Southwestern University

Guide for Writing in Chemistry

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About Writing in Chemistry

Scientific discovery depends as much on the development of innovative ideas as it does on a scientist's ability to communicate those ideas within the scientific community and to the public as a whole. The most important scientific discoveries can be set back decades if the results are not disseminated in an accurate and concise manner. This guide will give you the foundation for organizing and writing a clear paper in the field of chemistry.

The major goal of a scientific paper is not to simply articulate the work that has been conducted but to explain the scientific process behind the research. In a way, the science author is a storyteller, narrating an internal dialog that resulted in the ultimate findings. Therefore, a paper written for a chemistry class should explicate all steps of the scientific method.

The Scientific Method

1. Formulate a Question

It is important to articulate the fundamental scientific question that the research addresses.

Ex: Is the dissolution of ammonium chloride in water an endothermic or exothermic process?

2. Conduct Background Research

Determine what work has been done to address this question and confirm that the research is unique.

Ex: It has been shown that the dissolution of sodium chloride in water is an exothermic process.

About this guide

This guide contains the following sections:

The Disciplinary Writing Guides are designed to provide an introduction to the conventions, or rules, of writing in different subjects. These guides have been designed by Southwestern professors to help you understand what will be expected of you in your classes.

3. Construct a Hypothesis

Predict what will happen based on the background research collected.

Ex: The dissolution of ammonium chloride will be an exothermic process.

4. Experiment and Analyze Data

Develop procedures to test the hypothesis and analyze the experiments.

Ex: When ammonium chloride was added to water, the temperature of the water decreased from 23 °C to 10 °C.

5. Form a Conclusion

Determine the accuracy of the hypothesis and draw any additional conclusions from the data.

Ex: Because the temperature of the water decreased when ammonium chloride was added, the hypothesis was incorrect and the dissolution was endothermic.

Types of Writing in Chemistry

There are three types of documents that are commonly produced by chemists. All three types of writing follow the same standard guidelines but require slightly different sections. Students majoring in chemistry and biochemistry will have the opportunity to write all three types of papers.

Literature Review

A literature review summarizes research published by other authors focused on a common topics. Occasionally, authors will publish a review of a large body of their own work done over an extended period of time, called an **account**. Both of these types of papers focus on research that has already been published and rigorously documented. As a result, no experimental data is included in a literature review. Southwestern students will develop a literature review during their junior year Chemistry Literature class.

Research Proposal

A research proposal describes research that the author intends to complete, often with the intention of gaining funding or employment. These papers include an extensive literature review section to support the proposal as well as original ideas to further expand the field. Southwestern students will develop a research proposal their senior year if they elect to enroll in a literature capstone.

Research Paper

A research paper is the most important type of writing in chemistry and comprises the bulk of primary literature in the discipline. Research papers afford the author the opportunity to communicate original research conducted in the laboratory, rigorously documenting the results. Most laboratory reports are shortened versions of this type of writing. If Southwestern students elect to enroll in a research capstone, they will present their original research their senior year.

Writing the Chemistry Research Paper

Generally, research reports in chemistry are separated into four sections that help the reader follow the "chemical story" that the author is trying to convey. These sections can be loosely associated with the five steps of the scientific method and can assist an author in confirming that they have fully explained their research.

1. Introduction

This section incorporates the first three steps in the scientific method. Begin by formulating a question and painting a broader picture of the importance of the research that was conducted. For example, if your research was on the antioxidant potential of extracts from basil herbs, you may want to begin with a short explanation of the uses of basil as a medicinal herb and the importance of antioxidants to decrease free radical chemistry in the body. This informs the reader as to why basil extracts were chosen for the study and alludes to the importance of the research with regards to public health.

The introduction should continue with a short, rigorously cited literature review of work that has already been done either by the author or others. This further indicates the importance of the research in broadening the understanding of the specific field. From this background research, the question the paper is addressing can be more explicitly stated.

Finally, a hypothesis should be stated indicating the intention of the research. **In a way, the hypothesis is the "topic sentence" of the research paper.** The remainder of the manuscript serves to lay out data that supports the hypothesis.

2. Results and Discussion

This section, usually the longest, describes the work that the author has done and the results that have been obtained. While the necessary data presented in this section varies between the chemical disciplines, it is important to remember that this section is **not** simply a technical description of procedures. Instead, it is a narrative that continues the introduction, explaining the progress of research that eventually leads to the final results. For example, if you used HPLC to analyze the components of basil extracts, the specific solvent conditions should not be elaborated. Instead, the results of the HPLC should be described.

Below are a few questions designed to help you shape your analysis.

- Did the experiments work? What sort of explanation can be offered for this success or failure?
- How were shortcomings in the initial experimental strategy overcome?
- What fundamental chemical principles are demonstrated by the results?
- Are these results consistent with previously reported experiments?
- What other experiments can be conducted to either prove or disprove this analysis?

3. Conclusion

In this section, the author summarizes the main purpose of the report and determines if the original hypothesis was confirmed or denied. The importance of the work presented should be re-emphasized. Finally, future work should be described.

4. Experimental

This final section is often separate from the narrative portion of the paper (occasionally it appears in an independent document called "Supplemental Information"). It constitutes the raw data and in-depth experimental procedures that support the results and discussion section. Different disciplines require different types of analysis, but the following data should be included if applicable: NMR data and spectra, HPLC conditions and traces, IR data, mass spectrometry data, gel electrophoresis, and x-ray crystallography.

Conventions of Writing in Chemistry

The development of modern chemistry occurred during the 19th century, predominantly in Germany. As a result, most of the great historical advances in the chemical sciences before 1950 were communicated in German. Because style conventions reflect this history, chemistry is always written in the third person passive voice. Pronouns such as "I," "we," and "us" should never be used when writing a chemistry paper.

Incorrect Example: If we had analyzed lemongrass extracts instead of basil, we would have likely found a lower number of polyphenolic antioxidants.

Correct Example: If lemongrass extracts were analyzed instead of basil, a lower number of polyphenolic antioxidants would be expected.

It is also important to be as succinct as possible while describing chemical processes and phenomenon. Flowery language should be avoided in favor of clear analysis. Exhaustive descriptions of techniques that are considered "standard practice" can also be omitted.

Incorrect Example: Distillation fractions three and four were combined in a 100 mL round bottom flask. To this flask was added 1.966 g (0.0114 mol) of benzoic acid. The flask was then connected to a long column, distilling head, and condenser. Glass-wool and foil was again wrapped around the column and distilling head.

Correct Example: In a 100 mL round bottom flask equipped with a condenser and distilling head, 1.966 g (0.0114 mol) of benzoic acid was added to the combined third and fourth fractions.

Citation and Formatting

Citations

Citations should be written in American Chemical Society (ACS) format. Different journals and disciplines have different preferences for using footnotes versus endnotes, but notes always should be annotated with superscripts.[1] (To make a footnote in Word, go to "References" and choose "Insert Footnote.") Most of the references you will be citing will be journal articles/communications. Below is the format for a journal article:

> 1st author last, first initials; 2nd author last, first initials; etc. *Journal Abbreviation* **year**, *volume*, first page number–last page number.

Note the punctuation and style of each part.
The page numbers should have an en-dash between the numbers and not a hyphen (– vs -).

> *Example:* Gesinski, M. R.; Rychnovsky, S. D. *J. Am. Chem. Soc.* **2011**, *133*, 9727–9729.

For more information, the American Chemical Society Style Guide can be accessed online through the website of ACS Publications. A quick guide to ACS style is also available through the "Student Resources" website of the Debby Ellis Writing Center.

ChemDraw

All chemical structures should be drawn with ChemDraw, which is available for free from Southwestern. (To format your drawings, go to "File" then "Apply Document Settings from" and select "ACS Document 1996". This will set the drawing ratios to the standard for ACS documents.)

All drawings should be reduced to 80% of normal size. (To do this, highlights your drawings and right click. Select "Scale" and then "Scale by" 80%. Select the radial button to "Scale Atom Labels and Settings.")

It is important that your drawings are neat and organized. All bond angles should be exactly 60° unless that is not possible based on the structure. All arrows should be completely aligned with the center of the structures and should be distributed correctly. (Both "Align" and "Distribute" commands appear beneath the "Object" menu.)

Symbols and Punctuation

Below are some common symbols and punctuation that should be used in proper chemical writing. Since Microsoft Word provides every symbol that one could want, shortcuts are not acceptable:

Temperature: –78 °C	En-dash indicates a negative sign with a space between the number and the °.

[1] Your references would go down here.

Ratios: 98:2	No space should go before or after the colon; normalized to 100.
Yield: 95%	No space should go before the percent sign.
Joining names: Diels–Alder	En-dash adjoins the names of different people.
Melting point: 65–67 °C	Melting points should always be a range, so an en-dash is used.
Weight: 0.073 g	Always use a leading zero if a number is less than one. There is always a space between the number and units.
Micromoles: 13.2 μmol	Use a symbol for the Greek letter mu.
Naming: (2*R*,3*S*)-Dimethyl. . . (*E*)-2-butene *N*-methylmorpholine *N*-oxide	*R, S*, *E*, *Z*, and atom symbols are always italicized.
Common abbreviations	h: hour(s) min: minute(s) equiv: equivalents eq: equation mmol: millimoles calcd: calculated
Words that are never abbreviated	saturated quantitative aqueous powdered

A Few Common Errors to Avoid

Below are a few additional tips that often present problems for students:

1) Verb tense: Papers should maintain the same verb tense throughout. Past tense is generally preferred, but occasionally present tense is appropriate.

2) Subject/verb agreement: Both the subject and the verb of a sentence should either be singular ("the **amide was** reactive") or plural ("the **amide and amine were** reactive"). A subject that describes a collection is a common pitfall ("the **mixture** of amides and amines **was** reactive"; "mixture" is a singular noun).

3) Verb usage: Use of "to be" as the main verb in a sentence is generally thought of as weak, since no active verbs are required. Sentences starting with "There is" should be avoided. For example:

Incorrect Example: There is no analysis of the antioxidant potential of basil extracts.
Correct Example: Basil extracts have not been analyzed for their antioxidant potential.

4) Extraneous words: Common modifiers such as "surprisingly" and "interestingly" add very little to text. Additionally, the adverb "very" should be avoided.

5) Qualifications: Qualitative words such as "excellent," "moderate," and "poor" are descriptive but subjective. They are better replaced with more precise quantitative descriptors.

6) Colloquial expressions: Expressions that might be completely acceptable while communicating verbally should be replaced with more formal language. One common example is the use of the word "reacted" as a verb: "The alkene was reacted with bromine." The word "treated" can often be substituted for "reacted" to make writing in chemistry more formal. In certain situations sentence structure can be overused, so it is useful to have an arsenal of active verbs to employ when writing a formal report. It is also important to note that operations are not performed on a reaction. Instead, "reaction mixtures" are "concentrated," "heated," "filtered," etc.

7) Contractions: They are never appropriate in formal writing.

8) Imprecise sentence subjects: "This" should not be used as the subject of the sentence. Instead, specify what "this" is: "this reaction," "this result," and "this compound" are all acceptable sentence subjects.

9) Numbers: Numbers less than or equal to twelve are usually written out (13 is not).