Roanoke College Chemistry Department
Research Project Paper Guidelines

Rev. June 2007

Your paper is the final formal record of your research project. It is also your chance to shine, to show off your work and what you've learned. The Chemistry Department keeps copies of all research papers in Trexler 464. Write a paper so good that twenty years from now you will want to bring your children back for Alumni Weekend to show off your work.

A good paper requires time, multiple drafts, careful editing, and attention to detail. Start writing early. Use a formal, scientific style. Most of the paper should be in the third person. Use the active voice whenever possible, except in descriptions of procedures. ACS style calls for experimental procedures written in the third person, passive voice. Summarize facts or ideas of others with paraphrases and appropriate citations. Direct quotations should be reserved for the rare occasions when the exact words of another are required. You should be able to place ideas in your own words and thus cite them as a paraphrase. If you cannot explain an idea in your own words, it doesn't belong in your paper.

Avoid stream of consciousness or chronological organizational structures. Your paper should follow a format very similar to that used by professional chemists in journal articles. Although individual papers may vary a bit, a typical paper includes the sections below.

Cover Page: Include your project title, name, research advisor, research period (e.g. Summer 2007). Note if you are a Bondurant Scholar, Summer Scholar, and/or completing Honors in Major.

Abstract: Generally not longer than a paragraph, the abstract is a concise statement of what was accomplished. While the goals of the project are often included, an abstract is not primarily a statement of a project's goals or purpose.

Introduction: Often the longest section of a research paper, the introduction places the work in context by providing appropriate theoretical background, a history of previous work, reaction mechanisms, background on significant techniques or instruments, etc. A review of information available in the literature is often part of the introduction. Include structures, figures, graphs, formulas, and chemical equations as appropriate. Place figures as close as possible to the point where you describe them. Number figures and equations to help your reader. Be sure to include citations for sources of information and sources of any figures you borrow.

Methods and Materials: Describe the sources of all materials and the details of procedures followed. You need to provide enough detail so that a trained chemist could duplicate your work. You do not need to give details for methods that would be familiar to anyone with undergraduate training (e.g. how to do a titration). Experimental procedures are written in the third person, passive voice, past tense. While we try to avoid passive voice most of the time, we use it in descriptions of procedures because the doer is not considered important. Any chemist should get the same results following the procedure. See the end of this handout for examples and guidance.

Data and Results: Put data in tables if at all possible. You do <u>not</u> need to show details of calculations. Any graph should be computer-generated. If you have a lot of data or spectra, you will need to select those important enough to include. Be sure that your data tables are easy for the reader to follow. Normally, a table in the body of the paper should be generated in Word. Avoid pasting in spreadsheets unless you exercise great attention to formatting. A spreadsheet

is more appropriate for inclusion in an Appendix.

Discussion and Conclusions: Discuss your findings and the conclusions you draw. Explain the basis for conclusions. Offer explanations for problems encountered and suggestions for future work. This section is often written in the first person.

Acknowledgments: Acknowledge help received, borrowed samples, etc.

References: See pages 287-291 of the *ACS Style Guide, 3rd edition*, which is available in Trexler 464 and the library. ACS offers three options for citation style. You need to use the one that your advisor prefers. References may be noted in the body by numbers either superscripted or included in parentheses and italicized, e.g., idea[1] or idea (*1*). Sources are numbered in order from the first citation. The first source you cite will be #1, the second will be #2, etc. If you later need to cite that first source again, it is still #1. Although less commonly used, ACS also allows the author-date method, setting these in the body inside parentheses. Whichever system your advisor chooses, follow it consistently. See the *ACS Style Guide* for the correct format to list sources at the end of your paper.

Appendices: If your project generated data or spectra that should be preserved with your final paper but that were not directly referred to in the body of the paper, place them in an Appendix. See your research advisor for help deciding if you need an Appendix. For example, your advisor may wish to have NMR spectra for 20 samples included in an Appendix but only examine four spectra in detail within the body of the paper.

Submitting your paper:

1. Allow enough time to work with your research advisor, who will provide suggestions and help with your paper. You should be working on your paper throughout the time you work on research. At some point you should stop research with a week or so left to work on the paper full time.
2. Number your pages.
3. Meet the deadlines that your research advisor sets for work on certain sections and for submission of a full draft to the advisor.
4. Submit a hard copy of your final version at least one week before the date of your oral presentation. Mrs. Anderson will photocopy the paper and distribute it to faculty members.
5. Submit an electronic copy of your paper through SafeAssignment on the Chemistry Research BlackBoard site. SafeAssignment enters your paper into a national database. It also checks it against journal articles and webpages already in the database. If you want to be sure that you are properly paraphrasing material, you may submit a draft of your paper while you are still working on it. SafeAssignment will show you any sections that may be too similar to the original source. Your research advisor can help you interpret the results of a SafeAssignment report.

The Chemistry Department will maintain both print and electronic copies of your paper for the future.

Writing Style

Good scientific writing should be clear and concise. You may write in either the first or third person, except for the Experimental Section described below. Write for clarity. Write in the active voice whenever possible (except for that Experimental Section!).

Experimental sections (not the whole paper) are written in third person, passive voice, past tense. For example, you should write: "A 25 mL sample of 6 M HCl was added to the metal," not "I added 25 mL of HCl," or "Then add 25 mL of HCl." Follow standard rules of good English usage. Don't start a sentence with a number. "A 25 mL sample of acid..." not "25 mL of acid..." Describe what was done, do not give directions. For example, "The sample was titrated ...," not "Titrate the sample..."

The experimental section in a report should always include what was actually done, regardless of what the original directions were. Amounts are often included in parentheses. For example, if you used 0.205 g of $CrCl_3$, you might write A$CrCl_3$ (205 mg, 1.29 mmol) was added to the ...,@ or AAfter the blue color disappeared, 0.205 g $CrCl_3$ (1.29 mmol) was added to the ...,@ or AFinely divided crystals of the deep purple $CrCl_3$ (205 mg, 1.29 mmol) were added slowly to ...@

Do not include procedural details that an educated chemist should simply follow as part of good technique (e.g., correct filling of a buret). Do include details that are unusual, or are critical due to some peculiarity of the system (e.g., adding a reagent especially slowly or with an unusual need for stirring). The Experimental section is subdivided into "Materials" and "Procedures" sections.

SAMPLE: Below is a procedure first as it might appear in a laboratory manual, and then in an experimental section of a paper.

Procedure as it would appear in a handout from the instructor:

> Place 119 mg (1.00 mmol) of tin and 475 mg (1.87 mmol) of iodine into a 10-mL round-bottom flask containing a boiling stone and equipped with a reflux condenser (see Fig. 7.9). Add 6.0 mL of methylene chloride, which acts as the solvent for this reaction, through the condenser using a Pasteur pipet.
>
> Gently, heat the flask and contents using a hot water bath until a **mild** reflux is maintained. This can be detected through a moderate dripping rate from the bottom of the condenser joint. Maintain the system at the reflux temperature until there is no visible violet color of iodine vapor in the condenser throat (~30-40 min). . . . Wash the filter cake with two 0.5 mL portions of cold methylene chloride, and dry the crystals on a clay tile or on filter paper. Determine the melting point of the product, obtain an IR spectrum, and calculate a percentage yield.

Experimental as it would appear in the student's paper:

> Materials: Powdered tin (100 mesh) and reagent grade iodine were obtained from Fisher. ACS Certified methylene chloride was from Aldrich. Melting points were obtained on a Mel-Temp melting point apparatus, and IR spectra were run on a Perkin Elmer 1600 FTIR as KBr pellets.
>
> Procedure: Powdered tin (125 mg, 1.05 mmol) and iodine (480 mg, 1.89 mmol) were placed in a 10 mL round bottom equipped with a boiling stone and a reflux condenser. Methylene chloride (6.0 mL) was added through the condenser. The mixture was then heated to a mild reflux with a hot water bath. After 30 minutes, the violet color of iodine vapor was no longer observed, and heating was discontinued. . . . The solid was washed twice with 0.5 mL portions of cold methylene chloride and then air dried. Orange-red crystals of SnI_4 (580 mg, 0.925 mmol, 98% yield) were isolated.