Handout 3: How to Write a Procedure, Format Data Tables, and Results Tables

After writing the purpose and introduction, you will write the procedure. Before each lab begins, read over the lab carefully. Take some notes, jot down ideas about the lab, and underline key points in the lab manual. This will make it easier to write the purpose, introduction, and procedure.

From HANDOUT 1, each lab needs a title and a number. Using HANDOUT 2.1 and 2.2, 'How to write a Purpose and Introduction', should help you formulate a clear purpose and introduction for each lab. The purpose of this handout is to give guidelines about good procedures, data tables, and calculations sections, which most, if not all, labs have.

From the formatting handout, the procedure is the step-by-step method to perform the lab. Any procedural point from the lab instructions that requires an observation or a data collection point is written lab book in the procedure. Omit the informational procedure points.

Look at a page in the lab book. Notice that the paper is divided into two columns [if it is not, divide the page into two sections]. The column on the left-hand side of the paper is used for writing the procedure; the column on the right hand side of the paper is used for observations and data collection. Some procedures will be long and involve repetitive steps; these require repetitive steps in the procedure section. Read the addendums (pre-lab sheets) to the lab, sometimes you can skip writing repetitive steps.

PROCEDURE

We are going to first discuss how to write procedures for the types of labs you might encounter in class. The procedure should be clear enough so that it is understandable without having to check back with the lab manual. Some students prefer to photocopy the procedure and tape it into their lab book. THIS IS NOT A GOOD IDEA **AND YOU WILL LOSE POINTS FOR THIS**! Writing the procedure gives a clearer understanding of the steps to complete the lab. Also, I find that many students are concerned about keeping a neat, almost pristine, error free notebook. Science is about making mistakes and learning from those mistakes. The procedure section SHOULD be neat; the Observation section should be LESS neat.

Many of the labs involve both qualitative and quantitative data collection. Some of the labs, however, are strictly qualitative labs. We begin by writing a procedure for Part Ib of Experiment **1:** Use of Common Lab Equipment, and Determining Significant Figures in Equipment

Summarize the information given in **Part 1a** into a list of steps that are easy to understand and follow, (see below) notice that the list is placed on the left-hand side of the page, leaving plenty of room to write observations and data. Leave about ½-1 cm of space between unrelated procedural points; this holds true for observations as well. The idea is not to cram everything into a small, unreadable note.

BEFORE CLASS

Procedure	Data & Observations
Part Ia: Mass Of A Metal Sample Using Centigram Balance By Indirect Method	
1. Prepare the balance for use 2. Tare balance 3. Place weigh paper on balance 4. Record mass to ±0.01g 5. Place slug on paper 6. Record mass to ±0.01g	

Notice that not all the procedure is included from the lab experiment. Summarize the first paragraph into one sentence. Write down the precision needed for the mass measurement. These precisions are often given in the lab manual, but if they are not, read the pre-lab handouts, or infer them from Table 1 in Experiment 1. Table 1 lists the precision of various pieces of equipment.

The procedural section is complete before lab begins. The instructor (Me!!) collects the copy of pre-lab before the lab starts, or come around and checks for the pre-lab during lab. Points are awarded for preparing the pre-lab AHEAD of time, and lost for doing a crappy job.

Procedure	Data & Observations
Part Ia: Mass of a Metal Sample using Centigram balance by indirect method	
1. Prepare the balance for use 2. Unknown metal 1	Tared, and ready to go # 35, silver grey, rectangular, shiny
3. Place weigh paper on balance	
4. Record mass to ±0.01g	2.39g
5. Place slug on paper	
6. Record mass to ±0.01g	~~26.02g~~ *PA 1/23/1845* , 26.46g

Notice that the data and observations line up with the steps of the procedure. The data and observations are written directly into the lab book, in INK. The data shows the correct precision and units. The unknown number is present. The appearance of the metal is noted as neatly as possible. The student (me) made a mistake recording data. The number is crossed out, initialed, and the new data is written next to the mistake. The student did not use white out or scribbles. Pen is required for lab reports because proper data recording dictates mistakes are documented as such; mistakes in data collection will not reduce the overall grade of the lab-scribbles will. Record intermediate steps and thought processes during the experiment. Writing in pen insures academic integrity.

Now we will write a procedure for a lab that has a lot of qualitative data: Experiment 8 Double Displacement Reactions and NIE. The procedure can be written as follows:

PROCEDURE	*DATA & OBSERVATIONS*

There are 15-16 reactions that will be observed in this lab.

1) Clean 8 test tubes and rinse with distilled water
2) Obtain the reactants for the first four reactions.
3) Place 1 millileter of reactant A in one test tube and 1 milliter of reactant B in a second test tube.
4) Record the appearance of the reactants before mixing
5) Add reactant A to reactant B
6) Record the appearance and physical changes of the product
    a. 0.1M NaCl & 0.1 M KNO_3
    b. 0.1M NaCl & 0.1 M $AgNO_3$
    c. 0.1M Na_2CO_3 & 6M $HCl_{(aq)}$
    d. 6NaOH & 6M $HCl_{(aq)}$

Again, we start the lab and make observations and data collections on the right hand side of the paper. Here is the same section as above, but I have filled in data and observations that might occur in this section of the lab. The observations are clear and detailed. The procedure and observations are typed here for ease of presentation.

PROCEDURE	DATA & OBSERVATIONS
1) Obtain the reactants for the first two reactions. 2) Place 1 milliliter of reactant A in one test tube and 1 milliliter of reactant B in a second test tube. 3) Record the appearance of the reactants before mixing 4) Add reactant A to reactant B 5) Record the appearance and physical changes of the product	
a. 0.1M NaCl & 0.1 M KNO_3	NaCl: no color, no odor, transparent, no tyndall effect, nc with red or blue litmus KNO_3: no color, no odor, transparent, no tyndall effect, nc with red or blue litmus **Product:** no change in temperature, created solution presents clear, no color change, no tyndall effect, nc with red or blue litmus
b. 0.1M Na_2CO_3 & 6M $HCl_{(aq)}$	0.1M Na_2CO_3: no color, no odor, transparent, no tyndall effect, red litmus turned blue 6M $HCl_{(aq)}$: no color, transparent, blue litmus turned to red **Product:** slight fizzing, tube felt warm, clear solution, no color, no ppt, changed litmus from blue to red

DO NOT UNDERESTIMATE HOW QUICKLY YOU WILL FORGET EXPERIMENTAL DETAILS.

DATA TABLES

Once the experiment is finished, separate the necessary data from the unnecessary data. This requires organizing the data into a table. It is easier to do the calculations, and draw conclusions if data from the different parts of labs are not combined as this simplifies and unifies the data. The data tables should have headings and units, when necessary. Use a ruler to make the table. Neat tables and neat sketches are easier to interpret. Remember, data tables make referencing and analyzing the data easier. Calculated information, such as density, does not go in the data table. The data table is the collection of raw values and observations. Each data piece needs correct units and significant figures.

Part Ia Mass of Metal Sample Using the Indirect Method

Unknown #	UK# 35
Appearance	silver grey, rectangular, shiny
Mass of weigh paper to ±0.01g	2.39g
Mass of slug and paper to ±0.01g	26.46g

The data and observations for Experiment 8: Double Displacement Reactions and NIE**,** can be organized as presented below. Notice that the observations are summarized in the data table. The data table contains no conclusions or calculations; identification of the product is a conclusion. And YES! Sometimes the data tables look very similar to the raw data collected.

Data tables	
0.1M NaCl & 0.1 M KNO_3	NaCl: no color, no odor, transparent, no tyndall effect, nc with red or blue litmus KNO_3: no color, no odor, transparent, no tyndall effect, nc with red or blue litmus **Product:** no change in temperature, created solution presents clear, no color change, no Tyndall effect, nc with red or blue litmus
0.1M Na_2CO_3 & 6M $HCl_{(aq)}$	0.1M Na_2CO_3: no color, no odor, transparent, no Tyndall effect, red litmus turned blue 6M $HCl_{(aq)}$: no color, transparent, blue litmus turned to red **Product:** slight fizzing, tube felt warm, clear solution, no color, no ppt, changed litmus from blue to red

CALCULATIONS AND DATA ANALYSIS:

Callculations follow the data tables. Put all the calculations in the lab book and keep them separate from the data section. The calculations should show a complete setup with proper significant figures and units. Every value that is used in a calculation must have the correct significant figures and units, not just the answers. Show all the calculations in this section even if an analysis might have been done in triplicate. If arithmetic errors occur and the calculations are together and labeled as to what is being calculated, the errors will be easier to find. Reference the part of the lab that is linked to the calculations.

DO THE CALCULATIONS ON SCRATCH PAPER BEFORE YOU ENTER THEM IN THE LAB BOOK.

For example, in Experiment 11, the mass of copper samples before and after the reactions, and the percent recovery needed to be calculated. The calculation section might look like this:

Part Ia Mass of Metal Sample Using the Indirect Method

Unknown #	UK# 35
Appearance	silver grey, rectangular, shiny
Mass of weigh paper to ±0.01g	2.39g
Mass of slug and paper to ±0.01g	26.46g
Mass of slug	24.07
Recorded mass of slug #35	24.20g

$$\frac{(24.20g - 24.07g)}{24.20g} X100 = 0.537\% \; error.$$
$$Adjusting \; for \; Significant \; figures, 0.54\% \; error.$$

This is also the section where the calculations for creating a graph are recorded. Remember that graph data is scaled to the paper. The scale follows the 1-2-5 rule. Graphing is discussed in more detail in the GRAPHING HANDOUT.
GRAPHS: (see graphing handout)

RESULTS TABLE

The results of calculations should go into an easy to understand results table. One should be able to read the results in the table and be able to connect that result to a calculation in your calculation section, and to the purpose of the lab. The same care to significant figures and units that are presented in the Calculations Section is shown in the results table. Put the net ionic equations here and summarize your observations.

Listed below are several Results Tables: Data only, observations only, and combined. Compare the results section with the data tables. The data tables contain no calculations or conclusions. Looking at the quantitative portion of the lab, the data table has raw observations. The results section has observations and conclusions. It also shows percent error and difference.

DATA TABLE ONLY:

Experiment 1: Ia

Experimental Mass of Uk #35	24.07g
Recorded mass of Uk #35	24.20g
Percent error	0.54%

OBSERVATON TABLE ONLY
Experiment 8: Reaction c

Net Ionic Equation	Conclusions
$CO_3^{-}{}_{(aq)} + 2H^+{}_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$	Carbonate and acids create carbon dioxide gas and water and heat. This is evidenced by the bubbles and the rise in temperature. Carbonates are basic in water. This is an acid/base reaction. No ppt is produced in this reaction. The litmus changed from blue to red indicates that there is more acid present then base, passing the neutralization point.

COMBINED DATA AND OBSERVATIONS

Experiment 11: Reactions 1

Net ionic equations	Conclusions
Part 1:	
$3Cu_{(s)} + 8\,H^+{}_{(aq)} + 2\,NO_3^{-}{}_{(aq)} \rightarrow 3\,Cu^{+2}{}_{(aq)} + 2\,NO_{(g)} + 4H_2O_{(l)}$	The reaction produced aqueous copper(II) ions and nitrogen monoxide gas.

Results section: Percent recovery of copper
Mass recovered 0.08g
Mass percent recovered 70%

Notice also that each section leads into the next section. Careful observations and data collection lead to a good data table. A good data table makes calculations easy to do and follow. Calculations and observations lead to insightful conclusions for a result table. The result table should have the relevant theoretical data or predictions for comparison. The EVALUATION AND SUMMARY SECTION, which we will discuss in the next handout, comes from analyzing the data and making a good results table.