Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Period\_\_\_\_\_\_Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Determining an Equilibrium Constant Using a Spectrophotometer**

**Introduction:** In this experiment, the following equilibrium system will be observed:

Fe+3(aq) + SCN-(aq) ↔ Fe(SCN)+2(aq)

The reactants are both colorless solutions (the ferric ion is slightly colored, but it is treated with nitric acid to remove the color) while the product has a reddish color. The intensity of the color that is produced is directly proportional to its concentration. If a light source is allowed to shine through such a solution, it is found that the amount of light absorbed (i.e. the energy that is not being transmitted through the solution) is also directly proportional to the concentration of the solution. A spectrophotometer is a device that will shine light through a sample and measure the percent of light that is transmitted and absorbed. These data can be used to determine the equilibrium concentrations in a system by applying Beer’s Law.

Beer’s Law: absorbance = ab[colored species]

a = molar absorptivity coefficient of the colored species (constant for a particular wavelength)

b = thickness of the cell used in the measurement

[colored species] = molar concentration.

Since the same cell will be used throughout the experiment as well as the same wavelength, both a and b will be constants and they will be combined into a single constant labeled Z. Therefore:

**absorbance = Z[colored species]**

**Procedure:**

1. **Preparation of Solutions**: Place 6 test tubes in a test tube rack labeled 1-6. Add the reagents listed below using pipettes (pipettes are to be cleaned and prepared in the same manner as a buret). Note that the total volume in each test tube is 20.0 mL.

|  |  |  |  |
| --- | --- | --- | --- |
| Tube | mL of 0.0020 M Fe(NO3)3 | mL of 0.0020 M KSCN | mL of 0.25 M HNO3 |
| 1 | 10.0 | 2.00 | 8.00 |
| 2 | 10.0 | 4.00 | 6.00 |
| 3 | 10.0 | 6.00 | 4.00 |
| 4 | 10.0 | 8.00 | 2.00 |
| 5 | 10.0 | 10.00 | 0.00 |

1. **Calibrating the spectrophotometer:**
   1. Set the wavelength to 470 nm.
   2. Rinse a cuvet (small disposable test tube) with distilled water. Fill the cuvet with distilled water and wipe the outside of it with a paper towel to remove any liquid and fingerprints. From this point on, handle the cuvet by the rim only.
   3. Insert the cuvet into the sample compartment and press the green calibration button.
2. **Determining the Value of Z:** The value of Z is determined by measuring the absorbance of a solution of known concentration ( absorbance = Z[colored species] ). **The solution of known concentration was prepared by adding 5.00 mL of .00200 M KSCN and 25.0 mL of .200M Fe(NO3)3 and was diluted to a volume of 100.0 mL. From these quantities it is evident that the ferric nitrate is in extreme excess which forces the equilibrium to the right. It can be assumed that the magnitude of the excess reactant causes the reaction to go to completion. From this information, calculate the concentration of the Fe(SCN)+2 in the solution.** Rinse a cuvet with water and with the solution to be tested. Fill the cuvet with the known concentration solution and insert it into the sample compartment. Record the absorbance value and calculate the value of Z.
3. **Determining the Absorbance of the Equilibrium Mixtures:** Determine the absorbance for each of the five solutions. Be sure to clean the cuvet each time with distilled water, rinse it with the solution to be tested, and thoroughly wipe the outside of the cuvet.

**Data and Calculations:**

1. Known Concentration Solution

Concentration of Fe(SCN)+2 : \_\_\_\_\_\_\_\_\_\_\_\_

show work

Absorbance:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Z: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

show work

2. Equilibrium Solutions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test Tube | Absorbance | [Fe(SCN)+2] | Initial [Fe+3] | Equilibrium [Fe+3] | Initial [SCN-] | Equilibrium [SCN-] |
| 1 |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |

* Given the measured absorbance for test tube 2, show the work for the calculations for each of the concentrations requested in the table above. Record the concentrations for all the test tubes in the table above, but only show the work for test tube 2.

[Fe(SCN)+2]

Initial [Fe+3]

Equilibrium [Fe+3]

Initial [SCN-]

Equilibrium [SCN-]

* Write the expression for Kc for this reaction.
* Calculate the value of Kc for each of the five equilibrium mixtures and calculate the average. Show the work for test tube 2 only.

t.t. 1: Kc = \_\_\_\_\_\_\_\_\_\_\_\_ t.t. 2: Kc = \_\_\_\_\_\_\_\_\_\_\_\_

t.t. 3: Kc = \_\_\_\_\_\_\_\_\_\_\_\_ t.t. 4: Kc = \_\_\_\_\_\_\_\_\_\_\_\_

t.t. 5: Kc = \_\_\_\_\_\_\_\_\_\_\_\_ Average Kc =\_\_\_\_\_\_\_\_\_\_\_

* Using 131 as the accepted value for Kc, determine the percent error.

In theory section you should include an explanation of the following concepts:

1. Equilibrium – what is it!
2. Law of mass action
3. What the value of the equilibrium constant represents
4. What was happening in the reaction that allowed us to use the spectrophotometer.
5. Why the specific wavelength was chosen