

**Ch 24a (3-0-6)**  
**Winter Term 2009/10**

## **Introduction to Biophysical Chemistry**

Ch 24a discusses the interaction of light with matter (absorption, emission, scattering), methods of identification of macromolecules (absorption spectroscopy, mass spectrometry), methods of structural determination of macromolecules (x-ray diffraction, neutron diffraction, scattering from solutions of macromolecules, multi-dimensional NMR, EPR, linear and circular dichroism, optical rotatory dispersion, fluorescence resonance energy transfer, and single-molecule methods), reaction rates and mechanisms, and the methods of rapid and ultrafast kinetics. The concepts and mathematical manipulations will be illustrated with biochemical and biophysical applications. This material is covered in Chapters 9-15 and Chapter 7 of the textbook by James P. Allen, and Chapters 10-13 and 16-17 of the textbook by Eisenberg and Crothers.

### **GENERAL INFORMATION**

#### **Instructors**

Sunney I. Chan, [SunneyChan@yahoo.com](mailto:SunneyChan@yahoo.com), 234A Noyes, ext. 6508  
Douglas C. Rees, [dcrees@caltech.edu](mailto:dcrees@caltech.edu), 363 Broad, ext. 8393

#### **Graduate Teaching Assistants**

Jeen Joo Kang, [jiskang@caltech.edu](mailto:jiskang@caltech.edu), 312 Church, ext. 6032  
Kay Limapichat, [walrati@caltech.edu](mailto:walrati@caltech.edu), 254 Crellin, ext. 6009  
Christina Ting, [clting@caltech.edu](mailto:clting@caltech.edu), 018/014 Spalding, ext. 8404

#### **Undergraduate Teaching Assistants**

ZeNan Chang, [zlchang@caltech.edu](mailto:zlchang@caltech.edu).  
Changyi Li, [changyi@caltech.edu](mailto:changyi@caltech.edu).

*ZeNan and Changyi will hold office hours every Sunday from 9:30 -11:30 p.m. in the Ruddock House Library.*

#### **Class Hours**

Ch 24a meets Mondays, Wednesdays, and Fridays at 1:00 p.m. in Broad 100. There will be recitation sessions approximately every 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 homeworks and exams. You are strongly encouraged, if not expected, to attend ALL the lectures and recitations.

## Texts

**Required:** James P. Allen, "Biophysical Chemistry", Wiley-Blackwell, Oxford, England (2008).

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

**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 final (30%). To encourage class and recitation participation (attendance, questions, comments, etc.), a bonus of up to 10% will be added to your final grade based on your participation, prorated according to your actual attendance. A problem set will be due approximately every three weeks. If you fail to obtain a copy of a homework set when it is handed out in class, you may download it from the course website. The midterm and final exams will not be found on the course website. See Ms. Priscilla Boon in 234 Noyes if you did not pick up the midterm or final exam in class.

Completed assignments and midterm exams should be handed in during class hours, unless alternative arrangements are made with Jeon Joo Kang, the Head Teaching Assistant. Graded homework and exam papers will also be returned in class. Outside of class hours, you may pick up graded assignments from Mr. Kang. 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/a.html>

## Problem Sets

Homework will be handed out during class/recitation on a Friday (see schedule) and due 10 days later on Monday by 1:00 p.m. Solutions will be released at 5:00 p.m. Friday of the same week. 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 after Friday 1:00 p.m. following the Monday due date.

All homework must be turned in. Failure to do so will result in a grade of "F" or "I".

### **Excuses for Late Homework**

Excuses for late homework must be arranged *in advance* and *in writing*, signed by Dr. Chan or Dr. Rees. Extensions will only be granted for medical reasons or personal/family emergencies; situations (such as clashes in assignment due dates or travel for interviews) that can be *foreseen* days or weeks beforehand will NOT be considered. The maximum period of extension allowed is 4 days (as solutions will be released on Fridays). A maximum of 2 extensions will be allowed for the three homework assignments during the term. Staple the excuse to your homework. NO extensions will be allowed for the midterm or the final. There will be no exceptions.

### **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. The teaching assistants also provide excellent sounding boards for feedbacks, as they communicate with the instructors on a regular basis.

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

#### *8th Floor Reserve*

Alan Fersht. *Enzyme Structure and Mechanism* (1985). QP601 .F42 1985  
Norman Davidson. *Statistical Mechanics* (1962). QC175 .D3  
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 Life Sciences* (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

**CLASS SCHEDULE (23 lectures, 3 recitations, 3 homeworks, 1 midterm, 1 final)**

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

M	Jan 4	Organization. Introduction to spectroscopy.	W	Feb 10	Electron paramagnetic resonance. Spin labeling. <b>(MT due)</b> .
W	Jan 6	Interaction of light with matter: Classical description of absorption and dispersion.	F	Feb 12	Nuclear magnetic resonance. Nuclear spin relaxation.
F	Jan 8	Quantum mechanics. Simple applications.	M	Feb 15	President's Day. <b>(Holiday)</b> .
M	Jan 11	Interaction of light with matter: Quantum description.	W	Feb 17	Multi-dimensional NMR. Protein structural determination in solution.
W	Jan 13	Chemical Bonding.	F	Feb 19	X-ray spectroscopy. <b>(HO-3)</b> .
F	Jan 15	Selection rules. Electronic spectroscopy of biological chromophores. <b>(HO-1)</b> .	M	Feb 22	Light scattering. X-ray, electron, and neutron scattering.
M	Jan 18	Martin Luther King Day. <b>(Holiday)</b> .	W	Feb 24	X-ray diffraction. <b>(Drop Day)</b> .
W	Jan 20	Infrared and Raman spectroscopy. Total attenuated FTIR	F	Feb 26	<b>Recitation 3.</b>
F	Jan 22	<b>Recitation 1. (Add Day)</b> .	M	Mar 1	Mass spectrometry of macromolecules. Proteomics. <b>(HD-3)</b> .
M	Jan 25	Spontaneous emission. Fluorescence spectroscopy. <b>(HD-1)</b> .	W	Mar 3	Rates and mechanisms of chemical reactions. Transition state theory. Temperature dependence of reaction rates.
W	Jan 27	Fluorescence resonance energy transfer (FRET). Fluorescence depolarization.	F	Mar 5	Enzyme kinetics.
F	Jan 29	Single-molecule methods. <b>(HO-2)</b> .	M	Mar 8	Methods of rapid and ultrafast kinetics.
M	Feb 1	Spectroscopy of interacting chromophores. Exciton interaction. Hypo- and hyper-chroism.	W	Mar 10	Methods of rapid and ultrafast kinetics. <b>(Final out)</b> .
W	Feb 3	Polarized light. Circular dichroism and optical rotatory dispersion.		Mar 11-14	Study period.
F	Feb 5	<b>Recitation 2.</b>	T	Mar 16	<b>(Final due 1 p.m.)</b>
M	Feb 8	<b>(HD-2). (MT out)</b> .	W	Mar 17	<b>End of term.</b>

## Reading Assignments

James P. Allen, "Biophysical Chemistry", Wiley-Blackwell, Oxford, England (2008).

### Part 2: Quantum mechanics and spectroscopy

Chapter 9. Quantum theory: introduction and principles

Chapter 10. Particle in a box and tunneling

Chapter 12. Atomic structure: hydrogen atom and multi-electron atoms

Chapter 13. Chemical bonds and protein interactions

Chapter 14. Electronic transitions and optical spectroscopy

Chapter 11. Vibrational motion and infrared spectroscopy

Chapter 16. Magnetic resonance

Chapter 15. X-ray diffraction and extended x-ray absorption fine structure

### Part 1: Thermodynamics and kinetics

Chapter 7. Kinetics and enzymes

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

### Part Three Microscopic Systems

Chapter 10. Principles of Quantum Mechanics

Chapter 11. Chemical Bonds

Chapter 12. Principles of Spectroscopy

Chapter 13. Biochemical Spectroscopy

### Part Five Symmetry and Molecular Structure

Chapter 16. Symmetry

Chapter 17. X-ray Diffraction and the Determination of Molecular Structure

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**EXCUSE FOR LATE ASSIGNMENTS IN CHEM 24 ab**

**Date:** \_\_\_\_\_

**Excuse:**

**Signature of Student:** \_\_\_\_\_

**Signature of Instructor:** \_\_\_\_\_  
(S.I. Chan or D.C. Rees)

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**EXCUSE FOR LATE ASSIGNMENTS IN CHEM 24 ab**

**Date:** \_\_\_\_\_

**Excuse:**

**Signature of Student:** \_\_\_\_\_

**Signature of Instructor:** \_\_\_\_\_  
(S.I. Chan or D.C. Rees)

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**EXCUSE FOR LATE ASSIGNMENTS IN CHEM 24 ab**

**Date:** \_\_\_\_\_

**Excuse:**

**Signature of Student:** \_\_\_\_\_

**Signature of Instructor:** \_\_\_\_\_  
(S.I. Chan or D.C. Rees)