General Guidelines for Writing a Formal Laboratory Report

ABSTRACT

Abstract (NOT NEEDED for IB – this is for reference)

All formal lab reports should begin with abstract section that outlines the topic and specific area of focus that you will be investigating, your personal interest in the topic, and the scope of the investigation (why someone else might be interested in your topic). This should include your research question clearly identified (usually bolded), a brief description of the procedure (major steps undertaken to collect the data, not a numbered list of steps), the most important findings of your investigation (yes, provide your major results), and a brief description of the meaning/significance of your findings. If you still have some space available, you may also choose to include a brief description of next steps/further investigations that would lead from the findings of this investigation. Essentially, if your job was to research this topic, what would you investigate next.

This section is often read independently from the rest of your report and should be able to "stand alone" as a description of the essence of your investigation. The abstract should not exceed 300 words.

1. INTRODUCTION

1.1 Scope of the Investigation

Before getting into the specifics of your experiment, the reader needs to get an understanding of what topic you are investigating and why you have chosen this investigation. It is in this section of the introduction that you would outline what you are intending to investigate, without going into your detailed research question, in addition to a discussion of how and why this investigation is **personally engaging** to you.

1.2.1 Research Question

After the background information has been provided, you must include a concise **statement of the problem (question you are attempting to answer)** that is being investigated in the lab activity. Your question should be clear, concise, and extremely focused. Structure the question so it reads "How does … affect …" given a set of essential controlled conditions. This should not be a restatement of the topic of the investigation, outlined by the course instructor, but rather a detailed objective of the experiment outlining a specific aspect/area of focus being investigated. You will know that your research question is sufficiently focused when it reads in such a way that it could not be confused with any other similar experiment.

1.2.2 Background Information

Include all pertinent background knowledge (scientific theories) that are needed for a reader to understand the experiment (i.e., definitions of terms used, historical background if appropriate, pertinent scientific laws and theories, chemical equations, mathematical formulas, and so on). This should also read in such a way that the connection/relevance to the experiment at hand and the purpose of the experiment are clearly evident – make the connections. It is here that any literature values/tables would appear, if applicable.

1.2.3 Hypothesis (may be combined with background information)

Before being granted permission to conduct an investigation, you must demonstrate sufficient knowledge on the topic and the expected results by including a detailed hypothesis (a possible **explanation/answer** for what you expect to observe, which can be adequately tested in the lab activity). Be sure to include a justification for your expectations with some theory from the background information section presented earlier. Do not present new theory here.

2. METHODS

2.1 Variables

Clearly state the independent, dependant, and controlled variables. You do not need to discuss how these variables will be manipulated, measured, or controlled as your procedure should address every variable you have identified. All of your investigations also require experimental controls in order to validate the significance of results obtained. This should be written as a bulleted list of variables, not in a paragraph.

2.2.1 Materials and Equipment

In list form (NOT NUMBERED) you need to list the specific requirements to carry out the procedure. Equipment and materials should include descriptions and approximate quantities (e.g. 100 mL beaker x 2, 3 decimal place balance, 12g NaCl, 100 mL 2.0 mol/L HCl)

2.2.2 Procedure

The procedure needs to be written in the past passive tense, describing "what was done" rather than "what will be done." For a university report, this should be written in paragraph form outlining the important steps of the procedure, with reference to the appropriate section of the Appendix, where a numbered list with detailed, step-by-step instructions is present. It is at this point that clear control of the variables identified early must be done, so include very brief descriptions of why certain steps are being done and how the steps of the procedure assist in effectively controlling the variables. For the IA, no appendix is allowed. The full procedure is required in the main body of the IA. The procedure may or may not be a numbered list as you prefer.

When conducting the experiment, **you may find that there are some procedural steps that needed to be revised/altered in order to complete the investigation.** You have options as to how to deal with this to show personal engagement for the IA. 1) Do not change your "planned" procedure, simply outline the changes that were made in a brief paragraph following the procedure. 2) Include the final procedure, but include an "optimization" section BEFORE the final procedure that discusses the changes between the original and final procedures. For a university report or published paper the final procedure is the procedure included.

Note that if a "standard" procedure is described (e.g. calorimetry, titration) you MUST include a reference to a standard procedure you have optimized for your experiment (these techniques are NOT common knowledge)

2.3 Safety, Environmental and Ethical Concerns

Many of the chemicals used in our experiments have inherent danger/risk. Through an exploration of the appropriate materials and safety data sheets (MSDS), you are expected to outline the safety risks and environmental concerns of the chemicals being used. This can include, but does not need to be limited to, risks to personal health and/or proper disposal of hazardous materials.

3. EVALUATION SECTION

3.1 Data Collection

Consideration must be given to what is the best method to clearly display results. Generally, tables are clear and concise effective tools to summarize information. Qualitative observations should be written up in proper sentences and should generally describe what was seen before (e.g., the reactants in a chemical reaction), during (changes that occurred during the experiment), and after (e.g., the chemical products) the experiment was completed. Quantitative data must be recorded in table form and should only reflect data that was collected during the experiment. Calculations must **NEVER be included** in a data collection table.

Make every attempt possible to avoid "splitting" a data table (putting part of a table on 1 page and finishing it on another). If you absolutely have to split a table, make sure that you split the table in an appropriate place and ensure that you re-do the title and column headings. Uncertainties should be included wherever possible. Uncertainties and units should be included within the heading of every column.

Tables need to have an appropriate and descriptive title. The title of the investigation and your research question are NOT acceptable titles. The title should provide a glimpse of the data that is being collected and the method in which it was collected. You should also include any relevant quantitative data that is constant throughout the investigation and not used in the processing of the data. For example, if you are using 300mL of solution for every trial, include that value as part of your well-structured title, not as a repeated value throughout the table.

3.2 Data Processing

3.2.1 Calculations

Whenever you have collected quantitative data, you must include calculations showing how your results were obtained. When multiple, repetitive calculations are conducted, a **sample calculation** can be provided in favour of all the repetitive calculations. For example, if your experiment involved collecting data on mass and volume, and you are required to determine densities, you must show how you calculated the densities (using correct units). Your calculations must also include accurate propagation of the uncertainties. Upon showing a sample of all the calculations, a summary table may be used to show that all calculations were completed. For experiments that do not necessitate a graph, your calculations should end with a brief summarizing statement that outlines the end result generated by the calculations.

3.2.2 Graphs

You must also plot accurate graphs of quantitative data, whenever appropriate. In addition to graphs specifically needed to process data collected throughout the investigation, **the final graph should be a visual representation of the answer to your research question.** Trends can often be best represented utilizing graphs (be sure to use a trend line that shows "a line of best fit" for the data provided). It is for this reason you must collect sufficient relevant data to reveal any trends. HINT: You may want to reconsider any graphs constructed for which trends cannot be readily observed. After the graph, it is useful to have a general statement outlining the information that should be inferred from the graph.

4. CONCLUSION

4.1 Conclusion

A good conclusion is a summary statement that specifically answers the research question posed. A summary of the findings (specific evidence) made in the activity that supports how this conclusion was generated is also appropriate. **It is NOT APPROPRIATE to reference your hypothesis.** This summary should include a description of any trends in the data and must be supported by the evidence you collected. The validity of the results should be addressed with statistical data. If you had literature values the results of a percentage error calculation should be presented with reference to the Appendix for the actual calculation. You may also wish to discuss the R^2 value and/or slope of the trend line of your graph if you feel it is relevant to validating your conclusion. In most cases, it is also beneficial to briefly explain unexpected results and the omission of any outliers.

In the next paragraph, you need to refer back to the scientific theories introduced in the background information that support your conclusion. If your answer differs from what you expected, outline what the theory suggests was supposed to have happened.

4.2 Discussion / Analysis (THIS SECTION IS NOT DONE IN I.B. FORMAL REPORTS)

A discussion follows the conclusion and allows you to extend the ideas developed during the lab activity. The discussion should also introduce concepts intended to help improve your thinking and problem-solving skills. In some labs, you will simply be required to answer a set of prepared questions. In many cases you will be required to prepare your own analysis and discussion.

4.3 Experimental Error and Suggested Improvements

Since no science activity, or scientist for that matter, is perfect, you must list errors that may have been made during your collection of data. This list should be limited to procedural errors ***not human errors*** (i.e. the wrong volume of water was used, the equipment was misread).

1) State, clearly and concisely, what the error was. Avoid discussing the various factors that may have caused the error. DO NOT discuss "human errors" such as measuring wrong, dropping sample, using an incorrect formula to perform your calculations, etc.
2) Outline how this error came to be. What led to this error occurring?
3) Clearly and specifically explain how these errors affected your results. Do not simply say that the error caused your results to be "wrong" or "inaccurate".
4) Suggest a reasonable improvement for ensuring that this error would not affect your results, if the experiment were to be repeated.

This segment should be focused on the "big picture" of the experiment and used for two purposes:

- ***What improvements could be made to the design that would perhaps lead to better results next time?***
- ***What suggestions do you have for other possible experimental designs that may work better for answering this question?***

In some senior courses you may be required to quantify this error by assigning, with explanation, appropriate precisions to the observed and calculated results.

APPENDIX

(This information is included in the main body of an IB Internal Investigation Report)

A.1 Materials

A list of the equipment and supplies that you will be using are listed in bullet form. Be sure to include the item used, the unit of measurement, the uncertainty of the device if applicable, and the quantity of equipment needed.
(eg.) Graduated Cylinder, 1 (100 ± 0.6mL) or sulfuric acid, 250mL (1.00 mol/L)

A.2 Diagram

A picture of the equipment listed in the materials list as it would appear if a "snap shot" was taken in the middle of your experiment. This diagram should represent the most important setup in your experiment. DO NOT show a picture of each piece of equipment. This diagram needs a suitable title and appropriate labels (all to the same side).

A.3 Procedure

The procedure is best represented as a **numbered list** written up in the past passive tense, describing "what was done" rather than "what will be done." For example, write "10.0mL of solution A was added to 15.0mL of solution B in a 250mL beaker and left to reach room temperature" and "the volume of gas produced was recorded every 5.0 seconds for a total of 3 minutes (180.0 seconds)." Do not write statements such as "Set up the apparatus as directed" (present tense) or "Record observations" (active).
When conducting the experiment, you may find that there are some procedural steps that needed to be revised/altered in order to complete the investigation. These procedural changes should be outlined in a brief paragraph following the procedure.

A.4 Extra Calculations

Additional calculations that are not processing the raw data that you collected, such as a percentage error calculation, would be done here. Any calculation performed here must be specifically referenced in the body of your report in order to be considered.

A.5 Percentage Error Calculation

When the literature value(s) is available for your investigation, you must perform a percentage error calculation. The calculation should appear here with the value presented in the concluding paragraph that answers your research question.

WORK CITED

Sources

As the majority of the information presented in your report is compiled from research conducted by other scientists, or theories discovered by others, you must properly cite these sources throughout your report referencing all information that is not your own. You should be using the official "APA" methodology for referencing. In the body of the work, after the information needing to be cited, add the name of the author and the year of publication in parentheses. In addition, you will need to write out a full, properly constructed reference in the bibliography section at the back of your report.

GENERAL GUIDELINES FOR WRITING A FORMAL LABORATORY REPORT

LABORATORY REPORT CHECKLIST

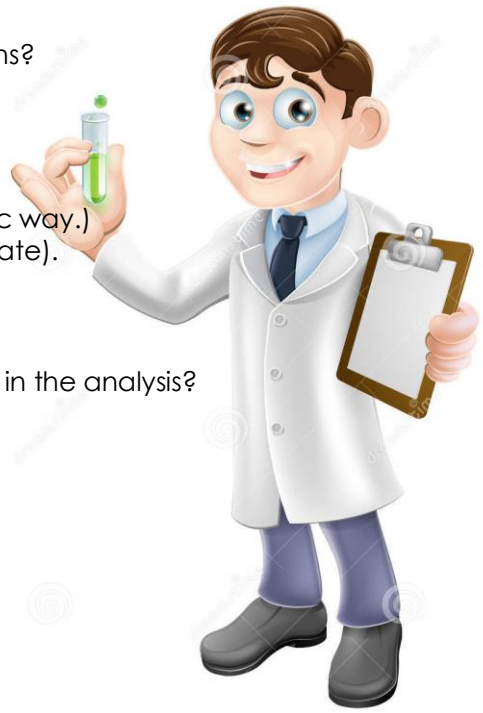
Each time you carry out an investigation check the following points:

Planning
- Have I written a short concise introduction?
- Have I expressed my personal interest in the topic?
- Have I stated my aim or objective, in a focused research question?
- Have I written a justified hypothesis (relating to previously introduced theory)?

Methodology
- Which variable will I be manipulating (the independent variable)?
- Which variable will I be measuring/observing (dependent variable)?
- How will I measure the dependent variable, and how often?
- Which other variables do I need to consider/control? (which ones will affect the experiment)
- How many trials do I need to ensure "sufficient data" has been collected?
- What equipment and materials will I need?
- What safety factors should I bear in mind?

Results/Data
- How accurate/precise must I be?
- What quantitative data should be collected?
- What qualitative data should be collected?
- How should I present the data? (annotated drawings, tables, prose)
- Where are the errors in my measurements/observations and how big are they likely to be?

Processing and Analysis of Results
- Do I calculate a change, a proportion/percentage, an average or other statistical value?
- Should I consider limiting/excess reagents?
- Do I present them as a table or graphically?
- If graphically, what sort of graph is best? What are the conventions?
- Do I need to analyze the graph to obtain a result?



Conclusions and Evaluation of Results
- What do the results show? (Are there any trends?)
- What can I interpret from the results? (Explain them in a systematic way.)
- Compare with literature values as a percentage error (if appropriate).
- Are the results consistent with what I expected?
- Are the results consistent with what was expected by theory?
- Can I explain any unexpected results?
- What are the sources of error: in my method, in the manipulation, in the analysis?
- What improvements could be made?
- Do I need to suggest a new hypothesis to account for the results?
- How could I take the investigation further?