IV. Measurements Problems

Quality of Measurements: Accuracy & Precision

0. a) Can a measurement be exact? No!

b) What two things do most measurements contain?

A numerical value and a unit. The unit is referenced to some standard.

c) In addition to specifying a numerical value for a measurement, scientists often need to know how much confidence to place in a measurement. State one way to provide information about how much confidence one could have in the quality of a measurement.

There is definitely more than one way to address this question. Certainly providing a percent error for a measurement gives you an estimate of how much confidence to have. The standard deviation of a series of measurements is informative in an analogous way. When we express a measurement, we recognize that it has a finite number of significant figures, and the more figures it has, the more confidence we should have in the measurement. However, significant figures link to percent error & standard deviation in a way that is sometimes less direct than you might think. (More detail than this is beyond the scope of CHM 109.)

d) True or false: There is only one rule for rounding/s.f. after a calculation. Explain your answer.

False!!! There are two rules for rounding/s.f. after a calculation. One rule applies to addition and subtraction, while the other applies to multiplication and division.

1. Define accuracy (use words, not a mathematical formula).

The accuracy of a measurement describes how close it is to the true value.

2. Identify a parameter that tells you how accurate a measurement is and write the equation for this parameter.

% error tells you how accurate a measurement is.

$$\% \text{ error} = \frac{(\text{experimental value} - \text{true value})}{\text{true value}} \times 100$$

3. Can you make an assessment of accuracy for a single measurement? Yes!

4. Define precision (use words, not a mathematical formula).

Precision describes how tightly grouped (close together) a series of measurements is. A precise set of measurements would have a small average deviation, standard deviation, and standard error.

5. Identify two different statistical parameters that provide information about the precision of a data set.

Average deviation and standard deviation. (There are other correct answers.)

6. Can you make an assessment of precision for a single measurement? No!

Unit Conversions

0. Write the symbols for the six metric units you need to memorize for this class.

In order of increasing size: n, μ, m, c, d, and k. As in: ng, μg, mg, cg, dg, and kg

Verbally: n = nano, μ = micro, m = milli, c = centi, d = deci, and k = kilo

1. Write the numerical relationships for the six metric units you need to memorize for this class.

By analogy to English units: 12 inches = 1 foot

For grams:

1×10^9 ng = 1 g
1×10^6 μg = 1 g
1×10^3 mg = 1 g
1×10^2 cg = 1 g
1×10^1 dg = 1 g
1×10^{-3} kg = 1 g

2. Re-write the relationships from question #1 above in inverted fashion. Ex: 1 inch = 1⁄12 foot.

1 ng = 1×10^{-9} g
1 μg = 1×10^{-6} g
1 mg = 1×10^{-3} g
1 cg = 1×10^{-2} g
1 dg = 1×10^{-1} g
1 kg = 1×10^{3} g

3. Perform the following conversions:

For English to metric conversions values see the "Math Issues" section of the web page.

455 mL = ? pt   455 mL = ? L   455 mL = ? nL

$$455 \text{ mL} \times \frac{1 \text{ pt}}{473.2 \text{ mL}} = 0.961\underline{538} \xrightarrow{\text{round}} 0.962 \text{ pt}$$

$$455 \text{ mL} \times \frac{1 \text{ L}}{10^3 \text{ mL}} = 0.455 \text{ L}$$

$$455 \text{ mL} \times \frac{1 \text{ L}}{10^3 \text{ mL}} \times \frac{10^9 \text{ nL}}{1 \text{ L}} = 4.55 \times 10^8 \text{ L}$$

(Note: If you can see 455 = 4.55 × 10^2 in your head, you do not need to use a calculator to solve this one.)

4. If my plasma LDL level is 128 mg/dL, how many g/L is that?

In two separate steps:

$$\frac{128\text{ mg}}{\text{dL}} \times \frac{1 \times 10^{1}\text{ dL}}{1\text{ L}} = \frac{1.28 \times 10^{3}\text{ mg}}{1\text{ L}}$$

$$\frac{1.28 \times 10^{3}\text{ mg}}{1\text{ L}} \times \frac{1\text{ g}}{1 \times 10^{3}\text{ mg}} = \frac{1.28\text{ g}}{1\text{ L}}$$

5. Convert your height from inches into meters, your weight from pounds into kilograms, and the volume of your favorite canned/bottled beverage from ounces (or pints) into mL.

My height in meters:

First convert feet ➜ inches

$$5\text{ feet }10\text{ inches} = \left(5\text{ feet} \times \frac{12\text{ inches}}{1\text{ foot}}\right) + 10\text{ inches} = 70.\text{ inches } \textit{(has 2 s.f.)}$$

Then inches ➜ meters

$$70.\text{ in} \times \frac{2.54\text{ cm}}{1\text{ in}} \times \frac{1\text{ m}}{100\text{ cm}} = 1.7\underline{78} \xrightarrow{\text{round}} 1.8\text{ m}$$

My weight in kilograms:

$$175\text{ lb} \times \frac{1\text{ kg}}{2.2046\text{ lb}} = 79.3\underline{79}\text{ kg} \xrightarrow{\text{round}} 79.4\text{ kg}$$

Drink:

$$1.25\text{ pt} \times \frac{473.2\text{ mL}}{1\text{ pt}} = 591.\underline{5}\text{ mL} \xrightarrow{\text{round}} 592\text{ mL}$$