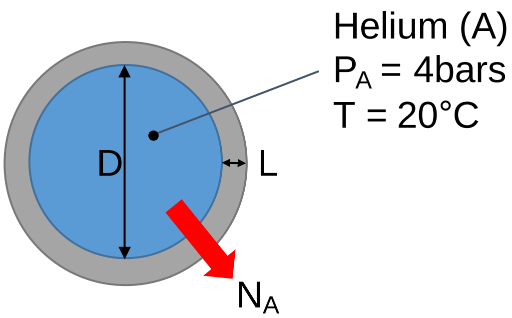
Introduction to Transport Phenomena: Exercises Recap Modules 4 and 5

Exercise 1 (very similar to 4.2)

Helium gas (A) is stored at 20°C in a spherical container of fused silica (B), which has an internal diameter D=0.20m and a wall thickness L=2mm. If the container is charged to an initial pressure P_A=4bars, what is the rate at which this pressure decreases with time (leakage rate)? (D_{AB} = 0.4 x 10^{-13} m^2/s and S_{AB} = 0.45 x 10^{-3} kmol/m^3 bar). Assume that the driving force does not change with time.



Exercise 2 (very similar to 4.4)

Humidification. Imagine that water is evaporating into initially dry air in a closed vessel. The vessel is isothermal at 25°C so the water's vapor pressure is 3.2 kPa. This vessel has 0.8 liters of water with 150 cm^2 of surface area in a total volume of 19.2 liters. After 3 min, the air is 5% saturated. What is the mass transfer coefficient? How long it takes to reach 90% saturation?

Notes:

1) If air is 100% saturated in water, it means that the water partial pressure in air is equal to its vapor pressure ($P_{saturation}$) at that specific temperature. If air is 5% saturated in water, it means that the water partial pressure in air is 5% of $P_{saturation}$.

$$x_{water\ at\ 5\%\ saturation} = 0.05\frac{P_{saturation}\ (3.2\ kPa)}{Total\ Pressure\ (101kPa)}$$

$$\frac{C_{water}}{C_{saturation}} = \frac{P_{water}}{P_{saturation}} = 0.05$$

2) If we assume that air is an ideal gas, its molar volume at 25°C is 24.4 L/mol. Thus, the concentration of pure air is 1/24.4 mol/L

Exercise 3 (too easy to be real)

A plate with area $1m^2$ moves at 60cm/s and it is 0.025 mm apart from a fixed plate. To keep this velocity, it requires a force of 2N. Find the fluid viscosity between the plates.

Exercise 4

A 25-mm diameter shaft is pulled through a cylindrical bearing. The lubricant that fills the 0.3-mm gap between the shaft and the bearing is an oil having dynamic viscosity 0.650 $\frac{N \cdot s}{m^2}$ $(or\ Pa \cdot s)$. Determine the force required to pull the shaft at a velocity of 3 m/s