Objective:
Determine the equilibrium constant, $K_c$, of the reaction below:

$$\text{Fe}^{3+} + \text{SCN}^- \rightleftharpoons [\text{Fe(SCN)}^{2+}]$$

Experiment:
1. To calculate the equilibrium constant, the equation below is used.

$$K_c = \frac{[\text{Fe(SCN)}^{2+}]}{[\text{Fe}^{3+}][\text{SCN}^-]}$$

2. The initial concentration of the reactants can be determined by multiplying the volume of the reactant with its molar concentration giving the number of moles. The calculated moles is then divided by the new volume.

$$\frac{\text{(volume Fe}^{3+}\text{in L})(\text{molarity Fe}^{3+})}{\text{(total volume in L)}} = \text{initial concentration of Fe}^{3+}$$

3. The concentration of the product, $[\text{Fe(SCN)}^{2+}]$, at equilibrium will be determined spectrophotometrically.
   - $[\text{Fe(SCN)}^{2+}]$ is a colored solution. When light is directed at a solution at its appropriate wavelength, it will absorb the light.
   - How much light the solution absorbs is dependent on the concentration, cell path and a constant, molar extinction, for that particular solution.
   - $A = a b c$ where $a$ is the molar extinction, $b$ is the path length and $c$ is the concentration of the solution.
   - The equation above is known as the Beer's Law.
   - When the Spec 20 is used, dependent on the concentration, light is absorbed and transmitted through the cell. Both transmission and absorbance are measured by the Spec 20
• \[ T = \frac{I}{I^0} \] and \[ \%T = \frac{I}{I^0} \times 100 \]
• \[ A = a \times b \times c \]
• \[ A = -\log \frac{1}{T} \] or \[ A = \log \frac{I^0}{I} = a \times b \times c \]
• To determine the concentration of a solution or solutions a standard curve is generated. This is done by determining the absorbance, \( A \), of solutions of known concentrations. A graph of **Concentration vs. A is plotted**. The graph should go through zero.

![](Standard_Curve.png)

• The absorbance, \( A \), of a solution is determined from the standard curve. The slope equation of the graph can be determined by using Excel. The concentration of the product is determined by plugging it absorbance (=y) into the slope equation and solving for "x"

4. Once the concentration of the product is determined, then the concentration of the reactants at equilibrium can be calculated as shown in your lab book

**Procedure**

**Check-out 2 matched cuvets.**

1. Work in pairs. In the chemistry lab pair is defined as **two** persons. Pick your partner ahead of time. It will take about 3 to 4 hours to complete this experiment alone.

2. Do the experiment in the following order:
   1. **Turn on the Spec 20**
   2. **Part A #1 Preparation of the standard curve solutions**
   3. **Part B #1 Preparation of the test solutions**
   4. **Part A # 2,3,4 Preparation of blank, calibration and transmission reading**
   5. **Part B# 2,3 Recalibration and transmission reading**

Save your solutions until after you have graphed your standard curve. An Excel template will be on the website.

3. Readings must be done in one sitting and on the same spec 20.

**PLEASE NOTE IMPORTANT PROCEDURE MODIFICATION BELOW!**

Follow the table below instead of the one on the book.
Part A

Step 1. **SKIP, measure the volumes from the table below.** The reagents are in self zeroing burets.

**Modification**
- Please note that there are two concentrations of Fe(NO$_3$)$_3$, 0.200M and .00200M. Make sure that you are using the correct concentration. **You will not need the pipets, remember all reagents are in self zeroing burets.**

1. **Use the volumes below.** If your measurement is not exactly as written below, record the actual measurement and calculate the concentration with the actual measurement.

<table>
<thead>
<tr>
<th>Beaker</th>
<th>0.00100 M NaSCN</th>
<th>0.200M Fe(NO$_3$)$_3$</th>
<th>010 M HNO$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>0mL</td>
<td>10.00 mL</td>
<td>15.00 mL</td>
</tr>
<tr>
<td>1</td>
<td>1 mL</td>
<td>10.00 mL</td>
<td>14.00 mL</td>
</tr>
<tr>
<td>2</td>
<td>2 mL</td>
<td>10.00 mL</td>
<td>13.00 mL</td>
</tr>
<tr>
<td>3</td>
<td>3 mL</td>
<td>10.00 mL</td>
<td>12.00 mL</td>
</tr>
<tr>
<td>4</td>
<td>4 mL</td>
<td>10.00 mL</td>
<td>11.00 mL</td>
</tr>
</tbody>
</table>

Part B

Step 1. **Volume modification of Nitric Acid.** The concentration of 0.002 M NaSCN as written in the book gave absorbance outside the standard curve. **Use the dilutions below. Please note that the concentration of the NaSCN is 0.00100.**

<table>
<thead>
<tr>
<th>Beaker</th>
<th>0.00100 M NaSCN</th>
<th>0.00200M Fe(NO$_3$)$_3$</th>
<th>0.10 M HNO$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.00 mL</td>
<td>5.00 mL</td>
<td>4.00</td>
</tr>
<tr>
<td>6</td>
<td>2.00 mL</td>
<td>5.00 mL</td>
<td>3.00</td>
</tr>
<tr>
<td>7</td>
<td>3.00 mL</td>
<td>5.00 mL</td>
<td>2.00</td>
</tr>
<tr>
<td>8</td>
<td>4.00 mL</td>
<td>5.00 mL</td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td>5.00 mL</td>
<td>5.00 mL</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Follow the instruction below to operate the Spec 20.

**Spec 20 Calibration**
- a. Turn on the machine using the left front knob. Let the machine warm up for at least 10 minutes. Set the wavelength to 447 using the top right knob.
- b. Set the toggle switch to % Transmission. The decimal point should be on top of T. For Spec 20 D model, press MODE to Transmission
- c. Calibrate the machine to 0% Transmission by adjusting the left front knob.
- d. Place the "blank" cuvet in the sample well. Align the vertical line on the cuvet to the notch on the sample well.
- e. Calibrate to 100% Transmission by adjusting the right front knob.
- f. Repeat #4 and #5. Adjust as needed. **Once calibrated, do not adjust the front knobs further.** You are now ready to read your sample.
% Transmission Determination of Samples

a. Start with the least concentrated solution and work yourself up to the most concentrated. **WHY?**
b. Place the cuvet solution in the sample well.
c. Align the vertical line on the cuvet with the hash mark on the well.
d. Close the well lid. Record the transmission.
e. Calculate absorbance using the equation:
   \[ A = -\log \frac{T}{100} \]