AP CHEMISTRY LAB NOTEBOOK

A lab notebook should be used to explain laboratory procedures, record **ALL** lab data, record observations, show how calculations are made, discuss the results of an experiment and explain the theories involved.

A record of your lab work serves to form an important document that will show the quality of the lab work that you have performed. You may need to show your notebook to the Chemistry Department at a college or university in order to obtain credit for the laboratory part of your Advanced Placement Chemistry course. As you record information in your notebook, keep in mind that someone who is unfamiliar with your work may be using this notebook to evaluate your laboratory experience in chemistry. When you explain your work, list your data, calculate values and answer questions, be sure that the meaning will be obvious to anyone who reads your notebook.

YOUR LABS MUST BE WRITTEN IN THE ORDER DESCRIBED IN THIS DOCUMENT. SOME OF THE LAB HANDOUTS YOU WILL RECEIVE WILL NOT FOLLOW THIS ORDER. HOWEVER, YOU MUST CREATE A DOCUMENT THAT ADHERES TO THIS ORDER. ANY DEVIATIONS IN LAB FORMAT WILL RESULT IN GRADING DEDUCTIONS!

Getting Started:

1. Purchase a 100 page bound laboratory notebook with duplicate pages. This can be purchased from me or you can obtain one on your own.

2. Put your name, and class on the front cover. Put your e-mail, address and phone# inside the front cover.

3. The Table of Contents should be kept current as you proceed. Each time you begin a lab, place the title and page number where the lab report begins in the Table of Contents.

4. Always write with ink that DOES NOT dissolve in water! Use only the right hand pages. The duplicate will not be formed on the backside of pages. The left-handed pages will not be graded. You must place the divider between pages or you will press through multiple pages and potentially waste them.

5. When you make mistakes DO NOT ERASE. Just draw ONE line through your error and continue. It is expected that some errors will occur. You cannot produce a perfect, error-free notebook. DO NOT SCRIBBLE OUT DATA! With excessive scribbling, point deductions will be made.

How to Write a Lab Report:

Include the following information in your laboratory notebooks:

1. Fill in requested info at top of lab sheet
- TITLE: The title should be descriptive. Experiment 5 is not a descriptive title.
- DATE: This is the date (or dates) you actually performed the experiment. Include DAY (Mon, Tues, etc.). This will help me remember you performed a lab on a day where something particularly unusual took place.
- NAMES: Your name and your partner's name(s). Include first/last names and spell them correctly!

2. Purpose

A statement that describes what you are attempting to do AND how you are going to do it.
The "how" portion should describe what measurements were taken and how they are going to be incorporated into the chemical equations used. Do not plagiarize the procedure. This section should be no longer than a few sentences.

3. Pre-Lab questions

If the lab has specific pre-lab questions, thoughtfully answer them in your lab notebook. Starting with the 2013/14 academic year, many inquiry questions will be included here. These questions will actually give you many hints about the lab you are going to perform.

4. Illustrated Procedure

Read the procedure given to you and use cartoon like pictures to illustrate each step. This process will be illustrated in class. It's fun! By creating pictures and icons for the procedure, you will have much deeper associations with what you are about to do. **No lab sheets (the ones provided by me) are allowed in the laboratory! YOU SIMPLY MUST CREATE A DETAILED PICTORIAL PROCEDURE. Use more pictures. Use fewer words!**

5. Important Chemical/Safety Data

In this section you will include chemical facts, which describe the physical properties of the chemicals used in lab. Focus primarily on the main chemicals used in the lab and any dangerous products. For your first lab, I would suggest including data on pure Manganese, Hydrochloric Acid, methane gas (CH_4), and hydrogen gas. You can transfer this information from lab to lab as the year goes by to save time. You can include things here that are different from the headings below. Just use your best judgment. What will help you the most?

Chemical (Formula and structure)	Formula weight	Melting pt. (C°)	Boiling pt. (C°)	Flash point (C°)	Solubility	Hazards
Mn (s)						
HCl (aq)						
CH_4 (g)						
H_2 (g)						

6. Data

Prepare neat, orderly, clearly labeled data tables before beginning the lab. Record all of your data directly in your lab notebook. (Never on scrap or notebook paper to be transferred later!) Data includes ***all*** measured values (in some cases this will include qualitative data – such as aromas or colors). Always read measurements on any instrument to as many digits as possible and estimate one additional digit to the 1/10th increment when applicable. Always include proper units (g, mL, etc). SPACE THINGS OUT - don't try to cram everything on one page in a tiny table. Remember, college admission people may have to read your labs and actually understand what you did!

If you truly understand a lab you are about to perform, you will be able to read the procedure and create a data table with no extraneous or missing data. When in doubt, leave room for 2-3 trials.

STEPS 1-6 MUST BE DONE BEFORE COMING TO LAB! IF STEPS 1-6 ARE NOT COMPLETE YOU WILL BE ASKED TO LEAVE LAB & YOU WILL HAVE TO COMPLETE A MAKE-UP LAB REPORT!

7. Observations

If you observe or experience something (color change, something became hot/cold, you bumped into someone and spilled your reagents/products) write it down. Be specific!!! It sounds very suspicious if you are referring to a major incident in your error analysis and there is no mention of it in your observations!!!

8. Calculations and Graphs - *if the lab consists of observations and no calculations, this section can be omitted.*

Show work for ALL calculations. Be sure to write down the equations used first. Then show how your values are substituted into it. If you are doing the same calculation repeatedly for numerous trials, you need only show work for the first trial. Simply state the results of the additional trials.

Consideration must be paid to significant digits! What measurement/calculation limits the accuracy of the experiment? Is this limitation an error? (No!)

If graphs are included, be sure to exhibit good graphing technique. Guidelines for graphing technique can be found on page 1039 in your text (appendix A.4). **ALL STUDENTS** need to create a graph and include it with their lab report. All lab members' graphs should be individually created and unique. You can find a tutorial on how to use Excel to graph on my teacher page: http://www.chemistrygods.net/how-to-graph-in-excel-screen-capture-tutorial.html

- You can complete graphs in two different ways:

a. If you create graphs by hand, the bigger the graph, the more accurate. Such graphs should take up at least 3/4 page. Also, if directly using the graph as a tool (weak acid titration), the smaller the cells on the graph paper, the more accurate the graph will be in determination of critical values. The boxes on the graph paper in your lab notebook are really too big for some graphs. If you create a graph by hand, please use separate graph paper with much smaller gradations. This paper can be purchased or downloaded from many free internet sites. Example: http://incompetech.com/graphpaper/lite

b. If you create graphs using a computer program, GREAT!!! This is much more accurate! If you use a computer program, be sure to print two copies, one for each copy of the lab. When using a computer, you MUST include equations/values representing the derived equation AND the R^2 values.

Be sure to include all relevant graph features:

- Label all axes! What is the graph representing? What are the units? Ex: Temperature (°C)
- Give each graph a descriptive title. "Graph A" is NOT descriptive. "Temperature dependence vs. Time of the Neutralization reaction, A + B ---> C" IS a descriptive title. (Don't forget molarities of solutions, wavelengths, orders of reaction, etc.!)
- Always include a best-fit line - never just connect the dots (computers will do this for you). Make sure your fit is the appropriate style (Solubility of KNO_3 is quadratic/Beer's law is linear/Rate laws are linear)

9. Conclusion

Make a simple statement concerning what you can conclude from the experiment (What is the outcome, trends, etc.?). Very short, provide numbers!

10. Error Analysis

This is a very important section! It tells us if you actually understand what the lab/procedures are about.

A. State your results (experimental) and compare them to what they should have been (accepted).
B. If possible, calculate a percent error.

% error = Experimental – Accepted / Accepted X 100 = % error

Accepted values are also routinely referred to as theoretical values (both terms are acceptable).

C. Use terms to describe if you were close, way off, or only very slightly off. Also, state if your errors are for values above or below the accepted values.

For example, the following statement is a nice one:

"In this experiment, the actual molar mass of the compound, X., is 56.7 g/mol. My experimental molar mass was 64.0 g/mol which is considerably higher than the actual."

D. What are some specific sources of error and how do they influence the data? This is undoubtedly the hardest part. Think of it as if you are a witness in court. You will need to be incredibly specific about what you say. You only get one chance! To be concise and to make this section more readable, feel free to put this information in a tabular (column based) format as illustrated below:

ERROR	EFFECT ON RESULTS
(what happened) - has to be something that actually happened -HUMAN ERROR (my partner's a klutz) is not a reasonable error. It helps if you have an observation cited that supports your statement. - Human error can be an error, but it is still YOUR fault and it is seen as such when your labs are evaluated.	(consequence of what happened) - need to EXPLAIN how the error you mentioned - would cause the results you received. Is the value you are stating too high or too low? -What is something reasonable that could cause a 10% deviation from a desired result? **Quantify your errors!

EXAMPLE: When the experimental result exceeds that of the accepted result.

The following equation is the ideal gas equation: PV = nRT

Explanation of variables: P = pressure in atm, V = volume in L, n = moles, R = a constant, T = temperature in K

Let's say you were supposed to get 22.41 liters for one mole of gas at 1.00 atm and 273.15 K. Instead you got 22.97 liters.

V = nRT/P As you can see, your experimental volume is too high. What measurements could cause it to be too high? Since n is a reference amount of 1.00 mole and R is a constant, they are off limits to scrutiny. Therefore, measurements of T and P are probably related to your error. A T that is incorrectly measured to be too high would provide an answer. A pressure measured that is too low would do the same. What equipment is of the poorest accuracy or precision? What observations do you have to single one variable out? If it was the temp, what is the accuracy/precision of the thermometer? Does this analysis provide you with enough of a margin to explain your error?
[MAKE SURE THIS ERROR IS REASONABLE OR IT IS **NOT** YOUR SOLE ERROR] **Quantify your errors!

- Calculation mistakes and sig. fig. miscalculations are errors (yours). They are not sources of error to be explained in error analysis. Redo your calculations properly and re-evaluate your error analysis!
- State your most significant errors first, and then follow below with lesser errors. Typically, you will need to state about three errors. If your error is very small (less than 2%) you may only need one. An error <5% is considered excellent. An error <10% is considered to be pretty good. Errors over 10% typically reveal many procedural errors.

**How do I quantify an error? Example: Let's say you were collecting some copper that precipitated from an experiment. You were then going to filter it, dry it and take its mass. This experimental mass would then be compared to the theoretical (actual) value determined from the stoichiometry of the reaction.

You determined that your experimental mass is 0.329 grams of copper. Your theoretical calculations provide a value of 0.419 grams. You observed (and recorded as an observation) that two small flecks of copper fell on to the table during transfer. You measured them as being approximately 1.2 mm^3 and 2.0 mm^3 in dimension (cubed). In reality, you could transfer the Cu flecks back into your beaker if possible.

$(1.2\ mm)^3 + (2.0\ mm)^3 = 1.7 + 8.0 = 9.7\ mm^3$ (remember sig fig rules!)

According to this site: http://www.webelements.com/webelements/elements/text/Cu/phys.html
(always cite your source!) copper has a density of 8920 kg/m^3.

$8920\ kg/m^3 \times 1000g/kg \times m^3/1.00 \times 10^9\ mm^3 \times 9.7\ mm^3 = 0.087\ g$

You were off of the accepted value by 0.090 grams (0.419-0.329).

You just quantified approximately 97% of your error in one statement!

11. Post Lab Questions

Answers to any post lab questions will be listed here. You do not have to copy the question into your lab notebook. However, you must somehow include enough of the question in your answer so at a later time, you can decipher what the question was. You must state your answers clearly. Use objects in your responses that are very specific (Do not use "it".). Use proper punctuation and complete sentences. If there are no questions, omit this section.

The End!

Significant Figures & AP Chemistry Lab

For the most part, sig figs are of low importance due to the fact that test problems are simply made-up. They are not based on measurements and therefore the numbers are insignificant. But in chemistry lab . . .

Sig Figs are extremely important and it is for this reason that we need to understand the rules!

The Rules:

1. Any digit that is not zero is significant.
2. Zeros between nonzero digit numbers are significant.

3. ATLANTIC - PACIFIC RULE (Atlantic ∝ right/Pacific ∝ left. Get it?) :

- Decimal point PRESENT. Come from the PACIFIC side. Ignore all zeros until you get to a nonzero number. ALL remaining digits are significant.
  EX: 0.007150 g = 4 sig figs 100. g = 3 sig figs

- Decimal point ABSENT. Come from the ATLANTIC side. Ignore all zeros until you get to a nonzero number. ALL the remaining digits are significant.
  EX: 100 mL = 1 sig fig** 100 cm = 1 sig fig (well, kind of)**

**You thought it was *that* easy? It's not! In chemistry numbers are measured! You would measure 100 ml using a graduated cylinder or a buret. A buret is accurate to 0.1 mL increments. Don't forget that you would also be estimating to the best of your ability $1/10^{th}$ of an increment. Therefore, 100 mL would actually be 100.00 mL and have 5 sig figs. Get it? The numbers above described after the heading "decimal point absent" may be given in a lab description. A lab might say, "Add 100 mL of HCl to your beaker." You would record the actual sig figs based on your method of measuring that 100 mL.

4. In scientific notation, whatever numbers are given are significant.
   EX: 1.09×10^{15} atoms = 3 sig figs 6.80×10^{-12} m = 3 sig figs

7. EXACT numbers obtained from definitions or by counting numbers of objects can be considered to have an infinite number of significant digits.
   EX: 1 meter = 100 cm or 1000 mm 1 mole = 6.022×10^{23} particles

8. CALCULATIONS:

A. **Addition and Subtraction**: Add/Subtract like normal. The final answer is then rounded to least precise place within the calculation. IT'S ALL ABOUT PLACES!!

EX:
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  58.690        So it's          78.935        So it's
 100.3          158.1          - 78.62         0.32
+  0.24                          00.315.....
 158.141....
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B. **Multiplication/Division**: Multiply/Divide like normal. In the final answer, the number of sig figs is equal to the smallest number of sig figs that went into the calculation. IT'S ALL ABOUT NUMBERS OF SIG FIGS!!

EX: $58.3 \times 6.0 = 349.8$ or $\underline{3}50$ $2.8 \times 4.504 = 12.6112 = \underline{1}3$

(some would place a line over the 5 or say it's 3.5×10^2)

(see how the "slop" in the 2.8 measurement limited the accuracy in the 4.504 measurement?)

C. **MULTI-STEP CALCULATIONS**:

- If the calculation involves ALL multiplication and/or division, wait until the end, and then consider sig figs.

EX. $\frac{(2.560)(8.8)}{275.15} = 0.08188 = 0.082$ $\frac{(\underline{2}500)(1.6093)}{1000.0} = 4.023 = 4.0$ (assuming 2500 has 2 sig figs)

- If the calculation involves BOTH multiplication/division AND addition/subtraction, determine the sig figs at each intermediate step. The use of dimensional analysis will limit the number of steps required to solve a problem.

EX. $\frac{(0.974)(0.128)(32.00)}{(0.0821)(273+24)} = 0.163613 = 0.164$ $\frac{1.00866 - 1.00728}{6.6789 \times 10^7} = 2.066208 \times 10^{-11} = 2.07 \times 10^{-11}$

Those of you who use graphing calculators to solve lab calculations need to be careful! The calculators simply spit out mathematical answers with no adherence to the method used in measurement. Your calculator will give you an incorrect answer most of the time. You need to think through the rules and decide where rounding applies.

CHEMISTRY RULZ DUDE!