6.R: Determination of Kc for a Complex Ion Formation (Lab Report)

Name: ______________________________ Lab Partner: __________________________

Date: _________________________ Lab Section: ___________________

Part A: Initial concentrations of Fe^{3+} and SCN^{-} in Unknown Mixtures

Experimental Data

Tube	Reagent Volumes (mL)			Initial Concentrations (M)	
--	2.00 x 10^{-3} M $Fe(NO_3)_3$	2.00 x 10^{-3} M KSCN	Water	Fe^{3+}	SCN^{-}
1	5.00	5.00	0.00		
2	5.00	4.00	1.00		
3	5.00	3.00	2.00		
4	5.00	2.00	3.00		
5	5.00	1.00	4.00		

- Show a sample dilution calculation for $[Fe^{3+}]$ initial in Tube #1 only

Part B and C: The Standard $FeSCN^{2+}$ Solution (Visual Method)

Given that 10.00 mL of **0.200 M** $Fe(NO_3)_3$, 2.00 mL of 0.00200 M KSCN, and 8.00 mL of water

- Equilibrium $[FeSCN^{2+}]$ in Standard Solution: ______________ M

> Note that since $[Fe^{3+}] \gg [SCN^{-}]$ in the Standard Solution, the reaction is forced to completion, thus causing all the SCN^{-} to convert to $FeSCN^{2+}$.

- Show the stoichiometry and dilution calculations used to obtain this value.

Equilibrium Concentrations of $FeSCN^{2+}$ in Mixtures:

Tube	Solution Depths (mm)		$[FeSCN^{2+}]_{equil}$ (M)
--	Mixtures	Standard	--
1			
2			
3			
4			
5			

- Show a sample calculation for $[FeSCN^{2+}]_{equil}$ in Tube #1 only.

Part D: Spectrophotometric Method

Calibration Curve Data

Tube	Absorbance	$[FeSCN^{2+}]$ (M)
Blank		
1		

Tube	Absorbance	$[FeSCN^{2+}]$ (M)
2		
3		
4		

- Show a sample dilution calculation for $[FeSCN^{2+}]$ in Tube #1 and 2 only.

> Note that since $[Fe^{3+}] \gg [SCN^-]$ in the Standard Solution, the reaction is forced to completion, thus causing all the added SCN^- to be converted to $FeSCN^{2+}$.

- Plot Absorbance vs.$[FeSCN^{2+}]$ for the standard solutions. Obtain an equation for the line. This can be used to determine the $[FeSCN^{2+}]$ in the table below. Attach your plot to this report.

Test mixtures

Mixture	Absorbance	$[FeSCN^{2+}]$ (M)
1		
2		
3		
4		
5		

- Show a sample calculation for $[FeSCN^{2+}]$ in mixture 1.
- Linear Equation (A vs. $[FeSCN^{2+}]$) of Calibration Curve: ____________________

Calculations and Analysis

The reaction that is assumed to occur in this experiment is:

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons FeSCN^{2+}(aq) \tag{6.R.1}$$

- Write the equilibrium constant expression for the reaction.
- Create a ***Reaction Table*** (or ICE table), as in Table 1, to demonstrate how the values below are calculated. Use the data for Mixture #1 only. Start with the known values for the initial concentrations of each species and the final value of $[FeSCN^{2+}]$ from the data table on the previous page. Show how you find the value of the stoichiometric change in reaction concentrations that occurs, and the resulting equilibrium concentrations of the reactants.
- Show a sample calculation for the value of K_c using the data for Tube #1.

Using the same method you outlined above, complete the table for all the equilibrium concentrations and value of K_c:

Tube	Equilibrium Concentrations (M)			K_c
--	Fe^{3+}	SCN^-	$FeSCN^{2+}$	--
1				
2				
3				
4				

- Average value of K_c _________________ (Use reasonable number of significant digits, based on the distribution of your K_c values.)

Optional Analysis: Is an alternative reaction stoichiometry supported?

Suppose that instead of forming $FeSCN^{2+}$, the reaction between Fe^{3+} and SCN^- resulted in the formation of $Fe(SCN)_2^+$. The reaction analogous to Equation 6.R.1 would be:

$$Fe^{3+}(aq) + 2\,SCN^-(aq) \rightleftharpoons Fe(SCN)_2^+(aq) \tag{6.R.2}$$

i.e., two moles of SCN^- displace two moles of H_2O in $Fe(H_2O)_6^{2+}$ to make $Fe(SCN)_2(H_2O)_4^+$.

- Write the equilibrium expression for this reaction.
- Create a ***Reaction Table*** for Mixture #1 only (or ICE table), as in Table 1, to clearly show how all the values below were obtained. Then show the calculation for the value of K_c for Tube 1. Pay special attention to the stoichiometry in this system. Begin by assuming that the equilibrium value for $[Fe(SCN)_2^+]$ is be equal to $\frac{1}{2}[FeSCN^{+2}]$ at equilibrium obtained previously. (This is because the moles of SCN^- assumed to be equal to the moles of complex ion product, $FeSCN^{2+}$, in our standard solutions. In the alternate reaction, moles of product, $Fe(SCN)_2^+$, equal ½ the number of moles of SCN^- added in the standard solutions.)

Using the method you outlined above, complete the table for all the equilibrium concentrations and values of K_c

Tube	Equilibrium Concentrations (M)			K_c
--	Fe^{3+}	SCN^-	$Fe(SCN)_2+$	--
1				
2				
3				
4				
5				

- Average value of K_c ________________ (Use a reasonable number of significant digits, based on the distribution of your K_c values.)
- Based on the calculated values of K_c for each reaction stoichiometry, which reaction is the valid one?
- Briefly explain your conclusion. Compare the percent difference between the average value and the individual measurements. What does this tell you about the two possible stoichiometries? Do these reactions give consistent values of K_c for different initial reaction conditions?