(a)

$$Q = V_3 A_3 + V A_1$$

$$Z_1 + H_p - E_3 - Z_2 = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + H_L$$

$$10 + 100 - \frac{400 \times 1000}{1000(9.81)} - 20 = 0.02\left(\frac{9900}{0.65}\right)\left(\frac{V_1^2}{2(9.81)}\right) + 14$$

$$V_1 = 1.506 \text{ m/s.}$$

$$Z_3 - E_3 - Z_2 = f\left(\frac{L}{D}\right)\frac{N^2}{2g} + H_L$$

$$V_3 = 0.4557 \text{ m/s.}$$

$$Q = 0.651 \text{ m}^3\text{/s.}$$

b)

Time	Draft	Supply	Cummulative def.
0 - 2	3	0	3
2 - 4	2	0	5
4 - 6	3	0	8
6 - 8	4	0	12
8 - 10	9	20	1
10 - 12	13	20	-6
12 - 2	18	20	-8
2 - 4	13	20	-15
4 - 6	12	20	-23
6 - 8	10	0	-13
8 - 10	9	0	-4
10 - 12	4	0	0

pumping period = 8am to 6pm

$$Q = \frac{50000}{10\text{hr}} = 5000 \text{ m}^3/\text{h}$$

ii) $E_s = \frac{(23+12)}{100} \times 5000 = 17500 \text{ m}^3$

iii) capacity $= 17500 + 1000 + 1000 + \frac{5}{100}(50 \times 1$ ...$) = 19500 \text{ m}^3$ #

2a). i)

Coagulation requires intensive mixing to properly and evenly distribute coagulants. gentle mixing is used for flocculation to increase effective collision but reduce probability of shearing formed flocs.

ii) $Q = 20\,000 \, m^3/d$

Coagulation

$$\text{Volume} = Q \times t$$

$$= \frac{20000}{24 \times 60 \times 60} \times 45$$

$$= 10.42 \, m^3$$

$$P = G^2 \mu V$$

$$= (1000)^2 (0.89 \times 10^{-3})(10.42)$$

$$= 9273.8 \, W$$

Flocculation

$$\text{Volume} = Q \times t$$

$$= \frac{20000}{24 \times 60 \times 60} \times 30 \times 60$$

$$= 417 \, m^3$$

$$P = G^2 \mu V$$

$$= (40)^2 (0.89 \times 10^{-3})(417)$$

$$= 593 \, W$$

iii) In coagulation: ensure coagulant is not added too much as it can re-charge destabilised colloids.
ensure PH is in the correct range so that efficiency is the highest

In flocculation: ensure that mixing power is decreasing across series of tank
ensure no sedimentation in flocculation tank.

2b ii) $V_0 = \frac{Q}{A}$

$= \frac{10\,000}{40 \times 15}$

$= 16.67 \text{ m/d} = 1.93 \times 10^{-4} \text{ m/s}$

b i) 

$\frac{h_s}{t} \leq \frac{h_o}{t}$

For 100% removal,

$\frac{h_s}{t} = \frac{h_o}{t}$

$\therefore V_s = V_o \text{ (SOR)}.$

$V_s = \frac{g(\rho_s - \rho) d^2}{18 \mu}$

$1.93 \times 10^{-4} = \frac{9.81(1030 - 1000)(d)^2}{18(0.89 \times 10^{-3})}$

$d = 1.02 \times 10^{-4} \text{ m}$ #

$Re = \frac{1000(1.02 \times 10^{-4})(1.93 \times 10^{-4})}{0.89 \times 10^{-3}}$

< 1 #

iii) the V_o would increase and V_s will be less than V_o.

Effeciency $= \frac{V_s}{V_o} \times 100\%$ and no longer be complete removal.

iv) $T \uparrow \rightarrow$ water less viscous, hence V_s increases. Hence more efficient.

3a)' $Q = 20\,000\ m^3/d$

$TSS = 20 mg/L \xrightarrow{95\%} 19 mg/L$ removed

$Al_2(SO_4)_3 = 50 mg/L$

Amount of $Al_2(SO_4)_3 = \frac{50}{342}$ (6 electron transfer)

≈ 0.1462 mmol/l

$= 0.877$ meq/l $\times 50$

$= 43.9$ mg/l of $CaCO_3$.

ii) less efficient as PH would be too low and Al residues wi form.

1 day

$TSS = 19 \times 10^{-6} \times 20\,000 \times 1000$

$= 380$ kg.

$Al(OH)_3 = 0.877 \times \left(\frac{78}{3}\right) \times 10^{-6} \times 20\,000 \times 1000$

$= 456$ kg.

Total Solids $= 836$ kg.

3b) i) $Q = 240 \times 5 \times 7 \times 20 = 7000$ m/hr.

ii) $$H_L = \frac{f'}{\phi} \frac{(1-e)}{e^3} \frac{L}{d} \frac{V_s^2}{g} \quad \text{where } f' = 150\frac{1-e}{Re} + 1.75$$

Sub in all values

$H_L = 0.8$. It has exceeded allowable headloss. build another tank (21 tanks) to reduce headloss.

4a) $H_2O + Cl_2 = HOCl + HCl \qquad HOCl \rightleftharpoons OCl^- + H^+$

using chlorine as disinfectant, it will lower the pH and buffer is required to be in the water.

b) $$-\ln\left(\frac{0.1}{100}\right) = 10\,C^{1.2}\,t$$

$$C^{1.2} = \frac{0.6907}{t_1} \quad (\text{for } 5°C)$$

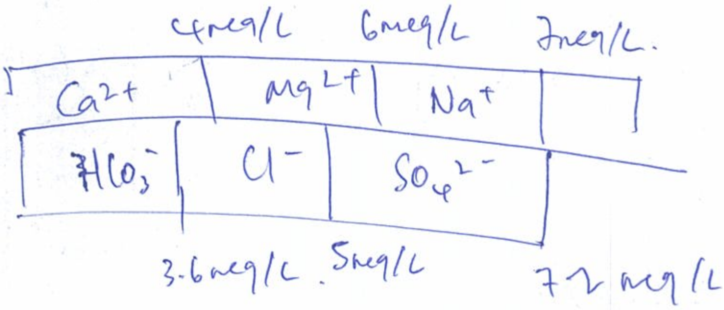
$$\ln\frac{t_1}{t_2} = 4130\left(\frac{30-5}{(303)(278)}\right)$$

$$t_1 = t_2\,(3.406)$$

$$t_2 = 0.29\,t_1$$

$$C^{1.2} = \frac{0.6907}{3.406\,t_2} = \frac{2.028}{t_2} \ast$$

4c)

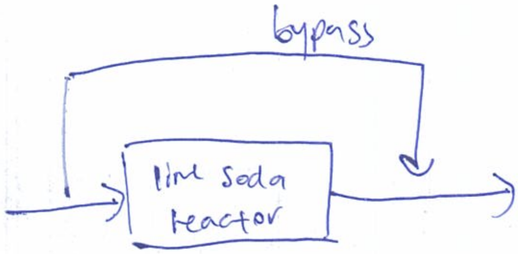
i) 

total hardness = 6meq/L.

ii) Carbonate hardness = 3.6 meq/L.

non carbonated hardness = 6 − 3.6 = 2.4meq/L.

iii) Since Σcation ≈ Σ anion, it is complete.

iv) 

James