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Chemistry 11  
EMPIRICAL FORMULA

The EMPIRICAL FORMULA is also known as the SIMPLEST FORMULA

**Example 1.** What do the following compounds all have in common?

C<sub>2</sub>H<sub>4</sub>, C<sub>3</sub>H<sub>6</sub>, C<sub>4</sub>H<sub>8</sub>, C<sub>5</sub>H<sub>10</sub> and C<sub>6</sub>H<sub>12</sub> ?

ALL COMPOUNDS contain TWICE as many H's as C's.

The Empirical Formula for the above compounds is CH<sub>2</sub>!!!!

To solve for the empirical formula we are going to work backwards from the Percent Composition values to determine the chemical formula.

**Example 2.** What is the EMPIRICAL FORMULA for a compound that is composed of 80.0 % Carbon and 20.0 % Hydrogen?

Step 1. Assume you have 100.0 grams

$$80.0\% \text{ of } 100.0\text{g} = 80.0\text{g C}$$

$$20.0\% \text{ of } 100.0\text{g} = 20.0\text{g H}$$

Step 2. Determine the # of moles of each element present

$$80.0\text{g C} \times \frac{1\text{ mol C}}{12.0\text{g C}} = 6.67\text{ mol C}$$

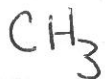
$$20.0\text{g H} \times \frac{1\text{ mol H}}{1.0\text{g H}} = 20.0\text{ mol H}$$

Step 3. Find the SMALLEST WHOLE-NUMBER mole RATIO!! → DIVIDE by smallest #

$$6.67\text{ mol C} \div 6.67 = 1\text{ mol C}$$

$$20.0\text{ mol H} \div 6.67 \approx 3\text{ mol H}$$

Step 4. Write out the EMPIRICAL FORMULA



**Example 2.** A compound is known to contain 58.5 % Carbon, 7.3 % Hydrogen and 34.1 % Nitrogen. What is the EMPIRICAL FORMULA for the compound?

Step 1. Assume you have 100.0 grams

58.5g C

7.3g H

34.1g N

Step 2. Determine the # of moles of each element present

$$58.5\text{g C} \times \frac{1\text{ mol C}}{12.0\text{g C}} = 4.88\text{ mol C}$$

$$7.3\text{g H} \times \frac{1\text{ mol H}}{1.0\text{g H}} = 7.3\text{ mol H}$$

$$34.1\text{g N} \times \frac{1\text{ mol N}}{14.0\text{g N}} = 2.44\text{ mol N}$$

Step 3. Find the SMALLEST WHOLE-NUMBER mole RATIO!!

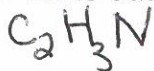
$$4.88 \text{ mol C} \div 2.44 = 2 \text{ mol C}$$

$$7.3 \text{ mol H} \div 2.44 = 2.99 \approx 3 \text{ mol H}$$

$$2.44 \text{ mol N} \div 2.44 =$$

$$1 \text{ mol N}$$

Step 4. Write out the EMPIRICAL FORMULA



**Example 3.** What is the EMPIRICAL FORMULA of a compound that contains 81.8 % C and 18.2 % H?

Step 1. Assume you have 100.0 grams

$$81.8 \text{ g C}$$

$$18.2 \text{ g H}$$

Step 2. Determine the # of moles of each element present

$$81.8 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 6.82 \text{ mol C} \quad 18.2 \text{ g H} \times \frac{1 \text{ mol H}}{1.0 \text{ g H}} = 18.2 \text{ mol H}$$

Step 3. Find the SMALLEST WHOLE-NUMBER mole RATIO!!

$$6.82 \text{ mol} \div 6.82 = 1 \text{ mol C}$$

$$18.2 \text{ mol} \div 6.82 = 2.67 \text{ mol H} \neq 3 \text{ mol H} !!!$$

**PROBLEM!!!!** You must be able to recognize the following fractional equivalents:

0.20 = 1/5	0.40 = 2/5	0.67 = 2/3
0.25 = 1/4	0.50 = 1/2	0.75 = 3/4
0.33 = 1/3	0.60 = 3/5	0.80 = 4/5

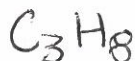
YOU ARE NOT CLOSE ENOUGH TO A WHOLE NUMBER RATIO TO ROUND, THEREFORE YOU MUST

multiply both values by the denominator of the fractional equivalent

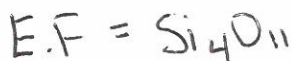
$$0.67 = 2/3 \therefore 1 \text{ mol C} * 3 = 3 \text{ mol C}$$

$$2.67 \text{ mol H} * 3 = 8 \text{ mol H}$$

Step 4. Now you can write out the EMPIRICAL FORMULA



**Sample Problem:** What is the empirical Formula of a compound containing 39.0 % Si and 61.0 % O?



$$39.0 \text{ g Si} \times \frac{1 \text{ mol Si}}{28.1 \text{ g Si}} = 1.39 \text{ mol Si} \div 1.39 = 1 \text{ mol Si} \times 4 = 4 \text{ mol Si}$$

$$61.0 \text{ g O} \times \frac{1 \text{ mol O}}{16.0 \text{ g O}} = 3.81 \text{ mol O} \div 1.39 = 2.74 \text{ mol O} \times 4 = 11 \text{ mol O}$$

$$0.75 \therefore 3/4$$

