Question 1 - Air Stripper Tower Design

$K_L a$ for benzene in 3.5-inch plastic tripacks = 0.011 sec^{-1}

Per Lecture 10 notes, pg. 9 — $\frac{Q_W}{A} \le 20$ gpm use $\frac{Q_W}{A} = 20$ gpm

$$\frac{Q_W}{A} = 20 \ \frac{gpm}{ft^2} = 0.014 \ \frac{m}{s}$$

$Q_W = 0.1 \ m^3/s = 1585$ gpm

$\rightarrow A = 7.1 \ m^2 = 79 \ ft^2 \ (= 7.3 \ m^2)$

$$HTU = \frac{Q_W}{A \, K_L a} = \frac{0.1 \ m^3/s}{7.3 \ m^2 \ 0.011 \ sec^{-1}} = 1.25 \ m$$

$C_{in} = 100 \ \mu g/L$

$C_{out} = MCL = 5 \ \mu g/L$

$S = 3.5$

$$NTU = \frac{S}{S-1} \ln\left[\frac{C_{in}}{C_{out}}\left(\frac{S-1}{S}\right) + \frac{1}{S}\right]$$

$$= 3.75$$

$$L = 3.75 \times 1.25 \ m = 4.7 \ m \simeq 5 \ m$$

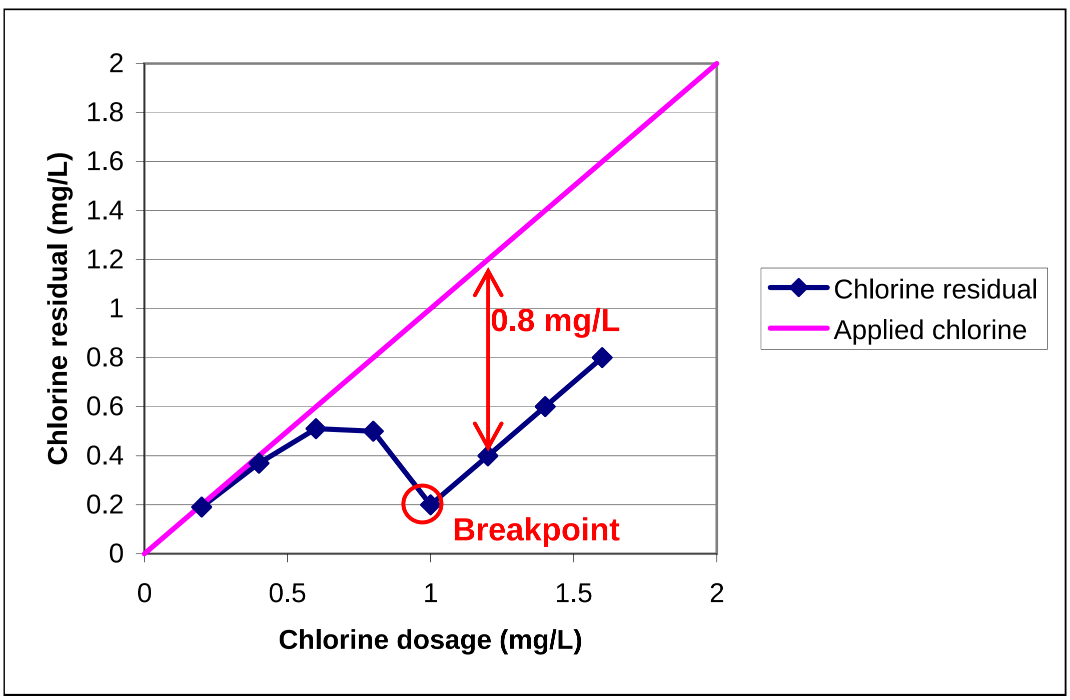
Question 2

a. See graph at right
b. See computed Chlorine demand column below
c. See labeled breakpoint on graph

Sample	Chlorine Dosage (mg/L)	Residual chlorine after 10 minutes of contact (mg/L)	Chlorine demand (mg/L) = Dosage - residual
1	0.2	0.19	0.01
2	0.4	0.37	0.03
3	0.6	0.51	0.09
4	0.8	0.5	0.3
5	1	0.2	0.8
6	1.2	0.4	0.8
7	1.4	0.6	0.8
8	1.6	0.8	0.8

Dosage vs. dosage curve:

0	0
2	2



Question 3 - Proportional Weir Design

$Q_{ave} = 17.6 \text{ L/s} = 0.0176 \text{ m}^3/\text{s}$
$Q_{max} = 28.4 \text{ L/s} = 0.028 \text{ m}^3/\text{s}$
$Q_{min} = 7.1 \text{ L/s}$

$V_s = 2.3 \text{ cm/s} = 0.023 \text{ m/s}$
$U = 0.3 \text{ m/s}$

From Lecture 5 $\quad \frac{V_s}{U} = \frac{H}{L}$

$U = \frac{Q}{A} = \frac{Q}{W \cdot H}$

$W = 30 \text{ cm} = 0.3 \text{ m}$
$Q = 0.0176 \text{ m}^3/\text{s}$

$H_{ave} = \frac{Q_{ave}}{W \cdot U} = \frac{0.0176}{0.3 \cdot 0.3} = 0.2 \text{ m} = 20 \text{ cm}$

$H_{max} = \frac{Q_{max}}{W \cdot U} = \frac{0.028}{0.3 \cdot 0.3} = 0.31 \text{ m} = 30 \text{ cm}$

Can use $H = 31$ cm

$L = \frac{HU}{V_s} = 4.06 \text{ m} \approx 4 \text{ m}$

If we provide a safety factor of 25%, $L = 5$ m

Grit chamber dimensions: 30 cm wide, 60 cm deep (for 30 cm freeboard) and 5 m long

Proportional weir — design for ave, check at min and max

$$\frac{Q}{h} = \sqrt{2g}\, CK = \text{constant} \qquad \text{from Lecture 13}$$

$$K = \frac{Q}{H\sqrt{2g}\,C} = \frac{0.0176\ \frac{m^3}{s}}{0.3\ m\ \sqrt{2\ 9.8\ \frac{m}{s^2}}\ 0.98}$$

$$K = 0.0135\ m^{3/2}$$

$$2x = \frac{K}{\sqrt{h}}$$

$$Q = \sqrt{2g}\ CK\ h$$

Question 3 - Proportional weir design

$2x = k/h^{1/2}$
k = 0.0135 $m^{3/2}$

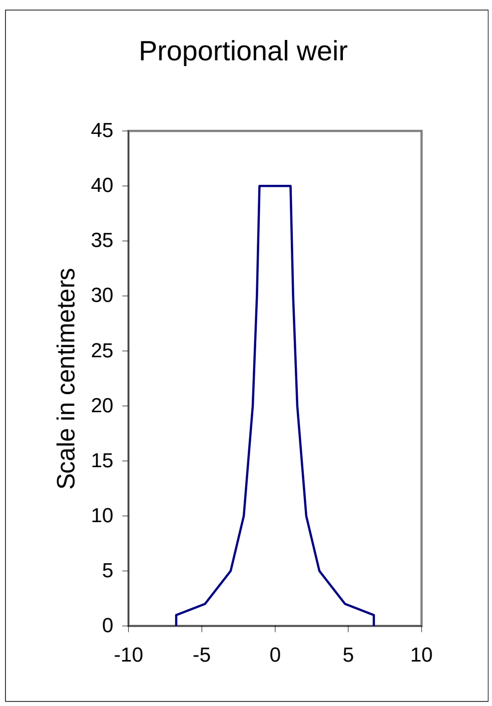
First try:

h (cm)	h (m)	2x (m)	2x (cm)	Q (m^3/s)	Q (L/s)	
0	0	0.135	13.5	0	0	
1	0.01	0.135	13.5	0.0006	0.6	
2	0.02	0.095	9.5	0.0012	1.2	
5	0.05	0.060	6.0	0.0029	2.9	
10	0.1	0.043	4.3	0.0059	5.9	
20	0.2	0.030	3.0	0.0117	11.7	
30	0.3	0.025	2.5	0.0176	17.6	
40	0.4	0.021	2.1	0.0234	23.4	< Not enough for max flow

Trial-and-error solution for k value:
Increase k to: 0.017

h (cm)	h (m)	2x (m)	2x (cm)	Q (m^3/s)	Q (L/s)	
0	0	0.135	13.5	0	0	
1	0.01	0.135	13.5	0.000738	0.7	
2	0.02	0.095	9.5	0.001475	1.5	
5	0.05	0.060	6.0	0.003688	3.7	
10	0.1	0.043	4.3	0.007376	7.4	
20	0.2	0.030	3.0	0.014751	14.8	
30	0.3	0.025	2.5	0.022127	22.1	
40	0.4	0.021	2.1	0.029503	29.5	< OK for max flow

x1 (cm)	h (cm)
6.75	0
6.75	1
4.77	2
3.02	5
2.13	10
1.51	20
1.23	30
1.07	40
-1.07	40.00
-1.23	30.00
-1.51	20.00
-2.13	10.00
-3.02	5.00
-4.77	2.00
-6.75	1.00
-6.75	0



Question 4

Overall reaction:

$$C_8H_{16}O + \frac{13}{2} O_2 + NH_3 \rightarrow C_5H_7NO_2 + 3CO_2 + 6H_2O$$

8 C	5 + 3 C ✓
1 + 13 O	2 + 6 + 6 O ✓
1 N	1 N ✓
16 + 3 H	7 + 12 H ✓

Oxidation of FOG

$$C_8H_{16}O + \frac{23}{2} O_2 \rightarrow 8CO_2 + 8H_2O$$

$$\frac{g\ COD}{g\ FOG} = \frac{g\ O_2}{g\ FOG} = \frac{\frac{23}{2}(32)}{(8 \cdot 12 + 16 \cdot 1 + 1 \cdot 16)}$$

$$= \frac{\frac{23}{2} \cdot 32}{128}$$

$$= 2.88 \ \frac{g\ COD}{g\ FOG}$$

Cell yield based on overall reaction

$$Y = \frac{5 \cdot 12 + 7 \cdot 1 + 1 \cdot 14 + 2 \cdot 16}{128} = \frac{113}{128}$$

$$= 0.88 \ g\ cells / g\ FOG$$

In terms of COD

$$Y = \frac{0.88\ g\ cells/g\ FOG}{2.88\ g\ COD/g\ FOG} = 0.31 \ \frac{g\ cells}{g\ FOG}$$