Equilibrium in Aqueous Solution

The purpose of this experiment is to determine the equilibrium constant for a reaction in aqueous solution:

$$Fe^{3+}\,(aq) + SCN^{-}\,(aq) \rightarrow FeSCN^{2+}\,(aq)$$

Various concentrations of reactants will be used, and the concentration of the $FeSCN^{2+}$ product measured spectrophotometrically. The equilibrium concentrations of all ions can be determined, and then the equilibrium constant can be calculated. Because the Fe (III) ion requires an acidic solution to remain stable, the solvent for the reaction will be 0.05 M HNO_3. Every solution will be 0.05 M HNO_3, and so it will not be necessary to do any calculations involving the H^+ ions.

Procedure:

Work in pairs. Obtain from the designated point in the lab: 50 and 100 mL volumetric flasks; 1, 3, and 5 mL transfer pipets; 5 mL Mohr pipet; pipet pump; 9 Spectronic 20 cuvettes; and cuvette rack.

I. Standard Curve for $FeSCN^{2+}$

Obtain about 30 mL (and only 30 mL) of the stock 0.00200 M KSCN, which provides the SCN^- ions, in a clean *dry* 50 mL beaker. Obtain about 30 mL (and only 30 mL) of the stock 0.200 M $Fe(NO_3)_3$ solution, which provides the Fe^{3+} ions, in a clean *dry* 50 mL beaker. Obtain about 300 mL (and only 300 mL) of the stock 0.050 M HNO_3 solution in a clean *dry* 400 mL beaker.

Use the 50 mL volumetric flask to prepare the standard solutions, beginning with the most dilute. Pipet 1.0 mL of the SCN^- solution into the flask, use a graduated cylinder to add about 10 mL of the Fe^{3+} solution, and fill to the line with the HNO_3 solution. Mix thoroughly; rinse and fill one of the Spectronic 20 cuvettes with this solution. For the other two standards, repeat the above except use 3.0 mL and 5.0 mL of the SCN^- solution.

To calculate product concentrations in these samples, we will assume that the very high concentration of the Fe^{3+} is sufficient to drive the equilibrium completely to product, which means that the equilibrium $[FeSCN^{2+}]$ equals the initial $[SCN^-]$.

II. Aqueous Equilibrium of $FeSCN^{2+}$

Prepare a 0.00200 M Fe^{3+} solution by pipetting 1.0 mL of the 0.200 M Fe^{3+} solution into the 100 mL volumetric flask, filling to the mark with 0.05 M HNO_3, and mixing thoroughly. Be sure to use this (much lower concentration) Fe^{3+} solution in the subsequent trials—and not the (much higher concentration) Fe^{3+} solution used previously.

Next, label your 16 x 150 mm test tubes, from your drawer, with numbers 1 through 5. Use the Mohr pipet to prepare the various concentrations of reactants as follows:

	$0.00200\ M\ Fe^{3+}$	$0.00200\ M\ SCN^-$	$0.050\ M\ HNO_3$
(1)	5.0 mL	1.0 mL	4.0 mL
(2)	5.0	2.0	3.0
(3)	5.0	3.0	2.0
(4)	5.0	4.0	1.0
(5)	5.0	5.0	----

Stir each solution thoroughly with a glass rod. Be careful not to transfer any solution from one test tube to the next. Rinse a Spectronic 20 cuvette with solution 1, and then fill that cuvette with solution 1. Repeat with the other solutions. Use a beaker to collect the rinses for appropriate waste disposal. Fill the remaining cuvette with 0.050 M HNO_3, and use it as the blank.

III. Measurement

Take all your cuvettes with the standards (from Part I), the experimental solutions (from Part II), and the blank to a Spectronic 20 instrument. Set the wavelength to 447 nm and zero the instrument. Measure and record the absorbance of each of the standards and the experimental solutions.

After completing the procedure but before leaving lab, write in your notebook a brief statement (two to three sentences) on the quality and reasonableness of the data you collected. Note what you might do differently if you performed the lab again.

Remember that you will treat the standards (three cuvettes from Part I) as having known [$FeSCN^{2+}$] concentrations and then use them to determine the at-equilibrium concentrations of all the components in the five experimental solutions (cuvettes from Part II). Before you leave the lab: Make sure that you have a plan for all the work required to get from the data you recorded in lab to the final numerical result of an equilibrium constant (K_c) value for the iron (III) thiocyanate complexation reaction, and talk to your instructor if you have any uncertainty.