

Determining the Stoichiometry of Chemical Reactions

Inquiry Guidance and AP* Chemistry Curriculum Alignment



Introduction

Double replacement reactions are generally considered to be irreversible. The formation of an insoluble precipitate provides a driving force that makes the reaction proceed in one direction only. The purpose of this laboratory is to find the optimum mole ratio for the formation of a precipitate in a double replacement reaction and use this information to predict the chemical formula of the product.

Opportunities for Inquiry

Using the experimental method of continuous variation to determine the stoichiometry of chemical reactions incorporates the concepts and principles of chemistry big ideas 1 and 3 and learning objectives such as reactions, stoichiometry, and precipitation. Determining the stoichiometry of chemical reactions requires students to develop science practice skills involving mathematical reasoning and data analysis.

Use some or all of the following strategies to transition the classic experiment to a guided-inquiry laboratory approach, which will improve student preparation and increase the level of student engagement and ownership of lab results.

- Replace data tables, post-lab questions and worksheet calculations with a detailed overview of the experiment with a description of the general calculations: "The purpose of this experiment is to determine the stoichiometry of a double replacement reaction. These reactions each produce one product that precipitates out of solution. The reactants have the same concentrations. Varying the amounts of each produces different volumes of precipitate. By comparing the volume of precipitate to the mole ratios of the two reactants, the optimum mole ratio for the reaction can be determined."
- Introduce the lab by demonstrating the general setup for making measurements using the continuous variation method. Guide students to design the actual experimental procedure through a series of leading questions. What information (data) is needed to calculate the mole ratio of the reactants? What variables will influence the experimental data? Choose the independent and dependent variables for the experiment and describe the variables that should be kept constant during the experiment. Students could also discuss variables or other factors that will affect the accuracy of the results and how these may be controlled.
- Challenge students to generalize the method of continuous variation for determining the mole ratio for other types of reactions. What other measurable properties or characteristics of a reaction or reaction product will be proportional to the amount of product formed? Opportunities for inquiry include the amount of gas formed in reactions of metals with acids and the amount of heat released in exothermic reactions.

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. x
(Enduring Understanding 1A)

1A3: The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level.

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.

Determining the Stoichiometry of Chemical Reactions *continued*

Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (Enduring Understanding 3C)

3C1: Production of heat or light, formation of a gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred.

Learning Objectives

- 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively.
- 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 completion.
- 3.10 The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.

Science Practices

- 1.4 The student can use representations and models to analyze situations or solve problems qualitatively and quantitatively.
- 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.
- 6.2 The student can construct explanations of phenomena based on evidence produced through scientific practices.
- 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 Determining the Stoichiometry of Chemical Reactions—AP Chemistry Classic Laboratory Kit is available from Flinn Scientific, Inc.

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