Formal LAB REPORT FORMAT
Mrs. Toombs SENIOR CHEMISTRY

General information:

- A lab report is a finished product - NOT a draft
- Lab reports MUST be handed in on the date due, at the BEGINNING of class
- A ruler MUST be used for all straight lines
- A computer generated lab report MUST use a minimum font-point of 12 and must be in black ink
- In Chemistry it is best to use a serif font such as Times – example: **$InCl_3$** *versus* $InCl_3$
- A handwritten report MUST be in dark **blue** or **black** ink or pencil, (avoid difficult to read colours) with graph lines, calculations and diagrams in pencil
- The procedure is always written in the past tense and passive voice
- Include all section headings, even if a particular section will not be fully represented in the write up
- Keep all section headings IN ORDER. If you are restricted by page size limitations (for example, you can not insert the graph mid-page in your report), show the headings in the correct order, and refer the reader to the page / location at which they may locate the next heading in the sequence

Format to be followed:

(pay attention to left margin / right margin / centred placement of headings)

Course	**YOUR first and last name**
Block	**Partner's first and last name(s)**
Unit (specify the topic) covered	**Date (lab was performed**

<u>Title</u> (centred)

Purpose:

- State the reason for doing the experiment and specifically what you are hoping to discover. For example, you may use one of the following:
  To determine...
  To discover...
  To investigate...
  To observe ...

Materials:

- As a rule, you may omit this heading unless you are explicitly told to include it
- Include this section when new / different equipment is used in the experiment

Procedure:

- Be concise, yet detailed
- Write a brief description of what you did in the lab, that would allow a reader to reproduce the entire lab using only your Procedure write-up
- Always use **<u>past tense</u>** and **<u>passive voice</u>**
- May include diagrams *along with* words describing the process
- May be in point form, numbered list form, or full sentences / paragraph structure

Results/Analysis:

Observations

- Describe what was observed / measured throughout the experiment
- In Chemistry include a description of ***before, during and after*** the reaction
- Describe the start, formation, and end materials as if the reader has never seen these chemicals and reactions before

Data Tables

- A table always has borders and grid lines
- In senior Chemistry, include uncertainties, units of measurement and the correct number of significant figures
- Include all numerical data collected, even experimental trials that may be discarded in calculations or conclusions

Graphs

- Must be on ***metric*** graph paper and hand drawn completely in pencil
- Computer-generated exceptions to this rule will be acceptable as long as graphs include:
- Proper titles, subtitles, proper axis labels, legends, best fit lines, units, uncertainties, graph fills the page as much as possible with a suitable scale, slope calculations shown on graph (if applicable)

Calculations

- A representative sample of each type of calculation (you need not show more than one of the same type of calculation)
- Include units and the correct number of significant figures
  (Statistical analysis of uncertainty throughout your calculations is *not required* in this course at this level)

The following sections of the Lab Report often hold the most importance, greatest analytical focus, and highest amount of overall points in the lab evaluation rubric:

Questions

- All answers MUST be in full sentences and must include elaboration to demonstrate your full understanding of the question and your answer!!!

DISCUSSION:

Includes **ALL 3** of the following sections *(that are described in detail on the following pages)*

1) **EXPERIMENTAL SOURCES OF ERROR**
2) **A COMPARISON OF EXPERIMENTAL VALUE TO ACCEPTED VALUE**
3) **DISCUSSION OF RELEVANT THEORY**

Conclusion:

- ***Directly*** answer the purpose in a concise manner.

Example: The boiling point of ethanol was found to be 76.0°C. The accepted value is 78.4°C.

EXPERIMENTAL SOURCES OF ERROR

An introductory explanation of Experimental error – a fact of scientific life

Experimental error is always with us; it is in the nature of the scientific measurement that ***uncertainty*** is associated with every quantitative result. This may be due to inherent limitations in the measuring equipment, or of the measuring *techniques* employed in the procedure, limitations in the experimental procedure, or perhaps lack of experience and skill of the experimenter. However, mistakes made by experimenters do not count as part of the analysis. Students must be careful not to present mistakes or *blunders* when analyzing the quantitative assessment of error.

WHAT NOT TO INCLUDE IN YOUR SOURCES OF ERROR SECTION:

Was it avoidable?

Then do not talk about it in the Sources of Error section. If the mistake could have been avoided, or the step could have been repeated, then you should not be talking about this issue as a way to excuse inaccurate results.

Blunders (Experimenter's mistakes)

Be sure that you are not describing inefficiencies of the experimenter or the use of inappropriate equipment or contaminated glassware (***if this was under your control***).

For example, if the experimenter tries to transfer a liquid from the graduated cylinder to a test tube, and spills the liquid, this is inexperience or lack of skill. The experimenter should start over and re-measure this sample. Mistakes such as dropping a small amount of solid on the balance pan, are not considered Sources of Error in a Scientific Lab Report. This trial, and its corresponding data, is not usable for the final analysis and conclusion of the lab activity. As such, it would not be mentioned as a source of error. Similarly, poor set up does NOT constitute a source of error. (For example: "we forgot to label the beakers and we weren't sure if we were transferring liquid A or liquid B because they looked the same"). Students should **avoid blaming impurity** of chemicals or contamination, as these would likely (except in a few specific cases) be attributed to human error / poor technique.

These examples of errors are often mistakenly considered by students as **Human error** *but they are actually* ***experimental mistakes.***

ACCEPTABLE SOURCES OF ERROR TO LIST AND DISCUSS IN THE REPORT:

Procedural Inadequacies

If the procedure, as laid out in the instructions, might cause inaccurate collection of data, then the student may list these as Sources of Error. In the previous example, where the student was transferring liquid A and B, if the procedure directed this transfer to occur, and it is difficult to complete this step in the timing of the experiment, or with the given glassware, or due to extraneous factors *beyond your control* (example, hot liquid, gas bubbles, type of glassware required in the procedure), then this could lead to questionable data, and these procedural shortcomings should be listed as sources of error.

Errors may originate from observing the system. For example if you have to take a particular reading of a reaction, there will be some judgment in the data you record (eg. time, temperature, volumes). If the experimental products require you to make some inferences or judgements as you collect and record your data, then these are issues that should be discussed in the Sources of Error Section.

Instrumental limitations / UNCERTAINTY

Uncertainties are inherent in any measuring instrument. A ruler, even one as well-made as is technologically possible, has calibrations of finite width. A 25.00 mL pipette might have an uncertainty of ± 0.01 mL if used correctly. Analogue devices such as thermometers, graduated cylinders or pipettes often require the observer to interpolate between graduations on the scale (i.e. make a judgement as to what line to read on the measuring scale). Some people will be better at this than others. A digital balance showing three decimal places can only weigh to within 0.001g by its very nature and even then, it rounds the figures to display those three places. Glassware is usually calibrated for 20^{o}C, for example, and the laboratory may not be at the calibrated temperature. These limitations exist, and it is worth stating the uncertainties, but these should not be the *primary* reason for your experimental result not matching the expected result.

Contaminated glassware, chemicals, or environmental interference

In very specific situations, you may be justified to discuss interactions occurring during the reaction between chemicals that may be in the air, on the table top, in the glassware, or within the chemical solutions themselves. Be VERY careful NOT to blame unclean (poorly-prepared) equipment as this is a HUMAN BLUNDER and constitutes a DO-OVER. Do not make the assumption that every chemical solution that you have been given has the potential to be compromised or inadequately prepared (as this is also a DO-OVER). If it is avoidable, correctable, or the step can be repeated to eliminate the issue, then do not discuss it in the Sources of Error Section.

YOUR SOURCES OF ERROR SECTION must present these three aspects for EACH SOURCE OF ERROR THAT YOU PRESENT.

- **State and Analyze the experimental error**

State the procedural shortcoming or instrumental inadequacy that is affecting the reliability of your data. Remember when assessing possible errors in your experiment, try to determine the importance of any error on your final result and only list and discuss Sources of Error which cause a significant impact on your experimental data, and are not indicative of your own shortcomings, mistakes or inexperience.

- **Analyze the strengths and limitations of your experimental design.**

For each error your present, relate directly to the *exact way in which the data would be affected.* Be very specific as to what aspect of the results or conclusion would be biased.

- **Suggest a way to overcome this Source of Error (in the assumption that the research or experiment was to be repeated or improved).**

If the flaws result from the experimental design, **explain how the design might be improved.**
If the flaws result from the judgement of the data readings, **explain how the repeated experiment might be repeated with a higher chance of success, if possible.**
If the flaws result from the conditions in which the experiment were carried out, then discuss why this error could not be avoided.

A COMPARISON OF EXPERIMENTAL VALUE TO ACCEPTED VALUE

This section is ONLY included when there is a known, accepted (standard) answer that experimental results can be compared to:

Percent error: $\frac{|\text{experimental result} - \text{accepted value}|}{\text{accepted value}} \times 100$

In some cases, it is legitimate to compare outcomes with classmates, to look for any anomalies between the groups and discuss those:

Percent deviation: $\frac{|\text{student } or \text{ group result} - \text{average class value}|}{\text{average class value}} \times 100$

If a mathematical calculation is not applicable, the comparison may be discussed in paragraph form instead.

In some lab experiments, this section will not be applicable.

DISCUSSION OF RELEVANT THEORY

At this level you are required to give a minimum of two or three appropriate theories or concepts related to the experiment. This will be a cohesive paragraph / short essay format, presenting the relevant theory / scientific concepts that are directly related to this experiment. The **Discussion** is the most important part of your report, because here, you show that you understand the experiment beyond the simple level of completing it.
Some people like to think of this as the "subjective" part of the report. This means you are elaborating on what is not readily observable. This part of the lab focuses on a question of ***understanding the significance or meaning of your results.***

Explain the theory as a frame of reference for the data that has just been presented. Often Science labs are intended to illustrate important scientific laws, theories or concepts. This is a paragraph introducing readers to the concepts that are inherently required to understand this experiment's purpose, results and conclusion.

Analyze how well the related theory has been illustrated in this experiment / with these results. Explain your results in terms of theoretical issues and relate your results to your experimental objective(s). What do the results indicate clearly? Explain what you know with certainty based on your results, and draw conclusions:

Interpret. What is the significance of the results? What ambiguities exist? What questions might we raise? Find logical explanations for problems in the data.

A SAMPLE RELEVANT THEORY SECTION.

(For your purposes, the three parts have been separated so that you can understand how to complete each aspect, but you should present your RELEVANT THEORY in a cohesive paragraph or short essay format.)

Explanation of Theory
Sulphide-induced corrosion occurs when sulphide in the water, most likely as HS^- *ions, greatly accelerate the corrosion of copper by acting as a catalyst for both the anodic and cathodic reactions. Corrosion is a reaction in which... A catalyst is defined as... An anode is...* HS^- *ions would originate from... (etc) (continue to elaborate on the meaning of concepts here)*
Analysis
Since none of the samples reacted to the Silver foil test, therefore sulphide, if present at all, does not exceed a concentration of approximately 0.025 g/l. It is therefore unlikely that the water main pipe break was the result of sulphide-induced corrosion.
Interpretation
Although the water samples were received on 14 August 2000, testing could not be started until 10 September 2000. It is normally desirably to test as quickly as possible after sampling in order to avoid potential sample contamination. The effect of the delay may have caused unexpected redox reactions to occur. A redox reaction is one in which…

AVOID phrasing such as:

"We are learning about this in the lab because…"
"The relevant concepts of this lab include…"