Oxidation States of Manganese

Introduction

The oxidation states of manganese (Mn) from +2 to +7 are easy to demonstrate.

Concepts

- Transition metals
- Oxidation states
- Redox

Materials

Manganous chloride or manganous sulfate solution, $MnCl_2$ or $MnSO_4$, 0.8 M, 70 mL

Potassium permanganate solution, $KMnO_4$, 0.01 M, 90 mL

Sodium hydroxide solution, NaOH, 50%, 8 mL

Sodium hydroxide solution, NaOH, 1 M, 5 mL

Sodium sulfite solution, Na_2SO_3, 0.01 M, 8 mL

Sulfuric acid, concentrated, H_2SO_4, 5 mL

Sulfuric acid solution, H_2SO_4, 3 M, 10 drops

Beral pipets, 6

Overhead projector

Petri dishes or 50-mL beakers, 6

Stirring rods, 5

Wash bottle containing distilled water

Note: Concentrations of the solutions except for the concentrated sulfuric acid are not critical.

Safety Precautions

Sulfuric acid, potassium hydroxide and sodium hydroxide are severely corrosive to eyes, skin, and other body tissue. They are also toxic by ingestion. Mixing sulfuric acid with water may cause spattering and severe heat of dilution. Potassium permanganate is a powerful oxidizing agent and common cause of eye accidents. Manganous sulfate and sodium sulfite may be body tissue irritants. 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.

Procedure

1. **For the Mn(VII) ion:** Fill a Petri dish one-half full (approx. 35 mL) with 0.01 M $KMnO_4$ and place on the overhead projector. Do the following steps on the stage of an overhead projector.
2. **For the Mn(VI) ion:** Fill a Petri dish one-fourth (approx. 18 mL) full with 0.01 M $KMnO_4$. Add about 5 mL of 1 M NaOH. Add 0.01 M Na_2SO_3 dropwise with constant stirring until a clear green color results. (Several milliliters of sodium sulfite solution will be needed.)
3. **For the Mn(V) ion:** Place 6–8 mL of 50% sodium hydroxide solution on the bottom of a Petri dish. Add about 8–10 mL of 0.01 M $KMnO_4$ and stir until a clear blue solution results. *Note:* This is better done away from the heat of the overhead. Some distilled water may need to be added to make the blue color apparent to the students. If a green color results, add another 2–3 mL of 0.01 M $KMnO_4$ and keep on stirring. The reaction takes 1–2 minutes to produce the blue ion—so be patient.
4. **For the Mn(IV) ion:** Fill a Petri dish one-third full (approx. 23 mL) with 0.01 M $KMnO_4$. Add 10 drops of 3 M H_2SO_4. Add 0.01 M Na_2SO_3 dropwise with constant stirring until a mud brown color results. (Several milliliters of sodium sulfite will be needed.)
5. **For the Mn^{3+} ion:** Fill a Petri dish one-half full (approx. 35 mL) with 0.8 M $MnCl_2$ or $MnSO_4$ (Mn^{+2} ion). Add about 5-mL of concentrated H_2SO_4 with constant stirring. Add 0.01 M $KMnO_4$ dropwise (approx. 5 drops will be needed) while stirring until the rose color of the Mn^{3+} ion appears.
6. **For the Mn^{2+} ion:** Fill a Petri dish one-half full (approx. 35 mL) with 0.8 M $MnCl_2$ or $MnSO_4$ (Mn^{2+} ion). In high concentrations this ion is pink but may appear colorless under these conditions.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Chemicals may be disposed of according to Flinn Suggested Disposal Methods #12a and #27f.

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 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Discussion

Advanced students should be able to recognize that the presence of H^+ or OH^- ions influences the identity of the product. The reactions forming the Mn(VI), (IV), and (III) ions are straightforward and advanced students should be able to write the equations for these reactions. The formation of the (V) ion is complex and can be omitted.

$$2MnO_4^- + 2OH^- + SO_3^{2-} \rightarrow H_2O + SO_4^{2-} + 2MnO_4^{2-}$$

$$2MnO_4^- + 2H^+ + 3SO_3^{2-} \rightarrow H_2O + 3SO_4^{2-} + 2MnO_2$$

$$MnO_4^- + 8H^+ + 4Mn^{2+} \rightarrow 5Mn^{3+} + 4H_2O$$

Acknowledgment

Special thanks to Dr. John Davison, chemistry teacher in Oak Park, Illinois for providing us with this activity.

Reference

Kolb, D. *J. Chem. Ed.* **1988,** *65*, 1004.

Materials for *Oxidation States of Manganese* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0228	Sulfuric Acid, 18 M, 100 mL
S0417	Sulfuric Acid Solution, 3 M, 500 mL
S0217	Sodium Hydroxide Solution, 50%, 100 mL
S0148	Sodium Hydroxide Solution, 1 M, 500 mL
S0111	Sodium Sulfite, Anhydrous, 500 g
P0176	Potassium Permanganate Solution, 0.01 M, 500 mL
M0027	Manganous Chloride, 100 g

Consult the Flinn Scientific website for current prices.