# Chemistry Lecture #56: Molecular Formulas

A molecular formula gives the type and actual number of atoms in a molecule. An empirical formula gives the ratio of atoms in a compound. It is possible to find the molecular formula if the molecular mass and empirical formula are known.

To find the molecular formula from the empirical formula,

1. Find the Empirical Formula Mass (EFM).
2. Divide the Molecular Mass (MM) by the EFM. You should get a whole number or something very close to a whole number.
3. Multiply the subscripts in the empirical formula by the answer in step 2 to get the molecular formula.

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One mole of a compound has a mass of 60.0 g. Its empirical formula is $CH_4N$. Find the molecular formula.

Answer:

C: 1 x 12.0 = 12.0

H: 4 x 1.01 = 4.04

N: 1 x 14.0 = 14.0

EFM = 30.04 = 30.0

$\frac{MM}{EFM} = \frac{60.0}{30.0} = 2.00$ or 2

Multiplying the subscripts in the empirical formula by 2, we get $(CH_4N)_2 = C_2H_8N_2$, which is the molecular formula.

The percent composition of a compound is 92.3 % C and 7.77 % H. If the molecular mass is 78.0 g, what is the molecular formula?

Answer: We need to determine the empirical formula first, then the empirical formula mass.

$$\frac{92.3\ g\ C}{1} \times \frac{mole\ C}{12.0\ g\ C} = 7.69\ mole\ C \div 7.69 = 1$$

$$\frac{7.77\ g\ H}{1} \times \frac{mole\ H}{1.01\ g\ H} = 7.69\ mole\ H \div 7.69 = 1$$

Since C and H are in a ratio of 1 : 1, the empirical formula is CH.

C: 1 x 12.0 = 12.0
H: 1 x 1.01 = 1.01
EFM = 13.01 or 13.0

$$MM = \frac{78.0}{EFM} = \frac{78.0}{13.0} = 6$$

The molecular mass is 6 times the empirical formula mass, so the molecular formula would have 6 times as many atoms as the empirical formula.

$(CH)_6 = C_6H_6$ is the molecular formula.

Find the molecular formula of a compound that is 40.9% C, 4.58% H, and 54.5% O, and has a molecular mass of 176 g.

$\frac{40.9\ g\ C}{1} \times \frac{mole\ C}{12.0\ g\ C} = 3.41 \div 3.41 = 1 \quad \times 3 = 3$

$\frac{4.58\ g\ H}{1} \times \frac{mole\ H}{1.01\ g\ H} = 4.53 \div 3.41 = 1.33 \quad \times 3 = 3.99 \text{ or } 4$

$\frac{54.5\ g\ O}{1} \times \frac{mole\ O}{16.0\ g\ O} = 3.41 \div 3.41 = 1 \quad \times 3 = 3$

The empirical formula is $C_3H_4O_3$.

C: 3 x 12.0 = 36.0
H: 4 x 1.01 = 4.04
O: 3 x 16.0 = 48.0
EFM = 88.04 or 88.0

$MM = \frac{176}{EFM} = 2.00$

$(C_3H_4O_3)_2 = C_6H_8O_6$ is the molecular formula.