Chap. 29. Interphase Mass Transfer

· single pahse : transfer between two contacting phases
  Gas-Liquid, Liquid-Liquid, fluid flow past a solid
· multiphase : 어떻게 전달되어 갈 것인가.
  물질전달과정, 물질전달량

1. Equilibrium

평형상태에 도달하는 과정

· Equilibration
· Chemical potential
  at equilibrium: net diffusion rate = 0
  transport가 존재한다 - far from the equilibrium

· Ideal phase (Liquid, Gas)

1) Liquid phase

$$P_A = x_A \, P_A^{sat}$$

2) Gas phase

$$P_A = y_A P$$

at constant P & T

Raoult-Dalton Equilibrium

$$y_A P = x_A \, p_A^{sat}$$

cf) i) Dilute Solution : Henry's Law

$$P_A = H c_A$$

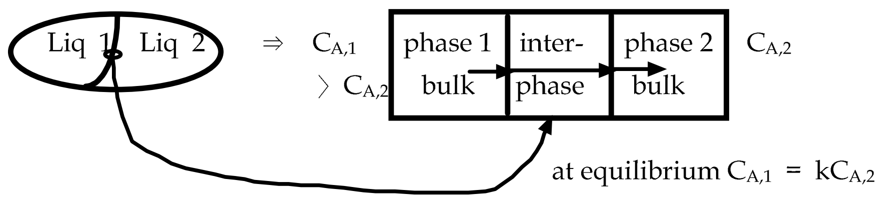
ii) Distribution Law at equilibrium

$$c_{A,\,liquid,\,1} = K c_{A,\,liquid,\,2}$$

· Basic concept

i) At constant T & P
  equilibrium relation follows the equilibrium curve
ii) At equilibrium, net mass transfer equals zero
iii) Far from the equilibrium, transport of component occurs in order to reach equilibrium

2. Two-resistance theory

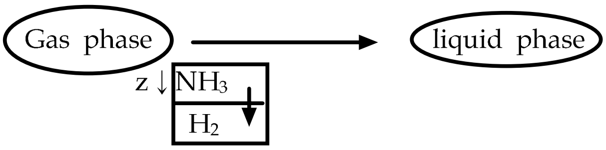


· diagram for two - resistance theory

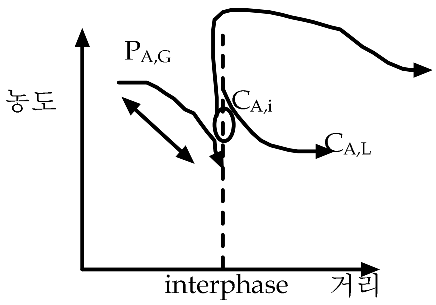
· Assumption - ① rate determining : rate of diffusion through the phases

- ② no resistance across the interphase

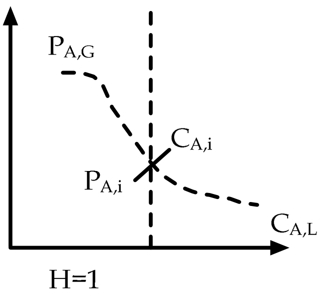
Ex.



$P_A = HC_A$: Henry's Law



$P_{A,i} = HC_{A,i}$



(1) Individual Mass Transfer Coefficient

$P_{A,G}$, $C_{A,L}$, $P_{A,i}$, $C_{A,i}$

$N_{A,Z} = k_G(P_{A,G} - P_{A,i})$: 기상

$N_{A,Z} = k_L(C_{A,i} - C_{A,L})$: 액상

k_G = convective mass transfer coefficient in Gas phase

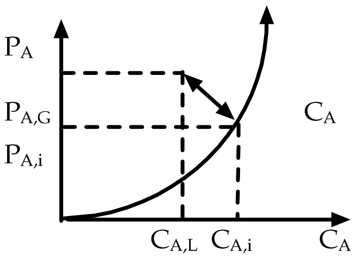
k_L = convective mass transfer coefficient in Liquid phase

$N_{A,Z} = k_G(P_{A,G} - P_{A,i}) = k_L(C_{A,i} - C_{A,L})$

unknown

$\Rightarrow -\dfrac{K_L}{K_G} = \dfrac{P_{A,G} - P_{A,i}}{C_{A,L} - C_{A,i}}$: slope

Equilibrium Curve



unique slope : $-\dfrac{k_L}{k_G}$

C_A vs $P_{A,i}$ 로 가정

k_L, k_G Table 29.1

(2) Overall Mass Transfer Coefficient

$P_{A,L}$ 와 $C_{A,L}$ 만 주로 알려져 있다.

$N_A = K_G(P_{A,G} - P_A^*)$ (P_A^* : partial pressure in equilibrium with bulk composition of liquid phase $C_{A,L}$)

$N_A = K_G(C_A^* - C_{A,L})$

$N_A \neq 0$ 이려면, $P_A^* \neq P_{A,G}$ (P_A^* : at equilibrium, $P_{A,G}$ 는 $C_{A,L}$ 과 평형을 이룸 $P_{A,G} = HC_{A,L}$ or $C_{A,L} \rightarrow P_A^{sat}X_A$)

low con'c - $P_{A,i} = mC_{A,i}$

- $P_A^* = mC_{A,L}$, $P_{A,G} = mC_A^*$

(m → small : Gas phase control , m → large : Liquid phase control)

$$\frac{1}{K_G} = \frac{P_{A,G} - P_{Ai}}{N_{A,Z}} + \frac{P_{A,i} - P_A^*}{N_{A,Z}} = \frac{P_{A,G} - P_{A,i}}{N_{AZ}} - \frac{m(C_{A,i} - C_{A,L}}{N_{A,Z}}$$

($N_{A,Z} = K_G(P_{A,G} - P_A^* = K_L(C_A^* - C_{A,L})$

$$\frac{1}{K_G} = \frac{1}{k_G} + \frac{m}{k_L}$$

$$\frac{1}{K_L} = \frac{C_A^* - C_{A.L}}{N_{A,Z}} = \frac{P_{A,G} - P_{A,i}}{m N_{A,Z}} + \frac{C_{A,i} - C_{A,L}}{N_{A,Z}} = \frac{1}{m k_G} + \frac{1}{k_L}$$

$P_{A,i} = m\, C_{A,i}$ (m : Henry's const)

$(\frac{1}{K_G} = \frac{1}{k_G} + \frac{m}{k_C}, \quad \frac{1}{K_G} = \frac{1}{mk_G} + \frac{1}{k_C})$