Classifying Chemical Reactions — Double Replacement

Double Replacement Reactions

Introduction

Colored molecular model balls are used to illustrate solubility, ionization, double replacement reaction, and precipitation. This demonstration will help students visualize the key concepts of a double replacement reaction.

Concepts

- Solubility
- Double replacement reaction
- Ionization
- Precipitation

Background

In double replacement reactions or precipitation reactions, the ions of two compounds exchange places in an aqueous solution to form two new compounds. One of the compounds formed is usually a precipitate. The other compound is often soluble and remains dissolved in solution as aqueous ions. A double replacement reaction is represented by the following general equation:

$$AX + BY \rightarrow AY + BX \qquad \textit{Equation 1}$$

A, X, B, and Y in the reactants represent ions. AY and BX represent ionic or molecular compounds. The formation of a precipitate occurs when the positive ions of one reactant combine with the negative ions of another reactant and form an insoluble or slightly soluble compound. For example, when a solution of silver nitrate is added to a solution of potassium iodide, a light yellow precipitate (AgI) separates from the mixture.

$$AgNO_3(aq) + KI(aq) \rightarrow AgI(s) + NaNO_3(aq) \qquad \textit{Equation 2}$$

The precipitate of silver iodide (AgI) forms as a result of very strong attractive forces between the Ag^+ and the I^- ions. Potassium ions and nitrate ions do not take part in the reaction and remain in solution as aqueous ions—they are called spectator ions. In the model depicted in this demo, a compound, such as $AgNO_3$, is represented by two colored balls (one magnetic and one not magnetic). A second compound (like potassium iodide) is similarly made with different colored balls. When each compound is dissolved in water, the ions dissociate. When the two resulting solutions are mixed together, the two magnetic balls form a precipitate that sinks to the bottom of the resulting solution (magnetic attraction). The other two ions (non-magnetic) are separate and dispersed (floating) in the solution—a perfect analogy of a typical double-replacement reaction.

Materials

Potassium iodide solution, KI, 0.1 M, 50 mL
Silver nitrate solution, $AgNO_3$, 0.1 M, 25 mL
Water, 600 mL
Balls, 4, four different colors (two magnetic and two non-magnetic)
Beaker, 1000-mL
Beakers, 400-mL, 2
Cellulose paper strips, ½″ × 2″, 4
Pipet, Beral-type, disposable
Scissors
Test tube, 25 × 200 mm
Test tube rack
White glue
White or grey board, 8½″ × 11″

Safety Precautions

Silver nitrate is highly toxic and causes burns. Avoid contact with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory.

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Preparation

1. Use white glue to glue two strips of cellulose paper to two colored balls (one magnetic and one nonmagnetic) as shown in Figure 1.
2. Create another model compound using different colored balls than those used in step 1. The two model compounds should contain four balls, all different colors. Allow the glue to dry.

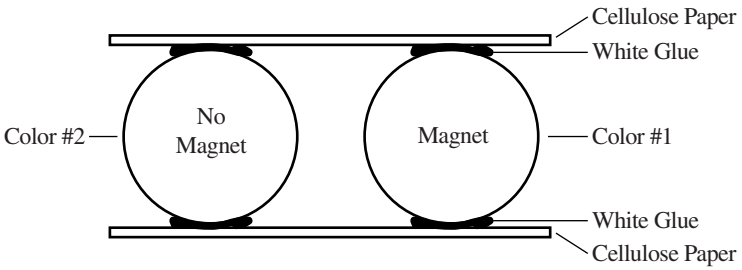

Figure 1.

Procedure — Part 1

1. Place 300 mL of water into each of two 400-mL beakers.
2. Show one of the pre-made model compounds to students. Have them note the colors of the balls in the model. Explain that the glued paper strips represent the bonds holding the atoms together.
3. Place the model compound into one of the beakers of water. The paper will dissolve very quickly and the two balls will separate. One should sink and one should float, making them separate dramatically. The ions have "dispersed" in the water.
4. Repeat step 3 with the other model compound in the other beaker of water. Again note the colors of the atoms and the ionization depicted.
5. Simultaneously pour the contents of the two "solutions" into the 1000-mL beaker and note the results. The two magnetic balls should bond and "precipitate" in the bottom of the beaker. The two floating balls will not bond and will float freely in the solution.
6. Discuss the entire demonstration. Be sure students understand all of the analogies illustrated and can explain the concepts illustrated by all of the model components. A specific chemical example, like the one given in the *Background* information, can be used to illustrate an actual chemical reaction shown in the demonstration.

Procedure — Part 2

1. Place 50 mL of the 0.1 M potassium iodide solution in the test tube. Place the test tube in the test tube rack and place the white board behind the test tube.
2. Fill the pipet with the 0.1 M silver nitrate solution and slowly add the solution to the test tube. Observe the light yellow precipitate as it slowly settles to the bottom of the test tube.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. All the glue can be soaked off the balls and they can be reused many times. The solid silver iodide can be filtered and disposed of according to Flinn Suggested Disposal Method #26a. The filtrate may be disposed of according to Flinn Suggested Disposal Method #26b.

Tips

- Use your imagination to illustrate other chemical reactions and principles with the materials.
- Double-sided tape may be used instead of glue to speed up the preparation time.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Classifying Chemical Reactions—Double Replacement* activity, presented by Lee Marek, is available in *Double Replacement Reactions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Classifying Chemical Reactions—Double Replacement* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6377	Keep Your Eyes on the Ions—Demonstration Kit
S0305	Silver Nitrate Solution, 0.1 M

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.