Introductory Chemistry Laboratory

Chem 123: Fall 2018

Course syllabus

The vast majority of your scientific knowledge has to be taken on authority, because there isn't enough time to verify every experimental result personally. But you can and should understand the *process* of creating such knowledge through experimental measurements. How can we trust that a measurement is valid? How do we account for the inherent variability of the physical world? What makes an experimental procedure good, and how does a scientist design one?

We will investigate these questions by studying experimental techniques, doing them, and then assessing the results. In the process, we will gain practical experience with laboratory equipment and techniques, and learn first-hand how they affect the reliability of a measurement. We will practice the habits of inquiry, questioning why we use certain procedures, and interpreting observations in terms of chemical theory. And we will do this in a collaborative environment, engaging in discussion and oral communication of ideas with fellow experimenters.

The study of experimental chemistry has *universal* value. The concepts of variation and bias arise in any natural or social scientific discipline. More generally, they reflect concerns over how we know *anything*, even conclusions drawn from quantitative measurement. A constant problem in measurement is agreeing on standards and developing consistent procedures that everyone can agree upon. In addition, we interpret chemical data based on theoretical assumptions about things and forces that we cannot see or touch; this type of analysis pervades every field of study, from cosmology to literary criticism. By studying and practicing experimental design, we understand more generally how knowledge of all kinds is built in the first place, and then communicated through discussion or through authority.

At a glance

Each laboratory section meets for 3 hours per week for 14 weeks. Expected study and preparation time is another three hours each week. A laboratory notebook, a pair of safety goggles, and closed-toe shoes are required for course work. Total credit is 0.25 units. Besides regular, weekly assessment of engagement, four major assessment tasks are due in Weeks 05, 09, 12, and 13; and final drafts of Portfolio and Journal are due Finals Week at the time scheduled by the Registrar for each section. Instructional staff include:

- Simon Garcia, he/him/his, instructor
- James Heironimus, he/him/his, instructor
- John Payton, he/him/his, instructor
- Carolyn Waggoner, she/her/hers, teaching laboratory coordinator
- Dennis Wiegman, he/him/his, instructor

Learning objectives

True learning is an **intentional** process, one you undertake with purpose and introspection. To promote intentionality we identify **learning objectives** and design course activities around them.

Skills

- Explain how an experimental action affects molecular state of system
- Interpret experimental observations in terms of molecular structure and processes
- Identify information relevant to replicating a procedure
- Organize data in a way that facilitates analysis and comparison
- Estimate the amount of reagent necessary for a step of a procedure
- Control amounts of materials using volumetric and gravimetric procedures
- Explain the relationship between molecular-structural features and spectral patterns
- Infer the rationale and intentions for an experimental design decision
- Discern potential sources of variability and bias in a procedure
- Propose steps to validate an experimental measurement
- Acknowledge team members' precise contributions in experimental work
- Adapt an established protocol to a novel measurement problem

Experiences

- Use critical analysis to better understand experimental techniques
- Practice implementing established experimental methods
- Document experimental actions consistently
- Master experimental techniques through practice
- Coordinate procedures and data collection within a team of 2–4
- Prepare in advance for experimentation
- Explain changes in knowledge and skills that result from course work

Concepts

- Random variation
- Systematic bias
- Precision and uncertainty
- Standard reference material
- Standardization
- Residue
- Quantitative transfer
- Contamination
- Dilution
- Concentration
- Molar mass
- Molar equivalence
- Functional groups
- Vibrational mode
- Titration
- Spectroscopy
- Acid-base neutralization
- Limiting reagent
- Balanced equation and stoichiometry
- Light absorption

Course structure and expectations

Most of the learning objectives are not about following directions. Instead, they are about understanding how each step of a procedure affects experimental conditions, and what knowledge you can gain from observations. You should ultimately be able to design your own procedures to solve new problems.

To help you reach the learning objectives and successfully complete the assessments, we chose specific activities, topics, assignments, and modes of instruction. These choices are based on a set of **expectations** about your engagement with different aspects of the course. In the first week of a unit you will typically analyze and practice an established protocol; a certain outcome is expected and you practice technique until you get it. In the second week you will modify the protocol and apply it to a new situation; the expected outcome is unknown, and one goal is to discover whether your modification worked. The third week will involve a practical assessment of your technique and/or knowledge.

Expectations — practicing an established method

Before class, analyze the procedure by completing a Decision-Explanation-Observation-Inference (DEOI) rubric; record your responses to reflection questions in Journal. At the beginning of class, discuss your analysis critically with classmates. Use remaining time to practice each step of the procedure, take measurements, and better understand design of the experiment. Give your classmates your full attention during discussion, and acknowledge their input. Connect observations to explanations. Wear closed-toe shoes and eye protection during "wet-lab" activities. When in doubt about a technique, ask instructors or TAs for clarification or advice. After experiment, share results with classmates; record responses to post-lab reflection questions in Journal.

Expectations — modifying a method for a new situation

You will be assigned a slightly different experiment, that requires the established protocol to be modified. Before class, write the modified procedure in notebook, informed by DEOI analysis and prepared for data collection; record your responses to reflection questions in Journal. At the beginning of class, compare procedure with laboratory partner and resolve differences. Implement procedure, recording observations and data. Wear closed-toe shoes and eye protection. When in doubt about a technique, ask instructors or TAs for clarification or advice. After experiment, share data with other teams and record data they share with you; draw inferences from the combined results. After class, record responses to post-lab reflection questions in Journal. Revise and refine any previous work, as instructed, and add it to Portfolio.

Expectations — Journal and Portfolio

You will maintain and update two documents throughout the course: a Journal and a Portfolio. The Journal is a "working tool" for your learning experience. You will receive prompts and tasks to prepare for class and to reinforce your learning afterward. Record these in your Journal, but you may record other notes as well. The Portfolio is for you to showcase your best work, and will often involve revising or remixing work from your Journal. You will receive directions on what to include, but feel free to include other evidence of your learning if it is especially meaningful to you. You are expected to update your Journal *before and after every class session*, and your instructor will spot check it for evidence of consistent engagement.

Assessment

At the end of the course, how do you convince yourself that the learning process was successful — that your mind actually changed? An **assessment task** is a realistic challenge that can only be solved if you have achieved the learning objectives. The ways you respond to it thus provide holistic evidence of learning. This course will offer four assessment tasks to evaluate your learning. Each one challenges you to apply the skills and experiences described above to a specific research question.

Grading

A letter grade of "B" will be assigned based entirely on evidence of **engagement** in the course. If a student is not providing sufficient evidence of engagement at any point in the course, the instructor is expected to file a progress report and the student is expected to consult with them. The instructor may assign a higher grade based on a holistic assessment of students' **mastery** of the course objectives.

Engagement

Engagement is defined here as meaningful actions to change one's mind, such as active participation in discussions, support of other students' learning, preparation for class activities, and reflection on the learning process. The following actions are evidence of engagement:

- Offer questions, ideas, and feedback during in-class discussion and laboratory work.
- Prepare journal and portfolio assignments (DEOI analysis, notebook preparation, data analysis, experiment proposals, metacognitive reflections, etc.) completely, consistently, and on time.
- Request frequent feedback on laboratory technique and on understanding of concepts.

Mastery

Evidence of mastery includes, but is not limited to:

- specifying procedures with sufficient detail to ensure consistent implementation
- awareness of what to expect from an experimental design
- providing evidence that an experimental design is reliable and fulfills conditions of task
- articulating conclusions precisely
- correcting misconceptions about experimental practices or theoretical concepts
- explaining what problems an experimental design solves and how it solves them
- performance of laboratory techniques

Policies

Academic honesty

Please note the College's principles and policies regarding academic honesty and integrity:

> Kenyon College is, at the core, an intellectual community of scholars — students and faculty — engaged in the free and open exchange of ideas. Critical to this lively exchange and deep engagement with ideas is the academic integrity of our work, both inside and outside the classroom. At Kenyon we expect all students, at all times, to submit work that represents these standards of academic integrity. It is the responsibility of each student to learn and practice the proper ways of documenting and acknowledging those whose ideas and words you have drawn upon (see *Academic Honesty and Questions of Plagiarism in the Course Catalog*). Ignorance and carelessness are not excuses for academic dishonesty. If you are uncertain about the expectations for academic honesty in a class, please ask your instructor for clarification.

Academic accommodations

Please note the College's principles and policies regarding academic accommodations.

> Students who anticipate they may need accommodations in this course because of the impact of a learning, physical, or psychological disability are encouraged to meet with their instructor privately — early in the semester — to discuss their concerns. In addition, students must contact Erin Salva, Director of Student Accessibility and Support Services (740-427-5453 or salvae@kenyon.edu), as soon as possible, to verify their eligibility for reasonable academic accommodations. Early contact will help to avoid unnecessary inconvenience and delays.

If an accommodation may require special conditions or services provided by the instructor, then please work with the Director of Student Accessibility and Support Services to communicate your needs with the instructor at least two weeks before the service is needed.

Discrimination and harassment

Please note the College's principles and policies regarding sexual misconduct and other forms of discrimination and harassment:

> Kenyon College does not discriminate in its educational programs and activities on the basis of race, color, national origin, ancestry, sex, gender, gender identity, gender expression, sexual orientation, disability, age, religion, medical condition, veteran status, marital status, genetic information, or any other characteristic protected by institutional policy or state, local, or federal law. The requirement of non-discrimination in educational programs and activities extends to employment and admission. All employees, including faculty, are considered Responsible Employees and must notify the College's Civil Rights & Title IX Coordinator with any relevant information. Relevant policies are detailed in the following documents:

- https://www.kenyon.edu/directories/offices-services/ocr/title-ix-vawa/kenyon-policies/title-ix-policy/
- https://www.kenyon.edu/directories/offices-services/ocr/discrimination/
- https://www.kenyon.edu/directories/offices-services/ocr/discrimination/504-ada-grievance/student-grievance-procedure-resolving-complaints-under-ada-section-504/

NB: Although instructors are expected to keep Journal entries in confidence, they are still bound to comply with mandatory reporting duties as Responsible Employees.

Absence

Absences are discretionary: you are responsible for judging the necessity to miss class. There are various reasons you might need to miss class, such as illness, athletic competitions, job interviews, religious observance, or simply oversleeping — none will be privileged over other reasons. Therefore you may miss two class meetings with no questions asked. Additional absences deprive your instructor of evidence of engagement. If you would like to work in a different laboratory section one week, you must have permission from *both* instructors *one week before* that lab session.

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

As a courtesy, please inform the instructor of any planned absence *one week before the experiment*. For an unplanned absence, please notify the instructor and teaching assistants of your situation, as soon as possible, so they can explain your absence.

Regardless of whether an absence is expected or unexpected, you are still expected to update your Journal and Portfolio documents, as instructed and on time.

Safety

You will receive instruction — both at the beginning of the course, and in each session — on safe laboratory practices. You are expected to conduct yourself in a safe manner at all times. Horse-play, unauthorized experimentation, belligerence, or other behavior deemed unsafe by the instructor will result in your immediate dismissal from the class for the day, without the opportunity to make up work. Attending class while impaired — from sleep deprivation, drug use, or other activities — is also grounds for dismissal. Severe or repeated incidents will result in permanent dismissal from course.

Safety rules are detailed in the orange document you signed, *Safety in Chemistry Department Laboratories*, but some important rules include:

- Wear shoes that cover your toes.
- Legs must be covered by long pants or lab apron.
- Do not eat or drink in the laboratory, and do not bring food or drink into the laboratory.
- Wear protective eyeware while you are in the laboratory.

Finals week

Your Journal and Portfolio are due by the scheduled date and time of the final exam for your section, which is set by the Registrar. It is your responsibility to check the Registrar's schedule before you make travel plans. *College policy explicitly requires instructors to set final deadlines to the time scheduled by the Registrar. College policy explicitly forbids instructors from accepting course work after this time.*

Schedule

Week	Experiment
01	Introduction: Check-in, Safety
02	Tutorial. Determining density of a solid (tutorial)
03	Titration I. Determining purity of aspirin
04	Titration II. Determining purity of another acid
05	Assessment 1. Evaluate reliability of titration
06	Reading Days (no lab this week)
07	Spectroscopy I. Determine concentration of a dye
08	Spectroscopy II. Evaluate reliability of spectroscopy
09	Assessment 2. Design solution preparation protocol
10	IR I. Infrared vibrational spectroscopy
11	IR II. Design procedure for identifying type of plastic
	Thanksgiving Break
12	Assessment 3. Identify unknown plastic by IR spectroscopy
13	Assessment 4. Design protocol for analysis and validation
14	Filtration; evaluations

Student research

The Chemistry department encourages students with interests in the sciences to consider an independent research experience at some point during your undergraduate education. If you are interested in doing research within the Chemistry department, first check the faculty websites for an introduction to each person's individual research.

http://www.kenyon.edu/academics/departments-programs/chemistry/chemistry/

If you find one (or more) faculty with interests that pique your curiosity, contact those people to set up an appointment to talk further. Some research groups may be full when you initiate contact, but this status may change semester to semester.

Section-specific information

Instructor:

Teaching assistant:

Teaching assistant:

Instructor’s office hours:

How to contact instructor:

Journal update expected each week by: