a.

Refer back to homework 2, the yield is

$$Y_0 = 0.07\ g\ cells/\ g\ BrO_3^-$$

Then we assume 80 % of the cell are biodegradable.

Thus,

$$Y = Y_0 \times 0.8 = 0.056\ g\ cells/\ g\ BrO_3^-$$

The information given from the question

$$\hat{q} = 12\ \frac{mgBrO_3^-}{mgcells \cdot d} \qquad K = 50\frac{\mu gBrO_3^-}{L}$$

$$S^o = \ 200mg/L \qquad b = 0.01\ d^{-1}$$

Then

$$S^{min} = K \times \frac{b}{Y\hat{q} - b} = \frac{50\mu g}{L} \times \frac{0.01\ d^{-1}}{0.056\ \frac{mg\ cells}{mg\ BrO_3^-} \times 12\ \frac{mgBrO_3^-}{mgcells \cdot d} - 0.01\ d^{-1}} = 0.76\mu g/L$$

$$[\theta^{min}]_{lim} = \frac{1}{Y\hat{q} - b} = \frac{1}{0.056\ \frac{mg\ cells}{mg\ BrO_3^-} \times 12\ \frac{mgBrO_3^-}{mgcells \cdot d} - 0.01\ d^{-1}} = 1.51\ d$$

c.

If a chemostat can achieve the target treatment goal

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

According the relative equation

$$\frac{1}{\theta_x} = Y\frac{\hat{q}S}{K+S} - b = 0.056\ \frac{mg\ cells}{mg\ BrO_3^-} \times \frac{12\ \frac{mgBrO_3^-}{mgcells \cdot d} \times 10\ \frac{\mu g}{L}}{50\ \frac{\mu g}{L} + 10\ \frac{\mu g}{L}} - 0.01d^{-1} = 0.11d^{-1}$$

$$\theta_x = 9.0\ d$$

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

$$\theta_x^{min} = \frac{K+S^0}{S^0(Y\hat{q}-b)-bK} = 1.51$$

$$SF\ = \frac{\theta_x}{\theta_x^{min}} = 10\ \text{ then }\ \theta_x = 15.1\ d$$

According the relative equation

$$S = K\frac{1+b\theta_x}{\theta_x(Y\hat{q}-b)-1} = \frac{50\mu g}{L} \times \frac{1+0.01d^{-1} \times 15.1d}{15.1d \times (0.056\ \frac{mg\ cells}{mg\ BrO_3^-} \times 12\ \frac{mgBrO_3^-}{mgcells \cdot d} - 0.01\ d^{-1}) - 1} = 6.40\mu g/L$$

d.

According to the reaction

$$0.01NO_3^- + 0.05CO_2 + 0.12BrO_3^- + 0.01H^+ + 0.5H_2 \rightarrow 0.01C_5H_7O_2N + 0.47H_2O + 0.12Br^-$$

Then

$$Y_{H_2}^0 = 0.12(129)/0.5(2) = 0.052\ g\ H_2/g\ BrO_3^-$$

Then we assume 80 % of the cell are biodegradable.

Thus,

$$Y_{H_2} = Y_{H_2}^0 \times 0.8 = 12.38\ g\ H_2/g\ BrO_3^-$$

Then if a chemostat can achieve the target treatment goal

$$C_{min}^{H_2} = (S^0 - S) \times Y_{H_2} = 10.34\ mg/L$$

e.

When Nitrite as electron acceptor

$$R_d : H^+ + e^- \rightarrow \frac{1}{2}H_2 \qquad 39.87\ kj/e^-eq$$

$$R_a : \frac{1}{5}NO_3^- + \frac{6}{5}H^+ + e^- \rightarrow \frac{1}{10}N_2 + \frac{3}{5}H_2O \qquad -72.20\ kj/e^-eq$$

$$R_c : \frac{1}{5}CO_2 + \frac{1}{20}NH_4^+ + \frac{1}{20}HCO_3^- + H^+ + e^- \leftrightarrow \frac{1}{20}C_5H_7O_2N + \frac{9}{20}H_2O$$

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

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

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

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

Then

For denitrification process

$$0.16NO_3^- + 0.04CO_2 + 0.05NH_4^+ + 0.05HCO_3^- + 0.4H_2 \rightarrow 0.05C_5H_7O_2N + 0.45H_2O$$

For Bromide reduction process

$$0.01NO_3^- + 0.05CO_2 + 0.12BrO_3^- + 0.01H^+ + 0.5H_2 \rightarrow 0.01C_5H_7O_2N + 0.47H_2O + 0.12Br^-$$

$$C_{extra}^{H_2} = C_{min}^{H_2} \times \frac{0.05(113)}{0.4(2)} \times \frac{2(0.5)}{0.01(113)} = 64.63\ mg/L$$

f.

$$C_{H_2}^0 = [C_{min}^{H_2} + C_{extra}^{H_2}] \times (1 + 10\%) = 82.47 mg/L$$