This handout is provided to help with report preparation. The ability to communicate in a written report is an important part of scientific investigation. The lack of this ability is a common complaint of industrial employers. Improvement in organization and writing skills should be a common goal.

As a “Writing Intensive” course at WSU, a minimum requirement is 18 pages of double spaced text in writing assignments. It is expected that the full laboratory reports will be from 6 to 10 pages in length for text only plus additional pages for figures. Additional post-lab assignments will add to this total so that the minimum writing requirement is attained. A separate “Pass/Fail” WI grade is required of the instructor of this course by the registrar. Students who do not reach the minimum writing requirement with satisfactory results will not receive a “Pass” grade for the WI portion of the course.

1. Review SGN’s chapter 1 and the syllabus. You must include seven sections in full reports: Abstract, Introduction, Experimental Method, Results, Discussion, References, and Sample Calculations. Figures should be presented either one or two to a page, and placed either (i) on the first page after mention of the figure or (ii) all together after the references.

2. Be CONCISE! "More" is not necessarily always better. Edit your report. Use proper grammar and spelling. Repeated grammatical mistakes and misspellings will result in grade reductions. (A translation will be provided if necessary.) Sentences that do not make sense (and non-sentences) will result in grade reductions. Edit your reports or have a friend read them for mistakes. Attend the workshops on grammar and sentence structure skills offered by the Writing Center if you need help, and take advantage of their reviewing services. Provide uncertainties for numerical values and use correct units.

3. Remember that the abstract is to be a distillation of the essence of the experiment. The abstract may be all that one reads to determine if a paper appears to be interesting or pertinent to their research or topic. Your reader should be able to read the abstract and gain a reasonable understanding of the method, the results, and the implications of the results. It is quite a challenge to do this in a concise manner. Include numerical results (units & uncertainties) in text format. Tables and figures should not be included in this section. Read some abstracts in the literature; it may help you (but note that there are some very poor ones written there also).

4. The introduction should "introduce" the reader to the important chemical concepts to be encountered in the experiment and include a short review of pertinent theories if applicable. Number equations as they are developed so that you may refer to "Eq. (3)", etc. Symbols used in equations should be defined for the reader. The tendency for many students is to assume too much knowledge on the part of the reader and to leave out important information in this section. Your target audience for these reports should be next year's group of CHM 458 students. What information would you like to have included here if the report were your first introduction to this topic?

5. The experimental method section should state briefly the main points of the method and give a reference for the technique. This reference is most likely to be the course text. Citing reference to Dr. Dolson's handouts is not very useful since they are not published. Consequently, deviations from the referenced procedure should be stated. These may be distilled from the handouts. A sketch of the apparatus is sometimes appropriate.
6. The results section is to be text, primarily, in order to communicate your results to your reader. Use graphs and tables as is appropriate; number these for reference in the text. For some data, such as Temperature vs. Time curves for the calorimetry experiment, only a representative sample of the raw data should be provided (don't provide every curve obtained). Think carefully how data should be presented in graphs and tables. It is a good idea to scale graphs so that the data "fill up" the figure. Often information can be combined into a small number of tables. At times literature values could be included in the tables.

Text is very important to aid the reader through all of the data reported in the results section. All tables and graphs should have titles. In the tables always include UNITS and UNCERTAINTIES (BE REALISTIC ABOUT UNCERTAINTIES - MOST STUDENTS TEND TO UNDERESTIMATE THESE VALUES). It is really bad form to report more "significant" figures than allowed by the stated uncertainty - for example: \( d = 1.10169 \pm 0.00325 \text{ g cm}^{-3} \) would be stated better as \( d = 1.102 \pm 0.003 \text{ g cm}^{-3} \) or sometimes as \( d = 1.1017 \pm 0.0033 \text{ g cm}^{-3} \). If one digit is uncertain, how can the next digit have much meaning?

7. Discuss your results as they relate to the expectations of theories presented in the introduction section, and as they compare to literature results. Within the stated uncertainties of your measurements, are your results in agreement with literature values or theoretical expectations? When analyzing results in the discussion section, avoid useless statements such as "several sources of errors were possible in this experiment". Be specific and quantitative as to the sources of errors! Are they random or systematic? What is the magnitude of the error? What is the combined effect upon the end result?

Some representative examples of useless statements without a quantitative reference are:
"... a possible reason (for inconsistent values, compared to literature values) for this could have been sample impurities or inaccurate measurements." - How might this affect results? Estimate the magnitude.

One of my favorite nebulous statements is:
"... (any measured value) is off due to ..." - what does "off" mean? We may say this in informal speaking, but it should not appear in a report.

and, a close runner-up:
"There were many sources of error in this experiment." - Identity? Effect? Magnitude?

When you address the topic of errors and uncertainties in your measurements, BE QUANTITATIVE !!! Even if you can only estimate the magnitude of the uncertainty, it is better to be too high or low with your assessment of the uncertainty than to omit it altogether. When several determinations of a value are performed, a standard deviation can be calculated and used as a reasonable uncertainty. When a value is determined from several other measured parameters, the propagated uncertainty in the final value is dependent upon the relative uncertainties of the measured parameters. Review chapter 2 of GNS (pp 52-59 have some useful equations and examples) for methods to determine the effect of propagation of errors.

If you will follow these guidelines, your reports will be more professionally constructed and your message is more likely to be communicated to your reader. The end result is a happier grader today and a happier employer tomorrow.

One final word (well, three): CONCISE, COMPLETE, CONCISE!
Some Overall Guidelines

Your paper must…

- have 1 inch margins,
- be typed with 10 or 12-pt. Arial, Times New Roman, or similar font (something easily readable),
- have justified paragraphs (even edges on both sides),
- have page numbers at the bottom center of each page starting on the first page,
- be double-spaced,
- have a title bold and centered on the top of the first page with your name centered below it (leave off the name for the rough draft),
- have a separate works cited page with your references (minimum 3) listed,
- and have all figures, tables, and schemes with captions on separate pages after the works cited page.

Symbols and Chemical Structures

Symbols (°, ×, ≡, ±, etc.) should be included using the appropriate symbol font. Symbols and abbreviations must be defined the first time they are used unless their meaning is accepted as fact (NIST should be defined but ± does not need to be). Do not write out the meaning of a symbol (degrees C instead of °C) just because you can’t find it or do not know how. Be sure to use subscripts and superscripts properly as well.

Equations, Figures, and Tables

Equations, figures, and tables should be numbered sequentially, e.g., Figure 1, Figure 2, etc. as they appear in the text and should be referred to by their numbers. Each figure and table should have a caption that the reader can understand without reading the text of the paper. Figure captions are positioned below the figure while table captions are found above the table. You must always reference a figure or table if obtained from one of your sources (i.e., it is not your original work). Complex equations should be separated from the text on a new line (only one equation on each line) and labeled as (1), (2), etc. to the right of the equation (with an additional 0.5 inch indentation on both sides). Equations do not need captions but each variable needs to be defined and its units given when encountered for the first time. You should use an equation editor such as Equation Editor provided with Word.
The Ten Commandments of the Introduction Section

☐ Thou Shalt Establish the Research Area – The first sentence should be intentionally broad to tell the reader the overall field of interest.

☐ Thou Shalt Establish Importance – Many themes are human health and/or environmental impact

☐ Thou Shalt Provide Relevant Earlier Results – Keep it short, but give relevant results from other works.

☐ Thou Shalt Find the Gap – Identify where the gap in the existing knowledge lies.

☐ Thou Shalt Fill the Gap – AFTER you review previous work AND you identify the gap, you may establish what your work will contribute to the “gap filling” to come.

☐ Thou Shalt Not Quote or Plagiarize – Learn how to paraphrase: read a paper; take notes; summarize your notes; check your summary; add a citation.

☐ Thou Shalt Focus on the Science – Don’t use authors’ names in citations, this takes away from the importance of the science.

☐ Thou Shalt Not “See Spot Run” – Effectively use commas, semi-colons, and colons to create more concise and fluent complex sentences that can convey ideas more effectively.

☐ Thou Shalt Use Linkages – Effectively use phrases and conjunctions to create more fluent, meaningful, and emphatic sentences.

☐ Thou Shalt Setup the Paper – A well-written Introduction will setup the rest of the paper by establishing the questions that the Methods & Materials, Results, and especially Discussion sections will answer.
The Ten Commandments of the Materials and Methods Section

 Thou Shalt Not Write Instructions – You are writing for an Audience of Chemists.

 Thou Shalt Follow the Proper Move Structure – I. Describe Materials; II. Describe Experimental Methods (Instrumentation and Procedures); III. Describe Numerical Methods (Statistical and Computational).

 Thou Shalt Give the Source and Quality of the Key Chemicals – Abbreviate and Capitalize Appropriately.

 Thou Shalt Describe the Instrumentation – Include Manufacturer, Model, and Parameters if Appropriate.

 Thou Shalt Describe the Procedures – Convey Order of Events (Avoid “First...Next”, etc.) and Use Appropriate Numbers and Units.

 Thou Shalt Describe the Numerical Methods – Report Statistical Analyses and/or Computational Analyses Including Software Name and Version If Necessary.

 Thou Shalt Use Past Tense – Use Present Tense only when Describing Properties of Chemicals or Equipment.

 Thou Shalt Use Passive Voice – Use Active Voice only when a Part of the Procedure is the Subject of the Sentence.

 Thou Shalt Not Use Quotations – It is Not Necessary to Quote Specific Pieces of a Reference in the Methods But You Can Refer to a Reference From Which You Adapted the Procedure.

 Thou Shalt Avoid Referring to “This” Project, Experiment, Paper, etc. – It is Only Appropriate When You are Referring to Work Done in Another Paper.
The Ten Commandments of the Results Section

☐ Thou Shalt Describe Your Results not Interpret Them – Ask yourself “What did I find?” not “What do my findings mean?”

☐ Thou Shalt Follow the Proper Move Structure – I. Briefly restate project goal and methods; II. Identify important results, describe trends, and highlight unexpected results.

☐ Thou Shalt Use Equations, Figures, Tables, and Schemes Only When Appropriate – If you include an equation, figure, etc. you must refer to it in the text and sequential reference numbers.

☐ Thou Shalt Produce Pretty Equations – Use Equation Editor, indent the equation 0.5” from the left margin, and give a numerical caption (i.e., (1), (2), etc.) indented 0.5” from the right margin.

☐ Thou Shalt Produce Pretty Figures – Use Excel and give a bolded caption title (i.e., Figure 1, Figure 2, etc.) and non-bolded caption text left-aligned under the figure.

☐ Thou Shalt Produce Pretty Tables – Use Word and give a bolded caption title (i.e., Table 1, Table 2, etc.) and non-bolded caption text left-aligned above the table.

☐ Thou Shalt Produce Pretty Schemes – Use ChemDraw and give a bolded caption title (i.e., Scheme 1, Scheme 2, etc. and brief non-bolded caption text left-aligned above the scheme.

☐ Thou Shalt Place Equations within the Text and Figures, Tables, and Schemes in a Section at the End of the Paper – Each on a separate page with its own caption.

☐ Thou Shalt Use Appropriate Combinations of Tense and Voice – Past-Active to describe specific results, Past-Passive to describe specific steps, Present-Active to state scientific “truths,” and either Present-Active or Present-Passive to refer to equations, figures, etc.

☐ Thou Shalt Use Appropriate Word Choices – Avoid the use of personal pronouns, use respectively correctly, use precise/quantitative language, and use appropriate pluralization.
THE FIVE COMMANDMENTS OF THE DISCUSSION SECTION

☐ Thou Shalt Interpret Your Results – Ask yourself “What do my findings mean?” and do not stray from relevant interpretations.

☐ Thou Shalt Suggest the Broader Implications of Your Results – Ask yourself “How do my findings apply to the ‘real world’?” and do not stray from relevant applications.

☐ Thou Shalt Follow the Proper Move Structure – I. Briefly restate important results; II. Interpret important results; III. Summarize the entire study; IV. Suggest greater, more general implications of results.

☐ Thou Shalt Use Appropriate Combinations of Tense and Voice – These are the same as for the Results section but also includes Present-Active for interpretations of results.

☐ Thou Shalt Not use “Fact,” “Truth,” or “Prove” – You cannot be as absolute as these words suggest, use hedging works such as “evidence,” “theory,” or “suggest.”