

Guidelines for Lab Reports

The exact format of a laboratory report will vary from place to place. Even different chemistry journals will prescribe somewhat different formats. However, the general principles of constructing a lab report remain constant. Here are guidelines to the construction of a lab report.

General Considerations

1. Lab reports should be typed using 1-inch margins and an easily readable font, such as Times New Roman 12 point or Arial 10 or 11 point. Do not use unusual fonts, such as script. If handwritten reports are acceptable to your instructor, they should be written in ink using one side of the paper.
2. Chemical formulas should use subscripts and superscripts properly. It is convenient to customize the toolbar in your word processor to have buttons for these formatting commands readily available. If you use Microsoft Word, there is a useful chemistry formatter add-in that will automatically format most subscripts and superscripts for you; it can be downloaded at the URL <http://spectrum.troy.edu/%7Ecking/ChemFormat/index.html>.
3. Learn to use the equation editor of your word processor. It is very helpful for typing scientific equations. It will also be worthwhile for you to learn to use a structure drawing program, such as ChemSketch <http://www.acdlabs.com/download/chemsk.html> or ISIS/Draw <http://www.mdl.com/downloads/downloadable/index.jsp> for drawing chemical structures.
4. Specialized scientific symbols and Greek letters should also be typed properly. Use the insert symbol command in the word processor, the symbol font, or the procedure described at the URL <http://web.centre.edu/shiba/Chemistry%20Symbols%20in%20Word1.htm>.
5. Staple your report before submitting it! Loose pages or those with the corner folded over will not be accepted.
6. Principles of good writing transcend disciplinary boundaries. In scientific writing it is important to pay attention to spelling, grammar (comma splices and run-on sentences are common errors), and good composition, i.e., put ideas in coherent order and group related ideas in the same paragraph. You are graded on these aspects as well as the scientific content!
7. Remember: *all* information in the report that is taken from other sources must be properly referenced!

The sections of a typical lab report include an abstract, introduction, experimental, results, discussion, conclusion, references, and appendixes. Following is a description of these sections and the content of each section. Each section of the lab report should be titled, e.g., “**Abstract**,” as shown below.

Abstract (Instructors in introductory courses may ask you to omit the abstract.)

The abstract is a brief synopsis that gives a quick overview of the entire investigation. For scientific journals, this abstract may run to around 200 words, but for an academic lab report it will usually be much shorter; in some cases a half-dozen sentences may suffice. The objective of the investigation should be stated succinctly at the beginning. This is followed by a *brief* description of the methodology. Finally, the results and conclusions are stated. When you write an abstract, ask yourself the following question: “If

someone were to read only the abstract, would they get a sense of what the experiment involved and its outcome?"

Introduction

This section begins the actual body of the report. Start by giving a concise statement of the objective of the investigation. The rest of the introduction will discuss the theoretical background of the experiment, i.e., identify those theoretical principles directly relevant to the investigation and how those principles are applied experimentally. For instance, suppose that you wish to determine the molar mass of a volatile liquid by making use of the properties of ideal gases. You would state that the liquid must be vaporized in a container with a tiny opening until only vapor remains and it fills the container. Then you would explain that the vapor obeys the ideal gas law, and you would present the equation, identifying all terms:

$$PV = nRT. \quad (1)$$

You would then show the manipulations that bring the molar mass into the equation, ending with the result

$$M = mRT/PV. \quad (2)$$

Finally, you would discuss how each of the quantities is obtained in the experiment. Note that you are not describing the *exact details* of the experimental procedure here, but giving a general description of the procedures necessary to obtain the information needed to reach the goal of the investigation. One way to look at this section of the report is to say that it rationalizes the procedure, i.e., explains the theoretical basis for doing the various steps of the procedure. If you are studying a chemical reaction or carrying out a chemical synthesis, be sure to show all relevant chemical equations. Each equation should be set off on a separate line and numbered at the right-hand margin, e.g.,



You may then simply refer to an equation by its number, e.g., "Solid copper and solid sulfur are heated together and react according to equation 3."

When reactions involve structurally complex species, these species should be shown with **structural formulas** (use ChemSketch or ISIS/Draw) rather than simple molecular formulas.

Experimental (Be sure to reference the original source of the published procedure.)

This section provides a succinct narrative description of the general procedures used. Omit minor details such as cleaning a crucible first or rinsing a buret or zeroing a balance (note that the instrument used to measure mass is called a balance, not a scale); it is assumed that the necessity for such operations is known to the audience. *Do not* simply write a numbered list of instructions (one of the most common mistakes in introductory science courses). Instead, the procedure is described as a narrative of *what was done*; this is generally written in third person, passive voice, past tense, e.g., "Weighed amounts of copper and sulfur were heated to red-hot in a porcelain crucible over a Meker burner."

In research (and advanced courses) it is common practice to identify reagents and instruments used. For instance, one might say "Granulated zinc metal (60 mesh, Alfa Inorganics) and concentrated hydrochloric acid (Fisher) were used as received, without further purification." The make, model, and sampling conditions for instrumentation are described thusly: "Infrared spectra were obtained on a Nicolet Avatar

FTIR. Samples were mounted as Nujol mulls on polished NaCl disks.” Another example: “Electronic (UV-visible) spectra were obtained on a Cary 100B spectrophotometer. Samples were run as 0.010 *M* aqueous solutions in 1-cm quartz cuvettes vs. deionized water.”

Results

Results and discussion will be described here as two separate sections, although many journal articles will join these into a single section called Results and Discussion. First, present your primary data (those data actually recorded in the laboratory) neatly. (*N.B.*, data is a plural word and requires a plural verb. The singular form is *datum*.) For repetitive numerical measurements, use a data table. Your word processor has a table command. Label each column clearly with the name of the quantity and the *units*. It is not necessary to place units on each individual datum in a table. If there is more than one table, each table should be numbered with a Roman numeral and titled, e.g., “Table I. Masses of Samples Before and After Heating.”

If calculations are to be carried out, a sample set of calculations should be shown. Using one set of your data, show in detail each step of the calculations leading up to the final result. All quantities must be clearly identified and contain units, and the purpose or method of each calculation should be stated. The goal here is to show the *method* of doing the calculations; it is not necessary to show the detailed calculations for *every* trial. If there were several trials, the ultimate results of the calculations for each trial are then presented in a table. Note that if spreadsheets are used to carry out the calculations, the methodology should still be explained. Spreadsheets must also be clearly labeled with an explanatory title and names of all columns with units. Try to format spreadsheets so that they do not extend over more than one page by using landscape format, narrowing the columns, or placing some columns below others.

Discussion

Begin by stating your results, e.g., “The molar mass of unknown number 12 was found to be 83.4 g/mol \pm 4%.” If the results relate to a table, graph, spectrum, or other figure, make specific reference to it, e.g., “See the infrared spectrum of the product, Figure 1.” State what the significance of the result (number, graph, spectrum, etc.) is, relating this back to the original objective of the investigation. Be as specific and detailed as possible. Always compare your results to literature values (give a reference) when possible. Present any quantitative values related to error and uncertainty (relative error, standard deviation) and discuss their significance. When linear regression techniques are used with graphs, always present the slope and intercept with proper units and discuss the size and significance of the uncertainties in the slope and intercept and the meaning of the correlation coefficient. In synthesis experiments, discuss the outcome of the experiment in as much detail as possible (color of product, yield, melting point, etc.).

A very important part of the discussion is an assessment of error sources. This is perhaps the part of a lab report that students find most difficult. Lab reports do not mention *human errors*. Do *not* say “I may have misread the buret.” First of all, there is no way of determining whether these mistakes might have occurred. We will assume that you had good lab technique (whether true or not). The only time that human errors should be mentioned is when they are known to have occurred. If you spilled half of your sample, it is legitimate to mention that as a cause for a low result. Also, do not blame a poor result on malfunctioning equipment *unless you know for a certainty that the malfunction occurred*.

The type of error that you should focus upon is known as a systematic error, and is inherent in the procedure used. Systematic errors affect the result in one specific direction, whereas misreading of a buret could

result in either a too-high or too-low result. For instance, if the volume of an uncalibrated container is determined by filling the container with water and then pouring the water into a graduated cylinder, the result will always be low, because it is impossible to completely empty water out of a container.

Analysis of systematic error may be difficult, but you should undertake to be as detailed as possible. For example, when using equation (2), a high result might be due to the recorded mass or temperature values being too high or the recorded pressure or volume values being too low. Possible reasons for all of these occurrences should be presented if possible. A reason for a low volume has already been presented. A high temperature reading might result if the temperature of the water bath was used, but the flask was not completely submerged and, hence, was partially subjected to room temperature. You should then attempt to identify which of the possible errors was most likely and most significant in size. If your ultimate result was too low, all of the above considerations must be reversed.

Conclusion

In a large investigation, there may be several conclusions that can be presented in a final paragraph. In most course experiments, a brief conclusion may simply be stated in the last sentence or two of the discussion rather than writing a separate conclusion section.

Place your signature and the date at the end of the conclusion!

References

All outside sources of information (not coming from your own personal work) must be properly acknowledged. For instance, the experimental section should include a footnote or endnote directing the reader to the complete details of the procedure (the web page or text). Theoretical information used in the introduction and literature values (“known” or accepted values) of numbers to which your result is compared must likewise be properly referenced. Examples of the citation format used in American Chemical Society Journals follow.

For journal articles: Author, *title*, year, *volume*, first page

ex.: O'Keefe, A.; Deacon, D. A. G. *Rev. Sci. Instrum.* **1988**, *59*, 2544

For books: Author, *title*, edition, publisher: city, year. page

ex.: Elschenbroich, C.; Salzer, A. *Organometallics*, 2nd ed., VCH Publishers: New York, 1992. p 253

Appendixes

Graphs, spectra, or other figures are attached at the end of the report. Each figure is numbered with an Arabic numeral and given an appropriate descriptive title, e.g., “Figure 1. UV-VIS Spectrum of Compound 1 after 20 Minutes.” In the case of graphs, the title should place the graph in context, not merely identifying the quantities plotted. A title such as “Figure 2. Concentration vs. Time” is unacceptable. A better title would be “Figure 2. Rate of Reaction of N₂O₅.” You may then refer to these figures by their numbers in your discussion of the results.

Some instructors may wish to have you attach the carbonless copies of your original data from your lab notebook as an appendix.

Final Notes:

There are many sources of information available to help you in the writing of lab reports. You are encouraged to use the Writing Center on campus. In addition, the sources listed on the following web page may prove useful to you: http://web.centre.edu/shiba/Scientific_Writing.pdf

Example of a synthesis-oriented journal article:

<http://pubs.acs.org/cgi-bin/asap.cgi/inocaj/asap/html/ic700772a.html>

Example of a physical-measurements-oriented journal article:

<http://pubs.acs.org/cgi-bin/asap.cgi/jpcafh/asap/html/jp0739972.html>

And, lastly, some additional web sites that discuss scientific writing:

- 1) [*Writing Guidelines for Science and Engineering Students*](#). Michael Alley, Virginia Tech
- 2) [*Writing for Scientists*](#). SLDC site
- 3) [*Scientific Writing*](#). Duke University Writing Studio
- 4) [*Writing in the Sciences*](#). UNC Writing Center
- 5) [*Writing in Scientific Journal Style*](#). Bates College Dept. of Biology

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