(1) $A + 2B \longrightarrow R$.

a) gaseous → variable volume.

$C_{A_0} = C_{B_0} = 100$ mol/L.

$C_{i_0} =$ 200 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	$\frac{F_{B_0}X}{2}$	$\frac{F_{B_0}X}{2}$
I	F_{I_0}	0	F_{I_0}
Total	$f_{T_0} = F_{A_0} + F_{B_0} + f_{I_0}$		$f_T = f_{A_0} + f_{B_0} + f_{I_0} - f_{B_0}X$

$$v = v_0 \frac{f_T}{f_{T_0}} = v_0\left(1 - \frac{f_{B_0}}{f_{T_0}}X\right) = v_0\left(1 - \frac{100v_0}{400v_0}X_B\right) = v_0\left(1 - \frac{X_B}{4}\right)$$

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

$$v = v_0\left(1 - \frac{X_A}{2}\right) \star$$

2(b) $C_A = 70$ mol/L.

$X_A, X_B, C_B, C_i = ?$

$$v C_A = F_A$$

$$= \frac{F_{A_0} - f_{B_0}\frac{X_B}{2}}{v_0\left(1 - \frac{X_B}{4}\right)} = \frac{C_{A_0}\left(1 - \frac{X_B}{2}\right)}{1 - \frac{X_B}{4}} = C_A.$$

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

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

$$\boxed{x_A = \frac{6}{13}}$$

$$C_B = \frac{F_B}{v_0\left(1 - \frac{x_B}{4}\right)}$$

$$= C_{B_0}\frac{(1 - x_B)}{1 - \frac{x_B}{4}}$$

$$= 100\frac{\left(1 - 12/13\right)}{1 - 3/13}$$

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

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

$$C_I = \frac{f_I}{v} = \frac{f_{I_0}}{v_0(1 - x_B/4)} = \frac{200}{1 - 3/13} = 20 \times 13 = 260 \text{ mol/L.}$$

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

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

$$C_A = \frac{f_{A_0} - f_{B_0} \frac{x_B}{2}}{v_0 (1 - \frac{x_B}{4})} = \frac{100(1 - \frac{x_B}{2})}{1 - \frac{x_B}{4}}$$

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

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

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

↳ implausible $X_B < 1$.

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

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

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

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

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

$$200 < 3C_A$$

$$\boxed{\frac{200}{3} < C_A}$$ → for plausible answers

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

a) $A + B \rightarrow 3R$.

$C_{A_0} = 100$ $C_{B_0} = 200$.
$T_0 = 400K$, $T = 300K$. $C_A = 20$ 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}	$-f_{A_0}X$	$\cancel{f_{B_0}(1}$ $f_{B_0} - f_{A_0}X$
R	0	$3f_{A_0}X$	$3f_{A_0}X$
Total.	$f_{A_0} + f_{B_0}$		$f_{A_0} + f_{B_0} + f_{A_0}X$

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

$$v = v_0\left(1 + \frac{x_A}{3}\right)\frac{T}{T_0}\cdot\frac{P_0}{P}$$

$$v_{exit} = v_0\left(1+\frac{x_A}{3}\right)\frac{3}{4}\cdot\frac{5}{4} = \frac{15}{16}v_0\left(1+\frac{x_A}{3}\right)$$

$$C_A = 20\text{mol/L} = \frac{f_A}{\frac{15}{16}v_0\left(1+\frac{x_A}{3}\right)} = \frac{f_{A_0}/v_0(1-x_A)}{\frac{15}{16}\left(1+\frac{x_A}{3}\right)} = 16.\frac{100}{15}\frac{(1-x_A)}{1+\frac{x_A}{3}}$$

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

$$\frac{16}{3} - 1 = \frac{1\cancel{5}7}{3}x_A$$

$$x_A = \cancel{\frac{13}{15}} \quad x_A = \frac{13}{17}$$

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

$$= \frac{1}{2}X_A = \frac{13}{\cancel{30}} \cdot \frac{13}{34}$$

$$C_B = \frac{F_{A_0}(2-x_A)}{\frac{15}{16}v_0\left(1+\frac{x_A}{3}\right)} = \frac{\cancel{16}\times\cancel{100}^{50\ 10}}{\cancel{15}\ 3}\times\frac{\frac{17}{\cancel{15}}}{\cancel{17}\ \frac{32}{\cancel{15}}}$$

$= \cancel{58.66\text{mol/L}}$.
$= 105$ mol/L

3.)

$$v = v_o(1+\epsilon_A x_A)$$

Material-Balance:-

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

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

$$f_A = v_o(1+\epsilon_A x_A)\, C_A.$$

$$r_A = -KC_A.$$

$$C_A = \frac{F_A}{v_o(1+\epsilon_A x_A)} = \frac{F_A}{v_o\left(1+\epsilon_A\left(\frac{f_{A_0}-f_A}{f_{A_0}}\right)\right)} = \frac{F_A}{v_o\left(1+\epsilon_A - \epsilon_A\frac{f_A}{f_{A_0}}\right)}$$

$$\cancel{C_A =} \frac{df_A}{dV} = \frac{-KF_A}{v_o\left(1+\epsilon_A - \epsilon_A\frac{f_A}{f_{A_0}}\right)}$$

$$\int_{f_{A_0}}^{f_A} \frac{df_A}{f_A}\left(1+\epsilon_A - \epsilon_A\frac{f_A}{f_{A_0}}\right) = \int_0^V -\frac{K}{v_o}\, dV.$$

FOR a batch-reactor.

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

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

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

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

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

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

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

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

Not equivalent unless $\epsilon_A = 0$

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

4.) $A \rightarrow B + C$.

gas phase, PFR, $v_o = 20 L/h.$, 60% A, 40% inert · 2atm - 150°C

$-r_A = K C_A$. → 0.865 min^{-1}.

$P_A =$ 0.1 atm.

$P_{A_0} =$ 2×0.6 = 1.2 atm.

species	initial	change	final
A	F_{A_0}	$-F_{A_0}X$	$F_{A_0}(1-X)$
B	0	$F_{A_0}X$	$F_{A_0}X$
C	0	$F_{A_0}X$	$F_{A_0}X$
I	$\frac{2}{3}F_{A_0}$.	0	$\frac{2}{3}F_{A_0}$

$F_{T_0} = \frac{5}{3}F_{A_0}$ $\qquad$ $F_T = \frac{5}{3}F_{A_0} + F_{A_0}X$

$$\frac{F_T}{F_{T_0}} = 1 + \frac{3}{5}X$$

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

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

→ assume constant $P_T = P_0$.

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

$$\frac{dF}{dV} = \frac{-KF_A}{v_0\left(1+\epsilon_A - \epsilon_A\frac{F_A}{F_{A_0}}\right)}$$

⇓

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

$\epsilon_A = 3/5 = 0.6$.

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

$X = 0.873$

$V \approx 1.07 L$

(5)

A	f_{A_0}	$-f_{A_0}\dfrac{X}{2}$	$f_{A_0}(1-X)$
B	0	$f_{A_0}\dfrac{X}{2}$	$f_{A_0}\dfrac{X}{2}$.
C	f_{C_0}	0	f_{C_0}

* assumed inital v_0 as constant

Case I $\quad f_{T_0} = 2f_{A_0} \quad f_A \to f_{A_0} \cdots \to 0.2f_{A_0}$

case II $\quad f_{T_0} = \dfrac{3}{2}f_{A_0}. \quad f_A \to 0.5f_{A_0} \to ?$

$$f_T = f_{A_0} + f_{C_0} - f_{A_0}\frac{X}{2}$$

$$f_T = f_{T_0} - \frac{f_{A_0}}{2f_{A_0}}(f_{A_0} - f_A)$$

$$f_T = f_{T_0} - \frac{f_{A_0}}{2} + \frac{f_A}{2}.$$

$$\frac{f_T}{f_{T_0}} = \left(1 - \frac{f_{A_0}}{2f_{T_0}}\right) + \frac{f_A}{2f_{T_0}}$$

$$v = v_0\left[\left(1 - \frac{f_{A_0}}{2f_{T_0}}\right) + \frac{f_A}{2f_{T_0}}\right]$$

$$\cancel{\int_{0.2f_{A_0}}^{f_{A_0}} \left(\frac{\frac{3}{4} + \frac{f_A}{4f_{A_0}}}{f_A}\right)^2 df_A = \int_{0.8f_{A_0}}^{f} \left(\frac{\frac{2}{3} + \frac{f_A}{3f_{A_0}}}{f_A}\right)^2 df_A}$$

$$\int_{0.2f_{A_0}}^{f_{A_0}} \left(\frac{\frac{3}{4} + \frac{f_A}{4f_{A_0}}}{f_A}\right)^2 df_A = \int_{f}^{0.5f_{A_0}} \left(\frac{\frac{5}{6} + \frac{f_A}{3f_{A_0}}}{f_A}\right)^2 df_A$$

$$\frac{df_A}{dV} = \frac{-KC_A^2 \cdot v^2}{v_0^2\left[\left(1 - \frac{f_{A_0}}{2f_{T_0}}\right) + \frac{f_A}{2f_{T_0}}\right]^2}$$

$f \approx 0.187 f_{A_0}$

$$X = \frac{0.5f_{A_0} - 0.187f_{A_0}}{0.5f_{A_0}} = 0.626$$

$$\frac{df_A}{dV} = \frac{-Kf_A^2}{v_0^2\left[\left(1 - \frac{f_{A_0}}{2f_{T_0}}\right) + \frac{f_A}{2f_{T_0}}\right]^2}$$

62.6 % conversion.

$$\frac{v_0^2}{K}\int\left[\frac{\left(1 - \frac{f_{A_0}}{2f_{T_0}}\right) + \frac{f_A}{2f_{T_0}}}{f_A}\right]^2 df_A = -\int dV$$

↳ equating this for I & II