

Converting Units

 Name: _____
 Date: _____

Information: Dimensional Analysis

“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:

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

Notice that the value of $\frac{1}{2}$ didn’t really change because $\frac{3}{3}$ 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:

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

Step 1
 Always begin by placing the number from the question into a fraction over 1.

$$\frac{3.75 \text{ cm}}{1}$$

Step 2
 Find a fraction that contains both units that you are working with. In this problem we are trying to convert centimeters to meters, so we have cm and m in our fraction.

$$\frac{1 \text{ m}}{100 \text{ cm}}$$

****Notice** that 1 m and 100 cm equal each other. The top and bottom of this fraction must always equal each other!

**** Special note:** Take a look at the fraction in step 2. Why is cm on the bottom instead of the top? Because in Step 1, cm is on the top. *Whatever unit is on the top in step one automatically goes on the bottom in step 2!*

Step 3
 Multiply the two fractions together.

$$\frac{3.75 \text{ cm}}{1} \cdot \frac{1 \text{ m}}{100 \text{ cm}} =$$

Step 4
 Write everything on the tops together and everything on the bottoms together. Then cancel like units.

$$\frac{3.75 \text{ cm} \cdot 1 \text{ m}}{1 \cdot 100 \text{ cm}} = \frac{\cancel{3.75 \text{ cm}} \cdot 1 \text{ m}}{1 \cdot \cancel{100 \text{ cm}}} = \frac{3.75 \text{ m}}{100} = 0.0375 \text{ m}$$

cm cancels out. EQUAL UNITS IN THE TOPS AND BOTTOMS CANCEL.

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

Critical Thinking Questions

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

- A) $\frac{100 \text{ g}}{1 \text{ kg}}$ B) $\frac{1000 \text{ kg}}{1 \text{ g}}$ **C) $\frac{1 \text{ kg}}{1000 \text{ g}}$** D) $\frac{1 \text{ g}}{1000 \text{ kg}}$ E) $\frac{1000 \text{ g}}{1 \text{ kg}}$ F) $\frac{10 \text{ kg}}{1 \text{ g}}$

Explain your reasoning:

grams need to be in the denominator and the numerator and denominator need to be equivalent.
 $1000\text{g} = 1 \text{ kg}$

2. How many meters are in 32.5 kilometers? (You are converting km to m.)

The problem is started for you:

$$\frac{32.5 \text{ km}}{1} \cdot \frac{1000\text{m}}{1 \text{ km}} = 32,500 \text{ m}$$

3. How many μL are there in 32.5 L?

$32,500,000 \mu\text{L}$

Information: Non-base unit \rightarrow 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 three steps...

a) First, identify the base unit: meters.

b) Second, convert to the base unit, which for this problem is meters (check part a). Fill in the blanks.

$$\frac{40 \text{ km}}{1} \cdot \frac{1000}{1} \frac{\text{m}}{\text{km}} = 40,000 \text{ m}$$

Fill in the numbers for the conversion factor. How many meters in one km?

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

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

$$\frac{40,000 \text{ m}}{1} \cdot \frac{100}{1} \frac{\text{cm}}{\text{m}} = 4,000,000 \text{ cm}$$

Put your answer to part b here

Fill in the numbers for the conversion factor. How many cm in one meter?

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

a) First, convert mL to L.

34.5 L

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

0.0345 kL

6. How many μm are there in 0.0035 km?

3,500,000 μm

7. How many grams are there in 1.45 Mg?

1,450,000 g

8. How many mg does it take to equal 2.5 kg?

2,500,000 mg

9. One "atomic mass unit" (amu) is equal to 1.66×10^{-24} g. Using a conversion factor, find the number of grams in 345 amu.

$$\frac{345 \text{ amu}}{1} \bullet \frac{1.66 \times 10^{-24} \text{ g}}{1 \text{ amu}} = 5.72 \times 10^{-22} \text{ g}$$

10. Using the information in question 9, how many amu is 2.55×10^{-23} g? 15.4 amu

11. Make the following conversions.

a) 24.5 mL = 0.0000245 L

b) 12.5 m = 1250 cm

c) 45.9 kg = 45,900,000 mg

d) 3.45×10^{-5} km = 34,500 μm

e) 4.6×10^{11} nm = 460 m

f) 31.95 Mg = 31,950 kg