Split treatment Problem

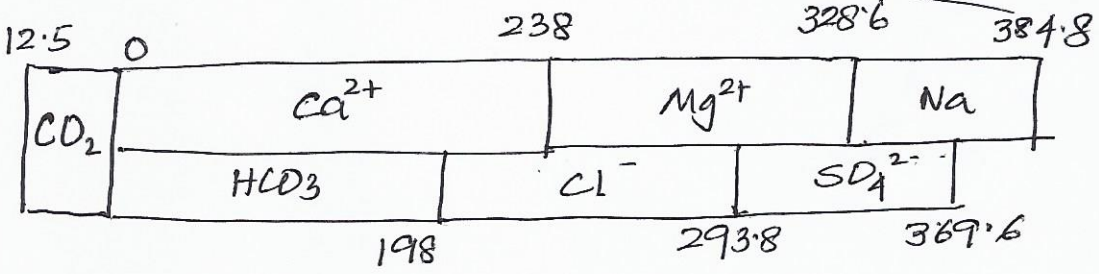
Determine the chemical dosage to soften the water to meet the following criteria:

max^m Mg-hardness = 40 mg/L as $CaCO_3$

Total hardness = 80–120 mg/L as $CaCO_3$

constituent	mg/L	mg/L as $CaCO_3$
CO_2	5·5	12·5
Ca^{2+}	95·2	238
Mg^{2+}	22	90·6
Na^+	25·8	56·2
Alk (as $CaCO_3$)	198	198
Cl^-	67·8	95·6
SO_4^{2-}	73	76

Bar diagram of raw water



For complete Ca + Mg removal: (practical solubility limits) [if 100% water treated]

Lime reqd = 12·5 + 198 + 90·6

= 301·1 mg/L as $CaCO_3$

Soda ash reqd = (238 − 198) + 90·6

= 130·6 mg/L as $CaCO_3$

For only Ca^{+2} removal (selective Ca removal: [if 100% water treated]

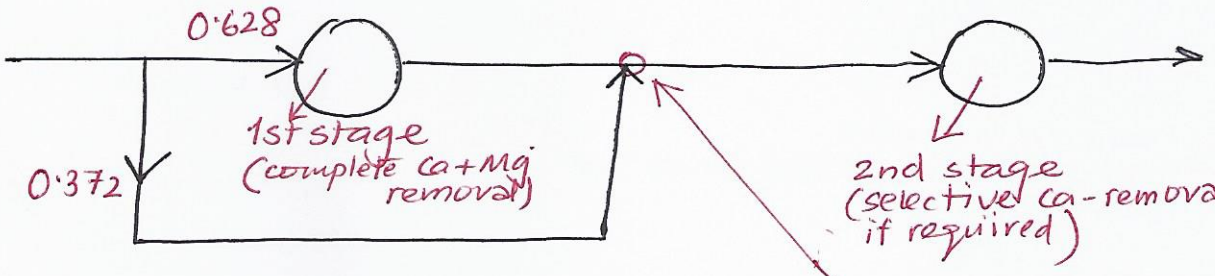
Lime reqd = 12·5 + 198 = 210·5 mg/L as $CaCO_3$

But in split treatment, 100% is not treated. Rather a fraction, X is bypassed which is given by

$$X = \frac{Mg_f - Mg_i}{Mg_{raw} - Mg_i}$$

(Mg_f ← desired Mg of finished water; Mg_i ← Mg_i = 10 mg/L as $CaCO_3$)

Fr. bypassed, $X = \frac{40-10}{90.6-10} = 0.372$



check the hardness when the two fractions are combined

Chemical requirement

Lime = 0.628×301.1 (1st stage (Ca+Mg)) $+ 0.372 \times 210.5$ (second stage (Ca only))

$= \boxed{267.4 \text{ mg/L as } CaCO_3}$ ANS

Soda ash = 0.628×130.6 (1st stage) $+ 0.372 \times 0$ (second stage no soda ash reqd. for selective Ca)

$= \boxed{82 \text{ mg/L as } CaCO_3}$ ANS.

Hardness = $0.372 \times$ raw water hardness $+ 0.628 \times$ treated water hardness

$= 0.372 \times 328.6 + 0.628 \times 40$

$= 147.4$ mg/L as $CaCO_3$

$>$ 80–120 mg/L as $CaCO_3$ requirement

$\therefore$ Further hardness treatment in second stage required.

Treated water hardness = 30+10

= 40 mg/L as $CaCO_3$

(Minm solubility possible for Ca+Mg)

Comment: economic analysis should be done to see whether installing a 2nd unit (involves high capital cost) or treating more water in the first stage more economical.