Chemistry 309 - Physical Chemistry I
Fall 2018

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Office Hours: I am usually in my office by 9:00 A.M. and stay at least until 5:00. Please feel free to stop by for help at any time. If you can't find me in my office, please check my lab, C-205. If I cannot help you immediately, I will make an appointment for you to come by later, on the same day if possible. If I am not in my office you can reach me by e-mail or by phone for an appointment. E-mail is generally the best way to reach me.

Prerequisites: Chemistry 141, Math 212 and Physics 132, 133 or 134. Chem 317, Math 235 (Calculus III) and Math 240 (Differential Equations), while not required, are strongly recommended.

Text:

Required: IF YOU ARE TAKING BOTH CHEM 309 and CHEM 310 THIS ACADEMIC YEAR:
Peter Atkins, Julio de Paula, and James Keeler, Atkins' Physical Chemistry, 11th Edition, Oxford University Press, Oxford, UK, 2018. ISBN 13 = 978-0-19-876986-6

OR:

IF YOU ARE ONLY TAKING CHEM 309:
Peter Atkins, Julio de Paula, and James Keeler, Atkins' Physical Chemistry: Volume 1: Thermodynamics and Kinetics, 11h Edition, Oxford University Press, Oxford, UK, 2018. ISBN 13 = 978-0-19-881789-5

Recommended: Physical Chemistry requires a lot of mathematics. You should have a solid command of your introductory calculus. Many of you will need to refer to your calculus book for help with differentiation and integration. In addition, we will be using mathematics beyond Math 211-212. In each case I will teach you the necessary math, but many of you will find it useful to have a reference available. The bookstore or online booksellers carry an inexpensive series that you may find helpful. It is the Schaum Outline Series, which includes volumes on Calculus, Differential Equations, Partial Differential Equations, Linear Algebra, and Advanced (Multivariable) Calculus. At the very least you should have either your book from Mathematics 211-212 or the Schaum Outline volume on Calculus.

Tentative Course Schedule: During our two semesters, we will be attempting to answer two very broad questions. The first is “What controls a chemical reaction?” This can include such diverse questions as where an equilibrium lies and what happens to the energy introduced into a molecule during a reaction. The second is “What makes some states of matter stable and others reactive?” It subsumes other questions like, “What causes some reactions to occur while others don't?” Alternatively, we could ask “What governs the stability of mixtures?” As we explore these questions in the course of our two semesters, we will be following a grand circle. We will begin with macroscopic treatments of chemical phenomena, using the tools and postulates of Equilibrium Thermodynamics. Toward the end of the semester we continue with macroscopic physical chemistry, but will turn to matter in a state of change, the study of Chemical Kinetics. At the beginning of the second semester we will turn to the microscopic world of atomic particles, atoms and molecules, which is ruled by Quantum Mechanics. We will then develop tools to take the results of Quantum Mechanics and use them to understand molecular spectroscopy, the interaction of molecules with light.

Our tentative course schedule for the first semester is:

Lecture	Date	Chapter	Topic
1	8/27	Lecture Notes, Ch. 1A.1	Review Syllabus; General Description of Physical Chemistry; Systems; Types of Variables
2	8/29	Lecture Notes, Ch. 1A.2	State Variables; Zeroth Law of Thermodynamics; Ideal Gas Equation of State
3-4	8/31-9/3	Ch. 1C	Real Gases; Critical Point; Equations of State for Real Gases; Introduction to Math for P-Chem
5-6	9/5 - 9/7	2A.1-2A.3	Work; State Functions; Path Functions; Reversibility; First Law of Thermodynamics
	9/10		Rosh Hashana - No Class
7-8	9/12-9/14	Lecture Notes, 2D.1, 2D.2	Heat; Non p-V work; Canonical Variables; Formal Definition of State Functions; Perfect Differentials
9	9/17	Lecture Notes, Ch.2A.4,	Calorimetry; Heat Capacity; Molecular Basis of Heat Capacity

	9/19		Yom Kippur - No Class
10	9/21	Ch. 2B.1, 2B.2, 2D.3,2D.4	Enthalpy; C_p - C_v; Joule Experiment; Joule-Thompson Experiment
11	9/24	2E	Adiabatic Processes
12	9/26	Ch. 2C.1-2C.3	Thermochemistry; Kirchoff's Law
	10/1		Test One
13	9/28	3A.3	Carnot Cycle; Discovery of Entropy
14-15	10/3-10/5	3A.1, 3A.2, 3B.1-3B.4	Entropy; Entropy Calculations; Second Law of Thermodynamics; Temperature Dependence of Entropy; Third Law of Thermodynamics; Debye Extrapolation; Statistical Approaches to Entropy; Standard Third Law Entropy; Entropy of Reaction
16	10/8	Ch. 3D, 3E.2	Gibbs Energy; Hemholtz Energy; Physical Meaning of Gibbs and Hemholtz Energies
17	10/10	Ch. 3E.1	Fundamental Equation of Thermodynamics; Maxwell Relations; Thermodynamic Square
	10/12		Dr. Abrash Medical Procedure - No Class
	10/13-10/16		Fall Break
18	10/17	Ch. 3E.2, 5A.1	Thermodynamic Equations of State; Pressure Dependence of Free Energy; Chemical Potential
19	10/19	Lecture Notes	Reduction of Partial Derivatives
20	10/22	Ch. 4A.1, 4A.3	Chemical Potentials of Real Gases - The Fugacity; Phase Diagrams
21-22	10/24-10/26	Ch. 4B	Thermodynamic Treatment of Phase Boundaries; Derivation of the Clausius-Clapeyron Equation; First and Second Order Phase Transitions

23	10/29	Ch. 5A.1a, 5A.2	Partial Molar Quantities; Thermodynamics of Mixing
24	10/31	Ch. 5A.3, 5B.1	Chemical Potential of Liquids; Chemical Potential of Ideal Liquid Mixtures; Henry's Law; Raoult's Law; Thermodynamics of Ideal Solutions
	11/5		Test Two
25	11/2	Ch. 5F.1-3	Chemical Potentials of Real Solutions; Activities
26	11/7	Ch. 5F.4, 6C, 6D.2	Ionic Activities; Mean Activity Coefficient; Debye-Huckel Equation
27	11/9	Ch. 5B.2, 4A.2	Fractional Distillation; Boiling Point Elevation; Osmotic Pressure, Gibbs Phase Rule
28	11/12	Ch. 6A.1	Reaction Gibbs Function; Extent of Reaction; Reaction Gibbs Function and Equilibrium Constants
29-30	11/14-11/16	Ch. 6A.2, 6B	Chemical Equilibria in Real Gases and Solutions; Temperature Dependence of K; Pressure Dependence of Equilibria; Le Chatelier's Principle
31	11/19	Ch. 17A	Introduction to Kinetics; Rate of Reaction; Simple Rate Laws; Order of Reaction
	11/21-11/25		Happy Thanksgiving
32 - 33	11/26-11/28	Ch. 17B, 17C	Determination of Rate Laws; Integral Rate Equations; Half Lives; Rate of Approach to Equilibrium
	12/3		Test Three
34-35	11/30-12/5	Ch. 17E, 17F	Mechanisms and Rate Laws
36	12/7	Ch. 17D	Temperature Dependence of Reaction Rates
	12/10 **through** **12/18**		**Final Exam** **9:00 A.M. to 12:00 Noon 12/10 or** **9:00 A.M. to 12:00 Noon 12/13 or**

			self-scheduled between December 10th and December 18th.

Next semester you will be covering atomic and molecular structure, spectroscopy, and a bit of statistical thermodynamics.

Tentative Test Schedule

There will be three hour exams and a final exam. The final exam can be taken at 9:00 A.M. on Monday, December 10th, at 9:00 A.M. on Thursday, December 13th, or can be self scheduled between December 10th and December 18th. Exams may be taken either at 9:00 A.M. or 2:00 P.M. on any of these dates. The final exam will be cumulative. The three one hour exams are tentatively scheduled for October 1st, November 5th and December 3rd. Tests will cover all material up to the next to last class before the test. Students who need extra time for tests due to LD should present me with the appropriate documentation as early as possible so I can make arrangements for a space that meets your needs and allows you the necessary time.

Notebook

This semester you will be given the option of keeping a double entry notebook on your reading. The notebook must be either a bound notebook, with each page divided vertically in half, or a word document, with each page formatted with two columns. On the left-hand side you are to summarize what you have read in a given section of the text, while on the right hand side you are to write a response consisting of questions, comments or ideas that arise from the reading. The summaries must be brief paragraphs, with one paragraph per section assigned in the textbook. For example, the first class's reading in the book is Chapter 1, Section A.1. Since section A.1 is divided into two sections, there should be two summaries, for section A.1a, and for section A.1b. The notebook will be due at the time you begin your final exam. The notebook grade will be based on completeness (did you do all the chapters?), on the accuracy and clarity of your summaries, and on the thoughtfulness of your responses. Up to 3.5 points of extra credit added to your final grade can be earned for completion of the notebook.

Grading

Homework, the one hour exams, and the final exam will be the basis for the course grade. The weighting for each of these components is as follows:

Homework:	15%
Three One Hour Tests:	60%
Final Exam:	25%

The grades for each of the one hour exams and the final exam will be based on a modified curve. This means that a traditional bell curve grading distribution will be my lower limit. If, for example, on examining the papers which would correspond to a C on the traditional curve, I feel that they are B work I will modify the curve to reflect this. I have no objection to assigning all A's if everyone does excellent work.

Homework

Regular completion of homework problems is essential in mastering physical chemistry. This is especially true since it will take time and practice for you to translate mathematical expressions into physical and chemical intuition.

Each homework assignment will be a selection of problems from Atkins, de Paula and Keeler. You are to attempt to complete all problems. For each problem, you should work until it's complete, or until you've spent 20 minutes working on it (whichever is a smaller amount of time). If you have not completed a problem after 20 minutes, then you must seek out another person in the class, and work on it with them for another 20 minutes or until it's complete (whichever is shorter). After you've either completed or attempted all problems, consult with one of the solution manuals to determine whether the answer is correct. Then mark on your homework report the problem number, the time spent, the person you consulted with and whether the problem was worked correctly.

Homework reports and homework will be due each Wednesday at the beginning of class. Everyone who attempts all problems for the week and turns in their homework report on time will receive full credit. Late reports will not be accepted. It is particularly important that you be completely frank about whether or not you have successfully completed a problem: it won't hurt your grade and it may be my only clue that you need help.

Collaboration on the problems from Atkins, de Paula and Keeler is strongly encouraged. A group of three to four people working together and discussing both the lecture materials and the problems together is often ideal. Talking through material is an excellent way to improve your comprehension or to zero in on areas in need of clarification. However, each of you knows how she or he works best and you should work in the way that you are most comfortable.

Attendance

You are expected to attend class. You are responsible for all material covered in class. No test makeups will be given. A missed test will count zero unless you are excused for a valid reason. I will determine the validity of the excuse. If you miss a test but are excused, the rest of the course material will count proportionally more. Please let me know if you have advance knowledge of missing a test.

Honor Code

The Richmond College and Westhampton College Honor Codes are very special and have the full support of this department. You will be expected to sign an honor pledge on each test. We expect that behavior in this class will be consistent with this code. However, collaboration on homework is allowed and encouraged.