LIME – SODA CALCULATION

L=90%, S=85%, Vol of Water 1 million litreL&S Required   ?

Lime = 74/100 ($Ca(HCO_3)_2$ + 2x $Mg(HCO_3)_2$ + $MgCl_2$ + OH^-)X Purity Factor xVol Of Water x $1/10^6$ Kg

= 74/100 (5 + 2x10 + 10) 100/90 x 10^6 x $1/10^6$ Kg

S. NO.	IMPURITIES	AMOUNT (mg/l)	Eq of $CaCO_3$(mg/l)	L /S Req
	RAW WATER			
1.	$Ca(HCO_3)_2$	8.1	100/162X 8.1 = 5	L
2.	$Mg(HCO_3)_2$	14.6	100/146X14.6 = 10	2L
3.	$CaSO_4$	13.6	100/136X13.6 = 10	S
4.	$CaCl_2$	11.1	100/111X11.1 = 10	S
5.	$MgCl_2$	9.5	100/95X9.5 = 10	L+S
	TREATED WATER			
6.	OH^-	3.4	100/34 X 3.4 = 10	L + S
7.	CO_3^{2}	6.0	100/60 X 6 = 10	S

= 74/100 (35) 100/90 Kg

= 28.77 Kg ---------------- Ans

Soda = 106/100 ($CaSO_4$ + $CaCl_2$ + $MgCl_2$+ OH^- + CO_3^{2}) x Purity Factor xVol Of Water x $1/10^6$ Kg

= 106/100 (10 + 10 + 10) 100/85 X 10^6 x $1/10^6$ Kg

=37.41 Kg---------------- Ans

OH^- = Eq of $CaCO_3$

17/1 = 100/2

Eq of $CaCO_3$= Lime $Ca(OH)_2$

100/2 = 74/2

74/100

Eq of $CaCO_3$= Soda (Na_2CO_3)

100/2 = 106/2

106/100

Inpurity	Type	Multiplication factor for Eq of CACO3	L/S Requirement
RAW WATER			
$Ca(HCO_3)_2$	T	100/162	L
$Mg(HCO_3)_2$	T	100/146	**2L**
$CaSO_4$	P	100/136	S
$CaCl_2$	P	100/111	S
$Mg SO_4$	P	100/120	L+S
$MgCl_2$	P	100/95	L+S
$FeSO_4.7H_2O$	C---- P	100/278	L+S
Alum $(Al_2SO_4)_3$	C ----P	100/114	L+S
$NaAlO_2$	C -----P	100/82X2	-L
HCl	A	100/36.5X2	L+S
H_2SO_4	A	100/98	L+S
CO_2	G	100/44	L
H_2S	G	100/34	L
NaCl, KCl	Does not impart hardness	-----	-------
$Ca2^+$	P	100/40	S
$Mg2^+$	P	100/24	L+S
H^+	A	100/ 1X2	L+S
$HCO3^-$	T	100/ 61X2	L, -S
TREATED WATER			
OH^-		100/17X2	L+S
$CO3^{2-}$		100/ 60	S

T = Temporary Hardness

P = Permanent Hardness

C = Coagulant

A = Acid

G = Gas

TREATED WATER

OH^- ---------- L + S

$CO3^{2-}$ ----------- S

$Ca(OH)_2$

(Na_2CO_3)

EDTA NUMERICAL

- One gm of $CaCO_3$ was dissolved in dil. HCl and the solution diluted to one litre.100 mL of this solution required **60 mL** of EDTA solution,
- 100 ml of the sample water required **40 mL** EDTA solution.
- 100 ml of boiled sample water consumed **20 ml** of EDTA solution.
- Determine the total, permanent and temporary hardness in ppm of $CaCO_3$ equivalent.

Soln :

V1 = 60

V2 = 40

V3 = 20

Total Hardness = V2/V1 X 1000 ppm

Perm. Hardness = V3/V1 X 1000ppm

Temp. Hardness = (V2-V3) / V1X 1000 ppm

SKIT

(Estd.-2000)

Swami Keshvanand Institute of Technology, Management & Gramothan

Engineering Chemistry B.Tech. I /II Semester (2020-21)

Chapter 1-WATER

Lecture-4

Calculation of L-S Requirement

Chemical Reaction of L-S

Solved Example

Formula for lime and soda requirement :

As 100 parts by mass of $CaCO_3$ are equivalent to (i) 74 parts of $Ca(OH)_2$ and (ii) 106 parts of Na_2CO_3. (As molecular weight of $Ca(OH)_2$ = 74 and Mg $(OH)_2$ = 10_6)

∴ **Lime requirement**

$$= \frac{74}{100}\Big[\text{Tem. } Ca^{+2} + 2 \times \text{Tem. } Mg^{+2} + \text{Per.}\left(Mg^{+2} + Fe^{+2} + Al^{+3}\right)$$

$$H^{+} + CO_2 + HCO_3^{-} - NaAlO_2\Big]$$ all in terms of $CaCO_3$ eq. × volume of water.

∴ **Soda requirement :**

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

All in terms of $CaCO_3$ equivalent × volume of water.

Table 2.1 : Calcualtion of soda–lime requirement

Constituents	Chemical reactions	Requirement lime/soda	Explanations
$Ca(HCO_3)_2$, ($CaCO_3$) (Temporary Ca hardness)	$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow 2H_2O$	L	It is completely removed, by lime only when reported as $CaCO_3$ consider it as temporary Ca hardness.
$Mg(HCO_3)_2$, ($MgCO_3$) (Temporary Mg hardness)	$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow MgCO_3 + CaCO_3\downarrow + 2H_2O$ $MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaCO_3\downarrow$	L	It is completely removed by lime When reported as $MgCO_3$, consider it as temporary Mg hardness. Since 1 mole requires 2 mole of $Ca(OH)_2$, M.F. (multiplication factors) is $2 \times \frac{100}{146}$
Ca^{2+} ($CaCl_2$, $CaSO_4$, $Cas(NO_3)_2$ (Permanent Ca hardness)	$Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3 + 2Na^+$	S	Ca^{2+} reacts with soda only

Mg^{2+} ($MgCl_2$, $MgSO_4$, $Mg(NO_3)_2$ (permanent Mg hardness)	$Mg^{2+} + Ca(OH)_2 \rightarrow Ca^{2+} + Mg(OH)_2 \xrightarrow{Soda(Na_2CO_3)} CaCO_3 + 2Na^+$	L + S	Mg^{2+} (Permanent hardness) is removed but soluble Ca^{2+} species produced which is removed by soda, therefore, soda and lime bath required.
HCO_3^-	$2HCO_3^- + Ca(OH)_2 \rightarrow CaCO_3 + 2H_2O + CO_3^{2-}$	Only lime but (-) soda	CO_3^{2-} is evolved, for every 1 equivalent of HCO_3^- considered to be 1 equivalent Na_2CO_3, production and hence HCO_3^- to be subtracted from the total requirement of data.
CO_2	$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$	L	It is completely removed by lime

Constituents	Chemical reactions	Requirement lime/soda	Explanations
H_2S	$H_2S + Ca(OH)_2 \rightarrow CaS + 2H_2O$	L	Does not produce hardness but reacts with lime only.
H+ (free acids like HCl, H_2SO_4, etc)	$2H^+ + Ca(OH)_2 \rightarrow Ca^{2+} + 2H_2O$ $Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3 + 2Na^+$	L + S	It reacts with lime to give hardness causing soluble Ca^{2+} species which consume soda. 2 mole of HCl combine with 1 mole of $Ca(OH)_2$, hence M.F. is 100/73
$FeSO_4$ (Coagulant)	$Fe^{2+} + Ca(OH)_2 \rightarrow Ca^{2+} + Fe(OH)_2$ $2Fe(OH)_2 + H_2O + \frac{1}{2}O_2 \rightarrow 2Fe(OH)_3 \downarrow Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3 + 2N_a^+$	L + S	Fe^{2+} reacts with lime and produce Ca^{2+} hardness (permanent) which require soda

$Al_2(SO_4)_3$ (coagulant)	$Al_2(SO_4)_3 + 3\,Ca(OH)_2 \rightarrow 2Al(OH)_3\downarrow + 3CaSO_4$ $3CaSO_4 + 3Na_2CO_3 \rightarrow 3Na_2SO_4 + 3CaCO_3$	L + S	1 mole of $Al_2(SO_4)_3$ reacts with 3 mole of $Ca(OH)_2$ and gives 3 mole $CaSO_4$, M.F. is $3 \times \frac{100}{342}$ or $\frac{100}{114}$ or $\frac{50}{57}$
$NaAlO_2$	$NaAlO_2 + 2H_2O \rightarrow Na^+ + OH^- + Al(OH)_3\downarrow$	(–) amount subtracted from lime (–L)	On hydrolysis give OH^-, which is considered 1 equivalent of $Ca(OH)_2$. Hence lime requirement is diminished by an amount equivalent of OH^- formed.
OH^- (excess of lime in treated water)	$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$ $Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3 + 2Na^+$	L + S	Hence, equivalent amount of OH^- ion is added to the total requirement of $Ca(OH)_2$ and Na_2CO_3
CO_3^{2-}	$Na_2CO_3 \rightarrow 2Na^+ + CO_3^{2-}$	L	Hence equivalent amount of CO_3^{2-} is added to the total requirement of Na_2CO_3.

Example 1 : A water sample has the analytical report as under.

$$MgCO_3 = 84 \text{ mg/L}$$
$$CaCl_2 = 55.5 \text{ mg/L}$$
$$KCl = 20 \text{ mg/L}$$
$$CaCO_3 = 40 \text{ mg/L}$$
$$Mg(NO_3)_2 = 37 \text{ mg/L}$$

Calculate the amount of lime (86% pure) and soda (83% pure) needed for the treatment of 80,000 liters of water. [RTU, ISem Feb, 2010]

Solution : Conversion into $CaCO_3$ equivalent of hardness producing sobstance.

S.No.	Substance	Amount of Substance (mg/L)	M.F.	$CaCO_3$ equivalent
1.	$MgCO_3$	84	100/84	$84 \times \frac{100}{84} = 100$
2.	$CaCO_3$	40	100/100	$40 \times \frac{100}{100} = 40$
3.	$CaCl_2$	55.5	100/111	$55.5 \times \frac{100}{111} = 50$
4.	$Mg(NO_3)_2$	37	100/148	$37 \times \frac{100}{148} = 25$
5.	KCl20	20	Does not impart any hardness	

Lime required :

$$= \frac{74}{100}\left[CaCO_3 + 2 \times Mg\left(NO_3\right)_2\right] \text{ as } CaCO_3 \text{ equivalent} \times \text{volume of water}$$

$$= \frac{74}{100}[40 + 2 \times 100 + 25] \text{ mg/lit} \times 80{,}000 \text{ lit}$$

$$= \frac{74}{100}[265] \text{ mg/lit} \times 80{,}000 \text{ lit}$$

$$= 196.1 \text{ mg/lit} \times 80{,}000$$

$$= 15688000$$

or lime required of given quality (i.e. 86% of purty) = $15688000 \frac{100}{86}$

$$= 18241860.47 \text{ mg/lit} = 18.241 \text{ kg}$$

Soda required :

$$= \frac{106}{100}\left[CaCl_2 + Mg\left(NO_3\right)_2\right] \text{as } CaCO_3 \text{ equivalent} \times \text{volume of water} \times \text{\% purity}$$

$$= \frac{106}{100}[50 + 25] \text{mg / lit} \times 80{,}000 \text{ lit} \times \frac{100}{83} \times \frac{1\text{kg}}{10^6 \text{mg}}$$

$$= \frac{106}{100}[75] \text{mg / lit} \times 80{,}000 \text{ lit} \times \frac{100}{83} \times \frac{1\text{kg}}{10^6 \text{mg}}$$

$$= 7662.650.6 \text{ mg/lit}$$

$$= 7.662 \text{ kg}$$

- THANK YOU