Writing Laboratory Reports

Laboratory Notebooks

In this class, you will each keep a lab notebook. Lab notebooks are permanent bound notebooks with numbered pages (not spiral notebooks). Most college level chemistry courses include keeping a lab notebook as part of their curriculum. I would like you to develop the professional skill of keeping a lab notebook.

For a professional scientist, the lab notebook is a legal document. Many millions of patent decisions come down to whether the scientist has properly documented their work. Often companies have to prove that they were the first to develop a specific procedure or product, and their proof is their laboratory documentation!

We will be using the kind of notebook that has duplicate pages, so you can turn in a copy and keep a copy of your lab work bound in the notebook. When you write in the notebook, you must use only waterproof, non-erasable ink. Do not use white-out or any type of correction fluid. Before the lab, you will prepare for lab by completing a prelab writeup in your notebook. During lab, data is written directly into the notebook. The purpose of all of this is so that data is not accidentally lost or purposely faked after the experiment. All data is labeled descriptively, so that anyone else who reads the notebook knows how the experiment was done and what each piece of data refers to. Calculations and conclusions from the data are written up in the lab notebook.

To encourage you to develop the skill of keeping a lab notebook, I will be checking each person's lab notebook at different times during the semester. You must keep your lab notebook complete and up to date at all times. There will be point deductions for incomplete lab notebooks and any violations of lab safety procedures.

Make sure to fill in your table of contents at the beginning of the lab notebook so that each experiment is easy to locate. You will need to update the table of contents with each experiment as you go.

Always keep the original pages attached/bound into your lab notebook. This way, you will always have a copy of all of your lab work. Turn in **only** the copy pages.

In general, make sure that your lab reports are neat, clear, and logical. It is your responsibility to make your work easily understandable to the reader.

Before Lab (Prelab Writeups)

Read the experiment, and write a "prelab" report in your lab notebook. You will turn in the copy and keep the original bound in your notebook. Make sure to use the cardboard flap between the pages so that your writing doesn't go through the next few pages.

Prelabs must be done before the lab period starts. To submit the prelab, scan all of the pages with a scanning app on your phone and convert it to a multipage pdf. Then upload it to Canvas on the assignment page for this prelab. Your prelab will be checked before the lab report is due. The prelab will also be the first part of the laboratory report, so you will actually be turning it in twice.

This is what must be included in the **prelab**:

1. **Name and lab partner**
2. **Title and procedure reference**
3. **Purpose and Overview**
4. **Procedure Outline**
5. **Prelab questions**
6. **Data Table**

A detailed explanation of each of these sections is given below.

1. **Your name** and lab partner's name.

2. **Title** of the experiment (a descriptive title, not just an experiment number) and procedure reference. The reference will usually be your laboratory manual. (Include page numbers from the lab manual.)

3. **Purpose and Overview** of the experiment:

Read the experiment, and write a **summary** (about one to three paragraphs long) **in your own words** of what you plan to accomplish and how. Be complete without going into too much detail. Example: "In this experiment the goal is to determine the molar mass of an unknown compound by freezing point depression. The freezing point of the pure solvent is determined by observing its temperature as it cools. The point at which the temperature remains constant is taken to be the freezing point. The unknown is then dissolved in the solvent, and the freezing point of the solution is also determined by observing its temperature as it cools. The molar mass will then be calculated using the formula $\Delta T_f = K_f m$ and the known masses of solvent and solute. " You should **not** list all of the procedure's steps in this section. **If there is a chemical reaction involved in the experiment, the balanced chemical equation must be given in this section.** Please **do not** copy the wording from the laboratory manual into your notebook. This section focuses on the idea behind the experiment. You must first try to understand the purpose before you write this section.

Please do not include any reference to what you, the experimenter, will be learning, practicing, or investigating, even if the lab manual mentions this as the purpose of the lab. Focus instead on what you will be *determining or finding out* in the experiment.

When writing this section, please resist the urge to use sentences or phrases that are copied from the lab manual. One suggestion that will help: first read through the description of the experiment a couple of times, then stop looking at it and write the purpose and overview. Usually, if you're not looking at the source, you can come up with your own way of wording the information.

4. **Outline of Procedure**:

On the left half of the notebook page, write a short outline of the procedure. Give yourself a framework to record your observations for each step, which you will record on the right side of the page. Leave lots of space for making notes and corrections. **Do not copy** the entire procedure section from the laboratory manual into your notebook.

Please just summarize the main points of the procedure. As part of the procedure, note how you will dispose of the chemicals used in the experiment.

5. <u>Prelab Questions or Calculations</u>:

If there are prelab questions, include them here. Many of our experiments do not have any prelab questions. If there are prelab questions, they would be labeled in the lab manual as "Prelab Questions" or "Advance Study Questions". (When answering these, always show your work and/or explain your reasoning.) If the questions are merely labeled "Questions", then they are meant to be answered at the end of the final lab report.

6. <u>Data and Observations</u>:

For the prelab, you will prepare a blank data table. Read through the procedure of the lab to see what measurements you will be making. In your notebook, write down in order a brief description of the data you will be taking, including units, and leave space for the actual data. Organize this information into a neat table. For example:

"mass of crucible _____g

mass of crucible and Na_2CO_3 before heating _____g

mass of Na_2CO_3 before heating _____g

mass of crucible and contents after first heating _____g

mass of crucible and contents after second heating _____g

mass of product after second heating _____g"

Leave lots of blank space for making notes and corrections and to make sure the table is readable. *Do not include spaces for calculations or the results of calculations* in this section – all calculations will go in the calculations section. Data and observations include only what you *directly measure or observe* in the laboratory.

If the experiment involves mainly observations, include a table of observations in this section.

<u>During Lab (Data Entry)</u>

During the laboratory period, as you do the experiment, write all data and observations in ink directly into your laboratory notebook in the "Data and Observations" section. *No pieces of scrap paper should ever be used for recording data.* Be sure to label all data clearly so that you know and the reader knows what each piece of data is. This does not need to be perfect, but try to keep it legible and logical. If you make a mistake, draw one line through it and initial it so that the original can still be seen. In order to keep the data table neat, it helps to leave some blank space between entries (things are more readable if they aren't cramped).

Important: points will be deducted if you do not write the data directly into your lab notebook as you make your measurements!

Be sure to include enough procedural information or labels so that someone with your background could repeat the experiment using only your lab notebook and the lab manual. Make sure to include all raw data (every measurement or reading made during lab). All data must be labeled with units and must have the correct number of significant figures. For each entry, it should be clear what specific part of the experiment it relates to and what quantity was measured. Include also a description of any unexpected results or mistakes. Do not include any calculations in this section (other than simple additions or subtractions).

When you are done with the experiment, before leaving the lab room, check in with the instructor to have your data pages in your notebook signed for verification purposes.

Lab Reports

Lab reports must be neat, organized, legible, and easy to follow. Most of the work will be done in the lab notebook, and you will turn in the *copy pages only*, leaving the original bound in the notebook. The laboratory report must include the following sections, in order:

1. **Name**
2. **Title and procedure reference**
3. **Purpose and Overview**
4. **Procedure Outline**
5. **Prelab questions**
6. **Data and Observations (with data filled in)**
7. **Calculations**
8. **Summary of Results**
9. **Evaluation of Results**
10. **Questions**

Notice that sections 1-6 will already be completed at this point. To finish the laboratory report, you only need to write sections 7-10 and staple them to the prelab and data. The content of the remaining sections is detailed below. Please make sure all of the sections are in order.

6. Data and Observations:

Make sure that the data is filled in the data table and that any observations are included. (This will be done during the experiment, so there's nothing extra to do here.)

7. Calculations:

Label all calculations and show your work logically and clearly. Make sure to include units in your calculation setups and answers, and report all results to the appropriate number of significant figures. Leave enough space between things so that your work is easily readable. Focus on making sure that your work is easily understandable by the reader.

8. Summary of Results / Conclusions:

Summarize the final results into a neat table. (Do not include data in this section. Results are calculated from the data.) There's no need to include the result of every step in the calculation – just include the final results. For example, if the purpose of the experiment was to calculate the molar mass, list the molar mass in this section. Include unknown numbers, if any. If several trials were done, list the result for each trial, the average of all the trials, and the percent difference* between the results. Anything that was mentioned in the "Purpose" must be addressed and resolved in the "Conclusion". For example, if the purpose of the experiment was to determine if acid A or acid B was the stronger acid, there should be a statement in the conclusion about which was stronger. This section should be short and needs no explanatory comments. You will make comments in the next section. **There is no need to re-explain what you did in the experiment.**

9. Evaluation of Results:

- Comment on whether your results agree with the expected results, if possible. If several trials were done, comment on the precision. If the true value is known, calculate the percent error and comment on it.
- This section should include a thoughtful, deep explanation of likely sources of experimental and systematic error. **The explanation should be clear, specific, and easy to understand.**
- It should include the most obvious sources of error, and if possible, a few other less obvious sources. Make sure to include an explanation of 3 or 4 sources of error.
- **In your error discussion, explain how your final calculated results would be affected by each** source of error. (For each source of error listed, would the error make your calculated final results **too high or too low**? Clearly explain **why**, both conceptually and mathematically.) First decide which measurement would be off and in which direction and why. Then explain how that error would affect your final calculated result and why. Include as much evidence as possible in these reasons, based on your observations during the experiment. When writing this section, show evidence of careful thought for full credit. For example, consider the following: Were there any experimental techniques that were difficult to perform accurately? Why? What are likely or possible sources of systematic error? Explain thoroughly. Are we making any assumptions in the calculations that might not necessarily be true in our case? How would your results be affected if the reaction did not go to completion? (These are not the only items to consider, but this should give you an idea of the type of depth I'm looking for.)
- The sources of error should be specific to each experiment, not just general errors that would apply to any experiment.
- Speculate about possible sources of error even if you don't think you made any errors. I'll be grading the depth of your analysis and the clarity and correctness of your explanation. If you don't include any analysis, I can't give you points for this section.
- If you did end up making any blunders, explain them in this section and discuss how they affected your results and why. Do not include potential blunders or

dumb mistakes (such as forgetting to weigh something, incorrect calculations, etc.) as possible sources of error, unless you know for sure you made a blunder and there is no way to re-do the experiment. Ideally, you would catch this kind of mistake before leaving the laboratory room, and then re-do that part of the experiment.

- This section should **not** include subjective opinions, such as what you learned, what you thought about the experiment, or whether or not you thought the experiment was difficult. (It shouldn't have any mention of you, the experimenter. It should focus on the experiment itself.)
- There's no need to explain or restate the steps in the experiment or the steps in the calculation. Just focus on the error analysis.
- For example, instead of writing "We might have made an error measuring volume", you could say something like: "We measured the volume in part 2 by measuring the length, width, and height of a rectangular piece of metal. The edges of the metal were rounded and the metal had scratches and marks on it. When we measured the length, width, and height, we didn't take into account any indentations in the metal surface. These indentations would make the actual volume of metal lower than the measured volume. Since density = mass/volume, if the measured volume is higher than it should be (higher than the actual volume), the calculated density will be too low. (Volume and density are inversely related.)"

10. <u>Questions:</u>

Answer any assigned questions. Always show your work and/or explain your reasoning, as appropriate.

<u>Which sections of the lab report can be typed?</u>

- You're not required to type/word-process the lab reports, but some of you might want to type some sections.
- **The data tables and the data itself must be written by hand directly on the original pages of the lab notebook.**
- Any of the other sections of the lab report can be typed if you want. Print two copies: one copy will be turned in, and the other copy will be attached to the pages in your lab notebook (see below).
- Any typed sections must be securely attached (using glue or many staples) to the appropriate pages of the lab notebook. Attach each typed page to its own numbered original page in the lab notebook.

Percent Difference and Percent Error formulas:

The ***percent difference*** is used to indicate how close repeated results are to each other:

* $$\%\ \text{difference} = \frac{(\text{highest result} - \text{lowest result})}{\text{average of all results}} \times 100$$

The ***percent error*** is used to indicate how close the experimental result is to the true value.

$$\text{percent error} = \frac{|\text{experimental value} - \text{true value}|}{\text{true value}} \times 100$$

Possible Point Deductions for Lab Practices

Certain lab practices are extremely important. I want to see 100% compliance with these rules. Points will be deducted if these rules are not followed.

Things you can lose points for:

- Not wearing safety goggles (points off if I have to remind you).
- Food or drink visible in lab (definitely don't eat or drink during lab, but also don't have any food or drink containers out in lab. This also applies to water bottles – they should stay inside your backpack. Assume all lab bench surfaces are contaminated with chemicals.)
- Legs or feet uncovered (don't wear sandals, open-toed shoes, shorts, or short dresses/skirts). No exposed skin below the waist.
- Writing data somewhere other than your data table in your lab notebook (like a scrap of paper or your lab manual).

For each violation of the above, 2 points will be deducted from your point total.
Repeated violations = more points off.
The maximum number of points you can lose is 10 points per lab day. This can add up quickly!

Everyone will get one waiver (total) for an infraction. (Meaning: no points off for the first infraction of the rules.)
If you don't use your waiver, always follow the safety rules, and always write data directly into your notebook, you will get 5 points of extra credit at the end of the semester!

Do each other a favor – I encourage you all to remind each other to wear safety goggles, make sure you don't have food or drinks in lab, and write data directly into your lab notebooks. You can help each other to not lose points, and help us achieve 100% compliance with the safety rules.

Shown here is a list of what I will be looking for when I grade your lab notebook:

Lab Notebook Check – Weeks # _____

	Yes	Not always
The table of contents is filled out for each experiment.		
All raw data is included in the data tables for all experiments. (This data must be written directly into the notebook in the appropriate section as you take the measurements.)		
Everything in the notebook was written in ballpoint pen (no pencil, no erasable ink, no water-soluble ink).		
Mistakes are corrected by drawing one line through the mistake, initialing and dating it.		
Nothing is blacked out or obliterated – the original entry is still visible even if it has been crossed out.		
No white-out or correction fluid was used anywhere in the notebook.		
If there are any typed pages included, they are permanently attached in the correct locations. These pages must never be removed or torn out and replaced. Data must not be written on typed pages – it must be written directly into your notebook.		
All pages are in lab notebook (no original pages have been removed).		
All experiments are present in lab notebook (unless you were absent for that lab).		
The teacher's initials are present on the data pages of every experiment.		
The lab notebook is reasonably neat and organized (it doesn't have to be perfect).		

Points:_____