Mass, Volume, And Units

“In this experiment, we’re going to be looking at mass, volume, and units. Specifically, we’re going to be looking at the density of aluminum.”

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Units of Conversion

“An important part of taking measurements and recording data in chemistry lab is looking at the units. For almost all numbers you’re going to record in this class you need to write down the units that go with them. Without them the numbers are meaningless. If I just have the number four written down, am I talking four grams, four milliliters? What does it mean? Always include the units. This will also help when you’re doing problems. Many of the problem-solving skills you’ll need come from looking at the units you’re given and looking at the units you need in your answer and figuring out how to get from one to the other.”

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Example – How many inches are in 2.5 miles?

Let’s look at an example. How many inches are in 2.5 miles? When I’m faced with a problem that looks like it’s going be involving unit conversions I start writing down all the different conversion factors that I know involving the units given. So in this case, I’ve got inches; I know that 12 inches equals 1 foot; I know 3 feet equal 1 yard; and I know 5280 feet equals 1 mile. Now it may be that I write down a conversion factor that I’m not going to end up needing, but it’s usually easier to have all the things that you might need written down before you start the problem.

So we’re going to start out with looking at the number of inches in 2.5 miles. So we need say, ‘Well we know we have 2.5 miles’, and I know that miles is going to be on the bottom of the next fraction, so that it will cancel out; and so the best conversion factor for that will be the last one we wrote, 5280 feet equals one mile, so miles cancels with miles. The next step, I’ve got feet, so I know I’m going to have that on the bottom, and I’m trying to get to inches and if I look up here I see I have a conversion factor directly from feet to inches, so 1 foot equals 12 inches; and I see that feet cancels with feet. So the only thing that I’m left with now is inches. And to find the answer to that, I just need to multiply across; so 2.5 times 5280 times twelve, and I get 158,400 inches. Now the next thing I need to do is write this number in the correct number of sig figs; and if we look back at our values used, well we know that 12 inches is an exact number, so that isn’t involved in our sig figs, and we look back at the original number in our problem, which is 2.5. So this tells me that I need to give two sig figs in my final answer. Well the only way to do that with such a large number is to use scientific notation. So I’ll write 1.6 times 10 to the one-two-three-four-five times 10 to the 5th inches; and this will be my final answer – notice that I have the correct number of sig figs and I’ve included a unit in the answer. As it turned out, I didn’t need to know that conversion from 3 feet to 1 yard. But it doesn’t hurt to have a little bit of extra information.
Measurements

So in this lab, we’re going to be taking in some different types of measurements, and we’re actually going to be measuring physical quantities - we’re going to be measuring mass, volume, dimensions – and the reliability of these measurements depends on two things: both the quality and the accuracy of the instrument or glassware we’re using, but also the skill of the experimenter. We understand that many of you have not used some of the glassware and equipment that you’ll be using in the course, and that’s OK. There are instructions in Chapter 3, and your TA is always happy to help.

Significant Figures

We also need to worry about significant figures. You should always record all of the significant figures you have when making measurements. For example, when using the balance, if it has four decimal places for the mass, you should write all the decimal places down, even if you think you’re probably going to be rounding to zero sig figs. Again, it’s better to have too much information, than not enough information. When looking at glassware, you should always estimate one additional decimal place beyond the markings on the glassware. Always assume that the last digit is in fact an estimate.

Let’s look at an example. I’m going to draw some markings of a graduated cylinder. So we’re going to mark this as 2, 2.1, and 2.2. Now when we pour a liquid into a graduated cylinder, it forms a meniscus, which is a slight curve in the top of the liquid. Now when I’m measuring the volume here I see that it’s going to be 2.1, but I’m can estimate how far it is between the 2.1 and 2.2 mark; so it looks to be about half way, so I’m going to estimate 2.15 milliliters. It’s assumed that the 5 is estimated; if I were to write this as 2.1 ml, then someone else looking at my data will assume that the 1 is estimated, but we know that it is 2.1-something, so we don’t want to do that. We always want to estimate one decimal place beyond the markings on the glassware.

Sig Fig Rules

And if you don’t remember them, you probably need to review the sig fig rules in your textbook. There’s a few things you need to look at, including the non-zero digits, zeroes, dealing with exact numbers – things like ‘there’s exactly 12 inches in 1 foot’, addition and subtraction rules, and multiplication and division rules. If you need help with these, check with your TA or go to the Learning Center for more help.
**Precision vs. Accuracy**

We’re also going to be evaluating two different things in this experiment: precision and accuracy. These two things mean something very different. **Precision** means how close your values are to one another. So if I record the mass of a sample five times and I have very low standard deviation, I can have high precision; that tells me all my values are very close to one another. **Accuracy** tells us how close our values are to the accepted value. So if I have a low percent error, that tells me that my experimental values were close to the accepted values. There are other videos which will demonstrate how to do these calculations; you can also ask your TA or go to the Learning Center for more assistance.

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**Density**

So now we’re getting to density, which is what we’re actually going to be determining for aluminum. We’re going to use the mathematical combination of mass and volume. In general, for most liquids and solids it’s reported in grams per milliliter (g/mL). Density is and **intensive** property, meaning it doesn’t matter if I have 10 mL, 100 mL, or 1 L of something; if it’s the same solution, the density will be the same as long as the temperature is constant. For example, water has a density of 1.00 g/ml at 20°C; this does change with the temperature, but only slightly.

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**Determine Density Graphically**

We can also determine density using the graphical method. So here’s an example graph of some data for some mass and volume measurements that have been recorded. If we look at the data points, we can see that we have mass on the Y axis and volume on the X axis. Remember that the equation for a line is y=mx+b. And m is our slope. And remember the old saying, rise over run or the change in y over the change in x. So when we’re looking at our graph, if we look at the slope, we’re going to have mass over volume which is the definition of density. So when we look at the formula of a line, we see that we have m, which is the slope, which is the same as density. If we look at our graph and look at the data generated by the graph, the slope will be the density of our sample.

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**Volume by Displacement**

In order to measure the volume, sometimes we can just measure the dimensions of the object. If we have a cube, it’s pretty easy. However, sometimes we have odd shaped objects that aren’t easy to measure and so we use a technique called volume by displacement. You measure the volume of liquid in the container using something like a graduated cylinder that’s very accurate. You add the object and
then you can measure the volume of liquid after. The change in the volume of water or whatever solution you are using will be the volume of the object you placed inside of it.

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**Volume by Displacement**

There are a couple of conditions. You have to be concerned about these because it can happen. The liquid must not be one that will react with the solid in the timeframe of the experiment. So if something is a very slow reaction over days it will be OK to measure it in there for just a few seconds. And the density of the object must be greater than that of the liquid. If the solid is floating on top of the liquid then you are truly not getting the exact volume of that solid. So you have got to make sure that your solid will sink in the solution or the liquid that you are using.

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**Writing the procedure**

Now for this experiment you will need to write a procedure, so the best thing to do is to start by reading the introductory material and read the data analysis questions and determine the data that’s needed to answer those questions. Start by making a list of all the information you need including things like density, well to find density, you’ll need mass and volume. Think about some of the following things: measuring multiple sample of multiple sizes; think about what the graph would look like if the pieces of foil are all the same size and therefore will have the same mass and same volume. The shape of the foil, does it matter if you crumple it in a ball or roll it up? And the type of glassware needed. Are you going to use a beaker a graduated cylinder and if so, what size glassware is needed. As a general rule, you always want to use the smallest glassware possible as it tends to be the most accurate when dealing with the volumes you’re measuring.

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**Writing the procedure**

You do need to write the procedure with enough detail that someone else could repeat the experiment with only your procedure and get similar results. Explain each step you take. If you record the volume by displacement, explain how you do that. It’s OK to change your procedure as you’re doing the experiment. Its’ only the final procedure that goes in your lab report. So if you get into lab and realize that something’s not working the way you thought it would, make the change, write it down and include that change in your final version.

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**Lab Notebook**

You also need to keep a lab notebook. The best thing to do is before you come into lab is to set up that lab notebook. If you are going to need tables for you data such as your mass volume pairs for different
samples, set up the table, make a list of the data you need. Write in units, draw lines or boxes where you are going to fill in numbers. The goal is when you come to lab, you’re just going to filling the numbers and not having to write a bunch of information. This will save you a lot of time and frustration because it makes sure you have all the information you need before you leave class. There are example pages in your lab notebook showing what lab notebooks should look like before you come to lab and after you leave lab. Please look at these examples. Just like with the procedure, it’s OK if it’s not perfect when come to class. Make a single line to mark out the incorrect information and rewrite the new information. It doesn’t have to be perfect. Lab notebooks are meant to be the original record of your data and should be just that. Don’t feel the need to rewrite them, to write on a scratch piece of paper to copy it into later. Just record the information directly in your notebook. If you have questions or need help with the procedure, the experiment or anything else, please talk to your TA, go to the learning center or talk to the lab supervisor