Chemistry Lab Report Format

General Style: Lab reports are written in the passive voice, to disassociate yourself from the results. Generally, the past tense is used as well, because it has already happened (there will be some exceptions to this throughout the report). The idea is that the experiment should work the same way and give the same results no matter who does it. **Do not use 'I', 'we', 'they', 'our group'** etc. If these words appear, *your sentence is incorrect.*

Active voice—don't do this**:** We heated the magnesium until it combusted.
Passive voice—do this**:** The magnesium was heated until it combusted.

<u>Only Exception:</u> the results from instruments can be put in the active voice *for the instrument*

Example: The Spec20 recorded an absorption of 0.834

The subject in these sentences are all inanimate objects—the magnesium or the Spec20. If you use Microsoft Word, it will probably give you a grammar warning about passive voice. Ignore it; passive voice is frowned upon for creative writing, but is proper for scientific writing.

<u>A note about grammar/spelling/style:</u> lab reports are about clear communication of scientific results, and communication is the basis of all scientific endeavors. If you work alone in a basement and just leave behind some incomprehensible scribbled notes, your work has no value or merit. Grammar, spelling, and style will factor into the grade (see the rubric). However, what I am looking for here is clear, direct language. You should use the proper scientific terms for everything, but do not feel the need to sit down with a thesaurus to "fancy-up" your language. One of the things that makes English really excellent as a language is that we have about 50 words for everything, each with slightly different connotations. Use the right one, even if it's the simple, everyday word. On the other hand, when the multi-syllabic word is the <u>best</u> one (e.g. 'multi-syllabic), <u>use it</u>.

Method vs Procedure: Method is how you do something. Procedure is step-by-step directions. For example, it I'm measuring the depth of a river, my method could be sonar or use of a rope with a weight on it. The procedure would be step-by-step directions for calibrating and using the sonar, or for tying the weight, choosing the right size weight, and lowering it.

Formatting:

1. Abstracts must be single-spaced.
2. Otherwise, use whatever formatting you want. Keep it professional and easy to read (I like Times New Roman 12 pt font, but opinions vary).
3. I am not grading based on length, but rather on content. Moving margins or expanding the spacing will just waste paper.
4. Lab reports must be typed. If this is problematic for you for reasons of computer access, let me know ASAP and we will deal with the situation on a case-by-case basis.

Citation:

You must cite sources, and you should be using outside sources. Failure to do so is plagiarism, for which dire consequences are laid out in the student handbook. For science purposes, each journal has a slightly different format, but the general principles are as follows:

* Every time you <u>use</u> a piece of information that is not your own, you cite your source with a footnote at the end of the sentence[1]. This does not just apply to direct quotes.

* You don't have to cite anything considered common knowledge. The definition of common knowledge is a little nebulous, but in general, if it was something you knew without looking it up, you don't have to find a source for it. If you looked it up, cite the source[2].

[1] Like this. Source information goes here.

[2] I will not be holding you to a particular format; include enough relevant information that I could find the exact page or webpage without any trouble.

SECTIONS OF THE LAB REPORT

*** Lab Title:** This should be a short, effective description of the *goal* of the experiment, though you can add a little flavor to it by using subtitles.

Example: Mass ratio of elements in the combustion products of magnesium.

Example: Blinded by the light: mass ratio of elements in the combustion products of magnesium.

*** Abstract Section: ~3-5 sentences:** This is basically a mini-report that summarizes the rest of the lab report for somebody who doesn't have time to read the whole thing. Even though it comes first, it is normally written last as some of the information is obtained during the experiment. This is the one section where it's actually suggested that you keep it short (albeit complete). If it takes up more than approximately a quarter of a page (single-spaced), it's too long.

- * State the objective(s) of the investigation. DO NOT do this with a formulaic sentence like "the objective of this experiment was XXX". Look at the example below for some guidance.
- * Summarize the <u>method</u> used for testing. DO NOT include procedure or specific quantities.
- * Then, in one sentence, summarize the overall results from the experiment.
- * Finally, the conclusion drawn from your experiment

<u>Reminder:</u> abstracts should be single-spaced, no matter what formatting you use for the rest.

Example Abstract:

One of the fundamental principles of chemistry is the fixed ratio of elements when combined to form a compound. The mass ratio of magnesium to oxygen was measured to observe the reproducibility of results. The ratio was determined using the change in mass after combustion of a magnesium sample. Despite some variability in the ratio, each trial produced a ratio within 10% of 3:2, demonstrating the validity of the law of definite proportions.

*** Introduction:** The introduction serves two goals:

1. Describe <u>what</u> we're doing, <u>why</u> we're doing it, and <u>how</u> it was done.
2. Provides background information or context the reader might need or want to help them better understand the experiment.

With regards to point number one: the how here is still about *method, not procedure.*

With regards to point number two: this is in particular where you help explain to the reader why to do the experiment. (NOTE: not "what skills will I gain from this/why did Mr McBee assign it"). Not just the objective, but the importance of the topic, or the history of the topic, or what other people have done on the same topic. This is the section where it really comes through who has figured out the purpose of the experiment and done some of their own reading about it, and who is just cramming something together because it's due tomorrow. This should be a significant portion of the report. If you look at journal articles, it's often as long as the portion describing the actual research.

You should be planning to use outside sources for this portion of the lab report. Make sure to cite them.

Results never go in here. You should be able to write the whole introduction before even starting the experiment.

Example from Biology: if I were writing an introduction for a lab on photosynthesis, I would give a bit of information about what photosynthesis is (probably including the chemical reaction), why plants do it, how it benefits us (turns energy in the form of sunlight into food calories that we can use), and maybe some examples of important experiments in photosynthesis (who discovered it? was it just in the news lately? Etc). Now my reader would have some background to understand the next part of the introduction, which is a description of the experiment and what should be learned from it.

*** Observations & Data Section:** This is where raw and calculated data goes. If you measured it, it goes here. If you calculated it, it goes here. You must show work for all calculations, but if the same calculation is repeated a bunch of times, you may show it just for the first example. It may be easier to hand-write some of the calculations in, rather than trying to format them on the computer. However, newer versions of Word have very good equation editors that will make it look nice and professional

You must include all the raw data with zero calculations performed, no matter how trivial they seem. If a volume started at 25 mL, then rose to 27 mL, that data should be included. The increase of 2 mL is calculated data.

1. Use a **table or a paragraph** form to organize what you **saw, heard, smelled or touched**, but only if it's applicable/useful to your investigation. Seeing a reaction happen, bubbles, gases etc. is useful if that's what you're investigating, feeling heat from a Bunsen burner is not—we know that fire is hot.
2. Put your data in tables wherever possible and reasonable. Do not forget to write **the units** with every single number.
Exception: You may put a unit at the top of the table column once and then you do not have to write it next to every number in that column.

Example: Increase in mass of combusted magnesium

Trial	Mg (g)	Combusted Mg (g)	Increase (g)
1	1.00	1.66	0.66
2	2.00	3.30	1.30
3	2.44	4.10	1.66
4	4.03	4.07	0.04

3. Every table needs a title and variables named at the top of each column.
4. As you are looking at the data you collected, ask yourself "*why* did I measure or record that?" If the answer is "I have no idea," then it's either not relevant and can be left out, or you missed the point of the lab.

*** Analysis of Data Section:** The Data section contains numbers, observations, and graphs only; the Analysis section is where you discuss the data. Things to highlight: any patterns you see in the data ("all masses increased by slightly more than half") and exceptions to the pattern ("Trial four is clearly an anomaly, as the mass did not change appreciably"), or any data that seems to contain an obvious flaw ("the mass of the penny was calculated to be 30 kg; this is clearly too large for a single penny"). You can tie in your observations with the numbers as well, but don't go too far into the error analysis here. Depending on the amount and type of data collected, this can be a fairly short section, or quite long.

(short) Example: The increase in mass of the combusted magnesium was proportional to the starting mass of the magnesium, with the exception of trial number four, for which no significant increase was observed. It was observed that the product was still a shiny metallic color in trial four, while all other trials produced a white powder; presumably the combustion did not proceed in this case. For trials one through three, the increase in mass was consistently 65-70% of the starting mass. Trial four was also the case with the largest amound of starting material, which may be relevant to its failure to combust.

*** Conclusion Section:** There is an important difference from an English paper here. In English papers, the conclusion is basically just summarizing the case that you have already made in preceding paragraphs. For scientific purposes, the *conclusion should contain something new—the deduction that you have reached based of your experiment and data*, and your justification for it. This is also where you should make some mention of where you could go from here for further experiments or applications.

Example: The (mostly) consistent ratio between the increased mass of the combusted magnesium and the starting mass suggests that magnesium and some other element combine in a fixed ratio of 3:2 regardless of the starting quantity of magnesium. Given oxygen's known role in combustion, and the fact that the ratio of magnesium's weight to oxygen's weight is also approximately 3:2, the observed data is consistent with the product being a combination of magnesium and oxygen. Given that metal oxide compounds are typically basic[3], further testing of the compound's pH would help confirm its identity. This experiment could be extended to observe the combustion of other metals with oxygen, or an oxygen-free chamber could test the combination of magnesium with other gasses.

*** Error Analysis Section:** This is where you would discuss any error that affected the results of your experiment. *If there is a known value for what the result should be, a **% Error** must be included.* For a few labs, there will be a **% Yield** instead. Unless you get a very small error (let's say <2%), this should be a significant portion of your report…not just one or two sentences.

A few key points:

* "Human error" is too vague. This should be a *specific* thing.
* "Reading the balance incorrectly" or "forgot to zero the balance" is *never acceptable*. Copying numbers off a balance and hitting the zero button are basic laboratory skills you should have mastered long before now.
* "An error was made in calculations" is even less acceptable. If your calculations have an error, *fix them now before you finish writing and turn it in.*
* All errors must be based on either observations or *reasonable* supposition. For example, if you were filtering a solid out of a liquid and you got a 2% error, 'some of the solid may have slipped through the filter paper' is reasonable if you don't have any other explanation. If you got a 75% error, that explanation is not reasonable unless you observed a *whole bunch* of solid going through.
* **Errors must correlate with your results**. If your result is too high, your error must be something that leads to results that are high, rather than low. I suggest always proving this with math where possible. You should almost always be pointing to a specific measurement and describing whether it's higher or lower than it should be, why it's that way, and how that gives the result obtained.

You should describe ways the study might have been improved upon had you done this again. It is a reflection and should still be supported by evidence. If you say you want to change something you should also say why you are changing it. Feel free to both describe what could be done better in our lab setup, and what could be done better if you had access to super-fancy technology. However, don't get trapped into thinking super-fancy technology is the cure for all your experimental woes: often, the problem is something as simple as using a beaker to measure volumes (BAD! NEVER DO THAT) when a volumetric flask was available.

Some good questions to ask yourself for the error analysis section:

1. What was your least trustworthy measurement, and why?
2. Which measurement had the greatest impact on the final answer?
3. Which values do you think were higher than they should be, and why? Lower, and why?
4. Does a high value for X lead to a high value for Y, or a low value for Y?

[3] You better cite that source.

*** Experimental Section:**
This section depends on whether I gave you step-by-step directions or not:

If you got directions:

You may write "the given procedure was followed." This section must still be present, however, even if only for that statement. There's no sense in reinventing the wheel.

Do make note of any changes you made to the procedure other than trivial things (like you got 1.04 grams instead of 1.00 grams)

In this case, the procedure will only be 2 points—it's either there or it's not

If you did not get step-by-step directions:

This is the only place where the step-by-step procedure goes. This should generally be written as a list of directions that include amounts, though there may be some exceptions. You do not need to write out completely trivial things stepwise ("1. Turn balance on. 2. Press zero button. 3. Place magnesium on balance. 4. Record mass"; it's ok to write things like "Record the mass of magnesium").

As you're writing the procedure, ask yourself whether a reasonably-competant person who had never done the experiment before could pick up your report and exactly repeat what you did.

RUBRIC FOR ASSESSING LAB REPORTS

	1 Beginning or incomplete	**2 Developing**	**3 Accomplished**	**4 Exemplary**	**Score**
Abstract	Several major aspects of the experiment are missing, student displays a lack of understanding about how to write an abstract	Abstract misses one or more major aspects of carrying out the experiment or the results	Abstract references most of the major aspects of the experiment, some minor details are missing	Abstract contains reference to all major aspects of carrying out the experiment and the results, is well-written	
Introduction **Background**	Introduction is missing, or does not provide any background information on the experiment	Introduction includes an irrelevant or inaccurate example(s) of context	Introduction includes objective of experiment and a relevant and accurate example of historical or scientific context	Introduction includes objective of experiment and multiple relevant and accurate examples of scientific and historical context	
Introduction **Purpose**	Introduction in missing, or does not address the purpose and method of experiment	Introduction does not address one portion of purpose, or is inaccurate	Introduction accurately addresses purpose of the lab, but does not expand on abstract	Introduction accurately addresses the purpose of the lab ("what, why, and how") with appropriate detail	
Observations & Data: **Presentation**	Figures, graphs, tables contain errors or are poorly constructed. Units missing or incorrect.	Most figures, graphs, tables OK, some still missing some important or required features.	All figures, graphs, tables are correctly drawn, but some have minor problems or could still be improved.	All figures, graphs, tables are correctly drawn, well organized, and contain titles/captions and units	
Observations & Data: **Calculation**	Calculations are missing	Calculations are present, but contain major errors or are unclear	Calculations contain minor errors or inaccurate rounding	Calculations are present, correct, and rounded appropriately	
Analysis of Data:	Very incomplete or incorrect analysis of data, indicating a lack of understanding.	Analysis of data is non-specific or contains a major or multiple minor errors or omissions.	Trends and data comparisons have been made, but are missing an important point or are overly vague	All important trends and data comparisons have been observed and discussed with clarity and specificity.	

Conclusion:	Conclusions missing, or conclusion does not address the important points.	Conclusions regarding major points are drawn, but are misstated, indicating a lack of understanding. No follow-up experiment suggested.	All important conclusions have been drawn, but could be better stated. Suggested follow-up experiment is included, but not relevant.	All important conclusions have been clearly made; student shows good understanding. Reasonable and relevant suggestion for follow-up experiment included.	
Error Analysis	Error analysis missing, unreasonable, or unsupported.	Error analysis is supported and reasonable, but contains major errors in logic. %Error or %Yield not included	Error analysis is reasonable and supported, but contains minor errors in logic. %Error or %Yield included, but incorrectly calculated.	Error analysis contains reasonable and supported suggestions for improvement that match actual results. % Error or %Yield correctly calculated where appropriate	
Procedure	Missing or changes in procedure unreported	Present and all changes in procedure reported.	Procedure could be accurately replicated given a small amount of extra information	Procedure can be accurately replicated. Does not contain irrelevant detail.	
Spelling, grammar, sentence structure	Frequent grammar and/or spelling errors, writing style is rough and immature.	Occasional grammar/spelling errors, generally readable with some rough spots in writing style	Less than 3 grammar/spelling errors. Mature, readable style	All grammar/spelling correct and well-written. Language is clear and readable.	