1. Problem 22.1-8

   (a)

   Fith polynomial to data in Exmaple 22.1-5

$$y_A(x_A) = 31.5057x_A^4 - 13.8911x_A^3 + 3.2917x_A^2 + 0.2981x_A$$

   Solve the system of equations:

$$\begin{aligned}
N_A &= \frac{k'_y}{(1-y_A)_{iM}}(y_{AG} - y_{Ai}) \\
N_A &= \frac{k'_x}{(1-x_A)_{iM}}(x_{Ai} - x_{AL}) \\
(1-y_A)_{iM} &= \frac{y_{AG} - y_{Ai}}{\ln\left(\frac{1-y_{Ai}}{1-y_{AG}}\right)} \\
(1-x_A)_{iM} &= \frac{x_{Ai} - x_{AL}}{\ln\left(\frac{1-x_{AL}}{1-x_{Ai}}\right)} \\
y_{Ai}(x_{Ai}) &= 31.5057x_{Ai}^4 - 13.8911x_{Ai}^3 + 3.2917x_{Ai}^2 + 0.2981x_{Ai}
\end{aligned}$$

   Where:

$$\begin{aligned}
y_{AG} &= 0.25 \\
x_{AL} &= 0.05 \\
k'_y &= 1.465 \cdot 10^{-3} \\
k'_x &= 1.967 \cdot 10^{-3}
\end{aligned}$$

$$\boxed{\begin{aligned}
x_{Ai} &= 0.1687 \\
y_{Ai} &= 0.1028 \\
N_A &= 2.625 \cdot 10^{-4}\ \text{kg mol/s}\cdot\text{m}^2
\end{aligned}}$$

(b)

$$y_A^* = 31.5057x_{AL}^4 - 13.8911x_{AL}^3 + 3.2917x_{AL}^2 + 0.2981x_{AL}$$
$$y_A^* = 31.5057 \cdot 0.05^4 - 13.8911 \cdot 0.05^3 + 3.2917 \cdot 0.05^2 + 0.2981 \cdot 0.05 = 0.02159$$
$$m' = \frac{y_{Ai} - y_A^*}{x_{Ai} - x_{AL}}$$
$$m' = \frac{0.1028 - 0.02159}{0.1028 - 0.05} = 0.6841$$
$$(1-y_A)_{*M} = \frac{y_{AG} - y_A^*}{\ln\left(\frac{1-y_A^*}{1-y_{AG}}\right)}$$
$$(1-y_A)_{*M} = \frac{0.25 - 0.02159}{\ln\left(\frac{1-0.02159}{1-0.25}\right)} = 0.8591$$
$$(1-y_A)_{iM} = \frac{y_{AG} - y_{Ai}}{\ln\left(\frac{1-y_{Ai}}{1-y_{AG}}\right)}$$
$$(1-y_A)_{iM} = \frac{0.25 - 0.1028}{\ln\left(\frac{1-0.1028}{1-0.25}\right)} = 0.8893$$
$$(1-x_A)_{iM} = \frac{x_{Ai} - x_{AL}}{\ln\left(\frac{1-x_{AL}}{1-x_{Ai}}\right)}$$
$$(1-x_A)_{iM} = \frac{0.1687 - 0.05}{\ln\left(\frac{1-0.05}{1-0.1687}\right)} = 0.8214$$
$$\frac{(1-y_A)_{*M}}{K_y'} = \frac{(1-y_A)_{iM}}{k_y'} + \frac{m'(1-x_A)_{iM}}{k_x'}$$
$$K_y' = (1-y_A)_{*M}\left(\frac{(1-y_A)_{iM}}{k_y'} + \frac{m'(1-x_A)_{iM}}{k_x'}\right)^{-1}$$
$$K_y' = 0.8591 \cdot \left(\frac{0.8893}{1.465 \cdot 10^{-3}} + \frac{0.6841 \cdot 0.8214}{1.967 \cdot 10^{-3}}\right)^{-1}$$
$$\boxed{K_y' = 9.876 \cdot 10^{-4} \text{ m/s}}$$
$$K_y = \frac{K_y'}{(1-y_A)_{*M}}$$
$$K_y = \frac{9.876 \cdot 10^{-4}}{0.8591}$$
$$\boxed{K_y = 1.149 \cdot 10^{-3} \text{ m/s}}$$
$$N_A = K_y(y_{AG} - y_A^*)$$
$$N_A = 1.149 \cdot 10^{-3} \cdot (0.25 - 0.02159)$$
$$\boxed{N_A = 2.625 \cdot 10^{-4} \text{ kg mol/s}\cdot\text{m}^2}$$

(c)

$$
\begin{aligned}
0.25 &= 31.5057x_A *^4 - 13.8911x_A *^3 + 3.2917x_A *^2 + 0.2981x_A* \\
x_A^* &= 0.2915 \\
m'' &= \frac{y_{AG} - y_{Ai}}{x_A^* - x_{AL}} \\
m'' &= \frac{0.25 - 0.1028}{0.2915 - 0.05} = 1.199 \\
(1 - x_A)_{*M} &= \frac{x_A^* - x_{AL}}{\ln\left(\frac{1 - x_{AL}}{1 - x_A^*}\right)} \\
(1 - x_A)_{*M} &= \frac{0.2915 - 0.05}{\ln\left(\frac{1 - 0.05}{1 - 0.2915}\right)} = 0.8234 \\
\frac{(1 - x_A)_{*M}}{K'_x} &= \frac{(1 - y_A)_{iM}}{m'' k'_y} + \frac{(1 - x_A)_{iM}}{k'_x} \\
K'_x &= (1 - x_A)_{*M} \left(\frac{(1 - y_A)_{iM}}{m'' k'_y} + \frac{(1 - x_A)_{iM}}{k'_x} \right)^{-1} \\
K'_x &= 0.8234 \cdot \left(\frac{0.8893}{1.199 \cdot 1.465 \cdot 10^{-3}} + \frac{0.8214}{1.967 \cdot 10^{-3}} \right) \\
&\boxed{K'_x = 8.951 \cdot 10^{-4} \text{ m/s}} \\
K_x &= \frac{K'_x}{(1 - x_A)_{*M}} \\
K_x &= \frac{8.951 \cdot 10^{-4}}{0.8234} \\
&\boxed{K_x = 1.087 \cdot 10^{-3} \text{ m/s}} \\
N_A &= K_x (x_A^* - x_{AL}) \\
N_A &= 1.087 \cdot 10^{-3} \cdot (0.2915 - 0.02) \\
&\boxed{N_A = 2.625 \cdot 10^{-4} \text{ kg mol/s·m}^2}
\end{aligned}
$$

2. Problem 22.5-12

$$\Delta P_{flood} = 0.115 F_P^{0.7}$$

Intalox Packing:

$$F_P = 41$$
$$\Delta P_{flood} = 0.115 41^{0.7} = 1.55 \text{ in. } \mathrm{H_2O/ft \ packing}$$
$$\text{flow param.} = \frac{G_L}{G_G}\left(\frac{\rho_G}{\rho_L}\right)^{0.5}$$

From Example 22.3-1

$$\rho_G = 0.07309$$
$$\rho_L = 62.25$$
$$\nu = 0.8963$$
$$\frac{G_L}{G_G} = 2.2$$
$$\text{flow param.} = 2.2 \cdot \left(\frac{0.07309}{62.25}\right)^{0.5} = 0.0754$$

From Figure 22.3-1:

$$\text{y-axis} = 1.65$$
$$\text{y-axis} = v_G\left(\frac{\rho_G}{\rho_L - \rho_G}\right)^{0.5} F_P^{0.5} \nu^{0.05}$$
$$v_G = 1.65 \cdot \left[\left(\frac{0.07309}{62.25 - 0.07309}\right)^{0.5} \cdot 41^{0.5} \cdot 0.8963^{0.05}\right]^{-1}$$
$$v_G = 7.56$$
$$G_G = v_G \rho_G$$
$$G_G = 7.56 \cdot 0.07309 = 0.552$$

At 60% flood:

$$G_{G,flood} = 0.552 \cdot 0.6 = 0.331$$
$$A_c = \frac{G_G}{G_{G,flood}}$$
$$A_c = \frac{\pi}{4} D^2$$
$$D = \sqrt{\frac{4}{\pi}\frac{G_G}{G_{G,flood}}}$$
$$D = \sqrt{\frac{4}{\pi} \cdot \frac{2000/3600}{0.331}}$$
$$\boxed{D = 1.46 \text{ ft}}$$

For pressure drop at 60% flood:

$$\text{New capacity param} = 1.65 \cdot 0.6 = 0.99$$

From Figure 22.3-1:

$$\boxed{\Delta P_{flood} = 0.25 \text{ in. } H_2O/\text{ft packing}}$$