Pima Community College
West Campus

CHM 151-152 Laboratory Notebooks and Laboratory Reports

THE LABORATORY NOTEBOOK

INTRODUCTION

Chemistry is an experimental science. As such, much of the progress of chemistry depends on the communication of scientific data and experimental results between researchers. It is important, therefore, that a course in chemistry should teach how to accurately record scientific data and experimental results through the use of the laboratory notebook and laboratory reports.

THE LABORATORY NOTEBOOK

The laboratory notebook is meant to be a permanent record of the experimental data and observations that one measures or observes during experiments. During the laboratory period all data and observations are to be recorded **DIRECTLY** into the laboratory notebook and **NOT** on separate sheets of paper nor the data pages of the experiment or laboratory manual.

The laboratory notebook is meant to be used as a **WORKBOOK**, it is functional, not pretty. It will contain both satisfactory and unsatisfactory results, errors and corrections, calculations, graphs, and other information from the laboratory experiments. Since all entries are made in the laboratory, it is expected that the information be orderly, legible, and clearly labeled, sufficient so that the information is comprehensible to someone with training comparable to your own. The notebook will not be graded on its appearance, it will be graded mainly on its content.

The laboratory notebook must be a **BOUND** book with sewn-in pages and a cover, such as a "Composition Book" or equivalent. Spiral, loose-leaf, and perfect binding (pasted-in pages) notebooks are **NOT ACCEPTABLE**. Quadrille pages are preferred, but lined pages are acceptable. The suggested guidelines for keeping the laboratory notebook are listed below: (**NOTE:** Your laboratory instructor may request that the information you record in your laboratory notebook differs from this format to fit the requirements for your particular laboratory course.)

SUGGESTED RULES FOR KEEPING THE LABORATORY NOTEBOOK

1. All entries must be made in **INK**.

2. All pages in the notebook must be numbered consecutively, beginning with the first page.

3. The first two sheets (pages 1 through 4) reserved for a **TABLE OF CONTENTS**, which must be kept up to date with the number of the experiment (number them consecutively), the title of the experiment, and the notebook page on which it begins.

4. When recording information in the notebook, write on the **RIGHT-HAND PAGES** only (unless a double page is needed for a large table or graph). Generally, the left-hand pages are used for notes or calculations for the experiment.

5. Under no circumstances should an erroneous entry be erased or obliterated. If an error is made, either draw a single horizontal line through it or a single X through it, **leaving the error readable** (you may later decide that the erroneous value was usable). The correct data should be recorded nearby.
6. Under no circumstances should any pages be removed from the notebook. If a page of data or notes is wrong, draw one large X through the page with a short notation explaining the reason for striking out the page. Continue with your notes on the next available page.

7. Start each new experiment on a new page. If you do not complete an experiment or miss an experiment, do not leave blank pages for the missing material. If you complete the experiment at a later date, the data should be entered on the next available page **in date order**. (Do not forget to note the page number in the table of contents.)

8. All data must be entered **directly into the laboratory notebook**. Never record data on loose pieces of paper for later transcription into the notebook.

9. As you complete each page in the notebook, sign and date the page at the bottom. Void all remaining blank spaces with either an X or a single diagonal line.

10. The following information should be recorded in the laboratory notebook for each experiment:

    a) The **title** of the experiment.

    b) The **date** the experiment is performed.

    c) The name of any **partner(s)** who worked with you. If you work alone, omit this part.

    d) A sentence stating the **object** or purpose of the experiment.

    e) A **reference** to the source of the procedure for the experiment, if known. List the author's name, title of the book (underlined), edition number (if second edition or later), publisher's name, location of publisher (city), most recent date of copyright of book, and page numbers of the experiment.

    f) Any **safety precautions** that must be observed in the handling and use of any of the chemical reagents in the experiment along with any safety modifications of apparatus or experiment set-ups. **It is recommended that you look up and record this information prior to the laboratory experiment**.

    g) Any **disposal** information that must be observed for the chemical reagents and products of the experiment.

    h) Any **changes** in the experimental procedure or other pertinent information from the pre-lab lecture.

    i) A *brief* account of the **PROCEDURE YOU ACTUALLY FOLLOWED** including **ALL THE EXPERIMENTAL DATA** as you record it. Include observations such as colors or color changes, formation of precipitates, odors of materials, textures or forms of compounds, visible physical changes, etc. For numerical data, label each item clearly, include all significant figures and the proper units. Be sure to include the number of any unknown sample used in the experiment. Do **not** copy the data pages in the experiment or laboratory manual directly into the notebook. The data pages can be used as a guide as to which numerical values are important, however, in many instances, there is more information needed for an experiment than what is asked for on the data page of the experiment. Remember, the information you record can give valuable clues in determining your final results or in determining what went wrong.

    j) **Calculation** of the final results. Show the complete set-up, including the formulas used, the numerical data, and the final answer. Observe the proper number of significant figures and be sure to include the proper units. A sample calculation is shown below:

Example: The density of unknown metal no. 25 (title)

$$Density = \frac{mass}{volume}$$ (Step 1: The formula)

$$= \frac{25.458 g}{3.85 mL}$$ (Step 2: Substitution of data)

$Density = 6.61$ g/mL (Step 3: The answer)

The calculations of the results can be written on the left-hand pages of the notebook, opposite the data. (The calculations can be completed at home.)

k) **Graphs** (when required) can be constructed directly in the laboratory notebook if it is quadrille ruled, otherwise, the graph should be drawn on graph paper, or constructed using a program such as Excel, and fastened into the notebook (paste or glue is preferred over tape or staples). The graph should be titled with all axes clearly labeled. (Graphs can be constructed at home.)

l) General **results and conclusions**. This is a *brief* discussion or summary of the results of the experiment with regard to such questions as "do the results of the experiment appear to be reasonable?", "do the values obtained agree with published results (if known or available)?", "did I prove the principle that the experiment was demonstrating?", or "was the purpose of the experiment accomplished?" Keep this discussion brief and in general terms in the notebook as its main purpose is to help you review the experiment and results before writing a more polished and detailed version for the laboratory report. (This discussion can be written at home.)

m) A brief discussion of **errors** (when required). (This section can be completed at home.)

11. At the end of each laboratory period, you must present your notebook to your laboratory instructor, who will initial or sign the pages of notes recorded during that lab period. Your instructor will also offer suggestions for improving future record-keeping.

Notebooks can be spot checked at any time and they are expected to be up to date. Should there be any major errors or omissions in your experimental results, as reported in your laboratory report, you will be asked to produce your lab notebook. Credit will NOT be given if the notebook is not up to date containing the proper information.

There will be no excuses accepted from groups who claim that one individual has all the data and that individual has been absent from the laboratory class.

LABORATORY REPORTS

CHM 151-152 is a science and engineering major class. You are expected to be able to write an organized laboratory report.

A laboratory report is the means by which a researcher or research team communicates the result of an experiment or series of experiments to his/her colleagues. It is a summary of the important information which a researcher recorded in his/her laboratory notebook with detailed explanations of the results. Such reports are often communicated as research papers at scientific meetings or are published in scientific journals.

The laboratory report is the means by which your instructor can determine your comprehension of the scientific principles involved in an experiment as well as to evaluate your ability to make careful measurements and observations, to calculate numerical results, and to organize your experimental data.

A single laboratory report is required for each experiment. If an experiment is divided into two parts, the laboratory report is for the entire experiment.

ONE WEEK after you have completed each experiment, a laboratory report must be handed in to your instructor. **The report should be printed on 8½ x 11 inch paper** and stapled together with a single staple in the upper left-hand corner. **All graphs (when required) should be drawn on graph paper and clearly labeled or, preferably, constructed using a program such as Excel.** The report must be written in the third person (do not use: I, me, my, we, our, etc.) and should follow the guidelines given below. (**NOTE:** Your laboratory instructor may request that your reports differ from this format to fit the requirements for your particular laboratory course.)

SUGGESTED FORMAT FOR CHEMISTRY LABORATORY REPORTS

1. ***Introduction***

The introduction should start at the top of the first page and contains two parts, the object of the experiment and the theory.

a) The **Object** of the Experiment

The object is usually given in one or two sentences. It is a statement of why the experiment was performed and it may also include the result to be obtained. For example, in an experiment on density, the object could be stated as:

"*The object of this experiment was to determine the density of an unknown liquid and an unknown solid.*"

b) The **Theory**

This is a *short* discussion of the theory or principle(s) behind the experiment. This section should give definitions of terms and the formulas to be used for any calculations. It should also include a brief explanation of how the measurements are to be made. For example, in an experiment on density, the theory cold be written:

"*Density is defined as mass per unit of volume and can be calculated using the formula*:

$$Density = \frac{Mass}{Volume}$$

where the mass is measured in grams and the volume in cm^3*. In this experiment, the mass of the unknown sample was measured directly on the laboratory balance and its volume was determined using water displacement.*"

2. ***Safety Precautions and Disposal***

This section should briefly list any safety precautions that were observed in the handling and use of the chemical reagents along with any modifications of apparatus and set-ups for safety purposes. Some example statements are:

"Safety goggles were required for this procedure.

"6 M hydrochloric acid was used in this procedure. Hydrochloric acid is corrosive. In the event of skin contact, the affected area must be washed with running water and the affected area be inspected for any reddening or burns.

"0.1 M sodium hydroxide was used in this procedure. Sodium hydroxide is caustic. The concentration used in this procedure is sufficiently dilute that minimal skin damage will result from direct contact. In the event of skin contact, the affected area must be washed with running water and the affected area be inspected for any reddening or burns."

Include any special disposal information for chemical reagents or products for this experiment. Some example statements are:

"All alcoholic solutions were disposed of in a waste container labeled for alcohol wastes.

"Used filter paper with chemical residues were disposed of in a waste container for contaminated chemical waste."

3. ***Procedure***

This should be a *brief* **description or summary of the operations** you followed in the experiment. It should be about one paragraph in length. The procedure should contain enough information so that someone with training comparable to yours could repeat the experiment. An example of a procedure is shown below:

> *"5.0 mL of a 0.10 M lead(II) nitrate solution was reacted with 8.0 mL of a 0.20 M sodium chromate solution. The resulting precipitate was collected by gravity filtration. The precipitate and filter paper were dried at 80°C in an oven until constant mass was obtained."*

4. ***Data and Results***

The data should be listed in tabular form, whenever possible, **using the correct number of significant figures and including the proper units**. When constructing the table for the data, arrange the numerical observations and results in the order they will be used in the calculations, not necessarily in the order recorded in the notebook. If properly recorded, the method of calculation, especially in the case of simple additions and -subtractions, will be readily apparent.

An example of data listed in tabular form is shown below:

Mass of beaker and sample	58.453 g
Mass of beaker	55.937 g
Mass of sample	2.516 g

A table of your data is an essential part of a laboratory report.

The final numerical results must be included in this section,

For the purpose of this course, if data pages were supplied with the experiment, you may include the data pages from the experiment **neatly filled in with all questions answered** for the Data and Results section.

Regardless of whether you use the data pages or you list the data in your own tables, you should also include a paragraph relating any observations which may be useful in explaining or interpreting your results. This paragraph can be labeled "**Observations**".

5. ***Sample Calculations***

Show a sample calculation for each different type of computation used in calculating the results. Show the complete set-up including the formula used, the numerical substitution, and the final answer, all with the proper units. **Do not show the arithmetic**. You may omit simple additions and subtractions from the sample calculations. Generally, there is space on left on the experiment data pages for sample calculations.
NOTE: Microsoft Word and other word processing programs have an equation editor. They can also print subscripts and superscripts. Learn how to use these features.

A sample set-up is shown below:

Example: The density of unknown metal no. 25 (title)

$$Density = \frac{mass}{volume}$$ (Step 1: The formula)

$$= \frac{25.458 g}{3.85 mL}$$ (Step 2: Substitution of data)

$Density = 6.61$ g/mL (Step 3: The answer)

6**. Graphs**

All graphs required for an experiment must be drawn on graph paper with properly labeled axes and data points. The use of a spreadsheet such as Excel or a graphing program is preferred over hand-drawn graphs.

7. Discussion and Conclusions

This section contains a discussion of the experiment, the data you obtained, and the results with respect to the object stated in the introduction. The type of conclusions you write will depend on the type of experiment that was performed, a measurement experiment, a principle experiment, or a preparation. It is important to discuss the actual numerical data and numerical results in your conclusions.

In a **measurement experiment** you are measuring quantities such as density, melting points or boiling points, specific heats, or other properties. For this type of experiment you would be concerned with the precision of your data and results between two or more trials and the accuracy of the final values in comparison with known or accepted values (if available). In this type of experiment, one often expresses the percent error of the measured value in relation to an accepted value using the formula:

$$percent\ error = \frac{\text{(accepted value - measured value)}}{\text{(accepted value)}} \times 100\%$$

In a **principle experiment** you are attempting to demonstrate that a principle, such as Boyle's Law for the pressure-volume relationship of a quantity of gas, is correct or that a hypothesis, such as the effects of chemicals on plant growth, is valid or invalid. For experiments such as these you would attempt to show how your data and results support (or do not support) the principle you are studying in addition to examining the precision of the data and the accuracy of the results.

In a **preparation**, you have prepared a specific compound or series of compounds. In your discussion you should review your yield data as well as any tests or observations that provide evidence that the compound(s) you have synthesized is the correct one, and you should be able to use the results of the tests to comment on the relative purity of the compound.

In all of the above types of experiments, your discussion should tell your major findings, what kind of accuracy was obtained, explain and discrepancies between experimental and expected results, and discuss possible errors which may contribute to poor results. In all cases, use your experimental data and observations to explain or support any statements you make.

8. ***References***

List any books or Internet sites that were used in writing up the laboratory report, including the laboratory manual. Number the reference (if more than one) and use standard reference form:

> Author (last name first), title (underlined), edition number (if second edition or later), publisher, place of publication, most recent year of publication, page numbers.

An example of a reference is:

> "Smith, Jones, and Rogers, Chemical Laboratory Experiments, 3th Ed., College Publishing Co., Philadelphia, PA, 2001, pages 25-6".

Your laboratory instructor may require individual laboratory reports or a single team report. If the laboratory report is a team effort. All members of the team should contribute to the report.

The laboratory report is part of your laboratory experiment. The experiment is **not** considered to be complete until the laboratory report has been received.

LATE LABORATORY REPORTS will be down-graded based on the number of days the report is late. Reports that are more than one class late will be graded on a pass/fail basis only (pass = "D"). Reports more than two classes late may not be accepted, at your instructor's discretion, and you may be assigned a grade of "zero" for that experiment. (If you are absent on the day a laboratory report is due, email the report to your instructor or take the report directly to your instructor on the day you return to school or leave it in his/her mailbox in the department office building.)

INCOMPLETE LABORATORY REPORTS will be graded “as is” with points deducted for missing sections.