Name (Print) ______________________ ID No. ________________
Signature ______________________

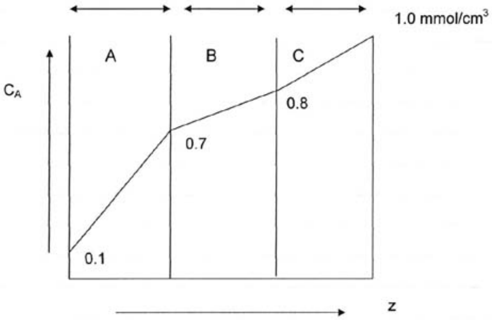
ChE 150B September 27, 2002

Midterm Examination I
(Closed book but one page of notes)
Answer all questions in the spaced provided after each question

1. (40 pts.) You have just been hired to test a membrane for a biomedical application. Blood is contained in a long cylindrical tube. The tube is made of your company's new biopolymer. The inner radius of the tube is 2.5 cm and the wall thickness is 0.2 cm. The ouside of the tube is exposed to a large volume of water, and urea diffuses across the membrane from the blood to the water. The concentration of urea at the inner wall of the tube is 2.3 mol/m^3 and the concentration of urea on the water side may be assumed to be zero. The diffusivity of the urea in the polymer is $2.2\text{x}10^{-10}$ m^2/s.

   a) Show that $(rN_{A,r})$ = constant
   b) Assuming that convective flow through the polymer film is small, find the molar flux at the inner wall of the tube.
   c) What is the functional form of the concentration profile in the membrane? Be sure to state your boundary conditions.

2. (20 pts.) CO_2 diffuses through a membrane composed of three distinct layers – A, B, and C – of the same thickness. A plot of the steady-state concentration profile is given below. In answering each of the following questions, be sure to provide a short explanation.



a) In what direction does mass transfer occur?

b) Which layer has the largest diffusion coefficient?

c) Which layer is the limiting resistance to mass transfer?

d) In which layer is the molar flux the largest?

3. (40 pts.) We have shown in lecture that Sh = f(Re, Sc). For a sphere the relationship is

$$Sh = 2 + 0.6\,\mathrm{Re}^{1/2}\,Sc^{1/3}$$

This means that when the velocity of the fluid surrounding the sphere goes to zero, the Sherwood number goes to 2.0. Recalling that $Sh = k_c D/D_{AB}$, where D is the sphere diameter, demonstrate that Sh = 2.0 for a stagnant fluid. Be sure to state any assumptions you needed to make in order to derive this result. For the sake of nomenclature define $C_A(r = R) = C_{A,s}$ and $C_A(r = \infty) = C_{A,\infty}$, where r is radial distance measured from the center of the sphere.