

# Warm up

- What is the % composition of C, H, and O in Ibuprofen? ( $\text{C}_{13}\text{H}_{18}\text{O}_2$ )
- How many grams of C do you have in an average dose (0.500g)?
- The max daily dose of Ibuprofen contains 0.496g of O, what is the max daily dose in grams?

# Empirical Formula

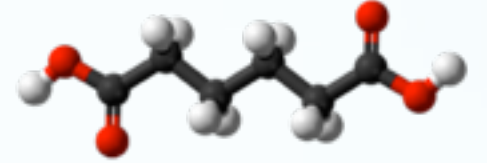
- Lowest ratio of elements in a compound.



$\text{C}_6\text{H}_{12}\text{O}_6$	C	H	O	Total
<i>Molar Mass</i>	72.07 g	12.09 g	95.99 g	180.16 g
<i>% Composition</i>	40%	6.7%	53.3%	100%

$\text{C}_3\text{H}_6\text{O}_3$	C	H	O	Total
<i>Molar Mass</i>	36.03 g	6.048 g	53.28 g	90.78 g
<i>% Composition</i>	40%	6.7%	53.3%	100%

# Finding molar mass using empirical formula - Adipic Acid



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

What is the molecular formula of adipic acid?

1. Find the formula mass of the empirical formula.
2. Divide the actual molecular mass by the empirical formula mass to get conversion factor.
3. Multiply the empirical formula subscripts by

# 1. Find the molar mass of the empirical formula.

The empirical formula for adipic acid is  $\text{C}_3\text{H}_5\text{O}_2$ .

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

**C**

**H**

**O**

2. Divide the actual molar mass by the empirical formula mass to get conversion factor.

Molar mass of  $\text{C}_3\text{H}_5\text{O}_2 = 73.08 \text{ g}$

Molar mass of adipic acid =  $146 \text{ g/mol}$

$$\frac{146 \text{ g}}{73 \text{ g}} = 2$$

Adipic acid is twice as large as the empirical formula

3. Multiply the empirical formula subscripts by conversion factor to get molecular formula.



*Working with molecular objects (single compounds/ molecules) we only use subscripts.*

## Practice - Write the molecular formulas from the following empirical formulas and molar masses

Molar Mass	Empirical Formula	Molecular Formula
78.11 g	CH	C <sub>6</sub> H <sub>6</sub>
239.76 g	AgC	Ag <sub>2</sub> C <sub>2</sub>
142.28 g	C <sub>5</sub> H <sub>11</sub>	C <sub>10</sub> H <sub>22</sub>

# Empirical Formula Determination

- Start with the number of grams of each element
  - -If percentages are given, assume that the total mass is 100 grams so that the mass of each element = the percent given.
- Convert the mass of each element to moles using the molar mass.
- Divide each value of moles by the smallest of the values.
- Multiply each number by an integer to obtain all whole numbers.



# Step 1: Find your grams - C<sub>3</sub>H<sub>5</sub>O<sub>2</sub>

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

Assume total grams = 100g

C:  $0.4932 \times 100\text{g} = 49.32\text{g}$

O:  $0.4384 \times 100\text{g} = 43.84\text{g}$

H:  $0.0685 \times 100\text{g} = 6.85\text{g}$

## Step 2 - Convert grams to moles - Adipic Acid

49.32 g C	1 mol C	4.107 mol C
	12.01 g C	
6.85 g H	1 mol H	6.78 mol H
	1.01 g H	
43.84 g O	1 mol O	2.74 mol O
	16.00 g O	

## Step 3- Divide calculated moles by lowest number - Adipic Acid

$$\frac{4.107 \text{ mol C}}{2.74 \text{ mol}} = 1.50$$

$$\frac{6.78 \text{ mol H}}{2.74 \text{ mol}} = 2.47$$

$$\frac{2.74 \text{ mol O}}{2.74 \text{ mol}} = 1$$

Your lowest element should always be 1.

Step 4: Multiply each number by the same integer to obtain all whole numbers.

Carbon: 1.50

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

Hydrogen: 2.50

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

Oxygen: 1.00

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

Values determined after multiplying will be subscripts for empirical formula.

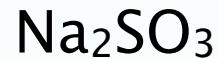
Empirical formula Adipic Acid:  $\text{C}_3\text{H}_5\text{O}_2$

# Common Multiplication Factors

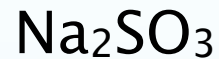
- If **0.5** present in decimal **multiply by 2**
- If **0.33** present in decimal **multiply by 3**
- If **0.66** present in decimal **multiply by 3**

# Practice

- Determine the empirical formula for an unknown compound composed of 36.5% sodium, 38.1% oxygen, and 25.4% sulfur by mass.



- If the molar mass is 126.043 g, what is the molecular formula of the compound?



- What can you say about the empirical formula of compounds (ionic bonding)?

They are the same for ionic compounds