

Determination of the Empirical Formula of Silver Oxide

Inquiry Guidance and AP* Chemistry Curriculum Alignment



Introduction

Determining the empirical formula of a substance is a classic experiment in AP chemistry to analyze the composition of chemical compounds. This is not an abstract problem, since more than 20 million different inorganic and organic compounds have been synthesized. Twenty million compounds—how is it possible to identify so many different compounds and tell them all apart?

Opportunities for Inquiry

This is an excellent, classic experiment to start the year in your lab. The experiment contains opportunities for inquiry that will allow your students to start thinking in an inquiry fashion for the rest of the year. The lab covers important concepts such as the law of conservation of mass, molecular formulas, and stoichiometry, that are readily aligned with the new curriculum framework.

The following ideas will help you transition the classic experiment to a guided-inquiry approach and improve student preparation, interest, and accountability in the lab.

- Remove data tables and post-lab questions. Provide students with a detailed overview of the procedure, focusing on Bunsen burner safety and the amount of sample needed to conduct the experiment. Before students perform the experiment, they will need to consult academic sources and brainstorm to determine the data needed to calculate the empirical formula of silver oxide. Students are more engaged in this lab when they have to identify all the materials that need massing in order to obtain accurate results.
- Incorporate unknown compounds for students to analyze. Determination of the empirical formula may be conducted on other materials besides silver oxide. Consider adding another sample such as magnesium ribbon to the experiment. Give different groups of students either silver oxide or magnesium ribbon and then inform the students that there are two unknowns in the classroom, magnesium ribbon and silver oxide. Students use a detailed overview of the experiment as a guide to perform the experiment and determine the composition of the unknown. Calculations and data analysis should confirm that the student has identified the composition of the unknown sample.
- Extend the lab by challenging students to adapt the calculations for determining the molar mass of silver from the experimental data. Students may accomplish this calculation by: 1) Determining the moles of oxygen driven off in the experiment. 2) Asking how many moles of silver were produced, assuming that 100% conversion of silver(I) oxide to silver has occurred. 3) Dividing the mass of silver produced by the moles of silver to give the apparent molar mass of silver.

Alignment with AP Chemistry Curriculum Framework—Big Ideas 1 and 3

Enduring Understandings and Essential Knowledge

All matter is made of atoms. There are a limited number of types of atoms; these are the elements.
(Enduring Understanding 1A)

1A1: Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions.

1A2: Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity.

Atoms are conserved in physical and chemical processes. (Enduring Understanding 1E)

1E2: Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the

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number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.

Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form. (Enduring Understanding 3A)

3A2: Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists.

Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions. (Enduring Understanding 3B)

3B1: Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often by the use of heat.

Learning Objectives

- 1.1 The student can justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.
- 1.2 The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.
- 1.3 The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.
- 1.18 The student is able to apply conservation of atoms to the rearrangement of atoms in various processes.
- 1.19 The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution.
- 3.3 The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.
- 3.4 The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completions.
- 3.5 The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.
- 3.6 The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

Science Practices

- 1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.
- 2.1 The student can justify the selection of a mathematical routine to solve problems.
- 2.2 The student can apply mathematical routines to quantities that describe natural phenomena.
- 4.2 The student can design a plan for collecting data to answer a particular scientific question.
- 5.1 The student can analyze data to identify patterns or relationships.
- 6.1 The student can justify claims with evidence.
- 6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.

The Determination of the Empirical Formula of Silver Oxide—AP Chemistry Classic Laboratory Kit is available from Flinn Scientific, Inc.

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