Writing a Lab Report

Notebooks

It will be impossible to write a good lab report without keeping a good laboratory notebook. Data should be in neat tables and include units. The more organized your notebook is the easier it will be to analyze your data and find any errors during calculations. You may want to include drawings of your apparatus since it may more clearly help you understand how things work and why certain steps are taken. Also, if you understand your apparatus clearly, you may discover more possible sources of error. List observations so that you remember to include them in your report. Don't forget that your lab notebook must be signed and dated following each day you run an experiment by your TA or the lab coordinator.

The Report

Size
The length should be no more than four (five for the KFR, HCl, and GLC experiments) pages double-spaced, 12-point Times Roman or larger with one inch margins. This does not include graphs and tables, but does include their accompanying text. Total length (including tables and graphs) should not exceed ten pages.

Title
Include an appropriate title, your name as well as your partners, your lab section (by day and time) and the date that the lab report is due.

Abstract
Although this part appears first in the report, it should be written last. An abstract is essentially a summary of your experiment in 3-7 sentences. It should include information about the procedure as well as any important theories and formulas used. Results should be listed with errors as well as any major conclusions. You want to highlight the major points of the experiment, so don't include things that aren't essential to determining your results. Good examples can be seen in any major journal.

Introduction
The introduction is essentially a purpose and theory section. You should include a brief experimental/procedural section. What did you do? It does not need to be detailed. Make sure you reference the procedures.

Explain the science of the experiment. Develop the theory of the experiment; this includes key concepts, important equations, and assumptions. Why did you do it? What kind of conclusions do you expect to come to? How do you plan to come to them? This should not be taken directly from the lab handouts. The best lab reports are usually written by people who have looked up one or more references cited in the lab handout and have used physical chemistry textbook to develop the background. You need to show that you thoroughly understand the concepts.

Data
Specify the instruments and instrument settings that you used. Be specific. Make and model number are important if they are available for the instrument. List any information about chemicals that you used. Specify manufacturer and purity. If any solutions have been made, record the concentrations.
Present a table of data taken during the experiment. Inserting a table into your text is the best way to present your data. Make sure that all entries are clearly labeled and use the correct units and significant figures. Your table must have a title. The word "table" should be capitalized. It there are more that one table, each table should be numbered. For example, "Table 1 – Temperature and Pressure Measurements". If you measured temperature in Celsius while collecting the data, report it as such. Do not automatically convert to Kelvin. This will make any mistakes you make traceable. The entries must be neat and clear. Do not simply reference attached notebook pages. Also list the error in the data from the measurement.

Calculations and Random Error
This section should be typed, but can be neatly hand written. Do not turn in MathCAD printouts as your calculations section, since they are difficult to read. In the calculation section, list the formula with the symbols defined, a sample calculation with your data, the corresponding error formula, a sample calculation if applicable, and a table of calculated values for that specific calculation. Include a sentence of description if needed. You must include enough explanation in order for the reader to follow your thought process. Make certain that you use correct units and significant figures.

Work carefully. If the final answer doesn't seem correct, check your calculations. It is possible that you made a simple mistake and a TA will know you didn't check your work when they find it. Make sure that you show all equations and error calculations.

Graphs should be included in this section. Make certain that your graphs are labeled with an appropriate title. The title "y vs. x" is not appropriate. The title of the graph should convey its importance to the reader. Label each plot with Figure # – then give a description of the figure. Make certain that the axes are labeled with appropriate titles and units, and that the axes have correct significant figures and an appropriate scale. Printing the background of a graph in Excel's standard gray is not recommended. If you print in black and white, make sure all of your data sets are easily distinguishable from one another and are identified in a legend. Graphs look best when they are placed one or two per page. They serve no purpose if the reader can't easily see them. If you are attaching additional information such as spectra or printouts, make an appendix at the end of your lab report. Title and label your appendix and refer to it in the appropriate section of your report.

Results
You must show your results in one concise table. Report the experimental values as well as their error. Include literature values. (These can always be found!) Be sure to compare the values you obtained to literature values.

Discussion and Systematic Error
Now it's time to analyze your results. This is an important section so make sure that you are addressing relevant issues.

What does your answer mean? How does it compare to what you expected? The sign or magnitude of the value will often give some insight into some physical phenomena. If you calculate a value in two different ways make sure you compare the two answers and methods. If you calculate the same quantity for two different molecules make sure you explain differences and similarities. Do you notice any trends in your data? Use your data to draw conclusions. If you have any tables or figures refer to them in this section.

What about error? Discuss the systematic error of your experiment and how it affects measurements you've made. Think about the magnitude of the error. An error bar may often seem large, but may in fact be acceptable when you consider the limitations of the theory used. Compare your value to a literature value and give a relative error. Similarity to published values does not mean that you deduced the "correct" answer: it just means that the values are consistent. How well does the theory that you used hold up? Talk about the assumptions made in the theory and their relevance. Suggest changes that could be made to the theory or procedure to improve results.

Answer all questions from the handout. Do not make statements like "This lab was successful" or "These results are reasonable" Statements need to be backed up with proof.

Conclusion
The conclusion should be only one or two sentences long. It is your last chance to report your results and relate them to the purpose of the experiment. Let the reader know the significance of the results.

References
Reference all information you have used. List the lab handout. References should include texts you've used to help write the introduction and discussion, and well as references to literature values. Use standard referencing techniques.

Other Requirements

Lab reports constitute the bulk of your grade and there are only five or six of them. Here are some other helpful hints to avoid losing points.

- The presentation of your lab report is worth points. Make certain that the report is neat, organized, clear and concise. Reports should be typed.
- Never use first person language while writing a lab report.
- Use subscripts and superscripts appropriately.
- Don't write out "delta" when you can use "Δ."
- Use units and significant figures– always!
- Don't leave your decimal places naked. 0.456 not .456.

- Spectrum is singular and spectra are plural. Make sure that you are using instrument, apparatus and machine correctly.
- Capitalize computer programs like Excel. If you fit a trend line you need to specify what type of fit it is and include the error. Excel can do that for you. If you do not know how to use the data analysis in Excel, ask your TA.
- All figures and tables must be labeled. Refer to all figures and tables in the text of your report.
- Include page numbers.
- Understand error and how to use it. See the Error Analysis handout.
- Write in a professional manner. Don't be wordy. Be specific. Don't overuse pronouns. Using "it" frequently can be quite confusing. Avoid generic sentences. Don't make statements like "The purpose of this lab was to introduce us to high vacuum systems."
- Turn in you lab reports on time. Lab reports that are one week or more late will not be accepted. Late labs can have a significant negative impact on your grade.
- Make sure that you are doing your own work. It is acceptable to do the experiment with your lab partner. This includes, for example, interpreting a spectra or determining the energy of peaks. The write up and calculations should be your own. Be careful not to plagiarize any references that you use.
- Your paper should be written at the comprehension level of your peers, not a general chemistry level or a PhD level.
- Most importantly, proofread! Obvious misspellings and typos indicate a lack of commitment to the class. Read your papers before turning them in. Make certain that sentences "sound right." The extra time will definitely be reflected in your grade.
- Make sure that you read the comments on your returned lab reports to avoid making the same mistakes again.
- If you need help, please ask.