Fe Analysis by REDOX Titration

Reaction of Ferrous Ion with Permanganate

Potassium permanganate is a widely used as an oxidizing agent in volumetric analysis. In acid solution MnO_4^- undergoes reduction to Mn^{+2} . Since the permanganate ion, MnO_4^- , is pink and the Mn^{+2} ion is colorless, the endpoint using permanganate as the titrant can be taken as the first permanent pink color that appears in the titration.

In this experiment $KMnO_4$ will be used to determine the percentage of Fe^{+2} by mass in an unknown sample. The oxidation of Fe^{+2} to Fe^{+3} is carried out acidic solution to prevent the air oxidation of Fe^{+2}. Phosphoric acid, H_3PO_4, is added to form a colorless complex with Fe^{+3} ion.

The $KMnO_4$ solution (about 0.02M) is first standardized by titration using Mohr's salt, ferrous ammonium sulfate hexahydrate, $(Fe(NH_4)_2(SO_4)_2(H_2O)_6$ as the source of Fe^{2+}. The Fe^{+2} is oxidized to Fe^{+3} while the MnO_4^- is reduced to Mn^{+2}. The exact molarity of the $KMnO_4$ is then determined.

$$Fe(NH_4)_2(SO_4)_2(H_2O)_6 \rightarrow Fe^{2+}(aq) + 2NH_4^+(aq) + 2SO_4^{2-}(aq) + 8H_2O(l)$$

$$MnO_4^- + Fe^{+2} \rightarrow Mn^{+2} + Fe^{+3} \quad \text{(unbalanced)}$$

Next the standardized $KMnO_4$ is reacted with a known mass of an unknown sample containing Fe^{+2} . The mass and percent by mass of Fe^{+2} in the unknown is then calculated.

Procedure

Standardization of $KMnO_4$ Solution

Prepare a 1 M H_2SO_4 solution by slowly pouring 20 mL of concentrated (18M) H_2SO_4 into 340 - 350 mL of distilled water in a 500 mL Erlenmeyer flask. Swirl to insure thorough mixing of the solution.

Weigh two 0.60 gram samples of Mohr's salt into two separate 250 mL Erlenmeyer flasks. To each flask add 50 mL of the 1 M H_2SO_4 and swirl to dissolve the salt. Then add 3 mL of concentrated (85%) H_3PO_4 to each flask. Titrate each solution with the permanganate until a stable pink color (30 seconds) is reached. Do a third trial if there is a big difference in the two results. The volume of $KMnO_4$ in each titration should agree within 1 %. Calculate the average molarity of the permanganate (about 0.02M)

Analysis of Unknown

Accurately weigh two 1.00 gram samples of your unknown into two separate 250 Erlenmeyer flasks. Add 50 mL of the 1M H_2SO_4 and 3 mL of the 85% H_3PO_4 to each flask and swirl to dissolve the unknown. Titrate each sample with the $KMnO_4$ to a stable pink color. Calculate the percent by mass of Fe^{+2} in each sample and determine the average percentage of Fe^{+2}.

Name:_____

Data and Calculations

Standardization of $KMnO_4$

(Permanganate is approximately 0.02M)

	Trial # 1	Trial # 2	Trial # 3 (If necessary)
Mass of Mohr's Salt, g	_____	_____	_____
Moles of Mohr's salt	_____	_____	_____
Moles of Fe+2	_____	_____	_____
Moles $KMnO_4$	_____	_____	_____
Final mL $KMnO_4$	_____	_____	_____
Initial mL $KMnO_4$	_____	_____	_____
Volume $KMnO_4$ used	_____	_____	_____
Molarity of $KMnO_4$	_____	_____	_____

Average Molarity of $KMnO_4$ _____

DISPOSE ALL SOLUTIONS IN THE HEAVY METAL WASTE CONTAINER.

Name:_____

Analysis of Unknown

Average $KMnO_4$ Molarity _____

	Trial #1	Trial # 2	Trial # 3 (If necessary)
Final mL of $KMnO_4$	_____	_____	_____
Initial mL of $KMnO_4$	_____	_____	_____
mL of $KMnO_4$ used	_____	_____	_____
Molarity of $KMnO_4$ (page 2)	_____	_____	_____
Moles of $KMnO_4$ used	_____	_____	_____
Moles of Fe^{+2} in sample	_____	_____	_____
Grams of Fe^{+2} in Sample	_____	_____	_____
Mass of unknown, g	_____	_____	_____
Percent by mass of Fe^{+2} in sample	_____	_____	_____

Average percent Fe^{+2} _____

Unknown Number _____

DISPOSE ALL SOLUTIONS IN THE HEAVY METAL WASTE CONTAINER.

Name:_____

Fe Analysis by REDOX Titration

Prestudy

1. Write the balanced net-ionic equation for the reaction of ferrous ion with permanganate in an acidic solution.

$$Fe^{+2} + MnO_4^{-1} \text{ -----> } Fe^{+3} + Mn^{+2}$$

2. A 0.5585 g sample of ferrous ammonium sulfate hexahydrate, $Fe(NH_4)_2(SO_4)_2(H_2O)_6$, requires 21.45 mL of a $KMnO_4$ solution to reach a pink endpoint. What is the molarity of the $KMnO_4$ solution ?

3. A 1.787 g sample containing some Fe^{+2} ion requires 31.50 mL of a 0.02188 m $KMnO_4$ solution to reach a stable pink endpoint. What is the percent by mass of Fe^{+2} in the sample ?

4. Calculate the percent by mass of Fe^{+2} in Mohr's salt (ferrous ammonium sulfate hexahydrate), $Fe(NH_4)_2(SO_4)_2(H_2O)_6$ to **four significant figures**. This is the maximum percent of Fe^{+2} you can have in your unknown