Keep Your Eye on the Ions

Precipitation Reactions and Solubility Rules

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
- Ionization
- Double replacement reaction
- Precipitation

Background

In *double-replacement reactions* or *ionic 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 sodium chloride, a white precipitate (AgCl) separates from the mixture.

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

The precipitate of silver chloride (AgCl) forms as a result of very strong attractive forces between the Ag^+ and the Cl^- ions. Sodium 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 sodium chloride) 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

Water, 600 mL

Beaker, 1000-mL

Beakers, 400-mL, 2

Cellulose paper strips, ½″ × 2″, 4

Colored balls, 4, four different colors (two magnetic and two non-magnetic)

Scissors

White glue

Safety Precautions

This demonstration is considered safe. Follow all normal laboratory safety rules.

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Preparation

1. Use white glue to glue two strips of cellulose paper to two colored balls (one magnetic and one non-magnetic) 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.

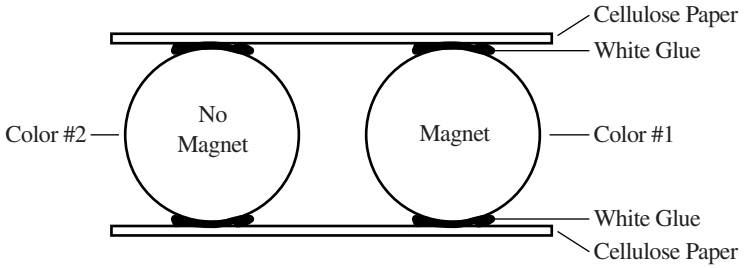


Figure 1. Model Preparation

Procedure

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.

Disposal

The glue can be soaked to remove from the balls. They may be saved for future use.

Tips

- Dissolving mole dollars (Flinn Catalog No. AP8678) can be used for making bonds if the kit is not purchased.
- Double-sided tape might 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

Answers to Worksheet Questions

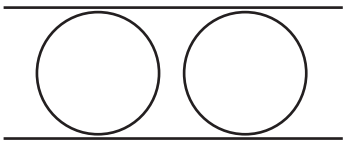
1. Draw a diagram of each of the following:

   a. The "compound"

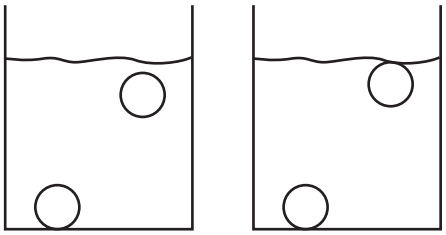
   b. The two beakers, after the compounds had been added

   c. After the compounds had been combined

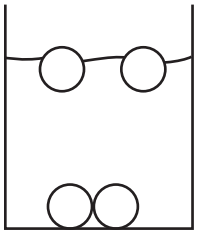
a.



b.



c.



2. Explain the chemical analogy behind what happens when the compounds are first added to water.

   When the compounds are added to the water, the two ions of the compound, each represented by a colored ball, separate from each other. They disperse into the water and the separated ions dissolve.

3. When the compounds are combined, which of the colored ball(s) represents the precipitate?

   The two colored balls that "bonded" and sank to the bottom of the beaker represent the precipitate, as they have combined together and are no longer floating freely in the solution.

4. Write the balanced chemical equation for a double replacement reaction between silver nitrate and sodium chloride.

   $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Keep Your Eye on the Ions* activity, presented by Peg Convery, is available in *Precipitation Reactions and Solubility Rules*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Keep Your Eye on the Ions* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Keep Your Eye on the Ions—Double-Replacement Model Demonstration* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP6377	Keep Your Eye on the Ions—Double-Replacement Model Demonstration
AP8678	Melting Mole Dollars

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

Keep Your Eye on the Ions Worksheet

Discussion Questions

1. Draw a diagram of each of the following:
   a. The "compound"
   b. The two beakers, after the compounds had been added
   c. After the compounds had been combined

2. Explain the chemical analogy behind what happens when the compounds are first added to water.

3. When the compounds are combined, which of the colored ball(s) represents the precipitate?

4. Write the balanced chemical equation for a double replacement reaction between silver nitrate and sodium chloride.