Name _____ Date _____ Period _____ 6E EPP

Chem 07-28 Chemical Quantities - Empirical and Molecular Formulas 6E EPP

A compound never before seen has just been prepared in a chemistry laboratory. What is the formula for that compound? In order to answer that question, a chemist must first determine the percent composition of the compound. From this information, the chemist can then determine the compound's empirical formula. The empirical formula of a compound shows the simplest whole-number ratio of elements present in the compound.

The first step in determining an empirical formula is to calculate the number of moles of each element present in the compound. Next, one must find the mole ratio of the elements in the compound by dividing the number of moles of each element by the smallest number of moles. The whole-number ratio obtained gives the subscripts for the empirical formula of the compound. The molecular formula may be the same as the empirical formula or some whole-number multiple of the empirical formula. In order to determine a compound's molecular formula, one needs to know both the empirical formula and the formula mass of that compound.

Example A

Analysis of a compound shows that it contains 10.88 g of calcium and 19.17 g of chlorine. Determine the empirical formula of this compound.

Solution A

Start by converting the mass of each element to its equivalent in moles.

$$\frac{10.88 \text{ g Ca}}{} \left| \frac{1 \text{ mole Ca}}{40.08 \text{ g Ca}} \right. = 0.2715 \text{ moles Ca}$$

$$\frac{19.17 \text{ g Cl}}{} \left| \frac{1 \text{ mole Cl}}{35.45 \text{ g Cl}} \right. = 0.5408 \text{ mole Cl}$$

Now calculate the mole ratio between the two elements by dividing both of the above numbers by the smaller of the two (0.2715 moles Ca is the smaller number, so that is the divisor).

$$\frac{0.2715 \text{ moles Ca}}{0.2715} = 1 \text{ moles Ca}$$

$$\frac{0.5408 \text{ moles Cl}}{0.2715} = 2 \text{ mole Cl}$$

The mole ratio of the two elements is nearly 1:2. Therefore, the empirical formula for the compound is $CaCl_2$.

You Try It

Determine the empirical formula of a compound that contains 69.5% oxygen and 30.5% nitrogen.

Example B

Calculate the molecular formula of a compound containing 24.1 g of carbon and 5.1 g of hydrogen. The molar mass of this compound is known to be 58.10 g/mole C_xH_y

Solution B

Convert the mass of each element to its equivalent in moles.

$$\frac{24.1 \text{ g C}}{} \left| \frac{1 \text{ mole C}}{12.01 \text{ g C}} \right. = 2 \text{ moles C}$$

$$\frac{5.10 \text{ g H}}{} \left| \frac{1 \text{ mole H}}{1.01 \text{ g H}} \right. = 5 \text{ mole H}$$

The ratio of carbon to hydrogen is 2:5. Therefore the empirical formula of the compound is C_2H_5. Then determine the molar mass of the empirical formula, C_2H_5.

$$\frac{2 \text{ moles C}}{} \left| \frac{12.01 \text{ g C}}{1 \text{ mole C}} \right. = 24.02 \text{ g C}$$

$$\frac{5 \text{ moles H}}{} \left| \frac{1.01 \text{ g H}}{1 \text{ mole H}} \right. = 5.05 \text{ g H}$$

$$+ \quad 29.07 \frac{\text{g}}{\text{mole}} \ C_2H_5$$

Divide the molecular mass by the empirical formula mass to determine the whole number multiple.

$$\frac{58.10 \text{ g/mole } C_xH_y}{29.07 \text{ g/mole } C_2H_5} = 2$$

Multiplying the subscripts by the whole number multiple gives the correct molecular formula

$$C_{2x2}H_{2x5} = C_4H_{10}$$

You Try It

The molar mass of a compound is 166.3 g/mole. The compound contains 47.1% potassium, 14.5% carbon, and 38.4 % oxygen. What is the molecular formula for the compound?

Determine the empirical formula of a certain copper sulfide ore if a 7.68 g sample of the compound contains 6.13 g of copper. (Will this be made up of copper II or copper I?)