Oxidation States of Manganese

**Description:** Three reactions are carried out separately with KMnO₄ resulting in solutions with colors reflecting the change in oxidation state from Mn⁺⁷ to +2, +4, and +6.

**Materials:**

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.002 M KMnO₄</td>
<td>Petri dishes (4)</td>
</tr>
<tr>
<td>0.01 M NaHSO₃</td>
<td>3 M H₂SO₄</td>
</tr>
<tr>
<td>0.10 M NaHSO₃</td>
<td>6 M NaOH</td>
</tr>
</tbody>
</table>

**Procedure:**

For large lecture halls, perform demonstration on overhead projector.

1. Fill each of 4 Petri dishes half way with 0.002 M KMnO₄ solution. Label the dishes A-D. Dish A will serve as the Mn (VII) control.

2. Dish B (+7 to +6): Add 2 mL of 6 M NaOH and 2 mL of NaHSO₃ to the KMnO₄ solution and stir. The color should change from purple to green.

3. Dish C (+7 to +4): Add 2 mL of NaHSO₃ to the KMnO₄ solution and stir. The color should change from purple to peach/pale brown.

4. Dish D (+7 to +2): Add 2 mL of 3 M H₂SO₄ and add 2 mL of NaHSO₃ to the KMnO₄ solution and stir. The color should change from purple to colorless.

5. Addition of a more concentrated NaHSO₃ to dishes B and C will result in precipitation of MnO₂ (Mn⁴⁺).
Electrochemistry

Discussion:

The following equations describe the redox chemistry observed in this demonstration.

Dish B \[ 2 \text{MnO}_4^- + 3 \text{OH}^- + \text{HSO}_3^- \rightarrow 2 \text{MnO}_4^{2-} + \text{SO}_4^{2-} + 2 \text{H}_2\text{O} \]

Dish C \[ 2 \text{MnO}_4^- + 3 \text{HSO}_3^- \rightarrow 2 \text{MnO}_2 + 3 \text{SO}_4^{2-} + 3 \text{H}_2\text{O} \]

Dish D \[ 2 \text{MnO}_4^- + \text{H}^+ + 5 \text{HSO}_3^- \rightarrow 2 \text{Mn}^{2+} + 5 \text{SO}_4^{2-} + 3 \text{H}_2\text{O} \]

Safety: Wear proper protective equipment including gloves and safety glasses when preparing and performing this demonstration. Care should be taken when using strong acids or bases as contact may cause burns. \( \text{MnO}_2 \) is a strong oxidizing agent.

Disposal: Solutions can be collected together and disposed of in an appropriate waste container.

References:

Summerlin, L. R.; Ealy, J. L. In Chemical Demonstrations: A Sourcebook for Teachers; American Chemical Society: 1985; Vol. 1, p 95-97.


Video:

http://www.youtube.com/watch?v=jRQserZYXbl