### Laboratory Notebook

**Purpose of a Notebook**

Whether you are working for yourself or for a company, records must be kept of all laboratory activities. These records may be used in court to (a) prove rights to patents or (b) defend or prosecute individuals/companies where evidence is presented that was gained through laboratory work. In the case of companies engaged in research, these records (a) may be critical to making management decisions involving millions of dollars or (b) in case of your death or departure for other reasons, are the means for your replacement to pick up the research where you left off. In all cases, the notebook belongs to the agency funding the laboratory work and is kept under their lock and key.

**Key Elements in a Proper Notebook**

* It must be **complete**. Every detail of your laboratory procedures, results, analysis and conclusions must be recorded so that any individual could repeat the work as you did it.
* It must be **honest**. The details must be recorded immediately after carrying out the procedure, as you first carry out the analysis of the data and as you make observations. Mistakes must be recorded and explained. Bad data must be included along with the good and included in the analysis and conclusions.
* It must be **readable**. Most records are read at one time or another by other individuals. Your notebook may never be neat, but your handwriting and your general organization must be good enough so that other people can interpret exactly what you did.
* Every activity must be **dated**. These activities include mental, as well as physical time spent on the project. Examples include ideas proposed to modify or improve the procedures, design of a follow-up experiment, as well as all thoughts pertaining to the interpretation of the results. Whenever a date is logged into the notebook all entries that follow that date page-wise up until the next logged in date must have occurred on that first date. Within any given day’s pages, the information is generally entered sequentially as it occurs.

**Keeping a Notebook**

A separate laboratory notebook is required for recording the observations that you make during lab experiments. A bound notebook with graph paper is **mandatory**. Loose pieces of paper for recording data are not acceptable. The notebook that you use for lecture notes may not be used for the lab. You record all Observations and Data from experiments in this bound notebook.

Before you leave lab, you must have the Observation and Data section in your notebook initialed. If you make a recording error or if the data is “no good”, draw a line through the data and initial it. Do not use white out! Continue recording on the same page, ignoring data that has been lined out.

Record all data in blue or black **ink** in a legible, organized fashion. Include all relevant information. For example, in recording numbers you should include both the units and the meaning of the numbers.

The lab notebook will be organized in the following order:

**1. Exterior Cover**

Your name, course title, section and semester should go on the cover. In the work arena, this would commonly be a project name or code and might be placed on the spine for quick identification on the shelf.

**2. Title Page**

Name, course title, number and section number, the name of the school, the semester and the name of your lab instructor. Also include either your address, phone or email address (in case your notebook is misplaced)

**\*\*Number the front of each page in the upper right hand corner from this point on, if pages are not enumerated.**

**3. Table of Contents**

One page should be set aside to list experiment number, experiment title, and page number(s). This is useful for quickly finding specific topics in the notebook and must be kept up to date. If your book does not come with a table of contents page be sure to leave two pages in the front to create a table of contents.

**4. Write up for each of the experiments:**

\*\*The first page of a new experiment should include the date, experiment name and number to clearly show the start of a new experiment (simply filling out the heading at the top of the page it not enough). The experiment name or number should then be repeated at the top of each page relating to that experiment (use the heading section here).

**Purpose/Objective**

Three to four sentences introducing and explaining the purpose of the experiment to be performed. \*\* Be sure to include the **experimental technique** to be used and determination of unknowns, if applicable. This section should be written in your own words. Copying from the lab manual is plagiarism and warrants a “0” for the assignment.

1. **Procedure** - Reference procedure using correct MLA/APA format. Note any changes you are instructed to make in the procedure.
2. **Safety and/or Waste Treatment** - List the any additional safety precautions or special waste handling procedures called for in the experiment; these are usually given in the lab manual.

**Procedure**

In the working world it is important that detailed instructions of the exact steps that you took during the experiment are very important. New procedures must be meticulously recorded, if you are repeating steps you would simply refer back to where they are already written rather than rewriting them (for example repeated steps 3-9 from page 35).

## DO NOT COPY THE PROCEDURE FROM THE LAB MANUAL. You are not required to write out the experimental procedure, unless changes are made. However, it is expected that the student will have read through the procedure (more than once) and understand the operations that are involved; it is essential that the student understand why each step is being done.

## The only thing that needs to be written in this section is a complete reference for the procedure.

## Leave blank at least one-half of a page to include additions or changes (if any) that are given to you by your instructor.

**Sample references**

Textbook:

 Tro, N. (2008).  *Chemistry: A Molecular Approach* (1st ed.), pp. xx-xx. Upper Saddle River, NJ: Pearson  Prentice Hall.

Lab Manual:

Lehman, J. & Olmstead, T. et al (2002).Experiment 1: Computer Warm-Up. In *Grossmont College Chemistry 141 Laboratory Manual* (4th Edition, pp. 1-3). El Cajon, California

Online Lab Manual:

Lehman, J., Olmstead, T. et al (2002). Experiment 1: Computer Warm-Up [Electronic version]. *Grossmont College Chemistry 141 Laboratory Manual*, 1-3.

Online Journal Article, Spreadsheet, or Directions: include author and date if known

Willard, C. (2007). Lab *1 – Error analysis*, Retrieved August 16, 2007, from <http://www.grossmont.edu/cwillard>

Handouts: include author and date if known

Dirbas, J. (2005). “Chemistry 141: Colligative Properties: Molar Mass Determined by Freezing Point Depression” [Handout 2007], Grossmont College, El Cajon, California.

\*\* NOTE\*\* The experiment title, objective, safety/waste treatment, and procedure reference must be completed in your lab notebook at the start of the lecture period on the day which the experiment is to be done or it will be assumed you are not prepared to do the lab and you will be asked to leave the lab.

**Data & Observations**

A legible and complete record of all observations and data collected during the course of the lab period in which the experiment is performed. These notes will lead you to accept or abandon a hypothesis and help you decide the course of future experiments. You must be as objective and honest in recording your observations as you are in making them. Most of the observations and data section can be a narrative description, a story telling what you did and what you saw. Use the first person to make clear that you did the work. If someone else did the work, be sure that point is obvious. If you work in pairs, be sure to note that as well.

Draw any equipment used and set up of apparatus if applicable. Indicate chemicals used along with amounts. Also include any safety information important to the experiment. The important thing to remember here is that you should theoretically be able to use the instructions in your procedure rather than the lab manual to perform the experiment although you will have the lab manual by your side as you complete the lab. This section should also be written in your own words. Use any format you prefer: paragraph, a list of procedures/drawings or numbered steps – whatever is easiest for you. Any change to the experiment on the day of the lab should be noted here as well, **along with the name of your lab partner** if you work in pairs.

Write in reasonably brief, declarative sentences as the work progresses. For example:

Step 1 1.0042 g of NH4Cl added to 5 mL of DI H2O in medium-size test tube

 obtained clear solution

 test tube was cold to touch (endothermic process?)

Step 2 approx. 1 mL of AgNO3 (aq) added dropwise to test tube

 immediate formation of ppt

 ppt was white, cloudy no heat observed no bubbles

Always record data directly into notebook; do not use scratch paper. Record colors, phases, odors and texture of all substances you observe.

This section must be dated and initialed by you and the instructor when you have completed your lab work for the day. For half completed pages sign under the last data recorded so that you may use the remainder of the page for the next lab period.

Write all observations and data for the experiment in this section. This section is your rough draft for the report. As you record your data and observations, this section may become messy and unorganized which is to be expected. You may want to add a summary of your data in the form of tables, charts or lists to facilitate writing the report rather than trying to "hunt" through disjointed recordings.

Suggestion: Carefully read the experiment, more than once, and create a mental list of the type(s) of information you will be collecting. Plan in advance; if you need a data table, decide on the number of columns in the table and column titles and consider how much room on a page you need for your table(s) (or charts, lists). *The post-lab write up cannot include any information which is not supported by the Data & Observation section.*

**Other Notebook Information**

* Always use non-erasable black or blue ink.
* The top of each page should have your initials, the date and Exp #
* Turn in the original pages (not the carbon copies) with your reports, even if the entire page is a deletion.
* Do not remove any pages from your notebook except for those pages that are turned in with the reports.
* To correct writing mistakes: draw a single line through the words or sentences you want to correct and place your initials after the deletion. To delete paragraphs, place a single X over the entire paragraph and initial the deletion. You may want to look at your deletions at some later date, this way, your original entries will be readable**. Never use white-out or try to black-out your writing mistakes!**

### Formal Report

**A general guide for writing lab reports follows. Guidelines specific to each experiment may be found on the instructor web site. Note that each experiment will require different parts of this formal write-up. All sections are not required for every experiment; see your instructor’s webpage for details.**

## Title Page

Include experiment name, date, your name, your lab partner’s name if appropriate, course number, section number, and your instructor’s name.

## Objective

The objective is a brief description of the purpose of the experiment. That is, why are you doing this experiment? To understand a concept? To determine a constant? To characterize a sample?

**The objective (or goal) can usually be stated in one sentence or at most, a short paragraph.** The objective is not always conveniently given at the beginning of each experiment in the lab manual. Often, the experiments in the manual begin with some background information which helps to elucidate the theoretical aspects of the experiment and it is left to the student to deduce the purpose of the experiment. Occasionally, the goal is stated in the body of this background text. Therefore, it is crucial that the student read each experiment thoroughly before coming to lab so that an appropriate (and accurate) objective can be formulated. This will also prepare the student for the experiment itself.

## Introduction

The introduction should explain the theory behind the experiment and explain how the procedure used will accomplish the objective of the experiment. This section will not be lengthy but it should be sufficient to allow the reader can understand the logic of the experiment simply by reading this section.

**The introduction will succinctly explain the theoretical basis of the experiment and describe the method that will be used to achieve the objective.** In some experiments, there is very little “theory” that can be discussed, for example, learning about a new lab technique or getting familiar with a particular piece of lab equipment. In these cases, simply describe how the technique or piece of equipment facilitates learning a new skill. However, note that many lab instruments are based on scientific principles and the student must decide whether a theoretical discussion regarding the instrument or its use is appropriate; if in doubt, ask your instructor.

Some lab reports will require a lengthier Introduction. Some examples:

* Qualitative experiments that investigate a particular type of chemical reactivity need to address in the Introduction some of the pertinent concepts and theories that are presented in Chem 141 lecture.
* Experiments which involve chemical synthesis or the interconversion of one compound into another should include balanced chemical equations for each reaction that is part of the experiment; this should be part of the introduction. Each balanced equation should be labeled (e.g. rxn 1, rxn 2…), so that you may reference the reaction in a latter part of the experiment without rewriting it.
* Experiments that are much more quantitative in nature will require a brief discussion of the mathematical process to be used in calculating the final results; this should be part of the Introduction. Each mathematical equation should be labeled (e.g. eq. 1, eq. 2), so that you may reference the equations in latter parts of the experiment without rewriting it.

In very simple terms:

* Your method description answers the question, “how will the experiment be run?”
* Your theoretical discussion answers the question, “why does this particular method apply to this experiment?”

The length of the introduction depends upon how much background material is included. If very little “theory” is discussed, the introduction may be as short as one-half to three-fourths of a page. If there are several chemical equations that need to be included, the Introduction may be two to three pages in length. A well thought-out Introduction is the key to writing a good lab report; quality is more important than quantity (length). In general a short introduction is preferred.

## Procedure

## The only thing that needs to be written in this section is a complete reference (as shown above) for the procedure and any changes that were made to the published procedure.

## Results and Calculations

The results from your experiment are always entered in this section. Recall in the objective that you asked the question, “What is being investigated in this experiment?” This is the place to answer that question**. State your results clearly so the reader knows exactly what happened in the experiment but do not discuss the reasons for your results in this section.**

Tell the reader exactly what you obtained in the experiment, for example: **quantitative results** from an experiment (% composition of a substance) or **qualitative results** (compounds A, B and C were identified as acids; D, E and F were bases).

Whenever you include statistical treatment of your data, which is a result which should be entered in this section.

Calculations (if any) are done in this section. Show all set-ups for each type of calculation; be explicit! If you must perform the same calculation more than once, you do not have to write the set-up for each one, but it should be clear as to which set-up correlates to which calculation(s). Be sure to include the final results of all calculations- consistently highlight your final answers in some fashion, draw a box around the result, double-underline the result or place final results in a table or chart.

It is a good idea to organize your results in a Table format to make it easier for the reader to understand the outcome of your experiment. Each table should be numbered (e.g. Table 1: Metal Shot Measurements). If your D&O section has become messy and a bit unorganized, this is the place to “clean it up” and present it to the reader with clarity.

## Discussion

The discussion is used to explain your results; **the previous section is used to present the results, this section is used to discuss these results**. Ask yourself provocative questions such as: Do the results make sense, is there some data missing? Did you obtain a result different from your expectations?

Sometimes the data you obtain in an experiment is straight-forward and self-explanatory. In these cases, your discussion may be brief. However, most of the time, you will need to explain to the reader why you obtained a particular result, especially if your result is different than expected.

Think of the discussion as a conclusion to your Objective and Introduction. If you have presented the objective clearly along with the theoretical background and some comments about the method to be used, then discuss your results in this context. If you posed questions in your Introduction, answer those questions here.

The discussion should also include error analysis (when appropriate): explain sources of error and how errors impact your results. Be sure to discuss only the connections between error analysis and your actual data and observations.

Include in the discussion answers to any pre or post-lab questions that have been asked in the experiment or by the instructor.

## Conclusion

State the final result of your experiment in a concise and thorough manner. This section should be brief (one-paragraph). It can often be a mirror of your objective, but with numerical data included.

## Questions

Give the answers to any questions appearing in the lab. These may be handwritten if they involve calculations.

**Grading Rubric for Lab Notebooks and Lab Reports**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Thoroughness | Supporting Information | Accuracy | Writing Level |
| “ A” Level Work | All components are complete and directions correctly followed; all questions answerer; all support materials included; information easy to follow; interpretation of results shows true insight into the experiment; went above expectations including information at a high level.  | All supporting materials of extremely high quality; graphs appropriately chosen for data presentation; graphs and data tables well labeled and easy to understand; appropriate graphs and tables included to allow thorough presentation and understanding.  | All content is accurate, including data in graphs, tables, and calculations; very few or minor errors; information is focused and utilizes appropriate scientific concepts and terms. | Excellent writing skills; writing is focused, clear, well organized, and easy to read; correct sentences with few mechanical writing errors; appropriate use of scientific language.  |
| “B” Level Work | Most components present and complete; directions generally followed with minor exceptions; most support materials included; did exactly what was asked for; interpretation of results show some insight unto experiment, but lacks the complete insight of an excellent report. | All materials are well prepared, including well labeled graphs and charts; graphs appropriately chosen for data presentation. | Generally accurate in all major concepts, however there are some minor errors; generally utilizes appropriate scientific concepts in explanations of information. | Good writing skills, generally well organized and readable, but some mechanical errors, some use of scientific language. |
| “C” Level Work | Missing some minor components; some minor support material missing or incomplete; covered what was asked for with some exceptions; errors in interpretation indicate some lack of understanding of the experiment. | Included all graphs and tables, but some minor errors present; graphs and charts do not support information as clearly as possible.  | No major errors, but a significant number of minor errors that indicate either lack of understanding of major concepts or haphazard preparation of the report; scientific concepts utilized in some cases, but not consistently in explanations.  | Level of writing less than what would be expected of a college student; numerous mechanical errors and little use of appropriate scientific language. |
| “D” Level Work | Missing some major components of the report; directions not followed in more than one area; support materials missing or inadequate; major errors in interpretation show lack of understanding.  | Some graphs or tables missing; significant errors in choice of type of graph or in data presentation; information is not well supported by graphs and tables. | At least one major error in interpretation of the experiment in addition to numerous minor errors; generally lacks appropriate use of scientific concepts in interpretation.  | Level of writing far below what is expected of a college student; mechanical errors in writing result in difficult interpretation of scientific concepts; little or no correct use of scientific language.  |
| “F” Level Work | Missing major components of report; directions not generally followed; most support materials missing or incomplete; major interpretation errors show complete lack of understanding of experiment. | Significant graphs or tables missing; significant errors in graphs or tables; data presentation is weak and does not support information. | Numerous major errors in interpretation of the experiment; does not utilize appropriate scientific concepts in interpretation of data.  | Level of writing is unacceptable; writing prevents understanding of scientific concepts; complete lack of use of appropriate scientific language.  |