

Name: _____

Section Day: _____ Time: _____

Chem 132.L7. Simplest Formula of Magnesium Oxide

Prelaboratory Exercise

Phenolphthalein used as an indicator in acid-base titrations and was also the active ingredient in laxatives such as ExLax. (A) Calculate the empirical formula for phenolphthalein if the compound is 75.46% C, 4.43% H, and 20.10% O by mass (hint: assume there is 100 grams of phenolphthalein total). (B) The molar mass of phenolphthalein is 318.31 g/mole. What is the molecular formula of the compound?

Introduction

The **simplest (or empirical) formula** of a compound gives the smallest whole-number ratio between the numbers of atoms of different elements in the compound. The **molecular formula** indicates the actual number of atoms of each element in a compound. In order to distinguish between the empirical and molecular formula, consider two nitrogen/oxygen compounds, NO₂ (nitrogen dioxide) and N₂O₄ (dinitrogen tetraoxide). Both of these compounds have the same simplest formula (NO₂), because the ratio of nitrogen to oxygen is the same for each molecule. However, these compounds have different molecular formulas because they contain different numbers of nitrogen and oxygen atoms, even though the ratio of nitrogen to oxygen is the same.

In order to calculate the simplest formula, it is necessary to know the masses of each of the elements present in a sample of the compound. In this experiment, a sample of magnesium is weighed. The magnesium sample is then heated in a crucible to convert the magnesium metal to magnesium oxide by reaction with oxygen in the air. It is assumed that no magnesium is lost during this reaction, so any increase in mass is caused by the addition of oxygen to form the magnesium oxide. This procedure allows the determination of the masses of magnesium and oxygen present in a sample of magnesium oxide.

In order to determine the empirical formula, the masses of magnesium and oxygen must be converted to moles of magnesium and oxygen by using the corresponding molar mass. This step is required because a mole is a simple way to represent number of atoms. Hence once we have determined the moles of Mg and moles of O, we can divide the moles of oxygen by the moles of magnesium to obtain the simplest formula.

Additional information is required to calculate the molecular formula. In particular, the molar mass of the compound must be known. In order to find the molecular formula, it is necessary to solve for the integer (n), and then multiply every subscript in the simplest formula by the integer. The formula to solve for n is shown in equation (1):

$$n = \frac{\text{molar mass of the compound}}{\text{molar mass of the empirical formula}} \quad (1)$$

For example, consider a molecule with simplest formula CH₂ whose molar mass is 42 g/mole. The simplest formula mass is 14.0 g/mole (molar mass of CH₂). The integer is determined by:

$$n = \frac{42 \text{ g/mol}}{14 \text{ g/mol}} = 3. \text{ The molecular formula is } (\text{CH}_2)_3 = (\text{C}_{1 \times 3} \text{H}_{2 \times 3}) = \text{C}_3\text{H}_6 \quad (2)$$

Procedure.

Support a clean crucible and cover on a triangle (refer to Figure 1) and heat strongly with a Bunsen burner for 10 minutes. **DO NOT PLACE THE HOT CRUCIBLE ON THE COUNTER FOR 5 MINUTES AFTER HEATING OR IT WILL CRACK.** Cool and weigh the crucible and lid to the nearest 0.001 g.

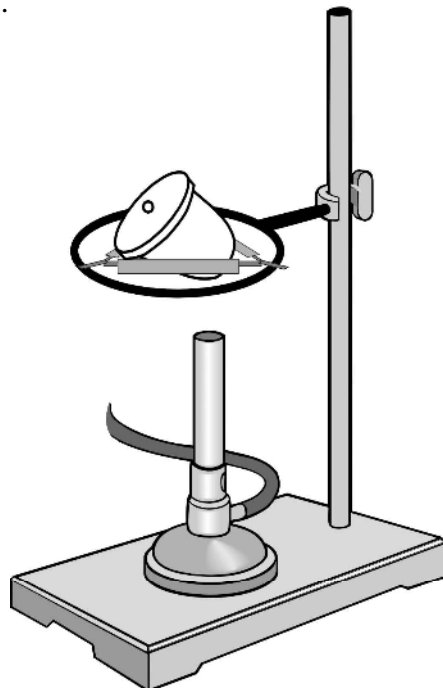


Figure 1: Experiment setup

Crumple about 0.3 g of magnesium (Mg) ribbon and place into the lower part of the crucible. Weigh the crucible, lid and contents to the nearest 0.001 g. Record your data below.

→Weight of crucible and lid _____ g

→Weight of crucible, lid, and magnesium _____ g

→Weight of magnesium _____ g

With the cover in place, heat the crucible gently at first for about 5 minutes and then adjust the burner so that you get a hot blue flame. Get help from your instructor if you are unsure how to adjust the flame. Displace the lid slightly (using tongs!) to allow more air to enter and heat strongly for 10 minutes. **COOL FOR 5 MINUTES** on the triangle. Add about 12 drops of water. Again, strongly heat for 5 more minutes. Break up any lumps using a glass rod but be sure not to remove any material with the rod. If the residue is not gray or white, cool, add water again, and reheat for 5 minutes. Allow the covered crucible to cool 5 minutes on the triangle and then to room temperature on the bench and weigh. Record your data below.

→Weight of crucible, lid, and contents, first weighing _____ g

With the cover somewhat displaced, heat the crucible strongly again for 7 minutes, and then let the covered crucible cool to room temperature. Weigh the crucible, lid and contents again; this second weighing should agree within 0.003 g of the first. If it does not, repeat the strong heating for 7 minutes more, allow the covered crucible to cool, and reweigh. Use your final weighing as the weight of crucible, lid, and contents.

→Weight of crucible, lid, and contents, second weighing _____ g

→Weight of crucible, lid, and contents, third weighing _____ g
(if necessary)

→Weight of compound of magnesium and oxygen _____ g

→Weight of oxygen in the compound _____ g

When you are finished, scrape all of the magnesium oxide out of the crucible and rinse well with water.

Calculation of Simplest Formula

Above you measured the mass of magnesium and the mass of oxygen present in the sample of magnesium oxide that you prepared. Use the molar mass of magnesium (Mg) and the molar mass of oxygen (O) to calculate the moles of magnesium and the moles of oxygen, respectively, showing your calculations in the space provided.

→Moles of magnesium _____ moles; Moles of oxygen _____ moles

Determine which of the moles is the smaller value and divide both numbers by that smaller number (like in lecture). The resulting numbers will represent the number of those atoms in the simplest formula. Show your work below

→ $\frac{\text{moles Mg}}{\text{smallest \# of moles}} = \# \text{ of Mg atoms}$

→ $\frac{\text{moles O}}{\text{smallest \# of moles}} = \# \text{ of O atoms}$

→Simplest formula of the oxide of magnesium _____

Questions

1. Osteoporosis is a disease common in older women who have not had enough calcium in their diets. Calcium can be added to the diet by tablets that contain either calcium carbonate, calcium sulfate or calcium phosphate. Determine the chemical formulas for these three calcium containing compounds. Calculate which will provide the greatest percentage of calcium. Show your work!

$$\%A = \frac{\text{mass of A in cmpd}}{\text{total mass of cmpd}} \times 100$$

calcium carbonate:

calcium sulfate:

calcium phosphate:

2. What is the simplest formula of a compound containing 19.81% C, 2.2% H, and 77.97% Cl? Show your work.

3. A 3.500 g sample of an oxide of manganese contains 1.288 g of oxygen. What is the empirical formula of the compound? If this empirical formula is actually the molecular formula of the compound, what would be the correct chemical name of the compound?

4. Styrene, the raw material for styrofoam, is 91.67 % carbon and 8.33% hydrogen. The molar mass of styrene is 104.2 g/mole. What is the molecular formula of styrene?

5. Determine the number of grams of calcium in one 0.500 g tablet of calcium carbonate.