Guided Inquiry

The guided inquiry lab is designed to introduce you to new material in a hands on way. You are given certain tasks to do. During each task you are to make observations about what is happening. At the completion of each task you are then asked to interpret what you observed. Did something happen? Did a color change? Did the beaker warm up or cool down? And most importantly: Why?

In this lab you are the scientist. You will conduct an experiment and then try to explain it with the observations you have made. Just like our scientists today you must follow certain rules. Whatever conclusions you come to, **MUST** be supported by your observations. And actually, in the real world, your conclusions must also be supported by the data of everyone else. You must use reason and logic to come to your conclusions explaining each step and each assumption. Consider yourselves like the great detective Sherlock Holmes. You must observe the clues then discover the truth.

My role in this adventure will be to watch your backs. I will be watching to make sure that you are safe as well as doing the procedures correctly. I **CANNOT** answer any questions which relate to: Is this right? What answer should I get? The only questions I can answer are things like: Where is the zinc? How do I rinse out the buret correctly? Aren't you the greatest T.A. ever?

To help you out, I'm providing some basic information about graphing and titrating.

Graphing

Whenever you graph something, you must be sure that the graph you produce would give the reader the proper impression. It is very easy, to mislead someone with graphs by using lines, bars, or pie slices. Data can easily be misrepresented in a graph, so you should be very careful how you display it.

Some terms you should know:
Abscissa – The x-coordinate or axis running perpendicular to the y axis. The horizontal axis.
Ordinate – The y-coordinate or axis running perpendicular to the x axis. The vertical axis.
Legend – An explanation or label of markers or lines on a graph.
Linear Regression, Least Squares, or Best Fit – A straight line either calculated or drawn through your data. This line can then be used to predict one variable given another.

When graphing, you should use a linear graph. This means that your axis should be linear. Some graph types are not linear so be careful. If you are using Excel, use the *scatter* type graph. An exception to this rule is when you graph something on a log scale. For now, just be thankful that you do not have to do this.

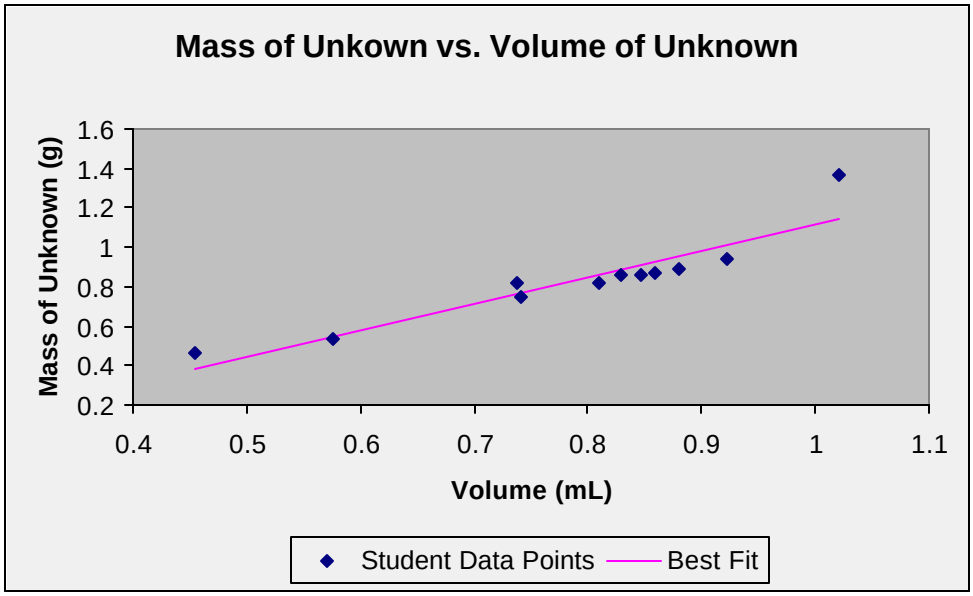
You should always be very careful about using pie and bar graphs. These types of graphs can be misleading. In science, they are almost never used.

The title of a graph indicates the Ordinate vs. Abscissa. For example, in the graph below, the y axis is "Mass of Unknown" while the x axis is "Volume of Unknown." Therefore, the title is Mass of Unknown vs. Volume of Unknown. You cannot entitle your graph anything else like: "Fred's graph," "The Really Weird Graph," or "A Few Dots And A Line."

Each axis will have its own title. The title **must** include the units of the measured value.

Legends are optional. In the graph below, the legend helps explain what the line is and what the points are. In most cases though, you will not have multiple objects to explain on your graph.

The graph below contains the data points taken by another class in the lab where the density of an unknown was determined. The x axis is the volume of the unknown liquid in the pycnometers. As you can see, there was a wide range of pycnometer sizes and hence volumes. The y axis contains the mass of the unknown liquid which was placed in the pycnometer. The plotted data shows a somewhat linear relationship so I used a least squares calculation or linear regression or best fit to draw the pink line. Is this data linear? What does it mean if it is linear?



Titrations

Whenever titrating, you are actually adding a known amount of something with a known concentration to an unknown. Hang on, I'll explain. Let's look at this in a qualitative way first. Let's say we have black paint and white paint. We want to make grey paint so we slowly start to add the black paint to our can of white paint. For each drop of black paint that we add it mixes with an equal amount of white paint to make our desired gray color. If we add slowly drop by drop we will eventually reach our desired gray color. This is our endpoint or goal. Let's say that Bubba, who is impatient, decides to pour the entire can of black paint into the white paint jar. After mixing we find that the color is too dark. Bubba has just over titrated or titrated past the endpoint. As a second example, let's say that Bubba is doing it correctly by adding the black paint slowly. Again he is impatient though and stops before reaching the desired color. This would be considered under titrating or not titrating to the endpoint. In either case, Bubba's wife, gets upset and Bubba sleeps on the couch.

In lab, you will sometimes need to measure how much of some chemical is in a liquid. To do this, we can add another chemical, our black paint so to speak, to our unknown amount of chemical, our white paint. As long as the two chemicals react in a certain way, we can tell when you have just reached the point where you have run out of the unknown chemical. Once you've run out of the unknown chemical, any further additions of a known chemical will result in an

excess of that known chemical. By using what is called an indicator, we will know when this point is reached.

For example:

$$HBr + KOH \rightarrow KBr + H_2O$$

If we have a solution of HBr, but don't know how much we have, we can find out by titrating with a known amount of a known concentration of KOH. Let's say you add an indicator, which changes colors when the KOH is in excess. Then you add small amounts of a 2.0 M KOH solution until the indicator changes colors. When you observe the color change, you note what total volume of KOH added was 25.12 mL by appropriately reading your buret. By noticing that in the above reaction, one mole of HBr reacts with exactly one mole of KOH, we can calculate the number of moles of HBr in the solution.

$$\frac{2.0\ moles\ KOH}{L} \times 0.02512\ L = 0.05024\ moles\ KOH$$

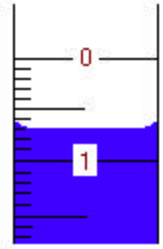
This is the total number of moles of KOH added to the HBr solution. If it reacts in a one to one ratio then we can calculate the number of moles of HBr in the solution.

$$0.05024\ moles\ KOH \times \frac{1\ mole\ HBr}{1\ mole\ KOH} = 0.05024\ moles\ HBr$$

Some terms you should know:
indicator – Chemical used to indicate by changing color when an endpoint has been reached.
endpoint – The end of a titration indicated by a color change of the indicator. It means that the titrant is now in excess in the solution being titrated.
titrant – The chemical of a known concentration being used to find the amount of unknown chemical.

Reading a Buret

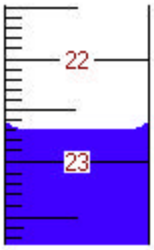
Always remember, the top of a buret has the zero mark. So the numbers increase going from top to bottom. The buret on the right shows an example of a buret ready to begin titrating. Note that the liquid level is near the 0 mark. This is what you want. You do not want the water level to be above the 0 however. That would mean that you are off your scale and then you would not be able to tell what volume of liquid you have titrated. In this buret, the bottom of the meniscus is between the 0 and 1 mL marks. By closer examination we see that the meniscus is actually between the 0.7 and 0.8 mL marks.



Remember, that when making measurements, we are allowed to determine volumes between the smallest tick marks. So we can say that the meniscus is located at 0.72 mL. In lab, this is what you will be required to do. You will need to read to two decimal places. Also remember though that the amount of error associated with your reading it this way is half of the smallest division or tick marks. The tick marks are in 01 mL divisions. Therefore the error is ± 0.05 mL. Our single reading is therefore reported as 0.72 ± 0.05 mL. I don't believe we will be requiring you to indicate the errors associated with your measurements again though.

Note the level of your meniscus before titrating. In this case it is 0.72 mL. Then titrate by adding slowly to your solution. Remember to add the appropriate indicator to your solution, otherwise you will be doing this until the end of time. When you add your titrant, you should do so slowly. As you add your titrant stir your solution to mix the two liquids thoroughly. Watch for small color changes. You should see some color when the titrant just hits the solution with indicator. Then as you stir, this color will go away. If it goes away rapidly, then you are not very close to your endpoint. If it goes away slowly, then you are close to your endpoint and you need to add your titrant drop wise.

When you reach the endpoint, you must again read the level of the meniscus in your buret. The buret on the right here has a meniscus between the 22 and 23 mL marks. By closer examination, we see that the level of the meniscus is between the 0.7 and 0.8 mL marks again. Using our very sound judgement, we therefore record our final volume as 22.73 mL.



Now we can use our initial and final recorded values to find the total volume of liquid added to our beaker or flask. This is simply, the final – the initial.

22.73 mL
-0.72 mL
22.01 mL

The total amount of titrant added is therefore 22.01 mL. If it was 2.0 M KOH then we can calculate both the number of moles of KOH added as well as the number of moles of HBr in the solution.