V. GENERAL GUIDELINES FOR KEEPING A LABORATORY NOTEBOOK

In your laboratory classes, you will be given detailed procedures on how to set up and conduct the experiment. It is important that you view these procedures as the intended way of conducting the experiment. As you carry out the experiment, you must write down every detail and what you actually did. If the experiment or lab did not go as planned, detailed record-keeping will be a valuable resource in understanding what happened. As you progress towards independent research, you will frequently be modifying published procedures and figuring out how to make something work or work better. In these cases, it is crucial to keep careful notes so that you or others can reproduce the experiment when it does work. The best discoveries arise from the unexpected, so make sure they get documented!

V.A General Requirements. Each laboratory notebook must:

(i) Be bound (you are encouraged to use a notebook with carbon copies, since you may be required to turn in copies of your notebook pages);

(ii) Record procedures and observations neatly in ink, **as you do the experiment** (in certain cases, you may be allowed to include calculations in pencil). Any mistakes should be crossed out with a single line. Do not record your notes on scraps of paper and later record them in your notebook.

Some faculty use a columnar method to integrate Pre-Laboratory and In-Laboratory notebook entries. For the experimental part, each page is divided roughly in half into two columns; prelab entries are made in the left-hand column and then, as the work proceeds in the lab, a record is made in the right-hand column where it relates to the pre-lab outline. This provides a nice way to compare and contrast the suggested procedure with what you **actually** did.

(iii) Have consecutively numbered pages;

(iv) Include a Table of Contents at the beginning of the notebook (make sure you reserve a few pages for this) that has:

Experiment Title	Pages	Date(s) performed

Each time you make a new entry, update the Table of Contents.

V.B Pre-Laboratory Notebook Entries.

Each experiment should begin on a new notebook page and have an experiment title. You should prepare a brief narrative that at least outlines the purpose of the experiment, and summarizes the recommended procedures and required equipment. For instance, if you are carrying out the synthesis of a compound, the equation(s) for each reaction(s) should be given and include the chemical structure and name of each reagent.

Below each structure, give the physical constants (molecular weight, density, melting/boiling points) for each reagent. Over the arrow, indicate the reaction conditions (temperature, solvent) you intend to use. Indicate the structure of the expected product and theoretical yield. When appropriate, include a table of physical constants for ancillary chemicals such as solvents, extracting liquids, drying agents, and acids or bases used for subsequent neutralizations. If solutions need to be made, be sure you do the required calculations so you know reagent masses and solution volumes that will be needed. If pre-lab questions are assigned, answers should be included in this section.

V.C In-Lab Notebook Entries.

In the laboratory, you must record, in a step-by-step fashion, what you actually do. If the procedure is followed exactly as indicated in your pre-lab work, simply state e.g. "steps (1) – (5) were carried out as described on the previous page." Recognize that while this is appropriate for only the very simplest steps, there are a variety of possible ways to accomplish even these relatively simple steps, and these differences in method could affect the overall outcome of the experiment. Thus it is essential to describe exactly what you did when there might be multiple methods for accomplishing even these 'apparently' simple steps. An uncomplicated example is: "NaI was added to the sulfuric acid solution with the aid of a glass funnel and the solution was stirred to homogeneity with a glass rod." It might seem that too much detail is being given, but the use of a metal spatula to add the salt and to stir the solution might have resulted in corrosion, thereby introducing foreign metal ions from the spatula into the solution that might alter the outcome of your experiment. You would only discover this phenomenon in reviewing several repetitions where the addition and stirring was done by different means that had been duly noted. Of course, if you've modified any of the procedures, equipment, or materials, indicate the changes you have made: "the experiment was carried out as indicated in steps (1) – (5) on the previous page, with the following modifications … "

Indicate the source, purity, and, if available, lot number of all reagents used. Occasionally, you will encounter a bad reagent lot; this can often be used to trouble-shoot unexpected results. All raw data (weights, instrument readings, etc.) should be recorded with **the proper number of significant figures and associated errors. Units must be included on each entry**. Record all observations (temperature changes, color changes, spills/accidents) in your notebook. For each data entry and observation, be sure to indicate where in the procedure the measurement/observation was made. Also, especially in synthetic procedures, it is useful to track time in your notebook. This can be done by recording the time anytime you make a significant entry. Not every entry has to be timed, but making frequent note does help. When the procedure calls for you to do something for a set period of time, do not note that 'the procedure was done as earlier described.' If the procedure says to heat to reflux and reflux for ca. ½ hour, what is expected is that you will note:

"2:23 placed flask on hotplate to begin heating
2:37 reflux initiated
3:15 removed from hot plate, allowed to cool to RT"

Six months later when you review what happened in this experiment and you discover that you improved on the published yield by 20%, you may note that you refluxed for longer than the ½ hour initially prescribed, and this may induce you to initiate an investigation of whether you can improve the yields even more with a longer reflux.

You will frequently be asked to carry out intermediate calculations and/or to graph your data prior to leaving the laboratory. These calculations/graphs should be included in a "Data Analysis" section in the laboratory notebook. More sophisticated analyses will be conducted outside of the lab and potentially be included in the laboratory report. The instructor may also request a discussion of the experiment and conclusions.

The true test of the adequacy of your laboratory notebook will come from your peers. To assess whether or not you have adequately prepared your notebook entry, give it to one of your friends who is familiar with scientific procedures, but has not carried out that particular experiment. If he/she cannot follow and envision what you actually did, you have not noted enough detail.

VI. GUIDELINES FOR PREPARING TABLES AND GRAPHS

VI.A Rules for Table Preparation.

(1) Each table should be assigned a Table number and include brief title that is descriptive enough to tell the reader what you are showing in the table.

(2) A table should have at least two columns. If it does not summarize a critical amount of related information, the results can be presented in the document text. Each column should be labeled with a heading describing what the column represents, and units for numeric quantities. Never head a column with just units.

(3) Be sure to refer to every table that is included in the report within the text.

VI.B Rules for Graphical Presentation.

Note that there are a number of computer programs available for preparing graphs and fitting your data to linear and non-linear models. One of the most common ones (e.g. Microsoft Excel) is available for use on all personal computers on campus.

(1) A graph is a way of showing how a *measured* dependent variable (quantity plotted on the y-axis) changes with a *parameter you control* in the lab (independent variable plotted on the x-axis).

(2) Experimental data values should be *plotted as points* and the fit to a particular model/equation (e.g. the best straight line) should be *superimposed as line or smooth curve*.

(3) The x and y axes must be labeled with the parameter they represent, along with the proper units.