CHEMISTRY 4800 – Undergraduate Research Problems

Meetings: Arranged weekly, 3-4 hours total contact per week (for 1 semester credit). Can be taken for 1-3 credits.

Requirements: Written initial proposal describing the project, and a final report as described below.

Keep a written notebook with complete description of research work and any reference material, spectral data, and other relevant materials. These must be turned in to your supervising professor at the conclusion of your research. At the start of your project, consult with your supervising professor about the expectations and format for the lab notebook. Bring the notebook to your regular meetings with your supervising professor and obtain feedback about correct practices in keeping your notebook.

A Final report is due to the Department Head no later than the last day of classes. Students should turn in a preliminary draft of the report to their supervising professor for feedback two weeks before the final due date. The graded final report with comments may be picked up from the main office after the semester. The final report should be a minimum of 3-5 single-spaced pages, including the project title, abstract, introduction to the problem addressed, results, discussion and conclusions. The final report must adhere to the format guidelines of the American Chemical Society, as described on subsequent pages. A set of anonymous previous reports, including models of excellent reports as well as some with common shortcomings, is available for students to view in the main office.

The report MUST contain the following sections:

Abstract
Introduction
Experimental Details
Results
Discussion (The Results and Discussion sections may be combined)
Conclusions and Summary
References

All final reports are collected and graded by the Department Head. The student's final CHEM 4800 grade is determined after consultation of the Department Head with the professor who supervised the research. This is determined both by the grade assigned to the written report, and the research supervisor's assessment of how well the student met their time and research commitment, the lab notebook, and the quality of their work.

The ACS guidelines give pointers for what should be contained in each section of the report. Some suggestions:

- The Experimental Details section is where you report the methods you used; do not put results here. Explain your methods in sufficient detail that someone else could exactly replicate your work.

- Results section: This is the section in which you report your data. If you wish, this can be combined with your discussion, which contains the interpretation of your results. Be sure to organize this section carefully; create an outline before you begin writing.

- Figure legends: make sure these completely describe the figure. The reader should be able to interpret your figure from it and the legend, without going back to the text. For example, if showing a chromatogram, lead the reader through what it presents in the legend.

- Use figures to present your data, and also to give background information. For example, if your report involves a reaction sequence, show the structures. A site license for ChemDraw software is available free to all students. It is also available on the computers in the Department computer lab in Widtsoe 334.

- IF YOU SUBMIT YOUR REPORT ELECTRONICALLY BE SURE TO CONVERT IT TO PDF FORMAT FIRST! Word documents containing figures may open on a different computer with the formatting of figures randomly affected. You are responsible for insuring a correctly formatted report is received; the surest ways to do this are to either submit a printed report, or, convert your Word document into pdf format, proofread it, and send that. You submit electronic Word documents at your own risk; reports are graded as received and no excuses for computer-induced errors will be accepted.

Preparing a Research Report

A research experience provides undergraduates a problem-solving activity unlike anything else in the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty advisor. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-the-art instrumentation. Ideally, undergraduate research should focus on a well-defined project that stands a reasonable chance of completion in the time available. A literature survey alone is not a satisfactory research project. Neither is repetition of established procedures. The Committee on Professional Training (CPT) strongly supports efforts by departments to establish active and vibrant undergraduate research programs, recognizing the role that research can play in developing a wide range of student skills. The 2015 guidelines allow for the use of undergraduate research both as in-depth coursework, as well as a means of meeting 180 of the 400 laboratory hours required for certification ***provided that*** a well-written, comprehensive, and well-documented research report is prepared at the end of a project (samples of such research reports must be submitted with the periodic reports.) The CPT has a separate supplement outlining the components of successful research programs and projects.

Preparation of a comprehensive, well-documented and appropriately referenced written research report is an essential part of a valid research experience, and the student should be aware of this requirement at the outset of the project. Interim reports may also be required, usually at the termination of the quarter or semester. Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be critiqued by the faculty advisor and corrected by the student at each stage. It may be expected that concrete outcomes of any research project would be student presentation of research results at a professional meeting and/or co-authorship on a journal publication. While desirable outcomes, they are not a substitute for a well-written comprehensive report that demonstrates that the student has a full grasp of the scope of the problem, the techniques/instrumental methods used, and the ramifications of the results generated (much as might be expected for a capstone paper or a B.S. thesis). The student report should receive substantive critique and correction by the faculty mentor in its development.

Guidelines on how to prepare a professional-style research report are not always routinely available. For this reason, the following information on report writing and format is provided to be helpful to undergraduate researchers and to faculty advisors. Much of what follows is similar to what authors would find in many ‘guidelines to authors’ instructions for most journal submissions.

The most comprehensive student research reports examined by CPT have been those student reports reviewed by more faculty than just the supervising research advisor. In some cases, programs require an approval of the report by several faculty members; in such cases, student research reports are often of high quality.

Organization of the Research Report

Most scientific research reports, irrespective of the field, parallel the method of scientific reasoning. That is: the problem is defined, a hypothesis is created, experiments are devised to test the hypothesis, experiments are conducted, and conclusions are drawn. The exact format of scientific reports is often discipline dependent with variations in order and content. The student is encouraged to adopt the format that is most appropriate to the discipline of the research. Many journals offer a formatting template to aid the author. One example of such a framework is as follows:

- Title
- Abstract
- Introduction
- Experimental Details or Theoretical Analysis
- Results
- Discussion
- Conclusions and Summary
- References

Title and Title Page

The title should reflect the content and emphasis of the project described in the report. It should be as short as possible and include essential key words.

The author's name (e.g., Mary B. Chung) should follow the title on a separate line, followed by the author's affiliation (e.g., Department of Chemistry, Central State College, Central, AR 76123), the date, and possibly the origin of the report (e.g., In partial fulfillment of a Senior Thesis Project under the supervision of Professor Danielle F. Green, June, 1997).

All of the above could appear on a single cover page. Acknowledgments and a table of contents can be added as preface pages if desired.

Abstract

The abstract should concisely describe the topic, the scope, the principal findings, and the conclusions. It should be written last to accurately reflect the content of the report. The length of abstracts varies but seldom exceeds 200 words.

A primary objective of an abstract is to communicate to the reader the essence of the paper. It should provide sufficient information to describe the important features of the project in the absence of the rest of the document. The reader will then be the judge of whether to read the full report or not. Were the report to appear in the primary literature, the abstract would serve as a key source of indexing terms and key words to be used in information retrieval. Author abstracts are often published verbatim in Chemical Abstracts.

Introduction

"A good introduction is a clear statement of the problem or project and the reasons for studying it." (The ACS Style Guide. American Chemical Society, Washington, DC, 2006.)

The nature of the problem and why it is of interest should be conveyed in the opening paragraphs. This section should describe clearly but briefly the background information on the problem, what has been done before (with proper literature citations), and the objectives of the current project. A clear relationship between the current project and the scope and limitations of earlier work should be made so that the reasons for the project and the approach used will be understood.

Experimental Details, Computation Procedures, or Theoretical Analysis

This section should describe what was actually done. It is a succinct exposition of the laboratory and computational details, describing procedures, techniques, instrumentation, special precautions, characterization of compounds and so on. It should be sufficiently detailed that other experienced researchers would be able to repeat the work and obtain comparable results.

In theoretical reports, this section would include sufficient theoretical or mathematical analysis to enable derivations and numerical results to be checked. Computer programs from the public domain should be cited. New computer programs should be described in outline form.

If the experimental section is lengthy and detailed, as in synthetic work, it can be placed at the end of the report so that it does not interrupt the conceptual flow of the report. Its placement will depend on the nature of the project and the discretion of the writer.

Results

In this section, relevant data, observations, and findings are summarized. Tabulation of data, equations, charts, and figures can be used effectively to present results clearly and concisely. Schemes to show reaction sequences may be used here or elsewhere in the report.

Discussion

The crux of the report is the analysis and interpretation of the results. What do the results mean? How do they relate to the objectives of the project? To what extent have they resolved the problem? Because the "Results" and "Discussion" sections are interrelated, they can often be combined as one section.

Conclusions and Summary

A separate section outlining the main conclusions of the project is appropriate if conclusions have not already been stated in the "Discussion" section. Directions for future work are also suitably expressed here.

A lengthy report, or one in which the findings are complex, usually benefits from a paragraph summarizing the main features of the report - the objectives, the findings, and the conclusions.

The last paragraph of text in manuscripts prepared for publication is customarily dedicated to acknowledgments. However, there is no rule about this, and research reports or senior theses frequently place acknowledgments following the title page.

References

Thorough, up-to-date literature references acknowledge foundational work, direct the reader to published procedures, results, and interpretations, and play a critical role in establishing the overall scholarship of the report. The report should include in-text citations with the citations collated at the end of the report and formatted as described in The ACS Style Guide or using a standard established by an appropriate journal. The citation process can be facilitated by using one of several available citation software programs. In a well-documented report, the majority of the references should come from the primary chemical literature. Because Internet sources are not archival records, they are generally inappropriate as references for scholarly work. They should be kept to a bare minimum.

Preparing the Manuscript

The personal computer and word processing have made manuscript preparation and revision a great deal easier than it used to be. It is assumed that students will have access to word processing and to additional software that allows spelling to be checked, numerical data to be graphed, chemical structures to be drawn, and mathematical equations to be represented. These are essential tools of the technical writer. All manuscripts should be carefully proofread before being submitted. Preliminary drafts should be edited by the faculty advisor (and/or a supervising committee) before the report is presented in final form.

Useful Texts

Writing the Laboratory Notebook, Kanare, H.M., American Chemical Society, Washington, DC, 1985.

This book describes among other things the reasons for note keeping, organizing and writing the notebook with examples, and provides photographs from laboratory notebooks of famous scientists.

ACS Style Guide: Effective Communication of Scientific Information, Coghill, A.M., Garson, L.R.; 3rd Edition, American Chemical Society, Washington, DC, 2006.

This volume is an invaluable writer's handbook in the field of chemistry. It contains a wealth of data on preparing any type of scientific report and is useful for both students and professional chemists. Every research laboratory should have a copy. It gives pointers on the organization of a scientific paper, correct grammar and style, and accepted formats in citing chemical names, chemical symbols, units, and references.

There are useful suggestions on constructing tables, preparing illustrations, using different fonts, and giving oral presentations. In addition, there is a brief overview of the chemical literature, the way in which it is organized and how information is disseminated and retrieved. A selected bibliography of other excellent guides and resources to technical writing is also provided. See also The Basics of Technical Communicating. Cain, B.E.; ACS Professional Reference Book American Chemical Society: Washington, DC, 1988.

Write Like a Chemist, Robinson, M.S., Stoller, F.L., Costanza-Robinson, M.S., Jones, J.K., Oxford University Press, Oxford, 2008.

This book addresses all aspects of scientific writing. The book provides a structured approach to writing a journal article, conference abstract, scientific poster and research proposal. The approach is designed to turn the complex process of writing into graduated, achievable tasks.

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Suggestions for avoiding common errors on Chem 4800 reports

Use the Science Writing Center. They are located in Eccles Science Center and provide advice and critiques of lab reports and research papers. Website: https://writing.usu.edu/programs/sci-writing

Typographical errors are killers. In your professional life, a job application or a CV with typographical errors will doom your application. The same policy is applied to grading CHEM 4800 reports. Any typos will result in immediate grade reduction. Do not rely on spell checking software. This will miss correctly spelled, but contextually inappropriate words, like thorough and through, for example.

Example reports are available.
A set of previous Chem 4800 final reports is available for students to view in the main office; see Geri Child. This selection includes both very good reports, and ones that illustrate common errors and shortcomings.

Specific suggestions for the report:

Abstract:
Write this section LAST. This should be a brief summary of the research objectives, your results, and conclusions. Begin with a strong attention-getting introductory sentence or two that describe the importance of the research and the main questions or goals that motivated the work but most of the abstract should summarize your results.

References:
Look at a recent major journal article and format your references according to that model. There is no particular journal style required, but it is important to BE CONSISTENT. Internet URL's should be avoided in references in professional papers because links change and disappear over time, rendering such references useless.

Figures:
Drawings should be clear and concise; look at recent journal articles for examples of best practices for formatting figures and drafting informative figure legends. **Figure legends are very important**; they must be more than a mere title, and must explain the contents of the figure. The department funds a university-wide site license for ChemDraw, which can be used to create professional-quality chemical structures for your report.

If you use a figure downloaded from the internet, be sure to cite the source. Insure that any downloaded images are clear after insertion into your report. Fuzzy image quality will result in markdowns.

Tables:
If you have a long table, avoid running it over from one page to the next. Rearrange things to fit tables entirely on one page, so that the reader has the column headings visible, but do not shrink it to the point that it is difficult to read. If you must run a table over more than one page, then repeat the column headings on the continuation page and refer to the continued data as "Table X, continued." Look at recent journal articles for examples of ways to format professional-looking tables.

Experimental Methods (or Material and Methods) section:
You do not need to describe every experiment you performed. However, every experiment discussed in your report should be described in sufficient detail that others could repeat your work. It is essential that this section contain the details about all experiments that produced results you discuss in your report.

What if your project failed to produce clear results? It is a fact of research life that many experiments fail. Your report grade is not affected by the success or failure of your research project. Clearly report what experiments you performed, what data and other results you obtained, and what conclusions you are able to draw. When the goal was not achieved or experiments were not successful, suggest potential reasons or logical future experiments.