UNIT CONVERSION

Physical quantities such as force, energy, mass, or density are described by both magnitudes and units. The magnitude supplies information about the size or amount of the physical quantity while the units tell us a relationship; that is, the units give us information about the size of quantity compared to some standard. For Example:

Length	=	12	feet
Physical Quantity		magnitude	units

However, sometimes in chemistry and other sciences, we need to express the physical quantity in units other than those given to us.

Example 1

$$2in = ?\,ft$$

$$2in = (2\,\cancel{in})\left(\frac{1ft}{12\cancel{in}}\right) = \frac{1}{6}ft$$

$\frac{1ft}{12in}$ is a conversion factor

Note in the above example, 2 inches and $\frac{1}{6}$ ft are describing the exact same length; one expression has been converted to an equivalent expression in different units. In accomplishing their conversion, 2 inches was multiplied by what is known as a conversion factor. A conversion factor is always equal to one, and, therefore, multiplication by the conversion factor never changes the value of the expression (L x 1 = L). In this example, a conversion factor was needed that

1) had inches in the denominator (to cancel the unwanted original units),
2) had feet in the numerator (to leave the desired units),
3) like all conversion factors, was equal to one (numerator and denominator are equivalent expressions).

Knowing that the relationship between inches and feet is 1 ft = 12 in, the conversion factor of $\frac{1ft}{12in}$ was formed.

Example 2

$$2ft = ?\,in$$

$$2ft = (2\cancel{ft})\left(\frac{12in}{1\cancel{ft}}\right) = 24$$

$\frac{12in}{1ft}$ is a conversion factor

Note that in forming the conversion factor, the same relationship between feet and inches (1 ft = 12 in) is used in Example 1. However, since this problem involves converting

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feet to inches, the conversion factor must now have feet in the denominator and inches in the numerator.

Example 3 2 in = ? m

In this example, we would like to have a conversion factor with inches in the denominator and meters in the numerator. However, conversion tables do not indicate how many inches are in a meter. The tables do indicate that 1 in = 2.54 cm and 100 cm = 1 m. Therefore, the combination of two conversion factors must be used:

$$2in = (2\cancel{in})\left(\frac{2.54\cancel{cm}}{1\cancel{in}}\right)\left(\frac{1m}{100\cancel{cm}}\right) = 0.0508m$$

$\frac{2.54cm}{1in}$ is conversion factor #1

$\frac{12in}{1ft}$ is conversion factor #2

The first conversion factor changes inches into centimeters thereby getting us "closer" to the desired units. Then, the second conversion factor changes the newly formed centimeters into the desired meters

$$\left[(2\cancel{in})\left(\frac{2.54\cancel{cm}}{1\cancel{in}}\right)\left(\frac{1m}{100\cancel{cm}}\right)\right]$$

Occasionally, we have physical quantities which involve 2 units such as velocity $\left(\frac{displacement}{\Delta time}\right)$. Thus, we need to convert both units to the desired ones.

Example 4

$$35\frac{cm}{hr} = ?\left(\frac{m}{\sec}\right)$$

$$35\frac{cm}{hr} = \left(35\frac{\cancel{cm}}{\cancel{hr}}\right)\left(\frac{1m}{100\cancel{cm}}\right)\left(\frac{1\cancel{hr}}{60\cancel{min}}\right)\left(\frac{1\cancel{min}}{60sec}\right)$$

$$= 9.72\times10^{-5}\frac{m}{\sec}$$

$\left(\frac{1m}{100cm}\right)$ is conversion factor #1

$\left(\frac{1hr}{60min}\right)$ is conversion factor #2

$\left(\frac{1min}{60sec}\right)$ is conversion factor #3

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Concentrating initially on changing centimeters to meters, the first conversion factor changes $\left(\frac{cm}{hr}\right)$ into $\frac{m}{hr}\left[\left(35\frac{\not{cm}}{hr}\right)\left(\frac{1m}{100\not{cm}}\right)\right]$. Now focusing on replacing the hours with seconds, the second conversion factor changes $\frac{m}{hr}$ to $\frac{m}{min}\left[\left(35\frac{\not{cm}}{\not{hr}}\right)\left(\frac{1m}{100\not{cm}}\right)\left(\frac{1hr}{60min}\right)\right]$, and the third conversion factor changes $\frac{m}{min}$ to $\frac{m}{sec}\left[\left(35\frac{\not{cm}}{\not{hr}}\right)\left(\frac{1m}{100\not{cm}}\right)\left(\frac{1\not{hr}}{60\not{min}}\right)\left(\frac{1\not{min}}{60sec}\right)\right]$.

In summary, remember that the conversion factor must equal one and that the conversion factor cancels out the undesired units and leaves the desired units.

Additional Problems:

1) Convert 13 cm to m
2) Convert 4.8 kg to g
3) Convert 3 $\frac{m}{hr}$ to $\frac{km}{sec}$
   (Note: 1 km = 0.6 mi)
4) Convert 8.1 x 10^2 m^3 to cm^3

Solutions:

1) $$13(\not{cm})\left(\frac{1m}{100\not{cm}}\right) = 0.13m$$

2) $$4.8(\not{kg})\left(\frac{1000g}{1\not{kg}}\right) = 4800g$$

3) $$\left(3\frac{\not{mi}}{\not{hr}}\right)\left(\frac{1km}{0.6\not{mi}}\right)\left(\frac{1\not{hr}}{60\not{min}}\right)\left(\frac{1\not{min}}{60sec}\right) = 0.0014\frac{km}{sec}$$

4)
$$1m = 100cm$$
$$\text{so } (1m)^3 = (100cm)^3$$
$$1m^3 = 1\times10^6 cm^3$$
$$\left(8.1\times10^2\not{m}^3\right)\left(\frac{1\times10^6 cm^3}{1\not{m}^3}\right) = \left(8.1\times10^2\right)\left(1\times10^6 cm^3\right)$$
$$= 8.1\times10^8 cm^3$$

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