Chapter 5

1. In gas separation by membrane, why gas film resistance is negligible?

   Ans: High diffusivity of gaseous components.

2. In gas separation which resistance is dominating?

   Ans: membrane resistance.

3. For complete mixing model in case of gas separation, find maximum composition of reject stream if, $\alpha^{*}=10;\ \frac{P_l}{P_h}=\frac{1}{60};\ x_f=0.3;$

$$x_{om}=\frac{x_f\left[1+(\alpha^{*}-1)\left(\frac{p_l}{p_n}\right)(1-x_f)\right]}{\alpha^{*}(1-x_f)+x_f}$$

Ans:

$$\alpha^{*}=10;\quad \frac{p_l}{p_h}=\frac{1}{60};\quad x_f=0.3$$

$$x_{om}=\frac{x_f\left[1+(\alpha^{*}-1)(\frac{p_l}{p_h})(1-x_f)\right]}{\alpha^{*}(1-x_f)+x_f}$$

$$x_{om}=\frac{0.3\left[1+9\times\frac{1}{60}\times 0.7\right]}{10\times 0.7+0.3}$$

$=0.045$

4. Counter current model in gas separation is like

   (a) CSTR (b) PFR (c) CSTR+PFR

   Ans: (b)

5. Find membrane area to separate air using a membrane 0.002 cm thick with oxygen permeability P_A=400x10^{-10} $\frac{cm^3(STP)cm}{s.cm^2.cmHg}$ and α^*=8 for permeability ratio of oxygen and nitrogen. Feed rate, q_f=10^6 cm^3/s and θ=0.3; P_h=150 cm Hg and P_l=10 cm Hg. Assume complete mixing model, calculate permeate composition, reject composition and membrane area.

Ans:

t=0.002 cm; $\alpha^* = 8$; $P_A = 400\times10^{-10}$; $q_f = 10^6 cm^3/s$; $\theta = 0.3$

$p_h = 150$ cm Hg; $p_l = 10$ cm Hg; $x_f = 0.21$

$$a_1 = \theta + \frac{p_l}{p_h}(1-\theta) - \alpha^*\theta - \alpha^*\frac{p_l}{p_h}(1-\theta)$$

$$= 0.3 + \frac{1}{15}\times0.3 - 8\times0.3 - 8\times\frac{1}{15}\times0.7$$

$$= -2.45$$

$$b_1 = 1-\theta-x_f - \frac{p_l}{p_h}(1-\theta) + \alpha^*\theta + \alpha^*\frac{p_l}{p_h}(1-\theta) + \alpha^* x_f$$

$$= 1-0.3-0.21-\frac{1}{15}\times0.7 + 8\times0.3 + 8\times\frac{1}{15}\times0.7 + 8\times0.21$$

$$= 4.897$$

$$c_1 = -\alpha^* x_f = -8\times0.21 = -1.68$$

$$y_p = \frac{-b_1 + \sqrt{b_1^2 - 4a_1c_1}}{2a_1}$$

$$= \frac{-4.897 + \sqrt{4.897^2 - 4\times(-2.45)\times(-1.68)}}{2\times(-2.45)}$$

$$= 0.44$$

$$x_0 = \frac{x_f - \theta y_f}{1-\theta}$$

$$= \frac{0.21 - 0.3\times 0.44}{1-0.3}$$

$$= 0.11$$

$$A_m = \frac{\theta q_f y_p}{\left(-\frac{p'_A}{t}\right)\left(p_h x_0 - p_l y_p\right)}$$

$$= \frac{0.3\times 10^6 \times 0.44}{\left(-\frac{400\times 10^{-10}}{0.002}\right)\left(150\times 0.11 - 10\times 0.44\right)}$$

$$= \frac{132000}{2\times 10^5 \times 12.1}$$

$$= 5.45\times 10^8 cm^2$$