Calculating Molecular Formulas

- as was mentioned in section 10-4, many different molecular formulas can share the same empirical formula because we have reduced/simplified larger Molecular formulas to do so.

ex) CH is an empirical formula for acetylene C_2H_2 & benzene C_6H_6

- each formula has a unique molar mass (GFM)

ex) acetylene, C_2H_2 = 26 g/mol
benzene, C_6H_6 = 78 g/mol

* We can determine the molecular formula of a compound if we know the empirical formula and its gram formula mass (Molar Mass)

to solve, $\boxed{\dfrac{\text{Gram formula Mass}}{\text{Empirical formula Mass}}}$ $\dfrac{GFM}{EFM} = \dfrac{\text{molar mass}}{EFM}$

Given

look up

ex) Empirical formula = CH_yN, gram formula mass of unknown = 60 g/mol
Molecular formula = ?

1st - determine the EFM by adding up masses

$12(1) + 1(4) + 1(14) = 12 + 4 + 14 = \underline{30\ g}$

2nd - divide gram formula mass (GFM) by calculated EFM

$$\frac{GFM}{EFM} = \frac{60\,g}{30\,g} = 2$$

* This means we need to multiply all moles of elements in empirical formula by 2 to get the molecular formula

$$2\,[CH_4N] \rightarrow \boxed{C_2H_8N_2}$$

molecular Formula

(caffeine) ex) what is the Molecular Formula of a compound that is 49.5% C, 5.15% H, 28.9% N, 16.5% O & GFM = 195 g

molar Mass

C $\frac{49.5\,g}{} \times \frac{1\,mol}{12.0\,g} = \frac{4.125}{1.03}$ 4

H $\frac{5.15\,g}{} \times \frac{1\,mol}{1.0\,g} = \frac{5.15}{1.03}$ 5

N $\frac{28.9\,g}{} \times \frac{1\,mol}{14.0} = \frac{2.06}{1.03}$ 2

O $\frac{16.5\,g}{} \times \frac{1\,mol}{16.0} = \frac{1.03}{1.03}$ 1

C H N O

ratio = 4:5:2:1

$\boxed{C_4H_5N_2O}$

empirical

FROM P.T.

empirical formula = $\boxed{C_4H_5N_2O}$

EFM = 12(4) + 1(5) + 14(2) + 16(1)
= 48 + 5 + 28 + 16 = $\boxed{97\,g}$

$$M.F. = \frac{195\,g\ (GFM)}{97\,g\ (EFM)} = 2$$

Molecular formula = $\boxed{C_8H_{10}N_4O_2}$

Emp. Form

ex) $\boxed{CO_2}$ = 12×1, 16×2 = 48 g/mol

a compound has molecular mass (GFM) of 96 g/mol

Molecular Formula = ?

$\frac{96}{48} = 2$

$2[CO_2] = \boxed{C_2O_4}$ Molecular

C 49.98 g

H 10.47 g

mass : 58.12

C $\frac{49.98\,g}{} \Big| \frac{1\,mol}{12.0\,g} = 4.165$ mol

H $\frac{10.47\,g}{} \Big| \frac{1\,mol}{1.0} = 10.47$ mol

H C

$\frac{10.47}{4.165} = 2.5 : 1$

2x 2x

5 : 2

Empirical formula

$\boxed{C_2H_5}$

$(2 \times 12.0) + (5 \times 1.0) = 29$ g/mol

Given $\frac{58.12\ g/mol}{29.0\ g/mol} = 2\,[C_2H_5] = \boxed{C_4H_{10}}$

molecular form.