

Analytical Chemistry
Course Number 50:160:325:01 (CHEM 325)
RUTGERS, CAMDEN

FALL 2024

I. LOGISTICS

Instructor: Dr. Kumi, SCI-225 (office), george.kumi@rutgers.edu (email)

Class Meeting Times & Location: Monday, Wednesday & Friday at 10:20 AM-11:15 AM; Fine Arts Building Room 225

Instructor Office Hours: Friday 3.00 – 4.00 PM or by appointment

II. COURSE DESCRIPTION AND OBJECTIVES

Pre-requisites and Co-requisites for Analytical Chemistry (50:160:325:01). The required chemistry *pre-requisite* is Chemical Principles II (50:160:116). The required chemistry *co-requisite* course is Analytical Chemistry Laboratory (Course 50:160:329). If for any reason, you do not meet (e.g., have not taken or are not taking) the stated course pre- and co-requisite courses, please notify the course instructor within the first week of classes.

Course description. This course presents the basic principles and techniques of chemical analysis with the goal of providing students with the skills necessary to address such analyses, particularly where quantitative determinations are of prime importance. More specifically, it covers topics such as Statistical Analysis of Data, Chemical Equilibria, Titrimetric and Electrochemical Analysis.

Student Outcomes for this Course. As a result of participating (and passing) this course, a student will be able to:

- Define, and provide a general picture about the importance of, Analytical Chemistry (as a field or area of chemistry)
- Statistically evaluate experimental data to report the uncertainty associated with a measurement (e.g., via propagation of error or confidence intervals) and compare results using various statistical tests (i.e., *t*-tests, *F*-test, and Grubbs Outlier test)
- Explain the importance of chemical equilibrium to the field of Analytical Chemistry
- Apply the fundamental concept of chemical equilibrium to quantitative chemical analyses (e.g., use common equilibrium constants in stoichiometric calculations related to aqueous solution chemistry, use the systematic treatment of equilibrium approach to carry out complex chemical equilibria calculations)
- Balance electrochemical reactions and describe galvanic cell operation (using terms such as standard cell notation, cell potential (*E*) and standard cell potential (E_{cell}°))

Course website. A Canvas-hosted course website has been created for this course. All students must have a Rutgers email address (RU NetID) in order to access the course material and information on Canvas. Go to <https://canvas.rutgers.edu> and log in. This Analytical Chemistry course (Fall 2024) should be listed as one of your courses (under the ‘Courses’ selection) if you have a Rutgers NetID and are enrolled in this course. It is important to check this course site on a regular basis for class announcements, e.g., new assignments, updated lecture schedules.

Required Course Text. *Analytical Chemistry 2.1*, by David Harvey. This open-access (i.e., free) digital textbook, and its accompanying solutions manual, is the latest edition of a conventional (i.e., print) analytical chemistry course textbook (*Modern Analytical Chemistry*, by David Harvey) that was first

published in 1999 (by McGraw-Hill). This well-organized and informative text can be viewed online (http://dpuadweb.depauw.edu/harvey_web/eTextProject/version_2.1.html) or via a pdf download of the textbook (at the above listed website).

Supplementary Course Material (not required but *very* useful for understanding concepts). *Quantitative Chemical Analysis, 8th ed.*, by Daniel C. Harris, W. H. Freeman & Company, ISBN:9781429218153. Unfortunately, this is not a freely available text.

III. COURSE TOPICS AND TENTATIVE TIME TABLE

Week 1 - 5

Analytical Chemistry: What is it and why is it important to chemistry and society?

Analytical chemistry versus (routine) chemical analysis, the analytical approach/process and what an analytical chemist does, classifying the different types of chemical analysis (quantitative, qualitative, characterization, and fundamental analyses)

The mathematical tools of Analytical Chemistry – a brief review

Systems of units, uncertainty in measurements, significant figure notation, common units of concentration and their interconversion, *p*-functions and their usefulness, standard (i.e., stock) solution preparation

Data analysis – an introduction to the treatment of experimental data

Understanding analysis terminology (i.e., accuracy, precision, error, uncertainty), characterizing errors – determinate versus indeterminate error, propagating uncertainty

Dealing with indeterminate error in measurements – population versus sample statistics

Statistical populations and samples, the normal or Gaussian distribution and its usage (e.g., determining areas under the normal distribution), confidence intervals and their meaning, significance and outlier testing

Week 6 - 12

Aqueous solutions and chemical equilibria

The importance of chemical reactions in Analytical Chemistry, chemical equilibrium and the nature of chemical reactions, chemical equilibrium and thermodynamics, common equilibrium constants, solving complex equilibrium problems (solubility, monoprotic/polyprotic acid-base, complexation) via the systematic treatment of equilibrium, activity and its role in equilibrium calculations, speciation and principal species determination

Volumetric analysis

Titration calculations, Monoprotic and polyprotic acid-base titration curve calculations, acid-base endpoint indicators

Week 13- 15

Electrochemical analysis – electrodes and potentiometry

Fundamentals of electrochemistry, Galvanic cells, Standard Potentials, the Nernst Equation, Formal potentials, ion-selective electrodes, potentiometry

IV. COURSE ASSESSMENTS AND ASSESSMENT POLICIES

Assignments. Over the course of the semester, there will be numerous (~10) assignments. These assignments are to be completed by their designated due dates, which will be explicitly shown on the assignment and made known to you on the course website (see Tentative Class Schedule posting on the

class website). Unless there is a documented extenuating situation that prevents an assignment from being submitted on time, the grade for that assignment is zero. With appropriate documentation, the grade for a late assignment is a student's average assignment grade for the entire course.

Assignments can be handwritten or typed (or a combination of these modes), and *all* assignments must be submitted online via the Canvas course website. Submitted documents should be a *single document in pdf format* (e.g., not a series of images or files); no other file types will be accepted/allowed for such submissions. In general, assignment submissions will be due by the beginning of a specified class session. However, the deadline for each assignment will be explicitly specified once the assignment is posted.

For assignments handed 'in-person', there will be a designated spot on the desk facing the class, e.g., on the teacher's desk, where assigned problem sets should be placed immediately preceding the class. Two minutes into class time, the pile of submitted assignments will be moved to another location. Any 'in-person' assignment not submitted prior to this transfer is late. To prevent any student from copying another student's work, all 'in-person' submitted assignments must be submitted personally. Please do not give your assignment to another student to hand in for you. If you know you will not be able to make it to class on the day an assignment is due, hand the assignment to me early (i.e., prior to the due date) or use the online submission option. Any assignment that is handed in and consists of multiple sheets of paper must be stapled prior to being handed in. Violations of this policy will incur point deductions on that assignment. Please note that no stapling devices will be provided in class, so all are advised to make their own arrangements to conform to this course policy.

Together, these assignments will count toward 100 out of the 680 points used to assign course grades (i.e., ~15 % of the course grade). They are an important aspect to doing well in this class – do not take them lightly! For the assigned problems sets, how you arrived at your final answer is more important than the answer itself. Any submitted assignment that does not explicitly show how calculated results were obtained will be deemed incorrect. In fact, if there is any ambiguity as to how you arrived at an answer for a specific problem, that problem will be assigned a score of zero. The assigned problem sets represent a subset of the problems available to you in your text, and it is strongly recommended that you further your understanding by tackling unassigned problems and perusing the listed additional resources in the chapters covered in this course. At the end of each chapter of the text, there is a list of 'Key Terms'. For chapters covered in class, it will be important for you to make sure you understand the each of the terms in this list *that were covered in class* – these are the terms that will typically be used in the wording of problems for exams and quizzes.

In this course, you *are permitted* to discuss any aspect of any assignment problem (e.g., resources that helped you understand the problem, the answer, the set-up of the problem solution) with anyone in this course who is willing to discuss that problem with you. However, you are not allowed (at any time and for any reason) to show (or provide) your written/typed out solution for any problem to anyone in the course. Conversely, you may not view the written/typed out solutions of any course participant. Put succinctly, you may discuss assignment problems (to enhance understanding and communication skills) but you may not view others written/typed out solutions to these problems (because this can lead to copying without understanding).

Quizzes. Several (~4) quizzes will also be used to assess how well students are attaining the course student learning outcomes (see above). Unless there is a documented extenuating situation that prevents a quiz from being done on time, the grade for that quiz is zero. With appropriate documentation, the

grade for a missed quiz is a student's average quiz grade for the entire course. *There are no make-up quizzes.* Together, these quizzes will count toward 80 out of the 680 points used to assign course grades (*i.e.*, ~12 % of the course grade).

Exam Policy and Grading Procedures. There will be 3 exams, each worth 100 points, and a comprehensive final exam, which is worth 200 points. No make-up exams will be given without the submission of supporting documents (e.g., a doctor's note, police report) for an extenuating circumstance. Notification about a missed exam should be done as soon as is possible (any delays may factor into how accommodations are provided). *Any make-up exam must occur within a week of the missed exam; be sure to provide times that you will be available to take a make-up exam when notifying the me.* Whenever possible, notification about missing an exam should be received before the date of the scheduled exam and with appropriate documentation. The course grading assignment scheme is listed in a boxed area within this document. Please note that no score adjustments (e.g., 'curving') will be performed on exams or quizzes. Also, there are no extra credit assignments or exams (so *please* do not ask if there are any of these available for this course). However, there are often extra credit questions included on course exams.

If your *percentage* score on the final exam is higher than the lowest percentage score of your 3 exams, this lowest percentage score will be replaced by your final exam percentage. This is to reduce the impact that one poor exam performance can have on your overall course grade, as well as to encourage and motivate you to review (or seek help reviewing) course material that you were unable to demonstrate an understanding of on an exam administered before the comprehensive final exam.

Re-grading. If you find or suspect an error in the grading of an assessment, you have the option of returning this material to me for a re-grade. Requests for re-grading must be submitted within a week after the graded material *is made available*. When requesting a re-grade, please include a note describing the issue of that assessment you would like to have addressed. Note that exams/quizzes/assignments submitted for re-grading are subject to a *full* re-grading so as to ensure there are no other grading errors on that assessment.

Late assignment advice. Please notify me as soon as possible whenever you are struggling to keep up with the assigned course work. Missing deadlines can be stressful, and my goal will be to help you develop a plan to mitigate (if not eliminate) your major struggles. Also, please contact me ahead of time if you believe you will not be able to complete an assignment on time to see if we can make other arrangements that will be fair to all in the course.

<u>Assessment</u>	<u>Course pts</u>	<u>Course %</u>
3 Exams (100 pts each)	300 pts	~44
1 Final	200 pts	~29
Quizzes	80 pts	~12
Assignments	<u>100 pts</u>	<u>~15</u>
Total	680 pts	100

Course Grade	% of 700 points
A	100 – 90
B+	89 – 87
B	86 – 80
C+	79 – 77
C	76 – 70
D	69 – 60
F	< 60

V. COURSE CONDUCT

Course Attendance. As per current Rutgers University stipulations/guidelines, this is an *in-person instructional mode* course (*i.e.*, there is no 'remote learning option' for this course). In accordance with

university policy, student attendance is *required* at every scheduled course meeting, *i.e.*, attendance is mandatory.

While attendance in this course will be checked, *no points are given for attendance*. The purpose of taking this record is simply for pedagogical reasons – to see how well good grades correlate with attendance – and to be able to say something about your sense of responsibility should someone inquire about this character trait during the semester or at some future time. That said, a bad attendance record generally has an indirect negative effect on your course grade through various factors, *e.g.*, missing in-class quizzes, missing peer-assisted collaborative learning, and missing lectures. Tardiness and early exiting (*i.e.*, leaving before class ends) can result in your being marked absent if attendance is taken during your absence. Therefore, be on time for class and do not leave class prior to its conclusion.

While no course points will be *given* for attendance, course points may be deducted for unexcused absences (for up to 5% of the total course points) and for being late to class. The institution of such measures will be based on the overall class conduct; if all course participants attend class regularly and are on time (*e.g.*, no more than one unexcused absence and one incidence of tardiness per student over the course of the semester), no course points will be deducted for absences and tardiness for all participants. The class will be informed prior to the commencement of measures to address absences, tardiness, and early exiting.

Use the Student Self-Reporting Absence system (<https://sims.rutgers.edu/ssra/>) to notify me about any absence and contact me directly. Note that reporting an absence does not automatically excuse that absence. It simply notifies the instructor about your absence. It is up to the instructor to determine how to accommodate or deal with this absence in accordance with the stated course policy described in the course syllabus. Excuses considered 'non-extenuating' (*e.g.*, I overslept, I forgot about class today, I had to work, traffic was a little slow) will not result in an excused absence. Also note that it is University policy to excuse **without penalty** students who are absent because of **religious observances**. If possible, notify the instructor of such absences during the first week of the semester (and also complete the Student Self-Reporting Absence system on the day or days of the absence). Also, note that by registering for this course you are stating that you are available to take the course Final Exam week during Finals Week at the end of the semester.

Calculators. Going along with the general philosophy that 'I hear and I forget, I see and I remember, I do and I understand', we will engage in many in-class examples. These examples will require that you have a calculator, and therefore it is your responsibility to bring a calculator to each and every class. There are no stipulations on the type of calculator except for the fact that it must be able to perform simple arithmetic (addition, subtraction, multiplication, division) and basic logarithmic calculations. Any student who does not bring a suitable calculator will be deemed 'unready' to participate in class activities and will be asked to leave the class.

It is generally a good idea to use a calculator that you are familiar with for any course quizzes/exams; unfamiliarity with a calculator can significantly slow you down and result in uncharacteristic errors. In this course, no cell phone calculators are allowed during quizzes/exams. Therefore, it is strongly recommended that students do not use cellphone calculators to solve assigned problems in this course (*in and outside of class*), instead students should use a calculator permitted for use in course quizzes/exams.

The University's Code of Student Conduct. It is the responsibility of each and every student to have read the *Rutgers University Code of Student Conduct* as it specifies the obligations of any individual

enrolled as a student ([University Policy 10.2.11 \(rutgers.edu\)](#)). If you have not read it, it is suggested that you do. The standards of classroom behavior are dictated by this code of conduct. Accordingly, students may not interfere with classroom procedures by distracting or disruptive actions (*e.g.*, talking while the instructor is talking, making distracting noises, coming late to class, allowing a cell phone to ring). Any students who engage in such prohibited acts *can* and may be penalized (*e.g.*, asked to leave the meeting for the remainder of the class period). Please do not drift off to other activities while in course sessions and please turn cell phones off during these sessions to minimize distractions (if possible).

Academic Integrity. *Every student is prohibited from engaging in violations of academic integrity.* Note that every instructor is ethically bound to follow certain procedures once a student is caught, or suspected of, breaching of academic integrity (see *Rutgers University Academic Integrity Policy*). In particular, any material submitted by a student in this course for academic credit (*i.e.*, grading) must be that student's own work. Also, all students should strictly adhere to the rules governing any particular quiz or exam that is assigned. It is the responsibility of each and every student to have read the current Rutgers Academic Policy as it specifies the obligations of any individual enrolled as a student (<https://deanofstudents.camden.rutgers.edu/academic-integrity>).

Audio/Visual Recordings. Neither audio nor video recordings of lectures are allowed without the explicit consent of the instructor. Also, listening to any audio or video recordings during class meetings is not allowed without instructor consent.

Course material copyrights. The lecture slides and other course materials (including exams and quizzes) are protected by copyright. You may take notes and make copies of course materials for your own use. You may not and may not allow others to reproduce or distribute these course materials publicly (whether or not a fee is charged) without the copyright holder's (*i.e.*, the course instructor's) express written consent.

VI. OTHER PERTINENT COURSE INFORMATION

Rutgers University has several support services and resources that exist to facilitate *your academic success* and well-being. Details of these services and resources can be found at <https://studentaffairs.camden.rutgers.edu/student-resource-list>, and you are **highly encouraged** to visit the aforementioned website *at the beginning of the semester* so that you know what services are available to you (in case you need them at some point during the semester). A few of these services are listed below.

Accommodations for Students with Disabilities. Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: <https://ods.rutgers.edu/students/documentation-guidelines>. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form at <https://webapps.rutgers.edu/student-ods/forms/registration>. Please note that this is a process (*i.e.*, it takes time to review requests) and that instructors cannot make any accommodations until instructed to do so by a Letter of Accommodations. Therefore, if you need (or

even think you might need) accommodations, please start the process as early as you can. The Rutgers-Camden disability office website can be found at <https://success.camden.rutgers.edu/disability-services>.

Time Management. Like most Chemistry courses, this course generally requires a relatively large amount of time and preparation. Though I will do everything in my power to guide and help you, what you ultimately get out of the course reflects the effort that YOU put into the course. That said, please remember that your grade is based on how well you demonstrate knowledge of course material - not attendance, effort, how polite you are, *etc.*

To adequately prepare and learn the concepts being imparted in this course, the general consensus is that for **every 1 hour of class time you will need 3 hours of study/reading**. We will meet for roughly 3 hours each week, **so you need to be able to have at least 9 hours** (interdispersed throughout the week) to study for this course alone. Please make necessary adjustments in your study habits, course load, time management and work schedule – at the start of the semester – so that you will be geared to succeed.

Division of Student Academic Success Services. The Division of Student Academic Success (DSAS) at Rutgers-Camden (<https://success.camden.rutgers.edu>) assists students through a variety of support and services including free tutoring, supplemental instruction, and academic coaching. It will be beneficial to contact DSAS to learn more about these services and to determine if you will be able to use any of their services to enhance your learning abilities and success in this and other courses. In particular, the Learning Center (learningcenter@camden.rutgers.edu) provides Learning Specialists who can help you build a learning plan based on your strengths and needs. Tutors, study groups and more services are available you at no additional cost (i.e., you have already paid for these services to be available). In addition, if English is not your first language and this causes you concern about the course, the Learning Center can help. To learn more about the Learning Center or to schedule an appointment, visit the Learning Center website (<https://learn.camden.rutgers.edu/>) or call (856) 225-6442.

Rutgers-Camden Dean of Students Office. The Dean of Students Office (<http://deanofstudents.camden.rutgers.edu/>) provides support, care, and advocacy to ensure students can thrive both academically and personally. One of the goals of this office is to limit student stress by providing resources to mitigate areas of student concern. For some students, personal, emotional, psychological, academic, or other challenges (inside or *outside the classroom*) may hinder their ability to succeed both in and outside of the classroom. The Dean of Students Office serves as your initial contact if you need assistance with these challenges. Thus, this office is a vital resource whenever you are unsure of how to proceed on *any* matter you feel is impairing your ability to thrive academically and personally.

Pronouns. This course affirms people of all gender expressions and gender identities. If you have a preferred gender pronoun, feel free to correct me. If you have any questions or concerns, please do not hesitate to contact me.

Title IX and the Violence Prevention & Victim Assistance Office. The office for Violence Prevention and Victim Assistance (VPVA) provides support to students who have experienced sexual violence, domestic/dating violence, stalking or any form of sex or gender discrimination. For more information about VPVA or to schedule a time to speak with an advocate visit the VPVA website (<https://vpva.camden.rutgers.edu>). To report an incident or speak with the Title IX coordinator, please

visit the Title IX website (<https://respect.camden.rutgers.edu>). If you choose to disclose to me, thank you for trusting me. However, please note that I am obligated to report any disclosure to our title IX coordinator to ensure you receive the appropriate support and university response.

Emailing the instructor. Emails are a common and effective way to communicate, and I strive to answer every student email¹. Thus, please do not hesitate to email me about any course-related matter you might have; be sure these emails originate from your official Rutgers email account to prevent any unexpected technical issues. However, please also have the professional courtesy to give me at least 24 hrs to respond to any email; sending multiple emails about the same query within 24 hrs will not result in a quicker response (and is, in general, not professional). If I have not responded in the 24-hr time frame, I encourage you to assist me by emailing again to notify me that you are still awaiting a response to your initial email. Please do not consider this follow-up email to be rude or unprofessional. It may be necessary if (for some reason) your original email was not received (or mistakenly overlooked or forgotten about). In the event that I have not responded to two consecutive emails, please take the time to wait behind after the next course meeting to directly inform me about your email.

Suggestions to facilitate your success in this course.

1. There is a good reason why many science courses have prerequisite courses – science courses *build* upon one another. Thus, just having taken the pre-requisite course is not enough, it is assumed that you understand and *remember* the material in that course. Thus, no (or only very brief) reviews of the pertinent pre-requisite material is typically undertaken in chemistry courses, and that will be the case for this course. Instead, the focus will be on how this required material applies to Analytical Chemistry. Thus, it is a good idea to have the textbooks for any pre-requisite courses on hand to help you review any forgotten concepts. That said, a lot of this information is also readily available online.
2. From the first day of class, start and continuously update a list consisting of every single problem we go over or solve as a group in class. This list will serve as a good review tool as you prepare for the course exams.
3. Read (and take notes for) the portions of the course textbook to be covered in class prior to coming to class. This reading often facilitates a better understanding of important concepts before class. It also will make you more prepared to participate in class discussions. Indeed, without constantly reading the text during the semester you are setting yourself up to fail.
4. Go over the lecture slides and your class notes after every class (as soon as is possible). Do this prior to the next class.
5. Use the assigned weekly office hours or schedule a different time to meet with me during the week. Come to these meetings with questions, even about course topics you **THINK** you understand. Frequently, students **THINK** they understand something, but they really don't (or at least not very well).
6. Doing well at the beginning of the semester is crucial to succeeding in this course. A lot of what is taught in the first few weeks permeates throughout the rest of the course. My advice is to really put in work during the first month; it makes a ton of difference.

¹ See <http://web.wellesley.edu/SocialComputing/Netiquette/netiquetteprofessor.html> about emailing etiquette

I have called the comments above 'suggestions' but in all honesty I find them to be requirements for most students. Rest assured that discussions as to why you are not doing well in this course will always commence with 'are you implementing all of these things?'.