

CHEM 130

Exp 6: Empirical Formulas

If we know the % composition of a compound by mass, we can determine its chemical formula, which is a critical technique used in forensic chemistry and other areas where an unknown compound must be determined.

An **Empirical Formula** is the simplest whole number ratio between the elements in a compound, but does not necessarily represent the true compound itself.

The **Molecular Formula** is the actual formula of the compound in question and is the empirical formula multiplied by some integer, n.

$$\text{Molecular Formula} = (\text{Empirical Formula}) \times n$$

To determine the value of n:

$$n = \frac{\text{molecular formula molar mass}}{\text{empirical formula molar mass}}$$

If $n = 1$, then the empirical formula = molecular formula

For example, glucose has the Molecular Formula: $\text{C}_6\text{H}_{12}\text{O}_6$, but the simplest whole number ratio between C, H and O in glucose is CH_2O , which is the Empirical Formula. The value of n would be 6.

Procedure for finding empirical formulas:

- (1) Determine mass of each element in g (usually from %).
- (2) Convert g of each element to actual # of moles by dividing by the atomic masses.
- (3) Find the moles of each element relative to one another by dividing all by the lowest mole value.
- (4) If the relative moles are not all integers, multiply them all by 2, 3, etc. to make them integers.

Example: An unknown sample has 47.08 % C, 6.59 % H, and 46.33 % Cl. What is its empirical formula?

<u>element</u>	<u>%</u>	<u>mass</u>	<u>actual # moles</u>	<u>relative # moles</u>
C	47.08 %	47.08 g (mol/12.011 g)	$= 3.919^{74} \div 1.306^{81} =$	$2.999^{47} \sim 3$
H	6.59 %	6.59 g (mol/1.00794 g)	$= 6.53^{80} \div 1.306^{81} =$	$5.00^{30} \sim 5$
Cl	46.33 %	46.33 g (mol/35.4527 g)	$= 1.306^{81} \div 1.306^{81} =$	$1.000 = 1$

$$\text{Empirical Formula} = \text{C}_3\text{H}_5\text{Cl}$$

For example above, if the molar mass of the actual compound is 153 g/mol, what is its molecular formula?

$$n = 153 \text{ g/mol} \div 76.525/40 \text{ g/mol} = 1.99/93 \sim 2$$

$$\text{Molecular formula} = \text{Emp. Formula} \times n = (\text{C}_3\text{H}_5\text{Cl}) \times 2 = \text{C}_6\text{H}_{10}\text{Cl}_2$$

Procedure:

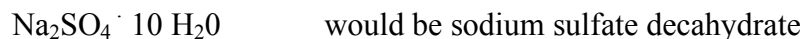
In this experiment, we will synthesize a compound by reacting magnesium metal and hydrochloric acid solution. After we have isolated the compound, we will determine its empirical formula from mass measurements and calculations. The compound in question will contain only combined atoms of magnesium and chlorine. The magnesium atoms in the compound will come from the magnesium metal, and the chlorine atoms in the compound will come from hydrochloric acid.

Once the masses of Mg and Cl in the compound formed are determined experimentally, the procedures given above for determining the empirical formula will be applied.

Safety Note: We will be evaporating excess HCl in this experiment and so this must be done in the HOOD!

The effect of certain experimental errors that may occur will also be analyzed to see how they would alter the actual data calculated.

In the second part of this lab, a certain class of compounds called hydrates will be studied. These are solids that contain water molecules as part of their crystalline structure, with the number of water molecules bound to it represented by a dot and a number:



The ability of some of these compounds to absorb water vapor from the air, or release it to the air will be studied and the terminology discussed. Some practice with percent composition calculations will be used in studying hydrated compounds.

Date: _____

CHEM 130

NAME: _____

Exp 6: Empirical Formula Prelab

1) An unknown compound was found to have a percent composition as follows: 47.0 % potassium, 14.5 % carbon, and 38.5 % oxygen. What is its empirical formula? If the true molar mass of the compound is 166.22 g/mol, what is its molecular formula?

2) Rubbing alcohol was found to contain 60.0 % carbon, 13.4 % hydrogen, and the remaining mass was due to oxygen. What is the empirical formula of rubbing alcohol (2 – propanol)?

3) What is the empirical formula for a weak organic base containing 48.6 % C, 13.6 % H, and 37.8 % N?