

Chapter 2 Diffusion in dilute solutions

1. Water evaporation

To find the rate of evaporation, we need to find the flux of water across the air film:

$$j_1 = \frac{DH}{\ell} \Delta c_1$$

Since the film is made up of air, $H = 1$. We are given D and ℓ , so we need to find Δc_1 . We first calculate the difference in the partial pressure of water across the film. From a steam table we find that at 20°C , $p_{\text{sat}} = 2.3388 \text{ kPa}$. Since the air immediately above the water is saturated we have:

$$\Delta p_1 = p_{\text{sat}} - 0.5 p_{\text{sat}} = 0.5 p_{\text{sat}} = 0.5(2.3388 \text{ kPa}) = 1.1694 \text{ kPa} = 1169.4 \text{ Pa}$$

Assuming an ideal gas, we can find the concentration difference:

$$\Delta c_1 = \frac{\Delta p_1}{RT} = \frac{1169.4 \text{ Pa}}{\left(8.3145 \frac{\text{J}}{\text{K} \cdot \text{mol}}\right)(293 \text{ K})} = 0.48 \frac{\text{mol}}{\text{m}^3} = 4.8 \cdot 10^{-7} \frac{\text{mol}}{\text{cm}^3}$$

We can now calculate the flux:

$$j_1 = \frac{0.25 \frac{\text{cm}^2}{\text{s}}}{0.15 \text{ cm}} \left(4.8 \cdot 10^{-7} \frac{\text{mol}}{\text{cm}^3}\right) = 8.0 \cdot 10^{-7} \frac{\text{mol}}{\text{cm}^2 \text{ s}}$$

To find the height change, we divide by the molar density of water:

$$\frac{8.0 \cdot 10^{-7} \frac{\text{mol}}{\text{cm}^2 \text{ s}}}{1 \frac{\text{g}}{\text{cm}^3} \cdot \frac{1 \text{ mol}}{18.015 \text{ g}}} = 1.44 \cdot 10^{-5} \frac{\text{cm}}{\text{s}} = 1.25 \frac{\text{cm}}{\text{day}}$$

2. Diffusion across a monolayer

Recalling that the resistance is the inverse of the permeance, we have:

$$\frac{1}{P} = 2 \frac{\text{s}}{\text{cm}} \Rightarrow P = 0.5 \frac{\text{cm}}{\text{s}}$$

We know that the permeance is given by:

$$P = \frac{DH}{\ell} \Rightarrow D = \frac{P\ell}{H} = \frac{\left(0.5 \frac{\text{cm}}{\text{s}}\right)(2.5 \cdot 10^{-7} \text{ cm})}{0.018} = 7 \cdot 10^{-6} \frac{\text{cm}^2}{\text{s}}$$

3. Diffusion coefficient of NO_2 in water

We treat the water as a semiinfinite slab. From Eq. (2.3-18) we know that the flux at the surface is given by:

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