ANALYTICAL CHEMISTRY LABORATORY
Course Number 50:160:329 (CHEM 329)
RUTGERS, CAMDEN

FALL 2024

I. LOGISTICS

Instructor: Dr. Kumi, SCI-225, george.kumi@rutgers.edu
Class Location and Time: Tuesday 2:00 – 5:00 PM; Science Building Room 329
Instructor Office Hours: Friday 2.30 – 3.30 PM, or by appointment and via open door policy

II. COURSE DESCRIPTION AND OBJECTIVES

Course Pre-requisite: CHEMICAL PRINCIPLES II (50:160:116)
Course Co-requisite: ANALYTICAL CHEMISTRY (50:160:325)

Course description. This laboratory course provides students with the practical (i.e., experiential) training required to undertake and interpret various quantitative chemical analyses. In particular, this course focuses on various *volumetric analyses* and also employs these analyses as means to apply various statistical analyses of data. The basis of electrochemical analytical methods and the application of potentiometric methods are also covered. Laboratory reports of each experiment are utilized to enhance a student's capability to find and effectively present written chemical information.

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

- Conduct various volumetric analyses, e.g., neutralization, complexation, and interpret the obtained results. This includes being able to statistically process 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 (*t*-tests, *F*-test, and Grubbs Outlier test only)
- Write a detailed report for a performed experiment; this process necessarily involves understanding what is typically included/excluded from scientific reports and the various ways such reports can be organized
- Describe or undertake one specific electrode-based electrochemical analysis (including the underlying principles associated with that method)

Course website. A Canvas-hosted course website has been created for this course. All students must have a Rutgers netid (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 laboratory 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 Materials. Each of the following materials (except for the text) must be brought to each lab session; see 'Lab Reports' section below for specifics on notebooks.

(a) Text: There is no required text for this course. Instead, all necessary handouts will be posted on the course website.
(b) Safety goggles (not glasses!)
(c) A laboratory coat; this coat must reach your knees – shorter coats will not be permitted – and cover your entire arm

(d) 1 bound laboratory notebook
(e) A scientific calculator

III. COURSE TOPICS/CONCEPTS

Laboratory Safety and basic quantitative chemical analysis laboratory procedures review
Review/assignment/discussion of several readings in Chemical Safety, e.g., *Safety in Academic Chemistry Laboratories: Best practices for First- and Second-year University students* (an American Chemical Society publication), serial dilution, solution preparation, pipetting, glassware cleaning, burette use, the precision of different volumetric lab glassware

Data analysis
Sample and population statistics, hypothesis testing

Neutralization-based volumetric analyses
A comparison of acid-base indicators, the standardization of acids and bases, the preparation of standard (acid and base) titrants and the determination of the concentration of base (e.g., $Mg(OH)_2$) in commercial antacid tablets, the generation and interpretation of pH titration curves (using pH electrodes), determining the alkalinity of a seawater sample

Complexation-based volumetric analyses
The argentometric titration of a chloride solution, the EDTA-based determination of seawater 'hardness'

Electrochemical analysis
The determination of the standard reduction potentials of galvanic cells

IV. COURSE ASSESSMENTS AND ASSESSMENT POLICIES

Course Grades. Course grades will be assigned using the grading distribution specified in the Grading insert. Grades will be based on these criteria alone. No extra credit will be available on an individual basis. The main source of assessment in this course will be laboratory reports for the experiments conducted. However, 1-2 quizzes/worksheets (e.g., on Laboratory Safety and the Syllabus) and laboratory conduct (e.g., preparedness, good housekeeping) will also contribute to the grade assignment. There are no scheduled exams for this course.

Grading:

Lab reports	80 %
Quizzes, Worksheets	10 %
Instructor's discretionary	10 %
Total	100 %

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

Most experiments will be conducted individually. For some experiments, all the data collected by course participants will be shared with the class and laboratory reports will involve analysis/processing of this pooled data.

Laboratory Reports. Complete laboratory reports (which should include the previously submitted Pre-lab associated with that report) for each experiment will be due *an hour before* the beginning of the ensuing course session (i.e., 1 pm for a 2 pm starting lab session); thus, in general, the report for a specific experiment will be due a week after that experiment is completed. No late submission will be accepted *unless* there are documented mitigating reasons. The grade for a late or 'not submitted' report is zero. Laboratory reports can be handwritten or typed (or a combination of these modes) but *must be submitted online via the Canvas course website*. Every submitted report should be a *single document in*

pdf format (e.g., not as a group of several images or files); no other file types will be accepted/allowed for such submissions. Graded reports will be made available within a week after they are submitted.

Pre-lab. Sections 0 – 5 of a laboratory report (see below) must be *completed and submitted online* ***prior to the day*** of the experiment associated with that report; due dates for each Pre-lab (i.e., Sections 0 – 5) will be explicitly stated on the course website. Each Pre-lab can be handwritten or typed (or have a mixture of both) but *must be submitted online via the Canvas course website*. Every submitted Pre-lab should be a *single document in pdf format* (e.g., not a several images or files); no other file types will be accepted/allowed for such submissions.

The Pre-lab (Pre-lab Questions and Sections 1 – 5) for a particular experiment will be checked *for completeness* (not graded) prior to allowing you to enter the laboratory to carry out that experiment. This check will serve as an indication that a student is prepared to safely conduct the experiment, e.g., knows the chemical hazards associated with the experiment. Any student who does not submit a completed Pre-lab by the stipulated deadline will be denied entry into the laboratory to perform the experiment associated with that Pre-lab. In such a circumstance, that student will receive a grade of zero for that experiment.

Laboratory Notebooks. All data collected in the laboratory should be entered ***in ink directly*** into the laboratory notebook. Evidence of transfer of data from another source (*e.g.*, a piece of paper) to your lab notebook will be taken very seriously, *i.e.*, points will be deducted from that lab. If a mistake is made, simply draw a single line through the error and sign your initials. Then, write the correct value. *Images of your handwritten data should be included in your completed laboratory report*.

Report Format The primary purpose of a laboratory report is generally to convey what you did and what you observed in an unambiguous manner so that others can replicate your experiment if this need arises. If things are not neat and legible, this objective is not met. Therefore, it will be your responsibility to make sure your report is neat and legible.

There are various styles of writing laboratory reports, with each style attempting to satisfy the primary goal of laboratory reports. For the purposes of this course, I have adopted a style that I think is conducive to an academic setting. In this chosen report configuration, all sections (0 – 10) of the report should be in your completed report (submitted online). Aside from the Experimental Results section, all sections can be handwritten or typed (or a mixture of both). The Experimental Results section should (in general) always be handwritten since it will contain data written into your notebook during the experiment. This lab report format listed below is **not optional**, and any failure to follow this order will result in deductions from the lab report. Also, please do not make any changes to the titles of the different sections – I find it makes grading more difficult.

Reporting results to the correct significant figures is an important aspect of this course. Any failure to follow appropriate significant figure rules when undertaking calculations will lead to a result that does not meet this requirement. Additionally, all measurements should be recorded with the correct significant figures. Let me know whenever you are uncertain about any of these two *things during the course* of an experiment.

Report Format (the number for each tab is also the section's number; 10 sections total)

Note: Every section must be included in all reports. If there is no entry for a section, ***you must say so under that section's heading***. You are not allowed to omit or combine sections and to rename sections, *e.g.*, using Experiment Title instead of Title of the experiment.

0. **Pre-lab questions** (not all labs have these) – include both the questions and your answers.

1. **Title of experiment** – write the title of the experiment
2. **Statement of purpose** – briefly state the goal or goals of the experiment IN YOUR OWN WORDS.
3. **Background information** – briefly describe (not in an outline or bulleted form!) the process that will be used to reach the goal of the experiment IN YOUR OWN WORDS; include any chemical reactions.
4. **Experimental procedural outline** – write what you will be doing step by step.
5. **Hazards –** list the Globally Harmonized System (GHS) hazards associated with each of the chemicals being used in the experiment and outline the routine/special handling/disposal processes for each chemical
6. **Experimental results and Procedural changes** – Be sure to document any procedural changes to the experiment! If there are none, state this fact. Before any table is inserted into ANY section of the report, there must be a descriptive (!!) explanation (with, if necessary, sample calculations showing how each entry in the first row of any column set in the table was obtained). This comes before the table. Before any graph is inserted into this section of the report, there must be a descriptive (!!) explanation as to what the graph is displaying and an indication of where (in which table) the data for the graph can be found in your report. *Clearly label any tables and graphs, e.g., 'Table 1: Table of data for the infrared spectrum of compound Z'*. Configure the size of graphs or tables in a manner that allows them to individually fit on a page.
7. **Calculations and data analysis**: Clearly label any tables and graphs (see comments about tables and graphs in 6 above). A spreadsheet (e.g., Microsoft Excel) can be used to process the raw data (*e.g.*, for calculations) and this spreadsheet can be used form a table that can then be included in your report. However, be sure to explain how the quantities in each table entry were calculated (see 'Example Spreadsheet Documentation' file on the course website). For any calculations, show a sample calculation. Your objective in this section should be to document things such that it is unambiguously clear how you processed the raw data – here, there is no such thing as 'over-documenting'! Again, configure the size of graphs or tables in a manner that allows them to individually fit on a page. Also, list all equations used either in the report or in an appendix to the report (*e.g.*, add a 'Formulas Used' appendix section).
8. **Discussion** – This section MUST include answers to any questions posed in the laboratory instructions but can also include other information that you find relevant. Failure to address any of the questions/issues raised in the lab instructions will result certain point deductions to the report.
9. **Conclusions** – This section should contain a summary of results and discussion (i.e., brief statements about the main points of the results and discussion), desired results/unexpected results, possible sources of error. *It should not be more than one paragraph (about 6 sentences long)*.
10. **References** – cite textbook or other sources from which information was obtained

Instructor's discretionary points. 10% of your course grade will depend on how you conduct yourself in laboratory. The key parameters used to award these points are (1) punctuality (i.e., were you always on-time?), (2) preparedness (i.e., how prepared were you?), and (3) your laboratory techniques (e.g., how you prepare you standards, how well you adapt to procedural changes, teamwork skills). With respect to preparedness, I am looking for behavior that demonstrates that you have read the entire lab handout for the experiment you are undertaking on any given day. For example, being able to answer specific questions about how the data being collected will be processed.

Re-grading. In the event that you find or suspect an error in the grading of report or quiz 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 attach a note describing the issue to the graded test. Note that quizzes/reports submitted for re-grading are subject to a *full* re-grading so as to ensure there are no other grading errors on that assessment.

V. COURSE CONDUCT

Course Attendance. In accordance with university policy, student attendance is *expected* at every scheduled course meeting, *i.e.*, attendance is mandatory/required. There is only one section of this course per semester. **Thus, there are no 'laboratory make-ups'**. Missing a laboratory session without a 'documented mitigating circumstance' will result in a grade of zero for that experiment. Every student is expected to be on time and prepared to perform the day's experiment. We will engage in a 10-15 min talk about the experiment prior to conducting it. Any procedural changes and particularly important points will be mentioned during this process. ***Should you come in during, or after, this talk do not be surprised by a deduction of points on your report. If you arrive after this talk you will not be allowed to perform the experiment.***

Use the Student Self-Reporting Absence system (https://sims.rutgers.edu/ssra/) to notify me about an absence and also contact me directly. Please note that reporting an absence does not automatically excuse that absence. It simply notifies the instructor and institution 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 syllabus. Excuses considered 'non-extenuating' (e.g., I overslept, I forgot about class today, I had to work, traffic was bad) 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 me of such absences during the first week of the semester.

Laboratory Safety. Safety comes before all else in the laboratory. Safety is a collective responsibility that requires the full cooperation of all. However, the ultimate responsibility for safety rest with you. Perceptiveness and preparedness (as well as a conscious effort to follow designated laboratory protocol) are all keys to accident prevention**.** To prevent the occurrence of any unsafe laboratory practices, no student will be allowed to be in the laboratory without me (the instructor) being present. Also, know where the eye washer and safety shower are located within the lab. Any questions concerning proper technique should be asked before the start of the experiment rather than after the analytical procedure has been completed incorrectly or unsafely.

Personal Protection Equipment. Any equipment or gear (*e.g.*, gloves, clothing, goggles, and helmets) used to protect an individual from one or more specific hazards of a particular substance is called personal protective equipment (PPE). It is important to understand that this equipment only mitigates the hazard - it does nothing to eliminate it. Thus, PPE only helps the individuals wearing it (and not others around who are not wearing any PPE!). We will be working with chemicals, and therefore we will use PPE to reduce the hazards of the chemicals used in our experiments.

(1) *Goggles must be worn **at all times** in the lab* (except during the pre-experiment discussion at the beginning of class). These goggles will serve as the last line of defense should a laboratory event cause the projection of chemicals towards your eyes. If you feel the need to take your goggles off for a while, please notify the instructor and leave the laboratory.

(2) Clothes and shoes worn in the laboratory should offer protection from spills and splashes. Hence, a laboratory coat must be worn during laboratory experiments, and only closed-toe shoes, i.e., no sandals, will be allowed.

(3) *Gloves should be worn when handling/touching any lab chemical*. Note that, no one type of glove (made from one material) will protect you from all chemicals. A type of glove (*e.g.*, nitrile, neoprene) that protects you from one chemical may do nothing for you when you are exposed to another chemical. Wearing the wrong type of glove is essentially the same as wearing no glove at all. Latex and nitrile gloves are by far the most used disposable laboratory gloves; this is simply because they are the least expensive, and it is not because they do the best job of protection. ***You can determine the type of glove that is suitable for each of the chemicals in any particular experiment*** by doing an internet search for Glove Chemical Compatibility charts or Glove Chemical Resistance Guides. Let me know if you think the glove provided for a particular experiment is not suitable for a particular chemical.

Waste disposal procedures. Any chemical waste generated during the course of the experiment must be disposed of in a designated waste bottle. No chemicals should be taken outside the laboratory, poured down the sink or thrown into the trash receptacle.

The University's Code of Student Conduct. It is the responsibility of each and every student to know the Code of Student Conduct (https://studentconduct.rutgers.edu/processes/university-code-student-conduct), as it specifies the obligations of any individual enrolled as a student. If you have not read it, it is suggested that you do. The standards of classroom behavior for this course are dictated by this code of conduct. Accordingly, students may not interfere with classroom procedures by distracting or disruptive actions (*e.g.*, 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 class for the remainder of the class period). In addition, *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, violating academic integrity (see *Rutgers University's Academic Integrity Policy*, *https://academicintegrity.rutgers.edu/*).

Laptop Computers and Cell Phones in the Classroom. Use of a cell phone is prohibited in the laboratory. Turn cell phones off or into 'vibrate' or 'silent' mode during laboratory sessions. Please inform the instructor and quietly leave the laboratory if you have to answer an emergency call. Do not answer (*i.e.*, begin to answer) the call in the laboratory. The use of laptops while conducting experiments will not be allowed (unless with the instructor's explicit consent).

Audio/Visual Recordings. Listening to any audio or video recordings during lab sessions is not allowed.

Course material copyrights. Any handout materials (including quizzes) are protected by copyright. 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., me) express written consent.

VI. OTHER PERTINENT COURSE INFORMATION

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.

Division of Student Academic Success Services. The Division of Student Academic Success (DSAS) at Rutgers-Camden assists students through a variety of support and services including free tutoring, supplemental instruction, and academic coaching. It will be beneficial to contact DSAS 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.

Rutgers-Camden Dean of Students Office. The Dean of Students Office 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. Thus, this office is a vital resource whenever you are unsure of how to proceed on a matter of importance to you.

Pronouns. This course affirms people of all gender expressions and gender identities. If you have a preferred gender pronoun, please do not hesitate to let me know (or correct me when I incorrectly refer to you). If you have any questions or concerns, please contact me.