

CHEM 541: PHYSICAL CHEMISTRY

Chemical Thermodynamics and Kinetics

SYLLABUS AND COURSE OUTLINE

COURSE CONTENT	The course develops core concepts of classical physical chemistry, in particular: <ol style="list-style-type: none">1. Properties of gases: ideal gas law and departures therefrom2. The laws of thermodynamics3. Phase transformations of pure substances4. Properties of simple mixtures5. Chemical & electrochemical equilibrium6. Kinetics of chemical reactions
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CLASS TIME	Mode of instruction: Face-to-face Lecture: Tu/Th 10:05 AM – 11:20 AM, Jones Physical Science Center (PSC) Rm. 006 Recitation: Wed. 1:10 PM – 2:00 PM, PSC Room 006
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CREDITS	3
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PREREQS	Grade of C or better in CHEM 112 (or CHEM 142), and in MATH 241 or higher MATH. PHYS 212 is a co-requisite, unless a grade of C or higher was earned previously.
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SPECIAL NOTICES	<p>Together with Chemistry 542, this course completes the Physical Chemistry lecture portion of the Chemistry degree requirements. Chem 541 is not a prerequisite for Chem 542. Both courses are offered each semester and you may take them in either order.</p> <p>Together with Chemistry 545, this course completes the Physical Chemistry lecture portion of the Biochemistry and Molecular Biology degree requirements. Chem 541 is a prerequisite for Chem 545.</p> <p>Lab course: Chem 541L is a corresponding laboratory course. It is run independently and can be registered as a 2-credit course.</p>
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INSTRUCTOR	Prof. Andrew B. Greytak Office: GSRC 409: Please note office hours can be attended virtually via the Blackboard Collaborate course room. Office Hrs: M/W 4:00-5:00 PM Email: greytak@sc.edu Telephone: 803-777-0672
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GRADER/TA	Mr. Md. Moinul Islam (Moinul) Office: GSRC 414 Office Hrs: W 2:00-3:00 PM Email: mdmoinul@email.sc.edu Telephone: 803-777-0205
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REQUIRED TEXTBOOK & EQUIPMENT **Required text:** *Atkins' Physical Chemistry*, P. Atkins, J. de Paula, and J. Keller, **11th ed.** (ISBN-13: 978-0198769866). This text covers Chem 541 and 542. [**Alternatively:** *Atkins' Physical Chemistry: Volume 1: Thermodynamics and Kinetics*. Covers 541 only. ISBN-13: 978-0198817895]

Note: The previous edition of Atkins (10th) has similar chapter organization and is a suitable alternative for learning, but we will have homework assigned from 11th ed. so you'll need access to it.

Optional solution manual: *Student Solutions Manual to accompany Atkins' Physical Chemistry 11th edition*. Has written-out solutions to selected exercises (the back of the textbook contains answers for these selected exercises, but not solutions).

Scientific calculator: For use on exams, and you should bring it to class every day. I encourage you to learn to use the polynomial (e.g. quadratic) equation solver function, if your calculator has one.

Internet access: While this is a face-to-face course, we will make use of Blackboard to distribute various course materials. We may use it to collect homework or exam solutions in some cases, or if public health or other emergencies require a transition to remote learning. You will need an Internet connection and a scanner or smartphone camera that you can use to scan and upload solutions to the homework and the Final Exam if needed.

COURSE GRADING	Based on 500 points total:	
	Three Mid-term Exams (100 points each):	300 points
	Final Exam:	150 points
	Homework:	<u>50 points</u>
		500

Following exams, approximate letter grades may be discussed to help you evaluate your performance. However, final grades will be assigned on the basis of point totals. Cutoffs between letter grades may be adjusted based on overall class performance and the difficulty of the problems (in recent years, an approximate scale of A > 87½%, B > 75%, C > 65%, D > 55% of total points is typical).

All required elements of the course are to be completed within the normal term. Failure to complete all the elements on time will result in a grade of F. **Incompletes will only be assigned in unusual circumstances, but we will strive to accommodate hardships due to COVID or other unforeseen circumstances. Any such hardships that impact your ability to participate in the course or do the assigned work and could require accommodation should be communicated as soon as possible, ideally prior to impacted deadlines or exams.**

For both homework and exams, the correct method of solution is more important than the numerical answer. For credit, every answer must be supported by a clear and complete explanation of the method used to obtain it.

LECTURE **Attendance and participation in lecture is expected** of all students (but is not directly considered in grading). In addition to presenting new academic material, important information including changes in the class schedule may be described.

If you are unable to attend lecture in person due to an excused absence, you may be directed to the Blackboard page for updates on what was covered and to obtain course materials as an accommodation.

Note: Lectures are **by far** more effective if you have read the relevant sections of the textbook before class.

Out of respect for your fellow students and instructor, please avoid texting, web surfing and other activities not related to the class when you are in lecture. During tests,

RECITATION An interactive session with practice of problem-solving techniques through worked examples. Student questions and problems are welcome! No new material is presented, but **attendance and participation is expected** of all students.

MIDTERM EXAMS There will be three midterm exams, taken during normal class time, as follows:

Exam I: Thursday, February 10

Exam II: Thursday, March 17

Exam III: Thursday, April 14

For each of these exams, please bring:

1. A calculator (that does not have pre-existing programs).
2. Pencils
3. ID card
4. ~~You may use your textbook AND~~ **Closed book!** One 8.5"×11" sheet with handwritten notes you have prepared beforehand. Details on allowed resources may change and will be made clear prior to the exam.

Notes, calculators and any other such materials may not be shared. Electronics other than calculators must be out of sight and inaccessible.

In the event of an excused absence from one exam, the score may be replaced with the percentage score on the corresponding section of the Final Exam as described below. No separate makeup exams will be offered.

If you are unable to take an exam in person (e.g. due to medical quarantine), but wish to take the exam remotely, it will be possible to do so by following the same procedure as for the remote Final Exam, which will require you to download, complete, and upload the exam within the exam time period according to instructions described in class.

FINAL EXAM **Tuesday, May 3, 12:30-3:00 PM**, Jones PSC 006

The final exam is comprehensive, includes new material on chemical kinetics, and is required of all students. The exam will include sections that correspond to the material covered on each of the three midterm exams. The score from one (at most one) section of previously tested material may be substituted for a low or missing score on one of the midterm exams. This policy will be used to deal with both excused and unexcused absences during the midterm exams.

HOMEWORK Graded homework will be assigned on an approximately weekly basis (see tentative due dates).

IMPORTANT NOTE!

Each homework assignment will consist of (1) Exercises assigned from the Atkins textbook, for which you will submit numerical answers through Blackboard that are graded automatically, and (2) Problems assigned from Atkins and/or provided on the homework handout, for which you will submit written answers that are graded by your TA. Detailed instructions for completing and submitting homework will be given separately.

Chem 541 perceived as a difficult course by some students. The primary difficulty is in learning *how to set up problems* in terms of textbook and lecture material. **Homework** is designed to give you experience with this. Study groups and discussion of the problems with other students, the TA, or the instructor can be helpful are encouraged, but if you want to succeed, you need to try solving the problems on your own **first** (and without the solution manual). The material turned in should represent the student's own work and understanding.

UNITS AND NOTATION On both homework and exams, as in real life, correct numerical answers must **include appropriate units**. Also please make appropriate use of **significant figures** in your final answers. You may lose points for answers that lack units, have an inappropriate level of precision based on the information provided, or are illegible to tired graduate students.

GRADUATE CREDIT Additional work consisting of two graded written assignments worth 75 points each must be completed to receive graduate credit for the course (note this course cannot be used to replace 700-level classroom courses for the Chemistry graduate degree requirements, but is occasionally taken for graduate credit by students in other disciplines). Please notify the instructor if you are taking this class for a graduate degree (Masters or Doctorate).

NOTICE ON INTEGRITY Cheating is not tolerated!!! Students (and instructor) are obliged to abide by the USC Honor Code of academic integrity. Students are encouraged to teach each other, but **all graded assignments must be completed individually**. For example, discussing the concepts needed to solve a homework problem is encouraged. Solving someone else's homework problem, or copying someone else's answers, is considered cheating. Cheating, or assisting or knowingly cooperating in academic dishonesty, will normally result in failure of the course. Additionally, such incidents will be reported to the University's Office of Academic Integrity, which can assign disciplinary actions **in addition** to academic consequences within the course.

All materials related to this course are copyrighted. They may not be sold for money or other consideration, nor distributed without permission. Any such distribution will be considered an academic integrity violation and reported to OAI.

The University of South Carolina prohibits unlawful discrimination and harassment, and these policies as they apply to employment and educational access are described in Office of Equal Opportunity Programs form EOP 1.03. These harmful behaviors will not be tolerated in Chem 541.

DISABILITY STATEMENT Students with disabilities should contact me to discuss accommodations. To receive accommodations, you must be registered with the Office of Student Disability Services: 777-6142, TDD 777-6744, email sasds@mailbox.sc.edu, or <http://www.sa.sc.edu/sds/>.

- LEARNING OUTCOMES** After completing Chem 541, students will be able to:
- Solve realistic problems in chemistry using the principles of thermodynamics
 - Derive new thermodynamic results from the basic laws of thermodynamics
 - Express a physical question as a mathematical problem and use methods up to and including multivariable calculus to solve that problem
 - Translate between thermodynamic and phase reference data and physical descriptions of a system's behavior
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- COVID** We have made several modifications to the course to support face-to-face instruction in the present environment:
- University requirement of face coverings in all classrooms and seating arrangements that foster social distancing. Anyone failing to comply will be asked to leave and can be referred to the Office of Student Conduct for violation of UNIV 3.04 and STAF 6.26
 - Electronic submission of homework
 - Lecture notes can be made available as an accommodation for students who are unable to attend due to an excused absence.

If the University is closed due to COVID or some other emergency, lecture, recitation, and exams will move online, via Blackboard Collaborate, at their regularly scheduled times. All other elements of the class will remain unchanged.

I am always willing to adapt to students' special circumstances or concerns, whether COVID related or not. Please let me know as soon as you can if a special circumstance prevents you from completing coursework.

COURSE SCHEDULE: SUBJECT TO CHANGE

Date			#	Topic	Due	
JAN	11	T	1	Prologue Ch. 1 Top 1A, 1B.1	Properties of Gases: Ideal / Kinetic Theory	
	13	Th	2	Top 1B.2, 1C	Real Gases and Equations of State	
	18	T	3	Ch. 2 Top 2A	First Law <i>Last day to add or drop w/o W</i>	
	20	Th	4	Top 2B	Enthalpy and Heat Capacity	HW1
	25	T	5	Top 2C	Reaction Enthalpies	
	27	Th	6	Ch. 2 Top 2E	Adiabatic Expansion & Compression	HW2
FEB	1	T	7	Chemist's Toolkit 9 & 10 Ch. 2 Top 2D	Exact Differentials / Physical Properties	
	3	Th	8	Top 2D	Physical Properties	HW3
	8	T	9	Ch. 3 Top 3A	Second Law	
	10	Th		Exam I		
	15	T	10	Top 3B	Heat Engines	
	17	Th	11	Top 3C	Third Law and reaction entropies	HW4
	22	T	12	Top 3D	Thermodynamic Potentials	
	24	Th	13	Top 3E	Fundamental equations, Maxwell relations	HW5
MAR	1	T	14	Ch. 4 Top 4A, 4B	Phase Equilibrium, Chemical Potential	
	3	Th	15	Top 4A, 4B	Clapeyron & Clausius-Clapeyron Eqns.	HW6
	7-11			No class – Spring Break		
	15	T	16	Ch. 5 Top 5A	Partial Molar Quantities; Mixing of Gases; Colligative Props. Review	
	17	Th		Exam II		
	22	T	17	Top 5B	Liquid Mixtures	
	24	Th	18	Top 5B	Colligative Properties	HW7
	28	M		<i>Last day to drop without receiving WF</i>		
	29	T	19	Top 5F	Chemical Activities and Standard States	
	31	Th	20	Ch. 6 Top 6A, 6B	Chemical Equilibrium	HW8
APR	5	T	21	Top 6C, 6D	Equilibrium Electrochemistry	
	7	Th	22	Ch. 16 Selected Topics	Kinetics 1: Diffusive motion	HW9
	12	T	23	Ch. 17,18 Selected Topics	Kinetics 2: Differential & Integrated Rate Laws	
	14	Th		Exam III		
	19	T	24	Ch. 17,18 Selected Topics	Kinetics 3: Temp. Dep.: Arrhenius & Eyring Models	
	21	Th		Kinetics discussion & course review		HW10
	25	M		<i>Last day of classes</i>		
	26	T		No class – Reading day		
MAY	3	Tues		Final Exam: 12:30–3:00 PM		

Note: Reading assignments, lecture topics, and homework due dates may deviate from the above: changes will be announced in class. Exam dates should not change after the start of class except in extreme circumstances (we *are* in extreme circumstances, but hopefully they still won't change).