Experiment
20

Chemical Equilibrium: Finding a Constant, K_{eq}

The purpose of this lab is to experimentally determine the equilibrium constant, K_{eq}, for the following chemical reaction:

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

(ferric) (thiocyanate) (ferric thiocyanate)

When Fe^{3+} and SCN^{-} are combined, equilibrium is established between these two ions and the $FeSCN^{2+}$ ion. In order to calculate Keq for the reaction, it is necessary to know the concentrations of all ions at equilibrium: $[FeSCN^{2+}]_{eq}$, $[SCN^{-}]_{eq}$, and $[Fe^{3+}]_{eq}$. You will prepare four equilibrium systems containing different concentrations of these three ions. The equilibrium concentrations of the three ions will then be experimentally determined. These values will be substituted into the equilibrium constant expression to see if *Keq* is indeed constant.

In order to determine $[FeSCN^{2+}]_{eq}$, you will use the Colorimeter shown in Figure 1. The $FeSCN^{2+}$ ion produces solutions with a red color. Because the red solutions absorb blue light very well, the blue LED setting on the Colorimeter is used. The computer-interfaced Colorimeter measures the amount of blue light absorbed by the colored solutions (absorbance, A). By comparing the absorbance of each equilibrium system, A_{eq}, to the absorbance of a *standard* solution, A_{std}, you can determine $[FeSCN^{2+}]_{eq}$. The standard solution has a known $FeSCN^{2+}$ concentration.

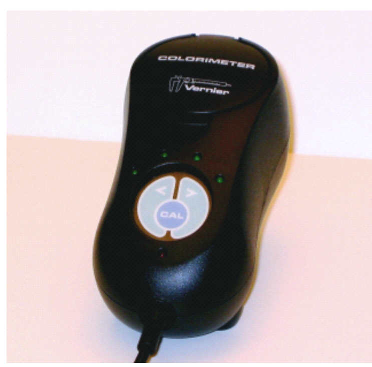

Figure 1

To prepare the standard solution, a very large concentration of Fe^{3+} will be added to a small initial concentration of SCN^{-} (hereafter referred to as $[SCN^{-}]_o$. The $[Fe^{3+}]$ in the standard solution is 100 times larger than $[Fe^{3+}]$ in the equilibrium mixtures. According to Le Chatelier's principle, this high concentration forces the reaction far to the right, using up nearly 100% of the SCN^{-} ions. According to the balanced equation, for every one mole of SCN^{-} reacted, one mole of $FeSCN^{2+}$ is produced. Thus $[FeSCN^{2+}]_{std}$ is assumed to be equal to $[SCN^{-}]_o$.

Assuming $[FeSCN^{2+}]$ and absorbance are related directly (Beer's Law), the concentration of $FeSCN^{2+}$ for any of the equilibrium systems can be found by:

$$[FeSCN^{2+}]_{eq} = (A_{eq}/A_{std})[FeSCN^{2+}]_{std}$$

OBJECTIVE

In this experiment, you will determine the equilibrium constant, *Keq*, for the following chemical reaction:

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

(ferric) (thiocyanate) (ferric thiocyanate)

MATERIALS

computer	0.00200 M KSCN
Vernier computer interface	0.00200 M $Fe(NO_3)_3$ (in 1.0 M HNO_3)
Logger*Pro*	0.200 M $Fe(NO_3)_3$ (in 1.0 M HNO_3)
Vernier Colorimeter	four pipets
1 plastic cuvette	pipet bulb or pipet pump
five 20 × 150 mm test tubes	three 100 mL beakers
thermometer	tissues (preferably lint-free)

☞ **Use and Care when handling cuvettes**:

- All cuvettes should be wiped clean and dry on the outside with a tissue.
- Handle cuvettes only by the top edge of the ribbed sides.
- All solutions should be free of bubbles.
- Never fill a cuvette more than 3/4 and always keep in an upright position.
- Always position the cuvette with its reference mark facing toward the white reference mark at the top of the cuvette slot on the Colorimeter.
- Alway rinse cuvettes and pipets with ~1-2 mL portions of each new solution before use.

PROCEDURES

1. Connect the Colorimeter to the computer interface. Prepare the computer for data collection by opening the file "20 Equilibrium Constant" from the *Chemistry with Computers* folder of Logger*Pro*

2. Calibrate the Colorimeter to remove any absorbance from pure water.
   a. Prepare a blank by filling a cuvette 3/4 full with distilled water. To correctly use a Colorimeter cuvette, remember
   b. Open the Colorimeter lid.
   c. Holding the cuvette by the upper edges, place it in the cuvette slot of the Colorimeter. Close the lid.
   d. If your Colorimeter has a CAL button, Press the < or > button on the Colorimeter to select a wavelength of 470 nm (Blue) for this experiment. Press the CAL button until the red LED begins to flash. Then release the CAL button. When the LED stops flashing, the calibration is complete.

3. Prepare a standard solution of $FeSCN^{2+}$ by pipetting 18.00 mL of 0.200 M $Fe(NO_3)_3$ into a 20 × 150 mm test tube and 2.00 mL of 0.00200 M KSCN into the same test tube, recording the exact volumes used. Stir thoroughly.

Fill the cuvette about 3/4 full with the standard solution and wipe the outside of the cuvette with a tissue. Place the cuvette in the Colorimeter and close the lid. Wait for the absorbance value displayed in the meter to stabilize and record this reading as A_{std} .

4. Before you begin to mix your equilibrium solutions, read the paragraph below and create a data table that summarizes the volumes you have chosen to use.

Label four 20 x 150 mm test tubes 1-4. Pipet equal volumes between 5-10 mL of 0.00200 M $Fe(NO_3)_3$ into each of these test tubes, then add decreasing volumes of deionized water and increasing volumes of 0.00200 M KSCN, neither to exceed the volume of $Fe(NO_3)_3$. When complete each test tube should contain the same total volume, between 10-20 mL (see example volumes shown below). Mix each test tube thoroughly with a stirring rod, being sure to rinse and dry the stirring rod after each use.

Example quantities:

Test Tube #	$Fe(NO_3)_3$ (mL)	KSCN (mL)	H_2O (mL)	Total Volume (mL)
1	7.50	4.50	3.00	15.00
2	7.50	5.50	2.00	15.00
3	7.50	6.50	1.00	15.00
4	7.50	7.50	0	15.00

5. Record the temperature of one of the above solutions to use as the temperature for the equilibrium constant, Keq.

6. You are now ready to collect absorbance data for each of the four equilibrium systems. Place the cuvette in the Colorimeter. After closing the lid, wait for the absorbance value displayed in the meter to stabilize and record the absorbance value for each or your solutions.