**CHM3915** **Spring 2007**

**Thermocouple lab report guidelines**

Below is a rough outline to assist you in writing your first lab report – you might use this as a checklist of the main points to include. This is only intended as a guide and is by no means a complete summary, but you should try to address all of the points summarized below – use this along with the "Hints for Writing a Good Lab Report" handout and the notes on the "Course Goals and Structure" handout that you were given on the first day and read the experimental handout carefully to be sure that you have addressed all the points asked for in there. The various subsections (A, B, C…) given under each main section are just for clarity and you should not split up your report in this way. Also note that although this guide focuses on the thermocouple experiment, it can be used as a rough guide for future lab reports, too. For this reason, some of the subsections may not be strictly applicable to the thermocouple report (e.g. the Instrumental Readout/Spectra section).

ABSTRACT

A. EXPERIMENTAL PURPOSE AND TECHNIQUE
   1. Used a copper-constantan thermocouple to find the relationship between emf and temperature.
   2. Examined both first- and second-order least squares fits.
   3. Examined necessity for reference thermocouple.

B. PRINCIPAL EXPERIMENTAL RESULTS WITH UNCERTAINTIES
   1. Deviation between experimental and literature results.
   2. Are the values within the uncertainties?
   3. First and second order coefficients and uncertainties.

C. MAJOR CONCLUSIONS
   1. First-order fit valid *or* second-order fit valid *or* neither fit valid.
   2. Is a reference thermocouple required?

I. INTRODUCTION

A. PURPOSE OF THE EXPERIMENT
   1. To calibrate a copper-constantan thermocouple.
   2. To find a relationship between emf and temperature.
   3. To evaluate the validity of a mathematical model.

B. KIND OF INFORMATION GAINED
   1. Emf produced for various junction temperature combinations.

C. HOW INFORMATION IS OBTAINED
   1. Constant temperature baths which utilized two phase equilibrium conditions.

D. BRIEF DESCRIPTION OF THE THEORETICAL MODEL(S) THAT RELATE THE DATA TO THE RESULTS **INCLUDING ALL IMPORTANT EQUATIONS**
   1. First- and second-order least squares analysis with relevant equation.
   2. Reference thermocouple.
   3. Show important and nonobvious equations used.
   4. Number each equation (mathematical or chemical) in the margin.
   5. Do not waste time and space on trivial equations and calculations.
   6. Reference detailed derivations of mathematical relationships when possible rather than using space in your report to repeat them.
   7. Refer to and discuss in text by equation number.

E. HOW INFORMATION IS USEFUL
   1. Thermocouples are a useful means of measuring temperature accurately.
   2. Allows determination of an unknown temperature.

II. EXPERIMENTAL

A. APPARATUS
   1. Copper-constantan thermocouple material and construction.
   2. Fluke digital multimeter, model 8860 A
   3. Constant temperature baths (Dewar flasks and contents)

B. REAGENTS
   1. Give source and grade of each reagent.

C. METHOD
   1. Give mainly as a reference to handout or book, but note in detail any changes to the published procedure.

D. BLOCK DIAGRAMS
   1. Draw (by hand or computer), Xerox, and/or cut and paste. You can white out any unwanted material; add needed additions and corrections.
   2. Label with figure number and caption.
   3. Make it attractive.
   4. Refer and discuss in text by its figure number.
   5. See the "ACS Style Guide" pp. 281-297 for format for illustrations (figures).

III. DATA

Begin this section with written text which introduces the reader to:

A. INSTRUMENTAL READOUT/SPECTRA
   1. Label with figure number and caption.
   2. Refer to and discuss in text by its figure number.
   3. All tables and figures can be either included in the body of the lab report or in appendices at the end of the report but please do not mix formats.

B. DATA TABLES
   1. Clearly label columns and rows, give units and precision (if no statistical analysis) of entries.
   2. Label with table number and heading.
   3. Reference any data supplied to you. See sample table in “Course Structure and Goals” handout.
   4. Refer to and discuss in text by table number.
   5. See the "ACS Style Guide" pp. 300-304 for format for tables.

IV. CALCULATIONS, PRECISION LIMITS AND RESULTS

Begin this section with written text that introduces the reader to:

A. EQUATION(S) AND NUMERICAL SET-UP(S)
   1. Clearly show sample calculations and the final values obtained, referring by number to equations in the Introduction. (Hand-written sample calculations are perfectly acceptable as long as they are clearly legible.)
   2. Introduce any additional equations (mathematical or chemical) and number them in the margin. Continue the equation numbering from where you left off in the Introduction.

B. PRECISION LIMITS BASED ON PROPAGATION OF ERROR OR APPROPRIATE STATISTICS
   1. Clearly show sample calculations and the final values obtained.
   2. Number each equation in the margin.
   3. Refer to and discuss in text by equation number.
   4. Clearly explain sources used for error estimates and the confidence level.

C. TABULATED SUMMARIES OF REDUNDANT CALCULATIONS
   1. Only one sample calculation of each type is required.
   2. See III. B.

D. TABLE OF FINAL RESULTS
   1. SEE III. B.

2. Include precision limits and correct number of significant figures.
3. Report literature values and give percent deviation.
4. Use footnote(s) to identify bibliographical reference(s) of literature source. See sample table in "Course Structure and Goals" handout.

E. GRAPHS
1. Use Excel or a similar software package to draw graphs.
2. Show axes with labels, magnitudes and units.
3. Show error bars when applicable. If they are so small that they do not show up, mention this in the text.
4. Label graphs with figure number and caption.
5. Refer to and discuss in text by its figure number.
6. See the "ACS Style Guide" pp. 281-297 for format for graphs (figures).

## VI. DISCUSSION

A. RESULTS VS. GOALS OF THE EXPERIMENT
1. Critically discuss the meaning of the results as compared with the goals of the experiment. That is, which model(s) relating emf to temperature for the copper-constantan thermocouple is(are) satisfactory, if any. Give the reasons for your choosing or not choosing a model.
2. Discuss possible sources of uncertainties (e.g. uncertainty in temperature, uncertainty in measured values, how assumptions and limitations affected results).
3. Critically discuss the success or failure of the experiment.

B. DEVIATIONS FROM LITERATURE OR EXPECTED VALUES
1. Compare your results with the literature results. Are the two sets of results within the quoted precision limits?
2. Discuss possible reasons for any observed discrepancies i.e. try to identify sources of error in your data collection or manipulation.

C. SUGGESTED IMPROVEMENTS OF THE EXPERIMENT
1. Suggest alterations in specific procedures for the experiment that should improve the results.
2. Suggest totally different ways to accomplish the goals set.

## VII. REFERENCES

A. REFERENCE SECTION
1. Add a separate References section to the end of your report.
2. Each reference should be numbered and referred to by number in the text. Do not list the same reference more than once in the References section. This can be accomplished by using the "Insert Endnote" and Insert Cross Reference" functions in MSWord.

B. ACS FORMAT
1. See handout or the "ACS Style Guide" pp. 173-229 for format.
2. Reference numbers in text can be shown as numbers in parentheses or as superscripts.
   a. ... in the literature (2,5,8)
   b. ... as shown by Shoemaker, *et al.*[2-5,15]