

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.

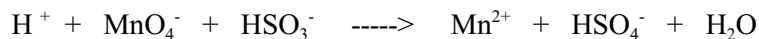
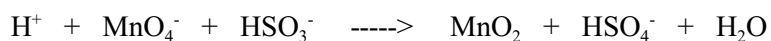
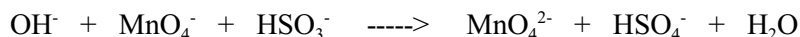
1. Put 10 drops KMnO_4 solution, (the oxidising agent, why?), in four wells of a 24-well plate, A-1 through A-4. (The well A-1 is your control)
2. Add four drops NaOH solution to well A-2, thus basic medium.
3. Add three drops 3M H_2SO_4 solution top well A-4, identifying an acidic medium.
4. Place the 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:



Conclusion

Application

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

1. $\text{CuFeS}_2 \longrightarrow \text{Cu}_2\text{S} + \text{FeS} + \text{S}$ (matte)
2. $\text{Fe}_2\text{O}_3 + \text{FeS} \longrightarrow \text{FeO} + \text{SO}_2$
3. $\text{FeO} + \text{SiO}_2 \longrightarrow \text{FeSiO}_3$ (Slag formation)
4. $\text{Cu}_2\text{S} + \text{O}_2 \longrightarrow \text{Cu} + \text{SO}_2$ (Blister copper)