Chemistry/Biochemistry 565 / 665
BIOPHYSICAL CHEMISTRY

- Spring 2004 -

LECTURE: 9:55 – 10:45 a.m. MTRF, B351 Chemistry

LECTURER: Prof. Silvia Cavagnero
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OFFICE HOURS: M, R 11:00 - 11:50 a.m. and by appointment

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TA OFFICE HOURS: M 2:00 – 3:00 p.m., R 3:30 – 4:30 pm and by appointment

TA MAILBOX: Room 1100P in the Chemistry Building (New Addition).
Please deposit homeworks and assignments in the TA mailbox

COURSE WEB SITE: http://genchem.chem.wisc.edu/physical/cavagnero/s04/pcourse.asp
You can either type the above or get to the course web site by following this path: www.chem.wisc.edu → Education → Course Pages → Current Courses

BIOPHYSICAL CHEMISTRY WEB SITE: http://www.library.wisc.edu/libraries/chemistry/biophysics/biophysicshome.htm

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INTRODUCTION

Chemistry/Biochemistry 565/665 is an introductory class on equilibrium thermodynamics and chemical kinetics with emphasis to biological applications. Issues of particular interest are the concept of entropy, enthalpy and free energy, the kinetics of complex reactions, the non covalent forces that determine protein and nucleic acid stability (particularly the hydrophobic effect, electrostatic interactions and the hydrogen bond) and the folding and misfolding kinetics of proteins and nucleic acids.

TEXTBOOK AND OTHER REQUIRED MATERIAL

1. Dill & Bromberg, *Molecular Driving Forces*, Garland Science, 2003.
2. An inexpensive calculator. It should have capabilities for square roots, logarithms and exponential operations. The calculator will be used on exams and homework assignments. A programmable calculator will not be allowed during exams.

ADDITIONAL USEFUL READING

Handouts distributed in class;
Tinoco, Sauer, Wang and Puglisi, *Physical Chemistry: Principles and Applications in Biological Sciences*, Pearson Education, 2001;
Van Holde, Johnson and Ho, *Principles of Physical Biochemistry*, Prentice Hall, 1998;
Hammes, *Themodynamics and Kinetics for the Biological Sciences*, Wiley& Sons, 2000;
Connors, *Chemical Kinetics, The study of Reaction Rates in Solution*, VCH, 1990;
Fersht, *Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding*, Freeman, 1999;
Daune, *Molecular Biophysics: Structures in Motion*, Oxford Un. Press, 1999;
Eisenberg and Crothers, *Physical Chemistry with Applications to the Life Sciences*, Addison-Wesley, 1979;
Cantor and Schimmel, *Biophysical Chemistry, Parts 1, 2 and 3*, Freeman, 1980;
Klotz and Rosenberg, *Chemical Thermodynamics*, Wiley & Sons, 1994;
Jencks, *Catalysis in Chemistry and Enzymology*, Wiley & Sons, 1975;
Klotz, *Ligand-Receptor Energetics***,** Wiley & Sons, 1997;
Weber, *Protein Interactions*, Chapman & Hall, 1992;
Espenson, *Chemical Kinetics and Reaction Mechanisms*, Mc Graw Hill, 1995;
Creighton, *Proteins: Structures and Molecular Properties*, Freeman & Co., 1992;
Crothers, Bloomfield, Tinoco, *Nucleic Acids, Structures, Properties and Functions*, University Science Books, 2000;
Nelson and Cox, *Lehninger Principles of Biochemistry*, Worth, 2000;
Stryer, *Biochemistry*, Freeman, 1995.

COURSE INFORMATION

Lectures. During lectures we will discuss principles, and illustrate them with examples. You should take your own notes during lecture. In addition, a set of lecture notes taken by a Teaching Assistant (TA) will be available on the web (see course website above).

Lecture Schedule. The Biophysical Chemistry (Chem/Biochem 565/665) lectures are on Mondays, Tuesdays, Thursdays and Fridays at 9:55 am. Please check the course outline (which follows) for a detailed schedule of the lectures.

Textbook. The textbook supplements the lectures. It provides background material for the lectures and also works out many relevant examples. In addition, at the end of each chapter are a number of problems. For an understanding of the material in this course it is important to solve as many of these problems as possible. Plan to buy your own textbook. A reference copy of the

textbook is available for consultation in the Chemistry library. This library also contains a copy of the Additional Useful Reading material listed above.

Problems. For each chapter a set of especially relevant problems is assigned. The formation of study groups for working on problems is strongly encouraged. Difficulties with any problems should be discussed with your TA in the discussion sections. Your solutions to the problems are due in the TA mailbox on selected Mondays by 5 p.m. (see detailed schedule below). The problems will be graded by your TA. Answer Keys to the problems will be distributed during Discussion Sections on Wednesdays.

Discussion Section. Discussion sections are primarily for review and problem solving relevant to the recent lecture material. Your TA will go over some examples similar to the assigned problems. You should be prepared when you come to discussion section. Ask specific questions to your TA and plan to be interactive.

Exams. There will be two two-hour exams, one class presentation on a special topic in biophysical chemistry related to the course, and a two-hour final exam. Check the course outline (which follows) for the examination dates and times. The exams will primarily be based on the material presented in the lectures, and on material illustrated by the assigned problems. No make-up exams will be given. The final exam will be comprehensive, covering topics from the entire semester.

Oral Presentation. All students will independently work on a well defined special topic in biophysical chemistry of their choice. Recommended special topics for this year's class are:

(a) Electrostatic forces and ion pairs: their role in protein stability and folding;
(b) Hydrogen bonds and protein stability and folding;
(c) What are the "dominant" forces in protein stability and folding?;
(d) The kinetics of biopolymer hydrophobic collapse;
(e) Energy landscape theory and protein folding: detailed aspects and relations with experiments;
(f) Mechanisms and kinetics of amyloid fibril formation;
(g) The helix-coil transition theory;
(h) A topic of special interest to you related to your current research or research interests.

It is very important that your presentation contains clear connections to the material studied in class during the semester. Plan to talk to Prof. Cavagnero well in advance to discuss your choice of special topic. The special topic will be presented to the class during the last two weeks of class according to the class schedule below. Either transparencies or a powerpoint presentation are recommended. A hard copy of your presentation panels is due to the teacher a few days ahead of the presentation. Oral presentations will be peer-reviewed by your class mates, the TA and the teacher. Students taking the course as Chem 665 or Biochem 665 are also expected to write a report on their special topic of choice.

Biophysical Chemistry Website. This web site contains a lot of valuable educational information on various areas of biophysical chemistry. Use it as a personal resource for learning

more about this exciting field. This site also contains a collection of valuable database information for researchers involved in the biophysics field. A selected number of assigned homework problems will involve using this web site.

Grades. This course will be graded on a maximum of 100 points divided as follows:

Exam I	20 points
Exam II	20 points
Special Topic Presentation	10 points
Homework Questions	20 points
Final Exam	30 points
Total	100 points

Your course grade will be determined by the total number of points you have accumulated.

Extra Credit Points. Up to 3 extra credit points (in addition to the total 100 points) will be assigned to students who provide, on a voluntary basis, a written outline containing detailed comments on the textbook typos and unclear statements. This outline is due on the last day of class. Comments on the textbook weaknesses and strengths are also appreciated.

COURSE OUTLINE

DATE	TOPIC	CHAPTER	NOTES ON PROBLEM SETS
T Jan 20	Principles of Probability	1	
R Jan 22	Principles of Probability	1	
F Jan 23	Principles of Probability and Biophys. Chem. Website Presentation by Emily Wixson	1	Problem Set #1 Assigned
M Jan 26	Principles of Probability	1	
T Jan 27	Predicting Equilibrium in Chemistry and Biology	2	
R Jan 29	Predicting Equilibrium in Chemistry and Biology	2	
F Jan 30	Heat, Work & Energy	3	
M Feb 2	Heat, Work & Energy	3	Problem Set #1 Due

T Feb 3	Math Tools	4	
R Feb 5	Math Tools	4	
F Feb 6	*Class Workshop on Problem Solving* 		Problem Set #2 Assigned
M Feb 9	Multivariate Calculus	5	
T Feb 10	Multivariate Calculus	5	
R Feb 12	Entropy & the Boltzmann Distribution Law	6	
F Feb 13	Entropy & the Boltzmann Distribution Law	6	
M Feb 16	Entropy & the Boltzmann Distribution Law	6	Problem Set #2 Due
T Feb 17	Thermodynamic Driving Forces	7	
R Feb 19	Thermodynamic Driving Forces	7	
F Feb 20	Thermodynamic Driving Forces	7	Problem Set #3 Assigned
M Feb 23	Thermodynamic Driving Forces	7	
T Feb 24	Free Energies	8	
R Feb 26	Free Energies	8	
F Feb 27	Free Energies	8	Problem Set #4 Assigned
M Mar 1	Maxwell's Relations and Mixtures	9	Problem Set #3 Due
T Mar 2	Maxwell's Relations and Mixtures	9	
R Mar 4	The Boltzmann Distribution Law	10	
F Mar 5	The Boltzmann Distribution Law	10	
M Mar 8	The Boltzmann Distribution Law	10	Problem Set #4 Due
T Mar 9	*Class Workshop on Problem Solving* 		

R Mar 11	Review Lecture	--	
F Mar 12	**Exam I** (5:30 – 7:30 pm, room TBA)	--	
M Mar 15	Spring Recess - No Lecture	--	
T Mar 16	Spring Recess - No Lecture	--	
R Mar 18	Spring Recess - No Lecture	--	
F Mar 19	Spring Recess - No Lecture	--	
M Mar 22	Temperature and Heat Capacity	12	
T Mar 23	Temperature and Heat Capacity	12	
R Mar 25	Temperature and Heat Capacity	12	
F Mar 26	Chemical Equilibria	13	Problem Set #5 Assigned
M Mar 29	Chemical Equilibria (TA Lecture)	13	
T Mar 30	Heat Capacity and the Origins of Protein Stability		--
R Apr 1	Heat Capacity and the Origins of Protein Stability		--
F Apr 2	Equilibria between Liquids, Solids & Gases	14	
M Apr 5	Equilibria between Liquids, Solids & Gases	14	Problem Set #5 Due
T Apr 6	Solutions and Mixtures	15	
R Apr 8	Solutions and Mixtures	15	
F Apr 9	Solvation and Phase Transfer	16	Problem Set #6 Assigned
M Apr 12	Introduction to Physical Kinetics (selected topics only)	18	
T Apr 13	Chemical Kinetics & Transition States	19	

R Apr 15	Chemical Kinetics & Transition States	19	
F Apr 16	Energy Landscape Theory: Simple Reactions and Protein Folding (special out-of-the-textbook reading: article to be distributed in class)	19	Problem Set #7 Assigned
M Apr 19	Water and its Unusual Properties	29	Problem Set #6 Due
T Apr 20	The Hydrophobic Effect	30	
R Apr 22	Selected Topics on the Hydrophobic Effect (special out-of-the-textbook reading: articles to be distributed in class)	30	
F Apr 23	*Class Workshop on Problem Solving* 		Problem Set #7 Due
M Apr 26	Review Lecture	--	
T Apr 27	**Exam II** (5:30 – 7:30 pm, room TBA)	--	
R Apr 29	Student Oral Presentations	--	
F Apr 30	Student Oral Presentations	--	
M May 3	Student Oral Presentations	--	
T May 4	Student Oral Presentations	--	
R May 6	Student Oral Presentations	--	
F May 7	Student Oral Presentations	--	
F May 14	**FINAL EXAM** (2:45 – 4:45 pm, room TBA)		