Your paper should follow MLA format which basically means 12-point font, 1-inch margins, double-spacing, and a reasonable font-like this template. The IA experiment and write-up are expected to take a total of 10 hours. There is a 6-12 page limit. Replace all headings in parentheses with detailed titles that match your experiment, and delete all red comments before turning in. Feel free to make this your own, just don’t leave anything out.

(Title)

(Name, Date, Course)

I. Introduction & Purpose

Research Question
Specific Question with a MEASURABLE outcome, should combine your independent and dependent variables.

Introduction
In this introduction, you need to convince your reader to keep describe your personal connection to this topic….and yes, you need to have one, but no it doesn’t have to be a major connection to your life outside of class. But, make it clear why you were interested in this topic. First person is okay.

II. Background & Design

Background
The background section should “enhance the understanding of the context of the investigation”. So, discuss the science and why this experiment is important. Give context to your topic: which science concepts helped you understand it? Which concepts did you have to review to fully understand what you were researching? Any concepts you had to learn about on top of what you learned in class to help you understand it? INCLUDE ALLLLLLLLLL of your answers to these three questions. Also, include any relevant chemical equations or mathematical formulas that you will be using.

Hypothesis
Provide a short hypothesis and justify your choice using the science concepts you’ve learned in class. It does not have to be in If, Then, Because format. Consider adding a graphical hypothesis.
Design

- **Independent Variable:** Manipulated factor which YOU set the parameters for
- **Dependent Variable:** Determined variable, if it’s a calculated value include “as measured by...”
- **Controlled variables:**
  List all factors, minimum of 5, which could SIGNIFICANTLY affect your experiment and describe how you have either attempted to control them or how you will be monitoring them. This section highlights your personal input, shows that you didn’t just grab a procedure from a book, so be sure to explain why you made the choices you did. For example, if you used 100mL of water, explain why you chose 100 and not a different volume.

Avoid using the word “same” because that often means you're not thinking it through. For example: “I’m going to use the same beaker” is yuck because (a) the beaker is not really a factor and (b) saying you’re going to use the same one doesn’t show that you put much thought into your design. A better one would be, “Surface area of the beaker- 250mL beaker with a 5cm diameter to keep a consistent surface area” shows that you purposefully selected a beaker.

You MAY want to use the chart below to organize your writing.

*Note: these are great to help you identify sources of error later in the report.*

<table>
<thead>
<tr>
<th>Variable controlled</th>
<th>Why it’s important to control</th>
<th>How this experiment will control or monitor the variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>EX: Moles of acid reacting</td>
<td>In order to study the reaction rate, each trial needs to produce the same amount of product</td>
<td>10mL of 1M HCl will be used for each trial; 10mL of 1M acid is 0.01 moles of HCl ensuring that HCl is always the limiting reactant</td>
</tr>
</tbody>
</table>

This does not have to be in chart form if you prefer to address it in a paragraph.

III. Procedure & Safety

**Materials**
Carefully choose the glassware and instruments that you use to maximize your accuracy (and minimize uncertainties). Describe them with detail (ex: “100mL graduated cylinder” instead of “graduated cylinder”)

**Procedure**
Write for a peer, another student.
Include at least 5 levels of the independent variable, and at least 3 trials at each level; 5 trials is ideal.
Aim for data which will produce a line/scatter graph, not a bar graph if possible.
Note: Think ahead about what your graph will look like and design an experiment which will produce a useful graph.

Diagram
Diagrams always help. Draw or take a picture of the setup for your experiment, not just the materials used. Photos are great, but only useful if they are labeled and against a white background. Be sure to cite any copied diagrams, subtitles are fine.

Safety/Ethical/Environmental Issues
List possible concerns and elaborate on why they are important and how your experiment addresses it (ex: Fumes produced can be damaging to mucus membranes, so experiment must be done in a fume hood; Products can pollute the water system, so must be stored in a waste container)
You can search for safety concerns for the specific materials in your lab here: www.flinnsci.com/msds-search.aspx or in the Flinn catalog.
If you're doing a research-only lab, you can skip this section.

IV. Data Processing

Data Tables (give them meaningful titles)
Include measured/raw data and calculations either together or separate
Label all columns and rows plus give the table a meaningful title. MERGE CELLS!
IF YOU FIND YOURSELF writing a label more than once, merge that baby!
Include all units & uncertainties in the column/row label, not next to each number
Record and report every measured value
Include QUALITATIVE data in or below the table
Report all significant figures (ex: 10.0 instead of 10), which you may need to adjust if using Excel

Calculations
You have to calculate something, average as the absolute minimum, to answer the purpose question.
Show work for 1 sample calculation (you don’t need to show the same calculation multiple times) and clearly label where every number came from. The easiest ways to do that are to provide a word formula (ex: density= mass/volume) or to put reference symbols next to the #s in your data table
If calculations are done with a spreadsheet and/or on a graph, you must discuss how you got the spreadsheet or graph to work (ex: “=B12/2.54” or “insert linear trendline”)
Bio: You need to collect enough data for calculating standard deviation, which would be 5 values for each trial minimum. You also need to include some statistical analysis. A t-test or Chi Square are good ways to use stats to validate your data.

Chem/Physics:
- Make sure your final answers have the correct # of significant figures.
- Include uncertainties on the final answer and
- show your work for the uncertainty.
- And, if possible, find a literature value to compare your results to and calculate %error.

Graphs (give them a meaningful title)
Must have proper labels and titles on the graph- including units
Graph should clearly answer purpose question, so chose the design and data that you include carefully. Include a trendline, $R^2$ and equation if possible so you can discuss the trend in your conclusion.
You may have several graphs, each showing the data in different ways. Consider graphing the data with and without outliers, graph the percent error....

Make sure you have (1) correct sig figs- Chem (2) only processed data (3) error bars (4) independent variable on x axis, dependent on the y-axis

V. Conclusion

Conclusion
Your conclusion is a simple statement that rephrases your purpose question, but inserting the TREND that you see on your graph. Is there a clear relationship? Is it direct or indirect? Linear or exponential?

Justification: (1) discuss the significance of the uncertainties (error bars) and/or statistical data, (2) consistency and actual values of data, (3) % error and/or comparison to literature values if applicable, and, (4) how your result matches theory, the science involved, you laid out in the background & design. You might feel like a broken record repeating some of the same info as before, but you're helping your reader make sense of your data using scientific concepts to bolster their understanding.

As a guide: your conclusion should focus heavily on the graph you made. If not, then you either need to rethink your graph or you’re discussing minutia instead of overall findings

VI. Analysis

Sources of Error and Improvements

Every lab has at least 4 significant sources of systematic error, in other words issues with the procedure, NOT mistakes or instrument issues.
Good words to use: impossible, inconsistent, assume, judgement, unavoidable
Bad words to use: forgot, mistake, possibly, accidentally
For each, explain how the issue would affect your final value (increase, decrease, or both-- but avoid having too many errors which could skew your data both up and down because those are usually weak sources of error)
Consider your qualitative data, controlled variables, any assumptions made during the experiment, and any portion that required human judgment

Address each source of error (if possible) with a suggested improvement- a specific amendment to the procedure. You should also discuss some interesting extensions to your lab either within the chart or separately.
Never say "more time", "better/robotic equipment", "be more careful", or anything along that line

You may use a chart like this, or write this section in paragraph form. Neither format is better, both are accepted equally.

<table>
<thead>
<tr>
<th>Source of Error</th>
<th>How it could skew (increase or decrease the final result)</th>
<th>Suggested Procedural Improvement</th>
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</table>

This does not have to be in chart form if you prefer to address it in a paragraph.

Citations
If you used any sources in your background or conclusion sections, cite them here. Use MLA format.

Good luck! Ask questions if you have them!