Determining Empirical Formula from Percents & Molecular Formula

Empirical Formula From % Composition

- Example Problem:

Find the empirical formula for a compound composed of 75% carbon and 25% hydrogen.

1. Start with grams (assume we have 100 g if given % comp)

What is 75% of 100 g → 75 g C
What is 25% of 100 g → 25 g H

- When given percents just CROSS OUT THE PERCENT SIGN and write grams.

- Continue solving with the remainder of the empirical formula steps. (written on next slide)

1. Start with grams (assume 100 g of given % comp)
2. Convert grams to moles (divide by Molar Mass)
3. Select smallest number of moles
4. Divide all moles by smallest #
5. Determine if numbers can be rounded:

   2.9 → 3 1.1 → 1 4.03 → 4

   Or if they need to be multiplied:

   2.256 → 2.25 x 4 = 9

   1.34 → 1.33 x 3 = 4

   3.45 → 3.5 x 2 = 7

PRACTICE

- On your HW worksheet from last class, complete the FRONT problems #1-5 determining empirical formulas using percents. Answer key is in my RED binder if you would like to check your answers.
- If you lost this worksheet, check the wire basket for another.

Determining Molecular Formulas

- Molecular Formulas – the actual or true amount of atoms that are in a compound.

- Molecular formulas can either be a multiple of an empirical formula or they can be the same as an empirical formula.

Examples

- Sugar is $C_6H_{12}O_6$ Ratio is 6:12:6
  - This is the molecular formula. Sugar is actually made up of 6 carbons, 12 hydrogens, and 6 oxygens.
- The empirical formula for sugar is CH_2O. Ratio is 1:2:1
  - This is NOT the same as the molecular formula because sugar does not contain 1 carbon, 2 hydrogens, and 1 oxygen

More Examples

- Water has the formula H_2O
  - This is an empirical formula because the ratio is 2:1 which cannot be reduced.
  - This is also the MOLECUAR formula because water actually contains 2 hydrogens and 1 oxygen.

Molecular Formula Equation

- To determine the molecular formula we use the equation

$$\frac{\text{Molecular mass}}{\text{Empirical mass}} = n$$

WRITE THIS DOWN!

- Empirical mass = the MOLAR MASS of the empirical formula

- Molecular mass = the MOLAR MASS of the molecular formula

Examples

- The empirical formula for a compound is N_2O_5. If the molecular mass of the compound is 216 g/mol, determine the molecular formula.

1. Determine empirical mass

   N = 14 x 2 = 28

   O = 16 x 5 = 80

   28 + 80 =

   108 g/mol

2. Use equation to find "n"

   $\frac{\text{Molec. Mass}}{\text{Emp. Mass}} = \frac{216}{108} = 2$ ← This is "n"

3. Multiply all subscripts in the empirical formula by "n"

   $(N_2O_5)_2$ Now distribute the 2 using multiplication

   Molecular formula = N_4O_{10}

- For the previous problem, since the molecular mass was 2x's as much as the empirical mass, the formula also had to be double.

N_2O_5	x 2	=	N_4O_{10}
108 g/mol	x 2	=	216 g/mol

What if I don’t give you the empirical formula?

- Then you must first use steps 1-5 to determine the empirical formula.
- After determining the empirical formula, you can then solve for “n”

Example

The percent composition of acetic acid is found to be 39.9% C, 6.7% H, and 53.4% O. The molecular mass of the compound is 60.0 g/mol. What is the molecular formula?

1. Start with grams

   39.9% C = 39.9 g C

   6.7% H = 6.7 g H

   53.4% O = 53.4 g O

2. Convert grams to moles

   $\frac{39.9 \text{ g C}}{12 \text{ g/mol}} = 3.36 \text{ mol C}$

   $\frac{6.7 \text{ g H}}{1 \text{ g/mol}} = 6.7 \text{ mol H}$

   $\frac{53.4 \text{ g O}}{16 \text{ g/mol}} = 3.33 \text{ mol O}$

3. Find smallest number of moles

   3.33 mol O

4. Divide moles by smallest number

$$\frac{3.36 \text{ mol C}}{3.33 \text{ mol}} = 1$$

$$\frac{6.7 \text{ mol H}}{3.33 \text{ mol}} = 2$$

$$\frac{3.33 \text{ mol O}}{3.33 \text{ mol}} = 1$$

5. Round or Multiply

Not needed because we have all whole #'s

Empirical Formula = CH_2O

Empirical Mass = 12 + 2 + 16 = 30 g/mol

Molecular Formula = ?

Molecular Mass = 60 g/mol

Use equation to find "n"

$$\frac{\text{Molec. Mass}}{\text{Emp. Mass}} = \frac{60}{30} = 2 \leftarrow \text{This is "n"}$$

Multiply all subscripts in the empirical formula by "n"

$(CH_2O)_2$ Now distribute the 2 using multiplication

Molecular formula = $C_2H_4O_2$

Classwork

- Complete Determining Molecular Formula worksheet (front and back)

- Complete Empirical and Molecular Formulas Review worksheet