Chem 24a (3-0-6)
Winter Term 2007/08

Introduction to Biophysical Chemistry

The central focus of Ch 24a emphasizes solution thermodynamics, including the concepts of energy, enthalpy, entropy, free energy, with connections to statistical thermodynamics; physical and chemical equilibrium of both ideal and real systems, including gases, solutions, and electrolytes; and electrochemistry. These concepts and mathematical manipulations used will be illustrated with biochemical and biophysical applications. This material is covered in Chapters 1–5, 7–10, and 14 of the textbook by ***David Eisenberg and Donald Crothers.***

GENERAL INFORMATION

Instructors
Sunney I. Chan, SunneyChan@yahoo.com. 234A Noyes, ext. 6508
Douglas C. Rees, dcrees@caltech.edu, 363 Broad, ext. 8393

Teaching Assistants
UTA: Ziqing Winston Zhao, ziqing@caltech.edu, office, ext., office hours TBA.
GTA: Xin Zhang, xinzhang@caltech.edu, 180 Braun, ext. 4071, office hours TBA.

Class Hours
Ch 24a meets Mondays, Wednesdays, and Fridays at 10:00 a.m. in 132 Noyes. There will be recitation sessions approximately every two or three weeks, according to the attached syllabus. The recitation sessions will focus on the elaboration of complex concepts and subtle points made during the lectures, as well as solving the types of problems that will appear on homework sets and exams. You are strongly encouraged to attend all the lectures and recitations.

Texts
Required: David Eisenberg and Donald Crothers, "Physical Chemistry with Applications to the Life Sciences", The Benjamin Cummings Publishing Company, Inc., 1979.

Suggested: Kensal E. van Holde, W. Curtis Johnson, and Pui Shing Ho, "Principles of Physical Biochemistry" (Second Edition 2006), Pearson Prentice Hall, Upper Saddle River, New Jersey 07458 (ISBN 0-13-046427-9).

Other: A selection of useful texts will be placed on reserve in Millikan Library (list attached below).

Grading
THERE WILL BE A MIDTERM AND A FINAL EXAMINATION. Your grade is based on: HOMEWORK (40%), MIDTERM (30%), and the FINAL EXAMINATION (30%). A problem set will be due

approximately every two or three weeks. If you fail to obtain a copy of a homework set (or the midterm examination or the final) when it is handed out in class, you may obtain one from Ms. Priscilla Boon in 234 Noyes, or from the course web site.

Assignments may be handed in either in class or before class to Ms. Priscilla Boon. If the office is closed, the homework may be slipped under the door. Graded homework will be returned in class; otherwise, it may be picked up from the teaching assistants. Please staple all work.

Ch 24a Web Site
Handouts, problem sets, answer keys, lecture notes and other useful material for this course may be found at:

http://chemistry.caltech.edu/courses/ch24/24a.html

Problem Sets
Homework will usually be handed out during class/recitation on a Friday (see schedule) and due 10 days later on Monday by 1:00 p.m. Answer keys will be posted on the Ch 24 web page. Late assignments will be accepted, with the following penalties for a 100-point assignment:

30% if turned in by Tuesday 1:00 p.m. following the Monday due date;
50% if turned in by Wednesday 1:00 p.m. following the Monday due date;
70% if turned in by Thursday 1:00 p.m. following the Monday due date;
90% if turned in by Friday 1:00 p.m. following the Monday due date;
100% if turned in by Monday 1:00 p.m. the following week.

All homework must be turned in. Failure to do so will result in a grade of "fail" or "incomplete" for the course.

Excuses for Late Homework
Excuses for late homework must be arranged in advance and in writing, signed by Dr. Chan or Dr. Rees. Staple the excuse to your homework. Unexcused late assignments will be penalized as described above.

Ch 24 and the Honor System
Students are encouraged to cooperate on the homework; however, outright copying of solutions to the homework problems from another student, textbook, material from any previous years of Ch 24a/b, etc. is NOT permissible. Each individual is expected to personally complete the homework he/she hands in, and he/she should be able to explain the homework handed in.

The examinations must be taken individually and without discussion among students.

Ombudsman Meeting
A student representative will be chosen to serve as a liaison between the class and the CCE Executive Officer (Dr. M. Okumura) and the CCE Division Curriculum and Undergraduate Studies Committee. If you have any complaints or suggestions about the course, please direct them to your ombudsman. However, given the timing of the ombudsman meetings, it is unlikely that this feedback will be received by the instructor in a timely fashion to help the course. Therefore, please feel free to see Dr. Chan or Dr. Rees at any time to discuss any issues related to this course.

BOOKS PLACED ON RESERVE IN MILLIKAN LIBRARY

Books Placed on Reserve in Millikan Library

1st Floor Reserve

Charles Cantor, Paul Schimmel. *Biophysical Chemistry Part 1: The conformation of biological macromolecules* (1980). QH345 .C36 pt.1

Charles Cantor, Paul Schimmel. *Biophysical Chemistry Part 2: Techniques for the study of biological structure and function* (1980). QH345 .C36 pt.2

Charles Cantor, Paul Schimmel. *Biophysical Chemistry Part 3: The behavior of biological macromolecules* (1980). QH345 .C36 pt.3

Gordon Barrow. *Physical Chemistry, 6th Edition* (1996). QD453.2 .B37 1996

8th Floor Reserve

Ch 7 Shelf:

Alan Fersht. *Enzyme Structure and Mechanism* (1985). QP601 .F42 1985

***Ch 21 Shelf*:**

Norman Davidson. *Statistical Mechanics* (1962). QC175 .D3

***Ch 24 Shelf*:**

Peter Atkins, Julio de Paula. *Physical Chemistry for the Life Sciences* (2006).

Charles Cantor, Paul Schimmel. *Biophysical Chemistry Part 1* (1980). QH345 .C36 pt.1

Charles Cantor, Paul Schimmel. *Biophysical Chemistry Part 2* (1980). QH345 .C36 pt.2

Charles Cantor, Paul Schimmel. *Biophysical Chemistry Part 3* (1980). QH345 .C36 pt.3

David Eisenberg and Donald Crothers. *Physical Chemistry with Applications to the Life Scienc*es (1979).

Norman Davidson. *Statistical Mechanics* (1962). QC175 .D3

Ken Dill. *Molecular Driving Forces* (2003). QC311.5 .D55 2003

John Edsall. *Biothermodynamics* (1983).

Dilip Kondepudi, Ilya Prigogine. *Modern Thermodynamics: From Heat Engines to Dissipative Structures.* (1998). QC311.K66 1998

Philip Charles Nelson: with the assistance of Marko Radosavljevic and Sarina Bromberg. *Biological Physics: Energy, Information, Life.* (2004). QH505 .N37 2004

Ignacio Tinoco, et al. *Physical Chemistry: Principles and Applications in Biological Sciences.* (2002). QH345.T56 2002

8th Floor (non-reserve)

Robert Alberty. *Physical Chemistry, 7th Edition* (1987). QD453.2 .D36 1987

Robert Alberty, Robert Silbey. *Physical Chemistry, 2nd Edition* (1997). QD453.2.D36 1997

Robert Alberty, Robert Silbey. *Physical Chemistry, 1st Edition* (1992). QD453.2 .D36 1992

Gordon Barrow. *Physical Chemistry, 5th Edition* (1988). QD453.2 .B37 1988

Gordon Barrow. *Physical Chemistry, 4th Edition* (1979). QD453.2 .B37 1979

Gordon Barrow. *Physical Chemistry, 2nd Edition* (1966). QD453.2 .B37 1966

Richard Dickerson. *Molecular Thermodynamics* (1969). QD501 .D47

9th Floor (non-reserve)

Alan Fersht. *Enzyme Structure and Mechanism* (1985). QP601 .F42 1985

Alan Fersht. *Enzyme Structure and Mechanism* (1977). QP601 .F42

James Espenson. Chemical Kinetics and Reaction Mechanisms, 2nd Edition (1995). QD502.E86 1995

Kensal van Holde, W. Curtis Johnson, P. Shing Ho. *Principles of Physical Biochemistry, 2nd Edition* (2006). QP517.P49 V36 2006 (1ST/8TH FLOOR MILLIKAN)

CLASS SCHEDULE

HO = Homework handed out, **HD =** Homework due, **MT** = Midterm

M	**Jan 7**	**Organization. Biological macromolecules and the forces that stabilize them.**	**W**	**Feb 13**	**Phase equilibrium and miscellaneous applications. Gibbs phase rule. Osmotic pressure. Chemical equilibrium.**
W	**Jan 9**	**Molecular energy levels and concept of energy. Chemical thermodynamics. First law of thermodynamics. Concepts of work and heat.**	**F**	**Feb 15**	**Gibbs free energy and ΔG for multicomponent systems. Chemical equilibria for ideal liquid and solid solutions. Chemical potential of a solute in solution. (HO-3).**
F	**Jan 11**	**Applications of the First law. Concept of enthalpy. Enthalpy changes for various processes. (HO-1).**	**M**	**Feb 18**	**Presidents Day (no class).**
M	**Jan 14**	**Concept of entropy. Concept of reversible heat. Second law of thermodynamics.**	**W**	**Feb 20**	**Gibbs-Duhem equation. Molal osmotic coeffients. Activity coefficients. Solute-solute interactions. Intermolecular forces.**
W	**Jan 16**	**Entropy and randomness and disorder. Entropy of mixing. Third law of thermodynamics.**	**F**	**Feb 22**	**Recitation 3.**
F	**Jan 18**	**Recitation 1.**	**M**	**Feb 25**	**Macromolecules in solution. (HD-3). (Drop Day).**
M	**Jan 21**	**Martin Luther King Day (no class).**	**W**	**Feb 27**	**Hydrophobic interactions. Melting of nucleic acids. Protein folding and unfolding.**
W	**Jan 23**	**Statistical thermodynamics of independent particles. System wavefunctions and degeneracy. (HD-1).**	**F**	**Feb 29**	**Ionic solutions. Debye-Huckel theory. (HO-4).**
F	**Jan 25**	**Microcanonical and canonical ensembles. Most probable distributions. (HO-2). (Add day).**	**M**	**Mar 3**	**Electrochemical equilibrium. Membrane potentials. Membrane biophysics. Dynamic structure of lipid bilayer membrane.**
M	**Jan 28**	**Statistical interpretation of entropy.**	**W**	**Mar 5**	**Ion channels and transporters. Ion pumps. Bioenergetics.**
W	**Jan 30**	**Partition functions.**	**F**	**Mar 7**	**Recitation 4.**
F	**Feb 1**	**Translation partition function for an ideal gas.**	**M**	**Mar 10**	**Chemical equilibria involving macromolecules. (HD-4).**
M	**Feb 4**	**Recitation 2.**	**W**	**Mar 12**	**Chemical equilibria involving macromolecules. Last day of classes. (Final out)**
W	**Feb 6**	**Molecular partition functions. (HD-2). (MT out).**	**Th-Sa**	**Mar 13-15**	**Study period**
F	**Feb 8**	**Criteria for equilibrium of a process. Helmholtz and Gibbs Free Energy.**	**Tu**	**Mar 18**	**(Final due)**
M	**Feb 11**	**Standard states. Concept of chemical potential. (MT due).**	**W**	**Mar 19**	**End of Winter Term**

(23 lectures, 4 recitations, 4 homeworks, 1 midterm, 1 final)

Reading Assignments

David Eisenberg and Donald Crothers, "Physical Chemistry with Applications to the Life Sciences", The Benjamin Cummings Publishing Company, Inc., 1979.

Introduction

Part One **Macroscopic Systems**

Chapter 1. Description of Macroscopic Systems

Chapter 2. Energy and the First Law of Thermodynamics

Chapter 3. Entropy and the Second Law of Thermodynamics

Chapter 4. Free Energy and Equilibrium

Chapter 5. Biological Applications of Thermodynamics

Part Three **Microscopic Systems**

Chapter 10. Principles of Quantum Mechanics

Part Four **Bridging the Macroscopic and Microscopic**

Chapter 14. Statistical Mechanics

Part Two **Solutions and Electrochemistry**

Chapter 7. Solutions

Chapter 8. Electrolyte Solutions

Chapter 9. Electrochemical Equilibria

EXCUSE FOR LATE ASSIGNMENTS IN CHEM 24 ab

Date: _____

Excuse:

Signature of Student: _____

Signature of Instructor: _____
(S.I. Chan or D.C. Rees)

✂----------

EXCUSE FOR LATE ASSIGNMENTS IN CHEM 24 ab

Date: _____

Excuse:

Signature of Student: _____

Signature of Instructor: _____
(S.I. Chan or D.C. Rees)

✂----------

EXCUSE FOR LATE ASSIGNMENTS IN CHEM 24 ab

Date: _____

Excuse:

Signature of Student: _____

Signature of Instructor: _____
(S.I. Chan or D.C. Rees)