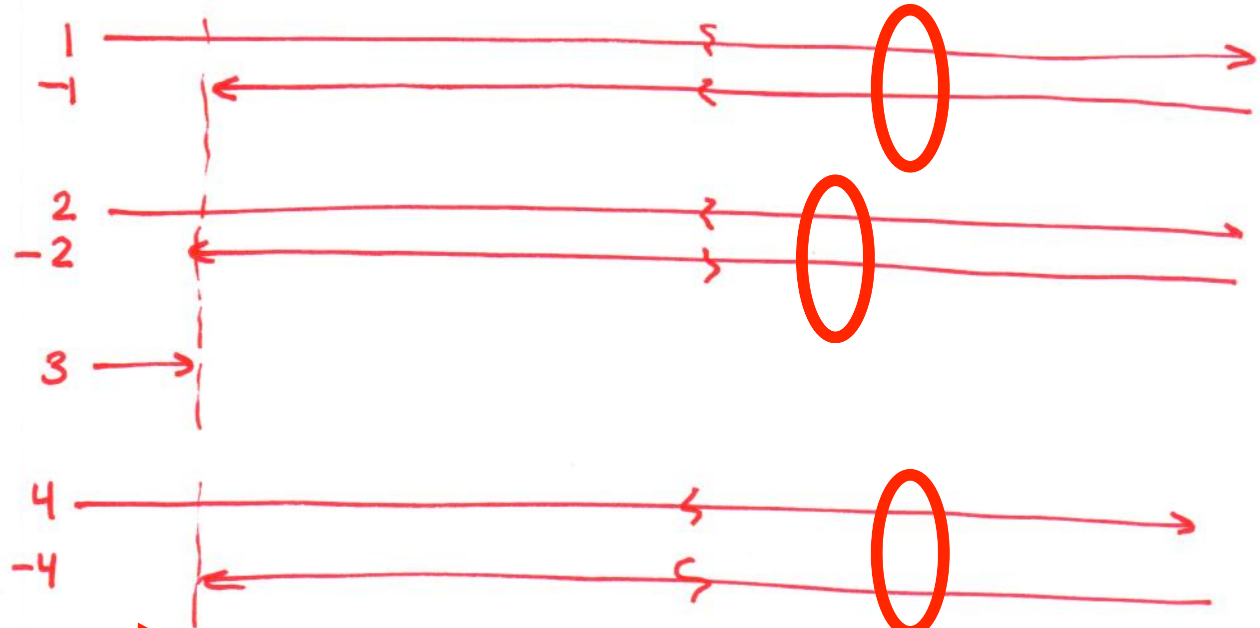
CRE **Homework 10- Spring 2020**

a.

Step



rnet

b. $r = r_3 = k_R (D*) \frac{(W*)}{C_T}$

$(D*) = K_D (D)(*)$

$(W*) = K_W (W)(*)$

$r = k_r K_D K_W (D)(W) \frac{(*)^2}{C_T}$

$C_T = (*) + (D*) + (W*) + (C*)$

$C* = \frac{(C)(*)}{K_C}$

$C_T = (*) + (D*) + (W*) + \frac{(C)(*)}{K_C}$

$C_T = (*) + K_D(D)(*) + K_W(W)(*) + \frac{(C)(*)}{K_C}$

$$(*) = \frac{c_T}{1 + K_D(D) + K_W(W) + \frac{(C)}{K_C}}$$

$$\boxed{r = \frac{k_r K_D K_W (D)(W) c_T}{\left(1 + K_D(D) + K_W(W) + \frac{(C)}{K_C}\right)^2}}$$

c. If $(*)$ is MASI $c_T = (*)$

$$\boxed{r = k_r K_D K_W (D)(W) c_T}$$

d. $$\psi = \frac{C_A}{C_{AS}} = \frac{1}{\lambda}\left(\frac{\sinh \phi_1 \lambda}{\sinh \phi_1}\right)$$

$$0.1 = \frac{1}{0.8}\left(\frac{\sinh[\phi_1 (0.8)]}{\sinh \phi_1}\right)$$

Solve for ϕ_1

$$\phi_1 = 12.6$$

$$\boxed{\eta_1 = \frac{3}{\phi_1^2}\left(\phi_1 - 1\right) = 0.22}$$

e. PFR DESIGN EQN.

$$F_{D0}\frac{dX}{dV} = -r_A = k(D)$$

$$(D)_0\, v\frac{dX}{dV} = \frac{k(D)_0(1-X)}{1+\varepsilon X}$$

$$\varepsilon = \delta y_{D0} = (1+0.2-1)(1) = 0.2$$

$$v\left(\frac{dX}{dV}\right) = \frac{k(1-X)}{1+0.2X}$$

$$\int\frac{(1+0.2x)dX}{1-X} = \frac{k}{v}\int dV$$

$$\int\frac{(1+0.2x)dX}{1-X} = k\tau$$

$$\int_0^{0.6}\frac{(1+0.2X)dX}{1-X} = k\tau$$

$$0.98 = \frac{0.10}{s}\tau$$

$$\tau = 9.8s$$

$$\tau = \frac{V}{v} = 9.8s \qquad V = 49L$$

f. This conversion is the same as with the segregation model, as mixing is not important in 1st order reaction g.

$$K = \frac{(C)(CO)^{0.2}}{(D)}$$

$$(D) = \frac{(D)_0(1-X)}{1+0.2X}$$

$$(C) = \frac{(D)_0 X}{1+0.2X}$$

$$(CO) = \frac{(D)_0(0.2X)}{1+0.2X}$$

$$(D)_0 = \frac{1.01E6\,Pa}{8.31\frac{J}{MOL\,K}(700K)} = 173\,\frac{mol}{m^3}$$

$$= 0.173\,\frac{mol}{L}$$

$$8 = \frac{\left[\frac{(D)_0 X}{1+0.2X}\right]\left[\frac{(D)_0(0.2X)}{1+0.2X}\right]^{0.2}}{\frac{(D)_0(1-X)}{1+0.2X}}$$

Solve for X

$$\boxed{X = 0.94}$$

h. $Q = -(\Delta H_R) F_{D0} X_D$

$$Q = -(-5000\, J/mol)\left(0.173 \frac{mol}{L}\right)\left(5 \frac{L}{s}\right)(0.6)$$

$$\boxed{Q = 2.60\ kW}$$

or 4.07 kW if X = 0.94

i. $$F_{D0} \frac{dX}{dV} = -r_A = k(D)$$

$$(D) = \frac{(D)_0 (1-X)}{1+0.2X} \frac{T_0}{T}$$

$$T = \frac{X(-\Delta H_R) + \sum \Theta_i c_{pi} T_0 + X \Delta c_p T_R}{\sum \Theta_i c_{pi} + X \Delta c_p}$$

$$\Delta c_p = 0.2\, c_p$$

$$T = \frac{X(-\Delta H_R) + c_p T_0 + 0.2 c_p X T_R}{c_p + X(0.2\, c_p)}$$

$$k = k(T_0) \exp\left[\frac{E}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right]$$

Substitute T INTO EQNS FOR k + (D)

$$\frac{dX}{dV} = \frac{k(D)}{F_{D0}}$$

INTEGRATE FROM $V = 0$ TO 49L

USING COMPUTATIONAL SOFTWARE.

WHEN $V = 49L$ $\quad X = 0.596$ $\quad T = 776K$

WHEN $X = 0.75$ $\quad V = 76.8L$

j. $$0.2 = \frac{F_C}{F_C + F_D + F_{CO}} = \frac{F_{DO} X}{F_{DO} X + F_{DO}(1-X) + 0.2 F_{DO} X_D}$$

$$\boxed{X = 0.208}$$