# Oxidation States of Manganese



## Introduction

Atoms in compounds may be found in various oxidation states. Atoms of some elements, like manganese, have many possible oxidation states. Oxidation-reduction reactions lead to changes in oxidation states.

## Purpose

The oxidation state of manganese in potassium permanganate is changed through a series of redox reactions. The redox reactions are controlled by adjusting the acidity of the reaction medium.

## Safety

1. Wear protective goggles throughout the laboratory activity.

2. Dilute sulfuric acid and dilute sodium hydroxide solutions are corrosive. Solid potassium permanganate is a strong oxidant. Potassium permanganate and sodium bisulfite, (aka: sodium hydrogen sulphite, $NaHSO_3$), are toxic.

3. Use caution when handling the dilute sulfuric acid solution.

4. Do not permit the potassium permanganate to come in contact with any reducing agents. Save any spilled material for disposal according to the procedure given.

5. Dispose of all materials as your teacher directs.

## Procedure

Use pulled Beral pipets.

1. Put 10 drops $KMnO_4$ solution, (the oxidising agent, why?), in four wells of a 24-well plate, A-1 through A-4. (The well A-1 is your control)
2. Add four drops NaOH solution to well A-2, thus basic medium.
3. Add three drops 3M $H_2SO_4$ solution top well A-4, identifying an acidic medium.
4. Place the plate on a sheet of white paper or other white background, for visibility.
5. Add three drops $NaHSO_3$ solution, (the reducing agent) to well A-2 while stirring with a clean stirring rod until there is evidence of a reaction.
6. Add three drops $NaHSO_3$ solution to well A-3 while stirring with a stirring rod. Note evidence for a reaction.
7. Slowly add $NaHSO_3$ solution to well A-4, while stirring with a stirring rod, until there is evidence of a reaction.
8. $MnO_2$ is an insoluble brown solid. $Mn^{2+}$ is faintly pink in solution. $MnO_4^{2-}$ is dark green in solution. Based upon these colours, identify the manganese reaction products formed in wells A-2, A-3, and A-4.
9. Thoroughly wash your hands before leaving the laboratory.

## Data Analysis and Concept Development

1. For each well, determine whether the Mn in $MnO_4^-$ undergoes oxidation or reduction.

2. Fill in the blanks: "$MnO_4^-$" acts as ______________ (oxidizing or reducing) agent because ____________________

3. Fill in the blanks: "the other agent in this reaction is _______. It acts as a _____________________ (oxidizing or reducing) agent because _________.

4. Predict the effect of replacing $NaHSO_3$ with $NaHSO_4$. Test your prediction.

5. Complete the table involving reactions between $KMnO_4$ and $NaHSO_3$ in your lab-book.

| | Well # | Change in oxidation state of Mn | Change in oxidation state of S | Electrons gained by Mn | Electrons lost by S |
|---|---|---|---|---|---|
| Reaction 1 | A-2 (basic) | | | | |
| Reaction 2 | A-3 (neutral) | | | | |
| Reaction 3 | A-4 (acidic) | | | | |

6. In Reaction 1 of the table above, each $MnO_4^-$ takes up one electron, but each $HSO_3^-$ gives up two electrons. Account for this difference.

7. Predict the stoichiometric ratio of $MnO_4^-$ to $HSO_3^-$ in Reaction 2 and 3.

8. Balance each of the following skeleton reactions based upon the stoichiometric ratios developed in Question 7:

$$OH^- + MnO_4^- + HSO_3^- \text{ -----> } MnO_4^{2-} + HSO_4^- + H_2O$$

$$H^+ + MnO_4^- + HSO_3^- \text{ -----> } MnO_2 + HSO_4^- + H_2O$$

$$H^+ + MnO_4^- + HSO_3^- \text{ -----> } Mn^{2+} + HSO_4^- + H_2O$$

## Conclusion

## Application

Balance the following redox reactions involved in the production of copper:

1. $CuFeS_2 \longrightarrow Cu_2S + FeS + S$ (matte)

2. $Fe_2O_3 + FeS \longrightarrow FeO + SO_2$

3. $FeO + SiO_2 \longrightarrow FeSiO_3$ (Slag formation)

4. $Cu_2S + O_2 \longrightarrow Cu + SO_2$ (Blister copper)