Spring 2020 CHEM 432: PHYSICAL CHEMISTRY FOR THE LIFE SCIENCES

Lecturer:
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Teaching Assistant:
TBA

Learning Objectives: Biology, despite its apparent complexity, follows the same principles of physical chemistry that govern the non-living world. Knowledge of physical chemistry established in relatively simpler model systems therefore serves as a key foundation for the study and understanding of living processes. The objective of this course is to present the principles of physical chemistry and their applications in the biological sciences. Particular areas that will be covered include thermodynamics, chemical and biochemical equilibrium, redox chemistry, kinetics and spectroscopy. After this course you will be able to:

(a) Understand the fundamental concepts stipulated by the physical principles covered in the course.
(b) Develop skills to apply these fundamental concepts and physical principles to solve basic problems in biochemistry.
(c) Develop an ability to connect these physical principles to current topics in research and developments in life sciences related fields.

Course Organization:

Lectures:	MWF	10:00 – 10:50 am	on-line via Blackboard
Discussion Sessions (*required*):	Friday	1:00 – 1:50 pm	on-line via Blackboard

*Note: February 5 is the last day to drop this course without a mark of W. April 9 is the last day to drop this course with a grade of W.

Office Hours:	**Qin**	Wed	1 – 2 pm	on-line via Blackboard
	TA (TBA)	Tue	12 – 1 pm	on-line via Blackboard

Class Web Page: Class materials will be posted on *Blackboard*. You are responsible for regularly visiting the class site web page for updated information and posting.

Problem Sets: Problem sets and solutions will be posted via *Blackboard*. Generally they are assigned in a weekly base, and are due 1-week from the date of assignment. The solutions to these should be written out by each student independently. With submissions that are 1 – 3 days late, 15% of the total grade are deducted per day. For those that are not submitted within 3 days, all points are deducted.

Exams: There will be two one-hour midterm exams and a two-hour final. The dates for the midterm and final exams are listed in the schedule. If you have a schedule conflict, please discuss with the instructor immediately.

Grading: *The course grade will be based on the following: Problem sets, 20%; Midterm 1, 20%; Midterm 2, 20 %; Final exam 40%.*

Textbook: Atkins & Paula, *Physical Chemistry for the Life Sciences*, 2nd Ed., W.H. Freeman (2011); ISBN-13: 978-1429231145; ISBN-10: 1429231149

Additional Reference Text: Tinoco, Sauer and Wang, *Physical Chemistry, Principles and Applications in Biological Sciences*, Prentice Hall (2001).

Lecture schedule: See the "schedule" section.

Academic Integrity: USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the Student Conduct Code, and can be found at http://www.usc.edu/scampus/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

Schedule of Lectures (updated 11/16/2020; subject to change)

Week	Date	Topics
Week 1 (Ch. 1)		•
		•
	Jan 15	• Introduction to Biophysical Chemistry • Review of basic concepts
Week 2 (Ch. 1)	**Jan. 18**	*MLK day; No Class*
	Jan. 20	**Thermodynamics** • First Law of Thermodynamics; • Heat, Energy, and Work
	Jan. 22	• P-V work; heat; State variables
Week 3 (Ch. 2)	**Jan. 25**	• Enthalpy • Enthalpy change on (designed path(s)
	Jan. 27	• Standard state; • Enthalpy of phase change; • Enthalpy of reaction, Enthalpy of Formation
	Jan. 29	• Hess's Law • Kirchoff's Law: Enthalpy vs. T
Week 4 (Ch. 2)	**Feb. 1**	• Entropy; • Spontaneity and 2nd Law
	Feb. 3	• Entropy and disorder • Entropy of Substances • T dependence of entropy
	Feb. 5	• Entropy of Chemical Reactions • Spontaneity and Gibbs Free Energy
Week 5 (Ch. 3)	**Feb. 8**	• Calculating ΔG • ΔG and maximal work
	Feb. 10	• Free energy and bio-molecular structure and interaction
	Feb. 12	• Thermodynamics of DNA duplex formation • Temperature and Pressure dependence of Free energy • Physical Equilibrium & Phase diagrams
Week 6 (Ch. 4)	**Feb. 15**	*President's day; No class*
	Feb. 17	• Equilibrium of mixture in different phases • Chemical potential;
	Feb. 19	• Osmosis
Week 7	**Feb. 22**	• Chemical potential; ΔG_{rxn} and reaction quotient;

(Ch. 4)		• ΔG^o_{rxn}, and equilibrium constant K
	Feb. 24	• ΔG_{rxn} and changes of composition & temperature
	Feb. 26	***Midterm Exam 1; in class***
Week 8 (Ch. 4 & 5)	**March 1**	• Reaction progress Q/K; • T-dependence of K • Coupled rxn
	March 3	• Acid Base Equilibria; • Ka, Kw, Kb • Calculating pH & 5% rule
	March 5	• Henderson-Hasselbalch equation; Buffers
Week 9 (Ch. 5)	**March 8**	• Biochemical standard state • Ions in solution; Non-ideality
	March 10	• Mean activity coefficient • Debey-Hukel theory
	March 12	*Wellness day; No class*
Week 10 (Ch. 5)	**March 15**	• Chemical potential in electrical field
	March 17	• Ions transport
	March 19	• Redox reactions • Standard reduction potential • Overall cell potential
Week 11 (Ch. 6)	**March 22**	• Nernst Equation; E and ΔG • E0 and K • Biological standard potential; • Electrochemical series
	March 24	**Chemical Kinetics** • Reaction Rates • Rate Laws
	March 26	• Kinetic data analysis for determining rate laws
Week 12 (Ch. 6 & 7)	**March 29**	• Equilibrium & Kinetics
	March 31	***Midterm Exam 2; in class***
	Apr. 2	• Reaction mechanisms
Week 13 (Ch. 6 & 7)	**Apr. 5**	• Temperature Dependence of Rate Constants; Arrhenius eq.
	Apr. 7	*Wellness day; No class*
	Apr. 9	• Reaction rate theories
Week 14 (Ch. 8)	**Apr. 12**	• Kinetics and Mechanisms of Enzymatic Reactions • Michaelis-Menten Equation
	Apr. 14	• Inhibition

	Apr. 16	• Enzyme lab
Week 15 (selective sections, Ch. 9, Ch.13)	**Apr. 19**	**Structure and Spectroscopy** • Spectroscopy; Basic concepts
	Apr. 21	• UV-Vis Absorption; Beers law
	Apr. 23	• Fluorescence spectroscopy
Week 16 (selective sections, Ch. 9, Ch.13)	**Apr. 26**	• Fluorescence lifetime and quantum yield
	Apr. 28	• FRET
	Apr. 30	*Wellness day; No class*
	May 3	*Final Review*
	May 10	**Final Exam, 8:00 − 10:00 am**