pH = 4.5 to 8.3 → only HCO_3^- alkalinity ($CO_3^{2-} = 0$)

pH = 8.3 → $HCO_3^- + CO_3^{2-} + OH^-$

~~pH = 10 → $HCO_3^- + CO_3^{2-} + OH^-$~~

total alkalinity calculation a neglected error

$CO_3^{2-} = 2 \times OH^-$ if needed

↳ 2 mole electron of x2

GTCL 'Ib

(5) A water sample with pH 9 had a caustic alkalinity of 70mg/l, total alkalinity of 230 mg/l and total hardness of 300mg/l all as $CaCO_3$. Calculate the amounts of the various forms of alkalinity present & the amount of non-carbonate hardness.

Soln:

pH = 9

∴ Carbonate (CO_3^{2-}) alkalinity = $2 \times OH^-$

$= 2 \times 70$

$= 140 mg/l$

Now, Total alkalinity = CO_3^{2-} alkalinity + HCO_3^- alkalinity

$230 = 140 + HCO_3^-$ alkalinity

∴ HCO_3^- alkalinity = $(230 - 140) = 90 mg/l$

Total Hardness = 300mg/l > Total alkalinity = 230mg/l

∴ N.C.H = TH − CH

= TH − Alkalinity

= (300 − 230) mg/l

= 70mg/l of $CaCO_3$

(6) The pH & $CaCO_3$ is 7.5 & 332 mg/L respectively. Find the value of carbonate alkalinity, bicarbonate alkalinity, carbonate concentration & bi-carbonate concentration [GTCL-16]

Solⁿ:

Carbonate (CO_3^{2-}) alkalinity = 0 [∵ pH < 8.3]

bicarbonate (HCO_3^-) alkalinity = 332 mg/L as $CaCO_3$

~~[CO_3^{2-}] = [D]~~

~~Assume~~, ~~[HCO_3^-] = [P]~~

concentration of CO_3^{2-} = 0

Assume, concentration of HCO_3^- is P mg/L

$\therefore$ HCO_3^- alkalinity $= P * \frac{50}{61}$

(মান - 332 mg/L $CaCO_3$ হিসেবে আছে)

$\Rightarrow$ $332 \text{ mg/L} = P * \frac{50}{61}$

$\Rightarrow$ $P = 332 \times \frac{61}{50} = 405.04$ mg/L

$\therefore$ concentration of HCO_3^- = 405.04 mg/L

Lime Calculation:

quicklime (CaO) required = use 56 instead 74

lime ($Ca(OH)_2$) required = HCO_3^- alkalinity as $CaCO_3 \times \frac{74}{100} + Mg^{2+} \times \frac{74}{24} + CO_2 \times \frac{74}{44}$ + acidity $(H^+) \times \frac{74}{1}$ + excess lime

*assume extra 15% lime

*** Never calculate CO_3^{2-} alkalinity

Soda [Na_2CO_3] required = $Ca^{2+} * \frac{106}{40} + Mg^{2+} * \frac{106}{24} + H^+ * \frac{106}{1} - HCO_3^-$ as $CaCO_3 * \frac{106}{100}$

approximate method:

Lime [$Ca(OH)_2$] required = Total Hardness, $TH \times \frac{74}{106}$

Soda [Na_2CO_3] required = $NCH \times \frac{106}{100}$

** If pH < 8.3; there's no CO_3^{2-}

∴ Total alkalinity means HCO_3^- alkalinity

∴ $Ca^{2+} + Mg^{2+} - HCO_3^- = NCH$

∴ soda required = $NCH * \frac{106}{100} + H^+ * \frac{106}{1}$

(ii) Analysis of hardwater gave the following results: Total hardness = 5meq/L; Ca-hardness = 2.6meq/L; alkalinity = 4meq/L; acidity = 0.2meq/L. Calculate the required doses of lime $\{Ca(OH)_2\}$ & soda (Na_2CO_3) for softening. Assume excess lime equivalent to 1.0 meq/L. [40th BCS]

Soln: Mg-hardness = (5 − 2.6) meq/L
= 2.4meq/L

Lime required
$= \frac{74}{100}$ [alkalinity + Mg^{2+} + acidity + excess lime; all as $CaCO_3$]

$= \frac{74}{100}$ [4x50 + 2.4x50 + 0.2x50 + 1x50]

= 281.2 mg/L

Soda required
$= \frac{106}{100}$ [Ca^{2+} + Mg^{2+} + acidity − HCO_3^-; all as $CaCO_3$]

$= \frac{106}{100}$ [2.6*50 + 2.4*50 + 0.2*50 − 4*50]

= 63.6 mg/L

Or,

$NCH = TH - TA$

$= 5 - 4$

$= 1 \text{ meq/l}$

$\therefore$ Soda (Na_2CO_3) require

$= \frac{106}{100} [NCH + \text{acidity}]$

$= \frac{106}{100} [1 \times 50 + 0.2 \times 50]$

$= 63.6 \text{ mg/l}$ Ans

**Solved Problems:

(1) Laboratory analysis of water sample with pH = 7.8. All concentration are "as substance". Ca^{2+} = 74 mg/l, Mg^{2+} = 18.3 mg/l, Na^{+} = 27.6 mg/l, K^{+} = 39.1 mg/l, HCO_3^{-} = 274.5 mg/l, SO_4^{2-} = 72 mg/l. Cl^{-} = 49.7 mg/l. Determine,

(i) Hardness of water in mg/l of $CaCO_3$

(ii) Amount of lime needed to remove hardness by $CaCO_3$

Soln:

(i) Total hardness = $Ca^{2+} * \frac{50}{20} + Mg^{2+} * \frac{50}{12}$

= $74 * \frac{50}{20} + 18.3 * \frac{50}{12}$

= 261.25 mg/L as $CaCO_3$

~~(ii) lime dose required~~

(ii) Total alkalinity

= $HCO_3^{-} * \frac{50}{61}$

= $274.5 * \frac{50}{61}$

= 225 mg/L as $CaCO_3$

Lime dose required = HCO_3^- alkalinity $* \frac{74}{100}$

$+ Mg^{2+} * \frac{74}{24}$

$= 225 * \frac{74}{100} + 18.3 * \frac{74}{24}$

$= 222.925$ mg/L

assume 15% extra lime

∴ Amount of lime needed $= 222.925 \times 1.15$

$= 256.36$ mg/L

(iii) Soda (Na_2CO_3) required

$= Ca^{2+} * \frac{106}{40} + Mg^{2+} * \frac{106}{24} - HCO_3^-$ alkalinity $* \frac{106}{100}$

$= 74 * \frac{106}{40} + 18.3 * \frac{106}{24} - 225 * \frac{106}{100}$

$= 38.425$ mg/L

Alternative

Non carbonate hardness = TH − TA

NCH = 261.25 − 225

= 36.25 mg/L as $CaCO_3$

∴ Soda required

$= NCH * \frac{106}{100}$

$= 36.25 \times \frac{106}{100}$

$= 38.425$ mg/L