The Laboratory Report

The typical report will be from 3-4 pages long. It should be complete, but concise. *Pages in excess of 5* (including Figures and Tables, but excluding the Title Page and Appendices) *will not be graded*. Avoid excessive experimental procedure and theoretical discussion - you will lose points. To receive full credit, use proper format and follow the instructions.

I. Format:

- Reports must be typed (double spaced) with 1" margins.
- Use 12 point font or larger (Times, Arial or Helvetica preferred).
- Reports must be organized as described below, with each section clearly identified.
- Figures may be handwritten, but should be neat and legible.
- The body of the report can be no longer than 5 pages, including figures and tables.
- *A general template for the lab report is available on the course website*.

II. Parts of the Report:

A. Title Page:

1. Title
2. Experiment #
3. Identifying information (at lower right): Your name, Section #, TA, date submitted.

B. Purpose:

Discuss the general purpose of the experiment in one or two sentences. Your purpose should be brief, but should cover all aspects of the experiment.

- For a *technique experiment*, describe *why* you did the experiment rather than what you did (e.g. to investigate…, to learn …, to compare …).
- In a *synthesis experiment*, your purpose will be to prepare a particular compound. In this case, you will need to include a balanced chemical equation for each reaction that you did. Note that the chemical equation provided in the lab manual may not be balanced!

Some experiments will incorporate both new techniques and synthesis. Be sure your purpose is complete.

C. Results and Discussion:

This is probably the most important section of the lab report. It is here that you report your experimental data, analyze and interpret your results, and draw specific conclusions. You will be graded for the completeness and clarity of your arguments, so you will need to support any conclusions you reach in a clear and logical fashion. You should write in clear and concise sentences. Be succinct. A concise, well reasoned argument is far superior to a long, rambling, discourse. Grammar and spelling are also important.

It usually works best to divide this section into multiple parts which correspond to the individual components of the experiment. More specific guidelines are provided at the end of each experiment, but in general, each part of your discussion should be organized roughly as follows:

- In a sentence or two, briefly what you did (e.g. reacted A with B to give C). *Do not include a detailed experimental account* - you have already done so in your notebook.
- For a technique experiment, *briefly* state the relevant theoretical principles (e.g. in general, what do you expect to see?)
- Report what you actually observed. Summarize your results in table format. You may also need to restate your findings in the text, for clarity. *Do not include calculations; do not include raw data* (e.g. measurements used in graphs and calculations).
- Interpret what your results mean. Give all the evidence you have that a particular technique or step was successful (or was not!). Include any graphs, structures, etc. that are necessary for your discussion.
- Discuss the recovery or yield of the product you obtained. Is it unreasonably low? Too high?
- Draw specific conclusions. Did you make the compound or not? Did the distillation work or not? Is your product pure? What is the identity of your unknown? Any conclusion you make must be supported with experimental evidence, either from the literature or from your own studies. Be sure to clearly explain how you drew your conclusions. Build your arguments on thoughtful , well reasoned comparisons. This might include a direct comparison of your theoretical expectations with the actual results you got, or a comparison of the physical and spectral properties of your product with those of the starting material. Be specific. When possible, compare the experimental data you obtain (mp, bp, etc.) to literature values. You can often find these values in the CRC handbook, Aldrich catalog, or on MSDS sheets.
- Clearly relate your findings to the anticipated outcome of your experiment. Do your results agree with your expectations? Does your data support the formation of the expected product? Why or why not. Be specific.
- As needed, identify possible sources of error to explain results that do not conform to your expectations. What errors in the experimental might account for observed discrepancies? Note that "human error" is not a suitable explanation.

You may not always be told how every piece of data you collected can be used to interpret your results. Think carefully about what you did and how your data can be utilized (you may find the section entitled "Interpretation of Experimental Data" in this manual to be helpful). In any case, you should always include and discuss the following information if available:

1. Amount of product (in grams)
2. Percent yield (indicate the limiting reagent) or recovery
3. TLC (report the R_f value). Do NOT draw the plate or show calculations.
4. mp or bp (always report a range)
5. Literature value of mp/bp
6. Physical properties (color, physical state, etc.)
5. GC (report the retention time, the # of other peaks present, and/or the % purity)
6. IR (report absorbance in cm^{-1}; explain their significance. Identify the functional group each absorbance represents. Note absent absorbances as appropriate. Do not over interpret.

D. Conclusion:

Briefly (2-3 sentences) state the conclusions you reached in the Results and Discussion section. Do not repeat all the discussion talking points. Rather, relate your results back to the purpose of your experiment. For example:

- Comment on the overall success of the experiment .
- Relate your findings to more generalized areas. What do your results tell you about a general theory or class of reactions?
- If a new technique was utilized, comment on it's effectiveness relative to what you were trying to accomplish.

E. Appendices:

You may not always have material for each appendix, but the material you do have must be labeled and appear in the following order:

1. Appendix A: Calculations

   For experiments which do not involve a synthetic transformation:

   a. Include one sample of each calculation that you do (R_f values, etc.). In each case, include the equation that you used, complete with units.

   For synthetic experiments, add the following:

   a. For each synthetic transformation you did, make a Table of Reagents which lists the amounts of reactants/reagents that you actually used in the reaction (in mL or grams). Convert these measurements into moles, and then into equivalents based on the limiting reagent (Note: a catalyst is never the limiting reagent). Clearly identify the limiting reagent for each step. For example:

reagent	amount	moles	equivalents	
p-toluic acid	0.52 g	0.0038	1	← limiting reagent
1-propanol	1.5 mL	0.020	5.3	
sulfuric acid	0.1 mL	---	catalyst	

   b. Include a complete percent yield calculation for each synthetic step of the experiment. Include calculation of the theoretical yield. Use the format specified in the Appendix to this manual. Include the equations that you used, complete with units. Also calculate the overall yield for multi-step sequences.

2. Appendix B: Spectra (gc trace, IR, NMR, etc.).

3. Appendix C: Answers to assigned questions.

4. Appendix D: Notebook pages (carbon copy; attached by your TA).

   During the course of the experiment, you will have kept a clear written account of the experiment. You should not reproduce those details in your report. Instead, a carbon copy of the prelab and other experimental information from your notebook will be submitted to your TA at the end of each laboratory period. These pages will be compiled by your TA and attached to your report. *Late notebook pages will not be accepted!*

F. Data Sheet:

For some experiments, you will be asked to complete a data sheet. This form should be completed in lab and submitted it to your TA at the end of the experiment. This sheet will be graded separately from your report and will not be returned.

III. Style:

Some rules for writing are commonly accepted for the scientific literature, and should be followed when writing your report:

- Write in the past, passive tense when describing what you did.
- Don't write in the first person (I, we) unless it absolutely can't be avoided.
- Don't write in the imperatives (e.g. don't give orders).
- Don't use "it", "that", or "this" when discussing your work. Such descriptors are ambiguous and lead to confusion.

For example:

Correct:	"The mixture was heated …."	
Incorrect:	"~~I~~ heated the mixture …."	(first person)
Incorrect:	"~~Heat~~ the mixture …."	(imperative)
Clear:	"The ester was separated from ethanol by distillation"	
Ambiguous:	"The ester was mixed with ethanol and it was collected by distillation" (What does "it" refer to? The ester? ethanol? the mixture?)	

IV. Experimental Results:

As this is a laboratory course, experimental results are significant. Thus, a portion of your report score will reflect your success experimentally, and/or the quality of the product(s) you submit. That said, it is more important to correctly evaluate and explain the results that you got than to get the "right" answer experimentally.