ChE 333 Transport Phenomena III, fundamentals of Mass Transfer
Studio Worksheet #13 Diffusional Flux and Convectional Flux

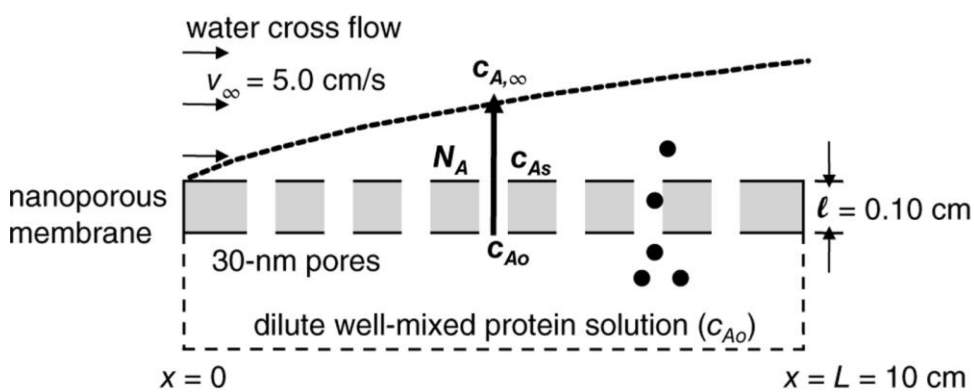
NAME____

Studio Section	**Studio 12:00-12:50**	**Studio 13:00-13:50**	**Studio 14:00-14:50**	**Studio 15:00-15:50**

Instructions: Open book, notes, and homework. Make sure to write your name and studio on any additional sheet of paper with your solution. Show your calculation, algebraic setup, and make sure to include units. If you do not complete the problem by the end of class, please turn in your completed solution to your Studio section Teaching Assistant at the next Studio session.

Problem 1: A cross-flow molecular filtration device with a mesoporous membrane is used to separate the enzyme lysozyme from a fermentation broth. Water at 25°C flows over the top surface of the flat plate membrane at a velocity of 5.0 cm/s. The length of the membrane in the flow direction is 10 cm and its thickness is (*l*) 0.10 cm. The uniform, parallel pores are 30 nm in diameter and the pore openings cover 30% of the membrane surface.

The dissolved enzyme diffuses through the pores of the membrane and across the boundary layer of the flowing fluid, so that there are two mass-transfer resistances in series, diffusion and convection.



Some useful parameters

T=298 K	D_{Ae}=5.54x10^{-7} cm^2/s	Turbulent flow k_c = 0.95 cm/s
v_∞=5.0 cm/s	c_{A0}=1.0x10^{-5} mole/cm^3	Laminar flow k_c = 1.05 x 10^{-4} cm/s
ν_w=9.12x10^{-3} cm^2/s	$c_{A\infty}$=0.4x10^{-5} mole/cm^3	

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A. Derive a steady state flux model for transfer from the protein mixture (c_{A0}) to the bulk water ($c_{A\infty}$). The flux from the outer side of the member is convective flux, $N_A=k_c\,(c_{AS}-c_{A\infty})$ where k_c is the convective mass transfer coefficient [cm/s] and ($c_{AS}-c_{A\infty}$) is the driving force from the surface of the membrane to the bulk water.

B. Estimate the average flux across the membrane and the boundary layer.

C. If $k_c >> D_{Ae}$ would the flux be limited by the flux through the membrane or through the bulk water?

D. Estimate the flux assuming all the transfer resistance is in the membrane (diffusion limited), (Note: the driving force is ($c_{A0}-c_{A\infty}$))

E. Estimate the flux assuming all the transfer resistance is in the boundary layer (convective limited) (Note: the driving force is ($c_{A0}-c_{A\infty}$))

F. Calculate the Biot number ($Bi=k_c\,l/D_{Ae}$), what does that tell you about importance of the different mass transfer resistances?