CHEM FAX!
eLearning

P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com

FLINN SCIENTIFIC, INC
"Your Safer Source for Science Supplies"

Publication No. 95004

Overhead Equilibrium

Exploring Equilibrium

Introduction

A colorless solution becomes dark orange upon addition of a solution and then a solid. The dark orange color disappears after the addition of another solid but reappears again when more solution and the original solid are added.

Concepts

- Complex ions
- Equilibrium
- LeChâtelier's principle

Materials

Iron(III) nitrate solution, $Fe(NO_3)_3$, 0.2 M, 6 drops
Potassium thiocyanate solution, KSCN, 0.002 M, 20 mL
Potassium thiocyanate, KSCN, 1 g
Sodium phosphate, monobasic, $NaH_2PO_4 \cdot H_2O$, 1 g
Cylinder, graduated, 50-mL
Overhead projector
Petri dish
Spatulas, 2

Safety Precautions

Please review current Material Safety Data Sheets for additional safety, handling, and disposal information. Potassium thiocyanate is toxic by ingestion and emits toxic fumes if strongly heated. Iron(III) nitrate solution may be skin/tissue irritant. Sodium phosphate monobasic (monohydrate) is moderately toxic by ingestion. Wear chemical-resistant gloves and chemical splash goggles.

Procedure

1. Using a 50-mL graduated cylinder, measure out 20 mL of potassium thiocyanate solution. Transfer the potassium thiocyanate solution to a Petri dish, and place the Petri dish on an overhead projector. Turn on the overhead projector.
2. Add 5 drops of iron(III) nitrate solution in different spots in the Petri dish. Note that the orange spots produced are a little darker than the iron(III) nitrate solution.
3. Swirl the solution until the orange color is uniform throughout.
4. Add ½ pea size amount of the potassium thiocyanate crystals in one spot. A dark orange spot results. Wait about 30 seconds so the students can observe the movement of the dark orange color through the solution.
5. Swirl the solution to dissolve the crystals and the dark orange color will become uniform throughout.
6. Add ¼ pea size amount of the sodium phosphate monobasic crystals in one spot. Wait about 60 seconds as the color in the vicinity of the crystals becomes lighter than the rest of the solution. This is a great example of ion diffusion in a solution.
7. Swirl the solution to dissolve the crystals and until the solution is colorless throughout.
8. Add one drop of the iron(III) nitrate solution in one spot off to the side. Note the blood red color. Don't stir.
9. Add a pea size amount of the potassium thiocyanate crystals in a different spot. Wait about 30 seconds so the students can observe that the area around the crystals becomes orange.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The solution may be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b. Clean up spills of iron(III) nitrate solution immediately; iron(III) nitrate solution easily stains.

Tips

- Steps 8 and 9 were incorporated into the demo based on the question: "Are the Fe^{3+} and SCN^- ions still present even though there is no color?"
- Put the chemical equations on the overhead while you are doing the demonstration. You can explain or, better yet, have the students explain, the equilibrium shifts.
- Beral pipets or wood splints are ideal to stir the solution.

Discussion

Fe^{3+} and SCN^- ions form the complex ion $FeSCN^{2+}$, which is dark red in color (Equation 1). Addition of $Fe(NO_3)_3$ or KSCN increases the concentration of these reactants and causes the equilibrium in Equation 1 to shift in the forward reaction, or to the right. This observation illustrates the effect of LeChâtelier's Principle—a change in any reaction condition causes the equilibrium to shift in a direction that counteracts the effect of the change.

Addition of $NaH_2PO_4 \cdot H_2O$ results in the equilibrium shifting in the reverse reaction (to the left). This is due to a competing reaction of Fe^{3+} and $H_2PO_4^-$ ions to form a colorless $[FeH_2PO_4]^{2+}$ complex. This effect can be reversed again by adding more Fe^{3+} or SCN^-.

$$\underset{\text{orange}}{Fe^{3+}(aq)} + \underset{\text{colorless}}{SCN^-(aq)} \rightleftarrows \underset{\text{red-orange}}{FeSCN^{2+}(aq)} \qquad \textit{Equation 1}$$

$$\underset{\text{orange}}{Fe^{3+}(aq)} + \underset{\text{colorless}}{H_2PO_4^-(aq)} \rightarrow \underset{\text{colorless}}{[FeH_2PO_4]^{2+}(a)} \qquad \textit{Equation 2}$$

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
Evolution and equilibrium

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Answers to Worksheet Questions

Sample Results Table

Substance Added	Color Observations
0.002 M Potassium thiocyanate solution	*Solution is colorless.*
0.2 M Ferric nitrate solution	*Orange spots appear where the ferric nitrate was dropped.*
Potassium thiocyanate crystals	*A dark orange spot appears around the crystals. The color spreads through the solution in about 30 seconds.*
Sodium phosphate monobasic crystals	*Area around the crystals becomes lighter than the rest of the solution. When the crystals dissolve, the solution is colorless.*
0.2 M Ferric nitrate solution	*A blood red spot appears where the ferric nitrate was dropped.*
Potassium thiocyanate crystals	*Area around the crystals turns orange.*

Discussion Questions

1. Write chemical equations for the following reactions.

   a. The reaction between Fe^{3+} and SCN^- ions

   $Fe^{3+}(aq) + SCN^-(aq) \rightarrow FeSCN^{2+}(aq)$

   b. The reactions between Fe^{3+} and $H_2PO_4^-$ ions

   $Fe^{3+}(aq) + H_2PO_4^-(aq) \rightarrow [FeH_2PO_4]_{2+}$

2. What direction does equilibrium for the first reaction above shift when ferric nitrate or potassium thiocyanate is added?

   Equilibrium in the reaction shifts to the right.

3. Why did the solution turn colorless when the sodium phosphate monobasic was added?

   The addition of the sodium phosphate monobasic shifts equilibrium to the left because of the competing reaction between the Fe^{3+} and $H_2PO_4^-$ ions. The product of that reaction is colorless.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Overhead Equilibrium* activity, presented by Irene Cesa, is available in *Exploring Equilibrium,* part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Overhead Equilibrium* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Overhead Equilibrium—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP8462	An Overhead Equilibrium—Chemical Demonstration Kit
F0046	Iron(III) Nitrate Solution, 0.2 M
P0225	Potassium Thiocyanate
S0097	Sodium Phosphate, Monobasic

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

Overhead Equilibrium Worksheet

Results Table

Substance Added	Color Observations
0.002 M Potassium thiocyanate solution	
0.2 M Ferric nitrate solution	
Potassium thiocyanate crystals	
Sodium phosphate monobasic crystals	
0.2 M Ferric nitrate solution	
Potassium thiocyanate crystals	

Discussion Questions

1. Write chemical equations for the following reactions.

   a. The reaction between Fe^{3+} and SCN^- ions

   b. The reaction between Fe^{3+} and $H_2PO_4^-$ ions

2. What direction does equilibrium for the first reaction above shift when ferric nitrate or potassium thiocyanate is added?

3. Why did the solution turn colorless when the sodium phosphate monobasic was added?