Physical Biochemistry
BCHM 420 and BCHM 420L
Fall 2022
Lecture: Tue, Thu 14:30 – 15:45 in Smith Hall 103
Lab: Monday 13:00 – 16:50 in Keck 281 and Tuesday 18:00 – 21:50 in Keck 382

Instructors:
Dr. Cedric Owens (lecture and Monday afternoon lab)
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Dr. Herbert Axelrod (Tuesday evening lab)
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Office hours:
Dr. Owens: Mon: 11:00 – 12:00, Wed: 11:00 am-12:00 and by appointment
Dr. Axelrod:

Required textbook:
Ignacio Tinoco *et. al.* Physical Chemistry: Principles and Applications in Biological Sciences, 5th edition, 2014, Pearson

You can use last year's textbook as an alternative:
Peter Atkins and Julio De Paula, *Physical Chemistry for the Life Sciences*, 2nd edition, 2011, Oxford University Press.

General description of the course:
This course discusses physical chemistry and how it applies to the study of biochemical problems. Students will learn important principles of physical chemistry, including thermodynamics, kinetics and quantum mechanics. In addition, students will become familiar with methods in biophysical chemistry that are used to study macromolecules such as proteins and DNA. The laboratory will complement the lecture, as students use material they learned in lecture to interpret experimental data and gain experience with common biophysical techniques.

Instructional format:
Most classes are conducted in a lecture format with in class exercises in critical thinking. Reading assignments will be posted for every chapter covered. In the lab, students will design experiments to test hypotheses, evaluate and interpret data, and write lab reports in the style of a journal article. Currently, classes are expected to be held in person.
If necessary due to COVID requirements, instruction may be held remotely via Zoom.
Attendance in lectures and labs is mandatory, regardless of whether they are held in person or online.

Make-up policy:
Students are expected to attend all classes and laboratories. Exams and assignments can be made-up only with prior consent of the instructor. All make-ups must be completed before the tests are handed back to the class. Lab reports handed in late will be marked down 25% per day they are turned in late.

Major fields of study:

1. *Quantum mechanics:* Overview of quantum theory, atomic structure, atomic and molecular orbitals, intermolecular forces, properties of light and interaction between light and molecules
2. *Biophysical methods:* X-ray crystallography, optical and vibrational spectroscopy
3. *Principles of thermodynamics:* Three laws of thermodynamics, equilibria, free energy, and bioenergetics
4. *Kinetics:* Chemical kinetics, derivation of rate laws, and enzyme kinetics.

Learning objectives:

1. Learn principles of physical chemistry, including key concepts in quantum mechanics, spectroscopy, thermodynamics and kinetics.
2. Realize how these principles relate to the properties and structures of enzymes, DNA and other biomolecules.
3. Gain experience with physical biochemistry methods that are used to study biomolecules, and understand the methods' theoretical backgrounds.
4. Learn about the relevance of these methods in academic and industrial research.
5. Gain experience collecting and interpreting experimental data, use error analysis, and understand accuracy and precision.
6. Improve problem solving and independent thinking ability
7. Become familiar with accessing, reviewing and evaluating scientific information.
8. Improve collaborative skills by working in groups.
9. Improve the ability to communicate work though written and oral communication.

Program Learning Outcomes:

In addition to the above learning outcomes, BCHM 420 and 420L support the program learning outcomes for the B.Sc. in Biochemistry and Molecular Biology:

1. Students will be able to apply the scientific method to solve problems
2. Students will communicate effectively to the science community.
3. Students will be able to apply critical thinking and analytical skills to design and execute a scientific experiment, thoroughly analyze the results, and arrive at well-reasoned scientific conclusions.
4. Students will be able to demonstrate an understanding of core knowledge in biochemistry

Tentative course schedule:

Week and date	**Day**	**Topics and due dates**	**Atkins chapters**	**Tinoco chapters and page numbers**
Week 1 8/28-9/03	Tue	Course overview, intro into quantum theory	N/A	11 408-415
	Thu	Heisenberg uncertainty, Schrödinger equation, particle in a box	9.1-9.3	11 415-423
Week 2 9/04-9/10	Tue	Particle in a box, tunneling	9.4-9.6	11 423-434
	Thu	Vibrational spectroscopy Atomic structure, atomic orbitals and properties **Perspective 1 announced**	12.3-12.13, 9.7-9.12	11 435-444

Week 3 9/11-9/17	Tue	Atomic structure, atomic orbitals and properties, the chemical bond, valence bond	10.1-10.6	12 453-466
	Thu	Molecular orbital theory **Perspective 1 due**	10.3-10.9	12 453-466
Week 4 9/18-9/24	Tue	Optical spectroscopy	12	13 492-522
	Thu	Methods in physical biochemistry	11.3-11.17	13 492-522
Week 5 9/25-10/01	Tue	Catch up day		
	Thu	**Midterm 1**		
Week 6 10/02-10/08	Tue	1st law of thermodynamics, Work and heat	1.1-1.5	2 13-30
	Thu	Internal energy, enthalpy	1.6-1.7	2 30-39
Week 7 10/09-10/15	Tue	Enthalpy, bond and reaction enthalpies	1.8-1.13	2 39-44
	Thu	Enthalpy, problems and applications, 2nd and 3rd law, entropy	1.8-13, 2.1-2.4	3 55-71
Week 8 10/16-10/22	Tue	**No class**		
	Thu	**No class**		
Week 9 10/23-10/29	Tue	Gibbs free energy	2.5-2.8	3 72-80
	Thu	Chemical equilibria **Perspective 2 announced**	3.7-3.10	4 119-143
Week 10 10/30-11/05	Tue	Chemical equilibria, Redox reactions	3.7-3.10	4 119-143 7 238-259
	Thu	Chemical equilibria, Redox reactions **Perspective 2 due**	4.1-4.9	4 119-143 7 238-259
Week 11 11/06-11/12	Tue	Reaction rates, rate laws, reaction order, Arrhenius equation	6.1-6.5	9 305-356
	Thu	Enzyme kinetics, Michaelis-Menten	8.1-8.3	10 379-390
Week 12 11/13-11/19	Tue	Enzyme inhibition, enzyme mechanisms, problems	8.2-8.4	10 391-398
	Thu	**Midterm 2**		
Week 13 11/20-11/26	Tue	**Thanksgiving break** **No class**		

	Thu			
Week 14 11/27-12/03	Tue	X-ray crystallography	11.3-11.17	15
	Thu	X-ray crystallography	11.3-11.17	15
Week 15 12/04-12/10	Tue	X-ray crystallography	11.3-11.17	15
	Thu	X-ray crystallography	11.3-11.17	15
Week 16 12/11-12/17	Tue	**Finals week** **Final is on Tuesday, December 13 at 10:45 – 13:15 in Smith 103**		
	Thu			

Assessment policy and grading:

Total points: 1000

Midterm 1:	12.5% (125 pts)
Midterm 2:	12.5% (125 pts)
Final exam:	15% (150 pts)
Perspective 1:	10% (100 pts)
Perspective 2:	10% (100 pts)
Participation:	2.5% (25 pts)
Quizzes	2.5% (25 pts, 4 quizzes, 6.25 each)
Laboratory:	35% (350 pts)
	Crystallography paper: 10% (100 pts)
	Formal lab reports (2 total): 15% (150 pts total, 75 pts per report)
	Short lab reports: 10% (100 points)

There will be 3 exams, 2 midterms and 1 final. Each midterm will cover new material only, whereas the final is cumulative. Each exam will consist of multiple choice, fill in the blank, short answer, and calculations and derivations.

The perspective consists of a commentary on a recent research paper in which you describe the paper's key findings, how it fits in the broader scientific context, and its potential shortcomings. The perspective may be turned into journal club, depending on class feedback.

Participation will be assessed based on in-class participation, in-class behavior and attendance.

Grading scheme:
Accumulation of lecture and lab combined points totaling:
934-1000= A; 900-933= A-; 867-899= B+; 834-866= B; 800-833=B-; 767-799=C+; 734-766=C; 700-733=C-; 667-699- D+; 634-666=D; 600-633=D-; 599 and below= F.

Class management system:
Important announcements and resources will be posted on Blackboard. Please make sure you are enrolled and can view this class at blackboard.chapman.edu.

Academic honesty:
Chapman University is a community of scholars which emphasizes the mutual responsibility of all members to seek knowledge honestly and in good faith. Students are responsible for doing their own work, and academic dishonesty of any kind will subject to sanction by the instructor

and referral to the university Integrity committee which may impose additional sanctions including expulsion. Cheating on exams or plagiarism will result in a zero (no credit) for that assignment or exam. Please see the full description of Chapman University's policy on Academic Integrity at www.chapman.edu/academics/academicintegrity/index.aspx.

Accessibility:
In compliance with ADA guidelines, students who have any condition, either permanent or temporary, that might affect their ability to perform in this class are encouraged to contact the Disability Services Office. If you will need to utilize your approved accommodations in this class, please follow the proper notification procedure for informing your professor(s). This notification process must occur more than a week before any accommodation can be utilized. Please contact Disability Services at (714) 516–4520 or visit www.chapman.edu/students/student-health-services/disability-services if you have questions regarding this procedure or for information or to make an appointment to discuss and/or request potential accommodations based on documentation of your disability. Once formal approval of your need for an accommodation has been granted, you are encouraged to talk with your professor(s) about your accommodation options. The granting of any accommodation will not be retroactive and cannot jeopardize the academic standards or integrity of the course.
Equity and diversity
Chapman University is committed to ensuring equality and valuing diversity. Students and professors are reminded to show respect at all times as outlined in Chapman's Harassment and Discrimination Policy. Please see the full description of this policy at http://www.chapman.edu/faculty-staff/human-resources/eoo.aspx.
Any violations of this policy should be discussed with the professor, the dean of students and/or otherwise reported in accordance with this policy.

Student support:
Over the course of the semester, you may experience a range of challenges that interfere with your learning, such as problems with friend, family, and or significant other relationships; substance use; concerns about personal adequacy; feeling overwhelmed; or feeling sad or anxious without knowing why. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. You can learn more about the resources available through Chapman University's Student Psychological Counseling Services here: https://www.chapman.edu/students/health-and-safety/psychological-counseling/

Fostering a community of care that supports the success of students is essential to the values of Chapman University. Occasionally, you may come across a student whose personal behavior concerns or worries you, either for the student's well-being or yours. In these instances, you are encouraged to contact the Chapman University Student Concern Intervention Team who can respond to these concerns and offer assistance: https://www.chapman.edu/students/health-and-safety/student-concern/index.aspx

While it is preferred that you include your contact information so this team can follow up with you, you can submit a report anonymously. 24-hour emergency help is also available through Public Safety at 714-997-6763.

BCHM 420 Laboratory:

Working in groups of two, students will complete all scheduled experiments. For each lab, you will complete either a long or short lab report. The long report takes the form of a 3-4 page paper. In the short report, you will answer the questions listed in the assignment and/or conduct data analysis of your results. You are expected to present your results as figures and/or tables. Short lab reports are due 72 hours after the end of lab, whereas long reports are due two weeks after the lab.

Long reports will be written with the following sections:

1. Title
2. Abstract (< 200 words)
3. Introduction, experimental theory, rationale and research question or hypothesis (about 1-1.5 pages)
4. Results (must be written out, figures, tables in appendix, see below) (about 1-1.5 pages)
5. Discussion (or combined results and discussion) (about 0.5-1 page)
6. Conclusion (0.1-0.25 pages)
7. References

Lab reports must adhere to following format and length guidelines:

- Maximum length of the main text: 3 or 4 pages, as instructed.
- Figures, tables and references should be appended after the main text.
- Font: Times New Roman 12 or Ariel 11, 1 inch margins, single or 1.15 spacing.
- Figures must be referenced in the main text (*eg*. "… the data is linear, as shown in Figure 1" or "…the demonstrates a linear relationship (Figure 1).")
- If writing a separate results section, it must contain descriptive text and not merely references to figures.

You will also perform a multi-week experiment involving crystallizing a protein, solving its protein structure and visualizing its structure. These labs will culminate in a report that will be written in the style of a 4-page scientific communication (short paper). While students will collaborate with each other during lab periods, each student will be responsible for turning in an individual report. Information on how to write a communication will be provided on canvas, in class and in lab.

Students are required to follow all safety rules and standards set forth by Schmid College of Science and Technology. Students not following these standards may be asked to cease activities and/or leave the laboratory. Laboratory instructors have full discretion to assess penalties as they see fit should students violate any of these policies. Furthermore, students are required to wear close-toed shoes, long pants, lab coats, and appropriate eye protection to participate in lab activities. Students will be asked to leave lab and marked absent if not appropriately attired. Furthermore, food and drink is not allowed in the laboratory, as is cell phone use, unless explicitly stated.

Laboratory schedule:

Week and date	**Experiment**	**Lab report type and due date:**
Week 1 8/28-9/03	Myoglobin extinction coefficient determination	Short report
Week 2 9/04-9/10	**Labor day. No lab.**	
Week 3 9/11-9/17	Computing wavefunctions and visualization of atomic orbitals using Mathematica	Short report
Week 4 9/18-9/24	Fluorescence microscopy	Short report
Week 5 9/25-10/01	Fluorescence quantum yield measurements	Full report due week 7
Week 6 10/02-10/08	Determining secondary structure by circular dichroism spectroscopy	Short report
Week 7 10/09-10/15	Measuring imidazole binding to hemoglobin	Full report due week 9
Week 8 10/16-10/22	**No lab**	
Week 9 10/23-10/29	Setting up a crystal tray	Week 9-14 form the basis of the short research paper, due in lab in week 15
Week 10 10/30-11/05	Field trip to Rinker campus	
Week 11 11/06-11/12	Protein crystallography: Data processing	
Week 12 11/13-11/19	Protein crystallography: Solving the structure	
Week 13 11/20-11/26	**Thanksgiving break. No lab.**	
Week 14 11/27-12/03	Protein crystallography: Refinement	
Week 15 12/04-12/10	Protein crystallography: Visualizing the structure in Pymol	Last day of exam week

In this class, software will be used to record live class discussions. As a student in this class, your participation in live class discussions will be recorded to assist those who cannot attend the live session, or to serve as a resource for those who would like to review content that was presented. These recordings will be made available only to students who are enrolled in the class, and only during the period in which the course is offered. All recordings will become unavailable to students in the class shortly after the course ends. Students who prefer to participate via audio only will be allowed to disable their video camera so only audio will be captured. Please discuss this option with your instructor.

In response to the current COVID-19 pandemic, Chapman University has developed the CU Safely Back program (CUSBP) and mandatory safety measures (https://news.chapman.edu/coronavirus/). The University's mandatory safety measures may be stricter than local, state or federal guidelines and may be subject to change at any time. Students are expected to adhere to the University's safety measures while attending classes, including when entering and exiting classrooms, laboratories, or other instructional areas. Individual faculty may choose to have requirements for their courses that are stricter than the University's. Safety precautions and procedures may change in response to emerging findings and the recommendations of scientific experts and authorities. Refusal to abide by the University's mandatory safety measures or to the safety requirements specific to this course will result in your being asked to leave the area immediately, and may result in an administrative dismissal from this course.

The COVID-19 pandemic requires all of us to accept the possibility that changes in how this course is taught may be required and that some changes may occur with little or no notice. For example, some or all of the in-person aspects of a course may be shifted to remote instruction. If this occurs, you will be given clear instructions as to how to proceed. The uncertainty of the situation is not ideal for any of us. We must all try to approach this situation with good-will, flexibility, and mutual understanding.