Fall 2002 (Przybycien) **42-101 Intro to BME** **NAME: _____**

EXAM #2

Part I: Short Answer Questions

Short written-answer and short calculation questions. I'll be looking for significant keywords, equations and/or diagrams. - *No more than two or three sentences in answer to any question in this section please.*

1. (6 pts) The metabolic pathway fragment shown below is regulated by repression.

   Describe what happens in this pathway as the concentration of substrate Z increases.

2. (6 pts) A noncompetitively-inhibited enzyme is well-described by the parameters K_I = 4.37 μM, K_M = 0.736 μM and v_{max} = 0.224 μM substrate/min. Which species binds to the enzyme more strongly, substrate or inhibitor? Give the logic behind your answer.

3. (6 pts) Give two biologically relevant examples each where living systems make use of negative feedback control, positive feedback control and feedforward control.

4. (6 pts) What is "homeostasis"?

5. (6 pts) What is the "chemiosmotic hypothesis"?

6. (6 pts) The bacterium *Escherichia coli* is known as a facultative anaerobe, meaning that it can grow in the absence of oxygen or in the presence of oxygen. If *E. coli* could freely choose to live in an aerobic or an anaerobic environment, which would it choose and why?

7. (6 pts) In some microbes, the reaction (pyruvate + CO_2 → oxalacetate) occurs and is catalyzed by the enzyme pyruvate carboxylase which also includes the hydrolysis of one molecule of ATP. With this information, place upper and lower bounds on the value for $\Delta G^{\circ\prime}_{rxn}$, in kcal/mol, for the reaction (pyruvate + CO_2 → oxalacetate) in the absence of pyruvate carboxylase. Justify your bounds.

8. (6 pts) What is "flow work"?

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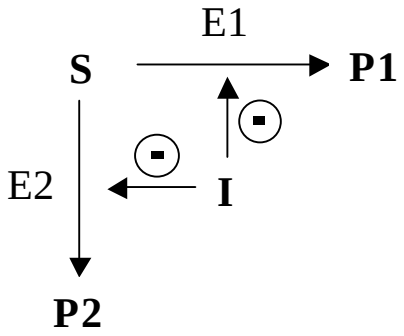
Part II: Detailed Questions

1. (26 pts) A branch point in a metabolic pathway is shown below. A carbon-containing substrate S is acted on by two different enzymes, E1 and E2, to make two different products, P1 and P2. The flow of carbon through this branch point is directed by negative feedback control: E1 is uncompetitively inhibited by inhibitor I and E2 is noncompetitively inhibited by inhibitor I. Kinetic parameters and concentrations for the two enzymes are given in the table below. For this system, estimate the percentage of substrate carbon that flows from S to P1 when the substrate concentration is constant at 47.2 mM and the inhibitor concentration is constant at 14 μM. You may assume that the substrate and both products each contain the same number of carbon atoms and that no product is present initially. [Hint: If no P1 or P2 is present initially, the amounts of P1 and P2 formed will be proportional to their rates of formation]



enzyme	$[E_o]$ (μM)	k_{cat} (mM S/(min•μM E))	K_M (mM S)	K_I (μM I)
1 (uncompetitive)	57.3	0.00142	40.0	12.0
2 (noncompetitive)	32	0.003339	50.0	25.0

2. (26 pts) A left ventricular assist device (LVAD) is an implantable pump that can be used to treat a patient whose heart muscle is too weak to provide adequate blood flow to the circulatory system on its own. An LVAD is connected as a shunt from the pulmonary vein to the aorta. A schematic diagram is given to the right. The total blood flow rate is 5.0 L/min; blood has a density of 1.056 g/mL. At rest, the mean velocity and pressure of the blood in the pulmonary vein are 30 cm/s and 6 mmHg, respectively; the mean velocity and pressure of the blood in the aorta are 30 cm/s and 90 mmHg, respectively. If the LVAD provides work at the rate of -0.00050 hp at rest, what is the rate of work, in hp, provided by the patient's left atrium and left ventricle at rest? [Note: 1 bar = 750.061 mmHg, 1 J = 10 cm^3•bar, 1 kW = 1.34102 hp]