Empirical and Molecular Formulas

Review your definitions for empirical and molecular formulas, remembering that an empirical formula is the simplest ratio of elements in a compound. A molecular formula is the formula in wwhich the subscripts give the actual number of each element in a compound. This may be more apparent if you determine the percent composition of both CH_2O and CH_3COOH.

$CH_2O = 30.03g$ %C = 12.01g ÷ 30.03g x 100 = 40%
%H = 2.02g ÷30.03g x 100 = 7%
%O = 16.00g ÷ 30.03g x 100 = 53%

$CH_3COOH = 60.06g$ %C = 24.02g ÷ 60.06g x 100 = 40%
%H = 4.04g ÷ 60.06g x 100 = 7%
%O = 32.00g ÷ 60.06g x 100 = 53%

Notice that both formulas have the same percent composition. That is because they have the same empirical formula. The empirical formula of a compound can be derived used the percent composition information. If you have the actual mass and percent composition you can determine the molecular formula for a compound. Use the direction below to help you determine the empirical and molecular formulas.

Calculating Empirical Formula (from % Composition)

1. convert % of each element to grams based on 100 grams of the compound
2. multiply grams of each element by 1/molar mass that element
3. compare ratio of moles of each element and divide each by the smallest
4. if result in step 3 gives ration with decimal equivalent to ¼, 1/3, ½, 2/3, ¾ instead of whole numbers, convert to the fraction and multiply all ratios by the denominator or the fraction

For example: What is the empirical formula for a compound whose percent composition is: 88.8% copper and 11.2% oxygen

$$Cu = \frac{88.8\%}{63.55g} \qquad O = \frac{11.2\%}{16.00g}$$

$$Cu = \frac{1.4}{0.7} \qquad O = \frac{0.7}{0.7}$$

Cu = 2 O = 1 resulting in the formula Cu_2O

Practice: Determine the following empirical formulas.

1. 40.0% carbon 6.67% hydrogen 53.33% oxygen

2. 70.0% iron 30.0% oxygen

3. 10.1% carbon 0.9% hydrogen 89.1% chlorine

4. 12.6% hydrogen 37.5% carbon 50.1% oxygen

Calculating Empirical Formula (from experimentally determined masses)

1. divide the mass of each element (in grams) by the molar mass of that element
2. continue with steps 3 & 4 from above.

For example: What is the mass of a compound whose make-up is 21.52g potassium, 8.82g sulfur and 17.62g oxygen?

$K = \frac{21.52g}{39.10g}$ $S = \frac{8.82g}{32.1g}$ $O = \frac{17.62g}{16.00g}$

$K = \frac{0.55}{0.27}$ $S = \frac{0.27}{0.27}$ $O = \frac{1.10}{0.27}$

K= 2 S = 1 O = 4, K_2SO_4

Practice: Determine the following empirical formulas.

1. 21.52g potassium 8.82g sulfur 17.62g oxygen

2. 13.80g mercury 1.15g oxygen

3. 5.91g magnesium 17.18g chlorine

4. 7.28g barium 3.74g chlorine

Calculating the Molecular Formulas (when molar mass is known)

1. calculate the empirical formula
2. use the equation: (empirical formula mass)x = molar mass
3. find value for x: x = molar mass/ empirical formula mass
4. multiply each subscript in empirical formula by value for x

For example: What is the molecular formula of a compound whose Percent composition is 80% carbon and 20% hydrogen and has a molecular weight of 75.00g?

$C = \frac{80\%}{12.01g}$ $H = \frac{20\%}{1.01g}$

$C = \frac{6.67}{6.67}$ $H = \frac{19.8}{6.67}$

$C = 1$ $H = 3$ ..... CH_3

Each CH_3 has a molar mass of 15.00g, 75.00g ÷15.00g = 3
There are 3 sets of CH_3 in our compound, resulting in a formula C_5H_{15}.

Practice: Determine the molecular formula of the following compounds.

1. Molecular mass = 26g
   92.3% carbon 7.7% hydrogen

2. Molecular mass = 334g
   76% iodine 24% oxygen

3. Molecular mass = 283.9g
   53.36g Oxygen 43.46g Phosphorous

Name: _____ **Block:** ____ **Date:** _____

Empirical and Molecular Formulas Homework

Show your work on a separate paper.

1. Calculate the empirical formula for the compounds below.
   a. 46.6% Fe 53.44% S
   b. 63.35% Fe 36.47% S
   c. 26.6% K 35.4% Cr 38.0% O
   d. 21.8% Mg 27.9%P 50.3% O
   e. 65.7% Sr 10.4% Si 23.9% O

2. Calculate the empirical formulas for the compounds below.
   a. 8.87g P 11.43g O
   b. 1.03g K 1.18g Cr 1.27g O
   c. 21.52g K 8.82g S 17.62g O

3. Determine the empirical and molecular formulas for the following compounds.
   a. Molecular mass = 78 g/mol
      92.25% C 7.75%H
   b. Molecular Mass = 220 g/mol
      56.4% P 43.7% O
   c. Molecular Mass = 26.02 g/mol
      92.26% C 7.74% H

4. A compound is known to have a molecular mass of 391.5 g/mol. Find the empirical and molecular formulas of the compound, given the results of the analysis of a 310.8g sample that reveals that the sample only contains boron and iodine. The mass of the iodine in the sample is 302.2g.