Converting Units

Name: _____

Date: _____

Information: Dimensional Analysis

Distance can be measured in millimeters (mm), centimeters (cm), meters (m), kilometers (km), and some others also. Sometimes you will need to change from one unit to another. By the way, the prefixes like milli- or centi- can be used with other "base units" besides meters. Thus, we have milliliters (mL) or centigrams (cg), etc. The following table will be helpful:

Prefix	Distance Unit	Conversion
nano-	nanometer (nm)	1,000,000,000 nm = 1 m
micro-	micrometer (μm)	1,000,000 μm = 1 m
milli-	millimeter (mm)	1000 mm = 1 m
centi-	centimeter (cm)	100 cm = 1 m
kilo-	kilometer (km)	1 km = 1000 m

"Dimensional Analysis" is a big scary term that doesn't really need to be scary. It's simple. The basis for dimensional analysis is this: if you multiply something by 1 you do not change its value! Pretty easy, eh? Here's an example:

$$\frac{1}{2}\bullet\frac{3}{3}=\frac{3}{6}$$

Notice that the value of ½ didn't really change because 3/3 is the same as 1. Again, in mathematics, multiplying by 1 doesn't change the real value of anything.

$\frac{100\,\text{cm}}{1\,\text{meter}}$ is a fraction that behaves just like $\frac{3}{3}$ because $100\,\text{cm}=1\,\text{meter}$! Therefore, neither $\frac{3}{3}$ nor $\frac{100\,\text{cm}}{1\,\text{meter}}$ will change the real value of a number.

Here's an example problem of a conversion:

Convert 3.75 cm into meters. All you need to do is multiply by a fraction.

Always begin by putting the number you are given in a fraction over 1.

Find a fraction that contains both units that you are working with. Here we have cm and m.

Notice that 1 m and 100 cm equal each other. THIS IS A MUST. You could also have "0.01 m" and "1 cm" because 0.01 m = 1 cm.

$$\frac{3.75\,\text{cm}}{1}\bullet\frac{1\,\text{m}}{100\,\text{cm}}=\frac{3.75\,\text{cm}\bullet 1\,\text{m}}{1\bullet 100\,\text{cm}}=\frac{3.75\,\text{cm}\bullet 1\,\text{m}}{1\bullet 100\,\text{cm}}=0.0375\,\text{m}$$

We put cm on the bottom here so that it cancels here.

m is the only unit left and it's the unit we want

Notice in the above example that cm was on the bottom in the conversion factor fraction. This is very important. "Tops and bottoms cancel each other." We need cm on the bottom so that it cancels out the one on the top!

Critical Thinking Questions

1. If you were converting 42 grams into kilograms, which fraction would you use as a converting factor?

   A) $\frac{1000\ \text{g}}{1\ \text{kg}}$ B) $\frac{1000\ \text{kg}}{1\ \text{g}}$ C) $\frac{1\ \text{kg}}{1000\ \text{g}}$ D) $\frac{1\ \text{g}}{1000\ \text{kg}}$

Explain your reasoning:

2. How many meters are in 32.5 kilometers? (You are converting km to m.)
   The problem is started for you:

$$\frac{32.5\ \text{km}}{1} \bullet \frac{\qquad}{\qquad} =$$

3. How many μL are there in 32.5 L?

Information: Non-base unit → non-base unit

So far we have been converting a prefixed unit into a base unit or vice versa. It gets a little more complex when we want to convert a prefixed unit into another prefixed unit. Whenever such is the case, convert to the base unit first and then finish the problem.

For example, if you needed to convert centimeters into kilometers, first convert to the base unit—meters. Then convert meters into kilometers.

Critical Thinking Questions

4. How many cm are there in 40 km? Let's break it into two steps…

   a) First, convert to the base unit, which for this problem is meters. Fill in the blanks.

$$\frac{40\ \text{km}}{1} \bullet \frac{\qquad\ \text{m}}{\text{km}} = \frac{\qquad\qquad\qquad}{\qquad\qquad\qquad}$$

km is on the bottom to cancel out the other km, which is on the top.

m and km are chosen because we are converting from km to m

   b) Now convert your answer to part a (which is in meters) into centimeters.

$$\frac{\qquad\ \text{m}}{1} \cdot \frac{\qquad\ \text{cm}}{1\ \text{m}} =$$

5. How many kL are there in 34,500 mL?

   a) First, convert mL to L.

   b) Now convert your answer to part a (in L) to kL.

6. How many μm are there in 0.0035 km?

Information: Quantities containing two units at once

It gets a bit more complicated if we have to convert a quantity containing two units. For example, speed has two units. "Miles per hour" contains two units. "Meters per second" contains two units. When you need to do a conversion on such a quantity, do one unit at a time. Here's an example.

Convert 50 km/hr to m/s.

hr is on the top here so that it cancels with the hr on the bottom. "Tops and bottoms cancel."

$$\frac{50\,\text{km}}{1\,\text{hr}} \bullet \frac{1000\,\text{m}}{1\,\text{km}} \bullet \frac{1\,\text{hr}}{60\,\text{min}} \bullet \frac{1\,\text{min}}{60\,\text{s}} = \frac{50\,\cancel{\text{km}} \bullet 1000\,\text{m} \bullet 1\,\cancel{\text{hr}} \bullet 1\,\cancel{\text{min}}}{1\,\cancel{\text{hr}} \bullet 1\,\cancel{\text{km}} \bullet 60\,\cancel{\text{min}} \bullet 60\,\text{s}} = 13.89\,\text{m/s}$$

First we converted km then we'll work on the hr.

Critical Thinking Questions

7. Convert 25 m/s to km/h.

8. The speed of sound is approximately 340 m/s. How many km/h is that?

9. The maximum highway speed in Michigan is 70 miles/h. How many km/h is this? (Note: 1 mile is equal to 1609 m.)

10. The flow of water in our kitchen tap is 3.2 L/min. How many mL/s is this?