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 $\frac{mg}{cm^2 \cdot d}$

Then $X_f L_f = YJ_{ss}/b'$ , solving $J_{ss}$ which is 0.03 $mg/cm^2$

Thus

$$A = \frac{Q(S^0 - S)}{J_{ss}} = \frac{1000\frac{L}{d} \times 240\frac{mg}{L}}{0.03\frac{mg}{cm^2 \cdot d} \times \frac{1m^2}{10000cm^2}} = 800\ m^2$$

2.

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

Where

$$S = S^0 \times remvoal\ efficiency = (1 - 0.96) \times 50 = 2mg/L$$

When bulk liquid concentration of benzoate is $2\ mg/L$

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

the numerical values are substituted into Equation 4.42

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

Solving the Volume equation to

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

3.

Using the equation Eq 5.39

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

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,

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

$$= 6\ d \times [0 + \frac{0.3\frac{g\ VSS}{g\ COD} \times (1000 - 4.72)\frac{mg}{L} \times (1 + (1 - 0.8) \times 0.15d^{-1} \times 6\ d)}{4000\frac{mg}{L} \times (1 + 0.15d^{-1} \times 6\ d)}]$$

$$= 0.28\ days$$