

1.

The removal is 80% removal efficiency and the numerical values are substituted into Equation 4.42

$$S = S^0 - \frac{J_{ss}aV}{Q} = S^0 - \frac{J_{ss}A}{Q}$$

Where A is in m^2 and J_{ss} is in $\frac{mg}{cm^2 \cdot d}$

Thus

$$K^* = \frac{D}{L} \left[\frac{K_s}{\hat{q}X_f L_f} \right]^{0.5} = \frac{1 cm^2}{d \cdot \mu m} \times \left(\frac{10 mg}{L \times 12 \frac{mg}{mg VSS d} \times 10 \frac{mg VSS}{cm^3} \times 0.75 \frac{cm^3}{d}} \right)^{0.5} = 1.1$$

Then

$$S_{min}^* = \frac{b'}{Y\hat{q} - b'} = \frac{0.15 d^{-1}}{0.5 \times 12 - 0.15} = 0.026$$

Using the Figure 4.11

$$J^* = 0.071 \text{ when } S_{min}^* = 0.026 \text{ and } K^* = 1.1$$

Thus

$$J_R = J^* (K \hat{q} X_f D_f)^{0.5} = 0.071 \times \left(\frac{10 mg}{L} \times \frac{12 mg}{mg VSS \cdot d} \frac{10 mg VSS}{cm^3} \times \frac{0.75 cm^2}{d} \right)^{0.5} = 2.13$$

$$\text{Then } S_{min} = K \frac{b'}{Y\hat{q} - b'} = 0.26 \text{ mg/L and } \frac{S}{S_{min}} = \frac{40}{0.26} = 153.8$$

$$J_{ss}/J_R = 20 \text{ where } \frac{S}{S_{min}} = 153.8 \text{ then } J_{ss} = 1.36 \text{ mg/cm}^2 \cdot d$$

$$A = \frac{Q(S^0 - S)}{J_{ss}} = \frac{1000 \frac{L}{d} \times 160 \frac{mg}{L}}{1.36 \frac{mg}{cm^2 \cdot d} \times \frac{10000 cm^2}{1 m^2}} = 11.76 m^2$$

2.

The information given from Question 4.24, the removal is 96%

Where

$$S = S^0 \times \text{removal efficiency} = (1 - 0.96) \times 50 = 2 \text{ mg/L}$$

When bulk liquid concentration of benzoate is 2 mg/L

$$J_{ss} = 0.15 \frac{\text{mg}}{\text{cm}^2 \cdot \text{d}} \text{ and } a = 3 \text{ cm}^{-1}$$

the numerical values are substituted into Equation 4.42

$$S = S^0 - \frac{J_{ss} a V}{Q}$$

Solving the Volume equation to

$$V = \frac{Q(S^0 - S)}{J_{ss} a} = \frac{100 \frac{\text{m}^3}{\text{d}} \times \frac{1000 \text{L}}{\text{m}^3} \times 48 \frac{\text{mg}}{\text{L}}}{0.15 \frac{\text{mg}}{\text{cm}^2 \cdot \text{d}} \times 3 \text{ cm}^{-1}} = 10.67 \text{ m}^3$$

3.

Using the equation Eq 5.39

$$S = K \frac{1 + b\theta_x}{\theta_x(Y\hat{q} - b) - 1} = 4.72 \text{ mg COD/L}$$

Then plug the value of S into equation Eq 5.47

$$X_v = \frac{\theta_x}{\theta} [X_i^0 + \frac{Y(S^0 - S)(1 + (1 - f_d)b\theta_x)}{1 + b\theta_x}]$$

Thus,

$$\begin{aligned} \theta &= \theta_x \left[\frac{X_i^0}{X_v} + \frac{Y(S^0 - S)(1 + (1 - f_d)b\theta_x)}{X_v(1 + b\theta_x)} \right] \\ &= 6 \text{ d} \times \left[0 + \frac{0.3 \frac{\text{g VSS}}{\text{g COD}} \times (1000 - 4.72) \frac{\text{mg}}{\text{L}} \times (1 + (1 - 0.8) \times 0.15 \text{ d}^{-1} \times 6 \text{ d})}{4000 \frac{\text{mg}}{\text{L}} \times (1 + 0.15 \text{ d}^{-1} \times 6 \text{ d})} \right] \\ &= 0.28 \text{ days} \end{aligned}$$

In general, "conventional" means medium-sized treatment systems that are expected to operate reliably with fairly constant supervision by reasonably skilled operators.

$$SF = \frac{\theta_x}{\theta} = 21.43$$

Because of the table 5.3 given in textbook
So this design is practical to treat medium.

Loading	Implied SF
Conventional	10–80
High Rate	3–10
Low Rate	>80