**Empirical Formula - Part Two**

Here's the rhyme from the article:

Percent to mass
Mass to mole
Divide by small
Multiply 'til whole

Here's the example problem: A compound is analyzed and found to contain 68.54% carbon, 8.63% hydrogen, and 22.83% oxygen. The molecular weight of this compound is known to be approximately 140 g/mol. What is the empirical formula? What is the molecular formula?

1) Percent to mass. Assume 100 grams of the substance is present, therefore its composition is:

carbon: 68.54 grams
hydrogen: 8.63 grams
oxygen: 22.83 grams

(2) Mass to moles. Divide each mass by the proper atomic weight.

carbon: 68.54 / 12.011 = 5.71 mol
hydrogen: 8.63 / 1.008 = 8.56 mol
oxygen: 22.83 / 16.00 = 1.43 mol

(3) Divide by small:

carbon: 5.71 ÷ 1.43 = 3.99
hydrogen: 8.56 ÷ 1.43 = 5.99
oxygen: 1.43 ÷ 1.43 = 1.00

(4) Multiply 'til whole. Not needed since all values came out whole.

The empirical formula of the compound is C4H6O.

Next we need to determine the molecular formula, knowing the empirical formula and the molecular weight.

Here's how:

1) Calculate the "empirical formula weight." This is not a standard chemical term, but I believe it is understandable.

C4H6O gives an "EFW" of 70.092.

2) Divide the molecular weight by the "EFW."

140 ÷ 70 = 2

3) Multiply the subscripts of the empirical formula by the factor just computed.

C4H6O times 2 gives a formula of C8H12O2.

This is the molecular formula.

**Empirical Formula Practice Problems**

1) A compound is found to have (by mass) 48.38% carbon, 8.12% hydrogen and the rest oxygen. What is its empirical formula?

2) A compound is found to have 46.67% nitrogen, 6.70% hydrogen, 19.98% carbon and 26.65% oxygen. What is its empirical formula?

3) A compound is known to have an empirical formula of CH and a molar mass of 78.11 g/mol. What is its molecular formula?

4) Another compound, also with an empirical formula if CH is found to have a molar mass of 26.04 g/mol. What is its molecular formula?

5) A compound is found to have 1.121 g nitrogen, 0.161 g hydrogen, 0.480 g carbon and 0.640 g oxygen. What is its empirical formula? (Note that masses are given, NOT percentages.)

**Empirical FormulaPractice Problem Answers**

**Problem 1**

1) Percent to mass.

carbon: 48.38 grams
hydrogen: 8.12 grams
oxygen: 43.50 grams

Note that the oxygen percentage came from 100% - (48.38 + 8.12) = 43.5%

(2) Mass to moles.

carbon: 48.38 / 12.011 = 4.028 mol
hydrogen: 8.12 / 1.008 = 8.056 mol
oxygen: 43.50 / 16.00 = 2.719 mol

(3) Divide by small:

carbon: 4.028 ÷ 2.719 = 1.48
hydrogen: 8.056 ÷ 2.719 = 2.96
oxygen: 2.719 ÷ 2.719 = 1.00

Note that the carbon value (4.028) is half the hydrogen value (8.056). That means there is one carbon for every two hydrogens in the answer. (4) Multiply 'til whole:

carbon: 1.48 x 2 = 3 hydrogen: 2.96 x 2 = 6 oxygen: 1 x 2 = 2

The empirical formula is C3H6O2

**Problem 2**

1) Percent to mass: N = 46.67 g; H = 6.70 g; C = 19.98 g; O = 26.65 g
2) Mass to moles: N = 3.33; H = 6.65; C = 1.66; O = 1.66
3) Divide by small: N = 2.01; H = 3.99; C = 1.00; O = 1.00
4) Multiply 'til whole: not required in this problem, the empirical formula is CH4N2O

**Problem 3**

The "EFW" of CH = 13.019.
78.11 ÷ 13.019 = 6.
The molecular formula is C6H6

**Problem 4**

The "EFW" of CH = 13.019.
26.04 ÷ 13.019 = 2.
The molecular formula is C2H2

**Problem 5**

1) Percent to mass: not required since the masses are given.
2) Mass to moles: N = 0.800; H = 0.156; C = 0.0400; O = 0.0400
3) Divide by small: N = 2.0; H = 3.9; C = 1.00; O = 1.00
4) Multiply 'til whole: not required in this problem, the empirical formula is CH4N2O

Note: examine the answers to problems one and five and you will see that these are the same empirical formula, but notice that the information is presented differently. You can generate the percentages by adding up the 4 masses given in problem five, then dividing each element's mass by the total to get the percentage. For example, nitrogen is 1.121 ÷ 2.402 = 0.46669 = 46.67%.