1. Problem 25.2-2

$$
\begin{aligned}
t &= 0.002 \\
P'_A &= 4 \cdot 10^{-8} \\
\alpha^* &= 10 \\
L_f &= 0.002 \\
x_f &= 0.413 \\
P_h &= 80 \\
P_l &= 20 \\
x_0 &= 0.3
\end{aligned}
$$

Finding y_p

$$
\begin{aligned}
r &= \frac{P_l}{P_h} \\
r &= \frac{20}{80} = 0.25 \\
a &= 1 - \alpha^* \\
a &= 1 - 10 = -9 \\
b &= -1 + \alpha^* + \frac{1}{r} + \frac{x_0}{r}\left(\alpha^* - 1\right) \\
b &= -1 + 10\frac{1}{0.25} + \frac{0.3}{0.25}\left(10 - 1\right) = 23.8 \\
c &= \frac{-\alpha^* x_0}{r} \\
c &= \frac{-10 \cdot 0.3}{0.25} = -12 \\
y_p &= \frac{-b + \sqrt{b^2 - 4ac}}{2a} \\
y_p &= \frac{-23.8 + \sqrt{23.8^2 - 4 \cdot -9 \cdot -12}}{2 \cdot -9} \\
\boxed{y_p &= 0.678}
\end{aligned}
$$

Finding fraction permeated

$$
\begin{aligned}
x_0 &= \frac{x_f - \theta y_p}{1 - \theta} \\
0.3 &= \frac{0.413 - \theta \cdot 0.678}{1 - \theta}
\end{aligned}
$$

Solve for θ

$$\boxed{\theta = 0.299}$$

$$A_m = \frac{\theta L_f y_p}{\frac{P'_A}{t}\left(P_h x_0 - P_l y_h\right)}$$

$$A_m = \frac{0.299 \cdot 0.002 \cdot 0.678}{\frac{4 \cdot 10^{-8}}{0.002}\left(80 \cdot 0.3 - 20 \cdot 0.678\right)}$$

$$\boxed{A_m = 1.94 \text{ cm}^3}$$

2. Problem 25.2-3

(a)

$$P'_A = 4 \cdot 10^{-9}$$
$$\alpha^* = 10$$
$$L_f = 2000$$
$$\theta = 0.529$$
$$P_h = 40$$
$$P_l = 10$$
$$x_f = 0.5$$
$$t = 0.0015$$

Finding y_p

$$a_1 = \theta + \frac{P_l}{P_h} - \frac{P_l}{P_h}\theta - \alpha^*\theta - \alpha^*\frac{P_l}{P_h} + \alpha^*\frac{P_l}{P_h}\theta$$
$$a_1 = 0.529 + \frac{10}{40} - \frac{10}{40} \cdot 0.529 - 10 \cdot 0.529 - 10 \cdot \frac{10}{40} + 10 \cdot \frac{10}{40} \cdot 0.529$$
$$a_1 = -5.82$$
$$b_1 = 1 - \theta - x_f - \frac{P_l}{P_h} + \frac{P_l}{P_h}\theta + \alpha^*\theta + \alpha^*\frac{P_l}{P_h} - \alpha^*\frac{P_l}{P_h}\theta + \alpha^* x_f$$
$$b_1 = 1 - .529 - 0.5 - \frac{10}{40} + \frac{10}{40} \cdot 0.529 + 10 \cdot 0.529 + 10 \cdot \frac{10}{40} - 10 \cdot \frac{10}{40} \cdot 0.529 + 10 \cdot 0.5$$
$$b_1 = 11.3$$
$$c_1 = -\alpha^* x_f$$
$$c_1 = -10 \cdot 0.5 = -5$$
$$y_p = \frac{-b_1 + \sqrt{b_1^2 - 4a_1c_1}}{2a_1}$$
$$y_p = \frac{-11.3 + \sqrt{11.3^2 - 4 \cdot -5.82 \cdot -5}}{2 \cdot -5.8}$$
$$\boxed{y_p = 0.678}$$
$$x_0 = \frac{0.5 - 0.529 \cdot 0.678}{1 - 0.529}$$
$$\boxed{x_0 = 0.3}$$
$$A_m = \frac{\theta L_f y_p}{\frac{P'_A}{t}(P_h x_0 - P_l y_h)}$$
$$A_m = \frac{0.529 \cdot 2000 \cdot 0.678}{\frac{4 \cdot 10^{-9}}{0.0015}(40 \cdot 0.3 - 10 \cdot 0.678)}$$
$$\boxed{A_m = 5.15 \cdot 10^7 \text{ cm}^3}$$

(b)

$$x_{0M} = \frac{x_f \left[1 + (\alpha^* - 1)\frac{P_l}{P_h}(1 - x_f)\right]}{\alpha^*(1 - x_f) + x_f}$$

$$x_{0M} = \frac{0.5\left[1 + (10 - 1)\frac{10}{40}(1 - 0.5)\right]}{10(1 - 0.5) + 0.5}$$

$$\boxed{x_{0M} = 0.193}$$

(c)

Same as part b except that $x_f = 0.6$

$$x_{0M} = \frac{0.6\left[1 + (10 - 1)\frac{10}{40}(1 - 0.6)\right]}{10(1 - 0.6) + 0.6}$$

$$\boxed{x_{0M} = 0.2478}$$

3. Problem 25.2-4

(a)

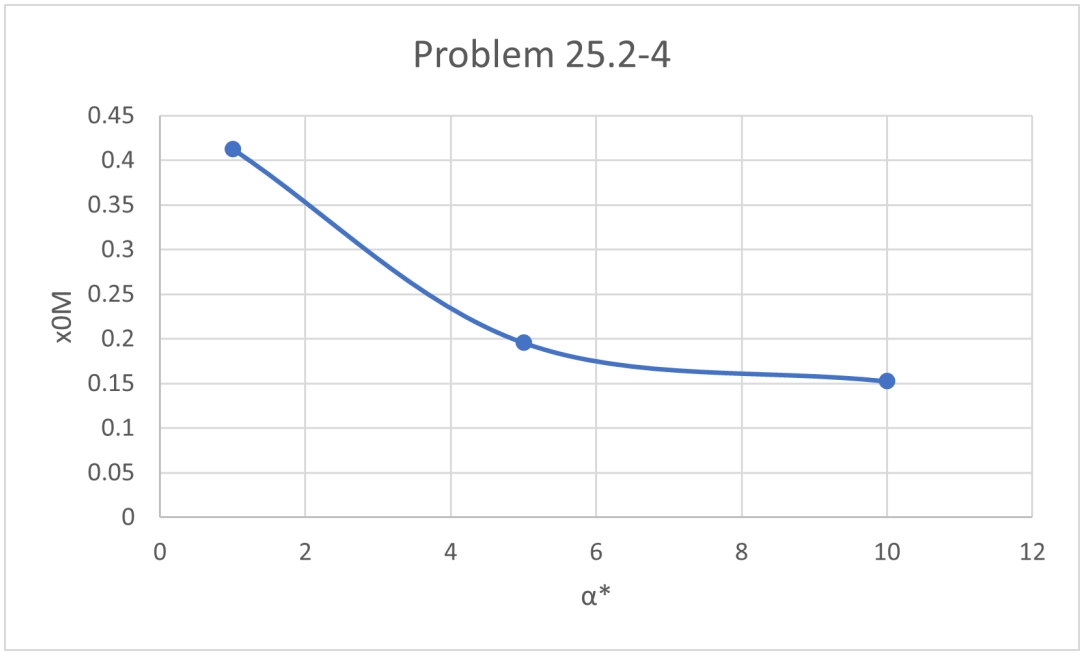
$$x_f = 0.413$$
$$\alpha^* = 10$$
$$P_l = 20$$
$$P_h = 80$$
$$x_{0M} = \frac{x_f \left[1 + (\alpha^* - 1)\frac{P_l}{P_h}(1 - x_f)\right]}{\alpha^*(1 - x_f) + x_f}$$
$$x_{0M} = \frac{0.413\left[1 + (10 - 1)\frac{20}{80}(1 - 0.413)\right]}{10(1 - 0.413) + 0.413}$$
$$\boxed{x_{0M} = 0.153}$$

(b)

$$\alpha^* = 5$$
$$x_{0M} = \frac{0.413\left[1 + (5 - 1)\frac{20}{80}(1 - 0.413)\right]}{5(1 - 0.413) + 0.413}$$
$$\boxed{x_{0M} = 0.196}$$

(c)

$$\alpha^* = 1$$
$$x_{0M} = \frac{0.413\left[1 + (1 - 1)\frac{20}{80}(1 - 0.413)\right]}{1(1 - 0.413) + 0.413}$$
$$\boxed{x_{0M} = 0.413}$$


Problem 25.2-4
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
x0M
0
2
4
6
8
10
12
α*