Colors of Manganese Ions

Recommended Grade Level(s):

Appropriate for: Middle school and High school

Time Requirements:

Activity Time: 20 minutes

Teaching Topics & Concepts:

- Illustrate the various oxidation states of an element
- Balancing redox equations
- Transition metals
- Evidence, models, and explanation
- Constancy, change, and measurement

Background:

The chemical element manganese is classed as a transition metal. Transition metals are known for having more than one stable oxidation state; manganese has more than any other. It was first recognized as a distinct chemical element in 1740 after chemist Johann H. Pott prepared potassium manganate by fusing caustic potash (potassium hydroxide) with pyrolusite (manganese dioxide) in the air. The color changes he observed in the product were green/blue/red/green, establishing that pyrolusite did not contain iron. In this activity, students can demonstrate the oxidative states of manganese and make their own observations.

Materials:

- Potassium permanganate, $KMnO_4$ (0.1 M)
- Sodium hydroxide, NaOH (2.0 M)
- Sulfuric acid, H_2SO_4 (3.0 M)
- Sodium bisulfite, $NaHSO_3$ (0.1 M)
- EDTA (1.0 M)
- Manganese(II) sulfate, $MnSO_4$ (powder)
- (5) 100 mL beakers
- 50 mL graduated cylinder

Safety

- Read the SDS sheets for all chemicals before using them.
- Adult supervision required when handling chemicals.
- Wear safety glasses, gloves, and lab coat.
- Concentrated acids and bases are used.
- Permanganate solution will stain.
- Sulfuric acid, potassium hydroxide, and sodium hydroxide are 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 a common cause of eye accidents.

Procedure:

1. Pour 50 mL of 0.1 M potassium permanganate in five 100 mL beakers (labeled 1 to 5).
2. To beaker number 1 add 15 mL of 3.0 M sulfuric acid and then, while stirring slowly, add 0.1 M sodium bisulfite until a color change takes place.
3. To beaker number 2 add 20 mL of 2.0 M sodium hydroxide and then, while stirring slowly, add 0.1 M sodium bisulfite until a color change takes place.
4. To beaker number 3 slowly add 0.1 M sodium bisulfite while stirring until a color change takes place.
5. To beaker number 4 add 5 mL of 1.0 M EDTA and a pinch of solid manganese(II) sulfate; then stir.

Expected Results:

This activity demonstrates the chemical process of oxidation and reduction or a redox reaction. The color changes we observe are attributed to different oxidation states of manganese as its reduced.

Follow up/Extension:

- Students can be asked to write balanced equations for beakers 1, 2, and 3 if they are told the oxidation half-reaction is HSO_3^{-1} => SO_4^{-2}
- The reduction half-reaction is MnO_4^{-1} => $Mn^?$ where the ? refers to the oxidation state of manganese in the appropriate beaker.
- What are the properties of transition metals?
- Name the other transition metals besides manganese. How are they different?
- Discuss how the burning of fuels, corrosion of metals, and the processes of photosynthesis and cellular respiration involve oxidation and reduction.

Teaching notes:

- You'll get the most dramatic effect if you swirl the mixture together to combine the reactants thoroughly.
- The chart below outlines color corresponding to the various oxidation states of manganese

Beaker	Oxidation State of Mn	Color
1	+2	colorless
2	+6	green
3	+4	brown
4	+3	violet/rose
5	+7	purple

- Advanced students should recognize that H+ or OH– ions influence the identity of the product. They should also be able to write the equations for the reactions.

Disposal/Clean-Up:

Remaining contents can be placed in the science department's heavy metal waste container for proper disposal.

5100 West Henrietta Road • PO Box 92912 • Rochester, New York 14692-9012 • p: 800 962-2660 • wardsci.com