Chemistry 2740 Spring 2016 Test 4

Time: 50 minutes
Marks: 29
Aids allowed: calculator, 8.5×11-inch formula sheet
Instructions: You can answer the questions in any order, but make sure that you clearly label each of your answers with the question number in your exam booklet(s).
Remember that a few short sentences go a long way to helping understand your work. Briefly note any procedures you carried out on your calculator (e.g. solving equations, linear regression, etc.).
If you use a graph to answer a question, make sure to provide a reasonable sketch of the graph, including properly labeled axes, as well as a brief explanation of what information the graph provides.

TATA-binding protein (TBP) is a DNA-binding protein involved in the initiation of transcription. TBP is known to form dimers under certain conditions.

1. Jackson-Fischer and co-workers have studied the dissociation of yeast TBP dimers,[1] i.e. the reaction

$$(\mathrm{TBP})_2 \xrightarrow{k_d} 2\,\mathrm{TBP}.$$

Dissociation is usually an elementary reaction. What order would you predict for this reaction? [1 mark]

2. This reaction is thought to be important *in vivo* because only the TBP monomers can bind DNA. They obtained the following data for the percentage of dimers dissociated vs time in an experiment in which reassociation should be negligible:

t/min	0.9	5.4	10.3	30.4	60.1	70.2
% dissociated	5	12	27	65	86	93

Obtain the rate constant for this reaction, k_d. [10 marks]

Note: You *must* show your graph.

3. What is the half-life of the TBP dimer? [2 marks]

4. The equilibrium constant for the dissociation of TBP dimers,

$$(\mathrm{TBP})_2 \underset{k_a}{\overset{k_d}{\rightleftharpoons}} 2\,\mathrm{TBP},$$

conventionally denoted K_D, is approximately $4\,\mathrm{nmol\,L^{-1}}$. What is the value of k_a? [6 marks]

[1] A. J. Jackson-Fisher *et al.*, *Biochemistry* **38**, 11340 (1999). Only a subset of their data is given in order to save you a bit of work.

5. TBP is not a very stable protein. Under typical experimental conditions, it tends to lose its ability to bind DNA fairly quickly. One hypothesis about the role of TBP dimerization is that it prevents TBP from breaking down too fast. This leads us to study the model

$$(\mathrm{TBP})_2 \underset{k_a}{\overset{k_d}{\rightleftharpoons}} 2\,\mathrm{TBP},$$
$$\mathrm{TBP} \xrightarrow{k_x} \mathrm{P},$$

where P represents a degradation product (i.e. an inactive TBP). The dimer/monomer equilibrium lies strongly to the left. Under these conditions, the equilibrium approximation is valid. Obtain a rate law for this mechanism, treating monomeric TBP as the intermediate. [10 marks]

Bonus: What feature(s) of the rate law you derived imply a protective role of dimerization? Explain.