Double Replacement Reaction

Copper(II) Chloride and Sodium Phosphate

Introduction

A blue-green solution of copper(II) chloride is combined with a colorless solution of sodium phosphate. The initial blue color of the combined solution fades and the final products consist of a turquoise solid and a pale-blue liquid in this example of a double replacement, precipitation reaction.

Concepts

- Double replacement reaction
- Precipitate

Materials (for each demonstration)

Copper(II) chloride solution, $CuCl_2$, 0.05 M, 70 mL
Sodium phosphate solution, Na_3PO_4, 0.05 M, 50 mL
Graduated cylinder, 100-mL
Graduated cylinder, 250-mL
Stirring rod

Safety Precautions

Copper(II) chloride solution is moderately toxic by ingestion. Sodium phosphate solution is a body tissue irritant. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

Copper(II) chloride solution:

Dilute 250 mL of 0.1 M copper(II) chloride solution to 500 mL with distilled or deionized (DI) water. This will make enough 0.05 M $CuCl_2$ solution for seven demonstrations.

Alternative: Dissolve 4.3 g of copper(II) chloride, $CuCl_2 \cdot 2H_2O$, in 250 mL of DI water in a 500-mL Erlenmeyer flask. Stir to dissolve, then add DI water to 500-mL mark.

Sodium phosphate solution:

Dilute 175 mL of 0.1 M tribasic sodium phosphate solution to 350 mL with DI water. This will make enough 0.05 M Na_3PO_4 solution for seven demonstrations.

Alternative: Dissolve 6.7 g of sodium phosphate tribasic, $Na_3PO_4 \cdot 12H_2O$, in 175 mL of DI water in a 500-mL Erlenmeyer flask. Stir to dissolve, then add DI water to 350 mL.

Procedure

1. Measure 70 mL of the 0.05 M copper(II) chloride solution in a 250-mL graduated cylinder.
2. Measure 50 mL of 0.05 M sodium phosphate solution using a clean, 100-mL graduated cylinder.
3. Have students observe the initial colors of the two solutions.
4. Add 50 mL of sodium phosphate solution to the 250-mL graduated cylinder. Stir the solution to mix.
5. Have students observe evidence for a chemical reaction and the properties of the product(s).

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The product mixture can be filtered, with the copper(II) phosphate solid disposed of according to Flinn Suggested Disposal Method #26a and the remaining sodium chloride filtrate may be disposed of according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
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

Tips

- Some unreacted copper(II) ions may remain in the final solution. The fewer the ions the paler the final solution color. Add a slight excess of 0.05 M sodium phosphate solution to completely remove copper(II) ions from the final solution—the supernatant (liquid remaining above the solid precipitate) should then be colorless.
- A 250-mL cylinder is recommended for this demonstration so students can easily observe the reaction. A beaker may also be used.

Discussion

Double replacement reactions involve the exchange of ions between two compounds. The general form for a double replacement reaction is shown in Equation 1.

$$AB + CD \rightarrow AD + BC \qquad \textit{Equation 1}$$

The ionic compounds in a double replacement reaction can be thought of as a pair of partners. In Equation 1, A and B are one set of reactant partners, while C and D are another set of reactant partners. When these two compounds react, they exchange partners so that A and D become a new set of partners, while B and C do the same.

A double replacement reaction generally occurs between two ionic compounds in aqueous solution and is driven by formation of a product that is released from solution, such as in the formation of a *precipitate* or a gas. Precipitation reactions occur when two soluble compounds react and the positive ions of one reactant combine with the negative ions of the other reactant to form an insoluble compound. Gas-forming reactions occur when one of the products is a gas that bubbles out of solution.

A solution of sodium phosphate reacts with a copper(II) chloride solution according to Equation 2. The reaction may be classified as a double replacement, precipitation reaction.

$$\underset{\textit{blue-green}}{3CuCl_2(aq)} + \underset{\textit{colorless}}{2Na_3PO_4(aq)} \rightarrow \underset{\textit{turquoise}}{Cu_3(PO_4)_2(s)} + 6NaCl(aq) \qquad \textit{Equation 2}$$

Insoluble copper(II) phosphate, $Cu_3(PO_4)_2$, precipitates out of solution as a turquoise-colored solid. The removal of most of the blue-green copper(II) ions, $Cu^{2+}(aq)$, from solution reduces the final solution color to a very pale green.

Materials for *Double Displacement Reaction—Copper(II) Chloride and Sodium Phosphate* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0382	Copper(II) Chloride Solution, 0.1 M, 500 mL
S0250	Sodium Phosphate (Tribasic) Solution, 0.1 M, 500 mL
GP2058	Graduated Cylinder, 250-mL

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