Conversions and Dimensional Analysis

Conversions are needed to convert one unit of measure into another equivalent unit of measure. Ratios, sometimes called conversion factors, are fractions that denote the correlation between the given unit and the desired unit. Dimensional analysis can be used to solve any conversion problem and allows problems to be easily checked for possible errors. This handout focuses on the most common conversions: metric, chemical, and multi-step.

Metric Conversions

A base unit is the basis of measurement in the sciences. The most commonly used base units are liters (L) for liquids, grams (g) for mass, and meters (m) for distance. Metric base units can be converted to other useful quantities by adding a prefix (see the common metric conversions table below). The base unit does not have a prefix, and these prefixes are not used in any other measuring system.

Common Metric Conversions

Prefix	Symbol	Exponential base units in given unit	Base units in given unit
Giga	G	10^9	1,000,000,000
Mega	M	10^6	1,000,000
Kilo	k	10^3	1,000
Hecto	h	10^2	100
Deca	da	10^1	10
BASE UNIT	-	10^0	1
Deci	d	10^{-1}	.1
Centi	c	10^{-2}	.01
Milli	m	10^{-3}	.001
Micro	μ	10^{-6}	.000001
Nano	n	10^{-9}	.000000001

Example 1: How many meters are in 350 kilometers?

Step1: Identify the relationship between the given unit and the desired unit.

$$1\ km = 10^3 m = \ 1{,}000\ m$$

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$\frac{1\ km}{1{,}000\ m}\ or\ \frac{1{,}000\ m}{1\ km}$$

Step 3: Multiply the given number by the appropriate ratio. Remember that the desired unit is on the top of the ratio, and the given unit is cancelled out.

$$350\ \cancel{km} \times \frac{1{,}000\ m}{1\ \cancel{km}} = \ 350{,}000\ m$$

Example 2: How many meters are in 57 millimeters?

Step 1: Identify the relationship between the given unit and the desired unit.

$$1\ mm = 10^{-3} m = \ 0.001\ m$$

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$\frac{1\ mm}{0.001\ m}\ or\ \frac{0.001\ m}{1\ mm}$$

Step 3: Multiply the given number by the appropriate ratio. Remember that the desired unit is on the top of the ratio, and the given unit is cancelled out.

$$57\ \cancel{mm} \times \frac{0.001\ m}{1\ \cancel{mm}} = 0.057\ m$$

Chemical Conversions

Chemical conversion factors are found by using the periodic table. Each element on the periodic table has a mass number, and the mass number of each element equals one mole. In addition, the conversion factor that relates atoms and moles is always $6.02 \times 10^{23} atoms = 1\ mol$. Remember, atoms, particles, and molecules are all the same unit.

Example 1: How many moles of magnesium are present in 42.68g of magnesium?

Step 1: Identify the relationship between the given unit and the desired unit. This is found by looking at the periodic table and finding the atomic mass.

$$1\ mol\ Mg = 24.31g\ Mg$$

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$\frac{1\ mol\ Mg}{24.31g\ Mg}\ or\ \frac{24.31g\ Mg}{1\ mol\ Mg}$$

Step 3: Multiply the given number by the appropriate ratio. Remember that the desired unit is on the top of the ratio, and the given unit is cancelled out.

$$42.68\cancel{g\ Mg} \times \frac{1\ mol\ Mg}{24.31\cancel{g\ Mg}} = 1.756\ mol\ Mg$$

Example 2: How many atoms of Argon are in 3.26 mols of Argon?

Step 1: Identify the relationship between the given unit and the desired unit. For all substances, the relationship of atoms to moles is 6.02×10^{23}atoms per one mole.

$$1\ mol\ Ar = 6.02 \times 10^{23}\ atoms\ Ar$$

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$\frac{1\ mol\ Ar}{6.02 \times 10^{23}\ atoms\ Ar}\ or\ \frac{6.02 \times 10^{23}\ atoms\ Ar}{1\ mol\ Ar}$$

Step 3: Multiply the given number by the ratio. Remember that the desired unit is on the top of the ratio and the given unit is cancelled out.

$$3.26\ \cancel{mol\ Ar} \times \frac{6.02 \times 10^{23}\ atoms\ Ar}{1\ \cancel{mol\ Ar}} = 1.96 \times 10^{24}\ atoms\ Ar$$

Note: This answer is rounded to three significant figures. For help with significant figures see the Significant Figure Rules Handout

Multi-Step Conversions

Multi-step conversions are needed when a direct conversion is not known or when multiple units are present that need to be converted. Multi-step conversions are solved the same way as one-step conversions. However, because there are multiple conversion factors, the steps are repeated as many times as needed.

Example 1: Convert 70 miles per hour into meters per second.

Remember miles per hour $= \frac{miles}{hour}$

Step 1: Identify the relationship between the given unit and the desired unit. Since there are two units to convert, focus on converting one unit first. In this example, the coversion of miles to meters will be accomplished first. Note: Either unit can be converted first.

$$1\ mile = 1609.34\ meters$$

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$\frac{1\ mile}{1609.34\ meters}\ or\ \frac{1609.34\ meters}{1\ mile}$$

Step 3: Multiply the given number by the ratio. Remember that the desired unit should be on top of the ratio and the given unit should be cancelled out.

$$\frac{70\ \cancel{miles}}{1\ hour} \times \frac{1609.34\ meters}{1\ \cancel{mile}} = \frac{112653.8\ meters}{1\ hour}$$

Now, the second conversion factor is $\frac{meters}{hour}$

Repeat steps 1-3 with the new conversion factor to find the meters per second.

Step 1: Identify the relationship between the given unit and the desired unit. Since the miles to meters conversion was accomplished in the first set of steps, focus on converting hours to seconds in the second set of steps.

$$1\ hour = 3600\ seconds$$

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$\frac{1\ hour}{3600\ seconds}\ or\ \frac{3600\ seconds}{1\ hour}$$

Step 3: Multiply the given number by the ratio. Remember that the given unit is cancelled out, this time the given unit will be on the bottom.

$$\frac{112653.8\ meters}{1\ \cancel{hour}} \times \frac{1\ \cancel{hour}}{3600\ seconds} = \frac{31.29272\ meters}{1\ second} = 30\frac{meters}{second}$$

Note: This answer was rounded to one significant figure.

Example 2: How many atoms are in 67.3 g of sulfur?

Step 1: Identify the relationship between the given unit and the desired unit. In this case, there is no direct ratio between atoms and grams, so use the unit atoms and grams have in common, which is moles.

$$Given\ unit: 1\ mol = 32.07\ g\ sulfur$$

$$Desired\ unit: 6.02\ x\ 10^{23} atoms = 1\ mol$$

Remember: The mole to gram relationship is found on the periodic table by finding the atomic mass of the element.

Step 2: Set up the ratios that show the relationship between the given and the desired unit.

$$Given\ unit: \frac{32.07g\ S}{1\ mol\ S}\ or\ \frac{1\ mol\ S}{32.07g\ S}$$

$$Desired\ unit: \frac{6.02\ \times\ 10^{23} atoms\ S}{1\ mol\ S}\ or\ \frac{1\ mol\ S}{6.02\ \times\ 10^{23}\ atoms\ S}$$

Step 3: Multiply the given number by the ratio. Remember that the desired unit should be on top of the ratio and the given unit should be cancelled out.

$$67.3\cancel{g\ S}\ \times\ \frac{1\ mol\ S}{32.07\cancel{g\ S}} = 2.09853\ mol\ S$$

Step 4: Change 2.09853 mols sulfur into atoms of sulfur.

$$2.09853\ \cancel{mol\ S}\ \times\ \frac{6.02\ \times\ 10^{23} atoms\ S}{1\ \cancel{mol\ S}} =\ 1.26\ \times\ 10^{24}\ atoms\ S$$

So, there are $1.26\ \times\ 10^{24}$ atoms Sulfur in 67.3 grams of Sulfur.

Note: This answer was rounded to three significant figures.

Practice Problems

Note: Conversion factors are located on the inside back cover of all chemistry books.

1. Convert 2.73 kilograms into grams.
2. Convert 37 grams of sodium into particles of sodium.
3. Convery 7.2 kilometers into miles.
4. Convert 54.67 millimeters into kilometers.
5. Convert 2.8 moles of Phosphorous into grams of phosphorous.
6. Convert 13.72 inches into centimeters.

Solutions

Note: all solutions are rounded to the appropriate number of significant figures.

1. $2{,}730\ grams$
2. $9.7 \times 10^{23}\ particles\ Na$
3. $4.5\ miles$
4. $0.00005467\ kilometers$
5. $87\ grams\ P$
6. $34.85\ cm$