Corrigé Examen Réacteurs Homogènes

2025 / 2026

Exercice N°1 (6pts)

$A \rightarrow 2R$ (phase gazeuse) RAO

$T_0 = 1219\,K$; $P_0 = 1\,atm$; $F_{A_0} = 1\,Kmol/h$; $K = 200\,h^{-1}$

$X_{AS} = 80\%$, $r = -r_A = KC_A$

$$\tau = \frac{C_{A0} X_{AS}}{-r_{AS}} = \frac{C_{A0} X_{AS}}{K C_{AS}} \quad (0{,}5)$$

$$C_{A_S} = \frac{n_{AS}}{V} = \frac{n_{A0}(1 - X_{AS})}{V_0 \beta (1 + \varepsilon X_S)} = \frac{C_{A0}(1 - X_{AS})}{1 + \varepsilon X_{AS}} = \frac{C_{A0}(1 - X_A)}{1 + X_{AS}} \quad (0{,}5)$$

$\beta = 1$ (T, P cts) (0,25)

$X = X_A$ (réaction $A \rightarrow$ Produits) (0,25)

$$\varepsilon = \frac{\Delta\alpha}{1 + I^0} = \Delta\alpha = 1 \quad (0{,}5)$$

$$\tau = \frac{(1 + X_{AS}) X_{AS}}{K(1 - X_{AS})} = \frac{(1 + 0{,}8)\,0{,}8}{200\,(1 - 0{,}8)} = 0{,}036\,h \quad (0{,}5)$$

$$\tau = \frac{V_{RAO}}{\Phi} \Rightarrow V_{RAO} = \tau . \Phi$$

$$\left.\begin{array}{l} F_{A_0} = C_{A_0}\Phi \\ P_0 = C_{A_0} R T_0 \end{array}\right\} \Rightarrow \Phi = \frac{F_{A_0} R T}{P} = \frac{10^3 . 0{,}082 . 1219}{1} = 99958\,l/h$$

(0,25) (0,25) (0,5)

$\therefore \Phi = 99958\,l/h \simeq 27{,}77\,l/s$

$V_{RAO} = \tau . \varphi = 3598{,}5\,l \simeq 3{,}6\,m^3$ (0,5)

2°) $F_{A_0} = F_I = 1\,Kmol/h$; $X_{AS} = 80\%$

$$\varepsilon' = \frac{\Delta\alpha}{1 + I} = \frac{\Delta\alpha}{1 + \frac{F_{I0}}{F_{A0}}} = \frac{1}{2} \quad (0{,}5)$$

$$\Phi' = \frac{F_{A0} R T_0}{\frac{P_0}{2}} = \frac{2 F_{A0} R T_0}{P_0} = 199916\,l/h \quad (0{,}5)$$

$$\tau' = \frac{X_{AS}\left(1 + \frac{X_{AS}}{2}\right)}{K(1 - X_{AS})} = \frac{0{,}8\left(1 + \frac{0{,}8}{2}\right)}{200(1 - 0{,}8)} = 0{,}028\,h \quad (0{,}5)$$

$V' = \tau' \Phi'$ (0,5)

$= 5597{,}64\,l$

$V' \simeq 5{,}6\,m^3$

Exercice N°2 (7,5)

$A + B \rightleftarrows C + D$; $r = K_1 C_A - K_2 C_C$, RAF

1°) $K_1 + K_2 = 0{,}018$; $\frac{K_1}{K_2} = 4$ $\Rightarrow$ $K_1 = 0{,}0144\ min^{-1}$ (0,25) ; $K_2 = 0{,}0036\ min^{-1}$ (0,25)

2°) Conversion à l'équilibre

à l'$\rightleftarrows$ $r = 0 \Rightarrow K_1 C_{Aeq} = K_2 C_{Ceq}$

$C_{Aeq} = C_{A0}(1 - X_{Aeq})$ (0,25)

$C_{Ceq} = C_{C0} + C_{A0} X_{Aeq}$ (0,25)

$\Rightarrow K_1 C_{A0}(1 - X_{Aeq}) = K_2 C_{A0} X_{Aeq}$

$\Rightarrow X_{Aeq} = \frac{K_1}{K_1 + K_2}$ (0,5)

$X_{Aeq} = \frac{K_1}{K_1+K_2} = \frac{0{,}0144}{0{,}018} = 0{,}8$. (0,25)

3°) $t_S = 2h$. , $X_A = ?$

$$t_S = C_{A0} \int_0^{X_{Af}} \frac{dX_A}{-r_A} = C_{A0} \int_0^{X_{Af}} \frac{dX_A}{K_1 C_A - K_2 C_C}$$ (0,25)

$$-r_A = K_1 C_A - K_2 C_C = K_1 C_{A0}(1 - X_A) - K_2 C_{A0} X_A = C_{A0}\left[K_1 - X_A(K_1 + K_2)\right]$$

$$-r_A = C_{A0}\left[(K_1+K_2)X_{Ae} - X_A(K_1+K_2)\right] = C_{A0}\left[(K_1+K_2)(X_{Ae} - X_A)\right]$$ (0,5)

$$t_S = \int_0^{X_{Af}} \frac{dX_A}{(K_1+K_2)(X_{Ae} - X_A)} = -\frac{1}{K_1+K_2} \ln\left(\frac{X_{Ae} - X_{Af}}{X_{Ae}}\right)$$ (0,5)

$$\frac{X_{Ae} - X_{Af}}{X_{Ae}} = e^{-t_S(K_1+K_2)} \Rightarrow X_{Af} = -X_{Ae} \cdot e^{-t_S(K_1+K_2)} + X_{Ae}$$ (0,5)

$$X_{Af} = -0{,}8 \cdot e^{-2 \cdot 60(0{,}018)} + 0{,}8 = 0{,}7077 \approx 0{,}71.$$

$\boxed{X_{Af} \approx 0{,}71}$ (0,5)

4°/ temps de cycle

Temps cycle = temps mort + t_R = 2 + 1 = 3 h (0,5)

Nombre de cuvées par jour : $N = \frac{24}{3} = 8$ cuvées/jour.

5°/ 2,5 Kg/jour $\rightarrow \frac{2,5}{8} = 0,3125$ Kg/cuvée (0,5)

$M_C = 116$ g/mol $= 0,116$ Kg/mol

$$n_C = \frac{0,3125}{0,116} = 2,69 \text{ mol} \quad (0,5)$$

6°/ Quantité de A à introduire dans la cuvée.

$$C_C = C_{A0} X_{Af} \Rightarrow C_{A0} = \frac{C_C}{X_{Af}} \Rightarrow n_{A0} = \frac{n_C}{X_{Af}} = \frac{2,69}{0,71} \simeq 3,79 \text{ mol} \quad (0,5)$$

7°/ Masse totale de la charge initiale

$$\frac{n_{B0}}{n_{A0}} = 10 \Rightarrow n_{B0} = 10\, n_{A0} = 10 \times 3,79 = 37,9 \text{ mol} \quad (0,5)$$

Masse de A : $3,79 \times 60 = 227,4$ g (0,25)

Masse de B = $37,9 \times 74 = 2804,6$ g (0,25)

Masse totale : $227,4 + 2804,6 = 3032$ g $= 3,032$ Kg (0,25)

Exercice N°3 (0,75)

$A + B \longrightarrow M + N$; phase liquide , $r = K C_A C_B$

$K = 6$ l/mol.min , (RAO) $V = 12,6$ l ; $Q = 300$ l/h.

$$\tau_a = \frac{C_{A0} X_{AS}}{-r_{AS}} = \frac{C_{A0} X_{AS}}{K C_A C_B} = \frac{C_{A0} X_{AS}}{K C_{A0}^2 (1 - X_{AS})(M - X_{AS})} \quad (0,25)$$

$C_{AS} = C_{A0}(1 - X_{AS})$ (0,25)

$C_{BS} = C_{B0} - C_{A0} X_{AS}$ (0,25)

$$\tau_a = \frac{V_{RAO}}{Q} = \frac{X_{AS}}{K C_{A0} (1 - X_{AS})(M - X_{AS})} = 2,52 \text{ mi} \quad (0,5)$$

$M = \frac{C_{B0}}{C_{A0}} = \frac{1,1}{0,8} = 1,375$; (0,25)

$$\Rightarrow K \tau_a C_{A0} (1 - X_{AS})(M - X_{AS}) = X_{AS}$$

$$\Rightarrow K \tau_a C_{A0} X_{AS}^2 - X_{AS} (K \tau_a C_{A0} + K \tau_a C_{A0} M + 1) + K \tau_a C_{A0} M$$

$4,2336\, X_{As}^2 - 11,0548\, X_{As} + 5,8212 = 0$ (0,5)

$\Delta = 23,63 \qquad X_{As} = 0,73. \quad (73\%)$ (0,5)

2°) REP $\quad X_{AS} = 73\%$

$$\tau_p = C_{A0}\int_0^{X_{AS}} \frac{dX_A}{-r_A} = C_{A0}\int_0^{X_{AS}} \frac{dX_A}{K C_{A0}^2 (1-X_A)(M-X_A)} = \frac{1}{K C_{A0}}\int_0^{X_{AS}} \frac{dX_A}{(1-X_A)(M-X_A)}$$ (0,5)

$$\int \frac{dX_A}{(1-X_A)(M-X_A)} = \frac{1}{M-1}\int \frac{dX_A}{1-X_A} + \frac{1}{1-M}\int \frac{dX_A}{M-X_A}.$$ (0,5)

$$\tau_p = \frac{1}{K C_{A0}}\frac{1}{M-1}\ln\left(\frac{(M-X_{AS})}{M(1-X_{AS})}\right) = \frac{1}{2,1 \cdot 0,8} \cdot \frac{1}{1,375-1}\ln\left[\frac{1,375-0,73}{1,375(1-0,73)}\right] =$$ (0,5)

$\tau_p = 0,876\ \text{min}$ (0,5)

$V_{REP} = \tau_p \cdot Q = \dfrac{0,876 \cdot 300}{60} = 4,39\ \ell$ (0,5)

3°) $M' = \dfrac{1,4}{0,8} = 1,75$; $\tau_a = \dfrac{X'_{AS}}{K C_{A0}(1-X'_{As})(M'-X'_{As})}$ (0,25)

$\Rightarrow K\tau_a C_{A0} X'^2_{As} - X'_{As}(K\tau_a C_{A0} + K\tau_a C_{A0} M' + 1) + K\tau_a C_{A0} M' = 0$

$\Rightarrow 4,2336\, X'^2_{As} - 12,6424\, X'_{As} + 7,4088 = 0$ (0,5)

$\Delta = 34,367 \qquad X'_{As} = 0,80$ (0,5)

Conclusion : L'excés du reactif B, fait augmenter le taux de conversion (0,5)

Lorsqu'on utilise l'excès stoechiometrique de B par rapport à A, on amelioire les performance du RAO