Three Cheers for the Red, White, and Blue

Chemical Demonstration

Introduction

Place three clear and nearly colorless solutions all in a row, put on a patriotic Sousa march in the background, and add a single new yellow solution to each. Three cheers for the red, white, and blue—the colors of Old Glory emerge in time to the music!

Concepts

- Complex ion formation
- Double replacement reaction

Materials

Iron(III) chloride solution, 0.03 M in 0.1 M HCl, 120 mL

Potassium ferrocyanide solution, $K_4Fe(CN)_6$, 0.001 M, 20 mL

Potassium thiocyanate solution, 0.002 M, 20 mL

Silver nitrate solution, $AgNO_3$, 0.1 M, 20 mL

Beakers, 150-mL, 4

Safety Precautions

Iron(III) chloride is a corrosive liquid and a body tissue irritant; it is slightly toxic by ingestion. Potassium ferrocyanide solution may liberate poisonous hydrogen cyanide upon contact with concentrated acids and heat. Do not heat or allow to come in contact with strong acids. Silver nitrate is moderately toxic by ingestion and irritating to skin, eyes, and mucous membranes; it will stain skin and clothing. Avoid contact of all chemicals with skin and clothing. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Place three 150-mL beakers in a row on the demonstration table.
2. Add 20 mL of the appropriate solution to each beaker, as follows:

Beaker	**1**	**2**	**3**
Solution	potassium thiocyanate	silver nitrate	potassium ferrocyanide

3. Measure out 120 mL of iron(III) chloride solution into a fourth 150-mL beaker.
4. Slowly and dramatically, add equal amounts (about 40 mL) of iron(III) chloride solution to each of the prepared beakers 1–3. (*Hint:* Fill the beakers to the 60-mL mark.) The solution in the first beaker will turn red, the second beaker white, and the third beaker blue.

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 red, white, and blue reaction mixtures that are produced may be combined in a beaker and washed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

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NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter
PS1.B: Chemical Reactions

Disciplinary Core Ideas: High School
HS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter
PS1.B: Chemical Reactions

Science and Engineering Practices
Asking questions and defining problems
Developing and using models

Crosscutting Concepts
Patterns
Cause and effect
Structure and function
Stability and change

Tips

- Add drama to the demonstration by playing patriotic march music in the background.
- Use this demonstration as a colorful introduction to the nature and types of chemical reactions. Discuss the types of observations that can be used as evidence that a chemical reaction has occurred.

Discussion

The red, white, and blue color changes illustrate three types of chemical reactions:

Reaction 1—Complex Ion Formation. Iron(III) ions (Fe^{3+}) react with thiocyanate ions to form dark red-orange complex ions, as shown in Equation 1. The value of n can vary from 1 to 3. This reaction is the basis of a classic experiment used to demonstrate reversible chemical reactions, equilibrium, and LeChâtelier's Principle.

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightarrow Fe(SCN)_n^{3-n} \qquad \textit{Equation 1}$$

Reaction 2—Double Replacement Reaction. Iron(III) chloride reacts with silver nitrate to form insoluble silver chloride and iron(III) nitrate, as shown in Equation 2. The driving force for the reaction is the formation of insoluble silver chloride, which precipitates out of the reaction mixture to give a milky white solution.

$$FeCl_3(aq) + 3AgNO_3(aq) \rightarrow Fe(NO_3)_3(aq) + 3AgCl(s) \qquad \textit{Equation 2}$$

Reaction 3—Formation of Prussian Blue. Iron(III) ions in iron(III) chloride react with the iron(II) complex ion in $K_4Fe(CN)_6$ to form a mixed iron(II)/iron(III) compound called ferric ferrocyanide, $Fe_4[Fe(CN)_6]_3$. The historical name for this compound is Prussian blue—discovered in 1710, it was one of the first dye pigments to be manufactured for commercial use.

$$4Fe^{3+}(aq) + 3Fe(CN)_6^{4-}(aq) \rightarrow Fe_4[Fe(CN)_6]_3 \qquad \textit{Equation 3}$$

Three Cheers for the Red, White, and Blue is available as a Chemical Demonstration Kit—*Old Glory*—from Flinn Scientific, Inc.

Catalog No.	Description
AP8463	Old Glory—Chemical Demonstration Kit

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