HW#2 TISSUE ENGINEERING Due 2/12/2019

Problem 1: Insulin is transported from the capillary to the interstitial space of tissues, particularly muscle tissue, to support glucose uptake by cells. The human insulin protein is a dimer composed of 51 amino acids, and has a molecular mass of 5808 Da. It has a molecular diameter of 2.7 nm. The length of a blood capillary is 1 mm, dimeter is 10 μm, and capillary wall thickness is 0.5 μm. The capillary wall contains intracellular pores with diameter of 7 nm for mass transport across the capillary wall. The pores cover 0.1% of the surface of the capillary wall and the rest is covered by endothelial cells such that only those compounds that have appreciable solubility in the cell lipid bilayer can diffuse through. Insulin does not have appreciable solubility in the cell lipid bilayer. Therefore, the overall insulin mass transfer, not including mass transfer by pinocytosis, through the capillary wall is given by the following equation:

$$N_{insulin,t} = N_{insulin,conv} + N_{insulin,diff}$$

Where $N_{insulin,conv}$ is the transport of insulin by convention through the capillary pores and $N_{insulin,diff}$ is the transport of insulin by diffusion through the capillary pores given by the following equations:

$$N_{insulin,conv} = C_{insulin,cap}\,(1-\sigma)\,J_{filt}$$

$$N_{O2,pore\,diff} = P_{insulin,pore}\,S\,(C_{insulin,cap} - C_{insulin,int})$$

In the above equations, $C_{insulin,cap}$ and $C_{insulin,int}$ are the concentrations of insulin in the capillary and in the tissue interstitial space, σ is the reflection coefficient of insulin, J_{filt} is the capillary filtration rate, $P_{insulin,pore}$ is the insulin permeability in the pores of the capillary, S is the total surface area of a capillary, $D_{insulin}$ is the insulin diffusion coefficient in plasma, and t_{wall} is the thickness of the capillary wall. The following values are given for muscle tissue under saturation insulin infusion:

$C_{insulin,cap}$ = 22000 picomoles/liter $C_{insulin,int}$ = 0 Wall tortuosity = τ = 2

J_{filt} = 5.75x10^{-9} cm^3/h per capillary (1 mm long) $D_{insulin}$ = 150 μm^2/s

A. Determine the reflection coefficient and the ratio of capillary membrane to plasma diffusion coefficient (D_m/D) for insulin.
B. Use the results in part A to find the contribution of each mechanism to insulin transport through the capillary wall (percent convection and percent diffusion).
C. Determine the total insulin transport through the capillary wall in picomoles/h.
D. What would the total insulin transport reduce to when the $C_{insulin,int}$ increases to 19000 picomoles/liter as insulin is transported to the interstitial space (the same $C_{insulin,cap}$)?