

Finding Empirical and Molecular Formulas

Problem:

A compound is 75.46% carbon, 4.43% hydrogen, and 20.10% oxygen by mass. It has a molecular weight of 318.31 g/mol. What is the molecular formula for this compound?

Strategy:

1. Find the empirical formula

- Get the mass of each element by assuming a certain overall mass for the sample (100 g is a good mass to assume when working with percentages).
 $(.7546)(100\text{ g}) = 75.46\text{ g C}$
 $(.0443)(100\text{ g}) = 4.43\text{ g H}$
 $(.2010)(100\text{ g}) = 20.10\text{ g O}$
- Convert the mass of each element to moles using molar mass of the element.
 $(75.46\text{ g C})(1\text{ mol}/12.00\text{ g C}) = 6.289\text{ mol C}$
 $(4.43\text{ g H})(1\text{ mol}/1.008\text{ g H}) = 4.39\text{ mol H}$
 $(20.10\text{ g O})(1\text{ mol}/16.00\text{ g O}) = 1.256\text{ mol O}$
- Find the ratio of the moles of each element.
Divide by the smallest mole value found in the previous step.
 $(1.256\text{ mol O})/(1.256) = 1\text{ mol O}$
 $(6.289\text{ mol C})/(1.256) = 5.007\text{ mol C}$
 $(4.39\text{ mol H})/(1.256) = 3.50\text{ mol H}$
- Use the mole values found in the previous step as subscripts to write the empirical formula.
 $C_5H_{3.5}O_1$
- Multiplying the mole ratios by two to get whole number, the empirical formula becomes:
 $C_{10}H_7O_2$

2. Find the molar mass of the empirical formula.

$$10(12.00) + 7(1.008) + 2(16.00) = 159.06\text{ g/mol}$$

3. Figure out how many empirical units are in a molecular unit.

$$(318.31\text{ g/mol}) / (159.06\text{ g/mol}) = 2.001\text{ empirical units per molecular unit}$$

4. Write the molecular formula.

Since there are two empirical units in a molecular unit, the molecular formula is:

