

a) gaseous \rightarrow variable volume.

$$C_{A0} = C_{B0} = 100 \text{ mol/L.}$$

$$C_{I0} = 200 \text{ mol/L.}$$

T, P constant.

SPECIES.	Initial.	Change	final.
A	F_{A0}	$- F_{B0} \frac{X}{2}$	$F_{A0} - F_{B0} \frac{X}{2}$
B	F_{B0}	$- F_{B0} X$	$F_{B0} - F_{B0} X$
R	0	$\frac{F_{B0} X}{2}$	$\frac{F_{B0} X}{2}$
I	F_{I0}	0	F_{I0}

Total $f_{T0} = F_{A0} + F_{B0} + f_{I0}$

$$f_T = f_{A0} + f_{B0} + f_{I0} - f_{B0} X.$$

$$V = V_0 \frac{f_T}{f_{T0}} = V_0 \left(1 - \frac{f_{B0} X}{f_{T0}} \right) = V_0 \left(1 - \frac{100 V_0 X_B}{400 V_0} \right) = V_0 \left(1 - \frac{X_B}{4} \right)$$

$$F_{A0} X_A = f_{B0} \frac{X_B}{2} \Rightarrow X_B = 2 X_A.$$

$$V = V_0 \left(1 - \frac{X_A}{2} \right) *$$

2(b) $C_A = 70 \text{ mol/L.}$

$$X_A, X_B, C_B, C_i = ?$$

$$C_B = 10 \text{ mol/L}$$

$$V C_A = V F_A$$

$$= \frac{F_{A0} - f_{B0} \frac{X_B}{2}}{V_0 \left(1 - \frac{X_B}{4} \right)} = \frac{C_{A0} \left(1 - \frac{X_B}{2} \right)}{1 - \frac{X_B}{4}} = C_A.$$

$$\begin{aligned} C_B &= \frac{F_B}{V_0 \left(1 - \frac{X_B}{4} \right)} \\ &= C_{B0} \left(\frac{1 - X_B}{1 - \frac{X_B}{4}} \right) \\ &= 100 \left(\frac{1 - 12/13}{1 - 3/13} \right) \end{aligned}$$

$$1 - \frac{X_B}{2} = \frac{7}{10} \left(1 - \frac{X_B}{4} \right)$$

$$\frac{3}{10} = X_B \left(\frac{1}{2} - \frac{7}{40} \right) \Rightarrow \frac{3}{10} = X_B \cdot \frac{13}{40} \Rightarrow X_B = \frac{12}{13}$$

$$X_A = \frac{6}{13}$$

$$= 100 \cdot \frac{1}{10} \Rightarrow 10$$

$$C_I = \frac{f_I}{V} = \frac{f_{I_0}}{V_0(1-x_{B/4})} = \frac{200}{1-3/13} = 20 \times 13 = 260 \text{ mol/L.}$$

(c) $C_A = 30 \text{ mol/L.}$

$$V C_A = f_A = f_{B_0} f_{A_0} - f_{B_0} \frac{x_B}{2}$$

$$C_A = \frac{f_{A_0} - f_{B_0} \frac{x_B}{2}}{V_0(1-x_{B/4})} = \frac{100(1-\frac{x_B}{2})}{1-\frac{x_B}{4}}$$

$$\frac{3}{10} = \frac{1-x_{B/2}}{1-x_{B/4}} \Rightarrow \frac{3}{10} - \frac{3}{40} x_B = 1 - \frac{x_B}{2}$$

$$\frac{7}{10} x_B = \frac{x_B}{2} - \frac{3}{40} x_B \Rightarrow \frac{7}{10} = \frac{17}{40} x_B$$

$$x_B = \frac{28}{17}$$

↳ implausible $x_B < 1$.

$$\frac{C_A}{100} (1 - \frac{x_B}{4}) = 1 - \frac{x_B}{2}$$

$$x_B (\frac{1}{20} - \frac{C_A}{400}) = (1 - \frac{C_A}{100})$$

$$\frac{200 - C_A}{400} = \frac{100 - C_A}{100}$$

$$x_B = \frac{400 - 4C_A}{200 - C_A} < 1$$

$$400 - 4C_A < 200 - C_A$$

$$200 < 3C_A$$

$$\boxed{\frac{200}{3} < C_A}$$

→ for plausible answers

2) Fluid, $T_0, \pi_0 \rightarrow T, \pi$



$$C_{A_0} = 100 \quad C_{B_0} = 200$$

$$T_0 = 400 \text{ K}, T = 300 \text{ K}, C_A = 20 \text{ mol/L}$$

$$\pi = 0.8 \pi_0$$

$$X_A, X_B, C_B = ?$$

SPECIES	INITIAL	CHANGE	FINAL
A	f_{A_0}	$-f_{A_0} X$	$f_{A_0}(1-X)$
B	f_{B_0}	$-f_{A_0} X$	$f_{B_0}(1-X) - f_{A_0} X$
R	0	$3 f_{A_0} X$	$3 f_{A_0} X$
Total	$f_{A_0} + f_{B_0}$		$f_{A_0} + f_{B_0} + f_{A_0} X$

$$\frac{f_T}{f_{T_0}} = \left(1 + \frac{1}{3} X_A\right)$$

$$V = V_0 \left(1 + \frac{X_A}{3}\right) \frac{T}{T_0} \cdot \frac{P_0}{P}$$

$$V_{\text{exit}} = V_0 \left(1 + \frac{X_A}{3}\right) \frac{3 \cdot 5}{4 \cdot 4} = \frac{15}{16} V_0 \left(1 + \frac{X_A}{3}\right)$$

$$C_A = 20 \text{ mol/L} = \frac{f_A}{\frac{15}{16} V_0 \left(1 + \frac{X_A}{3}\right)} = \frac{f_{A_0}/V_0 (1-X_A)}{\frac{15}{16} \left(1 + \frac{X_A}{3}\right)} = \frac{16 \cdot 100}{15} \frac{(1-X_A)}{1 + \frac{X_A}{3}}$$

$$\frac{16}{3} (1-X_A) = 1 + \frac{X_A}{3}$$

$$\frac{16}{3} - 1 = \frac{17}{3} X_A$$

$$X_A = \frac{13}{17} \quad X_A = \frac{13}{17}$$

$$X_B = \frac{F_{B_0} - F_B}{F_{B_0}} = \frac{F_{B_0} - F_{B_0} + F_{A_0} X_A}{F_{B_0}}$$

$$= \frac{1}{2} X_A = \frac{13}{36} \cdot \frac{13}{34}$$

$$C_B = \frac{F_{A_0}(2-X_A)}{\frac{15}{16} V_0 \left(1 + \frac{X_A}{3}\right)} = \frac{\frac{16 \cdot 100}{15} \times \frac{17}{3}}{\frac{15}{16} \times \frac{32}{15}}$$

$$= 58.86 \text{ mol/L}$$

$$= 105 \text{ mol/L}$$

3.)

$$v = v_0(1 + E_A \tau_A)$$

Material-Balance:-

$$f_A|_V - f_A|_{V+dV} + r_A \cdot dV = 0$$

$$r_A = \frac{df_A}{dV}$$

$$f_A = v_0(1 + E_A \tau_A) C_A$$

$$r_A = -K C_A$$

$$C_A = \frac{F_A}{v_0(1 + E_A \tau_A)} = \frac{F_A}{v_0(1 + E_A(\frac{F_{A0} - f_A}{f_{A0}}))} = \frac{F_A}{v_0(1 + E_A - E_A \frac{f_A}{f_{A0}})}$$

$$\frac{df_A}{dV} = \frac{-K F_A}{v_0(1 + E_A - E_A \frac{f_A}{f_{A0}})}$$

$$\int_{f_{A0}}^{f_A} \frac{df_A}{f_A(1 + E_A - E_A \frac{f_A}{f_{A0}})} = \int_0^V \frac{-K}{v_0} dV$$

$$\int_{f_{A0}}^{f_A} \left(\frac{1 + E_A}{f_A} - \frac{E_A}{f_{A0}} \right) df_A = -K \tau$$

$$(1 + E_A) \ln\left(\frac{f_A}{f_{A0}}\right) + E_A \left(\frac{f_{A0} - f_A}{f_{A0}}\right) = -K \tau$$

$$(1 + E_A) \ln(1 - X) + E_A X = -K \tau$$

$$\tau = \frac{(1 + E_A)}{K} \ln\left(\frac{1}{1 - X}\right) - \frac{E_A X}{K}$$

$$\tau = \frac{1}{K} \ln\left(\frac{1}{1 - X}\right) + \frac{E_A}{K} \left(\ln\left(\frac{1}{1 - X}\right) - X\right)$$

$$\tau_{P.F.R} = t_{batch} + \frac{E_A}{K} \left(\ln\left(\frac{1}{1 - X}\right) - X\right)$$

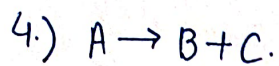
Not equivalent unless $E_A = 0$

because reaction ^{rate} is slower ($E_A > 0$) bigger volume is required to achieve the same conversion & vice-versa.

FOR a batch-reactor.

$$1 - X = \frac{C_A}{C_{A0}} = e^{-Kt}$$

$$t = \frac{1}{K} \ln\left(\frac{1}{1 - X}\right)$$



gas phase, PFR, $v_0 = 20 \text{ L/h.}$, 60% A, 40% inert. $2 \text{ atm} - 150^\circ\text{C}$

$-r_A = K C_A \rightarrow 0.865 \text{ min}^{-1}$.

$P_A = 0.1 \text{ atm.}$

$P_{A0} = 2 \times 0.6 = 1.2 \text{ atm.}$

species	initial	change	final
A	F_{A0}	$-F_{A0}X$	$F_{A0}(1-X)$
B	0	$F_{A0}X$	$F_{A0}X$
C	0	$F_{A0}X$	$F_{A0}X$
I	$\frac{2}{3} F_{A0}$	0	$\frac{2}{3} F_{A0}$
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	$F_{T0} = \frac{5}{3} F_{A0}$	$F_T = \frac{5}{3} F_{A0} + F_{A0}X$	

$\frac{f_T}{f_{T0}} = 1 + \frac{3}{5}X$

$P_A = P_0 \frac{(1-X)}{1 + \frac{3X}{5}}$

$\frac{df}{dV} = \frac{-K f_A}{v_0 (1 + \epsilon_A - \epsilon_A \frac{f_A}{f_{A0}})}$ \rightarrow assume constant $P_T = P_0$.

$X = \frac{11}{12.6} \approx 0.873$

$V = v_0 \left[\frac{1}{K} \ln \left(\frac{1}{1-X} \right) + \frac{\epsilon_A}{K} \left(\ln \left(\frac{1}{1-X} \right) - X \right) \right]$

$\epsilon_A = \frac{3}{5} = 0.6$.

$v_0 = \frac{20}{60} \text{ L/min} = 0.33 \text{ L min}^{-1}$.

$X = 0.873$

$V \approx 1.07 \text{ L}$