

Molecular Formula VS Empirical Formula

- Different compounds can have the **same empirical formula** but **different molecular formulas**.
- Empirical Formula is a **reduced** form of Molecular formula
- Molecular Formula and Empirical Formula can be the same.

An empirical formula is:

simplest whole-number ratio of atoms in a compound- Reduced form

A molecular formula is:

The actual formula of the molecule

Therefore....

CH_2O is an *empirical formula*

$\text{C}_6\text{H}_{12}\text{O}_6$ is a *molecular formula*

Empirical Formulas

- Step 1: Change % sign to grams (g)
 - if you are given grams, skip this step
- Step 2: Convert masses to moles using molar mass
- Step 3: Divide all # of moles by the smallest value
- Step 4: If dividing gave you 0.5, then multiply by **2**
- Step 5: If dividing gave you 0.3 or 0.7, then multiply by **3**
- Step 6: If step 5 or 6 do not apply, then round step 3 values to a whole number
- Step 7: **Once you know the ratios**, place them as subscripts in the formula

Empirical Practice #1: Find the empirical formula of a compound that is 33.38% Na, 22.65% S, and 44.9% O.

What is the important information from this problem? (the given)

33.38% Na
 22.65% S
 44.9% O

What are you looking for? (the want)

empirical formula

What do you need to solve problem? (the need)

MM_{Na} 23.00g/mole
 MM_S 32.07g/mole
 MM_O 16.00g/mole

Empirical Practice #1: Find the empirical formula of a compound that is 33.38% Na, 22.65% S, and 44.9% O.

	Step 1	Step 2	Step 3	Step 6
33.38% Na	→ 33.38 g Na	<u>33.38 g Na</u>	1 mole Na = 1.45 / 0.71 = 2.04	= 2
22.65% S	→ 22.65 g S		23.00 g Na	
44.9% O	→ 44.9 g O	<u>22.65 g S</u>	1 mole S = 0.71 / 0.71 = 1.00	= 1
? empirical formula			32.07 g S	
MM _{Na} 23.00g/mole		<u>44.9 g O</u>	1 mole O = 2.81 / 0.71 = 3.95	= 4
MM _S 32.07g/mole			16.00 g O	
MM _O 16.00g/mole				

Step 4: no 0.5 N/A

Step 5: no 0.3 or 0.7 N/A

Step 7: Na₂SO₄

Empirical Practice #2: A compound contains 3.26g of arsenic and 1.04g of oxygen. What is the empirical formula?

What is the important information from this problem? (the given)

3.26g As

1.04g O

What are you looking for? (the want)

empirical formula

What do you need to solve problem? (the need)

MM_{As} = 72.92 g/mole

MM_O = 16.00 g/mole

Empirical Practice #2: A compound contains 3.26g of arsenic and 1.04g of oxygen. What is the empirical formula?

3.26g As

1.04g O

?empirical formula

$MM_{\text{As}} = 74.92 \text{ g/mole}$

$MM_{\text{O}} = 16.00 \text{ g/mole}$

Empirical Practice #2: A compound contains 3.26g of arsenic and 1.04g of oxygen. What is the empirical formula?

$$\frac{3.26 \text{ g As}}{74.92 \text{ g}} \times \frac{1 \text{ mole}}{1} = \frac{0.0435 \text{ mole}}{0.0435} = 1$$

$$\frac{1.04 \text{ g O}}{16.00 \text{ g}} \times \frac{1 \text{ mole}}{1} = \frac{0.065 \text{ mole}}{0.0435} = 1.49$$

Step 4: If dividing gave you .5, then multiply by 2

Step 5: If dividing gave you .3 or .7, then multiply by 3

Empirical Practice #2: A compound contains 3.26g of arsenic and 1.04g of oxygen. What is the empirical formula?

$$\frac{3.26 \text{ g As}}{74.92 \text{ g}} \times \frac{1 \text{ mole}}{1} = \frac{0.0435 \text{ mole}}{0.0435} = 1 * 2 = 2$$

$$\frac{1.04 \text{ g O}}{16.00} \times \frac{1 \text{ mole}}{1} = \frac{0.065 \text{ mole}}{0.0435} = 1.49 * 2 = 3$$



Molecular Formulas

To find the molecular formula you must:

1. Find the **empirical formula** if not given
2. Determine the **molar mass** of the **empirical formula**
3. $\frac{\text{MM molecular formula}}{\text{MM empirical formula}} = X$
4. **multiply** each **subscript** in the empirical formula by "X"

Molecular Practice 4: The empirical formula of a compound is CH; the molecular molar mass is 78.11 g/mol. What is its molecular formula?

What is the important information from this problem? (the given) empirical formula =CH
molecular molar mass is 78.11 g/mol

What are you looking for? (the want) molecular formula

What do you need to solve problem? (the need)
empirical formula molar mass = 13.02 g/mol

Molecular Practice 4: The empirical formula of a compound is CH; the molecular molar mass is 78.11 g/mol. What is its molecular formula?

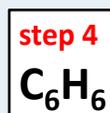
Empirical: CH

$MM_{\text{molecular formula}} = 78.11 \text{ g/mole}$

Step 2: $MM_{\text{empirical formula}} = 13.02 \text{ g/mole}$

step3

$$\frac{\text{Big (molecular)}}{\text{Small (empirical)}} = \frac{78.11 \text{ g/mole}}{13.02 \text{ g/mole}} = 6$$



Molecular Practice #5:A compound has an empirical formula of CH_3O and a molecular mass of 62 g/mol. What is its molecular formula?

What is the important information from this problem? (the given) empirical formula = CH_3O
molecular mass = 62 g/mol

What are you looking for? (the want) molecular formula

What do you need to solve problem? (the need) empirical mass = 31.04 g/mole

Molecular Practice #5:A compound has an empirical formula of CH_3O and a molecular mass of 62.00 g/mol. What is its molecular formula?

Empirical: CH_3O

$\text{MM}_{\text{molecular formula}} = 62.00 \text{ g/mole}$

$\text{MM}_{\text{empirical formula}} = 31.04 \text{ g/mole}$

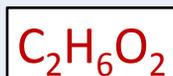
Molecular Practice #5:A compound has an empirical formula of CH_3O and a molecular mass of 62.00 g/mol. What is its molecular formula?

Empirical: CH_3O

$\text{MM}_{\text{molecular formula}} = 62.00 \text{ g/mole}$

$\text{MM}_{\text{CH}_3\text{O}} = 31.04 \text{ g/mole}$

$$\frac{62.00}{31.04} = 2$$



Summary

Determine the molecular and empirical formula for each:

- | | |
|--|--|
| a. C_6H_8 | molecular - C_3H_4 (empirical) |
| b. N_2O_6 | molecular - NO_3 (empirical) |
| c. $\text{C}_6\text{H}_{12}\text{O}_6$ | molecular - CH_2O (empirical) |
| d. BCl_3 | empirical |