Research Methods in Chemistry 371W

Course Syllabus Fall 2025

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Laboratory Tuesday & Thursday, 1–4 PM Science Center 1052
No unsupervised lab work is ever permitted

Class Thursday 12-1 PM before the regular lab session begins (SCCT 1056)

Course Content

The focus of this course will be a semester-long exploration of the preparation, characterization and catalytic function of a group of coordination complexes using porphyrins as ligands. The semester will be broken into three different projects. For the first project, you will synthesize a porphyrin ligand and use it to make a metal complex that you will characterize by a variety of techniques (IR, NMR, UV-Vis, Mass Spectrometry). For the second project, you will propose and execute a study of the electrochemical, ligand binding, and/or catalytic properties of metalloporphyrin complexes. In the final third of the semester you will carry out an independent project of your own design. The reactivity study will be done in groups of two; all other work will be done individually.

This course is Writing-Intensive (WI). Because learning to write well is an on-going process, the faculty has committed to a WI Program that will assist students in learning to write well in multiple disciplines and throughout their time at Hamilton. In this course, you will spend a significant amount of time working on your technical writing skills with the goal of transforming your writing from constructing good "lab reports" to producing quality, journal-style manuscripts. This process starts with careful **reading of papers from the primary chemistry literature** to evaluate different models of writing within the discipline and will continue as you work to write proposals and reports throughout the semester. Your discussion of the chemistry in your written work will be important but an equal focus will be placed on the quality of the writing itself: constructing well organized arguments, writing in an appropriate style and adhering to accepted conventions for figures, citations, etc. You will get feedback on your writing through several different mechanisms including peer review, writing conferences, and comments on graded first drafts and final drafts.

Specific Learning Objectives

- Engaging in the scientific research process from start to finish, including generating and evaluating project ideas, designing experimental approaches, responding mid-project to unexpected problems and/or findings, analyzing results, and communicating your findings orally and in writing
- Gaining experience in searching, reading, and critically evaluating the primary literature in chemistry
- Getting exposure to advanced laboratory synthesis and characterization techniques and increasing facility with the use of and interpretation of data
- Increasing awareness of and improving skills in evaluating potential safety risks in the lab
- Developing stronger communication skills, both oral and written. The specific goals with respect to writing include
    - refining your writing through a recursive process that involves drafting, revising and receiving

feedback from readers
- substantiating and developing ideas through the analysis of evidence and the critical use of sources
- employing appropriate rhetorical strategies and mechanical conventions for communication with a professional scientific audience
- properly incorporating, citing, and documenting sources

Alignment with College Goals

This course has been designed with all of Hamilton's educational goals in mind, but we would like to point out close alignment with five in particular. The most obvious goal addressed in this course is **Disciplinary Practice** because you will focus on generating original hypotheses while developing your own experimental methods to test them. Through sustained and focused research of your own design, you will transition further away from thinking like a student (e.g. following a protocol) and closer to thinking like a professional chemist (e.g. developing your own protocol). To achieve this, you must develop **Intellectual Curiosity and Flexibility** as there will often be more than one way to approach a problem in the laboratory or to design an experiment. At the same time, you will grow further in **Analytic Discernment** by, for example, analyzing spectral information, seeking and executing new analytical methods specific to your project, and interpreting your findings. In the laboratory, you will have the opportunity to show **Creativity** in designing your own experiments, and in reporting your work you will advance your skills in **Communication and Expression** through writing concise technical papers modeled after professional chemistry journal articles.

Beyond these primary applications of the College goals, you will also have opportunities to hone your **Aesthetic Discernment** in the context of science communication through presentation of complex data in visually appealing, readily interpretable graphs, schemes, and figures. **Ethical, Informed, and Engaged Citizenship** with regard to chemistry (e.g. impact on society and the environment, research ethics, etc.) will be discussed in the context of your readings and weekly discussions. Finally, we implore you to broaden your **Understanding of Cultural Diversity** in the context of our classroom and in the broader chemistry community, gaining better appreciation for the fact that science is a global enterprise that benefits greatly from contributions from people with diverse backgrounds and perspectives.

Graded Work

Your work in this course will be divided into three different multi-week projects. For each project, you will complete a written report on your work. For the second and third projects, you will also write a proposal outlining your objectives and present an oral report. Oral presentations will be ten to twelve minutes in length and will be given prior to submission of your written reports. Making the oral presentations will give you a trial run for the presentation of your findings and allow you to get feedback before completing your final, written report. Details about each project and due dates for assignments are given below. Please note that some work on the projects is overlapping – you will write the proposal for Project N+1 while you are still doing lab work on Project N and you will complete the reports for Project N after you have started lab work on Project N+1.

Project 1: Synthesis and Characterization of a Metalloporphyrin

In this project, you will begin by synthesizing tetraphenylporphyrin (TPP). You will each then choose a metal to coordinate with your TPP and you will fully characterize your metalloporphyrin complex. You will be responsible for searching the chemical literature to find papers that report a synthetic procedure for the preparation of your metalloporphyrin complex and also for finding spectral data that you can use for

comparison to assess the outcome of your synthesis. We will take some time in class to discuss strategies for searching the literature and for reading and interpreting the papers that you find.

For this first project, the report will be written in the style of a *JOC (Journal of Organic Chemistry) Note* and should include a brief introduction (one or two paragraphs), a results and discussion section and an experimental section. The report should include full citations with the reference format conforming to standard American Chemical Society (ACS) guidelines. A copy of the *ACS Style Guide* chapter that provides full details of citation formats is posted on Blackboard. (Copies of other chapters from the *ACS Style Guide* are also posted that you might find helpful.)

A draft of your report will be due before the final submission. This draft will receive ungraded feedback from the instructors and will also be exchanged with classmates for additional feedback through peer review. While the draft, itself, will not receive a grade, part of the basis of your final grade will be an assessment of how effectively you have revised your report based on feedback on your draft. Please turn in your original draft, with comments, when you submit your final draft.

Project 2: Reactivity Study of Metalloporphyrins (with a partner)

For this project, you will work with a partner to research, propose, develop, and carry out a study of the reactivity of metalloporphyrin complexes. You may examine aspects of ligand binding, electrochemical behavior or the catalysis of reaction chemistry. A number of articles will be posted on Blackboard to serve as "seeds" for your idea.

Each group will submit a (jointly) written proposal describing their project idea. Proposals should be 2–4 pages in length and contain a brief outline of important, relevant literature and an outline of the goals that you hope to achieve in your lab work, along with a list of chemicals and unusual lab apparatus that you will need to complete the project. Appropriate reaction schemes should be included to illustrate key reactions. Proposals need not contain specific experimental procedures copied from your source papers. Each group will informally present their project idea in a "group meeting" during lecture before the proposal is due.

Each group will present a formal oral report at the conclusion of their study before finalizing their report. The format for the jointly written report for Project 2 is the same as for Project 1, i.e. written in the style of a *JOC Note*.

Project 3: Independent Project

For this project, you may propose (almost) any porphyrin-related study you wish to undertake. As you search the literature and read papers throughout the early part of the semester, you should be scouting for potential ideas for your independent project. You will do a formal oral presentation of your proposal idea before an initial draft of your written proposal is due. The main purpose of the oral proposal will be to provide feedback on your idea before you commit to your project. Likewise, you will present your results orally before your final written report is due.

The written proposal will be similar to the proposal for Project 2 but should include a more extensive introductory section that outlines in greater detail the literature underlying your project. The introduction in this proposal will serve as an initial draft for the introduction section of your final paper. As before, your proposal should explain the specific goals of your project, describe the experiments you will do to achieve those goals and detail the means you will use to analyze your experimental results. For this proposal, you will submit an initial draft that will be graded before submitting a final version. Again, please submit your original draft with comments when you submit your final version.

The final report will be written in the style of a full paper from the *Journal of the American Chemical Society*, including an introduction with a significant literature review (a revised version of the introduction from your proposal), in addition to a results and discussion section and a full experimental section. The length of this report will be highly dependent on the nature of your project and the amount of progress you are able to make in the lab but will typically be 10–15 pages.

Tools for this course

We will use Blackboard for all information in the course. Posted there will be not only the syllabus and timeline for assigned work as we progress through the semester, but also resources for the projects. We will be using Signals electronic notebook where you can not only record what you have done in the lab, but can also upload your spectra, keep an electronic copy of your references, etc. Keeping an accurate and detailed set of lab notes is essential since you will be designing your own experiments and including experimental sections in your reports. To help with this you will submit copies of your notebook pages each week during Project 1 for feedback.

Other Course Expectations and Policies

Everyone shares responsibility for maintaining a lab environment that is safe and fully functional. That responsibility includes promptly washing glassware that is for communal use, cleaning up common areas, and occasionally cleaning your own hood. To help you understand the expectations for lab safety and lab citizenship, we will do a brief lab inspection at the end of each class. Each week one person will be given the responsibility of performing an end of day checklist and brief safety audit during the last 15 minutes of class. They will be responsible for addressing any minor violations and should bring more significant issues to the attention of the instructors who will work with the party or parties responsible to take corrective action.

Always wear your lab coat and safety glasses while in the lab whether you are actively working or not. The conference room (1056) is where you may use your computer, sip a drink, or finish a lunch without PPE. Please also make sure that you remove gloves when using computer keyboards on your laptop and on instruments.

Chemical orders must be submitted as soon as possible. For Projects 2 and 3 you will frequently have to order specific chemicals, reagents, solvents, etc. to perform your experiments, which means they will take time to be delivered. We will be using a shared google sheet for submitting chemical orders that the instructors will check regularly. To hopefully avoid any project delays you will be required to submit some initial chemical orders the same class as your proposal ideas presentations.

Attendance at all Chemistry Department Seminars is required as part of your class work. Seminars are usually scheduled for 3 pm on Fridays but may occasionally be held at alternate times. If you have a conflict with any seminar, please let one of the instructors know.

Getting Help

Research Methods is a challenging course that requires a major commitment of both time and effort. One of the major issues is that the structure of the course dictates that the due dates for significant assignments are clustered; the report for one project is due not long after the proposal for the subsequent project. If a deadline is creating excessive stress or anxiety, please speak with us about a short extension. Do not hesitate to consult with us at any time to discuss any questions you have on any assignment or lab procedure. We aim to make your SuperLab experience one of deep and individualized learning and we are happy to meet with you both during the scheduled lab period and by appointment or drop-in to our office.

We request that any student with a documented disability needing academic adjustments or accommodations speak with us during the first two weeks of class. All discussions will remain private/confidential. Students

with disabilities should also contact Allen Harrison in the Dean of Students Office (Burke Library) who coordinates services for students with disabilities.

If at any time you are experiencing anxiety or symptoms of depression or other mental health issues, you are encouraged to seek out resources on campus that may be helpful. These include:

- the Counseling Center (www.hamilton.edu/offices/counselingcenter, 315-859-4340) located at 100 College Hill Road offers individual and group therapy, peer counselors, psychiatric treatment, and a 24-hour hotline. If you need immediate assistance, phoning the Counseling Center and selecting option 2 will connect you with a counselor, 24 hours a day, 7 days a week.
- the Associate Dean of Students for Student Support, Sarah Solomon (315-859-4463; ssolomon@hamilton.edu)
- the Associate Dean of Students for Academics, Adam Van Wynsberghe (315-859-4600; avanwyns@hamilton.edu)
- Your faculty advisor
- Your RA and Area Director in your residence hall

If at any time you feel suicidal or in danger of harming yourself or others, please reach out for support! The Hamilton community cares and is available to help. Campus Safety is available 24/7 for urgent concerns at 315-859-4000.

Assignments, Due Dates and Grading Scheme (in chronological order)

Assignment		**Due Date**
Project 2 Proposal Ideas Presentation		Thu 9/18
Project 2 Written Proposal	5%	Fri 9/26
Project 1 Report Initial Draft		Fri 10/3
Project 1 Report Initial Draft Peer Review		Thu 10/29
Project 1 Report Final Draft	20%	Wed 10/15
Project 3 Proposal Ideas Presentation		Thu 10/23
Project 2 Oral Report		Thu 10/30
Project 2 Written Report	25%	Fri 11/7
Project 3 Written Proposal Initial Draft	5%	Fri 11/14
Project 3 Written Proposal Revised Draft	10%	Fri 12/5
Project 3 Oral Report		Thu 12/11
Project 3 Final Report	25%	Thu 12/18
Laboratory Technique and Presentations*	10%	

*an assessment of your oral presentations, peer review feedback, and laboratory technique (quality of your work in the lab including effort, neatness, waste disposal, safety, initiative, and improvement) throughout the semester

Schedule for Laboratory and Lecture Meetings

Discussion topics are indicated in italics

Dates	Tuesday (starts at 1:00)	Thursday (starts at 12:00)
Aug. 28		Lab Set-up *Reading a Scientific Paper*
Sept. 2, 4	Synthesis & Characterization of a Porphyrin **Submit Lab Notes End of Class**	Synthesis & Characterization of a Porphyrin *Searching the Chemical Literature and Types of Literature*
Sept. 9, 11	Synthesis & Characterization of a Porphyrin **Submit Lab Notes End of Class**	Synthesis & Characterization of a Porphyrin *Scientific Proposal Writing and Citation Managers*
Sept. 16, 18	Synthesis & Characterization of a Porphyrin **Submit Lab Notes End of Class**	Synthesis & Characterization of a Porphyrin ***Project 2 Proposal Ideas Presentations*** **Initial Chemical Orders Due**
Sept. 23, 25	Reactivity Studies	Reactivity Studies *Ligand Field Theory* **Project 2 Proposal Due Fri 9/26**
Sept. 30, Oct. 2	Reactivity Studies	Reactivity Studies *Writing Exercise* **Project 1 Report Draft Due Fri 10/3**
Oct. 7, 9	Reactivity Studies	Reactivity Studies **Report 1 Draft Peer Review Due by Class** *Discussion of Peer Review / Final Report*
Oct. 14	Reactivity Studies **Project 1 Final Report Due Wed 10/15**	FALL BREAK
Oct. 21, 23	Reactivity Studies *Discussion of Project 1 Report*	Reactivity Studies ***Project 3 Proposal Ideas Presentations*** **Initial Chemical Orders Due**
Oct. 28, 30	Reactivity Studies **Project 3 Proposal Draft Timeline & Budget Due 10/28**	Independent Projects ***Project 2 Oral Reports***
Nov. 4, 6	Independent Projects	Independent Projects *Project 3 Paper Discussion* **Project 2 Final Report Due Fri 11/7**
Nov. 11, 13	Independent Projects	Independent Projects ***Project 3 Troubleshooting Discussion*** **Project 3 Proposal Draft Due Fri 11/14**
Nov. 18, 20	Independent Projects	Independent Projects *"Towards a Responsible Chemistry"*
	THANKSGIVING BREAK	THANKSGIVING BREAK
Dec. 2, 4	Independent Projects	Independent Projects **Project 3 Revised Proposal Due Fri 12/5**
Dec. 9,11	Independent Projects	Lab Cleanup ***Project 3 Oral Presentations*** **Project 3 Final Report Due Thu 12/18**