

3. The Laboratory Notebook

We require you to keep a laboratory notebook in this class. The duplicate pages from that notebook will be collected and graded.

In the real world of laboratory research, the notebook serves as the primary record of a scientist's work. All data, observations, and results from each experiment must be recorded directly in the notebook. There are four important standards that these lab notebooks must meet.

1. It must be an honest and accurate record of the work done and the results obtained.
2. It must be recorded as you perform the work. Data and observations are written in the notebook as the experiment occurs.
3. It must be a permanent record. Changes to the notebook can make it suspect with regard to the standards above. It must be written in pen. All corrections must be legible.
4. The record must be kept in such a way that a competent person familiar with the field can repeat the work based on the notebook.

Ordinarily, a laboratory notebook is for a scientist's own use. However, a company or research director/advisor will often keep the original copy for practical or legal reasons. Especially in commercial work, the notebook may become legal evidence in patent or copyright disputes.

Reports on a scientist's work are almost always separate from the notebook. A report might take the form of a scientific paper, a written report to company management, or a legal report. A scientist uses the data and observations recorded in the notebook as the basis for these reports, but adds explanations and discussion of the work appropriate for the intended readers.

We collect and grade the notebook pages to teach you the proper way to keep a notebook. To ensure that these standards are met, we will require that you follow certain conventions regarding the keeping of laboratory notebooks.

As you progress in your scientific education, you will learn additional requirements and best practices when keeping a proper laboratory notebook. One of the primary objectives in 2230L is to learn the fundamentals of good notebook practices.


In 2240L you will write separate laboratory reports based on the data and observations that you recorded in your notebook during the performance of the experiment. This laboratory report is discussed in the next chapter.

In 2230L a separate data sheet is required at the end of each experiment. This is a focused analysis of the data collected during the experiment.

Format

There are many formats that are acceptable for lab notebooks in general. However, a company may require its employees to follow a standard format for their lab notebooks so that information can be found more easily. In the same way, it is useful to have everyone in the class use the same format. Therefore, in this class, we require you to follow a particular format that is described below. Your instructor may be grading over a hundred notebook page sets per week. Your instructor will expect to find them in the following format, and may deduct points or even refuse to grade notebooks that are not in this format.

Do not use the back of any page. Begin the first experiment on page 3, leaving pages 1 and 2 for a table of contents that you will build as you use the notebook. Your table of contents should include the title of each experiment and the number of the notebook page on which your description of that experiment begins. Each time that you begin a new experiment, make a table of contents entry for that experiment. Do not try to construct the table of contents ahead of time because changes may have to be made to it.

Write in pen not pencil. When you make a ~~miskake~~ mistake, simply put a single line through the error, and write the correction after. The information that was stricken must still be legible. Do not totally  blank out or ~~scribble~~ scribble over a mistake. Do not use whiteout.

Within your description of each experiment, keep each required section separate from the others. For example, don't mix data with procedures. Clearly label each section and separate it from other sections. Arrange the sections in the order prescribed and do not leave large blank spaces on a page. Do not skip any pages (except for the pages reserved for the table of contents).

Here are comments on the sections you must include in your lab notebook. Additional instructions on keeping the notebook follow the comments.

Before you enter the classroom complete sections 1-7 of your notebook. If you have not completed your notebook you will not be allowed to carryout your experiment and you will lose 10 points out of the possible 9 notebook points for that day. IF you come to class without your notebook prepared you will be asked to either leave and write up the procedure and then return, or you will be paired with someone to observe them carrying out the procedure. You will not regain your lost 10 points. Come to class prepared.

It is unsafe to attempt to carry out an organic experiement without first becoming familiar with the procedures and the safety risks of the chemicals that will be handled.

1. Date

There is a place for the date to be entered at the top of the page. This is the date on which you do the experiment. Enter the date on every page.

2. Name

Put your name in the space provided at the top of each page. If you work with a partner, also include your partner's name.

3. Title of Experiment

In this class you can use the title in the manual or the syllabus. Enter the title in the space marked "Experiment" at the top of the first page of your notebook writeup for each experiment. Your instructor may also require you to enter the title on subsequent pages. Even if he or she does not require it, it is a good idea to do this in case a duplicate page becomes separated from the rest of the pages after being removed from the notebook.

There are spaces for the course and section at the top of each page also. Your instructor will let you know whether he or she requires you to use them.

4. Purpose of the Experiment

A brief description of the purpose for doing the experiment serves as an introduction to the main body of the notebook writeup. It normally consists of one short paragraph of perhaps one to three sentences.

Generally, there are two types of purposes (or goals, or objectives) for doing each experiment. These could be called "educational" and "scientific." The purpose that should be described here is the scientific objective, not the educational goal. For example, in the first experiment in this manual you will learn about melting points and their use in identifying compounds, about how to take a melting point using a Mel-Temp apparatus, and several other things connected with melting points. These are the "educational" goals of the experiment. However, these learning goals are accomplished within the framework of an experiment in which your object is to identify an unknown organic compound from its melting point. This is the "scientific" purpose.

If your purpose uses the words "to learn" or some equivalent phrase, you are giving an educational objective instead of a scientific one. Educational objectives are fine in their place, but the laboratory notebook of a scientist is not that place.

Although it may be tempting to leave this section out if no one is collecting your notebook for grading, some discussion of the reasons for doing the work is useful, especially when the notebook has to be consulted long after the experiment was performed.

5. Chemical Equations and Structures

Include the *chemical* equations for all reactions that are involved in the experiment. All equations must be balanced and must show structures, not molecular formulas and not names alone, for organic compounds; $aA + bB \rightarrow cC + dD$. Many of the experiments in 2230L do not involve any reactions. In

these cases, simply write the name and structure of the chemicals used. Some later experiments involve four or more reactions.

Also include in this section the structures of any organic compounds used in the experiment that do not appear in the equations, such as solvents. If the structure already appears in the equation, you should not repeat it. If there are no reactions involved, you still must include the structures of any organic compounds used in the experiment. Structures and reactions may be found in the on-line course notes or in your textbook or standard reference materials.

Do not include any of the following in this section: Mathematical equations or formulas, structures of inorganic compounds, and reaction mechanisms.

Chemical equations are always included in laboratory notebooks when reactions are involved. Structures for common compounds are not always included in notebooks by working chemists. However, we require you to include all structures to help you learn organic chemistry.

6. Procedure

Write a summarized description of the procedure that you will be using in the experiment. This section should be more than a handful of sentences but typically less than one page long. Include enough detail to allow a knowledgeable chemist to carry out the entire experiment just following your written procedure. Include enough detail to be able to perform the procedure but do not rewrite the procedure from the manual verbatim. The procedure should contain target volumes, masses and temperature. It should also specify any unique glassware or materials to be used. Drawings of set-ups are valuable when carrying out an unfamiliar method for the first time.

If two procedures are going to be carried out in a single lab period, then write up both procedures. If there are two procedural options and you do not know which one you will be assigned, write up both procedures.

7. References

A bibliographic reference to each of the sources where the procedure or analysis methods was found needs to be included. Normally this is the hard copy of lab manual and the on-line notes and procedure. Book references should include: author or editor, title, publisher, city of publication, year of publication, and page numbers. (An example: Crago, Kathleen, *et al.*, *Organic Chemistry Laboratory Manual*, 6th edition, Wiley, New York, 2005, p. 18.) Materials gathered from the web also need to be referenced. A proper methodⁱ of referencing web material is Author (if available), Title of document (full web address) followed by date of access. (An example; EPA OPPT: Chemical Fact Sheet Styrene, <http://www.epa.gov/chemfact/styre-sd.pdf> (September 23, 2011).

If you get any part of the procedure from another published source, include that reference. If you perform an experiment using a procedure given

in a handout or verbally by your instructor, give the procedure reference this way: "(Name of handout author or your instructor), personal communication."

Do not include references of articles or books that you yourself have not read. Do not include all the references listed in an article you read. Only include the reference to the article itself.

7. Data and Observations

This section is always found in both lab notebooks and reports of working chemists. **It is probably the most important section of any laboratory notebook.**

Include in this section **all** of the measurements (mass, volume, times, temperatures) along with units and clear identifiers that you make in the laboratory. If the procedure calls for 4 g of starting material and you weigh out 3.965 g, record that as your number, not 4.00. Write data down directly into your lab notebook. Do NOT write data down on scratch pieces of paper and later neatly transfer to notebook. The data needs to be recorded directly in the notebook as it is obtained.

Be sure to include observations such things as color and phase of all starting materials and products. Record all changes such as colors, bubbling, a new phase, precipitations and temperature shifts such as if a flask gets cold or warm. Often observations are just as important as hard data. Many new discoveries were made based on keen observations. Your instructor will deduct points for few or no observations.

8. Summary Statement

After all of the data and observations have been collected, think about the experiment and whether the purpose was obtained. Make a brief, one to three sentence statement summarizing the findings and the success or failure of the stated objectives.

9. Signature and Date

Finally, at the end of your notebook for each experiment, sign the page and include the date on which you finish it. Lab notebooks in industry and government are always signed and dated. Your signature in the notebook attests that to the best of your knowledge and ability, the notebook meets the four standards described above. After you signature a line across the rest of the page is commonly added. This states that the data collection is complete, and no other information was gathered on that date.

Preparing Your Notebook Before Class

All of the sections before the data section need to be complete before coming to class. Due to safety concerns, you will not be allowed to carry out the experiment if you have not prepared your notebook. If you come to class without a prepared notebook you will lose 10 points in 2230L and 5 points in 2240L. Then you will either have to observe someone else as they conduct the experiment, or leave class, write your procedure, return to class and attempt to conduct the experiment yourself in the shortened amount of time remaining. Please come to class with your notebook fully prepared.

In many cases, you can also set up part of the data section ahead of time. For example, you can make a table with the names of all compounds that you will be weighing. Then, when you weigh them, you can fill in the masses.

You may occasionally have to leave space for the structure of an unknown. However, do not leave large amounts of space blank. If you find that you left something out, add it at the end of the report or after the data section. Place a note in the margin near where it should have gone stating where it can be found.

Other Notebook Requirements

The notebook should be used for recording your laboratory work only. No class notes, not even from the pre-experiment lecture, belong there.

Write only in ink, using a ball point pen, and only on the front pages. **Never correct errors by erasing, writing over, altering letters or numbers, or using correction fluid.** If you make mistakes of any kind, just put a single line through the mistake and go on. After the correction, the mistake should still be readable. It is considered unethical to change anything in a lab notebook in a way that makes the original entry unreadable. It is customary to initial and date any changes as well.

Ordinarily a scientist never tears out any original pages from the notebook, whether they are written on or not. Your instructor may require you to turn in the original pages because they are more legible than the duplicates, but note that this is not normal procedure in science. Never skip any pages except as specified for the table of contents. Start each experiment on a fresh page. All of these rules apply to lab notebooks in general, not just in this class. They are intended to ensure the integrity of the notebook.

Your notebook is where your data should be recorded as you collect it. Never use a scrap of paper, loose leaf paper, or anything other than the notebook to record the data. Both the paper scrap and the data can easily be lost that way. Your instructor may deduct points from your grade or even confiscate any paper being used in this way. The only exception to this is output from laboratory instruments such as spectrometers.

The work in the notebook must be your own. In some experiments, you will work with a partner. You may have the same data in that case. However,

all other parts of the writeup must be your own work. Under no other circumstances should any section of your notebook be copied from another person. This is plagiarism, which is a serious offense in any scholarly and scientific community, including Xavier. In the same vein, all data must be reported just as obtained in the laboratory. Any copying, altering, inventing, or fudging of data is cheating and will be dealt with as such according to university policy.

When writing in the notebook, imagine that the reader will be a competent chemist, but unfamiliar with the specific experiment that you are describing. Don't explain general things that a chemist would know, but do explain the particular experiment.

Don't leave necessary things out, but try to be brief and to the point. Your instructor will not be impressed with flowery language and is an expert at recognizing padding. Complete but concise writing will lead to the highest grades. Please write legibly and keep the notebook as neat as possible consistent with the fact that you are using it in a chemistry lab. You should follow the rules of grammar and good writing. Use complete sentences and correct punctuation. If you discover that you need help with the writing aspects of the notebook, your instructor can give you a referral to the Writing Center, or you can go there on your own.

Whether your career goals are in science, medicine, pharmacy, or some other field, it is likely that you will be required to keep complete and accurate records of your work. Developing good practices in this area now will be of value to you as your career unfolds.
