Fall 9-1-2000

CHEM 161.00: General Chemistry Laboratory I

Trina Valencich

The University Of Montana

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CHEM 161N
AUTUMN 2000

LABORATORY FACULTY
PACK (FacPac)

DR. TRINA VALENCICH
CHEMISTRY 161N  
LAB OUTLINE (Lo), AUTUMN 2000

Laboratory Coordinator: Dr. Trina Valencich, CP 202C, 243-5227 (voice mail)  
tvalenc@selway.umt.edu  
Office hours: M, 0810-0900; TR, 1310-1400; R, 1110-1200, and by appointment  
Required Materials:  
2. A bound laboratory notebook with permanently numbered duplicate pages (BLN).  
4. One floppy disk.

### SCHEDULE

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<tr>
<th>W</th>
<th>Ref (AP or HO)</th>
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<td>Lo</td>
<td>CP 402</td>
<td>Diagnostic testing; adds and drops</td>
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<td>2</td>
<td>CP 402</td>
<td></td>
<td>Using LoggerPro to Plot &amp; Fit Measured Data;</td>
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<td>CP 103a</td>
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<td>HO-W</td>
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<td>Apx. A</td>
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<td>C-1</td>
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<td>HO-W (100 pt.)</td>
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<td>C-1 (50 pt.)</td>
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<td>C-S</td>
<td>CP 402</td>
<td>Mass Relationship Systems</td>
<td>Poster C-S (100 pt.)</td>
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<td>HO-2</td>
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<td>Heat Systems</td>
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<td>11</td>
<td>D-S</td>
<td>CP 402</td>
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<td>14</td>
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<td>Chemical Periodicity Systems</td>
<td>F-1 (50 pt.)</td>
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<td>15</td>
<td>F-S</td>
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ADDITIONAL INFORMATION

1. If you withdraw from the course make sure you checkout of your lab locker before 1400 Friday 15 December 2000 to avoid an assessment for the contents of the locker. This charge will be included in your fees for the next registration, or transcript request. Remember that you are not automatically dropped from class rosters just because you stop coming. You must withdraw yourself from class enrollment.

2. The laboratory closes promptly at the end of each session. Please plan your work so that you will finish by the end of the laboratory session.

3. Students who arrive late and miss the safety instructions from the lab instructor will not be allowed to participate in that lab session.

4. Late lab reports destroy the continuity of instruction in this course. Reports submitted one day late will be graded as usual, and then the point total will be multiplied by 0.75. Reports two days late are multiplied by 0.5, three days late by 0.25, and reports more than three days late are not accepted and receive a score of zero.

5. Duplicate notebook pages must be submitted before leaving the laboratory at each session. Students who “forget” to submit pages will receive a 5 point penalty per page, regardless of the excuse.

6. Each missing notebook pages, cross-outs, deletions, etc. will result in a 5 point penalty.

7. There are no make-up lab periods.

8. If you know you will miss a session, discuss this with Dr. Valencich before the absence is recorded. In case of an emergency leave a message for Dr. Valencich as soon as possible. When more than two laboratory periods are missed, it is not possible to properly evaluate the work of a student. If more than two lab periods are missed dropping the course is recommended.

9. A two-point penalty will be applied for each Peer Critique evaluation that is not turned in to the laboratory instructor by the end of the presentation period.

10. All grading disputes should be resolved with your lab instructor. If a satisfactory resolution cannot be agreed upon, Professor Valencich will make the final decision.

11. Any student in this course who has a disability that may prevent the full demonstration of that student’s abilities should contact the lab instructor, and Professor Valencich as soon as possible so we can discuss accommodations.

12. This course outline is not a contract, and it is subject to change at any time at the discretion of Professor Valencich.

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SAFETY RULES

1. Splash-protection safety goggles must be worn in the laboratory whenever anyone is performing an experiment. Goggles must be worn over your eyes. Repeated disregard of this rule will result in dismissal from the laboratory and a grade penalty. Particle goggles are not acceptable.

2. You are responsible for knowing the location of all safety equipment such as the fire extinguishers, fire blanket, eyewash fountains, and safety shower. You must also know the fire escape routes.

3. Proper clothing must be worn. Shorts and sandals are not appropriate for lab work. Long hair should be tied back. Contact lenses are not recommended.

4. You may not conduct any experiment without prior approval of your laboratory instructor. You may work in the lab only when supervised by your laboratory instructor.

5. Do not touch, or taste, any laboratory chemical. Odor testing is to be done with caution.

6. You may not drink, eat, or smoke in the laboratory. Please do not bring open food, drink containers, or animals into the laboratory.

7. Do not use damaged glassware. If you have cracked or chipped glassware, bring it to the attention of your laboratory instructor.

8. Do not use an open flame without the permission of your laboratory instructor. Check your immediate area for flammable solvents before using an open flame.


10. Dispose of all chemicals as directed.

11. Behavior inappropriate to the laboratory situation will not be tolerated. Any such or similar activity will result in immediate dismissal from the laboratory and a grade penalty.

12. Dilute concentrated acids and bases by adding them to water. Do not add water to a concentrated solution of an acid or base.

13. All safety instructions specific to an experiment must be followed. This includes verbal instructions from your lab instructor.

I have read and understood the rules for safe conduct in the chemistry laboratory. I agree to abide by these rules, and I understand that I may be dismissed from the laboratory if I violate these rules.

________________________ ___________ ________________
Signature Date Printed Name Sec. #/TA

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I. The Laboratory Notebook

The laboratory notebook is an important part of any active chemical laboratory. All scientists use notebooks to record all data and the dates on which the measurements were made. Many labs use notebooks as reference sources; for example labels on containers frequently include a notebook page number for easy reference. When a scientist leaves a research group, the notebook remains in the lab for future reference. Disputes about priority of discoveries, legal issues, and questions of ethics are often settled by referring to laboratory notebooks.

Part of the purpose of your chemistry laboratory experience is to teach proper laboratory notebook techniques and to habituate its use. The overarching rule of notebook keeping is to record information that allows another reader to easily repeat what you have done. Keep this in mind when you organize your notebook.

A. Contents of Laboratory Notebook

1. The first page of your bound notebook is the title page. Label this page, “Chem 161N, College Chem. Lab, Fall 2000; <Your section number and meeting time>, CP 402; Instructor: <Lab Instructor’s Name>, <Lab Instructor’s office, phone>, <Your name>, If found please call <Your phone>. Replace the italicized material with the appropriate information. Repeat the same information on the front of the book. A 5 point penalty is assessed if this information is missing.

2. Pages 2 and 3 are reserved for a Table of Contents. Add to this Table the title and beginning page number of each new experiment. A 5 point penalty is assessed if there is no Table of Contents.

3. Each new experiment should begin with the title of the experiment, date started, name(s) of partner(s), and properly reference the procedures from the appropriate section of lab manual, or (FacPac) Hand Out. A 5 point penalty is assessed if this information is missing.

4. Any changes in the procedures given by the laboratory instructor are to be recorded next in your lab notebook. A 5 point penalty is assessed if changes are not recorded.

5. Data entries must be made with a ballpoint pen with black (preferable) or blue ink.

6. Cross-outs are not acceptable. Any entries to be disregarded should be boxed and marked as such. Add a comment explaining why the information is to be disregarded, for example Sample #2 was spilled. Never delete, cutout, cover-over, or erase any entries. A 5 point penalty is assessed for each cross, deletion, cutout, cover-over or erasure.

7. Write in the first person.

8. Each page must be dated and include your name, section number, and TA’s initials. A 5 point penalty is assessed if this information is missing.

9. Duplicate pages are to be submitted to your laboratory instructor at the end of each laboratory session. A 5 point penalty is assessed for each missing page.

10. Copies of all graphs, printouts, etc. must be taped into your notebook.

You will perform two types of experiments this semester, Guided Inquiry (GI), and Open Inquiry (OI).

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II. Reports on Guided Inquiry Experiments

Note that GI experiments introduce the concepts rather than verify them, read Section I. A. pg. 3 in the laboratory manual (AP3, Abraham and Pavelich, 3rd Ed., red cover; or AP2, 2nd Ed., green cover). You are not expected to "know the answer". You are expected to use the data you collect to come to a logical conclusion.

All data must be collected in regular supervised 161N laboratory sessions this semester by you, or by you and a partner, and recorded in your bound laboratory notebook. CP 402 is used by several classes and we do not have the resources to staff makeup sessions. Reading through the procedures before coming to lab enhances performance in the laboratory. Thinking about the sequence of what will be done, and sketching the steps in order into the notebook always helped me work more efficiently. Bring your bound lab notebook, laboratory text, goggles and this Faculty Pack to lab each week. You will also need to know your locker number and combination each week. Keep your Laboratory Outline and your returned graded material together until you have received your course grade. You should periodically check on how you are doing in the Chem 160 sequence, do not wait until the last week to seek help.

A verbatim replica of the procedures in your BLN is unnecessary and will not be read. A complete description of the data (this includes observations) and any changes indicated by your instructor is required to be recorded in your notebook. Roll is taken twice each day in lab, the page numbers turned in each day are recorded in your TA’s grade book, and penalties are assessed for missed lab sessions and incomplete records. Even though you will frequently share data with a partner(s), and we encourage you to discuss the work with your classmates, each of you is to write your own lab report. We suggest that you use your lecture text, your class notes and other references, like the Handbook of Chemistry and Physics (HBCP) to complete your reports. Copies of the HBCP are in the library, in CP 103a and in most faculty offices of the Chemistry Department. Duplicate reports are subject to penalties. Reports which follow the sequence of the directions, are neat, concise and clear to follow make it easy for your reader to credit your work. Better reports earn more points. The following is a general guide as to what your reader will be looking for in the report.

A. The lab book pages left with the TA at the end of each session when measurements were made (pages removed from the BLN) will be checked to see the following information, recorded in ball point pen, preferably with black or blue ink:

1. Label. Date on which data was collected, Title of Experiment, Lab Section #, TA’s initials, student name and name(s) of any partner(s).

2 A proper reference to the procedures in AP or HO is sufficient. Any procedure changes given in lab should be listed right afterwards
   For example, “The procedures followed in this experiment can be found in Ref. 1. We were instructed, however, to record the atmospheric pressure and delete section B.”

3 The data. Include with each piece of measured or provided data: an identification of what it is, the numerical value written out to the appropriate number of significant digits, and units
   For example: “Weight of stopper #1 = 1.267 g; and Concentration of Stock HCl(aq) = 4 M.”
   Unless otherwise indicated, when a linear scale is marked on an instrument (like on a ruler, a thermometer, or a buret), your recorded value should be reported to ±20% of the smallest unit marked on device.

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When the data (observation) is descriptive, use complete sentences. If a demonstration is provided, you are to record your observations into your BLN. A more complete description is worth more credit. Pay attention to details like: color, texture, changes in appearance, bubbles given off, an odor, precipitation formation, size and quantity of any solid that forms, moisture collecting on the sides of a test tube, the sample got warm or cool, the relative speed of a process, etc.

B. Report - Must include:
1. Repeat the same information as in A. above (even though this is already on your notebook pages). It is frequently difficult to read the carbon copies and penmanship varies greatly.
2. Fully answer the questions, and detail how the numerical quantities requested in the GI directions (either in AP or in a HO) were calculated. You are also usually requested to find a relationship between the measured quantities. Graphing the data is suggested in the AP directions, however we require graphing. The graphs (done with a spreadsheet program) are to be included in the report. The graph alone is an insufficient answer to this type of question. Axes must be labeled, include units for the axes, and both scales should be appropriate to spread the data out over the figure. In plotting the measured data keep the following objectives in mind.
   a.) Identify the independent variable and the dependent variable. The independent variable is the value you control, even if you have to do a calculation to get it, like convert the weight of a solute in a volume of solution to the molarity, M, of the solution. The dependent variable is the quantity that responds to independent variable. Frequently it is just read it off an instrument, sometimes that data must also be manipulated.
   b.) Try to find an equation which fits the data points.
   c.) Include a plot of the equation on the same figure.
   d.) Determine the values of the constants in the equation.
   e.) Ascertain whether or not a fit is good and/or expected
   f.) Recognize certain behaviors and determine whether they are appropriate or not, (like a zero intercept).

Spreadsheet programs make it easy to display the plot and look for fits and associated constants. Excel will add a requested TRENDLINE to the plot, and print the equation [for example, \( y = (slope \ value) x + (intercept \ value) \)] and \( R^2 \) (the correlation coefficient) on the figure. Notice that you just get numbers for the fitted constants, you will have to figure out what kind of units the constants should have.

If the value of \( R^2 < 0.96 \), the fit to the data is not very good. This could be due to errors in technique in making readings. For example in Part I. of B-3 in AP, one partner could be taller than other, the thermometer bulbs maybe not at same height, not read at same time, ...etc. Errors in sample preparation (like spilling some weighed material) or problems that are inherent limitations of the experimental design or the equipment used (like the calibration of the mass produced thermometers used in the lab). Comment on sources of experimental error. The statement that ‘human errors’ may have contributed requires the details of the errors meant as given in the early part of this paragraph. You should always

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identify the **least accurate measurement**.

Be aware that a value of $R^2$ close to one (the limiting value), does not guarantee that the functional fit is appropriate. This may coincidental (fortuitous cancellation of errors). It may mean that the range of the independent variable is too small to establish the functional form. For example, a curve looks like a straight line if a small segment of it is viewed.

**Comment** on the value of the constants of the equation. Perhaps the intercept should have been zero "because there is no electrical conductivity if there are zero moles of ionic solute in the solution". Is a non-zero value of a fitted intercept within the expected accuracy of the data? When appropriate, like Part I. of B-3 in AP, compare constants to expected values (you will need a proper reference here for the expected values). Sometime the data must be manipulated a bit to find a linear relationship. For example if the points fall below a linear fit for low values of $x$ and the points appear above the same line for the high values of $x$, perhaps the relationship is parabolic. In this case, try plotting $y$ vs. $(x^2)$, or select a polynomial regression, etc. Conversely, if points are above the line where the axis intercept one another and then fall below the line as $x$ increases, try $y$ vs. $(1/x)$. Exponential $[y$ vs. $\exp(x)]$ and log plots ($y$ vs. $\ln(x)$) are also sometimes useful.

3. Type-up your report on any PC, there are several campus computer labs available. CP 103a is open as often as we can staff it. The schedule will be posted on the door to CP 103a and on the bulletin board outside of CP 402. You can paste Excel plots into Word documents in our computer lab in CP 103a.

**III. Open Inquiry Experiments**

Read pages 275 and 276 in AP3 (or pages 223 and 224 in AP2) to get an understanding of the purpose of these experiments. Remember that the AP discussion does not address poster presentations. Refer also to the included Open Inquiry Evaluation Form that your TA will use. These experiments will allow you to design, perform, and report on an experiment of your own choosing. The rules for OI experiments are the same as those for GI experiments with the following additions.

**A. Conducting the Experiment**

1. OI experiments will performed in teams of two (a trio is ok, but teams of four are not). Your lab instructor may assign your partner(s). Team members should exchange phone numbers, and agree upon contingency plans. All members are expected to contribute equally to the successful completion of the laboratory exercise. Each person must keep a complete record of the experiment.

2. The first hour of the first laboratory sessions is a time for you to plan and test your project. Spend the first 15 minutes deciding upon a system to pursue. Promptly identify you intended system and group on the white board so the systems get distributed as evenly as possible. You should begin with a qualitative, small-scale investigation of the system you choose. Consult with your lab instructor before you conduct an experiment. Once you have a plan, you need to write a proposal. The proposal should be written in your laboratory notebook, and it should be no more than one page in length. Your project should contain qualitative as well as multiple sample quantitative measurements. The design should require 2.5 to 3.0 hours of laboratory work. The proposal should contain the information discussed below.

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a.) **Overview or Question**, give the question that prompts the experiment or a few sentences describing the system you will be investigating. For example, "Can solids which contain parts that look like independent molecules decompose (easily) upon heating to give off gaseous molecules and leave behind a non-gaseous, simpler residue?"

b.) **Hypothesis (if)**, state the natural principal which controls what you observe. For example, "Ionic compounds are held together by strong electrostatic forces. One part of a metal carbonate is the CO\(_3^{2-}\) anion. If this is a weak association of CO\(_2\) and O\(^2\), then when a metal carbonate is heated, perhaps they readily give off CO\(_2\) (a stable gaseous molecule) and leave behind a more strongly bound metal oxide."

c.) **Theoretical Background**, justify your hypothesis on the basis of earlier data. For example, "The hydrates which were heated in C-1, contained water (which can exist alone as stable molecule) in the formula, and they decomposed relatively easily by the loss of water molecules."

d.) **Procedures (and)**, briefly describe how you will carry out your experiment. Practice good reagent ecology in your design. Do not take large amounts of reagents when small amounts will give you good results. For example, "By repeated cycles of weigh-heat-cool, we will bring to a constant weight, first a clean crucible and then the residue left from heating several, individually weighed samples of three different carbonates. We will check with our TA to make sure that no flammable targets, or candidates, which could evolve dangerous products are being considered and ask for proper disposal procedures."

e.) **Prediction (then)**, briefly describe what relationship(s) you expect to find. For example, "The weight of carbon dioxide lost should be a linear function of the weight of starting carbonate because each sample of a compound contains identical formula units and each constituent element has the same average weight".

3. Your laboratory TA must tentatively approve your proposal before you can begin work. It must be signed and dated by the lab TA.

4. The second and third hours of the first sessions will be devoted to completing your experimental work. You are expected to design an experiment that requires nearly three hours of laboratory activity, include qualitative ("Is Ba(OH)\(_2\) more soluble than NaOH?") and multiple quantitative data.

5. The first hour of the second lab session can also be used to make any additional measurements. In the second hour, adjustments can be made to existing figures and tables, or written in on sheets for the poster. Your experimental results will be presented in a poster session/discussion in the last hour of the second lab session. Your laboratory grade for OI experiments will be based on the following.
   a) Your notebook pages.
   b) The verbal presentation (five minutes).
   c) The Peer Review (see included page) participation.
   d) The Poster.

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B. Roles in Open Inquiry Experiments

Another purpose of OI experiments is to involve you in cooperative learning. One part of your grade is assessed for your group, another part is for your specific role in the project. If an additional person needs to be incorporated into one team then the Manager role will be split into two roles. When the team consists of three members, the newly designed role of the Producer will then be responsible for production of the poster.

1. Experimentalist: Responsible for the execution of the experiment, can enlist assistance from the other team members (for example to watch the clock, while a reading is being taken).

2. Manager (/Producer): Record the experimental data. (Produce the poster). Make the verbal poster presentation and answer questions. If the manager does not appear for the poster, due to an emergency, the manager must make arrangements with the instructor for the verbal presentation.

Observing the work of others contributes to the laboratory experience. The Experimentalist (and Producer if the team contains three members) must attend each poster presentation in the section in its entirety. These observers respond to the material requested in the Peer Critique Form (included in this FacPac) on a separate piece of paper for each presentation. sign their name at the bottom of the paper, and turn the sheets into the TA before leaving the session. The TA will sort the sheets, document the evaluation, cut off the reviewer’s name from the paper and deliver them to the appropriate Managers. Students who fail to turn in a Peer Critique sheet for a poster, arrive late or leave early will have their lab report scores adjusted to reflect the missed responsibility.

C. Posters

OI experiments will be partially reported on with a poster presentation. The poster board may be any suitable material - cardboard, Styrofoam, etc. We have kept boards, donated by previous participants, which you may use. Some donated posters are also on view in CP 103a. Posters generally present the data on eight to twelve sheets of 8.5 by 11-inch paper. The poster should succinctly describe your experiments. The presentation should be high quality (color is not necessary), utilizing large, easy to read lettering and graphics when applicable. All four parts of the report guidelines must be included. The first panel should always include the title of the experiment, your names, and your college affiliation. At the conclusion of the poster session, all sheets of paper will be removed (do not glue or permanently affix it) from the poster board, assembled, and submitted to your lab instructor for grading evaluation.

It is recommended that each poster be organized in the following manner (making it easy to find and evaluate the work). In general, a five-minute presentation is too short to verbalize all of these details, however this information is required for proper evaluation of the work. Holding a copy of the pages helps the presenter speak to the audience and feel more in control. If there are several pages of spreadsheet tables of a similar kind, they may be held at the top by two thumbtacks, one over another, so the presenter can lift up sheets to point out details if asked. The speaker may also need to refer to these portions to fully answer questions.

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1. **Introduction** — briefly (usually about 2 sentences each) state the project plan; the first panel should include the title of the experiment, your names, and your college affiliation.
   a.) Question.
   b.) Hypothesis.
   c.) Justification.
   d.) Design.
   e.) Predictions

2. **Procedures** — details of the experiment. Sufficient information should be given so another could follow these instructions and reproduce your experiment.
   a.) Qualitative part.
   b.) Quantitative part.
   c.) Precautions, (for example “Make sure the precipitate is dried to a constant weight by gentle heating. However, be careful not to decompose your product.”)
   d.) Explain how changing the parameters you have chose, one at a time, tests your hypothesis.

3. **Evidence, or Data & Analysis**
   a.) Note all qualitative observations (smoke given off, an odor, color change, bubbles or solids formed – size and qualitative speed of formation, etc.) and whether or not this was expected.
   b.) Spread sheet list of raw data, remember significant figures and units. Be sure all required information is presented (for example: *atmospheric pressure and room temperature - if relevant, concentration of reagents, molecular weights*).
   c.) Show how calculations were done (for example, \( M_{\text{of NaOH}} = \frac{n(\text{NaOH})}{V(\text{aq. soln.})} \)
   \( = \frac{w(\text{NaOH})/MW(\text{NaOH})}{V(\text{soln.})} = \frac{0.563 \text{ g}}{40.0 \text{ g/mole}} \times 150 \text{ L} = 0.0938 \text{ M} \).

4. Include graphs when pertinent, with proper labels, a title, units, etc. Report on and evaluate functional fits, what about the values of the constants (remember units and SF.), was this expected, comment on sources of error, and when possible, compare your values, when possible to referenced quantities.

5. **Findings or Summary**
   a.) Conclusion. Restate your hypothesis, did your experiment confirm or deny your hypothesis? Repeat any quantitative relationships and constants found.
   b.) Design. What procedures or measurements limited the accuracy of your work. What type of equipment, procedural changes, or additional measurements would improve your results?
   c.) Evidence. If your experiment supported your hypothesis, could you now design an experiment to limit or expand its application? If your experiment negated your hypothesis, could you now better formulate a hypothesis on this type of experiment? Give a tentative new hypothesis. If the experiment was inconclusive, could you now design a better experiment? Briefly state an experimental design that would be better.

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Peer Critique Form

System: _________________________________________________________
Names (or Group ID): ___________________________________________

1. List the two best features of the experiment.

2. Write here a question for the presenter.

3. List here at least one feature that could be improved.

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HO-1. Volume & Masses of Solutions (C-S Supplement)

Name ______________________ Role______ Lab Section: ____________
Partner _____________________ Role______ Partner ______________ Role______

System 8 - Investigate mass relationships such as salt/water or sodium bicarbonate/water solutions.

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HO-W. Workshop - Scientific Reasoning

Name _________________________________ Lab _________________________________
Partner _______________________________

Pre-Lab assignment: Read pg. 3 and pages 275 and 276 in APS.

Introduction

What is science? Many scientists or scientific technicians live their whole lives without ever answering this question for themselves. When asked this question, some standard textbook definition of science that they once read is given. Since you are most likely going to be a scientist or a scientific technician, we want you to spend a few hours this week thinking about this issue. This experiment is designed to give you the opportunity to reflect on this question and to allow you to come up with your own answer.

I. Part I.

A. Procedure

Obtain a pie pan, a small piece of clay, a few birthday candles, a paper clip, and a small jar. Place a small lump of clay in the middle of the pan so that it can support candles. The size of the lump of clay should be sufficient to support the candle but not as large as the mouth of the jar. Fill the pan about half-full with water, then place a candle in the clay. Place a paper clip nearby in the bottom of the pie pan. Light the candle and then invert the jar over it to trap a fixed volume of air to support the burning of the candle. The mouth of the jar should be completely below the surface of the water, and resting on the paper clip on the bottom of the pie pan. Place a paper clip nearby in the bottom of the pie pan. Light the candle and then invert the jar over it to trap a fixed volume of air to support the burning of the candle. The mouth of the jar should be completely below the surface of the water, and resting on the paper clip on the bottom of the pie pan so as not to seal the water inside the jar from the water in the rest of the pie pan. Record your observations. Repeat the experiment so that you and your partner alternatively manipulate the equipment while the other serves as the primary observer. Repeat the experiment several times with changes in the experimental conditions, such as the number of candles, the size of the air volume for combustion, etc. Carefully record the conditions of each experiment and your associated observations.

B. Report on Candle Burning

Submit a brief, typed report on this experiment. In order to facilitate grading, we ask that you use the following format:

Section 1: Question #1 - What caused the candle to go out?
Section 2: Hypothesis (if)

Propose a scientific (natural) process that is responsible for the behavior noticed in the question.

Section 3: Design (and)

Write a brief description of how the controlling parameters of the hypothesis will be varied individually to test the hypothesis.

Section 4: Prediction (then)

Describe the behavior you expect to see from your data.

This outline is not a contract, it may be changed at any time by Dr. Valencich
Section 5: Experimental Conditions and Observations (data)

Write a concise summary describing the conditions of each experiment, follow with a detailed description of each experiment. Provide a complete description for the first experiment, in the subsequent situations simply state how the conditions were changed.

Section 6: Conclusion

Evaluate whether your experimental design supported your hypothesis as an answer to the posed question. If it did, can you design an experiment to explore the limits of the hypothesis? If not, can you now design a better experiment to test the hypothesis? If not, can you formulate a better hypothesis?

Section 7: Question#2 - What caused the water to rise in the jar?

Repeat the format given above for Question #1.

II. Part II. Report on Scientific Inquiry

This report is to be separate from the first report. It should be written in an essay-style. You will probably need about 400 words (two double-spaced typewritten pages) to write a complete report, however, the essay may be as long or short as you wish. Grading will not be based on the length of the essay. You essay should address three topics: 1. Your definition of “science”; 2. How well does your experiment on the burning candle fit (or not fit) you definition of “science”; and 3. Compare the definition of “science” from at least one recognized scientist with the your experience from topic 2 in this paragraph. The first two topics are relatively straightforward, but we will elaborate on the third.

The preferred definition of science from a recognized scientist will come from printed media and a scientist who has won a Nobel Prize in chemistry or physics is definitely recognized. Examples that fit this category include Einstein, Bohr, and Pauling. You will probably have to do some library research to find such a quote. You will receive less credit if you simply quote our current text or lecture instructor. Be sure to put all quoted material in quotation marks and properly cite your source(s). If you have difficulty finding a quote that you want to use, you may use any other scientist's definition of “science”. Our working definition of a scientist is a person who has earned a Ph.D. in a recognized natural science discipline and who manages and/or participates in scientific research. This definition necessarily excludes ancient scientific philosophers such as Aristotle. We have chosen to focus on a more modern definition to involve actual interaction with a measurable system. You may interview a UM Professor if you wish, please pick someone other than your lecture instructor. Avoid definitions from individuals that are philosophers or journalists.

C. General Lab Report Comments

Since this is your first laboratory experience in the Chemistry Department here at the University of Montana, it is appropriate to address the proper inclusion of data in writing lab reports. For all lab reports, you certainly must use the data collected by you, or by your team. Sometime you may also be directed to use data collected by others or the entire lab. When you use material from additional sources, such as:
1. Data directed measured by others;
2. Constants in calculations; or
3. Numerical values for comparison; put the material in quotation marks and cite your reference. When you paraphrase material (such as this document), cite your source. When in doubt, consult your lab instructor.

E. Reference