

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:
 $2.9 \rightarrow 3$ $1.1 \rightarrow 1$ $4.03 \rightarrow 4$

Or if they need to be multiplied:

$$2.256 \rightarrow 2.25 \times 4 = 9$$

$$1.34 \rightarrow 1.33 \times 3 = 4$$

$$3.45 \rightarrow 3.5 \times 2 = 7$$

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 MOLECULAR 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

$$\text{N} = 14 \times 2 = 28$$

$$\text{O} = 16 \times 5 = 80$$

$$28 + 80 =$$

$$108 \text{ g/mol}$$

2. Use equation to find "n"

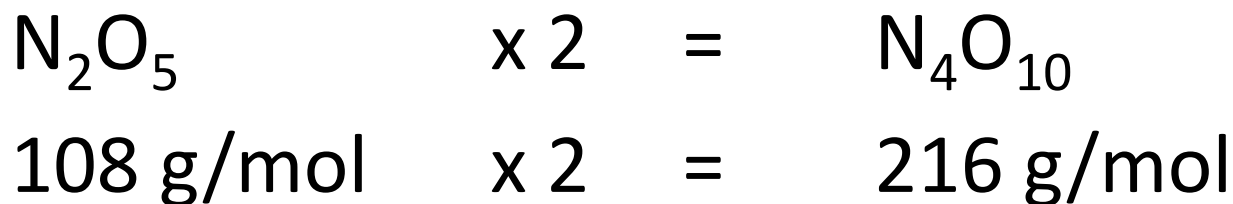
$$\frac{\text{Molec. Mass}}{\text{Emp. Mass}} = \frac{216}{108} = 2 \leftarrow \text{This is "n"}$$

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

$(\text{N}_2\text{O}_5)_2$ 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.



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

$$39.9\% \text{ C} = 39.9 \text{ g C}$$

$$6.7\% \text{ H} = 6.7 \text{ g H}$$

$$53.4\% \text{ O} = 53.4 \text{ g O}$$

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 = $12 + 2 + 16 = 30 \text{ g/mol}$

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”

$(\text{CH}_2\text{O})_2$ Now distribute the 2 using multiplication

Molecular formula = $\text{C}_2\text{H}_4\text{O}_2$

Classwork

- Complete Determining Molecular Formula worksheet (front and back)
- Complete Empirical and Molecular Formulas Review worksheet