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**BIEN 401/501**

**EXAM 2**

*Honor Statement:* On my honor, I promise that I have not received any outside assistance on this exam (I didn’t look at another student’s paper, I didn’t view any unauthorized written materials, I didn’t talk or listen to another student).

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The last 3 sheets of the exam contain useful equations. When the exam starts you may rip off these sheets for easy access. When the exam concludes, please stuff the torn pages back into your exam packet before submitting your exam. If you used any additional papers for scratch work, please stuff these in your exam packet as well.

**Concept Questions (1-10)**

**(3 points each)** Circle the correct answer choice for each of the following questions.

***Review concepts, vocabulary, correlations/causations from the notes.***

**Computational Questions (11-19)**

For each question, you must show your work to get credit (partial and/or full). Be sure to answer all parts if a question has multiple parts.

1. **(15 points)** A spheroid of hepatocytes is suspended within a large amount of stagnant nutrient media containing a drug. The experiment is being done to determine the metabolism of this drug by the cells in this spheroid. The spheroid has a diameter of 0.08 cm. At a particular time during the experiment, it was found that the drug concentration in the bulk media solution was 0.190 and the drug concentration at the surface of the spheroid was measured at 0.07 . The diffusivity of the drug in the media solution is . Determine **(A)** the mass transfer coefficient (), **(B)** the molar transfer rate of drug into the sphere (i.e., ), and **(C)** the reaction rate per volume of spheroid at which the hepatocytes metabolize the drug. (Hint: the characteristic length used in your dimensionless numbers will be the spheroid diameter. A second hint: you should assume any drug that diffuses to the surface of the spheroid will ultimately be taken up and metabolized by the spheroid. A final hint: the surface area and volume of a sphere can be calculated, respectively, using: and , where is the radius of the sphere.)
2. **(10 points)** A drug is administered to a patient using a continuous IV drip. The drug is introduced at a rate of 50 mg/hr. The elimination rate constant of the drug from the body is approximated to be 0.0031 min-1. The apparent volume for the drug in the body is 12 L. Assuming that the drug in the body can be modeled using a single compartment model, determine **(A)** the steady-state drug concentration after a long period of time. After a long period of time, the continuous drug perfusion is stopped. **(B)** How long after the IV drip has been stopped, will the plasma concentration be 30% of its value at the moment that that the perfusion stops? (Hint: you don’t need the answer to part A to find part B.)
3. **(10 points)** Determine the approximate apparent volume for a 90-kg (male) patient where an administered drug that is incapable of entering any cell volume has an unbounded-protein fraction of 0.85 (i.e., 85% of the drug is not bound to any proteins) in the plasma and interstitial spaces. (Hint: assume that the volumes scale proportionally to the patient’s mass; ignore any other factors such as disease, age, and injury.)
4. **(10 points)** A volume of tissue that can accurately modeled with the Krogh cylinder model has a constant glucose concentration of 5 mmol/cm3 on the outside surface of the capillary wall. The cell-volume specific consumption rate (i.e., ) of glucose in the tissue is 0.007 mmol/(cm3 s). The cylinder model has a terminal radius of 40 mm and the outer-capillary radius (i.e., capillary lumen plus capillary wall) is 5.5 mm. A glucose sensor probe located 15 mm from the capillary wall measures the concentration to be 2.2 mmol/cm3. **(A)** Determine the effective diffusion coefficient of the glucose in the tissue under these conditions. Under these conditions, **(B)** determine the concentration of glucose at the terminal radius.
5. **(15 points)** A thin cylindrical disk of genetically transformed hepatocytes 2.5 cm in diameter is suspended in a nutrient solution at 37oC; the solution has a density of 1 g/cm3 and a viscosity of 1.2 cP. The half thickness of the disk is , and the cell fraction is 0.35. The consumption rate of oxygen on a per ***cell*** volume basis is 18.5 . The partial pressure of oxygen in the bulk solution is 150 mmHg. At the centerline of the disk (i.e., ) the partial pressure of oxygen is 25 mmHg. The diffusivity of oxygen in both the solution and the cell disk is . The Henry’s constant for oxygen in the solution and the cell disk is 0.73 . Determine **(A)** the partial pressure of oxygen at the disk surface (hint: there is no membrane separating the solution from the cells, thus no membrane permeability), **(B)** the mass transfer coefficient (hint: at steady state, the rate at which oxygen enters the disk should be equal to the rate it is consumed), **(C)** the rotation speed of the disk expressed in RPM (hint: the revolution speed is equal to the product of the angular speed and [radians/revolution]).

1. **(10 points)** A well-mixed protein solution is being filtered across a semipermeable membrane. The nominal molecular weight cutoff (NMWCO) is 100,000 (g/mol). The bulk protein concentration on the feed side is 1 g/L. The protein can be assumed spherical in shape with a molecular radius of 2 nm. The protein’s mass transfer coefficient is and the filtration flux of the protein solution across the membrane is . Determine **(A)** the actual sieving coefficient and **(B)** the protein concentration in the filtrate.
2. **(10 points)** A molecule with a radius of 2.5 nm enters a membrane having pores with a radius of 7.5 nm. Assume the fluid is water at 37oC (viscosity is 0.76 cP). The membrane has a porosity of 40% and a tortuosity of 1.5. The membrane has a thickness of 200 . Determine **(A)** the hydraulic conductance of the membrane and **(B)** the permeability of the membrane.

**END OF EXAM**

**Answer Key**

11A.

11B.

11C.

12A.

12B.

13.

14A.

14B.

15A.

15B.

15C.

16A.

16B.

17A.

17B.