Significant Figures

In the laboratory we use devices to measure specific quantities. These instruments give us data that is subject to some uncertainty. As nice as an electronic balance, graduated cylinder, or ruler might look to us it can only measure to a certain number of decimal places, plus one more that is somewhat uncertain. We can not just add decimal points to numbers and place zeros at the end of measurements without thinking about what they physically mean. In math classes it is common practice to change the way a number looks to make it easier to work with. Unfortunately we can not do that. What we must understand here is that the instrument determines how precise a measurement can be made. Our first task is to learn the rules for significant figures.

1) All nonzero digits are significant.

123.45 g contains five significant figures.

2) All zeros between two nonzero digits are significant.

210.009 m contains six significant figures.

3) Zeros to the right of a nonzero digit are not significant unless a decimal point is present at the end of the measurement.

766,000 km contains *three* significant figures.

766,000. km contains *six* significant figures.

4) Leading zeros are not significant.

0.00321 kg contains *three* significant figures.

5)Trailing zeros that come with a decimal point present are significant.

0.02040 cm and 50.00 mg both contain *four* significant figures.

Working with Significant Figures

When we make a measurement of a physical quantity in lab we record its value and its unit of measurement. If we do not have its unit the number is pointless to us. No numbers in chemistry will be recorded without a unit telling us what they measure. When we record this measurement we are recording all of the significant figures in the measurement and one more digit that contains some uncertainty. If we use measurements to perform calculations it is necessary to maintain the correct number of significant figures in the answer to the calculation.

1. *Addition and subtraction*. Recall that the last significant figure in a measurement is uncertain. The *place* of the last significant figure in a sum or difference is the same as the last place of measurement that has the least amount of certainty.

Addition:

$$\begin{array}{l} 27.26\ \text{g} \\ 6.5\ \text{g} \\ \underline{4.025\ \text{g}} \\ 37.785\ \text{g} \end{array}$$

The sum is then rounded to 37.8 g since 6.5 only goes one place after the decimal point.

Subtraction:

$$\begin{array}{l} 20.63\ \text{cm} \\ \underline{11.4\ \text{cm}} \\ 9.23\ \text{cm} \end{array}$$

It is then rounded to 9.2 cm since 11.4 only goes one place after the decimal point.

2. *Multiplication and division.* The number of significant figures in a product or quotient is the same as the number of significant figures in the least precise factor. Meaning the one with the fewest significant figures. (In the following examples, the number above each term denotes the number of significant figures in the term.)

Multiplication: $\overset{(3)}{9.25\ \text{m}} \times \overset{(2)}{0.52\ \text{m}} = \overset{(2)}{4.8\ \text{m}^2}$

Division: $\overset{(4)}{45.32\ \text{m}} \,/\, \overset{(3)}{3.15\ \text{s}} = \overset{(3)}{14.4\ \text{m/s}}$

What happens to our calculations if we have just one poor measurement? The error from that measurement would propagate throughout the entire calculation. If we were to calculate the density of a block of wood we would need to know both its mass and its volume. We could use a balance to measure the mass and a ruler to measure the block's length, width, and height. First we would find the volume by multiplying the length, width, and height together. The answer to this calculation would then need to be rounded to the correct number of significant figures. Then we would divide the mass by the volume to get the density. This number would then be rounded to the correct number of significant figures.

If the value of the width was measured to just one significant figure, then the value of the volume is limited to one significant figure. This would mean that when we calculate the value for the density it is limited to just one significant figure.