Percent Composition, Empirical Formula, and Molecular Formula

Calculating Percent Composition (by mass)

% composition of element = _____ x 100

Example

Calculate the percent composition of each element in sodium bicarbonate.

Step 1: Write the chemical formula for the compound.

Sodium bicarbonate –

Step 2: Calculate the molar mass of the compound.

Na:

H:

C:

O:

Step 3: Substitute values in the percent composition equation and solve.

% Na = $\dfrac{g\ Na}{g\ NaHCO_3}$ x 100 = %

% H = $\dfrac{g\ H}{g\ NaHCO_3}$ x 100 = %

% C = $\dfrac{g\ C}{g\ NaHCO_3}$ x 100 = %

% O = $\dfrac{g\ O}{g\ NaHCO_3}$ x 100 = _____ %

100.0%

Practice

Find the percent composition of the elements in each of the following compounds:

1. Sodium nitrate

2. Ammonium sulfide

3. Aluminum oxide

Empirical and Molecular Formulas

Empirical formula: CH_2

Molecular formula: C_2H_4

Determining Empirical Formula

The percent composition of a sulfur oxide is 40.05% S and 59.95% O. Find the empirical formula.

When percent composition is given, use the given values with _____ as the unit.

Step 1: Find the number of moles of each element in the compound using _____ _____
as the conversion factor.

mol S = _____|_____ =

mol O = _____|_____ =

Step 2: Calculate the simplest mole ratio of the elements in the compound by dividing the
number of moles of each element by the _____ _____ in the mole ratio.
The resulting factor becomes the _____ for element in empirical formula.

Subscript for S: _____   =   Subscript for O: _____   =

If the results are not whole numbers, multiply both by a factor that will result in a whole number.

Step 3: Using the values calculated in Step 2 as _____, write the chemical formula.
The empirical formula for the sulfur oxide is _____.

Practice

No work, no credit. No kidding!

4. The percent composition of ammonia is 82.4% N and 17.6% H. Find its empirical formula.

5. A hydrocarbon is composed of 75% carbon and 25% H. Find its empirical formula.

6. Naphthalene is composed of 93.75% carbon and 6.25% H. Find its empirical formula.

Determining Molecular Formula
The empirical formula of propene is CH_2. What is its molecular formula if the molar mass is determined experimentally to be 42.0 grams?

Step 1: Find the molar mass of the empirical formula.
    C: 1 x 12.0 g =
    H: 2 x 1.0 g = _____

Step 2: Compare the mass of the molecular formula to that of the empirical formula.
    $$\frac{\text{molar mass of molecular formula}}{\text{molar mass of empirical formula}} = \underline{\quad\quad} = $$

Step 3: Multiply subscript of each element in the empirical formula by the resulting factor (n).
    _____ formula = (_____ formula)$_n$
    Subscripts in the empirical formula (CH_2) are multiplied by _____, and the molecular formula is written as _____.

Practice
Write the molecular formulas for the following compounds. *Show all work.*
7. A compound with an empirical formula of C_2OH_4 and a molar mass of 88.0 g/mol.

8. A compound with an empirical formula of C_4H_4O and a molar mass of 136.0 g/mol.

9. A deadly nerve gas with an empirical formula $C_6H_{14}O_3PF$ and a molar mass of 552.5 g/mol.

10. Nicotine with an empirical formula of C_5H_7N and a molar mass of 162.0 g/mol.

Mixed Review

11. The percent composition for hydrogen peroxide is 5.88% H and 94.1% O.
    a. Find its empirical formula.

    b. Suppose the molecular mass of hydrogen peroxide is 34.0 g/mol. Find its molecular formula.

12. Butene has a percent composition of 85.7% C and 14.3% H.
    a. Find its empirical formula.

    b. It its molecular mass is 56 g/mol, what is its molecular formula?

13. A solid is found to contain 36.84% nitrogen and 63.16% oxygen.
    a. What is the empirical formula for this compound?

    b. If its molar mass is found to be 152 g, determine its molecular formula.

14. One of the most deadly poisons, strychnine, has a molar mass of 334.0 g/mol and the composition of 75.40% C, 6.64% H, 8.38% N, and 9.58% O. Calculate the empirical and molecular formulas of strychnine, arranging the atomic symbols in alphabetical order.

15. Find the percent composition of water in copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$).
    Hint: To find the molar mass, add the mass of five water molecules to one $CuSO_4$.