Spring 2005 (Przybycien) **42-101 Intro to BME** **NAME: _____**

MAKEUP EXAM

Format: Open text, notes, homework and mind; closed neighbor.

Part I: Short Answer Questions (48 pts)

Short written-answer and short calculation questions - *No more than two or three sentences in answer to any question in this section please.*

1. (6 pts) Describe the two main differences between the rheological (stress-rate of strain) behavior of a Casson fluid, such as whole blood, and a Newtonian fluid, such as plasma.

2. (6 pts) Is the flow of air in the trachea during breathing laminar or turbulent? Justify your answer. The following data is available for this system: volumetric air flow rate during breathing is 6 L/min, length of the trachea is 20 cm, diameter of the trachea is 1.5 cm, density of air is 1.185 g/L, heat capacity of air is 0.238 cal, thermal conductivity of air is 0.0232 kcal/(hr•m^2•°C), viscosity of air is 1.75×10^{-5} Pa•s [=] kg/(m•s).

3. (6 pts) The rate of substrate consumption, v in mmol/(L•min), for an enzymatically catalyzed reaction as a function of substrate concentration, s in mmol/L, is given by the equation $v = 5.3s^4/(1.67 + s^4)$. What does the form of this expression suggest about the nature of the enzyme-substrate interaction and the structure of the enzyme?

4. (6 pts) The binding strength of a repressor to a unique operator site within an organism's genomic DNA is described by K_d = 24.3 nM. At what cytosolic repressor concentration, in nM, would expression of the genes within this operon, i.e. the genes under the control of this repressor-operator interaction, be attenuated by 90% relative to the unrepressed case?

5. (6 pts) Mylotarg™ (Wyeth Pharmaceuticals) is an anti-leukemia chemotherapy agent composed of an antibody covalently attached to a toxic antitumor antibiotic, calicheamicin. The antibody portion of Mylotarg binds specifically to the CD33 antigen; the CD33 antigen is a protein found on the surface of leukemic cells and some cells in blood that later give rise to red blood cells. If you were a protein engineer working on the next generation product for Wyeth, would you be interested in increasing or decreasing K_d for the antibody portion of the drug? Why? Why would this approach, covalently coupling a toxin to an antibody, be a promising approach to chemotherapy?

6. (6 pts) What is the "chemiosmotic hypothesis"?

7. (6 pts) Identify the four main phases of batch cell growth and describe what is happening during each phase.

8. (6 pts) The rate of insulin secretion from pancreatic islet cells, r in μinternational units/islet/min, as a function of glucose concentration, C in mg/mL, is given by the equation

$$r = 0.209/(1 + \exp\{-3.33C + 6.6\}).$$

What are the units associated with the constant "0.209"? Reformulate this equation so that the values for C in millimoles/L may be used to calculate r in μinternational units/islet/min.

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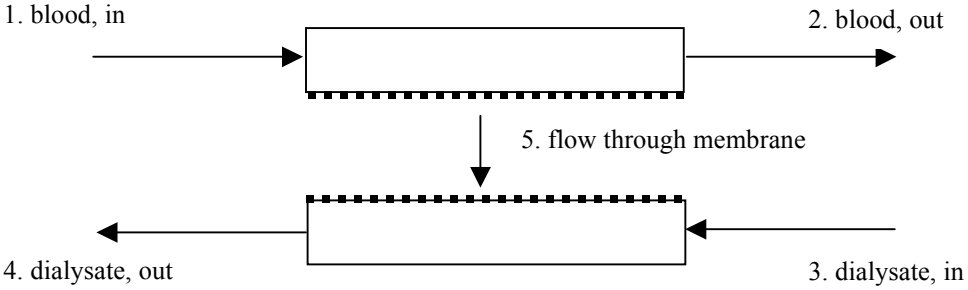
Part II: Detailed Questions (52 points)

1. (26 pts) Iggy V. Leeg visits an amusement park and decides to take a ride on the BME Screamer, an infamous stand-up roller coaster. At one point during the ride, Iggy is subjected to an upward force of 225 N. Iggy has a mass of 69 kg; his head is located 57 cm above the center of his heart; his feet are located 126 cm below the center of his heart; his blood density is 1.056 g/mL; the acceleration due to gravity is 9.81 m/s^2. Estimate the pressure of the blood, in mmHg relative to atmospheric pressure, on the arterial and venous sides of the circulation in the regions of the feet and head during this particular point in the ride. Is the pressure drop from the arterial to the venous side of the circulation in the head affected by the upward force? Why or why not?

2. (26 pts) Consider the expanded view of a counter-current hemodialyzer below:



Assume whole blood = cells + (w)ater + (g)lucose + (u)rea. Whole blood flows in to the dialyzer at 360 mL/min with a hematocrit of 0.41; $C_{1,g}$ = 100 mg/dL plasma; $C_{1,u}$ = 200 mg/dL plasma. The water flow rate through the membrane is 13 mL/min; the urea flow rate through the membrane is 180 mg/min; there is no net glucose flow rate through the membrane. Dialysate flows into the dialyzer at 720 mL/min; $C_{3,g}$ = 125 mg/dL soln. Determine the composition (mg/dL plasma or soln for urea and glucose, hematocrit for cells) and the total volumetric flow rate (mL blood or soln/min) for streams 2 and 4 as appropriate. *Use our mass-balancing problem-solving format for this problem.*