EXAM 2

BIEN 401

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Some folks suggest that the cell walls of living cells have pores that are 30 angstroms in diameter (1 angstrom = 10-8cm). Estimate the diffusivity (cm2/sec) at 370C for a solute 5 angstroms in diameter through such pores. Assume that the pores are filled with water having a viscosity of 0.76 cP (1cP = 0.01 g cm-1sec-1)/

Solve using the Renkin Equation 5.61:

 where a = solute radius and r = pore radius



Use Equation 5.5 to determine the molecular weight:

 Conversion for angstroms to centimeters



Now, use Equation 5.3 to determine the solute diffusivity:



Solving for Dpore:



1. A single hollow fiber is placed within a large diameter glass tube forming a shell space that surround the hollow fiber. The hollow fiber is 20 cm in length and has a diameter of 400µm. the flow rate of a liquid through the hollow fiber is 1 cm3min-1 and in the shell space, another liquid also flows through at a flow rate of 100 cm3min-1. The liquid entering the hollow fiber also contains a permeable solute. It is found that the concentration of the permeable solute exiting the hollow fiber is 10% of the concentration of this solute when entering the hollow fiber in the liquid. Estimate the permeability for this solute in cm sec-1.

Assumptions:

Because the flow rate in the shell space is so high, we can treat Cshell = 0 and use the Renkin-Crone Equation.



1. Blood perfuses a region of tissue at a flow rate of 0.35 mL min-1 cm-3 of tissue. The pO2 of the entering blood is 95 mmHg and exiting pO2 of the blood is 20 mmHg. Calculate the metabolic oxygen consumption rate of the tissue in µM/sec.

Using equation 6.10 and Figure 6.3 we have then that:



1. Islets of Lengerhans are sequestered from the immune system in a device similar to that shown in Figure 6.6. the pO2 of the blood in the capillaries adjacent to the immunoisolation membrane is 40 mmHg. The membrane oxygen permeability is 9.51 x 10-4 cm sec-1. If the islets consume oxygen at the rate of 25.9 µM sec-1, estimate the maximum half-thickness of the islet tissue in cm, assuming a void volume in the islet later of ꜫ=0.95.

We can use Equations 6.18 and 6.20, set the pO2 =0 mmHg at x = δ, and solve for the value of the oxygen consumption rate. We also set the value of De = 2.11 x 10-5  from Equation 5.84. So we basically solve the following equation for δ:



Bonus Problem: (15 points)

Blood is flowing through a hollow fiber that is 800µm in diameter and 30 cm in length. The average velocity of the blood within the hollow fiber is 25 cm sec-1. The concentration of a drug is maintained at 10 mg L-1 along the inside surface of the hollow fiber. The diffusivity of the drug in blood is 4 x 10 -6 cm2sec-1. Estimate the mass transfer coefficient, km, for the drug. Assuming no drug enters the hollow fiber with the blood, estimate the exiting concentration of the drug in blood.

Dtube = 800 μm; L = 30 cm; VAVG = 25 cm/sec; C0 = 10 mg/L; D = 4 x 10-6 cm2/sec;

μ = 3 cP, ρ = 1.02 g/cm3

First, calculate the Reynolds and the Schmidt number:





Since the residence time, L/VAVG ~ 1 sec assume a short contact time solution is valid. Now, determining the Sherwood number using Equation 5.48:



Next, determine the mass transfer coefficien:



To determine the exiting drug concentration, we first need to calculate the volumetric flow rate:



Next, we calculate :



Now by an overall mass balance on the drug we must have that JS = QCexit.

Hence we can solve for the exiting drug concentration where we find that Cexit is 0.53 mg/L. This solution is valid as long as *s* << *R* or that δC <<*R*. From Equation 5.42 we can calculate the value of δC as follows:



Hence at the exit of the tube the concentration boundary layer is quite a bit less thick than the tube radius so the short contact time solution is valid.