**UNIT CONVERSIONS**

In the field of science, the metric system is used in performing measurements. The metric system is actually easier to use than the English system, as you will see shortly. The metric system uses prefixes to indicate the magnitude of a measured quantity. The prefix itself gives the conversion factor. You should memorize some of the common prefixes, as you will be using them on a regular basis. Common prefixes are shown below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Prefix | Symbol | Power | Prefix | Symbol | Power |
| mega- | M | 106 | centi- | c | 10-2 |
| kilo- | k | 103 | milli- | m | 10-3 |
| hecto- | h | 102 | micro- | http://pages.towson.edu/ladon/image/mu.jpg | 10-6 |
| deca- | D | 101 | nano- | n | 10-9 |
| deci- | d | 10-1 | pico- | p | 10-12 |

**Metric - Metric Conversions**

Suppose you wanted to convert the mass of a 250 mg aspirin tablet to grams. Start with what you know and let the conversion factor units decide how to set up the problem. If a unit to be converted is in the numerator, that unit must be in the denominator of the conversion factor in order for it to cancel.

 

Notice how the units cancel to give grams. I've shown the conversion factor numerator as 1 x 10-3 because on most calculators, it must be entered in this fashion, not as just 10-3. If you don't know how to use the scientific notation on your calculator, try to find out as soon as possible. Look in your calculator's manual, or ask someone who knows. Also, notice how the unit, mg is assigned the value of 1, and the prefix, milli-, is applied to the gram unit. In other words, 1 mg literally means 1 x 10-3 g.

Next, let's try a more involved conversion. Suppose you wanted to convert 250 mg to kg. You may or may not know a direct, one-step conversion. In fact, the better method (foolproof) to do the conversion would be to go to the base unit first, and then to the final unit you want. In other words, convert the milligrams to grams and then go to kilograms:

 

**English - Metric Conversions**

These conversions are accomplished in the same way as metric - metric conversions. The only difference is the conversion factor used. It would be a good idea to memorize a few conversion factors involving converting mass, volume, length and temperature. Here are a few useful conversion factors:

length: 2.54 cm = 1 inch (exact)

mass: 454 g = 1 lb

volume: 0.946 L = 1 qt

temperature: oC = (oF - 32)/1.8

All of the above conversions are to three significant figures, except length, which is an exact number. As before, let the units help you set up the conversion.

Suppose you wanted to convert mass of my 23 lb cat to kilograms. One can quickly see that this conversion is not achieved in one step. The pound units will be converted to grams, and then from grams to kilograms. Let the units help you set up the problem:

 

Let's try a conversion that looks "intimidating", but actually uses the same basic concepts we have already examined. Suppose you wish to convert pressure of 14 lb/in2 to g/cm2. When setting up the conversion, worry about one unit at a time, for example, convert the pound units to gram units, first:

 

Next, convert in2 to cm2. Set up the conversion without the exponent first, using the conversion factor, 1 in = 2.54 cm. Since we need in2 and cm2, raise everything to the second power:

 

Notice how the units cancel to the units sought. Always check your units because they indicate whether or not the problem has been set up correctly.

**Unit Conversions Problem Set**

1. Perform the following unit conversions involving metric- metric conversions:

 a. 15.3 milligrams to grams

 b. 0.1544 kilometers to centimeters

 c. 35.78 micrograms to nanograms

 d. 55.8 cm/s to μm/hr

 e. 2.7 g/cm3 to kg/m3

2. Perform the following unit conversions involving English- metric conversions:

 a. 145 pounds to grams

 b. 34.65 milliliters to quarts

 c. 55 mi/hr to km/s

 d. 7.1 kg/cm2 to lb/ft2

 e. 5.6 x 103 ton/mi3 to Mg/km3 (assume US ton: 1 US ton = 2000 lb)

3. Convert the following temperatures:

 a. 45.3 °F to °C

 b. -2.3 °C to °F

 c. 341 °C to K

 d. 188 K to °C

 e. 456 K to °F

4. You are given the conversion factors shown below and may assume they are exact numbers:

 1 blink = 3 nods 5 sizzles = 2 squeaks

 2 squeaks = 7 clangs 4 clangs = 1 ping

 6 pings = 11 blinks

 a. Find how many clangs there are in 2 sizzles.

 b. Find how many pings are in 34 squeaks.

 c. Find how many blinks are in 15 sizzles.

 Note: Since the conversions were exact numbers, express all answers to one decimal place.

**Answers**

There are a few concepts that are useful in performing any unit conversion. The most important of these is to make sure the units cancel out in the problem setup. Gather the conversion factors you need and “map out” the conversion. The units will guide you on how to set up the problem. If you already haven’t done so, memorize the meanings (power of 10) for each of the metric prefixes. The metric prefixes are exact numbers, so they do no limit your significant figures. A “1” in any conversion factor is also exact. For English/metric conversions, only the length conversion, 2.54 cm = 1 in, is exact. For all other conversion factors, one needs to use a conversion factor expressed to the number of significant figures required. One should not limit the number of significant figures in an answer based on the conversion factor.

1. a. When performing a metric to metric unit conversion, place the “1” with the unit with the prefix and place the meaning of the prefix as a power of 10 next to the base unit. You will need a conversion from milligrams to grams. The gram unit is the base unit; it has no prefix. If you know the meaning of the prefix, milli-, you can easily set up the problem. The prefix, milli-, means 10-3. Thus, 1 milligram is 10-3 gram. Here is the setup showing how the units cancel:

$$15.3 mg x \frac{1 x 10^{-3} g}{1 mg} = 0.0153 g$$

 b. It is not worthwhile memorizing every combination of conversion factors for the metric prefixes. The simpler route is to convert the original prefixed unit to the base unit and then to the prefixed unit you need. In this case, convert kilometers to meters and then meters to centimeters. Let the units help you set up the problem:
$$0.1455 km x \frac{1 x 10^{3} m}{1 km} x \frac{1 cm}{1 x 10^{-2} m} = 1.455 x 10^{4} cm$$

 c. Covert milligrams to grams then to nanograms:

$$35.78 μg x \frac{1 g x 10^{-6} g}{1 μg} x \frac{1 ng}{1 x 10^{-9} g} = 3.578 x 10^{4} ng$$

 d. In this problem, one must convert two sets up units one at a time. It doesn’t matter which unit is converted first. Arbitrarily, the length units, centimeters is converted to micrometers; then the time units, seconds are converted to hours. If one knew that 3600 seconds equals 1 hour, one step could have been saved.
$$\frac{55.8 cm}{s} x \frac{1 x 10^{-2} m}{1 cm} x \frac{1 μm}{1 x 10^{-6}} x \frac{60 s}{1 min} x \frac{60 min}{1 hr} = 2.01 x 10^{9} μm/hr$$

 e. When exponents are needed for a conversion, set up the conversion factor in one dimension first (without the exponent) and then raise all the components of the conversion factor to the power needed. In this case, first convert grams to kilograms, then centimeters to meters and raise all the components in the length conversion to the third power:

$$\frac{2.7 g}{cm^{3}} x \frac{1 kg}{1 x 10^{3} g} x \frac{1^{3} cm^{3}}{(1 x 10^{-2})^{3} m^{3}} = 2.7 x 10^{3} kg/m^{3}$$

2. The United States is one of few countries in the world that is not metric, hence we have to be able to convert our English units to metric units and vice versa. Common units converted are length, mass and volume. It is convenient to learn one conversion for each of these variables to be able to bridge the two systems. (Personally, this author prefers the metric system and wishes the US would go metric.) For length, 2.54 cm = 1 in (an exact conversion), for mass, 453.6 g = 1 lb, and for volume, 0.9464 L = 1 qt are conversions you might want to commit to memory for convenience.

 a. Use the conversion factor, 453.6 grams equal to 1 pound and let the units set up the problem:

$$145 lb x \frac{453.6 g}{1 lb} = 6.58 x 10^{4} g$$

 b. Convert milliliters to liters then to quarts:

$$34.65 mL x \frac{1 x 10^{-3} L}{1 mL} x \frac{1 qt}{0.9464 L} = 3.661 qt$$

 c. Convert each unit one at a time. Another convenient conversion for length is 1.609 km = 1 mile. As stated in a previous problem, there are 3600 seconds in 1 hour:

$$\frac{55 mi}{hr} x \frac{1.609 km}{1 mi} x \frac{1 hr}{3600 s} = 2.5 x 10^{-2} km/s$$

 d. Convert kilograms to grams to pounds. Next, convert centimeters to inches, squaring all the components in the conversion factor and then inches to feet, once again squaring all the components in the conversion factor:

$$\frac{7.1 kg}{cm^{2}} x \frac{1 x 10^{3} g}{1 kg} x \frac{1 lb}{453.6 g} x \frac{2.54^{2} cm^{2}}{1^{2} in^{2}} x \frac{12^{2} in^{2}}{1 ft^{2}} = 1.5 x 10^{4} lb/ft^{2}$$

 e. Convert one unit at a time. Don’t forget to cube the length conversion factors.

$$\frac{5.6 x 10^{3} ton}{mi^{3}} x \frac{2000 lb}{1 ton} x \frac{453.6 g}{1 lb} x \frac{1 Mg}{1 x 10^{6} g} x \frac{1^{3} mi^{3}}{1.609^{3} km^{3}} = 1.2 x 10^{3} Mg/km^{3}$$

3. The easiest equation for the temperature conversion between Celsius and Fahrenheit is:

°F = 1.8°C + 32

Thus, you can rearrange this equation and solve for the Celsius temperature:

$$℃ = \frac{℉ - 32°}{1.8}$$

This eliminates the need to recall whether to use 9/5 or 5/9 in other temperature conversion equations you may have encountered in the past, such as °F = (9/5)°C + 32° or °C = 5/9(°F – 32°). Also, the “1.8” and 32° are exact and so they won’t impact significant figures.

The Kelvin scale, also called the absolute temperature scale, is based on the premise that there is an absolute zero temperature. The Kelvin temperature is calculated from the Celsius temperature according to the equation:

K = °C + 273.15

If you are starting with a Fahrenheit temperature, convert to Celsius first, then to the Kelvin scale.

 a.
$$℃ = \frac{℉ - 32°}{1.8} = \frac{45.3° - 32°}{1.8} = 7.4℃ $$

 b.
$$℉ = 1.8℃ + 32 = 1.8(-2.3 ℃) + 32° = 27.9℉$$

 c.
$$K = ℃ + 273.15 = 341℃ + 273.15 = 614 K$$

 d. Rearrange the equation to solve for Celsius:

$$℃ = K - 273.15 = 188 K - 273.15 = -85 ℃$$

 e. Convert Kelvin temperature to Celsius, then covert the Celsius temperature to Fahrenheit:

$$℃ = K - 273.15 = 456 K - 273.15 = 183 ℃$$

$$℉ = 1.8℃ + 32 = 1.8(183 ℃) + 32° = 361℉$$

4. Map out the conversion first, then carry out the steps.

 a. From sizzles, you can find squeaks;from squeaks you can find clangs:

$$2 sizzles x \frac{2 squeaks}{5 sizzles} x \frac{7 clangs}{2 squeaks} = 2.8 clangs$$

 b. From squeaks, you can find clangs; from clangs you can find pings:

$$34 squeaks x \frac{7 clangs}{2 squeaks} x \frac{1 ping}{4 clangs} = 29.8 pings $$

 c. From sizzles, go to squeaks; from squeaks, go to clangs; from clangs, go to pings; from pings, go to blinks:

$$15 sizzles x \frac{2 squeaks}{5 sizzles} x \frac{7 clangs}{2 squeaks} x \frac{1 ping}{4 clangs} x \frac{11 blinks}{6 ping} = 9.6 blinks$$