Chemistry Lab for Spring week 2
Determination of an equilibrium constant by spectrometry

Helpful reading from text: pp. 1043-1045 on color of metal compounds; p. 581 (" a closer look") on Beer's law. Pp. 1026-1028 on metal complexes as examples of Lewis acid-base chemistry.

The equilibrium we are studying today is the reaction of iron(III) with the thiocyanate ion to produce the deep red $FeSCN^{2+}$ ion by the reaction below:

$Fe^{+3}_{(aq)} + SCN^{-}_{(aq)} \rightleftarrows FeSCN^{+2}_{(aq)}$

If the reaction occurs as described in equation 1, it should possess an equilibrium constant defined as $K_{eq} = [FeSCN^{+2}]/[Fe^{+3}][SCN^{-}]$. In this lab we will mix varying amounts of iron(III) and thiocyanate ions, and then determine the concentration of the product complex by measurement of the light absorbed by the product ion. Since we know the starting amounts of each ion, and the concentration of the product, we can find the concentrations of all reacting species at equilibrium. We can then use these values to find the value of K_{eq}. If the reaction and equilibrium constant described above are the correct reaction for these two components reacting, the K_{eq} value should be constant regardless of the starting ratios of the component ions.

Procedure:

The first stock solution you will use today is 2.00×10^{-3} M $Fe(NO_3)_3$ in 1 M HNO_3. The nitric acid is present to prevent any appreciable level of hydroxide from forming. Hydroxide would make the analysis more difficult because it reacts with iron(III) forming other brown colored complex ions. Treat this solution as a strong acid solution! The other stock solution is 2.00×10^{-3} M KSCN

You will need 6 clean labeled test tubes. The first five will contain varying ratios of the two reacting species. The 6th tube will be used to make a standard reference solution of $FeSCN^{+2}_{(aq)}$ to determine the absorbance constant for this colored species.

For each of your first five tubes add 5.0 mL of the iron solution (by pipette) to each tube. Pipette 1, 2, 3, 4, and 5 mL of the KSCN solution into each of the respective tubes. Then add the appropriate amount of DI water to each tube so reach a total volume of 10.0 mL. The amount of each material in each tube is summarized in the table below

	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5
mL Fe(III) solution	5.0	5.0	5.0	5.0	5.0
mL KSCN solution	1.0	2.0	3.0	4.0	5.0
mL DI water	4.0	3.0	2.0	1.0	0.0

Mix each solution thoroughly with a clean glass stir rod. Be sure to rinse and dry the stir rod between each sample.

Preparation of a known standard $FeSCN^{+2}_{(aq)}$ solution.
Prepare the standard by mixing 10.0 mL of 0.2 M $Fe(NO_3)_3$ into a clean test tube with 2.0 mL of 2.00 x 10^{-3} M KSCN and 8.0 mL of DI water. NOTE THAT A DIFFERENT CONCENTRATION OF IRON(III) IS USED HERE! In this tube, the concentration of iron is much, much greater than the concentration of SCN^-. This will force the equilibrium far to the right until essentially all of the thiocyanate is converted into the $FeSCN^{+2}$ complex. Thus in this tube, [$FeSCN^{+2}$] is equal to the starting SCN^- concentration.

Data Collection:
Place a portion of each of your samples into the cuvette of the spectrophotometer and collect absorbance at 447 nm. Be sure to do this for you known standard sample as well.

Data Analysis.
1. For each of your tubes, first find the starting Fe(III) concentrations and the starting SCN^- concentrations. Here, your best bet is to remember C1V1=C2V2.
2. From your standard sample, determine what the absorption constant for the colored ion and use this value with the Beer-Lambert Law to determine the concentration of $FeSCN^{+2}$ in each one of your trial test tubes.
3. In our model, we assume that every molecule of $FeSCN^{+2}$ used up 1 iron ion and 1 thiocyanate ion. Using the amount of $FeSCN^{+2}$ in each tube, subtract the relevant value to find how much free Fe(III) and thiocyanate are left in each solution.
4. Now that you have the concentrations of all three components of the equilibrium, find the equilibrium constant in each of your test tubes. How constant is your value?