**Equilibria: Measuring an Equilibrium Constant Using Spectrophotometry**

**Chemistry 102***: General Chemistry I*

Post-Lab & Lab Report #9



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**Title: Equilibria: Measuring an Equilibrium Constant Using Spectrophotometry**

**Purpose:**

Observing the equilibrium of Fe3+ and SCN-,and measuring the equilibrium constant

**Spectrophotometry is** a method to measure how much a chemical substance absorbs light by measuring the intensity of light as a beam of light passes through sample solution in certain wavelength of the light for the known substance. “Spectrophotometry is one of the most useful methods of quantitative analysis in various fields such as chemistry, physics, biochemistry, material and chemical engineering and clinical applications.”(libre Text)

**Procedure**

Part 1: Calibration curve using standard Fe(SCN)2+ solutions.

1. Copy the following table from the canvas into your notebook and then prepare the solutions A-1 through A-7 and B1-B5. Note that the concentration (we do online lab since we get the given number from the canvas)
2. Calculate the concentration of Fe(SCN)2+ in each solution and complete the values in the column labeled ‘Calculated [Fe(SCN)2+]’ of table 1. For example, for solution A-2, the concentration of the Fe(SCN)2+ is the same as the initial concentration of SCN- (the limiting reagent). Therefore, the concentration is
3. Using Excel, plot a graph of [Fe(SCN)2+] on the x axis versus absorbance on the y axis.
4. Add a straight line fit to your data and include the equation (5 sig. fig.) of the line on your graph.

Part II Measuring the equilibrium constant, Kc

1. By using an equation we got from part I we can find the values from an equation then solve for X which is the concentration of Fe(SCN)2+ as absorbances are given in the this experiment

Part III calculating Kc

1. To find the initial values of the Kc we have to use the formula from the lab manual. The new initial concentrations (after dilution) of the Fe3+ and SCN-are calculated by taking the number of moles and dividing by the total volume of the solution. For example, the initial [SCN- ] in solution B-1 is given by [𝑆𝐶𝑁−]𝑖𝑛𝑖𝑡 = 𝑚𝑜𝑙𝑒𝑠 𝑆𝐶N-/𝑡𝑜𝑡𝑎𝑙 𝑣𝑜𝑙𝑢𝑚𝑒 = 1.82 × 10−4 𝑀 And the initial Fe3+ concentration in solution B-1 is given by [𝐹𝑒3+] = 𝑚𝑜𝑙𝑒𝑠 𝐹𝑒3+/ 𝑡𝑜𝑡𝑎𝑙 𝑣𝑜𝑙𝑢𝑚𝑒 = 9.1 × 10−4 𝑀
2. Then we had initial values of the concentration of each species, so we subtract from the Fe(SCN)2+eq so we find the different, since the initial values of concentration will decrease since we create more product in the experiment, [𝑆𝐶𝑁−]𝑖𝑛𝑖𝑡- [Fe(SCN)2+]eq then we will find the final equilibrium solution of each species.
3. Then calculate from Kc by, the equation for Kc is € [Fe(SCN)2+ ] /[Fe3+ ]⋅[SCN− ]
4. Then we find the deviation from an avg of Kc
5. Then we find average deviation.

**Data:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Solution** | **0.200 M Fe(NO3)3 (mL) Use a Volumetric Pipet or a Buret** | **0.00200 M KSCN (mL) Use a Buret** | **0.100 M HNO3 (mL) Fill up the 100 mL volumetric flask** | **Calculated [Fe(SCN)2+] (M) 3 sig. fig.** | **Measured Absorbance Should increase linearly** |
| **A-1** | **25.00** | **0.00** | **75.00** | **0.00E+00** | **0.00** |
| **A-2** | **25.00** | **1.00** | **74.00** | **2.00E-05** | **0.07** |
| **A-3** | **25.00** | **2.00** | **73.00** | **4.00E-05** | **0.20** |
| **A-4** | **25.00** | **4.00** | **71.00** | **8.00E-05** | **0.35** |
| **A-5** | **25.00** | **6.00** | **69.00** | **1.20E-04** | **0.47** |
| **A-6** | **25.00** | **8.00** | **67.00** | **1.60E-04** | **0.63** |
| **A-7** | **25.00** | **10.00** | **65.00** | **2.00E-04** | **0.93** |

|  |
| --- |
| **Slope (5 sig. fig. --> Adjust the number of sig. fig on the Format Trendline Label)** |
| **y = 4356.7x - 0.0073** |
|  |
| **y-intercept (5 sig. fig.)** |
| **-0.0073** |
|  |
| **r2 5 sig. fig.** |
| **0.98250** |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Solution** | **0.00200 M Fe(NO3)3 (mL) Use a Buret** | **0.00200 M KSCN (mL) Use a Buret** | **0.100 M HNO3 (mL) Use a Buret** | **Measured Absorbance Should increase linearly** | **Callculated [Fe(SCN)2+]eq (M) 3 sig. fig. & See pg. 8 of the lab handout** |
| **B-1** | **5.00** | **1.00** | **5.00** | **0.2** | **4.76E-05** |
| **B-2** | **5.00** | **2.00** | **4.00** | **0.31** | **7.28E-05** |
| **B-3** | **5.00** | **3.00** | **3.00** | **0.41** | **9.58E-05** |
| **B-4** | **5.00** | **4.00** | **2.00** | **0.54** | **1.26E-04** |
| **B-5** | **5.00** | **5.00** | **1.00** | **0.64** | **1.49E-04** |
|  |  |  |  |  |  |
| **Table 3. Calculated Concentrations needed to find Kc** | | | | | |
| **Solution** | **Initial [Fe3+] (M) 3 sig. fig.** | **Initial [SCN-] (M) 3 sig. fig.** | **[Fe(SCN)2+]eq (M)** | **[Fe3+]eq (M) 3 sig. fig. + 3 extra digits** | **[SCN-]eq (M) 3 sig. fig. + 3 extra digits** |
| **B-1** | **9.09E-04** | **1.82E-04** | **4.76E-05** | **8.61E-04** | **1.34E-04** |
| **B-2** | **9.09E-04** | **3.64E-04** | **7.28E-05** | **8.36E-04** | **2.91E-04** |
| **B-3** | **9.09E-04** | **5.45E-04** | **9.58E-05** | **8.13E-04** | **4.49E-04** |
| **B-4** | **9.09E-04** | **7.27E-04** | **1.26E-04** | **7.83E-04** | **6.01E-04** |
| **B-5** | **9.09E-04** | **9.09E-04** | **1.49E-04** | **7.60E-04** | **7.60E-04** |
|  |  |  |  |  |  |
| **Table 4. Summary of Equilibrium constants for solutions B1 to B5** | | | | | |
| **Solution** | **Kc 3 sig. fig. + 3 extra digits** | **pt** | **Solution** | **Deviation = |Kc - Avg. Kc| 3 sig. fig. + 3 extra digits** | **pt** |
| **B-1** | **4.13E+02** | **0.1** | **B-1** | **1.13E+02** | **0.2** |
| **B-2** | **2.99E+02** | **0.1** | **B-2** | **7.51E-01** | **0.2** |
| **B-3** | **2.62E+02** | **0.1** | **B-3** | **3.80E+01** | **0.2** |
| **B-4** | **2.68E+02** | **0.1** | **B-4** | **3.20E+01** | **0.2** |
| **B-5** | **2.58E+02** | **0.1** | **B-5** | **4.20E+01** | **0.2** |
| **Avg. Kc** | **3.00E+02** | **0.50** | **Avg. deviation of Kc** | **4.52E+01** | **1.00** |

Calculations

Part I:

1. we given the absorbance and we have to find the graph.
2. First of all we have to the limiting reagent, which SCN- by moles we got is the smallest in the solution.
3. We can find the total volumes of all species which is 75ml +24ml+1ml = 100m then we find the mole from SCN- By using the .002 M SCN- \* 1ml /total volume then we get the first portion equal to 2.00E-05
4. Then we can find all the rest.

Then we plot the graph Absorbance (y) vs. Molarity

1. We an equation by using linear fit which is equal to (y = 4356.7x - 0.0073)

Part B:

1. We use the formula then we substitute the absorbance then solve for x Example: .2 =4356.7x - 0.0073 then we solve we got the x =4.76E-05
2. Then solve all the rest.

Part 3

1. Then we calculating for initial concentration of each species, by using M\* V/total volume: .002M\*5ml/11ml = 9.09E-04
2. Then we solve like this for each species such SCN- and Fe3+
3. For SCN- 1ml\*0.002 M/ 11 ml =1.82E-04
4. We got the concentration for X which is [FeSCN2+] then we can using subtraction since the molarity of initial will decrease since we are making more product
5. Then we find [Fe3+] -[FeSCN2+] as same as [SCN-]-[FeSCN2+], then got the value of new equilibrium constant: which are

|  |  |
| --- | --- |
| 8.61E-04 | 1.34E-04 |

Then we find all the rest

1. To calculating Kc we use EQ expression : [Fe(SCN)2+ ] /[Fe3+ ]⋅[SCN− ]

Then we find first 4.76E-05/(8.61E-04\*1.34E-04) = 413 M

1. So we find all the rest then sum it up we got AVG M Kc = 300 M
2. To find deviation |Avg -cal| =

|  |
| --- |
| **Deviation = |Kc - Avg. Kc| 3 sig. fig. + 3 extra digits** |
| **1.13E+02** |
| **7.51E-01** |
| **3.80E+01** |
| **3.20E+01** |
| **4.20E+01** |

Then we are averaging them (113+75.1+38+32+42)/5 = 45.2

1. Avg Deviation = 4.52E+01

**Post-lab Questions.**

Why do we not have to include water in the equilibrium expression for this experiment? Why can we leave pure liquids (like the solvent water in this reaction) and pure solids out of equilibrium expressions?

**Pure liquid like water and solid are left of the equilibrium expression because It does not affect the amount of the reactant to have in chemical reaction and we determine the quantities as 1 and it does affect the concentration of the equilibrium solution.**

What do your values for Kc tell you about where this particular equilibrium lays (does it favor products or reactants)?

**Since Kc can tell us about what we are making it, if Kc is greater than 1 , it is the product favor. In contrast if it is less than 1, It is reactants favored .Since we have more product, the majority of the substance are product by equilibrium expression [Products]/[Reactants ] In my case the Kc is greater than 1 (300 M)so this means it was making more product and it is shift to the right**

Should the values of Kc for solutions B-1 through B-5 be the same or different? Explain. How close are your values?

**From B-1 to B-5 we have to look at the limiting regent which can determine the solution we want since all reactant can not all react thoroughly in chemical reactions, so the product that form is by smaller number of mole that we have by using calibrating curve to determine the solution.**

Can we calculate values for Kc for solutions A-1 through A-7? Why or why not?

**Since everything is given as same as part B, I can calculate the amount of initial solution and Kc  from part A, and SCN is also the limiting reactant in this chemical reaction, so we find equilibrium constant in the reaction then subtract from the initial value of concentration, then we can calculate for Kc of all in part A.**

If this reaction was exothermic as written, would you expect the value for Kc to increase or decrease at a higher temperature according to Le Chatelier’s principle? Briefly explain

**By in increasing the temperature in exothermic, the reaction will make more reactant and shift to the left . So the Kc would b smaller than the Kc at the certain temperature since it makes more reactant.**

Does the value of Kc tell us anything about how fast equilibrium is attained? Briefly explain.

**By using unit of Molarity (Mol/Liter)does not have unit of time to determine the rate of change of chemical equilibrium but it tells us about how what is dominant and minor in the solution that is concentrate and chemical equilibrium has no unit such S-1**