6.3

$pH = 10.5$

$CO_3^{2-} = 39 mg/L$

$HCO_3^- = 24.5 mg/L$

a) Alkalinity as $CaCO_3$ (ignore H^+ OH^-)

$$Alkalinity = (HCO_3^-) + (CO_3^{2-})$$

$$24.5 mg/L\ HCO_3^- \cdot \frac{50\ CaCO_3\ meq}{61.0 mg/meq} = 20.08 mg/L \text{ as } CaCO_3$$

$$39 mg/L\ CO_3^{2-} \cdot \frac{50\ CaCO_3\ meq}{30 mg/meq} = 65 mg/L \text{ as } CaCO_3$$

$$Alk = 85 mg/L \text{ as } CaCO_3$$

b) Alkalinity as $CaCO_3$ (include H^+ & OH^-)

$$H^+ = 10^{-10.5} mol/L \cdot \frac{1000 mg}{1 mol} \cdot \frac{50 mg CaCO_3}{1 mg/meq} = 1.58 \cdot 10^{-6} mg/L \text{ as } CaCO_3$$

$$OH^- = 10^{-3.5} mol/L \cdot \frac{17000 mg}{mol} \cdot \frac{50\ CaCO_3}{17 mg/meq} = 15.81 mg/L \text{ as } CaCO_3$$

$$\text{Total Alk} = 85.08 + 15.81 + 1.58 \cdot 10^{-6} = 100.89 mg/L \text{ as } CaCO_3$$

6.4 Chemical Analysis of Water

	mg/L	mg/L-$CaCO_3$
Ca^{2+}	90	224.1
Mg^{2+}	30	123.3
Na^+	72	156.24
K^+	6	7.68

	mg/L	mg/L-$CaCO_3$
Cl^-	120	169.2
SO_4^{2-}	225	234
HCO_3^-	165	135.3

pH = 7.5

H^+	0.00158
OH^-	0.0158

$$X_{mg/L \text{ as } CaCO_3} = \frac{X_{mg/L} \cdot \boxed{50 \cdot n}}{\boxed{MW_X}}$$

(conv. factor)

conv. factors

Ca^{2+}: $\frac{50(2)}{40.1} = 2.49$

Mg^{2+}: $\frac{50(2)}{24.3} = 4.11$

Na^+: $\frac{50(1)}{23} = 2.17$

K^+: $\frac{50(1)}{39.1} = 1.28$

Cl^-: $\frac{50(1)}{35.5} = 1.41$

SO_4^{2-}: $\frac{50(2)}{96} = 1.04$

HCO_3^-: $\frac{50(1)}{61} = 0.82$

a) Alkalinity = 135.3 + 0 + 0.0158 − 0.00158 = 135.314

135.3 as $CaCO_3$ ←

b) Hardness = 224.1 + 123.3 = 347.4

347 as $CaCO_3$ ←

c) TDS = 708 mg/L

6.7

Ca^{2+}	40.0	99.6	HCO_3^-	110 mg/L	90.2
Mg^{2+}	10.0	41.1	SO_4^{2-}	67.2	69.88
Na^+	?		Cl^-	11.0	15.51
K^+	7.0	8.96			

$\Sigma Cations = 99.6 + 41.1 + 8.96 + ? = 149.66$ mg/L as $CaCO_3$

$\Sigma Anions = 90.2 + 69.88 + 15.51 = 175.59$ mg/L as $CaCO_3$

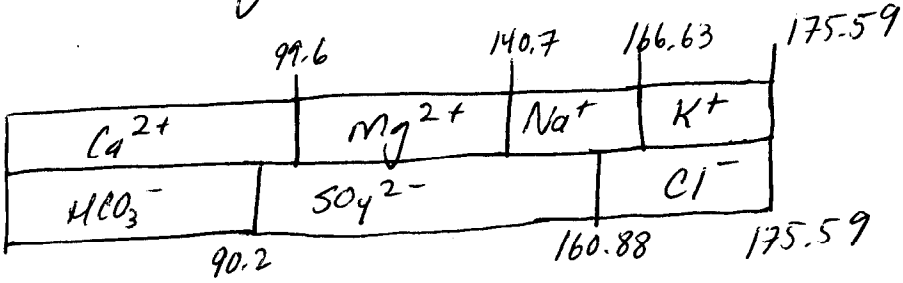
$\therefore Na^+ = 25.93$ mg/L as $CaCO_3$

a) $Na^+ * 2.17 = 25.93$

$Na^+ = \frac{25.93}{2.17} = 11.95$ mg/L

b) $TH = Ca^{++} + Mg^{++} = 99.6 + 41.1 = 140.7$ mg/L as $CaCO_3$

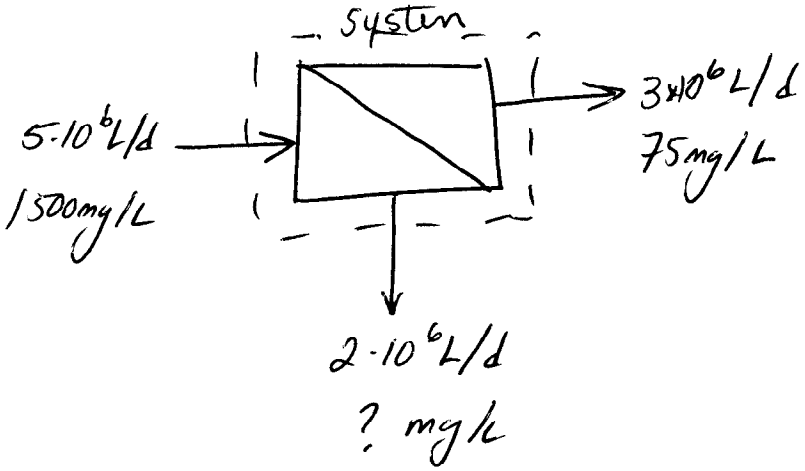
c)



6.8 RO plant treats $5 \cdot 10^6$ L/day feedwater 1500 mg/L TDS. 7/

Produces $3 \cdot 10^6$ L/d product water at 75 mg/L TDS

What is concentration in reject stream?



Simple mass balance

inflow − outflow = accumulation → 0

$$(5 \cdot 10^6 \text{ L/d})(1500 \text{ mg/L}) - (3 \cdot 10^6 \text{ L/d})(75 \text{ mg/L}) - (2 \cdot 10^6 \text{ L/d})(x \text{ mg/L}) = 0$$

Solve for x

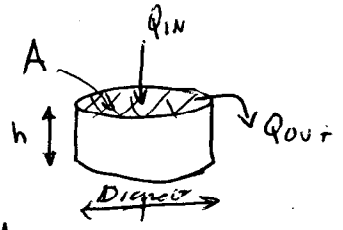
$$\frac{(5 \cdot 10^6)(1500) - (3 \cdot 10^6)(75)}{(2 \cdot 10^6)} = x = \text{~~3637~~ } 3637.5 \text{ mg/L} \longleftarrow$$

6/10

Settling tank 2 MGD plant. Overflow rate 800 gal/d-ft^2
Minimum HRT 2.0 hrs. Min depth = 11 ft.
Size the circular tank.

$$HRT = \frac{\forall}{Q}$$

$$\text{overflow rate} = \frac{Q}{A}$$



$$A = \frac{\pi D^2}{4}$$

$$\forall = Ah = \frac{\pi D^2 h}{4}$$

Convert Q into ft^3/d

$$2 \cdot 10^6 \frac{gal}{d} \cdot \frac{1\ day}{7.48\ gal}\ ft^3 = 267{,}379.7\ ft^3/day$$

Also in ft^3/hr

$$267{,}379.7\ ft^3/d \cdot \frac{1\ day}{24\ hr} = 11{,}140.8\ ft^3/hr$$

$\forall_{required}$ to meet HRT criterion

$$Q * 2hr = \forall = 11{,}140.8 \frac{ft^3}{hr} \cdot 2hr = 22{,}281.6\ ft^3$$

Volume will meet HRT criterion. Bigger volume is OK.

A required to meet overflow rate

$$800 \frac{gal}{d\text{-}ft^2} = \frac{Q}{A} \quad \therefore \quad A = \frac{Q}{800}$$

$$= \frac{2 \cdot 10^6}{800} = 2500\ ft^2$$

Solve for D

$$\sqrt{\frac{4A}{\pi}} = D = \sqrt{\frac{4(2500)}{\pi}} = 56.4\ ft$$

Now check if volume is big enough

$V = (2500 ft^2)(11 ft) = 27,500 ft^3$ which is larger than $V_{required}$.

∴ Design tank as

11 ft tall; 56.4 ft diameter for this problem.