CHEM 321:
Guidelines for Results, Discussion, and Appendix Sections of Lab Reports

Adapted from M.S. Robinson, F.L. Stoller, J.K. Jones, and M.S. Costanza-Robinson, Write Like a Chemist (pilot draft 2005-2006)

Guidelines for writing the **RESULTS** section of a lab report

GOAL: to clearly and concisely present the results of experimental work.

This section of a lab report presents data collected during an experiment – those things that you observed and/or measured, like mass recovered, % yield, melting range or boiling range, physical appearance, spectra, chemical tests, *etc*. It does NOT repeat or discuss experimental methods, nor does it interpret the results ("i.e. what do the data mean?"). Well-written Results sections use text and graphics very economically.

Results should be organized so that it is easy to see how they relate to the stated objectives of the experiment. This may mean that you need to present them in a different chronological order than you obtained them.

All numeric values must be identified with their *scientific name, must have proper units attached, and must have the proper number of significant figures*. The published sources where you looked up accepted values must be cited properly.

Common problems in novice reports

Vague descriptions: avoid words like "very", "excellent", "good", or "poor" unless you have a valid basis for comparison. It is normally best just to give a numeric result.

Use correct singular and plural forms of words (and the corresponding verb form):

Singular	Plural
datum	data
spectrum	spectra
apparatus	apparatus *(no change)*
criterion	criteria

Present tense rather than past is appropriate when you direct a reader to a graphic ("Results of chemical tests are shown in Table 2." The same holds any time you refer to things expected to be constantly true instead of "one-time" events from the experiment.

Required in Results sections (unless not pertinent to the experiment)**:**

- **yield** in grams and as percent of theory **in the following format:** "The yield of cyclohexene was 10.3 g (43%)." *[if you prefer, "recovery" can be used in place of "yield"]* Use the proper number of significant figures! *[Show all calculations in an Appendix, including those for finding the limiting reagent.]*
- **product characterization:** description of how you verified that you obtained the desired chemical. For example, if you use boiling / melting points or IR spectra, always compare to published values, cite where you looked up these values, and comment on the comparison. If you do chemical characterization, **name** every compound used for [+] and [-] controls and describe outcome of tests.

Optional (include if useful for completeness and clarity)**:**

- **other pertinent information** (unexpected results should be included here).
- numbered **Tables and/or Figures**. Tables are numbered sequentially in the order in which you mention them in the body of the report. Figures are treated separately the same way.

If you are including a Table or Figure in your report, please pay attention to the following important information. If you are NOT including one of these, you can skip to "DISCUSSION SECTION".

Each must have scientifically descriptive row/column or axis labels. *"Scientifically descriptive" means words that help the reader understand the relation of the information in the Table or Figure to the scientific objectives of the experiment. Labels tell exactly what the sample contains or what is being measured ("sample 1" and similar vague labels are not acceptable). Labels always include the* ***units*** *of measurement.*

Do NOT present a Table or Figure (a "graphic") without first alerting the reader what the graphic contains or what conclusion is to be drawn from its information.

Each Table and Figure should have enough information included in it so that a reader can make sense of it. Look at The Journal of Organic Chemistry on the web to get a better idea of how this is done. When you mention a Table / Figure anywhere in your report, you must do so by its number (*e.g.*, "Figure 3 shows . . .").

Tables and Figures should be of a size and format that makes them uncluttered and easily to understand.
No part of a Table or Figure may be split across two pages. This includes titles or legends. If necessary, reorganize your text so that such splits don't happen, or force a page break.

Tables must be numbered (separately from Figures) in the order they are introduced in the report. Each must be introduced by a sentence in the Results section that tells the reader what to look for in it.

- If you don't have enough data for at least 3 rows and 3 columns, do not use a Table. Instead, use sentences to describe results.
- Each Table must have *above it* a title that describes what the table is about *(not just* "Table 1").
  Example Table 1: Results of chemical characterization tests on cyclohexene [a]

  (A signal [a in the example] can be added to direct attention to a footnote beneath the Table where special conditions may be outlined.)
- "Causes" (independent variables) should be in left-hand columns; "Effects" (dependent) in right-hand columns

Figures must be numbered (separately from Tables) in the order they are introduced in the report. Each must be introduced by a sentence in the Results section that tells the reader what to look for in it.

- Each Figure must have *beneath it* a short legend that begins with a descriptive title for the Figure, and then, if appropriate, tells the reader how to interpret what is shown.

  Example for a picture Figure 3: A mechanism for dehydrohalogenation

  Example for a graph Figure 1: Progress of hydrolysis reaction. [H+] at various times determined by titration with 0.1 M NaOH.

Specific requirements for graphs:

- The professionally acceptable designation for a graph, plot or chart is "Figure 2", not "graph #2".
- *If you use software to make a plot, please* ***turn off the "plot area color"*** *so that it is not shaded.*
- The *dependent variable* (the quantity you measure) belongs on the vertical axis; the *independent variable* (the quantity you manipulate or select) belongs on the horizontal axis.
- Axis scales should be adjusted so that the plotted data occupy nearly all of the plot area. There should not be a lot of empty space above, below, to the left or to the right of what you plot.
- Numeric ***value*** labels on axes must display the proper number of significant figures without a lot of leading or trailing zeros. This may require multiplying or dividing data by some factor of 10. If you do this, it must be noted in the axis label. If your software supports it, it is easier to use scientific notation.
- Decide for a given plot whether it makes most sense to show data points without connecting them, to connect them, or not to connect but add a theoretical "best fit" line (the latter is often best, but not always).
- If you impose a trendline and calculate the slope of that line, check to see whether the result has the proper number of significant figures. If it does not, you will need to multiply or divide one of your columns of data by a power of 10 such that the new plot gives a slope with the right number of figures. But remember that the printed value of the new slope is not correct: it must be divided or multiplied by the power of 10 you chose.

Guidelines for writing the **DISCUSSION** section of a lab report

GOALS: a) to show how results relate to the reasons for doing the experiment
b) if yield is especially low or high, to explain or speculate on why
c) possibly to suggest how the experiment might be modified for better results

The Discussion helps the reader understand the significance of the results. *The significance of each result (or group of related results) should be linked to the objective that it serves.* The discussion section should begin with restating the experimental objectives and reviewing the theoretical principles relevant to the reaction and product recovery. The text should make clear how each result (or set of results) meets at least one of the objectives, as well as assuring that all the objectives have been addressed (met or not met). The text should be organized so that it follows the order in which the objectives for doing the work were laid out. This is the most important part of the Discussion.

You should always offer scientifically sound speculation for the reason(s) why the yield was low or high. Some possible reasons include: loss among drying agent, hold up volume in boiling flask, losses in washes, loss in recrystallization solvent, and incomplete reaction (perhaps due to equilibrium not lying strongly to the product side or the temperature not being high enough for a favorable reaction). Don't just guess: think critically about conditions or events that may have interfered, including whether unwanted side reactions would have been likely (describe specific suspected reactions). Also, think about the effect that side products would have on melting range and the % yield. *Generic "human error" is never a valid cause for low yield, and this phrase should never appear in a report.*

If you think you have a reasonable idea for improving the protocol, this is a good place to offer it.

Discussion sections should end with a concise (typically one sentence) summary of the outcome of the experiment, keeping in mind the stated objectives.

Guidelines for writing the **APPENDIX** section of a lab report

Goal: Helps a scientist understand how the data were obtained and allows for further explorations of scientifically related concepts.

In this section, you should give the detailed calculations including: limiting reagent, % yield, and any other calculations needed to report values in the "Results" section of your report. None of these calculations should be in the body of the report; instead refer the reader to the appendix by writing: "A detailed description of the calculations can be found in the Appendix."

In addition, your answers to the enrichment questions posed in the protocol should be here.