

Expectations for Laboratory Reports

The hypothetical audience for your written report is a fellow general chemistry student who has not performed the experiment. Your reports should be written in a professional manner, with good grammar, spelling, and style. Except for citation style (discussed below), you should follow the rules in Andrea Lunsford's *Easy Writer*.

You should pay particular attention to accuracy in your scientific expression. Scientists prize lucidity and conformity to convention, and disdain sloppiness and obscurity. We have precise meanings for words and expressions, and we expect others to hold to them. Do not be offended, therefore, if your writing assistant or I correct what may seem to you to be small infractions. While Chemistry 111 is not being offered by the English Department, it is nevertheless a course at a liberal arts college. You will find that in the outside world it pays to be a scientist who knows a preposition from a perchlorate.

You are required to use computer software both to create the text of the report and perform data analysis. You are also required to use Word's Equation Editor (or the equivalent utility in another word processing program) to format non-trivial equations. Figures may be created by hand or with a computer; scanning, with proper attribution of the figure's source (conforming to the citation format outlined below) is also acceptable.

Your written report should contain each of the following sections, in the order given. (Note that an Appendix is optional.)

Title (short but descriptive)

Your Names

Abstract

Introduction

Procedure

Results and Discussion

Conclusions

References

Appendix (spreadsheets and graphs not integrated into the text)

The **Title** should be specific and descriptive: "The Determination of the Enthalpy of Combustion of Sucrose by Bomb Calorimetry" is much more informative than "Bomb Calorimetry Experiment." However, "How 4.56 kcal/g Was Determined to Be the Caloric Content of C&H Pure Cane Sugar (from Hawaii, that's the one) Using a Grisham Model 534 Bomb Calorimeter With Optional Tailfins" is taking things way too far.

The **Abstract** should provide a less-than-150-word summary of the entire work: the purpose, underlying theory, procedure, and key results (for Experiment 4, the atomic mass of aluminum and the composition of your alloy), should all be **briefly** addressed in this essential part of your report. Note that today's web-based scientific databases typically allow one to search titles and abstracts, but often not the main bodies of papers. You should write your Title and Abstract accordingly. The Abstract should be short and snappy. It is not the place to introduce the experiment or describe the underlying principles in any detail. Stated in another way, the paper really begins with the Introduction, not the Abstract. Most scientists write the Abstract after they have written the rest of the paper, since it *summarizes* the work described.

The Abstract must never contain any information that is not also found somewhere in the main body of the report.

The **Introduction** should describe the specific goal(s) of your experiment—what have you synthesized or analyzed? You should also put your experimental work in context. This first involves answering the question, why should we care about your work? Putting your work in context also involves explaining the theory underlying the experiment. You do not need to provide an exhaustive symbolic derivation of every relevant equation, but you should mention key assumptions and approximations.

Specifically, for Experiment 4, you should discuss both stoichiometry and the ideal gas law. You should make reference to Chapters 3 and 5 of your textbook (at a minimum), and provide citations to these references at the end of your paper.

The **Procedure** should provide a concise description of how the experiment was *actually* conducted. While it should not provide an exhaustive account of every step in the experiment, you should not simply write, “See the lab handout and my notebook for details.” Another student in the class who has not performed the experiment should, after reading your procedure section, have a clear understanding of what you did and how to repeat your work. Note important observations (especially events that likely introduced error), highlight any deviations from the instructions in the handout, and document how uncertainties in experimental quantities were determined. You do not need to draw (or reproduce drawings of) the apparatus unless you feel it will aid your discussion.

The **Results and Discussion** section presents the key qualitative and numerical results. If a final numerical result is the average of more than one trial, you should report the uncertainty (either the standard deviation or the average deviation) in your average. Your raw data and calculations should be summarized in a spreadsheet. Please be sure to include this spreadsheet and any graphs used in your analysis either in the Results and Discussion section or in the **Appendix**. Carefully label all columns of data in spreadsheets and all axes in graphs – including units. Be sure that all numbers are presented to the correct number of significant figures. Also provide captions for all figures. Provide all of your *raw* data – this allows the reader to reproduce your calculations if there appears to be an error. You should also provide some qualitative discussion of your results, if appropriate.

You should compare your results to literature (or other accepted) values whenever possible. The *CRC Handbook*, your textbook, and the National Institute of Standards and Technology (NIST) Chemistry WebBook (<http://webbook.nist.gov/chemistry/>) are good sources. Be sure to indicate clearly the source of your literature value(s) (see citation formats below). Agreement with an accepted value exists if your experimental value’s error range overlaps at all with the accepted value’s error range:

For example, say your result is 53.5 mass %, and the accepted result is 53.3 mass %. Following the rule of significant figures, your result actually corresponds to the range (53.4 – 53.6) mass %, and the accepted result corresponds to the range (53.2 – 53.4) mass %. Your result therefore agrees with the accepted value, since both admit the possibility that the actual value is 53.4 mass %.

Finally, you should provide an error analysis. (See pp. 29-30 of your textbook for a brief discussion of experimental error.) First, there are always sources of random error which make measurements less than perfectly reproducible. (That is, the average deviation or standard deviation in your results will never be zero, unless you had some truly bizarre luck in lab!) You should not only identify the important sources of random error, but also try to estimate their

magnitudes. (For example, how much did the thermometer reading fluctuate? How big an effect would this fluctuation have on your ideal gas law calculation?) If your result differs from the literature or accepted value, your measurement suffers from systematic error as well. In this case, you should identify likely sources of systematic error, state their signs (that is, would a particular error make my result too high or low?), and estimate their magnitudes.

Your report's **Conclusions** should summarize what you have accomplished in the experiment. Unlike the **Abstract**, the conclusion need not recapitulate every part of the paper. This section also should contain reflections on anything you would do differently if you had the opportunity to repeat the experiment, and what hypothetical future experiments would be useful or interesting.

Usually, you will have one or more **References** to acknowledge. You do not need to cite course handouts, but you must cite all other sources you have used, including your textbook and web pages. Insert a superscript number the first time you cite a particular reference in the main body of the text, and always use the same superscript number whenever you cite the same source in your report. Instead of using footnotes, collect all references in this final section. We ask that you follow the American Chemical Society's conventions:

Books without Editors: Author 1; Author 2; Author 3; Author 4. *Book Title*, number of ed.; Publisher: Place of Publication, Year; Number of Chapter(s) Cited. For example,

Masterton, W. L.; Slowinski, E. J.; Stanitski, C. L. *Chemical Principles*, 5th ed.; Saunders: Philadelphia, 1980; Chapter 23.

Books with Editors: Author 1; Author 2; Author 3; Author 4. "Chapter Title." In *Book Title*, number of ed.; Editor 1; Editor 2, Eds.; Publisher: Place of Publication, Year; Number of Any Specific Chapter(s) Cited. For example,

Montgomery, M.; Norman, J. "RNAi and Cosuppression: Double-stranded RNA as an Agent of Sequence-Specific Genetic Silencing in Animal and Plants." In *Molecular Biology of Double-stranded RNA: Concepts and Applications in Agriculture, Forestry, and Medicine*. Tavantzis, S., Ed.; CRC Press: New York, 2001. (This cites the entire book; "Chapters 3-5" would follow "2001," if only those chapters were relevant.)

Articles: Author 1; Author 2; Author 3. "Title of Article." *Name of Journal* **Year**, *Volume*, Beginning – Ending Page. For example,

Kuwata, K. T.; Erickson, R. I.; Doyle, J. R. "Improved Interatomic Potentials for Copper and Aluminum Sputter Atom Transport Simulations." *Nuclear Instruments and Methods in Physics Research B* **2003**, *201*, 566-570.

Web Sites: Cite their URL. Also note the last day you accessed the site. For example,

<http://webbook.nist.gov/chemistry/> (accessed 9/25/2005).

Timetable and Grading for Experiment 4

- Monday, October 3: Meet in Olin-Rice 343 to do the experiment.
- Friday, October 14, 5 p.m.: Each lab team should turn in both of your lab notebooks, and the first draft of your report, either to Rob or to me. Note that each lab team should turn in only one report. Questions on calculations should be directed to Rob or me, while questions on the paper should be directed to Barbara (bhirschman@macalester.edu).
- Week of October 17: Each lab team will meet with your writing assistant, Barbara Hirschman, to discuss your draft.
- Wednesday, October 26: Final draft of paper due to me. Remember to turn in the corrected first draft of your paper as well.

This experiment (and Experiments 8-9) will each count three times as much as your other experiments. Rob will grade your notebooks as usual. Barbara and I will grade your papers based both on scientific content and writing quality. Barbara's grade of your first draft will be weighted half as much as my grade of your final draft.

I have attached an example of an excellent lab report from last year's chemistry first year course. While the students wrote on a different experiment, you can still get a sense of what Barbara and I will be looking for.