

Problem 10-01 Mean displacement and diffusion coefficient

The diffusion coefficient of ribonuclease was found to have the value of $1.2 \cdot 10^{-6} \text{ cm}^2 \text{ s}^{-1}$. Estimate how long it will take the ribonuclease molecule to pass through a porous membrane of thickness 1.8 mm. The molar mass of ribonuclease is $13.68 \text{ kg mol}^{-1}$.

[3.75 h]

Solution:

$$D = 1.2 \cdot 10^{-6} \text{ cm}^2 \text{ s}^{-1} = 1.2 \cdot 10^{-10} \text{ m}^2 \text{ s}^{-1}$$

$$M = 13.68 \text{ kg mol}^{-1}$$

$$x = \bar{\Delta} = 1.8 \text{ mm} = 1.8 \cdot 10^{-3} \text{ m}$$

Mean displacement:

$$\bar{\Delta}^2 = 2 D \cdot \tau$$

$$\tau = \frac{\bar{\Delta}^2}{2 D} = \frac{(1.8 \cdot 10^{-3})^2}{2 \cdot 1.2 \cdot 10^{-10}} = 13500 \text{ s} = 3.75 \text{ h}$$