FT II – Difusão em estado pseudo estacionário

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Conteúdo

1

$$
z = f(t) \begin{cases} t = 0 & z = z_0 \\ t = t & z = z_t \end{cases}
$$

$$
N_A = f(z) \iff N_A = f(t)
$$

$$
Q_A = -C_{A,l}\frac{\mathrm{d}V}{\mathrm{d}t} \qquad N_A = C_{A,l}\frac{\mathrm{d}z}{\mathrm{d}t}
$$

1.1

$$\boldsymbol{t = \frac{C_{A,l}\ \Delta(z^2)}{2\,D_{A,B}\,C\ \ln\frac{1-y_{A,1}}{1-y_{A,0}}}}$$

$$N_A = \frac{D_{A,B}\,C}{z}\ \ln\frac{1-y_{A,1}}{1-y_{A,0}} = C_{A,l}\frac{\mathrm{d}z}{\mathrm{d}t} \implies$$

$$\implies \int \mathrm{d}t = t =$$

$$= \int \frac{C_{A,l}}{D_{A,B}\,C\ \ln\frac{1-y_{A,1}}{1-y_{A,0}}}\ z\ \mathrm{d}z = \frac{C_{A,l}}{D_{A,B}\,C\ \ln\frac{1-y_{A,1}}{1-y_{A,0}}}\int z\ \mathrm{d}z = \frac{C_{A,l}}{D_{A,B}\,C\ \ln\frac{1-y_{A,1}}{1-y_{A,0}}}\frac{\Delta(z^2)}{2} =$$

$$= \frac{C_{A,l}\ \Delta(z^2)}{2\,D_{A,B}\,C\ \ln\frac{1-y_{A,1}}{1-y_{A,0}}}$$

1.2 Geometria esférica

$$\boldsymbol{t = \frac{C_{A,l}}{2\,D\,C\,ln(1 - y_{A,0})^{-1}}\,\Delta(-r^2)}$$

$$\lim_{\substack{r_2 \to \infty \\ y_{A,1} \to 0}} -C_{A,l}\,4\,\pi\,r^2\,\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{4\,\pi\,D\,C}{r_0^{-1}}\,\ln\left(1 - y_{A,0}\right)^{-1}$$

Exemplo 1

Calcule o tempo necessário para que a água evapore completamente.

- Uma camada de água com 1 mm de espessura
- É mantida a 20 °C
- em contato com o ar seco a 1 atm
- Admitindo que a evaporação se dá por difusão molecular através de uma camada de ar estagnado com 5 mm de espessura
- O coeficiente de difusão de água no ar é 0.26 $\mathrm{cm^2/s}$
- A pressão de vapor da água a 20 °C é 0.0234 atm

Resposta

$$N_A = y_A(N_A + N_B) - \frac{P\,D_{A,B}}{R\,T}\,\frac{\mathrm{d}y_A}{\mathrm{d}z} = y_A\,N_A - \frac{P\,D_{A,B}}{R\,T}\,\frac{\mathrm{d}y_A}{\mathrm{d}z} \implies$$

$$\implies \int N_A\,\mathrm{d}z = N_A \int \mathrm{d}z = N_A\,\Delta z =$$

$$\int -\frac{P\,D_{A,B}}{R\,T}\,\frac{\mathrm{d}y_A}{1-y_A} = -\frac{P\,D_{A,B}}{R\,T}\int \frac{\mathrm{d}y_A}{1-y_A} = \frac{P\,D_{A,B}}{R\,T}\ln\frac{1-y_{A,1}}{1-y_{A,0}} \xRightarrow[y_{A,1}=0]{}$$

$$\xRightarrow[y_{A,1}=0]{} \frac{P\,D_{A,B}}{R\,T\;\Delta z}\ln\frac{1}{1-y_{A,0}} = \frac{P\,D_{A,B}}{R\,T\,\delta}\ln\frac{1}{1-y_{A,0}} = N_A =$$

$$= Q_A/S = -C_{A,l}\,\frac{\mathrm{d}V}{\mathrm{d}t}\,\frac{1}{S} = -C_{A,l}\left(-S\,\frac{\mathrm{d}\delta}{\mathrm{d}t}\right)\frac{1}{S} = C_{A,l}\,\frac{\mathrm{d}\delta}{\mathrm{d}t} \implies$$

$$\implies \int C_{A,l}\,\delta\;\mathrm{d}\delta = C_{A,l}\int \delta\;\mathrm{d}\delta = C_{A,l}\,\Delta(\delta^2)/2 =$$

$$= \int \frac{P\,D_{A,B}}{R\,T}\ln\frac{1}{1-y_{A,0}}\;\mathrm{d}t = \frac{P\,D_{A,B}}{R\,T}\ln\frac{1}{1-y_{A,0}}\int \mathrm{d}t = \frac{P\,D_{A,B}}{R\,T}\ln\frac{1}{1-y_{A,0}}\,\Delta t \implies$$

$$\implies \Delta t = \frac{C_{A,l}\,\Delta(\delta^2)/2}{\frac{P\,D_{A,B}}{R\,T}\ln\frac{1}{1-y_{A,0}}} = \frac{C_{A,l}\;\Delta(\delta^2)\,R\,T}{2\,P\,D_{A,B}\ln\frac{1}{1-p_{A,0}/P}} =$$

$$= \frac{\left(\frac{1000\,\mathrm{kg_{Agua}}}{\mathrm{m^3\ (Agua)}}\,\frac{\mathrm{mol_{Agua}}}{18\,\mathrm{g_{Agua}}}\right) * ((6\,\mathrm{E}^{-}3)^2 - (5\,\mathrm{E}^{-}3)^2) * 8.206\,\mathrm{E}^{-5} * (20 + 273.15)}{2 * 1 * (0.26\,\mathrm{E}^{-}4)\ln\frac{1}{1-0.0234}} \cong$$

$$\cong 11\,939.248\,\mathrm{s}\,\frac{\mathrm{h}}{3600\,\mathrm{s}} \cong 3.316\,\mathrm{h}$$