

## Laboratory Report Logistics

- Thursday, October 7: Each pair of lab partners will turn in both your notebooks and the first version of your report to Rob. (Each pair should turn in one common report.) He will give the reports to Emma Whitcomb, who will grade them over the weekend. (He will grade your notebooks as usual.) Make an appointment to meet with Emma sometime the following week. (You can reach her at ewhitcomb@macalester.edu or x8281.)
- Week of October 11: Receive feedback from Emma and revise your report.
- Tuesday, October 19: Turn in final version of report to Prof. Kuwata.

## Expectations for Laboratory Reports

Your reports should be written in a professional manner, with good grammar, spelling, and style. The hypothetical audience for your written report is a fellow general chemistry student who has not performed the experiment. 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 professors correct what may seem to you to be small infractions. While Chemistry 112 is not an English class, it is 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 peroxide.

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) for 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, key results, and comparison with the literature 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. Under no circumstances should material appear in the Abstract that is not found somewhere in the body of the report.

The **Introduction** should describe the specific goals of your experiment. What have you synthesized or analyzed? This section of your report should also put your experimental work in context. Explain their significance (answer the question, why should we care about this work?), and discuss the theory underlying both the method and the general subject. Your Introduction should definitely cover the experiment's *motivation* and outline the overall *approach*. It is common to discuss here how your experimental data will be manipulated (via the underlying theory) to obtain the result(s) of interest. You do not need to provide an exhaustive symbolic derivation of every relevant equation, but you should mention key assumptions and approximations.

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 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 (usually the standard 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 here, in the Results and Discussion section, or in the **Appendix**. Carefully label all columns of data and all axes in graphs – including units. 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. (In Experiment 3, the mass of the crucible is *raw* data; the mass of the hydrated salt is not *raw* data because it is derived from two other pieces of data: the mass of the crucible and the mass of the crucible + the hydrated salt.)

You should always provide some qualitative discussion of any numerical results. For example, discuss whether your data indicate deviations from a simple "ideal" model, and if so, what these deviations reveal about your experimental system.

You should compare your results to literature values whenever possible. The *CRC Handbook*, the *International Critical Tables*, and your textbook are good sources. (The Internet is an acceptable, although less reliable, source. If you have any questions about the validity of a

web page, please e-mail your writing assistant or one of your instructors.) 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 the error range of the accepted value's error range: for example, if we take the rules for significant figures into account, 5.35 and 5.33 **do** agree, because both admit the possibility that the actual value is 5.34. Note that 5.35 and 5.4 also agree, but 5.35 and 5.5 do not.

Finally, you should provide an error analysis. First, there are always sources of random error which make measurements less than perfectly reproducible. You should not only identify important sources of random error, but also try to estimate their magnitudes. If your results differ from literature values despite averaging over multiple trials, your measurements probably suffer from systematic error. 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 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, 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://bcs.whfreeman.com/chemicalprinciples3e/> (accessed 9/24/2004).

We have attached an example of a lab report from the Physical Chemistry course. The author was an outstanding biology major and chemistry minor, and is now attending a top medical school. Note that while the author received a high grade, her paper was not free of some scientific and writing errors. However, in Physical Chemistry, we do not give students the opportunity to revise papers for re-grading. Even excellent writers rewrite their papers several times before submitting them for publication in a scientific journal. We believe the revision process will increase both your scientific and writing skills.

Please feel free to consult with Emma before your first draft is due.

### **Grading Scheme for Laboratory Work**

As p. 2 of your syllabus says, lab work is worth 25% of your grade. You will do a total of seven experiments this semester. (We are canceling Experiment 7: Calorimetry, which was originally scheduled for November 11.) Experiments 1, 2, 4, and 5 are worth 25 points each. Experiments 3, 6, and 8, which require formal reports, are worth 50 points each. The total number of points is therefore 250, which will be divided by 10 and added to your overall grade.

Note that for the experiments worth 50 points, 10 of these points will be based on your notebook. The other 40 points will be based on your report. Of these points, 30 will be based on the scientific content, and 10 will be based on the quality and mechanics of your writing. Emma's grade of your first draft will be weighted half as much as Prof. Kuwata's grade of your final draft.