LAB NOTEBOOK GUIDELINES

Summarized and expanded by P. F. Mendez from: Rod Beavon,
http://www.rod.beavon.clara.net/lab_book.htm

Faraday's hand-written notebooks…have long been of interest to historians and philosophers of science because of the extraordinarily direct insight they give into the way his thinking developed…. They are also remarkable in the amount of detail that they give about the design and setting up of experiments, interspersed with comments about their outcome and thoughts of a more philosophical kind. All are couched in plain language, with many vivid phrases of delightful spontaneity….

Peter Day, 'The Philosopher's Tree: A Selection of Michael Faraday's Writings'

Writing the Laboratory Notebook

The Laboratory Notebook is a vital part of industrial and academic research, and indeed can be required by law to establish, for example, patent rights.

How much should I write?

There is a balance between working much and having poor records, and recording much while accomplishing little actual work. This balance must be accomplished by practicing, until one is satisfied both of the productivity achieved and of the quality of the records. Some suggestions are easy to implement:

- If you are idle while waiting for an experiment to be completed: then put the time to good use by improving your notes! (there's no tradeoff with productivity here)
- Always record quantities that you measure, and remember to include the units.
- Always have a photograph and description of your set-up, with a marker that will help understand the size-scale.

Perhaps the most difficult, but most rewarding activity, is to try to anticipate the evolution of the experiment. You should definitely write any deviations from what you expect. However, you must be careful not to bias your experiments by discarding data or twisting it into what you expected.

Plain language

The lab notebook must be written in plain language. The whole point of a laboratory notebook is that it should:

- say exactly what was done, and when;
- make clear who did it;
- enable someone else to do the same thing at some future date;
- be durable and verifiable.

Hardware

Laboratory notebooks should be hardback bound notebooks – you can stick worksheets in where needed.

Writing must be done **in ink**. Black ballpoint pen is best, pencil should not be used for anything.

Organizing your notebook

Anyone should be able to pick up your notebook and understand what you have written. This must be the main thing - you are writing for someone else. If the writing is clear to them, then it certainly will be to you. Achieving this requires some organization as well as a certain style.

Title page: Give a page or use the cover to state your name, address (you might lose the book) and a brief indication of its purpose - 'Foundry Lab Notebook', for example.

Table of contents: Give two pages to the Contents so that you can list the experiments and find them easily when needed. But you will need to....

Number the pages: Tedious but essential. Do it when the notebook is new. Some notebooks come with the pages already numbered.

Table of abbreviations: They save time and effort. If you use them, give a table to explain them.

Good notebook practices

Experimental Introduction

The introduction to your experimental report should have the following:

- Title of the experiment - and this should appear on any added pieces of paper, graphs, whatever, that are pasted into the notebook. The title should be concise and descriptive.
- Statement of the problem or task - short and to the point. The statement responds to the question “What aam I trying to accomplish?.”
- Date. In industry or research this is exceedingly important, and may be in your work too. Write the date unambiguously and include the year - for example January 12, 2006. Do not write 1/12/2006 since it can cause confusion with the European system… is it January 12^{th}, or December 1^{st}?

Experimental plan

This is the part of the account that tells what you are going to do. It may be that you have detailed instructions already, in which case they can be written or pasted into the notebook. All information must be recorded in your lab notebook, even if you have handouts with blank spaces to be filled in. If you are planning an investigation you will have to write out your own plan. If so:

- use simple, direct statements or a bulleted or numbered list of instructions;
- look forwards to what you intend to do - do not repeat the introduction;
- comment on any special features of the materials to be used - perhaps they require special storage or handling, or there may be several varieties of the compound available (e.g. linseed oil vs. boiled linseed oil). Such factors are very important and must be recorded.

Safety! Part of your education is the instruction in handling potentially hazardous materials safely. There are some compounds that are not permitted in schools, mainly because they are carcinogenic or explosive. There are still plenty of hazards around, and you should take these into account when planning the experiment. It may affect the quantities you use, or whether a fume hood is needed or not, and many other things. Standard practical exercises will have been assessed by teachers, but this does not remove the need for you to consider safety for your own experiments.

Observations and Data.

The observations and data are **central to the whole exercise.** They need to be:

- recorded honestly
- recorded as you go along, in the notebook, in ink, immediately
- do not trust to memory, even for a minute or so - someone talks to you, and that data is forgotten
- do not trust to memory; you do not want your mind occupied with trivial things and small details. You need to keep the overall experimental plan in mind
- **do not use odd scraps of paper** or the edge of your lab coat to record data
- the raw data is **precious**
- the data must be recorded as completely as is possible. Don't worry too much about interpreting the data as you go along, and don't worry if some of the observations appear banal.
- use good penmanship. Take care with numbers - **never over-write**, always cross out erroneous material with a single line and re-write the correct data. **NEVER** use white-out corrector.

Format

- tables must be written in vertical columns, each column being headed with the quantity and the appropriate units. Tables are ubiquitous in lab notebooks.
- drawings should be large enough to allow labeling
- drawings should be simple and to the point.

Graphs

- each graph should have the experimental title and the date written clearly
- the axes must be labeled with the quantity and its units
- include error bars if you know the error limits
- give a clear table of the data you used to plot the graph
- graphs are less common than tables in lab notebooks. Typically graphs appear on the final report, based on data gathered from tables in the lab notebook.

Discussion and conclusion

- write any calculations out clearly, showing all the steps and using units throughout
- relate your results to your hypothesis - do they support or refute it? Comparisons must be as quantitative as possible.
- record any ideas you have, however brief - if you don't write them down, you'll forget them

Conclusions

Should state:

- what you found out
- whether the hypothesis was supported or not, if appropriate
- the error limits on your answer(s); a quantitative assessment of error should be made if possible, so that you can decide whether the use of a measuring cylinder rather than a pipette, say, really did make any meaningful difference to the result
- suggestions for improvement in experimental design, if appropriate; the error analysis will be useful here.
- what to do next, if appropriate.

Remember....

> Science does not take place on the pages of textbooks or learned journals, but it is recorded there. The quality of any work is only as good as the report that remembers it when the test-tubes have long been washed up.

Appendix: Guidelines for carrying-out and recording calculations

The ability to lay out calculations in a comprehensible manner depends on

- knowing what you are doing and NOT being reliant on rote formulae;
- realizing that calculations need linking words and phrases to make them readable;
- a correct use of units *throughout the calculation*.

The advantages of using units throughout include:

- an awareness that equations are not merely symbols, but express relationships between physical quantities;
- an check on whether the equations used are in fact right, because of the in-built check on the units of the answer;
- a gradual awareness of what sort of magnitude of answer is reasonable in a given set of circumstances.

Here is a simple titration example, easily extended to other types of calculation:

25.0 cm^3 of a solution of sodium carbonate was titrated with 0.108 mol dm^{-3} hydrochloric acid solution using methyl orange indicator. The volume needed was 27.2 cm^3. Find the concentration of the sodium carbonate solution in mol dm^{-3}, and in g dm^{-3} of the anhydrous salt.

The reaction is: $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Amount of hydrochloric acid used= 0.0272 dm^3 × 0.108 mol dm^{-3} = 0.00294 mol

Thus amount of sodium carbonate = ½ x 0.00294 mol = 0.00147 mol in 25.0 cm^3

Thus concentration of sodium carbonate solution = 0.00147 mol /0.025 dm^3

= 0.0588 mol dm^{-3}.

The molar mass of anhydrous sodium carbonate is

$$\{(2\times23) + 12 + (3\times16)\}\text{g mol}^{-1} = 106 \text{ g mol}^{-1};$$

The concentration of the sodium carbonate is therefore

$$0.0588 \text{ mol dm}^{-3} \times 106 \text{ g mol}^{-1} = \boxed{6.233 \text{ g dm}^{-3}}$$

Note that units have been used throughout, and the box indicates that its contents are the final result of a calculation.