HOMEWORK #1

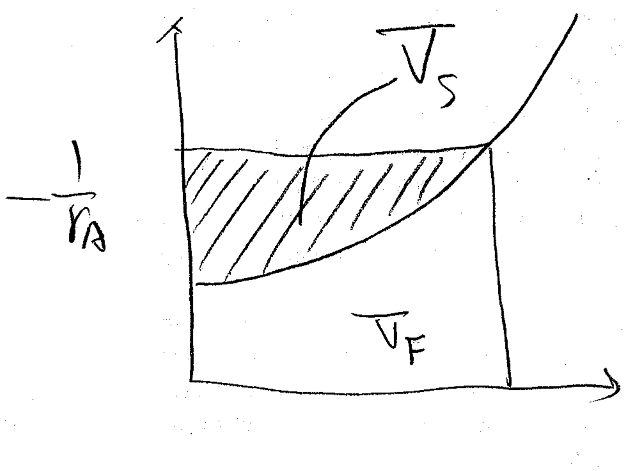
1. N/A

2. liquid phase reaction. there is no volume change. for CSTR

$$V = \frac{v_0(C_{A0}-C_A)}{-r_A} = \frac{v_0\,(C_{A0}-C_A)}{kC_A} = \frac{v_0}{k}\left(\frac{C_{A0}}{C_A}-1\right)$$

$$= \frac{10\ dm^3/min}{0.23\ min^{-1}}(10-1)$$

$$= 391.3\,(dm^3)$$



⇒ at the same conversion volume of CSTR is V_s greater than PFR.

⇒ CSTR tends to operate at diluted situation so the average reaction rate is lower in the reactor, so that the size must be larger to achieve the desired conversion.

3.

$X_A = 0.9$, $v_0 = 10\ l/hr$ $F_{A0} = 5\ mol/hr$

① $-r_A = k$ $k = 0.075 \frac{mol}{hr \cdot l}$

CSTR $V = \frac{5 - 0.1 \cdot 5}{0.075} = 60\ l$ #

PFR $V = \frac{1}{-0.075} \int_{F_{A0}}^{F_A} dF_A = \frac{5 - 0.1 \cdot 5}{0.075} = 60\ l$ #

② $-r_A = k \cdot C_A$ $k = 0.01\ s^{-1}$

CSTR $V = \frac{5 - 0.1 \cdot 5}{3600 \cdot 0.01 \cdot \frac{5}{10}} = 0.25\ l$ #

PFR $V = -\frac{1}{k} \int \frac{dF_A}{C_A} = -\frac{v_0}{k} \int_{C_{A0}}^{C_A} \frac{dC_A}{C_A} = \frac{v_0}{k} \ln \frac{C_{A0}}{C_A}$

$= \frac{10}{3600 \cdot 0.01} \cdot \ln 10 = 0.64\ l$ #

③ $-r_A = k C_A^2 \quad k = 15 \frac{l}{mo \cdot hr}$

CSTR :

$$V = \frac{F_{A0} - F_A}{k \cdot C_A^2} = \frac{F_{A0} - F_A}{k \left(\frac{F_A}{v_0}\right)^2}$$

$$= \frac{5 - 0.1 \cdot 5}{15 \cdot \left(\frac{0.1 \cdot 5}{10}\right)^2} = 120 \; l \;\#$$

PFR :

$$V = \frac{v_0}{k} \int_{C_{A0}}^{C_A} \frac{dC_A}{C_A^2} = \frac{v_0}{k} \left(\frac{1}{C_A} - \frac{1}{C_{A0}} \right)$$

$$= \frac{10}{15} \left(\frac{10}{5 \cdot 0.1} - \frac{10}{5} \right)$$

$$= 12 \; l \;\#$$

4.

a. $N_{A0} = \frac{P_T V y_{A0}}{RT} = \frac{25 \cdot 200}{0.082 \cdot 450} 0.6 = 81.3 \text{ mol}$ #

$C_{A0} = \frac{N_{A0}}{V_0} = \frac{81.3}{200} = 0.4065 \text{ mol/l}$ #

b. $t = \int \frac{dN_A}{r_A V} = -\frac{1}{kV} \int \frac{dN_A}{C_A} = -\frac{1}{k} \int \frac{dN_A}{N_A}$

$= \frac{1}{k} \ln \frac{N_{A0}}{N_A} = \frac{1}{0.15} \ln \frac{1}{0.25}$

$= 9.24 \text{ min}$ #

c. $t = -\frac{V}{k} \int \frac{dN_A}{N_A^2} = \frac{V}{k} \left(\frac{1}{N_A} - \frac{1}{N_{A0}} \right)$

$= \frac{200}{0.75} \cdot \left(\frac{1}{81.3 \cdot 0.4} - \frac{1}{81.3} \right)$

$= 4.92 \text{ min}$ #

$P = [(81.3 + 81.3 \times 0.6) \cdot 0.082 \cdot 455] / 200$

$= 24.27 \text{ atm}$ #