Advanced Rxn Engineering / Session 13

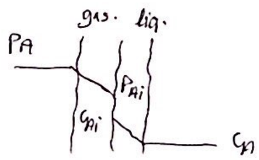
① Clues to kinetic Regime

1.1 from solubility data

- $P_{Ai} = H_A C_{Ai}$ → large H_A : slightly soluble gas (liquid film resistance controls)
  → small H_A : highly " " (gas " " ")
- for fast rxns occuring in the film, the solubility of the gas in the liquid can determine whether the overall process is gas phase or liquid phase controlling
- Consider straight mass transfer of A across the gas and liquid films: $-\frac{1}{S}\cdot\frac{dN_A}{dt} = \frac{1}{\frac{1}{k_{Ag}}+\frac{H_A}{k_{Al}}}\cdot\Delta P_A$, $\Delta P_A = P_A - P_A^*$, $P_A^* = H_A C_A$

1.2 From experiment → double CSTR

- for straight mass transfer across gas and liquid films without any rxn we have:



$$-r_A'' = \frac{-1}{S}\cdot\frac{dN_A}{dt} = k_{Ag}(P_A - P_{Ai}) = k_{Al}(C_{Ai} - C_A)$$

$P_A^* \triangleq$ equilibrium partial pressure of A in the liquid phase $= H_A C_A$

$$\Rightarrow k_{Ag}(P_A - P_{Ai}) = k_{Al}(C_{Ai} - C_A) = K_{Ag}(P_A - P_A^*)$$

$C_A = \frac{P_A^*}{H_A} \Rightarrow$ $P_A^* = P_{Ai} - \frac{H_A k_{Ag}}{k_{Al}}(P_A - P_{Ai})$, $\frac{1}{K_{Ag}} = \frac{1}{k_{Ag}} + \frac{H_A}{k_{Al}}$

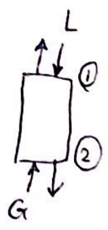
- Advantages ✓
- we have CSTRs : $-r_{Bl} = \frac{-1}{V_l}\cdot\frac{dN_B}{dt} = \frac{v_l(C_{B0} - C_B)}{V_l}$, $-r_B'' = \frac{-1}{S}\cdot\frac{dN_B}{dt} = -r_{Bl}\frac{V_l}{S} = \frac{v_l(C_{B0} - C_B)}{S}$
- Increase in gas phase agitation → ↑ k_{Ag}
  → would increase the rate if gas phase resistance is important, otherwise no effect
- change in S & V_L → If independent of V_L, but proportional to S → fast rxn regime
  → " affected by both S, V_L → Intermediate
  → " rate independent of S, but proportional to V_L → slow rxn

1.3 Extension to 3 phase systems

1.4 Tower Design

$Y_A = \frac{P_A}{P_U}$, $X_A = \frac{C_A}{C_U}$

• case 01 "straight mass transfer without chemical rxn"



$$G\frac{dY_A}{dh} = (-r_A'').a \Rightarrow h = \frac{G}{a}\int_{Y_{A1}}^{Y_{A2}}\frac{dY_A}{-r_A''}$$

$$\frac{dX_A}{dC_A} = \frac{C_T}{(C_T - C_A)^2} \Rightarrow \frac{G\pi\, dP_A}{(\pi - P_A)^2} = \frac{L C_T\, dC_A}{(C_T - C_A)^2}$$

$$h = \frac{G\pi}{a}\int_{P_{A1}}^{P_{A2}}\frac{dP_A}{k_{Ag}(P_A - P_{Ai})(\pi - P_A)^2} = \frac{LG}{a}\int_{C_{A1}}^{C_{A2}}\frac{dC_A}{k_{Al}(C_{Ai} - C_A)(C_T - C_A)^2}$$

- special case: dilute system

• case 02