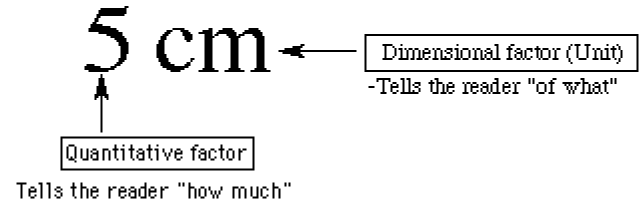
Dimensional Analysis

The ability to convert from one measured quantity to another is absolutely essential in Chemistry. Converting grams to moles, moles to grams, grams to molecules, and many other important conversions should be second nature to anyone attempting Chem 30. The basic process is quite simple. First, we must look at the terminology.

Whenever a measured quantity is recorded to be used in a calculation, both the magnitude of the unit and the symbol for the unit must be included. For example:



When converting a measured quantity like 5 cm to another unit, like decameters for example, you must include the unit, (**dimensional** factor), in the calculations, (**analysis**). That's why it is called **dimensional analysis**. Including your units in your calculations is so important, that marks may be deducted without them, even if the numerical portion of the answer is correct. When units are included in calculations, they actually tell you how to do the conversion. For example:

Convert 5 cm to meters. First, remember this formula:

New unit (answer) = old unit × conversions factor

Recalling that 1 meter (m) = 100 cm, substituting into this formula gives:

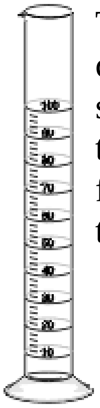
$$\text{New unit (answer)} = 5\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}}$$

Canceling the "old" unit produces this:

$$\text{New unit (answer)} = 5\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}$$

⇐ the units cancel!!!

New unit (answer) = 0.05 m (and you're left in the units you want)



The units in the given or "old" dimension must always be placed in the denominator of the conversion factor, because that is the unit that needs to be cancelled, and algebraically speaking, only that arrangement will allow the cancellation to take place. The unit you want to "end up with" or convert to, is always placed in the numerator of the conversion factor. You then put the number that relates the two units in the appropriate position and do the arithmetic. The correct answer is automatic.

Understandably, the tricky part is in the design and construction of the conversion factor. The prefixes for multiples and sub multiples of the SI are useful here. The units however, tell one how it should be built. Any unit can be converted to any other unit using this method, and you are not restricted by any formula that needs to be memorized. Using your head to set up a conversion factor allows you to manipulate successfully such conversions as:

1. Any measured quantity to any other measured quantity

a) Convert 5.000 km to m

$$5.000\,\cancel{\text{km}} \times \frac{1000\text{ m}}{1\,\cancel{\text{km}}} = 5000\text{ m}$$

b) Convert 30 km/h to m/s

$$30\,\frac{\cancel{\text{km}}}{\cancel{\text{h}}} \times \frac{1000\text{ m}}{1\,\cancel{\text{km}}} \times \frac{1\,\cancel{\text{h}}}{3600\text{ s}} = 8.3\text{ m/s}$$

c) Convert 512 cm^2 to m^2

$$512\,\cancel{\text{cm}^2} \times \frac{1\text{m}^2}{10000\,\cancel{\text{cm}^2}} = 0.0512\text{ m}^2$$

2. mole to mole calculations

a) Given: $2NH_{3(g)}$ -----> $N_{2(g)}$ + $3H_{2(g)}$

How many moles of hydrogen will be produced if 4.19 moles of ammonia decompose? (In other words, convert 4.19 moles of ammonia to moles of hydrogen).

$$4.19\,\cancel{\text{moles NH}}_{3(g)} \times \frac{3\text{ moles of H}_{2(g)}}{2\,\cancel{\text{moles of NH}}_{3(g)}} = 6.29\text{ moles of H}_{2(g)}$$

3. moles to mass calculations

a) convert 0.0094 moles of NaOH to grams of NaOH

$$0.0094\,\cancel{\text{moles NaOH}} \times \frac{40.00\text{ g NaOH}}{1\,\cancel{\text{moles NaOH}}} = 0.38\text{ g NaOH}$$

4. mass to mole calculations

a) Convert 286.5 grams of $AlCl_3$ to moles. (Try this one on your own. The answer is 2.149 moles).