P14-9

→ Gas phase, adiabatic, irreversible reaction

→ NO ΔP

→ Packed bed.

a) Mole balance $F_{A0}\frac{dX}{dW} = -r_A$ ——— (1)

rate law $-r_{As} = k' C_{As}$

C_{As} is not known

Assume reaction is mass transfer limited.

$$W_A = k_c(C_A - C_{As}) = k' C_{As}$$

$$C_{As} = \frac{k_c C_A}{k_c + k'}$$

$$-r_{As} = \frac{k' k_c C_A}{k_c + k'} \quad \text{——— (2)}$$

Estimate k_c

$$Sh = 100\ Re^{1/2}$$

$$\frac{k_c d_p}{De} = 100\left(\frac{u \cdot dp}{\nu}\right)^{1/2} \Rightarrow k_c = 70.7 \text{ cm/s}$$

converting $\Rightarrow k_c = 70.7 \times a_{cat} = 70.7 \times 60 = 4242 \text{ cm}^3/\text{s-g-cat}$

Stoichiometry :

$$C_A = C_{A0}\left(\frac{1-x}{1+\epsilon x}\right) \qquad \epsilon = y_{A0}\delta = 0.5 \times 0 = 0$$

← const. p & T.

$$C_A = C_{A0}(1-x) \quad \text{——— (3)}$$

Solve eq. (1), (2), (3) numerically.

$\Rightarrow$ For $x = 0.6$ $W_{cat} = 925$ kg.

b) Adiabatic operation

Mole balance and rate law remain same.

$$k(T) = 0.01 \exp\left[\frac{4000}{1.987}\left[\frac{1}{300} - \frac{1}{T}\right]\right] \quad \text{—— ④}$$

Stoichiometry:

$$C_A = C_{A0}(1-X)\frac{T_0}{T} \quad \text{—— ③ —⑤}$$

Energy balance:

$$\frac{dF}{dt} = \frac{Q^{\nearrow 0} - W_s^{\nearrow 0} - \sum F_i C_{pi}(T - T_{i0}) + F_0 X \Delta H_{rx}}{\sum N_i C_{pi}} = 0$$

$$\Rightarrow \sum F_i C_{pi}(T - T_{i0}) = 10 \times 25(T-300) + 10 \times 75(T-300)$$

$$= 1000(T-300)$$

$$-1000(T-300) + 10 \cdot X \cdot 10000 = 0 \quad \text{——} \quad ⑥$$

Solve numerically.

For $X = 0.6$ $W_{cat} = 1020$ kg.