UNIT CONVERSION AND PROBLEM SOLVING

In any chemistry course students are often asked to interconvert quantities with different units. It can be as simple as converting centimeters to inches or as complex as converting the mass of a limiting reactant to amount of product in a stoichiometry problem. While the type of problem can vary widely in an introductory chemistry course, the basic skill itself is the same and is the focus of this lab tutorial. Due to the importance of this skill throughout the course all students are encouraged to understand it and ask questions throughout this tutorial session.

In any problem the student must first identify what the problem is to solve. In other words what is the goal or answer to the problem? The student must also be able to recognize what quantity they are supposed to take and convert into the desired answer or goal of the calculation.

Consider the following example where a student is asked to convert the following mass quantity from the typical units of lbs. into the metric unit of kilograms(kg). This is a basic unit conversion problem.

Ex:1 Convert the following mass of a person that weighs 172 lbs into kilograms(kg).

Step one is to first identify what is the student being asked to do. In this problem the student is asked to take 172 lbs and through a mathematical process convert to kilograms(kg).

$$172\ \text{lbs} \times ? = \text{kg}$$

In this calculation you are simply converting the units so you can not alter the amount of 172 lbs. In other words you cannot alter how much the person weighs. The only mathematical operation that does not alter the numerical amount is to multiply by a factor of 1.

$$172\ \text{lbs} \times 1 = 172\ \text{lbs}$$

Unfortunately multiplying by 1 does not change the units. To change the units we need an equality. An equality is a known relationship that relates one set of units to another. For this problem the equality needed is:

$$1\ \text{lbs.} = 0.4536\ \text{kg}$$

which means that 1 lbs. is defined to have the same mass as 0.4536 kg. In other words

1 lbs. is equivalent to 0.4536 kg or 0.4536 kg is equivalent to 1 lbs. This equality is a known relationship that the student can look up or be given. If you are expected to memorize such equalities, check with your instructor.

If you take an equality and convert it into a fraction, the numerical value of that fraction will always be equal to 1.

$$\frac{\text{numerator}}{\text{denomenator}} = \frac{1\,\text{lbs}}{0.4536\,\text{kg}} = \frac{0.4536\,\text{kg}}{1\,\text{lbs}} = 1$$

In unit conversion and problem solving it now simply becomes a problem of which term gets placed in the numerator and which term gets placed in the denominator. In a unit conversion the units we are changing from appear in the denominator so that they may cancel out leaving us the desired units in the numerator.

$$\text{given unit} \times \frac{\text{new unit}}{\text{given unit}} = \text{new unit}$$

When applied to this problem we are given 172 lbs and use the equality with the 1 lbs. in the denominator and the 0.4536 kg in the numerator.

$$172\,\text{lbs} \times \frac{0.4536\,\text{kg}}{1\,\text{lbs}} = 78.0\,\text{kg}$$

When the math is performed it can be seen that 172 lbs. is equivalent to 78.0 kg. Since 1 lbs. is approximately half the amount in kilograms(1 lbs. = 0.4536 kg) it makes sense that 78.0 kg is about half numerically to the 172 lbs.

In more complex problems in which multiple equality and unit conversions are required the above steps can be repeated until the desired amount is achieved.

Ex:2 Calculate the number of seconds in 31.0 days.

In identifying what this question is asking it can be seen that the quantity 31.0 days must be converted from the unit of time in days into seconds.

$$31.0\,\text{days} \times ? = \text{seconds(s)}$$

It is important to look up and list the equalities needed to solve this problem. We know the problem is solved when we are left with the units we are looking for in seconds(s). Known data:

$$1\,\text{day} = 24.0\,\text{hours}$$

$$1\,\text{hour} = 60.0\,\text{minutes}$$

$$1\,\text{minute} = 60.0\,\text{seconds}$$

Going back to our problem we take the 31.0 days and use the equality that relates days to hours(1 day = 24.0 hours).

$$31.0\,\text{days} \times \frac{24.0\,\text{hours}}{1\,\text{day}} = 744\,\text{hours}$$

This allows us to convert 31.0 days into 744 hours. Since this is not the desired answer we must continue using an equality that contains hours(1 hour = 60.0 minutes). It should be noted that we cannot use the equality 1 day = 24.0 hours because it would give us the original quantity back again.

$$744\,\text{hours} \times \frac{60.0\,\text{minutes}}{1\,\text{hour}} = 44600\,\text{minutes}$$

Since this is still not the desired units we continue using the equality 1 minute = 60.0 seconds.

$$44600\,\text{minutes} \times \frac{60.0\,\text{seconds}}{1\,\text{minute}} = 2680000\,\text{seconds}$$

Here we are left with a quantity in the desired units of seconds so we are finished. Intuitively we know there are many seconds in a day so it would be expected that there is a large number of seconds in 31.0 days. When the calculated answer agrees with the expected result it helps ensure that the unit conversion is done correctly.

The above problem took three unit conversions to achieve the desired quantity. The calculation could also be done in one single step with each equality used until the desired units of seconds appeared in the numerator.

$$1\,\text{day} = 24.0\,\text{hours}$$

$$1\,\text{hour} = 60.0\,\text{minutes}$$

$$1\,\text{minute} = 60.0\,\text{seconds}$$

$$31.0\,\text{days} \times \frac{24.0\,\text{hours}}{1\,\text{day}} \times \frac{60.0\,\text{minutes}}{1\,\text{hour}} \times \frac{60.0\,\text{seconds}}{1\,\text{minute}} = 2680000\,\text{seconds}$$

No matter whether done in a single step as above or using three separate calculations as demonstrated the answer will be the same and comes down to an issue of personal preference.

Summary of Unit Conversion Steps:

1. Identify the given quantity with units to convert.
2. Identify the new quantity to be determined with units.
3. Determine the conversion factors or equalities that will appear in the form of a fraction.
4. Set up the calculation according to the following format:

$$\text{given unit} \times \frac{\text{new unit}}{\text{given unit}} = \text{new unit}$$

PROCEDURE:

For this work sheet students are required to complete the data sheet problems and pass in before leaving the lab. For best results students should work on these problems as much as possible on their own. Students are free to discuss with fellow classmates and to ask their instructor for assistance.