

CHEM 146

Quantitative Chemistry Laboratory II

Spring 2026

S.1 Overview

Welcome to CHEM 146! CHEM 146 is the second semester of a two-semester laboratory sequence that seeks to introduce the central principles and practices of quantitative chemical analysis. There will be an emphasis on the development and application of quantitative skills and methods. The attendant calculations, data analysis including basic statistical treatment and application of a spreadsheet program (EXCEL), are stressed as well as the formal presentation of data, calculations and results consistent with current best practices.

Format: Online/at-home hybrid: six (6) at-home, hands-on lab experiments and four (4) online only activities. All *Lab Quizzes* and *Lab Worksheets* have specific due dates and times (**all deadlines follow Official UA Time**) but otherwise are self-paced. Students are free to work ahead by up to three (3) weeks.

Credit Hours: 1.

Number of Weeks: Course runs for 14 weeks during a regular semester.

Approximate Hours: Time commitment is approximately 1 - 3 hours per week in preparation and 3 - 5 hours per week to conduct and conclude the assignments or activities. For the entire course, this represents approximately 60 - 75 hours.

Intended Audience: This course is designed for students who would benefit from a technically oriented laboratory approach, in particular science and engineering undergraduates planning to take additional lab coursework and/or interpret the results of quantitative chemical analyses in their studies and/or profession.

A working understanding of algebra will be assumed. Calculus and trigonometry are not required. Students lacking skills in algebra are certainly welcome to this course but should understand that additional work may be necessary to remediate any math deficiencies. CHEM 146 is not an introductory math course. That said, an effort will be made to present the mathematics in a reasonably transparent manner.

Laboratory Instructor: Chemistry and Biochemistry (CBC) teaching assistant. Your **lab instructor's name** and **email address** can be accessed on D2L/Brightspace in the gradebook section. Click on 'Gradebook' in the menu bar of this D2L/Brightspace site. In the gradebook you will find your lab instructor's (TA's) **name** and **email**. *This is the individual to which all lab related (CHEM 146) questions/correspondence should be directed, not your CHEM 142 lecturer.*

Office Hours: The lab instructor will hold online (Zoom) office hours weekly (open format) with student attendance optional. The Zoom office hours and link/password will be posted on the course D2L/Brightspace site (*CHEM 146 Lab Instructor Contact Information* section under *Content/Start Here*) after 01-12-26.

Lab D2L/Brightspace Site: Course lab manuals, worksheets and supplemental materials will be posted on the CHEM 146 D2L/Brightspace site (<http://d2l.arizona.edu>).

S.2 Student Resources

Online (D2L/Brightspace, no additional cost to students):

- Written Materials (no texts are required for CHEM 146)
 - Lab Manuals (10 in total, all accessible on D2L/Brightspace)
 - Supplemental documents
- Graded Assignments
 - *Lab Quizzes* (10 in total, all taken on D2L/Brightspace)
 - *Lab Worksheets* (9 in total, all available on D2L/Brightspace)

S.3 Required Items

You will need, or have access to, a **reliable internet connected computer** with the spreadsheet program **EXCEL** installed. As a University of Arizona student, you should have free access to the “full” version of EXCEL (as part of Office 365). Avoid the “trial,” Google share, or other “simplified” versions, as these lack features needed to successfully complete the lab coursework.

Access to a **smart phone** or **digital camera** to record images (photos) during your at-home laboratory experiments will be necessary.

CHEM 146 requires a **custom at-home chemistry kit** that includes most of the materials and equipment needed to complete the hands-on portion of the course. There are two convenient options to purchase this kit:

- **Direct Online ordering*:**

<https://www.carolina.com/catalog/detail.jsp?prodId=582799>

The cost of the kit direct from Carolina is roughly \$215 + shipping. The kit will ship directly to you. ***This is the fastest and least expensive option – and is STRONGLY recommended to avoid delays and frustration.***

- **U of A Campus Store voucher:** You can purchase a voucher (cost approximately **\$265 + shipping**) from the *University of Arizona Campus Store* (which allows use of financial aid) and redeem it at the above link. To purchase the voucher, on UAccess go to your Booklist, there you will find a voucher purchase option. ***Select this method ONLY IF YOU SEEK TO USE YOUR FINANCIAL AID (Bursars account). The UA Campus Store voucher option is slower and costlier – you will still have to order the kit from Carolina using the voucher, but the voucher must first be mailed to you from the UA Campus Store, and if the UA Campus Store is out of stock on vouchers (which occurs frequently), this may add weeks of delay! Further, the voucher increases the cost of acquiring the kit by about \$50.***

**Please note, international students must contact Carolina Distance Learning directly to place an order. A Carolina Distance Learning Account Specialist can be reached at 1-800-334-5551 or distancelearning@carolina.com.*

The above CHEM 146 custom Carolina kit contains goggles, gloves, and a lab apron – so purchasing these separately is not necessary unless you desire an additional set. This online course *does not* require a formal lab notebook.

Please keep in mind, the kits are nonreturnable to Carolina – all kit sales are final.

Several at-home hands-on lab activities require items not included in the Distance Learning Kit. This includes, **bottled or purified water, paper towels, scissors, sandpaper (or emery boards)**, plain white sheets of **paper**, a **calculator**, and a **timing device** (smart phone, clock, stopwatch).

It is strongly recommended to wear **loose-fitting, full-length pants** and **completely closed shoes** while conducting the experiments at home. *In other words, no skin exposure from the waist down.* This means wearing socks as well. If you are concerned about chemical stains/damage to your pants, inexpensive loose-fitting reusable “scrub” pants can be purchased. Such scrub bottoms usually run \$6 to \$20 online.

S.4 Course Objectives and Learning Outcomes

The objective of CHEM 146 is to introduce and develop the principles and practices of laboratory chemistry in support of further laboratory coursework. After successfully completing CHEM 146, you should:

- Be proficient in the control of significant figures, scientific notation, and units.
- Gain further experience with dimensional analysis and chemical stoichiometry in laboratory calculations.
- Know how to employ EXCEL to process data and present the results.
- Be able to apply statistical techniques to analyze and express the precision of experimental data.
- Appreciate the purpose, principles, and process of calibration for instruments and experimental conditions.
- Understand the role of standards (knowns) in experimental design and data interpretation.
- Analyze flame atomic absorption spectroscopy data to quantitate a metal analyte via the constant-volume standard addition method.
- Perform volumetric neutralization titrations and back-titrations to determine analyte concentrations.
- Characterize the acid neutralizing capacity of antacids via gravimetric-titrimetric analysis.
- Analyze weak acid titration data to determine pK_a and molar mass values.
- Prepare and characterize buffered solutions.
- Collect and analyze kinetic data to explore the effect of concentration on a reaction rate and determine the rate law.
- Conduct experiments and analyze the results to develop a metal activity series.
- Build and measure voltaic cells and apply the Nernst equation.
- Apply the Nernst equation in the calibration of an ion selective electrode and analyte quantitation.

S.5 CHEM 146 Schedule of Assignments Spring 2026

Week	Dates	Lab	Modality	Assignment	Assignment Deadlines <i>(Official UA Time)</i>
1	Jan 14 - 23	Safety Agreement	Online Only	-	Before 9 pm 1-23-26
2	Jan 26 - 30	Lab 1 At-Home Laboratory Safety	Online Only	Lab 1 Quiz (25 p)	Before 7 am 1-30-26
3	Feb 2 - 6	Lab 2 Flame Atomic Absorption Spectroscopy (FAAS)	Online Only	Lab 2 Quiz (5 p)	Before 7 am 2-02-26
				Lab 2 Worksheet (25 p)	Before 9 pm 2-06-26
4	Feb 9 - 13	Lab 3 Acid-Base I: Titrimetric Determination of the Acetic Acid Concentration in Vinegar	At Home Hands-On	Lab 3 Quiz (5 p)	Before 7 am 2-09-26
				Lab 3 Worksheet (25 p)	Before 9 pm 2-13-26
5	Feb 16 - 20	Lab 4 Acid-Base II: Evaluating the Acid Neutralization Capacity of Commercial Antacids	At Home Hands-On	Lab 4 Quiz (5 p)	Before 7 am 2-16-26
				Lab 4 Worksheet (25 p)	Before 9 pm 2-20-26
6	Feb 23 - 27	Lab 5 Acid-Base III: Determining pK_a and Molar Mass by Weak Acid Titration	Online Only	Lab 5 Quiz (5 p)	Before 7 am 2-23-26
				Lab 5 Worksheet (25 p)	Before 9 pm 2-27-26
7	Mar 2 - 6	Lab 6 Acid-Base IV: Preparing and Characterizing Buffered Solutions	At Home Hands-On	Lab 6 Quiz (5 p)	Before 7 am 3-02-26
8	Spring Recess (Mar 9 - 13)				
9	Mar 16 - 20	Lab 6 Continued Acid-Base IV: Preparing and Characterizing Buffered Solutions	At Home Hands-On	Lab 6 Worksheet (25 p)	Before 9 pm 3-20-26
10	Mar 23 - 27	Lab 7 Session 1 Kinetics I: Effect of Concentration on Rates	At Home Hands-On	Lab 7 Quiz (5 p)	Before 7 am 3-23-26
11	Mar 30 - Apr 3	Lab 7 Session 2 Kinetics II: Determining a Rate Law Experimentally		Lab 7 Worksheet (25 p)	Before 9 pm 4-03-26
12	Apr 6 - 10	Lab 8 Electrochemistry I: Developing an Activity Series	At Home Hands-On	Lab 8 Quiz (5 p)	Before 7 am 4-06-26
				Lab 8 Worksheet (25 p)	Before 9 pm 4-10-26
13	Apr 13 - 17	Lab 9 Electrochemistry II: Voltaic Cells	At Home Hands-On	Lab 9 Quiz (5 p)	Before 7 am 4-13-26
				Lab 9 Worksheet (25 p)	Before 9 pm 4-17-26
14	Apr 20 - 24	Lab 10 Electrochemistry III: Calcium Ion Selective Electrode	Online Only	Lab 10 Quiz (5 p)	Before 7 am 4-20-26
				Lab 10 Worksheet (25 p)	Before 9 pm 4-24-26

S.6 Evaluation (Grading and Grades)

For CHEM 146 you will take 10 *Lab Quizzes*, and complete/submit 9 *Lab Worksheets*. **Table S.1** compiles all the *graded* items that will make up your CHEM 146 lab grade.

Grading Scale: 90 to 100% = A, 80 to <90% = B, 70 to <80% = C, 60 to <70% = D, 0 to <60% = E

Table S.1. CHEM 146 Graded Laboratory Assignments

CHEM 146 Lab Assignment	Points	% of Lab Grade
Lab 1 Quiz	1 online (D2L) Lab 1 (safety) quiz (25 p)	8.48
Lab Quizzes	9 online (D2L) quizzes (5 p each, 45 p total)	15.25
Lab Worksheets (and associated EXCEL files)	9 worksheets (25 p each, 225 p total)	76.27
<i>Total</i>	<i>295 p</i>	<i>100</i>

All the quizzes are automatically graded within D2L/Brightspace. Your performance on the *Lab Worksheets* will be evaluated by your CHEM 146 laboratory instructor.

No Extra Credit and No “Redos”

No extra credit and/or bonus points of any kind can be offered. Also, re-doing any laboratory assignment (quiz and/or worksheet), in part or whole, for a grade is not possible after the assignment deadline. Sorry, we cannot accommodate “redos” of any kind for any reason.

Lab course grades will be based solely on students' performance on lab assignments (quizzes and worksheets); these are not up for subjective negotiation. No other factors in addition to those described above and below will be considered (including, but not limited to, the need to get a certain grade to maintain a scholarship or get into a certain professional school). The laboratory instructor and laboratory supervisor will not respond to requests for higher grades or requests to discuss or negotiate grades, except if a technical grading error has occurred.

Dispute of Lab Assignment Grade

Any grading errors must be disclosed within **three days** of the release of a graded work. This means if you have concerns regarding a particular grade received (grading error) on a *Lab Quiz* or *Lab Worksheet*, you must discuss this with your lab instructor immediately. Do not wait! *After three days from the release of the graded assignment it will be assumed the grade received is accepted by you and*

*no further challenges to the grade will be considered. Please remember – you have **three days** to challenge an assignment (quiz or worksheet) grade, after which no further claims regarding the grading and/or grade will be entertained.*

After discussing a lab grading concern with your lab instructor, if you feel the matter is not resolved, you may contact the laboratory supervisor, Mark Yanagihashi (op106bf@arizona.edu). The supervisor will review your grading concern and if necessary, regrade the work. Understand, any regrade is absolutely final and that the entire work may be re-graded, which can result in a lower score. A given assignment may be submitted for grading error review only once. **The supervisor review must be requested within three days of the release of a graded work. It is strongly recommended that you first attempt to resolve any grading errors with your lab instructor and only resort to the supervisor in the case of irreconcilable differences.**

Please remember – you have only **three days** after the release of a graded assignment to discuss a grading error concern with your lab instructor and submit for a supervisor review – after **three days** it will be assumed the grade received is acceptable to you. A given assignment may be submitted for grading error review only once.

The absolute last day for a supervisor grading error review is Apr 30th, 2026. **There will be no extensions to this deadline**, so for the last CHEM 146 assignment, please bring forward any grading issue *well before* Apr 30th, 2026.

Incomplete (I) or Withdrawal (W)

Incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at:

<http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete>

and

<http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal>

A grade of “Incomplete” can only be granted when all but a minor portion of the course work has been satisfactorily completed and a valid argument can be made as to why an incomplete should be awarded. For example, missing the last two *Lab Worksheets* due to a documented emergency (assuming satisfactory performance during the semester) may result in an incomplete. To the contrary, realizing at any point during the semester that you are in danger of a failing course grade is not a valid reason for granting an incomplete.

S.7 Assignment Deadlines

You are free to work ahead by up to 3 weeks - however your lab instructor will grade a given *Lab Worksheet* only after the posted deadline for the worksheet. This is being done for greater grading consistency and to avoid releasing “answers” before the deadline.

Lab Quizzes

All *Lab Quizzes* must be completed before 7 am (Official UA Time) on the dates stated in *CHEM 146 Schedule of Assignments Spring 2026* on page 4. *Quizzes cannot be reopened. No extensions are possible and a zero must automatically apply to any missed quiz.* The quizzes open THREE WEEKS before the deadline, so you have three weeks to complete a relatively simple quiz. **Hence, the deadlines are absolute.** Please do not procrastinate. If you wait until the last-minute and run out of time or encounter a technical difficulty, the resulting quiz grade must stand.

If you are aware of a potential time conflict and/or personal matters that may interfere with completing a *Lab Quiz* by the published deadline, then please take the quiz in advance. On a similar note, if you want insurance against the unforeseen, completing a quiz well before its deadline would be a fantastic idea!

Lab Worksheets

The *Lab Worksheets* are due before 9 pm (Official UA Time) on the dates stated in the *CHEM 146 Schedule of Assignments Spring 2025* on page 4. You are given sufficient time (at least a week with the ability to work up to three weeks in advance) to complete the *Lab Worksheets*, so the stated deadlines are absolute. **No extensions can be granted for ANY reason**, and a zero must automatically apply to any missing or late submission. No “late penalty” will be available. The only acceptable excuses are situations such as an illness of significant duration (many days), in which case proper documentation must be presented. In such cases, with valid, verifiable documentation, an *exempt* may be granted, and the associated *Lab Worksheet* waived. In other words, the missing score from the associated worksheet can be excused. **To be considered for an “exempt,” you must contact your lab instructor within one day of the missed deadline stating the request and reason for an exempt.** The number of such *exempts* (excused *Lab Worksheets*) is limited to two (2), meaning after two *exempts*, additional *exempts* will not be entertained.

If there are potential time conflicts and/or personal matters that may interfere with completing and submitting a *Lab Worksheet* by the published deadline, then please complete and submit in advance. If you want insurance against the unforeseen, completing and submitting each worksheet well before its stated deadline would be an excellent strategy!

Your D2L *Lab Worksheet* submissions should be PDF files to avoid compatibility issues. The PDF format historically has been the least problematic and so is **strongly recommended.** If you submit any other file format and your lab instructor cannot open/read the file, you will have to resubmit as a PDF file and a 10% penalty may apply. [*This PDF requirement does not apply to possible EXCEL file submissions, which should be submitted as is (not converted into PDF files).*]

It is your responsibility to submit all the *Lab Worksheets* and any associated files on time and to the correct D2L/Brightspace **Assignment Submission** folder.

Always check to confirm the correct document(s) has(have) imported. Please pay attention! A low score resulting from an unintended submission cannot be changed.

If you submit an unintended document, or need to update a submission, you can always resubmit so long as the deadline has not passed. If you submit the wrong document and fail to realize this until after the deadline, a resubmission cannot be accepted. So, please be careful and always double check!

Always check to confirm you have uploaded to the correct lab D2L Assignment Submission folder. Each Lab Worksheet submitted by its stated deadline, but to an incorrect Assignment Submission folder, may be subject to a 10% penalty. Always double check!

Please do not procrastinate. If you put off completing and submitting your *Lab Worksheet* until the last minute, and for some reason cannot complete the assignment on time, or encounter a technical difficulty, the consequences are of your making. ***As insurance against the unforeseen, it is strongly recommended to work in advance.***

While your lab instructor takes seriously the timely response to emails, expecting a response within an hour, and/or at odd times of the day (local time), may not be reasonable. This is another reason for completing assignments well in advance of their deadline. Your lab instructor has the authority to specify appropriate limits on responding to emails, especially very close to the lab worksheet deadlines.

If you are submitting well before the deadline (as in at least a half day) and experience a technical difficulty beyond your control, then please immediately notify your lab instructor. If you do not contact your lab instructor *well before the deadline*, the work will automatically receive a “zero” if submitted after the deadline. There are alternatives should you encounter a D2L/Brightspace upload problem. For example, you can arrange with your lab instructor for submission via email attachment.

Just to be clear, you alone are responsible for submitting all Lab Worksheets on time and to the correct location. If you encounter a legitimate technical difficulty, you must inform your lab instructor well before the deadline to avoid a score of “zero.”

If for some reason, you believe your lab instructor did not receive your *Lab Worksheet*, say something! Please don't wait for days/weeks on end before acting. You should routinely check your lab D2L/Brightspace grades; if a grade is absent for work submitted over a week ago, please contact your lab instructor.

A grade of zero will be awarded for each missed quiz. An “exempt” cannot be awarded to quizzes because they are available for weeks in advance. There will be NO EXCEPTIONS to this policy.

For each Lab Worksheet not submitted by the published deadline, a grade of zero will result unless an “exempt” has been granted. There will be NO EXCEPTIONS to this policy.

S.8 Online Office Hours with Your Laboratory Instructor

Your lab instructor will hold online (Zoom) office hours weekly (open format) with attendance optional. **You are strongly encouraged to attend.** The Zoom office hours and link/password will be posted the course D2L site (*CHEM 146 Lab Instructor Contact Information* section under *Contents/Start Here*) after 1-12-26.

S.9 Absence Policy

If you are planning an absence or have a potential time conflict such that completing and submitting an assignment by the published deadline may prove difficult or impossible, then please complete and submit your Lab Quiz and/or Lab Worksheet in advance. This also applies to religious observances that conflict with the published assignment deadline(s).

For planned absences from your lab instructor’s online office hours, inform your lab instructor by email well in advance so accommodations can be secured. In many cases, you can arrange with your lab instructor alternate times – but please do not abuse this.

The UA and CBC policies regarding absences for a sincerely held religious belief, observance or practice will be accommodated where reasonable:

<http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

The calendar of religious holidays recognized by the University of Arizona is posted here:

<https://www.registrar.arizona.edu/calendar-religious-holidays>.

The lab instructor will provide reasonable accommodations for students observing religious holidays, *only if the date(s) of the observed holiday(s) overlap with (an) online office hour(s)*. To receive an accommodation, you are required to inform your lab instructor by email about the potential conflict between the observed religious holiday(s) and the scheduled remote office hour date(s). Accommodation requests for all religious holidays that occur during the Spring Semester must be received by your lab instructor no later than Jan 23rd, 2026. The lab instructor is not obliged to provide accommodation for online office hours missed due to such holidays if the request is not submitted by 1-23-26.

S.10 Behavior

The University's **Code of Academic Integrity** and **Student Code of Conduct** governs behavior in CHEM 146. The Dean of Students' office provides a comprehensive index of important University policies and procedures:

<http://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity>.

All students must follow the University Code of Conduct and Code of Academic Integrity. Any violations will be reported to the Dean of Student's Office.

Further, you must adhere to all rules and regulations regarding safe chemical practices as detailed in the *Lab 1 Manual (At Home Lab Safety Guide)*.

Online Behavior

Students will treat the lab instructor and their fellow students with respect.

The University seeks to promote a safe online environment where students and employees may participate in the educational process without compromising their health, safety or welfare. The policies are outlined on the following website:

<https://deanofstudents.arizona.edu/accountability/disruptive-student-behavior>

To foster a constructive learning environment, our focus must be on the tasks at hand and not on extraneous activities such as texting, chatting, phone calls, web surfing, playing music, etc. while with the lab instructor and/or other students during online office hours.

Discrimination and Harassment

The University has policies against discrimination and harassment. The policies are outlined on the following website:

<http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>.

Our online courses are places where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without bullying or discrimination.

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See:

<http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>

Accessibility and Accommodations

The goal is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please

contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit <http://drc.arizona.edu>. Should you have reasonable accommodations, please discuss with your lab instructor and/or the lab supervisor implementation of the accommodations.

Originality and Plagiarism

Presenting material (for a grade) under your name that is *substantially the same* as some other work such as, but not limited to, another worksheet, notebook, report, proposal, presentation, journal article, textbook, or webpage, constitutes an Academic Integrity violation. In other words, material submitted under *your name alone must be your own original work*. Occasionally, you may need to use exterior sources for physical constants, reference values, chemical structures, etc. When using such sources, they must be properly attributed. Failure to properly attribute work is an Academic Integrity violation.

The guiding principle of academic integrity is that any work you submit must be your own work. All calculations, graphs, tables and writing must be entirely your own work product. Failure to do so constitutes a violation of academic integrity and will automatically result in a score of “zero” for the *Lab Worksheet*. Violations will also be reported to the Dean of Students and may result in sanctions. If you are unsure about any of the above policies or conditions, ask your laboratory instructor or the CHEM 146 lab supervisor.

Selling and Posting Course Materials

Selling course materials to other students or to a third party for resale is not permitted. Posting course materials on external file sharing sites (Chegg, Course Hero, etc.) or the internet is strictly prohibited. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in sanctions. Additionally, students who use D2L/Brightspace or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct also constitutes copyright infringement.

S.11 Additional Resources for Students

UA Academic policies and procedures are available at:

<http://catalog.arizona.edu/policies>.

S.12 Subject to Change Statement

Information contained in this course syllabus may be subject to change with advance notice, as deemed appropriate by the laboratory supervisor.