CHEM 445 Physical Chemistry Laboratory I
Lab Reports

Laboratory reports from students who have taken CHEM 445 in previous semesters are available, but not from us. It is plagiarism, a serious academic infraction, to take a previous report and replace the data with yours. We have electronic copies of lab reports from several previous semesters. Although it is unlikely that the Lab Instructor will check your report against previous reports, such a check may be made (and has been done in the past). It is not worth the risk to try such a stunt.

There is, unfortunately, no standard form that everyone uses for reports – as you will discover when you go to work for a living or write reports for other courses.

These reports are not journal articles because you cannot obtain enough data in 4 – 8 hours for a publication and you are not obtaining "new data". If these were reports to your boss in an industrial situation, you would not need to provide all of the data that we ask to verify your calculations. {However, if you made computational errors in a report, you might soon be out of a job.} If these were progress reports on a research project, you would need to provide much of the data – because neither you nor your research advisor would be sure of the results.

REPORTS ARE TO BE SENT AS FILES IN PDF FORMAT. The appearance of a report is important and there are problems with formatting errors in switching from one version of Word to another.

For this laboratory, reports should be written in the following general form.

1. The report should begin with a **Title (5 points)** that indicates the experiment by **title**, the **laboratory section**, the **person(s) writing the report** (joint or single author), the **due date of the report** and the **date when the report was submitted**.

The reports are to be submitted and graded in Canvas. This should be your first page of your lab report.

{This should be 5 points for everyone!}

2. There should be an "**Abstract**"**, (5 pts).** This is a brief summary of the results and conclusions of the experiment. **The Abstract may not be more than half page**. **This should be your second page of your lab report.** The summary is written for someone with a technical background who is interested in the results and not the details of the experiment. It should include the important values that you determined with uncertainties for average values, as % error for a single number or average % error for multiple determinations. Do not give a table of data. If you have determined several values as a function of concentration, give the algebraic equation that fits your data. Give reasonable numbers of significant digits for your values, including coefficients. Do not "brag" about the precision of your uncertainty or error: one or two digits in the uncertainty are allowed; four looks ridiculous. Keep the same number of decimals in your values and the uncertainties: -15.62 ± 0. 10 kJ/g is OK. 15.6234 ± 0.01026 kJ/g is absurd (and will cost you points).

3. There should be brief **Introduction** to the experiment **(10 pts)**. **Do not copy** directly from the laboratory write-up. This report is not an article for a journal, but a report, perhaps to your supervisor about what you did. Don't belabor the obvious. No derivations are needed. Minimal {or no} equations are needed here. No defense of the

experiment is needed. State the purpose of the experiment clearly. The **Introduction** should be no more than **one page**. When you write proposals, you will discover that there are frequently page limits.

Do not write "The purpose of this experiment is … ."

4. There should be a brief **Experimental Section** or **Procedure** **(10 pts)** that describes the general procedure that was followed. Do not write all of the detail that was given in the laboratory experiment. You are writing for a technically literate audience. Do not use the imperative mood: you are not telling someone what to do; you are telling what you did. **The Experimental Section may not exceed one page.**

5. The bulk of the report is the **Results and Discussion** section **(45 pts)**. Tables, figures, and necessary equations should be given here. The methods of presenting data vary from experiment to experiment, but the essential data should be provided in this section as well as derived quantities. Do not present tables of data at the end of the report as an appendix.

Pay attention to significant digits in tables, including trailing zeros. The number of decimals should reflect your experiment, not a standard computer format. With Excel, it is necessary to specify the number of decimals in each cell or column. When multiple values of a single quantity are directly measured, give each value in the table and use each value in your plot. Use scientific notation: $3.265*10^{5}$ or simple notation, 0.00156. $1.56*10^{-3}$ is OK, but $1.6*10^{-1}$ looks ridiculous, in spite of your calculator.

Tables and Figures should appear in the body of the text near the first reference. All tables of data should be discussed at least briefly. If a figure is derived from a table, the table should precede the figure in the text. Each table and figure should be numbered and have a brief descriptive title. No data may be discussed that are not presented in the report.

A set of numbers in columns is a table, not a figure; a plot of data is a figure, regardless of Excel. Figures and tables should be numbered consecutively in the report and discussed in sequential order. Tables have brief descriptive headings **above** the table. Do not refer to Table 2 before Table 1. Footnotes are useful in tables for a value that is common in the calculations of data in the table: {N{NaOH}, V{flask}, etc}. Gridlines help in tables. Align columns so that they look "presentable". Symbols or abbreviations reduce the width of columns. Don't get fancy about the Excel format for the tables: plain is better than "pretty".

Figures should be in Portrait (not Landscape) form. An Excel Trendline is often useful to show the general outline of the data and to identify obvious outliers. Polynomial fits are about your best try, but don't use more than a third-order fit. If your Trendline has obvious "wiggles" it is probably wrong. Do not put the equation in the figure. Axes should be labeled, with units. **Do not have Excel put a title in the figure because you will put a caption below the figure.** {Journal editors still don't like titles within a figure, although I expect that Microsoft will convert them eventually.} Adjust the scale of your figures to fit your data: the initial computer values are often not useful: a mole fraction of 1.2 is embarrassing, as well as an absorbance of – 0.1. Vertical gridlines are essential in figures. Data points should be visible in the figure when a line is drawn through them. Do not use the "connect a dot" format for the figures. The horizontal axis is the variable that you changed {the independent variable}; the vertical axis is the dependent variable. Use

different shapes or colors for different sets of data, but don't get carried away with your artistic temperament. Background colors seldom help the appearance of a figure.

Traditionally, each table is numbered with brief (not a sentence) descriptive heading **above** the table. Each figure is numbered with brief (not a sentence) descriptive title **below** the figure. {Sorry about that: but this is the generally accepted practice.} The title or caption should be carefully written to describe what is displayed.

Equations that you use to analyze your data should be presented in the Results and Discussion section near the point in the text where they are used – and numbered. Your equations with numerical values and appropriate symbols for the variables should be numbered as well and given in the text – with the appropriate uncertainties for each parameter calculated with a standard program {Regression, etc. in Excel}. **Do not type equations in terms of x and y**; use appropriate symbols: P, for pressure; T {or t}, for temperature, d, for density, etc. **Equations should be written with Equation Editor or another appropriate program** so that they are easily understood.

Don't waste space in your report. Rearrange text to keep from having an empty half page.

6. Conclusions (10 pts) this section contains all major findings and experimental results written in a concise manner and no more than one paragraph.

7. References (5 pts) should be given at the end of the report in a standard form and should refer to a specific point. The ACS style guide is available on the Internet, from which you can find the appropriate reference style.

8. Technical Writing (10 pts) See below.

Lab reports must be written with a word processor and carefully edited and proofread before submission. They are to be submitted electronically in Canvas no later than the beginning of the lab period two weeks after the experiment was begun.

Mistakes in writing and presenting data are often associated with mistakes in analyzing data. The spelling and grammatical programs on word processors are not infallible. You must check.

The report must be written in the **past tense**: what you did, not what someone else should do. Conditional verbs, like "can", don't belong in the report; if you did something say so. The report should not be written in the style of the lab procedures that describe what you are to do. The report should be written in the third person and generally in the passive voice, not the active voice. The first person singular for a joint report is a definite *faux pas*. You may have difficulty with the word processor because some programs object to the passive voice and past tense. Ignore these "helpful" hints.

Technical reports are different from the papers that you wrote in ENGL 110. You are not writing a news article, either. Do not lead the report or a paragraph with conclusions. You draw conclusions from data that have been presented and arguments in the paragraph.

For most of the experiments a table of data in a specific form is to be submitted as an Excel spreadsheet to Canvas. We use these data to grade your data for accuracy and also for a statistical analysis over time.

If you do not have Adobe Acrobat pdf maker, there are (at least) two free pdf sites (Pat McMahon):

CutePDF:

http://www.cutepdf.com/Products/CutePDF/writer.asp

PDFCreator:

http://sourceforge.net/projects/pdfcreator/

In addition, you can make the conversion in the basement of the Library.

If you do not have access to Regression or LINEST in Microsoft Excel, other programs exist that will produce these statistics. Open Office will work. One possibility for a regression analysis with statistics (also courtesy of Pat McMahon) is

http://www.wessa.net/slr.wasp

ORIGIN, for which the University has a site license will also analyze and plot data. ORIGIN is a PC-only program.

You will need the Excel Solver function to analyze data.

The computers in PCHEM Lab have Regression and Solver in an earlier version of Excel. The computers in the PCHEM Lab are not connected to the Internet. You will need a flash drive or USB port to handle your data. DO NOT BRING ANY VIRUSES TO OUR COMPUTERS!

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