

a.

Refer back to homework 2, the yield is

$$Y_0 = 0.07 \text{ g cells / g BrO}_3^-$$

The information given from the question

$$\hat{q} = 12 \frac{\text{mg BrO}_3^-}{\text{mg cells} \cdot \text{d}}$$

$$K = 50 \frac{\mu\text{g BrO}_3^-}{\text{L}}$$

$$S^o = 200 \text{ mg/L}$$

$$b = 0.01 \text{ d}^{-1}$$

Then

$$S^{min} = K \times \frac{b}{Y\hat{q} - b} = \frac{50 \mu\text{g}}{\text{L}} \times \frac{0.01 \text{ d}^{-1}}{0.07 \frac{\text{mg cells}}{\text{mg BrO}_3^-} \times 12 \frac{\text{mg BrO}_3^-}{\text{mg cells} \cdot \text{d}} - 0.01 \text{ d}^{-1}} = 0.60 \mu\text{g/L}$$

$$[\theta^{min}]_{lim} = \frac{1}{Y\hat{q} - b} = \frac{1}{0.07 \frac{\text{mg cells}}{\text{mg BrO}_3^-} \times 12 \frac{\text{mg BrO}_3^-}{\text{mg cells} \cdot \text{d}} - 0.01 \text{ d}^{-1}} = 1.20 \text{ d}$$

b.

In my opinion, I think the volume value is missing for this part, because S value depends on the

$$\theta_x = \frac{V}{Q} \text{ directly due to the equation } S = K \frac{1 + b\theta_x}{\theta_x(Y\hat{q} - b) - 1}$$

Or according to the a part, possibly

the $S_{min} = 0.60 \mu\text{g/L} < 10 \mu\text{g/L}$ if the θ_x is much larger

Then this design can achieve the goal concentration of bromide.

c.

If a chemostat can achieve the target treatment goal

$$S = 10 \mu g/L$$

According the relative equation

$$\frac{1}{\theta_x} = Y \frac{\hat{q}S}{K + S} - b = 0.07 \frac{mg \text{ cells}}{mg \text{ BrO}_3^-} \times \frac{12 \frac{mgBrO_3^-}{mgcells \cdot d} \times 10 \frac{\mu g}{L}}{50 \frac{\mu g}{L} + 10 \frac{\mu g}{L}} - 0.01d^{-1} = 0.13d^{-1}$$

$$\theta_x = 7.7 d$$

If a chemostats cannot achieve the target treatment goal and its safety factor is 10

$$\theta_x^{min} = \frac{K + S^0}{S^0(Y\hat{q} - b) - bK} = 1.20$$

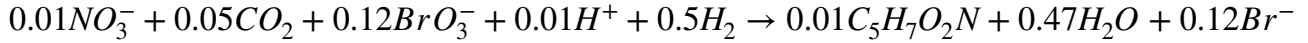
$$SF = \frac{\theta_x}{\theta_x^{min}} = 10 \text{ then } \theta_x = 12 d$$

According the relative equation

$$S = K \frac{1 + b\theta_x}{\theta_x(Y\hat{q} - b) - 1} = \frac{50\mu g}{L} \times \frac{1 + 0.01d^{-1} \times 12d}{12d \times (0.07 \frac{mg \text{ cells}}{mg \text{ BrO}_3^-} \times 12 \frac{mgBrO_3^-}{mgcells \cdot d} - 0.01 d^{-1}) - 1} = 6.2\mu g/L$$

d.

According to the reaction



Then

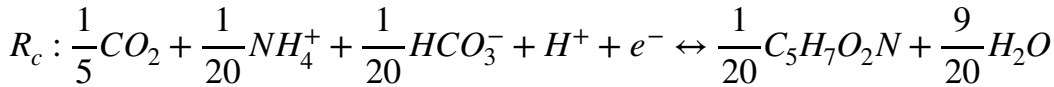
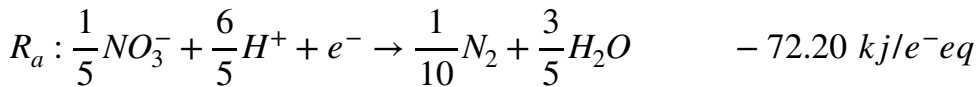
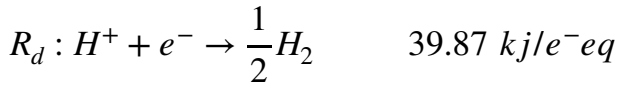
$$Y_{H_2}^0 = 0.5(2)/0.12(129) = 0.0064 \text{ g } H_2/\text{g } BrO_3^-$$

Then if a chemostat can achieve the target treatment goal

$$C_{min}^{H_2} = (S^0 - S) \times Y_{H_2} = 12.92 \text{ mg/L}$$

e.

When Nitrite as electron acceptor



According to the Table 3.1 $f_s^0 = 0.2$

$$R = f_e^0 \times (R_a - R_d) + f_s^0 \times (R_c - R_d)$$

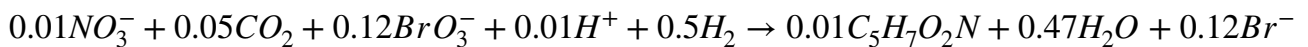
$$= 0.80 \times \left[\frac{1}{5}NO_3^- + \frac{1}{20}NH_4^+ + \frac{1}{20}HCO_3^- + \frac{1}{2}H_2 \rightarrow \frac{1}{20}C_5H_7O_2N + \frac{9}{20}H_2O \right] +$$

$$0.20 \times \left[\frac{1}{5}CO_2 + \frac{1}{20}NH_4^+ + \frac{1}{20}HCO_3^- \leftrightarrow \frac{1}{20}C_5H_7O_2N + \frac{9}{20}H_2O \right]$$

For denitrification process



For Bromide reduction process



$$C_{extra}^{H_2} = C_{min}^{H_2} \times \frac{0.05(113)}{0.4(2)} \times \frac{2(0.5)}{0.01(113)} = 80.75 \text{ mg/L}$$

f.

Refer back to the c part, I choose SF = 10 design, where $\theta_x = 12d$ and $S = 6.2\mu g/L$

$$X_a = Y(S^0 - S) \frac{1}{1 + b\theta_x} = 0.07 \frac{mg\ cells}{mg\ BrO_3^-} \times (200 - 0.0064) mg/L \times \frac{1}{1 + 0.01d^{-1} \times 15.1d} = 12.50 mg/L$$

$$X_i = X_i^0 + X_a(1 - f_d)b\theta_x = 0 + X_a \times (1 - 0.8) \times 0.01d^{-1} \times 15.1d = 0.30 mg/L$$

$$X_v = X_i + X_a = 12.80 mg/L$$

$$r_{ut} = -\frac{S^0 - S}{\theta_x} = -\frac{(200 - 0.0064) mg/L}{15.1d} = -16.66 mg\ BOD_L/L \cdot d$$

For SMP calculation,

Where

$$k_1 = 0.12g\ COD_p/g\ COD_s \quad \hat{q}_{UAP} = 1.8g\ COD_p/g\ VSS_a$$

$$k_2 = 0.09g\ COD_p/g\ COD_s \quad K_{UAP} = 100mg\ COD_p/g\ VSS_a$$

$$UAP = \frac{-(\hat{q}_{UAP}X_a\theta + K_{UAP} + k_1r_{ut}\theta) + \sqrt{(\hat{q}_{UAP}X_a\theta + K_{UAP} + k_1r_{ut}\theta)^2 - 4K_{UAP}k_1r_{ut}\theta}}{2} = 6.8 mg/L$$

$$BAP = \frac{-(K_{BAP} + (\hat{q}_{BAP} - k_2)X_a\theta) + \sqrt{(K_{BAP} + (\hat{q}_{BAP} - k_2)X_a\theta)^2 + 4K_{BAP}k_2X_a\theta}}{2} = 11.69 mg/L$$

$$Total\ COD = S + SMP + (1.42\ gCOD/g\ VSS) \cdot X_v = 97.68mg/L$$

$$Total\ BOD_L = Total\ COD \times 80\ \% = 78.14 mg/L$$

$$BOD_5 = BOD_L \times (1 - e^{-0.23d^{-1} \times 5d}) = 53.40 mg/L$$

g.

The N source may be insufficient with time passing by, causing the lower water treatment

efficiency. On the other hand, Br^- is likely to oxide in the real world conditions, thus, oxidation equilibrium should be considered.