Physical Chemistry Laboratory I

Chemistry 355, Fall 2023

Course Information

Class time: Monday/Thursday, 1:30pm–2:20pm
Class location: North Building, 1412B
Course webpage: Microsoft Teams (Teams join code: **8jykqnn**)

Instructor

Dustin Wheeler, Ph.D.
Office: HN1313B
Office hours: By appointment only, in person or remote
Email: dustin.wheeler@hunter.cuny.edu

Course goal

Chemistry 355 is a laboratory course in physical chemistry. By the end of this course, you will have experience with a variety of instrumental and computational techniques designed to help you understand fundamental processes related to thermodynamics and kinetics.

This course is intended to help you grow as a scientist by
1. exposing you to a variety of chemical modeling and characterization techniques, and
2. developing your reasoning and critical thinking skills for better problem solving.

Course Materials

Required: One carbon copy laboratory notebook (available in the Hunter College bookstore). A USB flash storage drive will be necessary to retrieve data from various instrumentation.

There is no textbook for this course. I will provide handouts or post the relevant material on the course page for you. You should print out each lab and *must* complete a summary of the lab procedure in your notebook before you come to class.

If you are interested in purchasing a physical laboratory book (entirely optional), many of our experiments will be modified from the standard physical chemistry laboratory lab manual by Garland, Nibler, and Shoemaker: *Experiments in Physical Chemistry,* 9th Ed., 2014, McGraw-Hill, New York, NY. Used copies of the 7th and 8th edition are often available for a reasonable price and contain nearly the same information.

Web site

Course communication, lectures, help sessions, and announcements will be posted on the course page in Microsoft Teams. All students should have been invited to the team prior to the start of the semester.

Computational work for the course will be performed with JupyterLab on shared departmental resources. This server can be accessed at https://sugarcube.hunter.cuny.edu. Students will need to create an account using the "Sign up" link below the login window.

Attendance and Tardiness

Your attendance in each and every lab is mandatory. There will be no makeup labs offered for this course. For safety reasons, if you are **more than 15 minutes late** for class, you will not be permitted to perform the lab and you will lose participation points for the session.

Lab Safety

- First and foremost you will be **required** to wear safety goggles at **all** times when in the laboratory. If you are caught without safety glasses on more than one occasion you will be asked to leave the lab.
- Open-toed shoes are not permitted in the laboratory.
- No food or drink is allowed in the laboratory at any time.
- Do not sniff or taste **any** of the chemicals you will be using.
- Toxic substances must be used only under the hood. You will be responsible for looking up and understanding the MSDS of **all** chemicals used in the laboratory.
- Cell phones should be silenced prior to coming in to lab. Please refrain from using phones during the lab session. Your attention should be focused on the work being performed, and distractions can be dangerous when working with some of the equipment.

Complete the safety training linked below and email the certificate to me before the first lab meeting.
https://www.ncbionetwork.org/iet/labsafety/

Grading

Your grade for this course will be based on the following factors:

- Attendance and participation in every laboratory period. You will work in groups of two on all experiments, your partner will remain the same all semester. (**30%** of semester grade)
- Practice exercises for lab-related skills, graded for completion (**15%** of semester grade)
- Summaries for four lab exercises, details given below. (**15%** of semester grade)
- Written lab reports for two labs, details given below. (**30%** of semester grade)
- A final group presentation based on one of the labs performed during the semester. More details will be given later in the semester. (**10%** of semester grade)

Pre-lab preparation is worth 10 points of the grade for each summary or report. At the end of each lab period, you will be required to clean up your work and submit your notebook to the instructor for sign-off. Failure to do either of these will result in a loss of participation points for the lab and 10 points from the submitted report or summary.

Summaries are due *one* week after the completion of the lab, while full reports are due *two* weeks after completing the lab.

The table below shows which sections should be included in each assignment and how many points each section is worth.

Lab Report Grading Rubric

Points	Section	Summary	Report
10	Pre-lab	✓	✓
10	Intro/Objective		✓
10	Procedure	✓	✓
30	Results/Discussion		✓
10	Conclusion		✓
10	References	✓	✓
20	Appendix (raw data/calcs)	✓	✓
	Total points	50	100

- Prior to arriving for each experimental lab, a pre-lab should be completed. This should contain an outline or flowchart of steps to be taken in the lab. It should be written in such a way that you can follow each step quickly and accurately during the lab, without needing to refer back to some section of the lab guide. Another researcher looking at your notebook should be able to replicate your work with relatively little difficulty, and your pre-lab is the start to this "instruction set". All masses, volumes, etc. should be calculated ahead of time, and a list of necessary equipment should be included so you can come in to lab, collect your equipment, and begin working within a few minutes.
- Summaries should include Procedure and Appendix sections. The Appendix should include your data analysis and any resultant figures or tables, as well as a comparison to literature values (with references). Each summary will be focused on one particular component of the analysis work (*e.g.,* figure preparation, data manipulation, error analysis). Focus topics for each summary analysis are listed in the experiment descriptions below.
- Lab reports should be clear, concise evaluations of the experiment, including any observations, experimental procedures, instrumental methods and instrumentation used, computational methods and results, and any additional analyses you performed. Lab reports should be written in the style of *The Journal of Physical Chemistry A* (JPCA). If you are unfamiliar with this style, please look up a few articles in a recent issue to familiarize yourself with the format. The Information for Authors page and Author Guidelines (specifically the author guidelines section on *Manuscript Text Components*) may be helpful if you aren't sure how to structure a manuscript. Please structure the report section of your Jupyter notebooks accordingly (*i.e.,* header cells for each section, formatted text/equations, inline figures created from your analysis section, and formatted references listed at the end).

CUNY Policies and Statements

Academic Integrity Statement

Hunter College regards acts of academic dishonesty (*e.g.,* plagiarism, cheating on examinations, obtaining unfair advantage, and falsification of records and official documents) as serious offenses against the values of intellectual honesty.

The college is committed to enforcing the CUNY Policy on Academic Integrity and will pursue cases of academic dishonesty according to the Hunter College Academic Integrity Procedures.

ADA Statement

In compliance with the ADA and with Section 504 of the Rehabilitation Act, Hunter College is committed to ensuring educational access and accommodations for all its registered students. Hunter College's students with disabilities and medical conditions are encouraged to register with the Office of AccessABILITY for assistance and accommodation. For information and appointment contact the Office of AccessABILITY (located in room E1214B) or call 212–772–4857 or VRS 646–755–3129.

Hunter College Policy on Sexual Misconduct

In compliance with the CUNY Policy on Sexual Misconduct, Hunter College reaffirms the prohibition of any sexual misconduct, which includes sexual violence, sexual harassment, and gender-based harassment retaliation against students, employees, or visitors, as well as certain intimate relationships. Students who have experienced any form of sexual violence on or off campus (including CUNY-sponsored trips and events) are entitled to the rights outlined in the Bill of Rights for Hunter College.

1. Sexual Violence: Students are strongly encouraged to immediately report the incident by calling 911, contacting NYPD Special Victims Division Hotline (646–610–7272) or their local police precinct, or contacting the College's Public Safety Office (212–772–4444).
2. All Other Forms of Sexual Misconduct: Students are also encouraged to contact the College's Title IX Campus Coordinator, Dean John Rose (jtrose@hunter.cuny.edu, 212–650–3262) or Colleen Barry (colleen.barry@hunter.cuny.edu, 212–772–4534) and seek complimentary services through the Counseling and Wellness Services Office, Hunter East 1123. For more information, view the CUNY Policy on Sexual Misconduct.

Course Schedule

Schedule for Fall, 2023

Week	Date	Group 1	Group 2
1	8/29	Check-in, JupyterLab/Python Tutorial	Check-in, JupyterLab/Python Tutorial
2	9/5	Calorimetry	pK_a of Methyl Red
3	9/12	Calorimetry/Error Analysis	pK_a of Methyl Red
4	9/19	pK_a of Methyl Red	Calorimetry
5	9/26	pK_a of Methyl Red	Calorimetry/Error Analysis
6	10/3	Kinetics of Aquation – Cobalt Ion	Two-phase Solution Properties
7	10/17	Kinetics of Aquation – Cobalt Ion	Two-phase Solution Properties
8	10/24	Two-phase Solution Properties	Kinetics of Aquation – Cobalt Ion
9	10/31	Two-phase Solution Properties	Kinetics of Aquation – Cobalt Ion
10	11/7	Binary L-V Phase Diagram	K_{sp} of $PbCl_2$
11	11/14	Binary L-V Phase Diagram	K_{sp} of $PbCl_2$
12	11/21	K_{sp} of $PbCl_2$	Binary L-V Phase Diagram
13	11/28	K_{sp} of $PbCl_2$	Binary L-V Phase Diagram
14	12/5	Checkout, final reports due	Checkout, final reports due

Description of Experiments

Introduction to Data Analysis and Plotting

This one-week exercise will give you an introduction to the JupyterLab interface, the Jupyter notebook, basic plotting techniques using `matplotlib`, and show you how to work with data in a variety of digital formats.

Instrumentation used: JupyterLab

Report type: Submit completed Jupyter notebook

Introduction to Error Analysis

This one-week exercise will guide you through the principles of error analysis, propagation of error, and probability distributions.

Instrumentation used: None

Report type: Submit homework problems

Calorimetry

This lab will introduce you to basic calorimetry concepts. You will also learn to use an instrument by reading through the user manual and gain familiarity with designing an experimental procedure based on simple objectives.

Instrumentation used: Solution calorimeter

Report type: Summary, focus on discussion and appropriate presentation of numbers (*i.e.,* significant figures)

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pK_a of Methyl Red

During this experiment, you will use visible spectroscopy to determine the acid dissociation constant of the azo-dye methyl red.

Instrumentation used: UV/Vis spectrometer

Report type: Summary, focus on figure preparation (clear labels, captions, presentation of data in a clear and compelling manner)

Kinetics of Aquation – *trans*-dichlorobis(ethylenediamine)cobalt(III) Ion

Using visible spectroscopy, you will analyze the kinetics of aquation for a cobalt complex.

Instrumentation used: UV/Vis spectrometer

Report type: Full report

Two-phase Solution Properties

You will construct the mutual solubility curve for a binary two-phase liquid system.

Instrumentation used: Density measurement devices (volume and mass)

Report type: Summary, focus on error analysis, plot creation

Binary Liquid–Vapor Phase Diagram

You will analyze the liquid–vapor phase diagram for a pair of liquids, including analysis of the azeotrope.

Instrumentation used: Distillation apparatus

Report type: Full report

Solubility Product of Lead Chloride via Electrochemical Methods

Using electrochemical measurements, you will determine the solubility product of lead chloride.

Instrumentation used: Multimeter, electrochemical cell

Report type: Summary, focus on discussion and description of accompanying data (tables/plots)