml)	Burette Reading		Vol of EDTA consumed (ml)	Avg burette reading (ml)
		Initial	Final		
1	10	30.2	37.1	6.9	
2	10	37.1	43.5	6.4	6.5
3	10	39.8	46	6.2	

Before treatment Hardness = 700 ppm

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→ Hardness of water after lime soda treatment

Sr. No.	Vol of treated H_2O (ml)	Burette Reading		Vol of EDTA consumed (ml)	Avg reading (ml)
		Initial	Final		
1	10	18.3	23.2	4.9	
2	10	23.2	28.3	5.1	5.2
3	10	28.3	34.9	5.6	

After Treatment Hardness

→ Result

- Hardness of water before lime-soda treatment = 700 mg/L
- Hardness of water after lime-soda treatment = 500 mg/L

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