UCB ID:_____

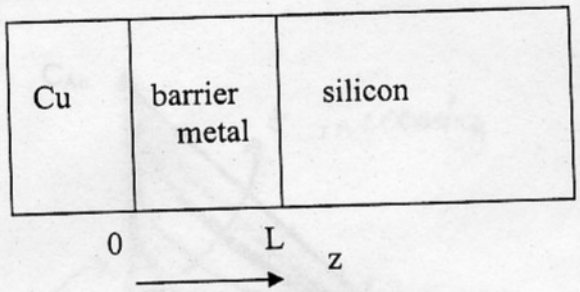
By signing my name below, I affirm that I have not received assistance in completing this examination paper nor have I given assistance to another student.

Name: Solutions

Chemical Engineering 150B
Midterm Exam 1
October 4th, 2006
8:10 - 9 am
100 Points Total

Three Problems

1. (25 points)



Copper is often used in semiconductor devices to connect one element to another. Unfortunately, though, Cu can diffuse rapidly into the silicon comprising the device, causing defects that ruin the chip. In order to prevent this, a barrier metal is deposited between the copper and the silicon. When a computer is turned on, the temperature of the chips rises rapidly to a steady value and the copper begins to diffuse through the barrier metal. At L the barrier is in contact with a much thicker piece of silicon containing virtually no copper. The maximum solubility copper in the barrier metal is C_{Ao} and the effective diffusivity of copper in the barrier metal of D_{AB}.

a) (5 points) Assuming the total concentration of metal in the barrier region is roughly constant, the barrier metal is at an average temperature, and copper is very dilute in the barrier metal, write down an overall mole balance on copper (C_A) in the barrier.

Note:
1. Very dilute → $x_A \approx 0$
2. c = constant
3. Constant $T \Rightarrow D_{AB}$ constant
4. No rxn
5. 1 D
6. ~~*~~ "Copper begins to diffuse" implies non-steady state

- general mole balance -

$$(+1)\ -\frac{\partial}{\partial z}(N_{Az}) + \cancel{R_A}^{\,0} = \frac{\partial C_A}{\partial t}$$

$$(+1)\ N_{Az} = -D_{AB}\frac{\partial C_A}{\partial z} + \cancel{x_A(N_{Az}+N_{Bz})}^{\,0,\ (+1)\ \text{dilute}}$$

$$+\frac{\partial}{\partial z}\left(+D_{AB}\frac{\partial C_A}{\partial z}\right) = \frac{\partial C_A}{\partial t} \rightarrow \boxed{D_{AB}\frac{\partial^2 C_A}{\partial z^2} = \frac{\partial C_A}{\partial t}}$$

(+1) (+1) 1