Empirical Formulas - EF

- When a new compound has been created and its percent composition has been experimentally determine, the next step is to determine its empirical formula - a simplified formula.

Steps

1. Assume you have 100. g of the substance & convert % to grams. (most easily, change the % to a g because, for example, 49% of 100 = 49)
2. Convert grams to moles. Use your mole map if necessary.
3. Look for the smallest answer. Divide all your answers by the smallest. This will give you the ratio of one element to another.
   A. If you get whole numbers, or close to it, those are the subscripts for your formula.
   B. If you get anywhere from .25 → .75 in your answers, you cannot round to whole numbers. You have to multiply all the answers by a digit that will give you whole numbers.

Examples

1. Determine the empirical formula (unknown) for a substance found to be 89.14% Au and 10.80% O. (given)

step 1: 89.14% Au ⇒ 89.14 g Au 10.80% O ⇒ 10.80 g O

step 2:

$$\frac{89.14\text{ g Au}}{1} \left| \frac{1\text{ mol}}{196.97\text{ g}} \right. = .4525562268 = .4526\text{ mol Au}$$

$$\frac{10.80\text{ g O}}{1} \left| \frac{1\text{ mol}}{16.00\text{ g}} \right. = .675 = .6750\text{ mol O}$$

always give at least 4 sig. figures in this step!

↗ smallest answer

This is NOT a whole #

step 3:

$$\frac{.4526\text{ mol Au}}{.4526\text{ mol}} = 1\text{ Au} \qquad \frac{.6750\text{ mol O}}{.4526\text{ mol}} = 1.49138312 \Rightarrow 1.5\text{ O}$$

If I multiply 1.5 by 2 I'd get a whole #, so I will multiply both answers by 2 to get the Empirical Formula.

2(1 Au) + 2(1.5 O) = 2 Au & 3 O EF = Au_2O_3

2. The chemical responsible for the scent of freshly cut grass is composed of 73.411% C, 10.289% H, and 16.300% O. Determine its empirical formula. (given; given; unknown)

step 1 | step 2 | step 3

$\frac{73.411\text{ g C}}{} \left| \frac{1\text{ mol}}{12.01\text{ g}} \right. = 6.1125\text{ mol C} \;/\; 1.0188\text{ mol} = 5.99\text{ C} \Rightarrow 6\text{ C}$

$\frac{10.289\text{ g H}}{} \left| \frac{1\text{ mol}}{1.01\text{ g}} \right. = 10.1782\text{ mol H} \;/\; 1.0188\text{ mol} = 9.99\text{ H} \Rightarrow 10\text{ H}$

$\frac{16.300\text{ g O}}{} \left| \frac{1\text{ mol}}{16.00\text{ g}} \right. = 1.0188\text{ mol O} \;/\; 1.0188\text{ mol} = 1\text{ O}$

$EF = C_6H_{10}O$

3. Ibuprofen contains 75.69% C, 8.80% H, and 15.51% O. Determine the empirical formula. (given; given; unknown)

$\frac{75.69\text{ g C}}{} \left| \frac{1\text{ mol}}{12.01\text{ g}} \right. = 6.3022\text{ mol C} \;/\; .9694\text{ mol} = 6.50\text{ C} \Rightarrow (6.5\text{ C})2 = 13\text{ C}$

$\frac{8.80\text{ g H}}{} \left| \frac{1\text{ mol}}{1.01\text{ g}} \right. = 8.7129\text{ mol H} \;/\; .9694\text{ mol} = 8.99\text{ H} \Rightarrow (9\text{ H})2 = 18\text{ H}$

$\frac{15.51\text{ g O}}{} \left| \frac{1\text{ mol}}{16.00\text{ g}} \right. = .9694\text{ mol O} \;/\; .9694\text{ mol} = (1\text{ O})2 = 2\text{O}$

$EF = C_{13}H_{18}O_2$