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***

$C_6H_{12}O_6$ is a ***molecular formula***

Empirical Formulas

Step1: 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

33.38% Na → 33.38 g Na
22.65% S → 22.65 g S
44.9% O → 44.9 g O

? empirical formula

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

Step 2

$\frac{33.38 \text{ g Na}}{} \left| \frac{1 \text{ mole Na}}{23.00 \text{ g Na}} \right.$ = 1.45

$\frac{22.65 \text{ g S}}{} \left| \frac{1 \text{ mole S}}{32.07 \text{ g S}} \right.$ = 0.71

$\frac{44.9 \text{ g O}}{} \left| \frac{1 \text{ mole O}}{16.00 \text{ g O}} \right.$ = 2.81

Step 3

/0.71 = 2.04
/0.71=1.00 =1
/0.71=3.95 =4

Step 6

= 2

Step 4: no 0.5 N/A

Step 5: no 0.3 or 0.7 N/A

Step 7: Na_2SO_4

Empirical Pracitice #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 Pracitice #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_{As} = 72.92 g/mole
MM_{O}= 16.00 g/mole

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

$$\frac{3.26 \text{ g As}}{} \left| \frac{1 \text{ mole}}{74.92 \text{ g}} \right. = \frac{0.0435 \text{ mole}}{0.0435} = 1$$

$$\frac{1.04 \text{ g O}}{} \left| \frac{1 \text{ mole}}{16.00 \text{ g}} \right. = \frac{0.065 \text{ mole}}{0.0435} = 1.49$$

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

$$\frac{3.26 \text{ g As}}{} \left| \frac{1 \text{ mole}}{74.92 \text{ g}} \right. = \frac{0.0435 \text{ mole}}{0.0435} = 1*2=2$$

$$\frac{1.04 \text{ g O}}{} \left| \frac{1 \text{ mole}}{16.00} \right. = \frac{0.065 \text{ mole}}{0.0435} = 1.49*2=3$$

$$\boxed{As_2O_3}$$

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. $$\frac{\textbf{MM molecular formula}}{\textbf{MM empirical formula}} = \textbf{X}$$
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

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

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

step3

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

step 4

C_6H_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_30

$MM_{molecular\ formula}$ = 62.00 g/mole

$MM_{empirical\ formula}$= 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_30

$MM_{molecular\ formula}$ = 62.00 g/mole

MM_{CH_3O} = 31.04 g/mole

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

$C_2H_6O_2$

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. $C_6H_{12}O_6$ molecular - CH_2O (empirical)

d. BCl_3 empirical