

N29 – PERCENT COMPOSITION **AND EMPIRICAL FORMULAS**

Target: I can calculate the percent composition of an element in a molecule, and can determine the empirical and molecular formulas for substances.

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Remember – make a clear, obvious title! It needs to be numbered and titled. Don't forget KCQ boxes and color *annotations* as homework!

Percent Composition

Determining how much of a molecule's mass is from each element

$$\frac{\text{Part}}{\text{Whole}} \times 100 = \%$$

$$\frac{\text{Element's Mass}}{\text{Molecule's Mass}} \times 100 = \% \text{ Composition}$$

% Composition Steps

- 1) Find the molar mass of the molecule
- 2) Divide each element's atomic mass by the molar mass of the molecule
- 3) Multiply by 100 to put answer in terms of an actual %

note *If you add up the % for each element it should add up to 100%...but rounding answers may make it not quite add up to 100%. That's ok.*

Example

$$\frac{\text{Element's Mass}}{\text{Molecule's Mass}} \times 100 = \% \text{ Composition}$$

Calculate the % composition of Magnesium Carbonate

Molar Mass of Molecule $24.31 + 12.01 + 3(16.00) = 84.32 \text{ g/mol}$

$$Mg = \left(\frac{24.31}{84.32} \right) \bullet 100 = 28.83\%$$

$$C = \left(\frac{12.01}{84.32} \right) \bullet 100 = 14.24\%$$

$$O = \left(\frac{48.00}{84.32} \right) \bullet 100 = 56.93\%$$

3 x 16 because there are 3 oxygens!

Check that it adds
up to 100% !!!

Empirical Formula

The simplest, reduced version of a formula.
Smallest whole number ratios possible.

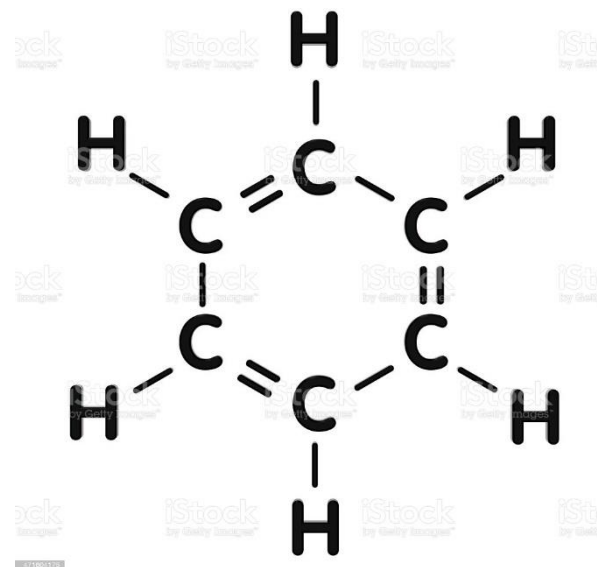
Molecular Formula

The **real** version of the formula – may or may not be in the simplest most reduced form, just depends on the specific formula.

Example

Molecular: C₆H₆

Empirical: CH



Ionic Formulas

Are always empirical! NaCl , MgCl_2 , $\text{Al}_2(\text{SO}_4)_3$

Covalent Formulas

Sometimes empirical, sometimes not.

Molecular:



Empirical:



Determining Empirical Formula

- 1) Given: % composition
- 2) Assume you have 100g sample to make #s easy
- 3) Use the poem!

*Percent to mass
Mass to moles
Divide by small
Multiply 'till whole*

Adipic acid contains 49.32% C, 43.84% O, and 6.85% H by mass. What is the empirical formula of adipic acid?

1. Percent to mass – 49.32g C, 43.84g O, 6.85g H

2. Mass to mole

$$\frac{49.32 \text{ g carbon}}{12.01 \text{ g carbon}} \times \frac{1 \text{ mol carbon}}{1} = 4.107 \text{ mol carbon}$$

$$\frac{6.85 \text{ g hydrogen}}{1.01 \text{ g hydrogen}} \times \frac{1 \text{ mol hydrogen}}{1} = 6.78 \text{ mol hydrogen}$$

$$\frac{43.84 \text{ g oxygen}}{16.00 \text{ g oxygen}} \times \frac{1 \text{ mol oxygen}}{1} = 2.74 \text{ mol oxygen}$$

3. Divide by small –
divide the mole
values by the
smallest mole
value found...
gets you the
simplest ratios!

Carbon: $\frac{4.107 \text{ mol carbon}}{2.74 \text{ mol}} = 1.50$

Hydrogen: $\frac{6.78 \text{ mol hydrogen}}{2.74 \text{ mol}} = 2.47$

Oxygen: $\frac{2.74 \text{ mol oxygen}}{2.74 \text{ mol}} = 1.00$

4. **Multiply 'till whole** – If necessary, multiply the values found until they are whole numbers. The numbers may not be perfect, might have to round a little bit!
YOU HAVE TO MULTIPLY THEM ALL BY THE SAME # !

Carbon: 1.50

$$\begin{array}{r} 1.50 \\ \times 2 \\ \hline 3 \end{array}$$

Hydrogen: 2.47 →

$$\begin{array}{r} 2.50 \\ \times 2 \\ \hline 5 \end{array}$$

Oxygen: 1.00

$$\begin{array}{r} 1.00 \\ \times 2 \\ \hline 2 \end{array}$$

Empirical formula:



Determining Molecular Formula

- 1) Find molar mass of the empirical formula
- 2) Divide molecular formula mass by empirical formula mass
- 3) Multiply empirical formula subscripts by the multiplier # found in step 2

*No cute rhyme this
time...sorry! 😊*

The empirical formula for adipic acid is $\text{C}_3\text{H}_5\text{O}_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

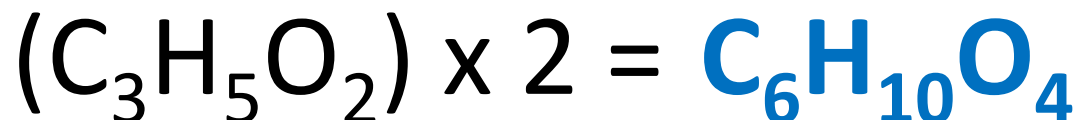
1. Molar mass of empirical formula

$$3(12.01 \text{ g}) + 5(1.01) + 2(16.00) = 73.08 \text{ g/mol}$$

2. Divide molecular by empirical masses

$$\frac{146}{73.08} = 1.997 \rightarrow 2 \quad \text{*you will usually have to round a bit*}$$

3. Multiply empirical by multiplier found in step 2



YouTube Link to Presentation

- https://youtu.be/5OxEDmFjv_w