Unit 7 Chemical Formulas and Reactions Name _____

Intro to Chemical Formulas Block _____

Types of Chemical Formulas

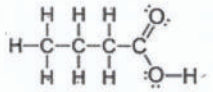
A **Molecular Formula** describes the exact number and type of atoms in a single molecule of a compound. The number of atoms is represented using subscripts. The molecular formula for sodium sulfate is **Na_2SO_4** and for acetic acid it is **$C_2H_4O_2$**.

An **Empirical Formula** represents the simplest whole-integer ratio of atoms in a compound. The molecular formula for a compound can be the same as or a multiple of the compound's empirical formula. The empirical formula stays the same for ionic compounds, such as sodium sulfate (**Na_2SO_4**), but it reduces to the lowest ratio for covalent compounds, such as acetic acid (**$C_1H_2O_1$**).

A **Structural Formula** shows the number of atoms and their exact arrangement in the molecule. The structural formula stays the same for ionic compounds, such as sodium sulfate (**Na_2SO_4**), but it changes for organic compounds, such as acetic acid (**CH_3COOH**).

For more information visit: https://courses.lumenlearning.com/boundless-chemistry/chapter/chemical-formulas/

Write the molecular, empirical, and structural formulas for butanoic acid below:

 Butanoic acid	**Molecular Formula**	**Empirical Formula**	**Structural Formula**
	$C_4H_8O_2$	$C_2H_4O_1$	$CH_3CH_2CH_2COOH$

same same

Empirical Formulas can be calculated by using the **Percent Composition** of each element in a compound. For instance, suppose a chemist used **Combustion Analysis** to determine that a sample of **butanoic acid** was composed of **54.529% C**, **9.152% H**, and **36.319% O**. Follow the steps below to calculate its empirical formula.

Percent Composition	Change to Grams	÷ Molar Mass	= Moles	÷ Smallest Moles	= Subscripts
54.529 % C	54.529 g C	÷ 12.011	= 4.540	÷ 2.270	= 2
9.152 % H	9.152 g H	÷ 1.008	= 9.079	÷ 2.270	= 4
36.319 % O	36.319 g O	÷ 15.999	= 2.270	÷ 2.270	= 1

Write the empirical formula for butanoic acid using the subscripts calculated above. $C_2H_4O_1$ Compare this to the empirical formula for butanoic acid written in the first table above.

The **Molecular Formula** can be calculated by scaling up the empirical formula proportionately based on the measured molecular mass of the compound. Use the empirical formula from above and the molecular mass of 88 g/mol to calculate the molecular formula for butanoic acid. Compare it to the molecular formula shown above.

Follow these steps to determine the molecular formula.

Step 1: Write the empirical formula and molecular mass in the appropriate boxes.

Step 2: Calculate the empirical mass using the molar masses of each element.

Step 3: Divide molecular mass by empirical mass to determine the scale factor.

Step 4: Multiply subscripts in empirical formula by scale factor to determine subscripts in molecular formula.

Empirical Formula:	**Empirical Mass:**
$C_2H_4O_1$	44.053
Molecular Formula:	**Molecular Mass:**
$C_4H_8O_2$	88 g/mol

2× ÷ 2

$C_2H_4O_1 = 2(12.011) + 4(1.008) + 1(15.999) =$ (C, H, O)

$= 44.053$ g/mol

Unit 7 Chemical Formulas and Reactions Name Answer Key

Intro to Chemical Formulas Block _____

Calculating Empirical Formulas. ***Show your work.***

1. The main ingredient in the antacid called Tums is composed of 40.043% Calcium, , 12.000% Carbon, and 47.957% Oxygen. Write the empirical formula and name the compound.

Element	Change % to Grams	÷ Molar Mass	= Moles	÷ Smallest Moles	= Subscripts
Ca	40.043 g	÷ 40.080	= 0.999	÷ 0.999	= 1
C	12.000 g	÷ 12.011	= 0.999	÷ 0.999	= 1
O	47.957 g	÷ 15.999	= 2.997	÷ 0.999	= 3

Empirical Formula = $CaCO_3$ **Name of Compound =** calcium carbonate

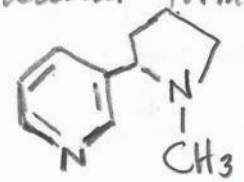
2. Using Combustion Analysis, a chemist determines that Nicotine, the addictive drug in cigarettes, contains 74.0% carbon, 8.65% hydrogen, and 17.35% nitrogen. Determine the empirical formula for nicotine.

Element	Change % to Grams	÷ Molar Mass	= Moles	÷ Smallest Moles	= Subscripts
C	74.00 g	÷ 12.011	= 6.161	÷ 1.239	= 4.973 → 5
H	8.65 g	÷ 1.008	= 8.581	÷ 1.239	= 6.926 → 7
N	17.35 g	÷ 14.007	= 1.239	÷ 1.239	= 1.000 → 1

Empirical Formula = $C_5H_7N_1$

* Actual Molecular formula

$C_{10}H_{14}N_2$



Calculating Molecular Formulas. ***Show your work.***

1. The empirical formula of a substance is C_2H_4O and the molecular mass is 88 grams per mole. Determine its molecular formula.

Step 1: $C_2H_4O = 2(12.011) + 4(1.008) + 15.999 = 44.053$

Step 2: $88 \div 44 = 2$

Step 3: $C_2H_4O_1$ (×2, ×2, ×2) → 4, 8, 2 → $C_4H_8O_2$

2. The empirical formula of a substance is CH_2O and its molecular mass is 180 g/mol. What is its molecular formula?

C 1 × 12.011 = 12.011
H 2 × 1.008 = 2.016
O 1 × 15.999 = 15.999
30.026

EF CH_2O_1	EM 30.026
MF $C_6H_{12}O_6$	MM 180

6× ↑ ÷ 6

3. Methylpropionylacetate is a carboxylic acid anion derived from a hexanoate. Its empirical formula is C_2H_3O and its molecular mass is 129.13 g/mol. Determine its molecular formula.

$C_2H_3O =$

$2(12.011) + 3(1.008) + 15.999 =$

43.045

EF C_2H_3O	EM 43.045
MF $C_6H_9O_3$	MM 129.13

3× ↑ ÷ 3