Exercise 8 / TKP4105 Håkan Olvik

① $L = 1 \cdot 10^{-6} m$, $\dot{n}_0 = 1 \ mol/s$ $y_{CO_2} = 0,5 = y_{met}$

$T = 35°C = 308K$

$P_{CO_2} = 15 \cdot 10^{-10} [cc(STP)cm]/[cm^2 \ s \ cm \ Hg]$

$P_{met} = 0,48 \cdot 10^{-10}$

$p_r = 20 atm$, $p_p = 1,1 atm$

a) Stage cut = fraction of feed gas that permeates the membrane.

~~0,25%~~ $\theta_1 = 0,25 = \frac{\text{Permeate flow}}{\text{Feed}} \Rightarrow \dot{n}_p = 0,25 \cdot 1 \ mol/s = 0,25 \ mol/s$

$Y_{A,r} = \frac{(Y_{A,0} - \theta Y_{AP})}{(1-\theta)}$ will be the operating line

$Y_{Ar} = \frac{Y_{AP}(R(1-Y_{AP})(\alpha - 1) + 1)}{\alpha - (\alpha - 1)Y_{AP}}$ will be the rate transfer

$R = \frac{P_p}{P_r} = \frac{1,1}{20} = 0,055$, $\alpha = \frac{P_{CO_2}}{P_{met}} = \frac{15}{0,48} = 31,25$

$\theta = 0,25$

Y_{Ar}	Y_{AP}
0	2
0,25	1,25
0,5	0,5
0,35	0,93

0,50

Y_{Ar}	Y_{AP}
0	1
0,25	0,75
0,5	0,5
0,17	0,83

0,75

Y_{Ar}	Y_{AP}
0	0,67
0,25	0,59
0,5	0,5
0,09	0,64

b) Evaluating fluxes and membrane area

$$J_A = \left(\frac{P_A}{L}\right)(P_r y_{Ar} - P_p y_{Ap}) \quad , \quad A = \frac{\dot{n}_{AP}}{J_A} \cdot \frac{\dot{n}_{in} \theta y_{AP}}{J_A \, \rho \, m_A}$$

$\theta = 0{,}25$:

$$J_A = \frac{13{,}0 \text{ barrer}}{1 \cdot 10^{-6} m} \cdot (20 \text{atm} \cdot 0{,}35 - 1{,}1 \text{atm} \cdot 0{,}93)$$

$$= 89.655.000 \text{ barrer atm/m}$$

$$J_B = \frac{0{,}48 \text{ barrer}}{1 \cdot 10^{-6}} (20 \text{atm} \cdot 0{,}65 - 1{,}1 \text{atm} \cdot 0{,}07)$$

$$= 6203.040 \text{ barrer atm/m}$$

$$A = \frac{0{,}25 \cdot 0{,}93}{89655000} \cdot \frac{22{,}4}{1} = 75{,}8 m^2$$

Just change the numbers for $\theta = 0{,}5$ and $\theta = 0{,}75$

c) Maximum ~~permeability~~ permeate purity when $\theta = 0$

$\theta = 0 \Rightarrow y_p = 0{,}96$

(2) $A = 4 \cdot 10^{-3}\, m^2$ $T = 25°C$

$C_0 = 12\, kg/m^3$, $\rho_0 = 1005{,}5\, kg/m^3$

$C_1 = 0{,}468\, kg/m^3$, $\rho_1 = 997{,}3\, kg/m^3$

$\dot{V}_p = 3{,}84 \cdot 10^{-8}\, m^3/s$, $\Delta P = 56 atm$

$$N_w = \frac{\dot{V}_p \cdot \rho_1}{A} = \frac{3{,}84 \cdot 10^{-8} \cdot 997{,}3}{4 \cdot 10^{-3}} = 9{,}57 \cdot 10^{-3}$$

$$N_s = \frac{N_w \cdot C_1}{\rho_w} = \frac{9{,}57 \cdot 10^{-3} \cdot 0{,}468}{997{,}3} = 4{,}49 \cdot 10^{-6}$$

$$m_p = \left(\frac{12}{58{,}45}\right) \bigg/ \left(\frac{1000}{993{,}5}\right) = 0{,}204$$

$\pi_1 = 9{,}5 atm$

$m_p = 0{,}008$, $\pi_2 = 0{,}35 atm$

$\Delta\pi = 9{,}15 atm$

$N_w = A_w (\Delta p - \Delta\pi)$

$$A_w = \frac{N_w}{\Delta p - \Delta\pi} = 2{,}04 \cdot 10^{-4}$$

$N_s = A_s \Delta c$ $A_s = 3{,}9 \cdot 10^{-7}$

$R = 1 - \left(\frac{C_2}{C_1}\right) = 0{,}961$