

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:

$$1 \text{ mile} = 1609 \text{ m}$$

$$1 \text{ hour} = 3600 \text{ s}$$

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).

$$1 \text{ mg} = 10^{-3} \text{ g}$$

$$1 \text{ kg} = 10^3 \text{ g}$$

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}

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

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

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

2. Replace: $\left(\frac{0.25 \text{ nm}}{1}\right)\left(\frac{\text{_____}}{\text{_____}}\right) = ?? \text{ cm}$ {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 }:

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