GEORGIA INSTITUTE OF TECHNOLOGY

COLLEGE OF ENGINEERING

BMED3300 – BIOTRANSPORT

QUIZ 4 (SPRING 2014) – KEMP

STUDENT NAME: Key

GTID NUMBER: ______________________

RECITATION SECTION: ______________________

(Section A is Wednesdays at 12 pm; Section B is Wednesdays at 10 am)

Closed Book
All non-communicating calculator types allowed
Time allotted: 15 minutes
Do all work in this booklet

Reminder: for questions that require numerical answers, units are required and worth 50%

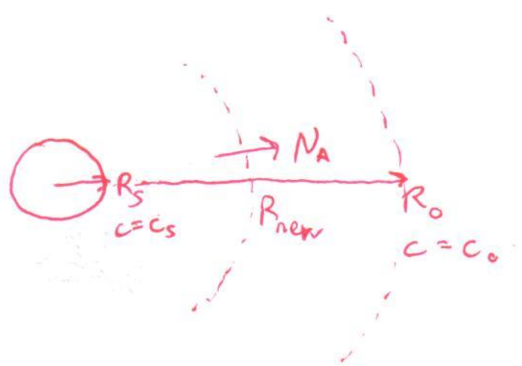
Question	Maximum Mark	Actual Mark
1	2	
2	8	
Total	10	

Suture thread of radius $r=R_s$ is made of a dissolving polymer A so that surgical stitches will biodegrade in the body. When the stitches are first made, you can consider the quasi-steady state condition when the diffusion rate of the polymer is not changing significantly with time, nor is it decreasing the radius significantly. You are told that the concentration profile associated with the polymer release is

$$c(r) = \frac{c_S - c_O}{\ln\left(\frac{R_S}{R_o}\right)}\left(ln\frac{r}{R_o}\right) + c_O$$

This is based upon the knowledge that $[A] \rightarrow c_o$ at a distance R_o away from the surface and the effective concentration at the surface of the suture thread R_s is c_S, where $c_s > c_O$. The diffusion coefficient of polymer A in tissue is defined as D_A.

1) Draw a diagram of the system and indicate the directionality of the flux of polymer A at a distance R_{new} away from the suture thread surface, where $R_s < R_{new} < R_O$.



flux will be directed outward from the thread and driven from high to low concentration

2) Derive an expression for the flux of A at a distance R_{new} away from the suture thread surface, where $R_s < R_{new} < R_o$.

Fick's 1st law in cylindrical coordinates:

$$N_A = -D\frac{\partial c}{\partial r}$$

if $c = \frac{(c_s - c_o)}{\ln\frac{R_s}{R_o}}\left(\ln\frac{r}{R_o}\right) + c_o$ then take 1st derivative

$$\frac{dc}{dr} = \frac{(c_s - c_o)}{\ln\frac{R_s}{R_o}} \cdot \frac{1}{r}$$

$$N_A\Big|_{R=R_{new}} = -\frac{D_A(c_s - c_o)}{\ln\frac{R_s}{R_o}} \cdot \frac{1}{R_{new}}$$

Definition of ∇ and ∇^2 operators in different coordinate systems:

Cartesian:

$$\boldsymbol{\nabla} = \mathbf{e}_x \frac{\partial}{\partial x} + \mathbf{e}_y \frac{\partial}{\partial y} + \mathbf{e}_z \frac{\partial}{\partial z}$$

$$\boldsymbol{\nabla}^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

Cylindrical:

$$\boldsymbol{\nabla} = \mathbf{e}_r \frac{\partial}{\partial r} + \mathbf{e}_\theta \frac{1}{r}\frac{\partial}{\partial \theta} + \mathbf{e}_z \frac{\partial}{\partial z}$$

$$\boldsymbol{\nabla}^2 = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2}{\partial \theta^2} + \frac{\partial^2}{\partial z^2}$$

Spherical:

$$\boldsymbol{\nabla} = \mathbf{e}_r \frac{\partial}{\partial r} + \mathbf{e}_\theta \frac{1}{r}\frac{\partial}{\partial \theta} + \mathbf{e}_\varphi \frac{1}{r\sin\theta}\frac{\partial}{\partial \varphi}$$

$$\boldsymbol{\nabla}^2 = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial \varphi^2}$$