



a) gaseous  $\rightarrow$  variable volume.

$$C_{A_0} = C_{B_0} = 100 \text{ mol/L}$$

$$C_i = 200 \text{ mol/L}$$

T, P constant.

SPECIES.	Initial.	Change	final.
A	$F_{A_0}$	$-F_{B_0} \frac{X}{2}$	$F_{A_0} - F_{B_0} \frac{X}{2}$
B	$F_{B_0}$	$-F_{B_0} X$	$F_{B_0} - F_{B_0} X$
R	0	$F_{B_0} \frac{X}{2}$	$F_{B_0} \frac{X}{2}$
I	$F_{I_0}$	0	$F_{I_0}$

$$\text{Total} \quad f_{T_0} = F_{A_0} + F_{B_0} + F_{I_0}$$

$$f_T = f_{A_0} + f_{B_0} + f_{I_0} - f_{B_0} X$$

$$V = V_0 \frac{f_T}{f_{T_0}} = V_0 \left(1 - \frac{f_{B_0} X}{f_{T_0}}\right) = V_0 \left(1 - \frac{100 V_0 X_B}{400 V_0}\right) = V_0 \left(1 - \frac{X_B}{4}\right)$$

$$F_{A_0} X_A = F_{B_0} \frac{X_B}{2} \Rightarrow X_B = 2 X_A$$

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

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

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

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

$$V C_A = F_A$$

$$= \frac{F_{A_0} - F_{B_0} \frac{X_B}{2}}{V_0 \left(1 - \frac{X_B}{4}\right)} = C_{A_0} \left(1 - \frac{X_B}{2}\right) = C_A$$

$$\begin{aligned} C_B &= \frac{F_B}{V_0 \left(1 - \frac{X_B}{4}\right)} \\ &= C_{B_0} \left(1 - \frac{X_B}{1 - \frac{X_B}{4}}\right) \\ &= 100 \left(1 - \frac{12/13}{1 - 3/13}\right) \end{aligned}$$

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

$$\frac{3}{10} = X_B \left(\frac{1}{2} - \frac{1}{4}\right) \Rightarrow \frac{3}{10} = X_B \cdot \frac{1}{4} \Rightarrow X_B = \frac{12}{13}$$

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

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

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

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

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

$$C_A = \frac{f_{A_0} - f_{B_0} \frac{x_B}{2}}{\nu_0 (1 - \frac{x_B}{4})} = \frac{100 (1 - \frac{x_B}{2})}{1 - \frac{x_B}{4}}$$

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

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

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

$\hookrightarrow$  implausible  $x_B < 1$ .

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

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

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

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

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

$$200 < 3C_A$$

$$\boxed{\frac{200}{3} < C_A} \quad \rightarrow \text{for plausible answers}$$

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	$f_{B_0}$	$-f_{A_0}x$	$f_{B_0}c_1 f_{B_0} - f_{A_0}x$
R	0	$3f_{A_0}x$	$3f_{A_0}x$
Total.	$f_{A_0} + f_{B_0}$		$f_{A_0} + f_{B_0} + f_{A_0}x$

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

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

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

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

$$\frac{16}{3} (1-x_A) = 14 \frac{x_A}{3}$$

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

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

$$x_B = \frac{F_{B_0} - F_B}{F_{B_0}} = \frac{F_{B_0} - F_{B_0} + f_{A_0} x_A}{F_{B_0}}$$

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

$$c_B = \frac{F_{A_0} (2-x_A)}{\frac{15}{16} V_0 \left(1 + \frac{x_A}{3}\right)} = \frac{\frac{16 \times 100}{15} \times \frac{10}{3} \frac{17}{15}}{\frac{15}{16} \times \frac{32}{15}} = 58.82 \text{ mol/L}$$

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

3.)

$$V = V_0(1 + \epsilon_A \chi_A)$$

Material-Balance:-

$$(f_A)_V - f_A)_{V+dV} + \gamma_A \cdot dV = 0$$

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

$$f_A = V_0(1 + \epsilon_A \chi_A) C_A$$

$$\gamma_A = -K C_A$$

$$C_A = \frac{f_A}{V_0(1 + \epsilon_A \chi_A)} = \frac{f_A}{V_0(1 + \epsilon_A(\frac{f_{A_0} - f_A}{f_{A_0}}))} = \frac{f_A}{V_0(1 + \epsilon_A - \epsilon_A \frac{f_A}{f_{A_0}})}$$

$$\frac{d\chi_A}{dV} = -\frac{K f_A}{V_0(1 + \epsilon_A - \epsilon_A \frac{f_A}{f_{A_0}})}$$

$$\int_{f_{A_0}}^{f_A} \frac{df_A}{f_A(1 + \epsilon_A - \epsilon_A \frac{f_A}{f_{A_0}})} = \int_0^V -\frac{K}{V_0} dV$$

$$\int_{f_{A_0}}^{f_A} \left( \frac{1 + \epsilon_A}{f_A} - \frac{\epsilon_A}{f_{A_0}} \right) df_A = -Kz$$

$$(1 + \epsilon_A) \ln \left( \frac{f_A}{f_{A_0}} \right) + \epsilon_A \left( \frac{f_{A_0} - f_A}{f_{A_0}} \right) = -Kz$$

$$(1 + \epsilon_A) \ln(1 - x) + \epsilon_A x = -Kz$$

$$\boxed{z = \frac{(1 + \epsilon_A)}{K} \ln \left( \frac{1}{1-x} \right) - \frac{\epsilon_A x}{K}}$$

$$z = \frac{1}{K} \ln \left( \frac{1}{1-x} \right) + \frac{\epsilon_A}{K} \left( \ln \left( \frac{1}{1-x} \right) - x \right)$$

$$z_{P.F.R} = t_{batch} + \frac{\epsilon_A}{K} \left( \ln \left( \frac{1}{1-x} \right) - x \right)$$

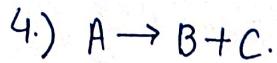
Not equivalent unless  $\epsilon_A = 0$ 

because reaction rate is slower ( $\epsilon_A > 0$ ) bigger volume is required to achieve the same conversion & vice-versa.

FOR a batch-reactor.

$$1 - x = \frac{C_A}{C_{A_0}} = e^{-Kt}$$

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



gas phase,  $PfR$ ,  $v_0 = 20 \text{ L/h.}$ , 60% A, 40% initial. 2 atm - 150°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	$\underline{\frac{2}{3} f_{A0}}$

$$f_{T0} = \frac{5}{3} f_{A0}$$

$$\underline{f_T = \frac{5}{3} f_{A0} + f_{A0}x}$$

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

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

$$v = v_0 \left(1 + \frac{3x}{5}\right) \left(\frac{P_0}{P_T}\right)$$

$$\frac{df}{dV} = \frac{-K f_{T0}}{v_0 (1 + \epsilon_A - \epsilon_A \frac{f_A}{f_{A0}})} \rightarrow \text{assume constant } P_T = P_0. \quad x = \frac{11}{12.6} \approx 0.873$$

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

$$\cancel{\epsilon_A} = 3/5 = 0.6.$$

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

$$x = 0.873$$

$$V \approx 1.072$$