PHYSICAL CHEMISTRY LABORATORY

mtu Home Page  Chemistry Home Page  Organic Lab Home Page  Instruments  Summer Youth Program

WELCOME to the MTU Physical Chemistry Laboratory Web pages. The P. Chem. laboratory is located in Room 706 of MTU's Chemical Science and Engineering Building.

Feel free to browse these pages or contact the lab supervisor, lab advisor, or a lab teaching assistants for additional information regarding this course.

LAB SUPERVISOR
Ms. Kelley M. Smith, ChemSci 706C, 906/370-7401, kmsmith@mtu.edu, OFFICE HOURS: 9a-12n & 2-4p Tuesday, 9-12n Thursday, or by appointment.

LAB ADVISORS
CH3511
Professor Richard E. Brown, ChemSci 702, 906/487-2383, rebrown@mtu.edu

CH3521
Professor Bahne C. Cornilsen, ChemSci 706A, 906/487-2295, bccoril@mtu.edu
Professor Richard E. Brown, ChemSci 702, 906/487-2383, rebrown@mtu.edu

TEACHING ASSISTANTS, OFFICE HOURS: By Appointment

Ming Niung, mnian@mtu.edu, ChemSci 609
Matt Reuter, mpreuter@mtu.edu, ChemSci 717
Xin Bai, xbai@mtu.edu, ChemSci 704

COURSE INFORMATION

INTRODUCTION/COURSE OBJECTIVES
LAB SCHEDULE (Times, Census, etc.)
EXPERIMENT SCHEDULE
* CH3511
* CH3521
REPORT GRADING AND FORMATTING
QUANTITATIVE METHODS
* Outline
* Videos
ERROR/DATA ANALYSIS
LAB SCORES
* CH3511
* CH3521, Spring 2005
LAB SAFETY RULES
ACKNOWLEDGEMENTS

EXPERIMENTS

NOTE: References to the 5th Ed. of Levine's Physical Chemistry follow each experiment in brackets [ ].

CH3511

1. Energy of Combustion of Breakfast Cereals [Sec. 2.3-2.6 (pp. 44–53) & Sec. 5.4 (pp. 144-151)]
   Part 1425 Operation Manual
2. Entropy of Mixing from EMF Measurements [Sec.9.3 (pp. 258-258) & Chap. 14 (sec. 1-6)]
3. Iodine, Iodide, Triiodide Equilibria [Sec. 11.1-11.4 (pp. 319-328)]
   Spectrometer Operation Instructions, Calculation program for E
4. Vapor Pressures of a Volatile Liquid [Sec. 7.3 (pp. 212-219)]
   Volatile Liquid: 2-propanol
5. Molar Volumes in Aqueous Solutions [Sec. 9.4-9.6 (pp. 258-268)]
   Solute: 1-propanoll
6. Chemical Kinetics: Study of the Iodide-Persulfate Reaction [Sec. 17.1-17.5, 17.8 (pp. 528 -545, 554-559 ]
   Spectrometer Operation Instructions (Time Acquisition Mode)

CH3521

Particle in a One-Dimensional Box [Sec. 18.8, pp. 614-617]

HyperChem Exercises

- IMPORTANT COMPUTER USAGE/SCHEDULING INFORMATION
- TUTORIAL INFORMATION (To be completed prior to beginning of the exercises that follow)

1. A Conformational Search on the C₃X₂H₆ Molecule Using Quenched Molecular Dynamics: a) Background
   b) Experiment
   c) Qdynam.txt,
   d) Subdynam.txt
2. Heat of Formation of a First-Row Compound by Ab Initio Quantum Mechanical Methods: a) Background
   b) Experiment
3. The Vibrational Spectrum of a Polyatomic Molecule
4. Final Experiment: TBA

Access to these files (*.pdf) requires the installation of Adobe Acrobat Reader.

This web page was last edited on 1/8/04. Please contact Kelley M. Smith if you have any questions or comments about the materials found on this page or any pages linked to it.
## PHYSICAL CHEMISTRY LABORATORY I

**CH3511 EXPERIMENT SCHEDULE: SPRING 2006**

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**SUPERVISOR**
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**GTAS:**
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Professor Richard E. Brown, ChemSci 702, ☎️ 487-2383, rebrown@mtu.edu
PHYSICAL CHEMISTRY LABORATORY SCHEDULE

SPRING 2006, ChemSci 706

TUESDAY

8:05 to 11:55a
CH3511, Section 01
(6) Students Enrolled, Groups 1-2

CH3521, Section 01
(7) Students Enrolled, Groups 1-2

1:05a to 4:55p
CH3511, Section 02
(16) Students Enrolled, Groups 1-5

THURSDAY

8:05 to 11:55a
CH3521, Section 02
(8) Students Enrolled, Groups 1-2

1:05a to 4:55p
CH3511, Section 03
(10) Students Enrolled, Groups 1-3
GRADING AND LAB REPORT INFORMATION

GENERAL GRADING INFORMATION

Grades will be assigned so that 35% of the lab's total points are based on the pre lab reports, 50% on the final reports, and 15% on the instructor's evaluation (effort/preparation, attitude, safety, clean-up, etc.).

Reports will normally be group reports. Any student who wishes to turn in a separate report may do so and their grade will be based on that report for that experiment. The remaining members of the group must also submit a report for their grade. The names of all students contributing to a report must be included on the title page of the reports. If your name is not included on the title page, you will not receive credit for the preliminary or final report and you must turn in another.

There may be up to a 10% deduction for each class day that a report is late after the due date. Note that pre lab reports are due the day the experiment collection begins, whereas final reports are due within 2 weeks of the scheduled completion of data collection.

FORMATTING

If you were to submit your research results to a journal or to a proceedings (of a conference) for publication, you would be required to follow a given style of format defined by the particular publisher. For example, references cited would often follow the rules as defined by Chemical Abstracts and used in many American Chemical Society publications. The purpose of such rules is not simply to make all papers look neat and concise in appearance; more importantly, the purpose is to encourage and assure the inclusion of all pertinent information in a logical and concise manner. The following topics define the rules that should be followed for your Physcial Chemistry Laboratory reports; these are very similar to actual rules used by publishers. Please see the note that follows, for additional formatting comments.

- PRELIMINARY REPORT Formatting
  Includes submission requirements. CH3521 Submission Requirements

- FINAL REPORT Formatting
  Includes submission requirements. CH3521 Submission Requirements
  SAMPLE Final Report
  SAMPLE Data Sheet

- GENERAL Style AND Formatting GUIDE
  Contains style and formatting information for tables and figures, equations, foreign abbreviations, and referencing for both reports.

NOTE: Pay close attention to formatting, as points will be deducted for improper formatting as well as (but not limited to):

- Multiple spelling errors and/or typos
• Awkward or overly-wordy sentences
• Insufficient data
• Missing sections
• Improper use of significant figures
• Incomplete error analysis
• Insufficient narrative
• Conceptual errors
• Too many sentences starting with prepositions
• Poorly labeled figures or tables
• References not properly cited
CH3521 SUBMISSION REQUIREMENTS (Effective Spring 2006)

A preliminary report is your group's "admission ticket" into lab. Therefore, it must be submitted no later than the beginning of the first lab period the experiment is scheduled. The report should be submitted as an attachment to an e-mail message addressed to the laboratory supervisor. The subject line of the e-mail message should be formatted in the following manner:

SUBJECT: CH3521Exp3pSec2Group4 or CH3521Exp3fSec2Group4

The above is an example for the e-mail submission for the Experiment 3 preliminary report from CH3521 (P. Chem. Lab II), section 2, group 4, specifically:
- CH3521: indicates the attached report is for a CH3521 (Physical Chemistry Laboratory Course II)
- Exp3: indicates the attached report is written for Experiment #3 (numbered according to the lab schedule)
- p: the attachment is a preliminary report (or f: if the attachment is a final report)
- Sec2: the group's Section number is 2 (according to your class registration)
- Group4: the group's number is 4 (group numbers will be assigned sometime between the 1st and 3rd weeks). Please follow the group number with the letter "i" if the report is being submitted individually.

NOTE: Failure to use the above formatting will increase the likelihood of delayed grading and/or point deductions.
PRELIMINARY REPORTS

SUBMISSION AND FORMATTING REQUIREMENTS

1. A preliminary report is your group's "admission ticket" into lab. Therefore, it must be submitted no later than the beginning of the first lab period the experiment is scheduled. The report should be submitted as an attachment to an e-mail message addressed to the laboratory supervisor. The subject line of the e-mail message should be formatted in the following manner:

SUBJECT: Exp3pSec2Group4

The above is an example for the e-mail submission for the Experiment 3 preliminary report from section 2, group 4, specifically:
- Exp3: indicates the attached report is written for Experiment #3 (numbered according to the lab schedule)
- p: the attachment is a preliminary report
- Sec2: the group's Section number is 2 (according to your class registration)
- Group4: the group's number is 4 (group numbers will be assigned sometime between the 1st and 3rd weeks).

NOTE: Failure to use the above formatting will increase the likelihood of delayed grading and/or point deductions.

2. Each report must contain a title page with the following items:
- Title of experiment
- Type of report (Preliminary or Final)
- Date submitted
- Laboratory Section and Group Number
- Names and e-mail addresses of those contributing to the report.

3. The remainder of the Preliminary Report should contain the following sections. Answers to specific questions in the pre laboratory exercises should be included in the appropriate report section.

A. INTRODUCTION

The introduction should be only one paragraph in length and should not include procedure. The introduction should explain the following:
- The purpose and/or objectives of the experiment
- What system will be studied
- How the system will be studied
- The types of measurements that will be made.

B. THEORY
This section should include the following:
- Fundamental principles underlying the experiment.
- Definitions of important terms and/or concepts.
- Derivations that contribute to the understanding of the fundamental principles underlying the experiment.
- Any assumptions made in the derivations and/or development of this section.
- All equations that will be used during the performance and reporting of this experiment, along with definitions of all terms and symbols and how they relate to the measurements that are to be obtained. Use narrative to describe how the equations relate to the calculation of the experiment's objective(s).
- Number each equation according to the miscellaneous formatting guide.

NOTE: The experimental information available on the lab web pages are not all inclusive and a copy of the theory section from the experiment's web page is insufficient background to perform the experiment and is therefore unacceptable.

C. PRELIMINARY LAB EXERCISES

This material must be completed as preparation and understanding of what you will be doing in the laboratory. Be sure to ask your instructor, lab supervisor, or the faculty advisor if you do not know how to complete the exercises. Your mastery of this material will be ultimately graded in the final report!

D. EXPERIMENTAL PROCEDURE

This section should describe how all reagents will be prepared, a description of how and why various measurements are made, and how these measurements will be used to calculate the experiment's objective(s). Include sample calculations with narrative/subtitles that describe them and/or their purpose. Use numbers, letters, or bullets to make the outline easier to follow. Be sure to print out a copy for your group to follow during the experiment!

SAFETY

This section should include a description of all chemicals used in the experiment, applicable physical constants (important to the experiment), acute (as opposed to chronic) chemical hazards associated with each, and a procedure for the safe disposal of unused chemicals and any accidental spills. This information may be obtained from an MSDS found on the Internet or from other safety literature. Do not attach an MSDS to the pre lab! Equipment and other safety concerns (general or specific) should also be addressed in this section.

REFERENCES

This section should contain a list of all references used in the preparation of the report. Quotes, literature data/values, specific theory and/or equations, or other specific information should be cited within the body of the text. See Style and Formatting for more detailed information concerning referencing.
FINAL LABORATORY REPORTS

SUBMISSION AND FORMATTING REQUIREMENTS

1. Final reports should be submitted for grading no later than two weeks after the completion of each experiment. The report should be submitted as an attachment to an e-mail message addressed to the laboratory supervisor. The subject line of the e-mail message should be formatted in the following manner:

SUBJECT: Exp3fSec2Group4

The above is an example for the e-mail submission of the 3rd experiment final lab report from section 2, group 4, specifically:
• Exp3: indicates the attached report is written for Experiment #3 (numbered according to the lab schedule)
• f: the attachment is a final lab report
• Sec2: the group's Section number is 2 (according to your class registration)
• Group4: the group's number is 4 (group numbers will be assigned sometime between the 1st and 3rd weeks).

NOTE: Failure to use the above formatting will increase the likelihood of delayed grading and/or point deductions.

2. Each report must contain a title page with the following items:
• Title of experiment
• Date submitted
• Laboratory section and Group Number
• Names and e-mail addresses of those contributing to the report.

NOTE: Insert the letter "a" after the group number if you choose to submit a report separate from your group.

3. The remainder of the final lab report should contain the following sections. Answers to specific questions in the pre laboratory exercises should be included in the appropriate report section.

A. ABSTRACT

The abstract should provide a concise summary of the experiment, usually stated in one paragraph. The system studied and the method used, not the procedure, should be stated here, along with a statement of the numerical results and error.

B. RESULTS AND DISCUSSION

This section should include procedures used to obtain the data, minimize error, and difficulties in the experiments; written in paragraph form. Tables (of data with and/or without compilation of
results) and calculated results should be included in this section. Each calculated result should include sample calculations and be described by narrative. Error analysis of the experimental measurements/results should always be included and explained in the narrative. These include:

- determination of precision (using standard deviation and/or the correlation coefficient)
- determination of accuracy (comparison to literature or theoretical values)
- propagation of error (if appropriate)

Omission of any data should be supported with narrative describing appropriate statistical or experimental reasons. Appropriate graphs and/or tables should be included. Sufficient narrative should be included so that any table or graph is self-explanatory. See Style and Formatting for more detailed information concerning graph and table formatting.

C. CONCLUSIONS

This section should include a re-statement of the results and their comparison with literature and/or theoretical values. A discussion of possible, significant systematic sources of error and ways to improve the experiment should also be included. Indication of a real life application and/or implication is desirable. It will normally be one or two paragraphs long, depending on the experiment.

D. REFERENCES

This section should reference all sources of quotes, literature data, theory or equations, or any other information for which the authors deserve credit. Cite all references in the body of the text. See Style and Formatting for more detailed information concerning referencing.

E. ADDITIONAL COMMENTS

Use sufficient words to describe each part of the report as it is presented. Each table, figure, or calculation should be titled and/or described with narrative so that each is understandable to someone who is not familiar with this information. Headings and sub-headings are particularly appreciated by graders:

HEADING WITH SUB-HEADINGS (EXAMPLE):

RESULTS AND DISCUSSION

Procedure

Follow the “Procedure” sub-heading with procedure in regular text. The procedure should clearly communicate sources of error and methods/procedures used to reduce experimental error!

Calculations
Calculations do not necessarily have to be listed in a separate sub-heading. It is perfectly acceptable to incorporate them within the procedure section. Sub-headings (such as in this example) are only necessary when you divide a major portion of the report into sub-sections.
STYLE AND FORMATTING: General Format Information for use in the Pre Lab and Final Reports

Contributed by Bahne Cornilsen, 3-28-00

TABLES AND FIGURES

Each table or figure should be numbered, and referred to by that number (as Figure 1 or Table 1) in the text. Each should exhibit a title or caption following "Figure 1." or "Table 1."

Each should be placed at the top (i.e. above a table) or at the bottom (i.e. below the figure) of the page. Tables should be numbered consecutively using Roman numerals. Figures should be numbered consecutively using Arabic numbers. The caption or title of each should contain enough information to uniquely define the purpose of the table or figure; but, should not be excessive. For example, the differences between a series of tables or figures should be clearly distinguished in their captions.

GRAPHS

Graphs should exhibit the following:

- Graphs fill the page (1/2 page minimum).

- Graphs are properly titled (axes as well as graph).

- Units are specified.

- The dependant variable is plotted vs. the independant variable (y vs. x). Hint: Time (or t) is usually plotted on the x axis.

- Points on the graph are not connected (please, no connect-the-dot graphing).

EQUATIONS

Each equation should be numbered with an Arabic number placed in parentheses at the right-hand margin of the page. The equations may then be referred to in the text by number, e.g. as "equation 3." The equation itself should be centered, for example:

\[ F = ma \]

This is easily done using the Format, Tab-setting feature in MS Word; The equation is centered using a "centered-tab," and the number is placed using a "right-tab" set at the margin.

FOREIGN ABBREVIATIONS

Foreign language abbreviations should be underlined or italicized, for example, etc. or etc., ca. or ca., et al., i.e., in situ, etc. Be sure to use the correct punctuation with each; note the correct placement of periods. (The underlined versions were common in the days before word processors and/or typewriters with changeable typing heads with different fonts.)

REFERENCING
References should be cited when information is used or obtained from any other source. The citation in the text should immediately follow what is referenced and be given in one of two alternative styles, by first author and year (in parentheses) or, more simply, by number (in square brackets or as a superscript). When using the authors' names in the text, only the first author's name (followed by et al.) should be used if there are more than 2 authors. If there are two authors, both names should be used. The entire reference, including all authors, is then given at the end of the report. The references will be given in alphabetical order, or in order of their use, respectively. The format of a particular reference depends upon the type of reference source. Formats for the 3 principle types, journal article, text book, or treatise with chapters by different authors (with an editor), are given below. Note the use of italics or bold fonts in each. As with abbreviations, above, the use of italics is now preferred vs. underlining.

**Journal Format**

John J. Doe, Jane Smith, and Ricardo W. Jones, *J. of Irreprod. Evid.*, (2001), 95, 209-210. (Note: *J. of Irreprod. Evid.* = *Journal of Irreproducible Evidence*), year in parentheses, volume number in bold, and pages. The authors' first names can be replaced by initials, e.g. J. Doe, J. Smith, and R.W. Jones. The citation in the text would be "(Doe, 2001)" if this style is chosen; and then the first author should be typed as last name first, e.g. "Doe, J.J., J. Smith, and R.W. Jones" in alphabetical order.

**Text Book Format**


(Note: the page numbers are not always needed in this type of citation.)

**Treatise Format, Edited and with Chapters by Different Authors**

Authors' Names as above, "Title of the Chapter (in quotes)," *Name of the Text*, 88-3, (Editor's name or names, followed by a comma and "ed." or "eds." in parentheses), Publisher, City, State, 1999, pp. 33-35.

(Note: The volume number, in bold, should be included if the treatise is numbered.)

**Thesis or Dissertation Format**


**Internet Reference Format**

Internet sources are generally not primary sources of information, i.e. they usually contain data from another source. When citing or quoting information obtained from the web, you should include both the primary reference and the internet or Web address. If no primary reference is given in the Web document, the citation should include the author's name, the Web address, the title of the document (in quotes), and the date you found it.
RULES, REGULATIONS AND SAFE LABORATORY TECHNIQUES
Michigan Technological University Department of Chemistry (Rev'd 9/2/99)

1. Eye protection (safety goggles) must be worn at all times while anyone in the laboratory is working with chemicals unless the instructor states they are not required. The wearing of contact lenses is not recommended.

2. No work is to be done in the laboratory without having a lab instructor or supervisor present.

3. Report all accidents and/or injuries to your instructor or supervisor.

4. Never carry out unauthorized, unplanned, or non-scheduled experiments. Discuss any unusual work with your instructor prior to doing it.

5. Never eat, drink or taste anything (food or chemicals) while you are in the laboratory. Don't place pencils, pipets, etc. in your mouth. Food and beverage containers do not belong inside a lab!

6. Shorts and miniskirts are not allowed. Wear closed shoes, not sandals, in the lab. Confine long hair and sleeves when working. Wearing a lab coat or apron is recommended.

7. Wear appropriate gloves and protective clothing while working with hazardous materials.

8. Always use a suction bulb (never use your mouth) when filling a pipet.

9. Do not force glass tubing and/or thermometers into rubber stoppers - always lubricate the hole in the stopper with glycerin or water and protect your hand with a towel when inserting the glass.

10. Never use an open flame (Bunsen burner) in the vicinity of flammables and never leave a lighted burner unattended.

11. Clean up all spills immediately. If you are unsure about the proper procedure for clean-up or disposal, consult your instructor. Broken mercury thermometers require special clean-up; consult your instructor.

12. Handle broken glass carefully; cuts from broken glass are a common injury in lab. Use a dustpan and broom for clean-up. Discard all broken glass in a glass disposal box.

13. Do not test odors by direct inhalation from the container.

14. In case of chemical contact with skin or eyes: wash affected area with water for 15 minutes. Use faucets, safety shower or eye wash, as appropriate. Remove contaminated clothing immediately.

15. Wash hands before leaving lab.

16. During the first day of lab: locate all emergency and safety equipment that you may need to use at some time. This includes: safety shower, eye wash, fire extinguisher. Locate the nearest emergency exit and emergency telephone.