

# Honours Thesis Research Project

## Introduction

The experimental project course is designed to introduce students to a real-life research situation. In contrast to the laboratory portions of your previous courses, the outcome of your experiments is genuinely unknown, not only to you, but also to your Supervisor. In that sense, there is no “right” or “wrong” outcome; rather, you will be attempting to answer a question such as: “Can this compound be made?” or “What is the effect of these conditions on this system?” In the process, you will doubtless encounter surprises, frustrations and even the occasional dead end. You will be expected to use creativity and common sense, as well as your Supervisor's advice, to overcome these obstacles.

## Using the Literature

The published literature is one of the most powerful tools the chemist, or indeed, any scientist, has available. It forms the “institutional memory” for your field. By careful use of the literature, you will be able to form an idea of what work has already been done on your problem, and what methods may help you in finding a solution to it. You will find that there is a great deal of published material, and that it comes in a variety of forms.

The journal article is one of the most common and important sources of information for researchers. A journal article is a report of a specific piece of research, usually containing experimental details (sufficient to allow a reasonably skilled person to repeat the work) and references to earlier work in the area. Most new work in chemistry is first disseminated in this way. Much of the rest is first disclosed in patents. There are perhaps 10,000 journals publishing chemical articles. Journal articles come in the form of (full) papers, which are composed of an Abstract, an Introduction which sets the work in context, a Discussion section in which the results of the work are detailed, an Experimental or Methods section which gives a precise description of the actual experiments, and a Conclusion in which the main points to be drawn from the results are presented succinctly. Journal articles are usually extensively referenced. There are also shorter articles, typically called a “Communication”, which are preliminary reports of new work. Communications are usually followed up by a full paper which may or may not be in the same journal. These shorter articles contain minimal experimental detail, short or no abstracts, and are thought by their authors to contain urgent results which cannot wait to be fleshed out into a full report. The contents are often republished as part of the later more-detailed publication.

Contributions to reputable journals are screened by a peer-review process. Journal editors send the contributions which they receive to other researchers working in the area or field for evaluation. These researchers are called Referees or Reviewers; they are asked to read the paper, to determine whether it should be published in the journal and to suggest corrections, changes and additional work. Referees and Reviewers base their evaluations on the quality of the work itself, its timeliness, and on the way the work is presented. They are expected to make their judgements quickly, objectively and anonymously, and not to make any use of their “prepublication” access to the results. Their recommendations are returned to the journal's editor, who decides whether the paper should be published "as is", or with modifications, or not at all. Sometimes, the editor may recommend submitting the article to another journal for whose readership or mandate is more appropriate.

Patents were mentioned above. Many chemical and instrumental patents are issued, and often they are the first arena for disclosure of new results, especially for researchers working for industry. A patent is supposed to disclose an invention or discovery, with full experimental details, and to make claims as to the usefulness and applications of the invention. In practice, the experimental details may not be quite complete, and the claims may be overly broad, but the patent literature is still a useful guide to previous work in some areas.

Patents and the kind of journal articles described above make up what is called the “primary literature”. That is, they are the sources closest in time and space to the actual work. Unfortunately, chemists publish an enormous amount of work, and it is difficult to keep up with the primary literature even within the narrow limits of one's own specialty. Thus we are led to the “secondary literature”.

The secondary literature is that set of sources which compile or condense reports like those described above, into a more concise form that makes it possible to find more readily information on a particular subject. Textbooks fall into this category, along with other books, including monographs, abstracting services, reviews, handbooks, and other sources. What follows is a brief description of some of the more useful of secondary literature sources.

Reviews are articles, usually rather lengthy, which summarize the work done in a particular area. The scope of the review may be limited to the period since the last such review was published, or it may go right back to the origins of the area. They are referenced copiously and may even contain some experimental details. These articles are very useful for establishing the outlines of a research area. Many journals publish reviews, and some (Chemical Reviews, Accounts of Chemical Research) are devoted exclusively to them. Other journals (Angewandte Chemie) publish one or more reviews in every issue.

There are also many other secondary sources. These include (for organic chemists) Beilstein's "Handbook der Organischen Chemie", which organizes the names, formulae, properties and preparations of organic compounds. There are handbooks such as the CRC Handbook of Chemistry and Physics, which is very useful for locating physical properties of organic and inorganic compounds, and a wealth of other information. One convenient (and free) source which should not be overlooked is the Aldrich Catalogue, which lists some of the properties of the over 30,000 compounds sold by that company. It also is an excellent source for quickly locating CA registry numbers. The Merck Index gives brief monographs on about 10,000 compounds of interest largely, but not exclusively, to the organic chemistry and pharmaceutical communities.

## After the Literature Search

Once you have searched the literature, it will be necessary to sit down with your Supervisor to formulate a research plan. Your Supervisor will likely have an outline in mind already, but it will be important to contribute your own ideas. Then it is time to start the actual experimental work. Other than providing good ideas and carrying out your research using sound techniques, the most important thing that you can do to help yourself is to keep good records. Your notebook is the record of your work, often the only record, and so it should be kept meticulously. Each experiment should be described clearly, each page dated, the intent of each experiment stated clearly. All observations during the course of an experiment should be noted as the experiment is performed, along with any relevant literature references. Your Supervisor will have some idea of how the notebook should be formatted. Remember, others may have to consult your notes. If your work leads to further research projects, the notebook will be a primary source of information. You will have to use the information recorded in the notebook when you write up your project at the end of the year. After a few months, all the experiments tend to run together, so do not trust your memory.

Try to approach your experiments in a logical manner. Each experiment should have a clearly defined purpose. Make sure you have everything you need, and know what you have to do at each step, before you start. Make careful observations, and try not to let your preconceptions colour your interpretations. After all, the unexpected is what makes research interesting. Be familiar with the principles upon which your instrumentation is based, and know its limitations. Avoid the trap of overstating your conclusions; in other words, do not make any connections which are not firmly supported by the facts.

## Oral and Written Presentations

At various times during the year, you will be expected to present your work to the Department. Your introductory talk is a brief presentation of the pertinent literature, to set your work in context, and an outline of what you propose to do. In other words, we should come away with an idea of where the field is now, where you would like to take it, and how you will accomplish this. Your final talk will be a longer presentation focused on your experiments, results and conclusions along with a comparison to how these matched or differed from your project objectives.

When presenting your seminars, remember that the audience is usually not very familiar with the details of the field. While you may assume that we all have a basic chemistry background, you may not assume that we know the subtleties of enzyme kinetics or of gas phase ion kinetics. Whatever visual aids you may use, please make sure that they are clear and readable to the audience. Try not to block the audience's view of the screen, and do not address the screen; talk to us. Make your talk a story, with a beginning, a middle, and an end. Each talk is different, but most good speakers use an introduction that sets the work in context, and states the question that the work attempts to answer. The bulk of the talk describes the results to the questions originally posed. Remember that you know (or should know) more about this work than anyone else in the room, so tell your story clearly. Communicating results is as important as getting them. Be sure to adhere to the time limit. Too short a talk gives the impression that you do not have much to say, while a talk that goes overtime indicates that you cannot isolate the salient points and express them succinctly. Always rehearse a talk, preferably in front of an audience that can give you feedback on pace, clarity and organization. It is not excessive to go over the talk six or seven times, until it is smooth, professional and “feels right”.

You will also have to give two written accounts of your work. The first, due just after Christmas, is a Progress Report. It is a brief summary of your progress to date. It should outline how things are going, and how you intend to finish up in light of what you have learned thus far. The Progress Report is graded by the project coordinator. At the end of the year, you will submit a Final Report or Thesis. Your Supervisor may have particular ideas on the format. The Final Report or Thesis should consist of a review of the literature, followed by a section in which you describe and discuss your results; this section is followed by a conclusions section. The experimental details may be presented in a separate experimental section. There is no set page length, but typical reports are in the neighbourhood of twenty-forty pages. Figures and tables should be made as clear as possible so as to enhance the “readability” of the whole work. Be very careful to avoid plagiarism in your writing. Any ideas or statements which are not your own should be properly attributed. This practice extends also to illustrations and tables copied from texts, journals or other sources.

## The Chemistry Seminar Series

In order to be exposed to a broader range of scientific work than is typical in a project course, students are required to attend all of the Chemistry seminars, as well as any other departmental seminars as recommended by the student’s project supervisor.

## Evaluation

Since this is a course, a grade is assigned. Evaluation of this kind of course is somewhat different from that of a typical lecture course. You will be marked on the oral presentations, the thesis, and your Supervisor will assign a grade which reflects your performance of the research. The thesis will be read by your Supervisor, and at least one other member of the Department. We will be looking for clarity of presentation, quality of the research itself, and an impression that you understand what you are doing, in terms of the scope and limitations of your work. The oral presentations will be graded by all the Departmental faculty, with basically the same expectations. Your Supervisor's grade will be based on an impression of your ability to understand, organize, and carry out your research. Creativity and personal initiative are important here. By the end of the course, you should be coming up with your own ideas and becoming a more independent researcher. You will be expected to devote eight-ten hours per week per credit to the project, and this will also be reflected in this mark. This portion of the grade is admittedly highly subjective, but very important in determining what you have learned from the course.

## Role of the Project Course Co-ordinator

The Project Course Co-ordinator is responsible for scheduling the student seminars, arranging for readers for the papers, collecting and presenting the final marks, and doing any other tasks which fall normally to the professor in any course. The Project Course Co-ordinator is available for consultation on any problems which you may have and which cannot be solved by consultation with your Professor or Supervisor; these problems may include scheduling conflicts with the presentations, grade appeals (through the Registrar's office), equipment access problems, or anything else which may come up.

## Marking Scheme

* Oral Presentations:
  + October Seminar 5%
  + April Seminar 30%
* Written Reports:
  + Progress Report 5%
  + Final Thesis 30%
* Supervisor's Grade 30%

## Chemistry Project Course Marking Guidelines

The project course is a difficult one to evaluate, involving as it does, the comparison of subjective evaluations of dissimilar work. The following guidelines offer some suggestions as to cope with this problem. The marking scheme for the course consists of three elements:

### Written work

Written work consists of the final report, or thesis, and contributes 35% of the total mark. Written work is graded by the Supervisor, the Course Co-ordinator or his delegate, and one other reader. In assigning a grade, attention is paid to the following points:

1. Clarity; the work should be written clearly using normal grammar and punctuation and with all symbols and terms defined carefully. The thesis should be written so as to be comprehensible to a reader who is familiar with Chemistry but not necessarily an expert in the particular field of the research covered in the thesis.
2. Technical merit; the thesis should make clear the scope and limitations of the work undertaken. The thesis should illustrate the clear understanding by the student of the project subject matter and of the implications of the results described in the thesis. In particular, the student should show how the conclusions are supported by the experimental evidence; it is especially important that, when the limitations of the instrumentation are approached or exceeded, conclusions which go beyond the experimental evidence be not drawn. The student should strive to demonstrate that a good piece of scientific research has been carried out.
3. Literature awareness; the work presented in the thesis should be set in context by reference to the chemical literature. While this task is carried out mainly in the Introduction to the thesis, it may be continued in the Discussion with comparison to the results of other workers in the field.

### Oral presentations

There are two oral presentations; the first is given in October and is limited to a duration of 10 minutes, and the second is given at the end of the year and is limited to 20 minutes. After each presentation there is an opportunity for questions; the durations of these question periods is approximately 5 minutes for the former and 5-10 minutes for the latter. Oral presentations contribute 35% of the total mark. Oral presentations are graded by all faculty, as well as by the student's Supervisor from another Department where appropriate. In addition to the three criteria discussed for written work above, that is, clarity, technical merit and literature awareness, the student should remember that faculty will base their evaluation on the following criteria also:

1. Pace and length: the talk must be given in the time allowed thus the material must be organized so that each of the important points is discussed in turn and at a pace which is neither rushed nor plodding.
2. Familiarity with the topic: the student must convince the audience that he/she is familiar with the topic and understands the specific area of research. Mere memorization without understanding is not acceptable.
3. Ability to answer questions: the ability to comprehend clearly posed questions and to respond succinctly to them is a valuable asset for every scientist. The student is expected to respond to reasonable questions about the work presented, the relationship of the work to other work in the field, and the conclusions drawn. It can be very useful to suggest other avenues for future research.

### Conduct of research

The manner in which the research has been carried out, starting from the first exploratory interview with the prospective Supervisor and up to completion of the thesis, is judged solely by the Supervisor and contributes 30% of the total mark. Even casual conversations in the laboratory can contribute, mostly positively, to the overall evaluation of this element. The expected mark for a student who does work competently but unimaginatively usually falls in the 65-75% range; this mark is for the B-C student, or the average student, that is, one not destined for graduate school. Any student who has been accepted into a project course should not perform at a level lower than this range.

The student who is more creative and, by the end of the year, generates his or her own ideas (or who is so well informed of the literature that can suggest other paths proven by other workers in the field) falls into the 76-85%, or B-A, range. A grade of 90% (A+), is reserved for those students who have demonstrated that they are working at a level expected normally of a graduate student. A grade of 95% indicates that the student is better than nearly all of the other students that the Supervisor is likely to meet in the remainder of his/her teaching career.

## Chemistry Department Policy on Completion of Course Work

The Department of Chemistry considers that completion of all components of a course is necessary for a student to be given credit in that course. Therefore, it is the policy of the Department that a student must complete, and hand in if applicable, all material associated with each component of the course. This applies equally to work that is handed in or completed too late to earn any marks in the course, in conjunction with the policy of the course instructor on lateness.  
Students who fail to meet this requirement for reasons that would make it reasonable to assign an ”incomplete” mark for the course should consult the instructor well before on which final marks are due for the course in question. In the absence of an incomplete standing being assigned, the student will receive a mark of “0” and an “F” grade in the course.