Corrigé examen RH 2023/2024

Exercice N°1 (5 pts)

$A \rightarrow 2B$, $r = kC_A$, RAF

1°) $V = V_0$, $T = T_0$ ; $P_A = P_{A0}/2$, $t_s = 1\,min$

a- Calcul de X

$A \rightarrow$ Produits $\Rightarrow X = X_A$.

$$\left.\begin{aligned} P_{A_0} &= C_{A0}RT \\ P_A &= C_ART \\ P_A &= P_{A0}/2 \end{aligned}\right\} \Rightarrow C_A = C_{A0}/2 \quad 0,5$$

2,25

$$V = V_0 \Rightarrow X = \frac{C_{A0} - C_A}{C_{A0}} = \frac{C_{A0} - \frac{C_{A0}}{2}}{C_{A0}} = 0,5 \quad 0,5$$

b- Calcul de la constante K, Pour un RAF nous avons

$$t_s = C_{A0}\int_0^{X_A} \frac{dX_A}{-r_A} = C_{A0}\int_0^{X_A} \frac{dX_A}{KC_{A0}(1-X_A)} = -\frac{1}{K}\ln(1-X_A) \quad 0,75$$

$t_s = 1\,min$, $X_A = 50\%$

$$K = -\frac{1}{t_s}\ln(1-X_A) = -\frac{1}{1}\ln(1-0,5) = \ln 2 = 0,693\,min \quad 0,5$$

2°/ REP ; $X_{As} = 99\%$ ; $V_{REP} = 1\,m^3$ ; $Q_0 = ?$

$$\tau_{REP} = \frac{V_{REP}}{Q_0} \Rightarrow Q_0 = \frac{V_{REP}}{\tau_{REP}} \quad 0,5 \quad ; \quad \varepsilon = \frac{\Delta\nu}{1+\nu^0} = 1 \quad 0,5$$

$$V = V_0(1+ \ldots X_{As})$$

$$\tau_{REP} = C_{A0}\int_0^{X_{As}} \frac{dX_A}{-r_A} = C_{A0}\int \frac{dX_A}{KC_A} = C_{A0}\int \frac{dX_A}{\frac{KC_{A0}(1-X_A)}{(1+X_A)}} = \int \frac{(1+X_A)dX_A}{K(1-X_A)} \quad 0,75$$

$$\tau_{REP} = \frac{1}{0,693}\left(-2\ln(1-0,99) - 0,99\right) = 11,86\,min \quad 0,5$$

$$\int \frac{(1-X_A)\,dX_A}{(1+X_A)}$$

Car $\int_0^{X_A} \frac{(1+X_A)\,dX_A}{(1-X_A)} = -2\ln(1-X_A) - X$ (1) $= -(\varepsilon+1)\ln(1-X_A) - \varepsilon X_A$

2,75

$$Q_0 = \frac{V_{REP}}{\tau_{REP}} = \frac{1}{11,86} = \underline{0,084\ m^3/min}$$ (0,5)

## Exercice N°2 (5,5 pts)

$$A \underset{k_2}{\overset{k_1}{\rightleftarrows}} P \quad ; \text{REP}$$

1°) Expression de la conversion à l'équilibre ($X_{Ae}$) (0,5)

1,5

à l'é $r = 0 \Rightarrow k_1 C_{Ae} - k_2 C_{Pe} = 0 \Rightarrow k_1 C_{Ae} = k_2 C_{Pe}$ (0,25)

$$\left.\begin{array}{l} C_{Ae} = C_{A0}(1 - X_{Ae}) \\ C_{Pe} = C_{P0} + C_{A0} X_{Ae} \end{array}\right\} \Rightarrow k_1 C_{A0}(1 - X_{Ae}) = k_2 (C_{P0} + C_{A0} X_{Ae})$$ (0,25)

$$\Rightarrow \boxed{X_{Ae} = \frac{k_1 C_{A0} - k_2 C_{P0}}{k_1 C_{A0} + k_2 C_{A0}} = \frac{k_1 C_{A0} - k_2 C_{P0}}{C_{A0}(k_1 + k_2)}}$$ (0,...)

on divise par $k_2$ puis par $C_{A0}$ $/k_2 C$

2°/ $C_{A0} = 1M$

0,75

$C_{P0} = 0,5M$

On pose $M = \frac{C_{P0}}{C_{A0}}$

$K = k_1/k_2$ $\qquad \frac{k_1}{k_2} = 10$

$$\Rightarrow X_{Ae} = \frac{K - M}{1 + K}$$ (0,5)

$$\left.\begin{array}{l} K = k_1/k_2 = 10 \\ M = \frac{C_{P0}}{C_{A0}} = 0,5 \end{array}\right| \Rightarrow X_{Ae} = 0,864$$ (0,25)

3°/ $X_A = 30\%$ $\quad \tau = 2min$ ; $k_1 = ?$ $k_2 = ?$

$$\tau = C_{A0} \int \frac{dX_A}{-r_A}$$ (0,5)

$$-r_A = r = k_1 C_A - k_2 C_P$$ (0,25)

$$C_P = C_{P0} + C_{A0} X_A = C_{A0}(M + X_A)$$ (0,5)

D'où $r = -r_A = C_{A0}\left(k_1 - k_2 M - X_A(k_1 + k_2)\right)$

3,25

$-r_A = C_{A0} K_2 [K - X_A(K+1)] = K_2(1+K) C_{A0} (X_{Ae} - X_A)$ 0,5

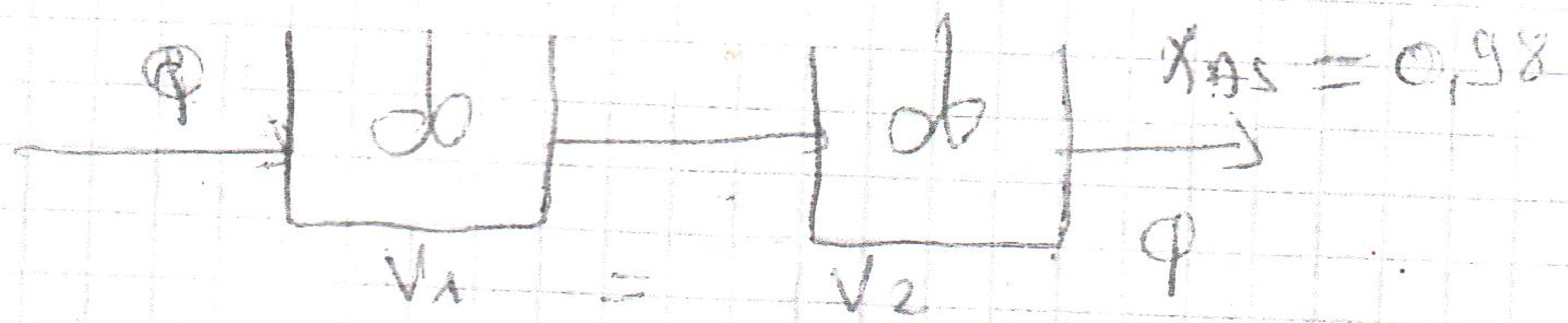
$\tau_p = \frac{1}{(1+K)K_2} \int_0^{X_A} \frac{dX_A}{X_{Ae} - X_A} = \frac{1}{K_2(1+K)} \ln\left(\frac{X_{Ae}}{X_{Ae} - X_A}\right)$ 0,5

$\tau_p = 2\,min$
$X_{Ae} = 0,864$
$X_A = 0,3$

$\Rightarrow K_2 = 0,019\,min^{-1}$ 0,5
$K_1 = 10 K_2 = 0,19\,min^{-1}$ 0,5

Exercice n°3 (4pts)

$A \rightarrow B$, à densité constante, $K = 1\,min^{-1}$




$\varphi = 0,5\,m^3/min$ , $C_{A0} = 0,1\,mol/l$

$\tau = \tau_1 + \tau_2 = \frac{V_t}{\varphi}$ ; $(\tau_1 = \tau_2 = \frac{\tau}{2})$ 0,5

$\tau_1 = \frac{C_{A0} - C_{A1}}{K C_{A1}} \Rightarrow C_{A1} = \frac{C_{A0}}{1 + K\tau_1}$ 0,5

$\tau_2 = \frac{C_{A1} - C_{A2}}{K C_{A2}} \Rightarrow C_{A2} = \frac{C_{A1}}{1 + K\tau_2} = \frac{C_{A0}}{(1 + K\tau_1)(1 + K\tau_2)}$ 0,5

$C_{A2} = C_{As} = \frac{C_{A0}}{\left(1 + K\frac{\tau}{2}\right)^2}$ ; $X_{As} = \frac{C_{A0} - C_{As}}{C_{A0}} = 1 - \frac{C_{As}}{C_{A0}}$ 0,5

$\Rightarrow X_{As} = 1 - \frac{1}{\left(1 + \frac{K\tau}{2}\right)^2}$ 0,5 $\Rightarrow \tau = \frac{2}{K}\left(\frac{1}{\sqrt{1 - X_{As}}} - 1\right) = 2\left(\frac{1}{\sqrt{1 - 0,98}} - 1\right)$ 0,5

$\boxed{\tau = 12,14\,min}$ 0,5

$\tau = \frac{V_t}{\varphi} \Rightarrow V_t = \tau \varphi = 12,14 \cdot 0,5 = 6,07\,m^3$

0,5

Exercice n°4 (5 pts)

$A + 2B \rightarrow C + D$ (phase liquide) ; RAF

$r = K C_A C_B$ $\quad K = 2,8.10^{-4}$ l/mol.s ; $t_S = 1h = 3600$ secondes

$C_{A0} = C_{B0} = 8.10^{-2}$ mol/l

1°) Taux de conversion $X_{Af}$

$$t_S = C_{A0}\int_0^{X_{Af}} \frac{dX_A}{-r_A} = C_{A0}\int_0^{X_{Af}} \frac{dX_A}{K C_A C_B} \quad 0,25$$

$C_A = C_{A0}(1 - X_A)$ 0,25

$C_B = C_{B0} - 2C_{A0}X_A \Rightarrow K C_A C_B = K C_{A0}^2 (1-X_A)(1-2X_A)$ 0,5

$C_{A0} = C_{B0}$ 0,50

1,5

$$t_S = \frac{1}{K C_{A0}} \int_0^{X_{Af}} \frac{dX_A}{(1-X_A)(1-2X_A)} = \frac{1}{K C_{A0}}\left[\int_0^{X_{Af}} \frac{\alpha\, dX_A}{1-X_A} + \int_0^{X_{Af}} \frac{\beta\, dX_A}{(1-2X_A)}\right]$$

$\alpha(1-2X_A) + \beta(1-X_A) = 1 \Rightarrow \begin{cases} \alpha = -1 & 0,25 \\ \beta = 2 & 0,25 \end{cases}$

$$t_S = \frac{1}{K C_{A0}}\left[\int_0^{X_{Af}} \frac{-dX_A}{(1-X_A)} + \int_0^{X_{Af}} \frac{2\, dX_A}{1-2X_A}\right] = \frac{1}{K C_{A0}} \ln\left(\frac{1-X_{Af}}{1-2X_{Af}}\right) \quad 1$$

$$\Rightarrow \frac{1-X_{Af}}{1-2X_{Af}} = e^{t_S K C_{A0}} \Rightarrow X_{Af} = \frac{1 - e^{t_S K C_{A0}}}{1 - 2e^{t_S K C_{A0}}} = 0,072 \quad 1$$

$\boxed{X_{Af} = 0,072}$ 0,5

4,5

2°) $C_A = C_{A0}(1 - X_{Af}) = 0,074$ mol/l 0,25

$C_B = C_{A0}(1 - 2X_{Af}) = 0,068$ mol/l 0,25

$C_C = \cancel{C_{C0}}^{0} + C_{A0}X_{Af} = 5,76.10^{-3}$ mol/l 0,25

$C_D = \cancel{C_{D0}}^{0} + C_{A0}X_{Af} = 5,76.10^{-3}$ mol/l 0,25

1

Car $\int_0^{X_A} \frac{2\, dX_A}{1-2X_A}$

$= \cancel{(2)} \; -\frac{1}{2}\left[\ln(1-\right.$