In chemistry, converting units from one unit system to another (especially within the Metric system) can appear daunting at first glance. However, with a little guidance, and a lot of practice, you can develop the necessary skill set to master this process.

To begin, here is a simple mnemonic to guide you through the unit conversion process:

1. **Eliminate**
2. **Replace**
3. **Relate**

All unit conversions, regardless of how complex they appear, involve these 3 simple steps. In the following sections, you will be stepped through the unit conversion process using these 3 words as a guide.

Example: How many can 25.2 miles/hour be expressed in m/s? i.e. $25.2\,\frac{\text{miles}}{\text{hour}} \rightarrow ??\,\frac{\text{m}}{\text{s}}$

Note: *It is important to recognize that* $25.2\,\frac{\text{miles}}{\text{hour}} = \frac{25.2\,\text{miles}}{1\,\text{hour}}$

Let's breakdown the unit conversion process into 2 individual processes, miles to meters and hours to seconds:

1. **Eliminate** – the unit(s) you begin with must be eliminated in a mathematically consistent manner.

If a unit to be eliminated is a numerator unit, it must be divided out:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{??}{??\,\text{miles}}\right) = ??\,\frac{\text{m}}{\text{s}}$$

If a unit to be eliminated is a denominator unit, it must be multiplied out:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{??\,\text{hour}}{??}\right) = ??\,\frac{\text{m}}{\text{s}}$$

2. **Replace** – the desired unit(s) you end up with must replace the original unit in a mathematically consistent manner.

If a unit to replace is a numerator unit, it must be multiplied in:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{??\,\text{m}}{??\,\text{miles}}\right) = ??\,\frac{\text{m}}{\text{s}}$$

If a unit to be eliminated is a denominator unit, it must be divided in:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{??\,\text{hour}}{??\,\text{s}}\right) = ??\,\frac{\text{m}}{\text{s}}$$

3. Relate – the units must be related to each other in some mathematical expression. Identify the relationship between the starting and final units:

1 mile = 1609 m

1 hour = 3600 s

To take the guess work out of where the values should go, match the value with its corresponding unit:

For the distance conversion:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{1609\,\text{m}}{1\,\text{mile}}\right)=??\frac{\text{m}}{\text{s}}$$

For the time conversion:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{1\,\text{hour}}{3600\,\text{s}}\right)=??\frac{\text{m}}{\text{s}}$$

Putting both conversions together:

$$\left(\frac{25.2\,\text{miles}}{1\,\text{hour}}\right)\left(\frac{1609\,\text{m}}{1\,\text{mile}}\right)\left(\frac{1\,\text{hour}}{3600\,\text{s}}\right)=??\frac{\text{m}}{\text{s}}$$

Extending the Process: When the explicit relationship between the units is not known, it is often necessary to link them to a common unit (in the "Relate" phase).

For example, when converting from mg to kg it is difficult to find a direct expression that relates these units. However, these units can both be related to grams (g) (by replacing the prefix with its corresponding power of 10).

1 mg = 10^{-3} g

1 kg = 10^{3} g

Therefore we can no relate mg to kg. To do so, divide the top expression by the bottom expression:

$$\frac{1\,\text{mg}}{1\,\text{kg}}=\frac{10^{-3}\,\text{g}}{10^{3}\,\text{g}}=10^{-6}$$

or

$$1\text{ mg} = 10^{-6}\text{ kg}$$

Note: *the smaller unit (mg) has a larger value and the larger unit (kg) has a smaller value.*

Let's try one: How is 12.5 mg expressed in kg (i.e. 12.5 mg = ___ kg)?

1. Eliminate: *{assign mg units to the denominator of the conversion factor}*

$$\left(\frac{12.5\text{ mg}}{1}\right)\left(\frac{??}{??\text{ mg}}\right) = \_\_\_\_\_\text{ kg}$$

2. Replace: *{assign kg units to the numerator of the conversion factor}*

$$\left(\frac{12.5\text{ mg}}{1}\right)\left(\frac{??\text{ kg}}{??\text{ mg}}\right) = \_\_\_\_\_\text{ kg}$$

3. Relate: *{assign the corresponding value to its unit, using 1 mg = 10^{-6} kg}*

$$\left(\frac{12.5\text{ mg}}{1}\right)\left(\frac{10^{-6}\text{ kg}}{1\text{ mg}}\right) = \frac{12.5x10^{-6}kg}{1} = 1.25x10^{-5}\text{ kg}$$

Now, it's your turn: 0.25 nm = ___ cm?

1. Eliminate: $\left(\frac{0.25\text{ nm}}{1}\right)\left(\frac{??}{\text{\_\_\_\_}}\right) = ??\text{ cm}$ *{fill-in the blank with correct unit}*

2. Replace: $\left(\frac{0.25\text{ nm}}{1}\right)\left(\text{\_\_\_\_}\right) = ??\text{ cm}$ *{fill-in both blanks with correct units}*

3. Relate:

a) Write-out the relation between nm & m:

b) Write-out the relation between cm & m:

c) Divide expression (a) by expression (b):

d) Solve this expression for the original unit in (a), in this case 1 nm = _____ cm:

e) Now put all of the pieces together {fill-in the blanks with correct values and units then do the math }:

$$\left(\frac{0.25\text{ nm}}{1}\right)\left(\text{\_\_\_\_\_}\right) = \text{\_\_\_\_\_} = \text{\_\_\_\_\_}$$