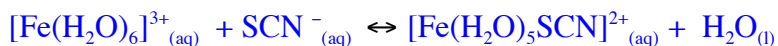
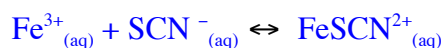


## Determination of an Equilibrium Constant

For this experiment we are going to use the following chemical reaction:



For simplicity, the above reaction can be abbreviated as:



so the reaction quotient expression becomes:

$$Q = \frac{[\text{FeSCN}^{2+}_{(\text{aq})}]}{[\text{Fe}^{3+}_{(\text{aq})}][\text{SCN}^-_{(\text{aq})}]}$$

In this experiment, the concentrations of  $\text{FeSCN}^{2+}_{(\text{aq})}$ ,  $\text{Fe}^{3+}_{(\text{aq})}$ , and  $\text{SCN}^-_{(\text{aq})}$ , in a series of aqueous solutions, will be determined, and the value of Q for each of those solutions will be able to be calculated. If the solutions are in equilibrium, then Q will be the same for each solution (Q = K).

### Part A: Preparation of a Standard Series

In this part of the experiment,  $[\text{Fe}^{2+}] \gg \gg [\text{SCN}^-]$ .

So,  $[\text{FeSCN}^{2+}] = [\text{SCN}^-]$

$[\text{SCN}^-]$ : For 1.00 mL  $\text{SCN}^-$

$$(0.00100\text{L})(0.00100 \text{ mole/L}) = (0.0250\text{L})(x \text{ mole/L})$$

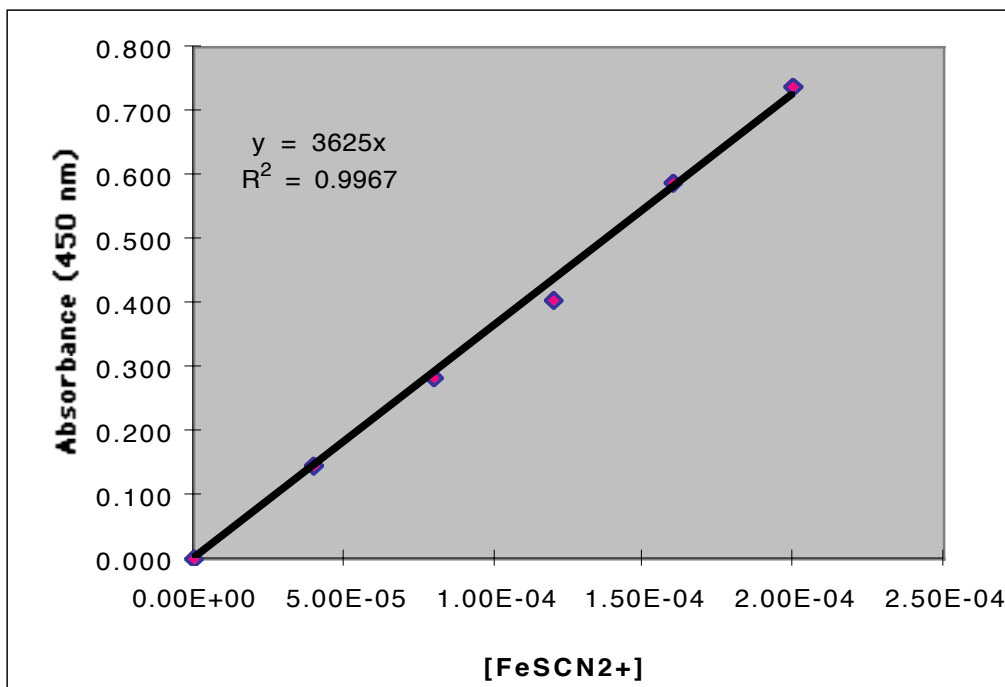
$$x = 4.00 \times 10^{-5} \text{ M}$$

Table 1: Standard Absorbance Data for  $[\text{FeSCN}^{2+}]$

<i>Calibration Curve:</i>		$[\text{SCN}^-]$	1.00E-03	mol/L
		$[\text{Fe}^{3+}]$	2.00E-03	mol/L
Solution #	mL $\text{SCN}^-$	$[\text{SCN}^-]$ (M)	$[\text{FeSCN}^{2+}]$ (M)	A(@ 450 nm)
1	0.00	0.00E	0.00	0.000
2	1.00	$4.00 \times 10^{-5}$	$4.00 \times 10^{-5}$	0.147
3	2.00	$8.00 \times 10^{-5}$	$8.00 \times 10^{-5}$	0.285
4	3.00	$1.20 \times 10^{-4}$	$1.20 \times 10^{-4}$	0.404
5	4.00	$1.60 \times 10^{-4}$	$1.60 \times 10^{-4}$	0.589
6	5.00	$2.00 \times 10^{-4}$	$2.00 \times 10^{-4}$	0.738

Plot Absorbance (@ 450 nm) vs  $[\text{FeSCN}^{2+}]$ :

Graph 1: Standard Absorbance Curve for  $[\text{FeSCN}^{2+}]$  (M) @ 450 nm



Use Beer's Law:  $A = \epsilon l c$ ,  $\epsilon l$  = slope of the line, and  $l = 1$  cm.

In this example,  $\epsilon = 3625 \text{ M}^{-1}\text{cm}^{-1}$

### Part B: *The Equilibrium Constant*

In the second series of reactions, neither  $\text{Fe}^{3+}_{(aq)}$  nor  $\text{SCN}^{-}_{(aq)}$  will be present in vast excess.

To determine the value of  $K_{eq}$ , you must prepare a series of solutions, each of which contains known initial concentrations of  $\text{Fe}^{3+}_{(aq)}$  and  $\text{SCN}^{-}_{(aq)}$  ions.

$$K_{eq} = Q = \frac{[\text{FeSCN}_{(aq)}^{2+}]}{[\text{Fe}_{(aq)}^{3+}][\text{SCN}_{(aq)}^{-}]}$$

The ratio of  $\text{Fe}^{3+}$  and  $\text{SCN}^{-}$  for each sample should have varied so that the absorbance of the samples ranged between 0.100 and 0.400.

Table 2: Equilibrium Data for [FeSCN<sup>2+</sup>]*Reaction Quotient:*

Trial #	1	2	3	4	5
mL SCN <sup>-</sup>	8.00	10.00	12.00	15.00	15.00
mL Fe <sup>3+</sup>	10.00	10.00	10.00	9.00	7.00
[Fe <sup>3+</sup> ] <sub>INITIAL</sub> (M)	8.00 x 10 <sup>-4</sup>	8.00 x 10 <sup>-4</sup>	8.00 x 10 <sup>-4</sup>	7.20 x 10 <sup>-4</sup>	5.60 x 10 <sup>-4</sup>
[SCN <sup>-</sup> ] <sub>INITIAL</sub> (M)	3.20 x 10 <sup>-4</sup>	4.00 x 10 <sup>-4</sup>	4.80 x 10 <sup>-4</sup>	6.00 x 10 <sup>-4</sup>	6.00 x 10 <sup>-4</sup>
A(@ 450 nm)	0.213	0.244	0.306	0.336	0.276
[FeSCN <sup>2+</sup> ](M)	5.88 x 10 <sup>-5</sup>	6.73 x 10 <sup>-5</sup>	8.44 x 10 <sup>-5</sup>	9.27 x 10 <sup>-5</sup>	7.61 x 10 <sup>-5</sup>
[Fe <sup>3+</sup> ] <sub>EQ</sub> (M)	7.41 x 10 <sup>-4</sup>	7.33 x 10 <sup>-4</sup>	7.16 x 10 <sup>-4</sup>	6.27 x 10 <sup>-4</sup>	4.84 x 10 <sup>-4</sup>
[SCN <sup>-</sup> ] <sub>EQ</sub> (M)	2.61 x 10 <sup>-4</sup>	3.33 x 10 <sup>-4</sup>	3.96 x 10 <sup>-4</sup>	5.07 x 10 <sup>-4</sup>	5.24 x 10 <sup>-4</sup>
Q (M <sup>-1</sup> )	303	276	298	291	300
mean Q (M <sup>-1</sup> )	291				
Std Dev	10.88525				

$$[\text{Fe}^{3+}]_{\text{INITIAL}} = (0.01000\text{L})(0.00200\text{ M}) = (0.0250\text{ L})(x\text{ M})$$

$$x = 8.00 \times 10^{-4}\text{ M}$$

$$[\text{SCN}^{-}]_{\text{INITIAL}} = (0.00800\text{ L})(0.00100\text{ M}) = (0.0250\text{ L})(x\text{ M})$$

$$x = 3.20 \times 10^{-4}\text{ M}$$

$$A_{450} = 0.213$$

$$0.213 = (3625\text{ M}^{-1}\text{cm}^{-1})(1\text{ cm})[\text{FeSCN}^{2+}]_{\text{EQ}}$$

$$[\text{FeSCN}^{2+}]_{\text{EQ}} = 5.88 \times 10^{-5}\text{ M}$$

$$[\text{Fe}^{3+}]_{\text{EQ}} = [\text{Fe}^{3+}]_{\text{INITIAL}} - [\text{FeSCN}^{2+}]_{\text{EQ}}$$

$$= 8.00 \times 10^{-4}\text{ M} - 5.88 \times 10^{-5}\text{ M}$$

$$= 7.41 \times 10^{-4}\text{ M}$$

$$[\text{SCN}^{-}]_{\text{EQ}} = [\text{SCN}^{-}]_{\text{INITIAL}} - [\text{FeSCN}^{2+}]_{\text{EQ}}$$

$$= 3.20 \times 10^{-4}\text{ M} - 5.88 \times 10^{-5}\text{ M}$$

$$= 2.61 \times 10^{-4}\text{ M}$$

$$K_{eq} = \frac{5.88 \times 10^{-5}}{(7.41 \times 10^{-4})(2.61 \times 10^{-4})} = 303\text{ M}^{-1}$$