Guidelines for Post-lab Assignments

In CHEM 1211K, post-lab assignments will be administered and graded through Canvas. The last assignment in each experiment module is the post-lab assignment for that experiment; it should be completed before the start of your next lab period. Most post-lab assignments will be abbreviated technical reports including some of the sections of a full technical report. Occasionally, an infographic, technical poster, or other non-traditional piece may be assigned.

The overarching structure of post-lab assignments is designed to help you develop familiarity and skill with technical writing in chemistry. A complete technical report consists of five sections: *Abstract*, *Introduction*, *Data and Results*, *Discussion*, and *Conclusions*. In early experiments, you will write these sections individually, building to reports containing multiple sections and a full report near the end of the semester. In addition, instructions for reports will become more "hands off" as the semester progresses.

Purpose:

Lab reports are an essential part of developing and demonstrating understanding of the content and experimental findings from the laboratory. They model the peer-reviewed research articles scientists publish to share their results with the broader community and are an excellent opportunity to learn how that process works.

1. They are a typical assignment for upper-level lab courses and will become more complex with higher expectations the more advanced you become in your scientific coursework. This is one major reason for introducing them gradually in an introductory course.
2. Another significant factor in using reports as a typical assignment format in introductory chemistry is that it serves as an assessment of your understanding of your own experimental results. It forces you to examine the data, analyze it, make sense of it, and explain what it means. This allows you to rationally present a position based on your findings and compare it with the conceptual knowledge gained in your lecture course and in the experiment background.
3. A final significant rationale for using lab reports as an assignment is that it is in the *process* of writing the report that a lot of the learning from the lab course actually occurs. This is because it is the point at which you must put all of the pieces together into a coherent explanation or argument and this requires critical thinking.

Task:

Most weeks you will be expected to include at least your results and conclusions (or discussion of results). There will be some weeks that you are asked to incorporate one or more additional sections in your report. If there was only a single experimental option, you will typically have suggested data tables and detailed instructions for what to include in the instructions and the rubric for the assignment. If multiple research questions were presented and you had a choice of experimental path, you will have a bit more room for interpretation as to what results are crucial and how to present them. This is more authentic because science researchers have to make decisions about how and what to present when it comes to their experimental findings. The document is to be prepared in your own words and should provide sufficient explanation that a person who did not complete the experiment can understand what you did and how you came to your conclusions about what they mean. A pdf of your document will be uploaded to the assignment folder in Canvas by the due date in order to receive the opportunity for full credit.

Criteria:

The criteria for each report are stated in the items of the grading rubric associated with that assignment. If you have questions about grading criteria, it is helpful to ask your TA or Dr. Santos (via Piazza or email) for clarification. Keep in mind that specific grading questions should be directed to your TA because they will be the one reading and assigning points using the rubric. In general, the expectation is that you will 1) present all required data/results in an appropriate format, 2) provide either an argument based on your actual data (not on what you expected to observe) or an explanation of your data in light of the concepts you have learned, 3) divulge any reasonable experimental errors that may impact your results and conclusions ("human error" is not specific and shows no consideration for what could be improved if you were to redo the data collection), 4) include anything described in the rubric.

Completing Post-lab Assignments

Each abbreviated report comes with two key files: a *data workup spreadsheet* used to perform calculations, create graphs and tables, and otherwise analyze the raw data collected in the lab, and a *post-lab template* document that will contain your final submitted report. Detailed instructions for data workup are included at the end of each protocol. Instructions for each section of the report are included in the Canvas assignment. Work up your data, copy and paste required tables and figures into the Data and Results section of the template, and complete any additional required sections from there. Instructions will suggest a general order for completing sections: *Data and Results → Discussion → Conclusions → Introduction → Abstract*.

Entering Equations

Many post-lab assignments will require you to describe and illustrate your thought process using a series of mathematical and/or chemical equations. You should use the equation editor within Word or an online equation editor to create these. Imagine, for example, that I had taken measurements of the pressure, volume, temperature, and amount of a gas with the aim of measuring R, the ideal gas constant. To illustrate how R can be calculated from this data, I first include a general equation with variables as letters. If a calculation is based purely on dimensional analysis (e.g., stoichiometry), this is not required.

$$R = \frac{PV}{nT}$$

On the next line, my actual measurements are included. Including actual measurements allows the reader to easily see how your measured data leads to the calculated results. Once actual measurements have been included, the result can be shown after an equals sign or on a separate line. If you'd like to use multiple lines to clarify how your calculations proceed, you are more than welcome to do so!

$$R = \frac{(1.00 \text{ atm})(0.535 \text{ L})}{(0.0223 \text{ mol})(293 \text{ K})} = 0.0830\,\mathrm{L\cdot atm/K\cdot mol}$$

Notice that measured values are included with the proper number of significant figures and the calculated result has the proper number of significant figures. Limit the number of digits you show throughout calculations and ensure that your measurements and final result have the correct precision. Intermediate values need not have proper precision, but should include a limited number of digits to ensure readability.

Data and Results

See below for general specifications for figures and tables that appear in the Data and Results section.

All Figures (Tables and Graphs)

- Figure is numbered appropriately based on its position in the document
- Figure includes a descriptive caption that describes the nature of the data or results depicted

Scatter Plots

- Data are plotted as points without lines or curves connecting the points
- Vertical axis label is included with units in parentheses
- Vertical axis includes at least major tick marks (minor tick marks are optional)
- Horizontal axis label is included with units in parentheses
- A legend is included that enables the viewer to distinguish multiple data series (if applicable)
- Grid lines are **NOT** included!
- A title is **NOT** included!
- A line of best fit is included with equation and correlation coefficient (if applicable)

Bar Graphs

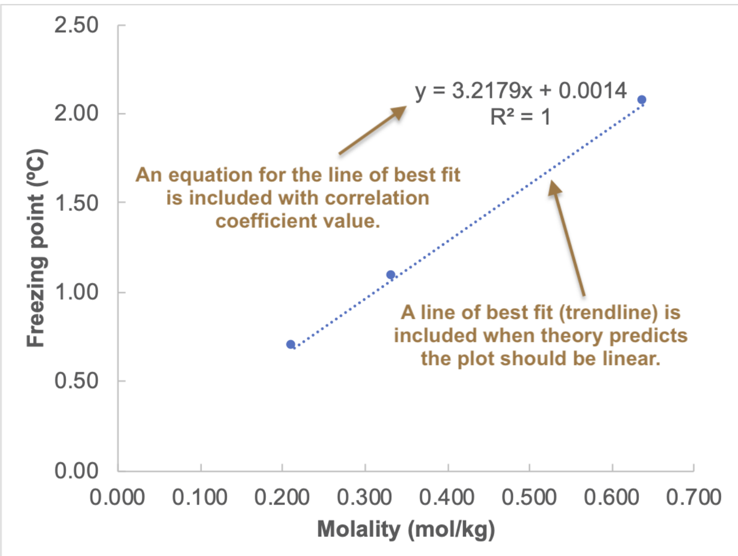
- Data are plotted as bars
- Bar color is professional; multiple colors are used for different data series (if applicable)
- Horizontal axis includes two or more categories; labels are present
- Vertical axis label is included with units in parentheses
- A legend is included that enables the viewer to distinguish multiple data series (if applicable)

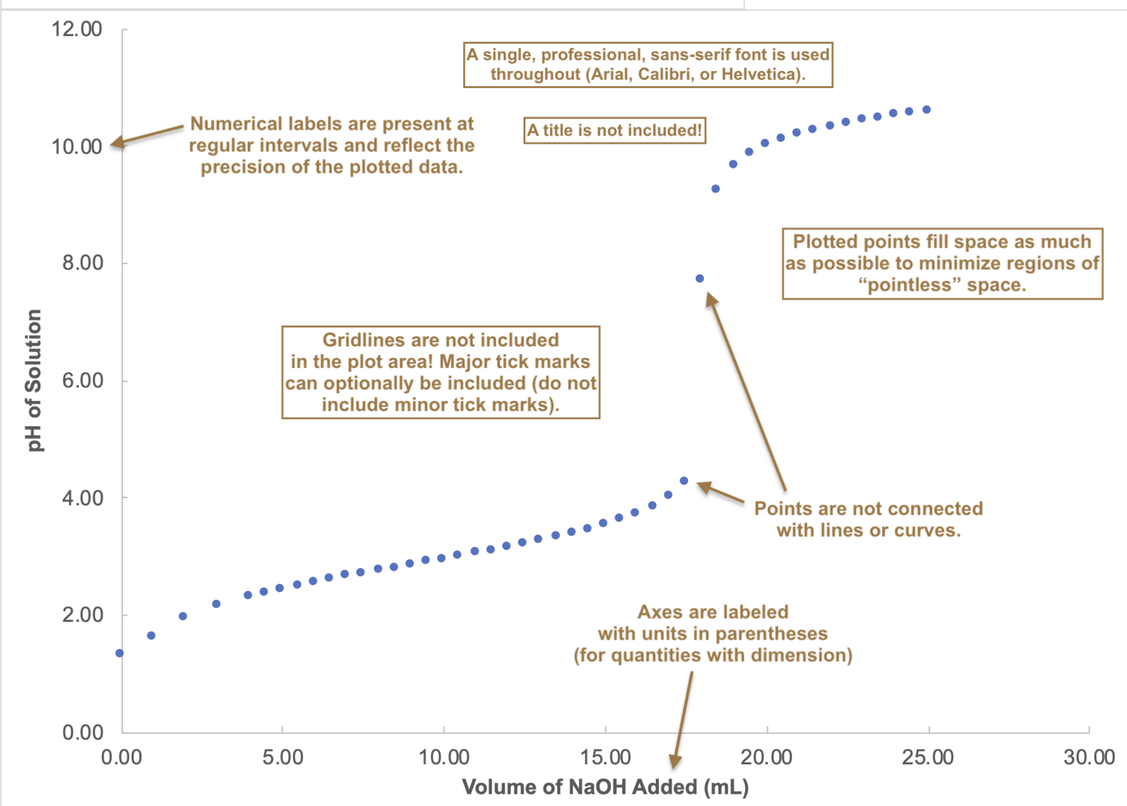
- Grid lines are **NOT** included! Grid lines are unnecessary visual clutter.
- A title is **NOT** included! A title takes up space unnecessarily and is redundant with the figure caption.

Tables

- Units of all tabulated data are clear
- Tabulated values have appropriate precision based on the precision of measuring instruments
- Tabulated data are organized in a sensible and intuitive way

See below for examples of graphs that meet the specifications above.





Other Sections

Abstract

Imagine you're stepping into an elevator on the fifth floor of Clough Commons with the President of Georgia Tech, who asks you what you were up to in chemistry lab that day. You have roughly sixty seconds to describe what you did, and it's clearly important to make a good impression. You'll want to work in the background, significance, results, and conclusions of your work. The Abstract of a technical report is the written equivalent of the sixty-second elevator speech. The Abstract should provide one to two sentences describing background and/or motivation for the work, present the key question or issue the work was meant to address, lay out the major results, and describe the most important evidence for those results. In general, abstracts are between one hundred and two hundred words—conciseness is very important.

When considering what background information to include in the abstract, keep in mind the ultimate goal of motivation. You should provide just enough background to motivate your work. Temporarily put out of your mind the idea that your experiment has been done before—when the theory you are studying was new, how would your work support or refute that theory? What theoretical questions does the work address?

Results reported in the Abstract should include both qualitative and quantitative results, but qualitative results should dominate. If the goal of the experiment was to measure *R* (as in the Exploring Gas Laws experiment), then reporting the value of *R* obtained is just fine. On the other hand, if the goal was to validate Boyle's Law, simply stating "an inverse relation between pressure and volume was observed" is sufficient. The Abstract should also give a sense of the quality of the data—is it close to what theory would predict? Again, both qualitative and quantitative measures of data quality are useful. In the Abstract, just report on data quality and avoid listing reasons why your data is good or bad (unless they have great relevance—but stay concise).

Ultimately, keep in mind the "elevator speech" model for an abstract. Consider your audience to be someone with considerable knowledge of chemistry, but remain concise and try to sell your work by highlighting its most important implications.

Introduction

Where does your work sit in the grand historical scheme of things? What's the state of the field, and where is it going? What theoretical background must the reader understand before she dives into your work? These are a few of the key questions that the Introduction of a scientific report should address. Generally, the introduction has the most references to prior work of any section. The introduction should enable the reader to understand and appreciate the importance of your results (evidence) and conclusions (claims that follow from the evidence).

Discussion

The focal point of a technical piece is the Discussion section. In the Discussion, the idea is to craft an argument that explains how the evidence presented in Data and Results points to a set of broader conclusions. In the Discussion, you will explain how raw data and observations are transformed (via calculations or interpretations) into broader results or conclusions. This may involve showing how your results were calculated and/or describing how your data is consistent with broader chemical theories. In both cases, you will need to bring in concepts and skills from the lecture to be successful.

In some cases you may also need to supply *sources of uncertainty* that result in systematic or random errors in your data. Describing sources of uncertainty with insight is an art that demands mindfulness and attention in the laboratory. The more carefully you document your practices in the lab, the more confident you can be in your identification of important sources of uncertainty. Before throwing out a pie-in-the-sky (or overly vague) reason why something went wrong, carefully consider the likelihood of the error and whether you have any documented evidence that it actually affected the results. In addition, consider the design of the experiment itself: could imprecise instrumentation, leaky glassware, or impure reagents have played a role? These sources of uncertainty may have nothing to do with your technique *per se*. Consider the design of the experiment first, *before* deeming your technique inferior.

Conclusions

The Conclusions section summarizes the experiment as a whole, including big ideas that can be extended beyond the experiment performed or tested further. To generate conclusions, the big results calculated or otherwise determined in the Discussion are compared to predictions of chemical theory. In some cases, it is important in a Conclusions section to suggest future directions for experimental work. This demonstrates an understanding of how the experiment performed fits into a bigger picture.