

Magnesium Oxide

Percent Composition and Empirical Formula

Introduction

There is an official database that keeps track of the known chemical compounds that exist in nature or have been synthesized in the lab. The database is updated daily, and millions of different inorganic and organic compounds have been recognized. With millions of compounds—how is it possible to identify as many different compounds and tell them apart?

Concepts

- Percent composition
- Empirical formula
- Molecular formula
- Percent yield

Background

The composition of a chemical compound—what it is made of—can be described at least three different ways. The *percent composition* gives the percent by mass of each element in the compound, and is the simplest way experimentally to describe the composition of a substance. According to the law of definite proportions, which was first formulated in the early 1800s by Joseph Proust, the elements in a given compound are always present in the same proportion by mass, regardless of the source of the compound or how it is prepared. Calcium carbonate, for example, contains calcium, carbon and oxygen. It is present in eggshells and seashells, chalk and limestone, minerals and pearls. Whether the calcium carbonate comes from a mineral supplement or a seashore shell or from seashells at the ocean shore, the mass percentage of the three elements is always the same: 40% calcium, 12% carbon and 48% oxygen.

The *percent composition* of a compound tells us what elements are present in the compound and their mass ratios. In terms of understanding how elements come together to make a new compound, however, it is more interesting to know how many atoms of each kind of element are in a compound. Since all the atoms of a given element in a compound have the same average atomic mass, the elements that are present in a fixed mass ratio in a compound must also be present in a fixed-number ratio as well. The *empirical formula* describes the composition of a compound in terms of the simplest, whole-number ratio of atoms in a molecule or formula unit of the compound. The formula of calcium carbonate, for example, is CaCO_3 . The empirical formula gives the ratio of atoms in a compound and does not necessarily represent the actual number of atoms in a molecule or formula unit. It is possible, in fact, for many different compounds to share the same empirical formula.

The organic compounds acetylene and benzene, for example, have the same empirical formula, CH —one hydrogen atom for every carbon atom. These two compounds, however, have different properties and different molecular formulas— C_2H_2 for acetylene and C_6H_6 for benzene. Notice that in both cases the molecular formula is a simple multiple of the empirical formula. The *molecular formula* of a compound tells us the actual number of atoms in a single molecule of a compound. In order to find the molecular formula of a compound, whose empirical formula is known, the molar or molecular mass of the compound must also be known.

In this experiment, the percent composition and empirical formula of magnesium oxide, the main compound formed when magnesium metal combines with oxygen in air, will be determined. Heating magnesium in the presence of air causes the metal to ignite and burn—lots of light and heat are given off, and a new compound is obtained. According to the law of conservation of mass, the total mass of the products of a chemical reaction must equal the mass of the reactants. In the case of the combustion of magnesium, the following equation must be true:

$$\text{Mass of magnesium} + \text{Mass of oxygen} = \text{Mass of magnesium oxide}$$

If both the initial mass of magnesium and the final mass of the magnesium oxide are measured, the increase in mass must correspond to the mass of oxygen that combined with magnesium. The percent composition and empirical formula of magnesium oxide can then be calculated, based on the combining ratios of magnesium and oxygen in the reaction. Finally, once the formula of magnesium oxide is known, the amount of magnesium oxide that was produced can be compared against the maximum amount possible based on 100% conversion of the magnesium used in the experiment. This information can be used to calculate the *percent yield* of magnesium oxide in the reaction.

Experiment Overview

The purpose of this classic experiment is to determine the percent composition and empirical formula of magnesium oxide.

Quick Lab Percent Composition Magnesium Oxide Answers

Ying Liu



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Merrill Chemistry Robert C. Smoot, Smoot, Richard G. Smith, Jack Price, 1998 **Power**, 1973 Chemical
Calculations, with Explanatory Notes, Problems, and Answers, Specially Adapted for Use in Colleges and Science Schools
Richard Lloyd Whiteley, 1898

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