Chemistry 4000/5001/7001 Fall 2010 Assignment 10

Due: Friday, Nov. 26, 4:00 p.m.

Marks: 20

1. The Bliss-Painter-Marr model is a simple model of gene expression with negative feedback in which a product generated indirectly after transcription of a gene inhibits the latter process (textbook, page 246). Write down a mechanism corresponding to these equations, i.e. a set of chemical reactions that would have these rate equations. [4 marks]

2. Find conditions under which this model has oscillatory solutions. Give your parameters, as well as a sample graph of one of the variables. [2 marks]

   Hint: Read section 9.4.3 of the textbook. If you spend a few minutes doing this, you should be able to identify oscillatory conditions without doing much work.

3. The model contains a term for removal of the final product (x_3). In order to get oscillations, the removal term can't be a simple first-order rate term. In the Bliss-Painter-Marr model, a Michaelis-Menten form is used for this parameter. There are two ways to "simplify" the Michaelis-Menten equation, by taking either very large of very small values of K.

   (a) Discuss what happens (algebraically) in the Michaelis-Menten equation when K is either very large or very small. Do you foresee any potential problems if you replaced the Michaelis-Menten term by one or the other of these limits? [4 marks]

   (b) Generate a bifurcation diagram for the parameter K, and discuss your diagram in relation to the effect on the Michaelis-Menten equation, as well as the observation made above that the removal term should not be a first-order rate term in order to get oscillations. [10 marks]

   Bonus: Based on your results, can you generate a plausible hypothesis regarding the limitations on the order of the x_3 removal reaction required to get oscillations? [2 marks]

   Bonus: Replace the Michaelis-Menten removal term by one that conforms to your hypothesis. Can you get oscillations? Credit will be given for using a rate term that fits your hypothesis and for then carrying out a reasonable search for oscillatory solutions. It is not necessary to actually find oscillatory solutions, provided you used the tools at your disposal in a reasonably thorough way. [10 marks]