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Dr. Buckley

e-mail: gbuckley@cameron.edu
Experiment #6 – Determination of an Empirical Formula

Laboratory Overview

CHEM 1361

August 2010

Gary S. Buckley, Ph.D.
Department of Physical Sciences
Cameron University
Learning Objectives

• Determine the percent composition of a chemical compound

• Determine the empirical formula from % composition information
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• Description of Empirical Formula

• Determining Empirical Formula from Percent Composition

• Experimental Aspects
An empirical formula gives the relative numbers of atoms of each element present in a chemical compound.

For example, the formula NaCl, indicates that in this compound there is one Na atom for every Cl. In H₂O there are two hydrogen atoms for every oxygen atom.

By now you may have learned how to write formulas for inorganic compounds based on an element’s position on the periodic chart, but in this experiment you will synthesize a compound and determine its empirical formula. The compound of choice is the one formed between magnesium (Mg) and oxygen (O).
Determining Empirical Formula from Percent Composition

It is possible to determine the empirical formula of a compound from its percent composition.

As an example, suppose a compound is found to consist of 47.4% C, 10.5% H, and 42.1% O. The procedure below will lead to the empirical formula for the compound.

\[
\begin{align*}
47.4\% \text{ C} & \quad \frac{47.4}{12} = 3.95 \\
10.5\% \text{ H} & \quad \frac{10.5}{1} = 10.5 \\
42.1\% \text{ O} & \quad \frac{42.1}{16} = 2.63
\end{align*}
\]

The numbers in the last column give the relative number of atoms. However, we want these to be whole numbers. Writing the formula as \(C_{1.5}H_{3.99}O_{1.00}\) does not result in whole number subscripts. Notice that multiplying 1.5 by 2 gives a whole number and the 3.99 can be rounded easily to 4. Thus, if the whole set of numbers is multiplied by two the result is \(C_3H_8O_2\), the empirical formula for the compound.
Experimental Aspects

You will make the compound formed in the reaction of magnesium with oxygen. Magnesium is a shiny metallic element and the source of oxygen will be the air in the room.

The synthesis of the compound is fairly simple. Magnesium, when heated in the presence of oxygen, will form the compound magnesium oxide. If the initial mass of magnesium is recorded and the final mass of the compound is recorded after the synthesis, the amounts of magnesium and oxygen in the compound may be determined. From these data, the percent composition may be found and, as on the previous slide, the empirical formula may be determined.
Experimental Aspects (continued)

Since we are using the air in the room as our oxygen source there are actually two reactions that occur – the reaction with oxygen and the reaction with nitrogen, as shown below:

\[
2 \text{Mg (s)} + \text{O}_2 (g) \rightarrow 2 \text{MgO (s)}
\]

\[
3 \text{Mg (s)} + \text{N}_2 (g) \rightarrow \text{Mg}_3\text{N}_2 (s)
\]

Since MgO is the only product of interest, the Mg\textsubscript{3}N\textsubscript{2} must be converted to MgO. This is done by reacting the compound formed with water to form magnesium hydroxide:

\[
\text{Mg}_3\text{N}_2 (s) + 6 \text{HOH (ℓ)} \rightarrow 3 \text{Mg(OH)}_2 (s) + \text{N}_2 (g)
\]

Further heating of the magnesium hydroxide results in its conversion to MgO, our desired product.
Experimental Aspects

The crucible and lid:
The crucible and lid are ceramic materials (made by Coors). They are fragile but may be heated directly in a flame without problem. They cannot be subjected, however, to sudden temperature changes. Check your crucible initially visually for cracks – you want to keep it intact for the whole experiment.

The crucible and the clay triangle:
The clay triangles may be found in the community drawers. Notice in the picture to the right that one of the legs of the triangle is broken. This allows one to adjust the triangle size to accommodate the crucible.

A side picture of the crucible in the triangle is to the right.
Experimental Aspects (Continued)

The magnesium must be polished to remove any pre-existing magnesium oxide coating. Once this is done the magnesium ribbon is folded into an accordion shape as shown below. The strip below started out at 15 cm when stretched out. As you can see (except for the poor focus) it is considerably shorter than that now – about 3 cm. If you need to cut it in half to fit it into the crucible that is ok.
Experimental Aspects (Continued)

- You need a good dry mass of the crucible so you will heat it and the lid according to the laboratory instructions and get the mass once it cools down.

- The magnesium strip is placed in the crucible and the lid is tilted as shown in the figure to the right.

- The crucible, lid and magnesium are heated with the Bunsen burner. Control the reaction by adjusting the lid – you don’t want smoke coming out.

- After this heating step add water and heat again. After this has dried out, you will record the first mass of the crucible, lid, and magnesium oxide.
End of Presentation