Syllabus

Chemical Principles

The technology of a civilization is fundamentally determined by the materials it can make and use. When people have materials that possess the right set of properties, they can assemble these materials into devices, tools, and structures that make things happen. For this reason, molecular scientists have two general goals: (a) manipulating the structures of materials to control their properties, and (b) combining these materials into heterogeneous systems that perform useful functions.

This perspective applies not just to human societies, but to living organisms as well. Through natural selection, nature "discovers" ways to make complex materials and assemble them into structures that carry out crucial biological functions. When these functions fail, the culprit usually involves a change in a material's properties, or in the existence of a new material.

Engineers and physicists also worry about materials and their properties. When they invent new technologies, they rely on functional materials to control the exotic forces that drive these technologies. Many of the breakthrough discoveries of physics became possible after scientists learned to control the properties of a material at a microscopic level.

What is this course about?

A molecular perspective of the world is crucial to understanding materials: their structures, properties, and functions. In this course, we will learn the most significant principles of modern chemistry — principles that revolutionized our understanding of nature while transforming the world. At the same time, we will learn to combine these principles with quantitative methods. Ultimately, these molecular insights will prepare you to investigate and solve problems facing humanity in the years to come.

In this course, we will practice wielding the concepts and methods of modern chemistry: molecular structure, equilibrium, acid-base chemistry, thermodynamics, electrochemistry, atomic theory, chemical bonding, electronic structure, and chemical kinetics. Aside from specific chemical topics, we will also practice more general scientific skills: using theory to evaluate observations (and *vice versa*), presenting quantitative arguments, and using evidence to support conclusions.

What are the goals of this course?

You should keep in mind two main objectives throughout the semester. The first is to use the principles, language, and methods of modern chemistry to explain phenomena that you will encounter in advanced science courses. This means that you will be able to solve a set of common, "standard" problems that chemistry students face all over the world.

The second goal is one that exemplifies a rigorous, liberal-arts education. Using what you learn in this course, you will solve *novel problems that you have never seen before*. You will likely find this challenge frustrating, but be patient and persistent. Talk with fellow students and your instructor. Previous students say that they find the challenge to be ultimately rewarding and excellent preparation for advanced courses in biology, chemistry, and physics. In addition, you will need practice with this type of problem solving if you plan to take advanced examinations, such as the MCAT, GRE, or graduate-school qualifying exams.

How does this course fit in?

Chem 122 covers a full year of general chemistry. It satisfies the requirements of several majors, including chemistry, biochemistry, molecular biology, biology, and neuroscience. Students who complete this course can enroll in a variety of upper-level courses, such as inorganic chemistry, organic chemistry, and biochemistry.

Course information

Instructor

Simon Garcia, Department of Chemistry, Tomsich 108

Availability

Drop-in office hours: Monday, 10:00a–11:30a; Wednesday, 10:00a–11:30a; and Wednesday, 2:00p–4:00p.

Appointments: Look up the gmail calendar for garcias@kenyon.edu and check for mutually available times. Create an event in your calendar and send me an invitation. If I accept it, the appointment will show in both my calendar and yours.

Class meetings

MWF, 9:10a – 10:00a, Tomsich 103

Resources

Required materials

Calculator. Your calculator should be capable of exp, ln, 10^x, log, x^y, sin, and $\sin^{-1}$ functions (devices with internet, voice, or text-messaging functions are prohibited on exams). A calculator is expected for assignments and exams.

Binder. Use a 3-ring binder to keep together notes and other materials.

Textbook

You can use any modern textbook on college-level, general chemistry. A few examples are listed below; they are popular among the chemistry faculty at Kenyon.

- Zumdahl, *Chemical Principles*
- Chang, *Chemistry*
- Gilbert, *Chemistry*
- Pauling, *General Chemistry*

Solutions to exercises

For Zumdahl's *Chemical Principles*, 6th edition, the Math-Science Skills Center (MSSC) has copies of the complete solutions to all exercises, so you can check your work on them. You must be in the MSSC while looking at the solutions.

Model Kit

The HGS Molecular Structure Model Kit, type "C," includes pieces for sp, sp^2, sp^3, dsp^3, and d^2sp^3 geometries. It is also used in organic chemistry and biochemistry.

Assessment system

Sapling Learning is an adaptive learning tool for developing chemistry skills and knowledge. It does this by offering assessment items (*i.e.*, quiz questions) for each chemical principle covered in the course. It is adaptive in that it offers hints and coaching on each item as needed. It is modular, so you can test yourself on specific concepts and get feedback to improve your performance.

Prerequisites and corequisites

Chemistry

This course assumes you have taken one year of introductory chemistry beyond 9th-grade physical science, in a course that meets or exceeds the 2nd-tier standards listed in *Science Content Standards for California Public Schools*. Enrollment is open to 1st-year and 2nd-year students; 3rd- and 4th-year students need instructor permission.

You must enroll in Chem 123 (Introductory Chemistry Laboratory) concurrently.

Mathematics

You should be comfortable with standard algebraic procedures (*e.g.*, solving for unknowns, simplifying expressions, canceling factors). You should know the algebraic properties of exponents, logarithms, and powers, and you should be able to enter these operations (including exponentiation and logarithm) into a calculator or spreadsheet.

Physics

High-school physics is not required, but you should be familiar with basic physical concepts (like force, energy, temperature, and waves) and unit conversions for energy. These topics are normally covered in a typical "physical science" or "general science" course in high school.

Course structure

Study guides

I will post a study guide for each topic, which will contain a list of learning objectives, study questions, and notes. Check the relevant sections of a textbook or other resource to research each topic and become familiar with the associated concepts and methods. Use the study questions to make your study more active and directed. If you are not certain about the relevant section, or just want confirmation that you're on the right track, check with study partners and the instructor.

Participation

Part of the grade for this course certifies your experience in discussion-oriented, collaborative work. Missing class, refusing to contribute to discussions, or failing to respect team members deprives your fellow students of this experience, and will thus incur a penalty of 10% from your participation grade. Failing to submit proposals for problem sets, will also incur this penalty.

Waiver. Because there are various reasons to miss class, such as illness, athletic competitions, and religious obligations, I will waive the penalty for the first three absences, *with no questions asked*. Additional absences will not be waived.

Problem sets

I will pose a number of novel problems and case studies throughout the course. We will use these problems to prompt in-class discussions about chemical principles. Each one will involve a seemingly simple question about a challenging, complex issue; some will include short tutorials on how to use particular concepts. To solve each problem, you will need to apply standard chemical principles and methods.

In each case, you will not receive direction on which principles and methods to use. This is a typical situation faced by scientists, clinicians, and engineers in their professional work. We will instead explore problems in class and determine the relevant concepts through the process of structured discussion, asking "What does the question actually mean?" and "What do I need to know in order to answer the question?" For this reason, you should read each problem thoroughly before coming to class, and participate in discussions and activities.

Please do not disseminate or post problem sets in a public venue. The data and information in some cases are from private communications with my professional colleagues, who asked that I use them for course work only.

After introducing a problem set in class, I will post a forum discussion prompting you to propose a method of solution. You will meet with a team of 3–4 students, outside of class, to discuss and decide on an appropriate method. You will then submit a proposal of your method within one week of the original post. An honest, good-faith effort to submit a *complete and timely* response is a necessary component of participation in this class.

Final Examination

The final examination will be 2 hours long. Because of limited time, it is impossible to include every concept or skill encountered in class. For this reason, the exam will *sample* topics, so you should expect that *any* topic may appear. 10–20% of each exam will include novel problems that test not just your knowledge, but your mental agility as well.

You should bring a calculator and a sheet of personal notes for reference. You may write on both sides of this note sheet.

The Registrar will set the date and time of the final exam. It is your responsibility to check the Registrar's schedule before you make travel plans. *The College explicitly requires professors to give the final exam at the time scheduled by the Registrar.*

Optional exams. For your convenience, I will administer optional examinations on October 04 and November 08. If your score on any exam is higher than on the final exam, then it will replace one third of the final exam grade. You may bring an index card (3″ × 5″) of notes for reference to each exam, and write on both sides of it.

Grading

The total grade is based on participation (25%) and the final exam (75%).

Policies

Attendance. Attendance at all class meetings is expected. Excessive, unexplained absences will result in dismissal from the course. Only the Dean of Students (not the instructor) can excuse an absence. If you must miss a class meeting, or will be late, please notify the instructor by email, or ask a friend to tell the instructor.

Etiquette. Upon arriving in class, please greet the instructor and the students sitting near you. Silence any devices you have. Maintain a respectful presence in class, and avoid disrupting or distracting fellow classmates once class begins. If you use a keyboard-type computer to take notes during class, please sit in the back of the classroom to avoid distracting other students. If circumstances require you to leave the classroom throughout the period, please seat yourself near the door so that you can exit unobtrusively. Finally, keep in mind at all times how your actions affect the people around you. Please inform the instructor when leaving the classroom and indicate where you are going.

Classroom Space. We will move around during class, so please keep unnecessary items off the tables. You only need your notebook, pencil/pen, and calculator at the desk. Place bags and food at the back of the classroom or on window sills.

Academic honesty. Please read the College's statement on Academic Honesty in the *Course of Study*, pages 26–29. Pay special attention to the definition of plagiarism and to the examples of activities that violate the standards of academic honesty. I expect you to avoid plagiarism and cheating and to avoid even the mere appearance of possible plagiarism or cheating in all of your work.

Excused absence. There are no excused absences.

Unexcused absence. There are no unexcused absences.

Discretionary absence. All absences are considered discretionary. This means that you are responsible for judging the necessity to miss class. Your first three absences will carry no penalty.

Extenuating circumstances. In special cases, such as an extended or serious illness that confines you to your bed (the "Dorm List"), long-term emotional distress due to bereavement, MagiKarp evolution, or other emergency situation, please inform the Dean of Students, who will notify me of your absence (while keeping the reason confidential). Afterward, consult with me and the Dean of Academic Advising to make special arrangements for completing your course work.

Disability services and accommodations. If you have a learning disability or other disability that impacts your ability to learn, or think that you might have one, please schedule an appointment with Disability Services *as soon as possible*. Only the Coordinator of Disability Services is authorized to review your documentation and to recommend an accommodation. All discussions with the Coordinator are confidential. The Coordinator will work with you to design an accommodation tailored to your exact situation. If your accommodation requires special testing conditions (*e.g.*, extra time, separate venue, extra breaks, assistive devices, assistive services), then you must inform me *at least two weeks in advance*. It is your responsibility arrange these conditions with the Office of Disability Services.

If your accommodation requires special testing conditions (*e.g.*, extra time, separate venue, extra breaks, assistive devices, assistive services), then you must inform me *at least two weeks in advance*. You must also plan arrangements necessary for your accommodation, such as reserving a scribe or assistive device.

Changes to syllabus. The policies articulated in this Syllabus are subject to change in response to unusual situations. You will be notified of any changes at least 48 hours before they go into effect.

Exam days. The optional exams are on October 04 and November 08. Each will be 45 minutes and are both on Fridays. The final exam for Period 2 is posted on the Registrar's site. Check your calendar to ensure these dates are free, as make-up exams will not be available.

Schedule

Week	Topic	Events
1	Materials structure	
2	Thermochemistry	
3	Thermodynamics	
4	Equilibrium	
5	Acid-base chemistry	Optional exam on Friday
6	Buffer chemistry	*No class on Friday*
7	Electrochemistry	
8	Atomic Theory	
9	Covalent Bonding	
10	Molecular Architecture	Optional exam on Friday
11	Electronic Structure	
12	Chemical Kinetics	
13	Condensed phases	
14	Elective	
Finals		**Scheduled by Registrar**

Comments

The following comments are responses to two narrative questions on course evaluations for Chem 122 in 2012.

Classroom activities

- *Which activities did you learn the most from? — the least from?*
- *Which activities did you enjoy the most? — enjoy the least?*
- *Do you suggest any changes to specific activities, or perhaps to all of them?*
- *Do you suggest any changes to the overall use of class time?*

- I really loved the class dynamic. Class was organized in an incredibly unique way, and it worked. Every student got to know every other student really well, and the "pair-up" discussions and explorations were excellent uses of time. Professor ___ and ___ ___, the AT, were very available during these discussions to help guide us if we needed it. Even for an early-morning class, Chemistry 122 never felt like a burden to attend. I always looked forward to it -- class never moved slowly, Professor __ was friendly, funny, and engaged, and it really was a great experience.

- I learned the most from the model building activities because it helped me visualize the structure and I had never really built models before. I like the drug decay rate activity I think it was an effective way to learn the material and was fun at the same time. I think sometimes we spent to much time talking in our groups especially if we did not really know what was going on. The group time was not really effectively if neither member knew how to talk about the discussion question. I think possibly starting with a small lecture and then breaking into groups worked really well and I wish that we could have had the structure more often.

- I learned the most from the model kit activities. It was very useful to have a nice visual of the concept and found the structure of molecules the most enjoyable, mainly because I think they're cool looking. I also really enjoy electrochemistry. Equilibrium is probably one of me least favorites because I find it boring, but that is just personal preference.

- I learned most from the study guides and the quizzes. Though the problem sets were challenging, it was good to see the real world applications of these concepts. However I think there were some days when too much class time was spent talking about the problem sets and we could have gone over some of the key concepts of the topic, such as during the acids and bases and buffer chemistry sections.

- I enjoyed getting into groups of four to work on assignments. I learned the most from Problem sets, they were very interesting. No changes

- I would suggest less collaboration to increase classroom efficiency, this would cut out redundancy. I would have liked to see more tim spent on learning the concepts instead of merely talking about possible ways to look at or solve problems.

- By far the most challenging and enjoyable activity was the Problem Sets. Although they required time outside of class and were difficult thought-problems, they complemented what we learned in the course in a way that simple homework cannot. We had to apply our knowledge and tackle the situations from different angles; they were tough, but the feeling of accomplishment afterwards was well worth it.

Although it is the nature of the course to have students be self-motivated, it did sometimes hinder the discussion when some students didn't yet understand the material.

- The problem sets helped me learnt he topics a lot, but they were extremely difficult at times. It's nice being able to put it in google docs and getting ___'s feedback on them. The feedback definitely helps me better understand what I did wrong or how I could improve each problem set.

- I enjoyed using the model sets to visualize the structure of the molecules and the demonstration involving the black light that would blind us. I don't feel like the mini experiment for thermochemistry, in which we heated water and calculated the delta H. I liked the conversation that followed the experiment, but I don't think it was absolutely necessary for everyone to go to the lab and conduct the experiment.

- I learned most when lectures were placed before class discussion activities. I also felt like class time was used more effectively when lectures were placed before discussion activities because on the whole, each student was able to get more out of the discussion and fundamental questions were minimized.

- I enjoyed the in class discussions the most and learned the most from them too. No, i feel that the activities were fine as is.

- Some of the details of the earlier activities have left my memory, but recently I enjoyed the models. I also have enjoyed the structure of having discussions and then explanation of the topic.

- I think having more of class devoted to what you expect us to be able to do skill-wise, such as things you expect us to be able to do on a test, as well as having a brief overview of a new topic the first day we start one, would be helpful.

- I learned the most from the discussions and in class group discussions. I think discussing with our peers helped us learn the material, however maybe if every monday you did notes on the topic and then spent wednesday and friday letting the students discuss that would be more helpful.

If you had to describe this course to a new student who had never heard of it, how would you describe it?

- Chemical Principles helps you gain a well-founded understanding of a wide variety of introductory chemistry topics through collaboration, real-life situations and problems, and exploration.

- A general chemistry class that looks at each unit through a real world situation.

- I would describe this class as very thought-provoking and not a class where you blindly compute calculations. It helps you to analyze to data effectively and question things that do not necessarily follow chemical principles. However, you should have a semi-strong background on chemical concepts because the course if fairly quick paced and not much time is devoted to learning how to calculate an answer.

- It is a fairly easy chemistry class if you have a good background. Problem sets are required for the majority of the weeks and can sometimes be confusing and are usually based off of one detail about a topic and not an overall picture.

- This course elaborates on the basic knowledge gained through any standard general chemistry lecture. It challenges assumptions, demands critical thinking, and pushes students to weave subject material into a coherent framework rather than treat topics as individual entities. Rather than ask for regurgitation of facts and calculations, the course looks for cooperation and out-of-the-box thinking.

- Chem 122 is an accelerated introductory chemistry course, where it would be beneficial for you to have a strong chemistry background. If your background isn't as strong, you have to be willing to put in the work to read the and to meet Professor __ for office hours. But overall, it's a really fun class where you get to interact with other students - rare in a science lecture class.

- A fun and stimulating course that will challenge you to the point of breaking, then reward you with satisfaction.

- I would say that it is like an intro-chem course, but focuses a lot more on critical thinking skills. There is not as much work, but since class time is more devoted to expanding and applying what you've studied, the trade-off is in order to understand the homework and class discussion you will need to do more studying. If you are at least moderately comfortable with Chemistry you should consider this class since it takes only one semester, but if you know very little about chemistry than you will probably have difficulties with this class. The class structure will be a bit disorienting in the beginning, with the aforementioned focus on synthesis versus introduction of information, but you get used to it in about 2-3 weeks and it works very well.

- This course focuses on practical applications of chemistry topics in the classroom, while the exams are a test of the knowledge associated with these topics. - As an acellerated chemistry class, in which you learn a lot of material in one semester. It is discussion based.