P6-7

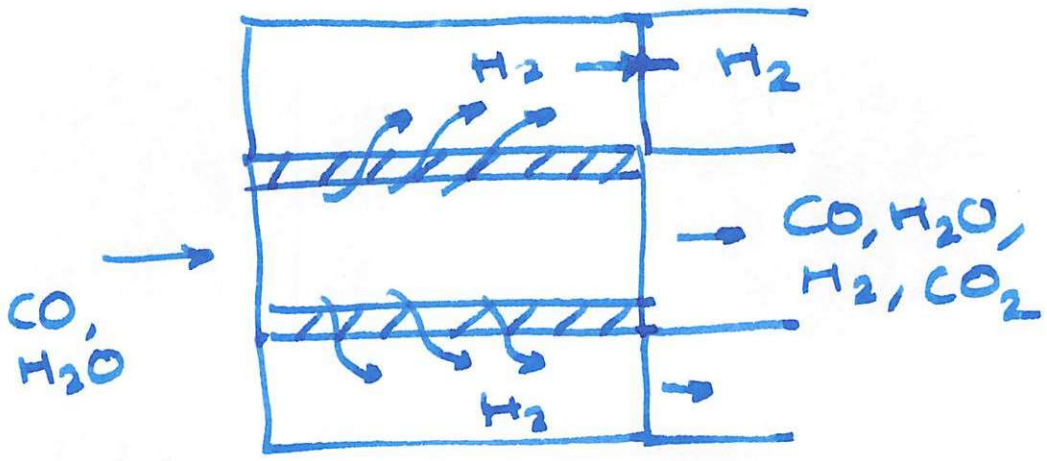
Fuel cell

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

$$A + B \rightleftharpoons C + D$$

Assumption

- catalyst distributed evenly over whole volume



Mole balance

$$\frac{dF_A}{dW} = r'_A \quad \text{—— (1)}$$

$$\frac{dF_B}{dW} = r'_B \quad \text{—— (2)}$$

$$\frac{dF_C}{dW} = r'_C \qquad \text{—(3)}$$

$$\frac{dF_D}{dW} = r'_D - R_{H_2} \qquad \text{—(4)}$$

rate law:

$$r'_A = r'_B = -r'_C = -r'_D = r \qquad \text{—(5)}$$

$$r = -k\left[C_A C_B - \frac{C_C C_D}{K_{eq}}\right] \qquad \text{—(6)}$$

$$R_{H_2} = K_{H_2} C_D \qquad \text{—(7)}$$

stoichiometry:

$$C_A = C_{T0}\frac{F_A}{F_T} \; ; \; C_B = C_{T0}\frac{F_B}{F_T} \qquad \text{—(8)}$$

$$C_D = C_{T0}\frac{F_D}{F_T} \; ; \; C_C = C_{T0}\frac{F_C}{F_T}$$

$$F_T = F_A + F_B + F_C + F_D \qquad \text{—(9)}$$

⇒ Solve eq^{n} (1) - (9) numerically.
to get answers to (a), (b), and (c)

(b) If membrane reactor is replaced by PFR, Hydrogen cannot escape.

$\Rightarrow$ maximum conversion that can be obtained is equilibrium conversion

$$K_{eq} = \frac{C_C C_D}{C_A C_B} = \frac{C_{A0}^2 X^2}{C_{A0}^2 (1-X)^2}$$

$$1.44 = \frac{X^2}{(1-X)^2} \Rightarrow X = 0.54$$

(c) If feed rate is doubled F_{A0} and F_{B0} are doubled when solving ①-⑨