CHE 323: Physical Chemistry I
Block 2 2018-19

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Catalogue description

Concepts of physical chemistry, including the kinetic-molecular theory of gases, kinetics, quantum mechanics, atomic and molecular structure and energetics, spectroscopy, symmetry, and classical and statistical thermodynamics. Prerequisites: CHE 122 or 161, and MAT 122. Recommended prerequisite: PHY 263. (Laboratory Science)

Course overview

Physical chemistry is the fundamental branch of chemistry. In other words, physical chemists seek to explain observed chemical phenomena or predict new phenomena using simple models based on fundamental concepts in chemistry, physics, and mathematics. Physical chemistry has both theoretical and experimental branches, and the historical development of the field mirrors this fact. Together, these dual branches of physical chemistry provide significant insight into the nature of matter and the changes it undergoes.

Traditionally, physical chemistry has been divided into six subareas, and this course will provide an overview and introduction to all six subareas: classical thermodynamics, statistical mechanics/thermodynamics, kinetics, dynamics, quantum chemistry, and spectroscopy. The division of the field in this way is somewhat arbitrary in modern physical chemistry; in part, these divisions are historical. Connections and overlaps between the subareas are emphasized in this course. The discussion of all six subareas will continue in CHE 324.

Course goals and objectives

Among other topics, we will discuss what atoms and molecules "look" like; what their energies are, both individually and collectively; how fast they move and react; how they interact with each other in a bulk substance such as a glass of water; how microscopic properties lead to macroscopic behavior; and how (and why) any change—reaction, phase change, electron jump, or mass transport through diffusion—happens at all. With a full grasp of these topics, one can, in principle, predict the behavior of any substance, any mixture, and any reaction! All of chemistry, and by extension nearly all of biology, is within our grasp.

We will see that mathematics and physics play an important role in understanding chemistry at a fundamental level. This course will provide a foundation for your study of chemistry thus far and prepare you for future studies in physical chemistry as well as advanced studies in other areas of chemistry. Connections will be made to other branches of chemistry, including all the way back to general chemistry.

With the above in mind, specific learning objectives include but are not limited to the following. Students will be able:

- To model and describe chemical systems using fundamental chemical, physical, and mathematical ideas
- To analyze experimental data in order to understand behaviors of atoms and molecules
- To evaluate limitations in experimental data and assumptions in models
- To evaluate chemical systems using logical, mathematical, and statistical reasoning
- To make decisions about how to proceed in lab and in problem solving
- To integrate and connect different subareas of physical chemistry, different branches of chemistry, and different disciplines within science and math
- To effectively explain ideas in both oral and written form
- To collaborate with other students in class group work and in lab
- To reflect on their learning and their interactions with the material and other students
- To work safely in lab
- To do all the above while demonstrating respect for others and their ideas, both formally (e.g., proper citations) and informally (e.g., not talking over each other in groups)

This class emphasizes the following Educational Priorities and Outcomes of Cornell College: knowledge, inquiry, reasoning, communication, ethical behavior, and, for some students, vocation. See http://www.cornellcollege.edu/about-cornell/mission/index.shtml.

Texts and other materials

Required:

1) Quantum Chemistry & Spectroscopy: A Guided Inquiry by Shepherd & Grushow
2) *One* of the following, either the current edition or one edition prior:
   Physical Chemistry by Engel & Reid
   Physical Chemistry by Atkins & de Paula
   Physical Chemistry: A Molecular Approach by McQuarrie & Simon
3) scientific calculator (not a cell phone calculator)
4) access to Microsoft Excel or a similar program
5) lab notebook (from a previous class should be fine)
6) safety goggles (from a previous class should be fine)

Optional: Student Solutions Manual for your text; The Physical Basis of Chemistry, 2e, by Warren

Meeting times, format, and expectations

Plan to meet each day from 9-11 am and each day from 12:30-3:00 pm. On some days our afternoon class will meet at 1 pm. This class is based on a specific type of team work (more details to follow) with supplemental lectures as necessary. We will also have labs as discussed below. I expect prompt attendance at all class sessions, although attendance will not specifically count in the grade. I do require active and constructive participation in teams, and you will get more from the class if you are more involved.

Usually, we will introduce a topic or subsection of material in class before you need to read your text on that topic. You are encouraged to read the appropriate sections of your text thoroughly, usually after class. I recommend reading the text more than once; reading physical chemistry takes more 'work' than other types of reading. Working problems is also crucial to your success in this course.

Point distribution and explanation

Team work and participation		45
Laboratory	points scaled to	160
Problem sets	6@20	120
Midterm exams	3@100	300
Final exam		175
Total		800

Team work: You will work on the activities in class and in teams, and you will turn in one copy of the activity (and sometimes other reports as directed) per team. Roles will be assigned within each team, and both the roles and the team membership will rotate throughout the block. More information will follow.

Labs: Expect to carry out labs during the block. More details will be handed out separately. Lab report guidelines will also be given separately, but you should expect to include any raw data obtained during the experiments in your report.

Problem sets: Working together on problem sets is appropriate and even encouraged; science is a collaborative endeavor. However, be certain that the work you hand in is your own (see below). You must be able to solve problems to understand physical chemistry. I will check for completeness in the problem sets, and detailed answer keys will be available after you hand in each problem set. Usually, I will post daily problems and you will turn in 2-3 days' worth of problems per problem set. Due dates will be announced in class.

Midterm exams: There will be three midterm exams covering specific portions of the course.

Final exam: In order to provide balance to all material covered, some points for the final will come specifically from material covered since the third exam. The remaining points will equally cover the entire block, including material since the third exam. My goal for the sum of all exams is that all material is tested equally by the end of the block.

Extra credit: 1) If you are the first to report an error to me (in writing) in the group activities, you will receive bonus points. The number of points correlates to the magnitude of the error. 2) We may have a science speaker on campus this block; if you attend and turn in a short writeup you are eligible for bonus points.

Grading

Grading brackets are 12% wide. Cutoffs will be no higher than:

A-/B+	704
B-/C+	608
C-/D+	512
D-/F	416

Cutoffs may be lower depending on the difficulty of the exams.

Miscellaneous course policies

Late work will not be accepted, and makeup exams will not be given. If you need to miss class, let me know ahead of time; if the reason is good the assignment in question might be excused at my discretion. Please contact me if you are having difficulty with the course or if a serious sickness/incident occurs during the block.

Electronic mail is an official form of communication at Cornell College, and College policy requires everyone to check his/her College email address at least once per day. I will often communicate with you via email and it is your responsibility to be aware of these communications.

Cell phones cannot be used for any reason (including a quick check to see who just texted you) during class or office hour times. Do not use your phone as a calculator or to look up data or information on the web unless specifically instructed to do so. Turn it off and put it in your bag under the table. It's OK—you'll survive. If you use a laptop or similar device to take notes, you should be using it *only* for class work. I reserve the right to restrict the use of any electronic device.

Any student with a situation which could affect your learning (e.g., health condition, serious family trouble) must contact me by the third day of the term. Student Affairs staff members do not automatically notify faculty members concerning student health issues. Health conditions include but are not limited to asthma or similar breathing issues, seizure disorder, pregnancy, known chemical sensitivities, etc. You must inform me due to safety concerns in the lab.

Students wishing to do a 15th day drop must complete all assignments and participate in class. See http://catalog.cornellcollege.edu/content.php?catoid=3&navoid=74#adding-and-dropping-courses, Item 7.

If medical or psychological conditions arise during the block, please consult with me, and/or with a medical or psychological health provider, *before* your progress in the course may become impeded. If such concerns make the completion of this course or an incomplete (I) infeasible, you may petition for a health withdrawal (WH). Be aware that Cornell counselors and health professionals will not normally issue support for a WH unless you have consulted them at or near the onset of the problem. See http://catalog.cornellcollege.edu/content.php?catoid=3&navoid=74#adding-and-dropping-courses, Item 9.

Cornell College makes reasonable accommodations for persons with disabilities. Students should notify the Coordinator of Academic Support and Advising and their course instructor of any disability related accommodations within the first three days of the term for which the accommodations are required, due to the fast pace of the block format. For more information on the documentation required to establish the need for accommodations and the process of requesting the accommodations, see http://www.cornellcollege.edu/academic-support-and-advising/disabilities/index.shtml.

I will provide reasonable accommodation for those students whose religious observances may intersect with planned class activities. You must see me within the first three days of the term to arrange any accommodation.

As mentioned above, working on homework sets (as well as lab exercises) together is appropriate. However, academic and scientific misconduct will be dealt with harshly. Examples include, but are not limited to, 'collaborating' on exams, illegal material stored in your calculator, submitting another's work as your own, and falsification of lab data. **Any** question about what is (or is not) appropriate in academia or science should be directed to me. If there is any doubt at all then please ask. Here is the College's statement on Academic Honesty: Cornell College expects all members

of the Cornell community to act with academic integrity. An important aspect of academic integrity is respecting the work of others. A student is expected to explicitly acknowledge ideas, claims, observations, or data of others, unless generally known. When a piece of work is submitted for credit, a student is asserting that the submission is her or his work unless there is a citation of a specific source. If there is no appropriate acknowledgement of sources, whether intended or not, this may constitute a violation of the College's requirement for honesty in academic work and may be treated as a case of academic dishonesty. The procedures regarding how the College deals with cases of academic dishonesty appear in the Catalogue, under the heading "Academic Honesty." See http://catalog.cornellcollege.edu/content.php?catoid=3&navoid=74#academic-honesty.

Schedule

Below is a tentative schedule of topics. This schedule is somewhat flexible, but there is a certain core of material that we must cover this block. More specifics regarding which sections of your text are most important will be given as we proceed. The lab schedule will be discussed in class. Deviations from this schedule will be announced in class.

Week 1M: chemical kinetics and mechanisms
- T: activation energy and catalysis
- W: kinetic molecular theory
- R: collision theory of reactions (end of Exam 1 material)
- F: am: molecular energies
  pm: **Exam 1**

Week 2M: quantum mechanics
- T: translational energy
- W: vibrational energy and spectroscopy
- R: bonding and symmetry (end of Exam 2 material)
- F: am: bonding and symmetry
  pm: **Exam 2**

Week 3M: molecular structure and symmetry
- T: distribution of energy in an ensemble
- W: the First Law
- R: the Second Law (end of Exam 3 material)
- F: am: Gibbs energy
  pm: **Exam 3**

Week 4M: equilibrium
- T: finish material
- W: **Final Exam** over all material