Determination of an Equilibrium Constant K_{eq}

Abstract

The general purpose of this lab was to determine the equilibrium constant for a reaction containing a complex ion (HSCN) to produce $FeSCN^{2+}$ and to determine the equilibrium concentration for this complex by use of Beer's law. This was done in an acidic solution and absorbencies were measured by a Spec 20 and graphed vs. initial [HSCN]. This gave molar absorbtivity, the slope, (4440 mol L^{-1} cm^{-1}) and then concentrations were calculated by Beer's law and seen in table 4. The average K_{eq} was found by Ice table and the average was found to be 63.2.

Introduction

The two main purposes of this lab are to use beer's law to measure the equilibrium concentration of a complex ion, and to calculate the equilibrium constant (K_{eq}) for the formation of a complex ion[1].

Beer's law is given by

$$|¿|\varepsilon l[X] \quad (1)$$

Abs standing for absorbance, [X] is the concentration, l standing for path length, and ε standing for the molar extinction constant. Beer's law can be used to measure transmittance which was then converted to absorbance which is directly related to concentration. Concentration can then be used in an ICE table (Initial, Change, and Equilibrium Concentrations). Thus the final concentrations can easily be found if the initial concentrations are known, and then the equilibrium concentration is easily found. In this lab, the following reaction given is the basic reaction

$$Fe^{3+} + HSCN_{(aq)} \Leftrightarrow H^{+}_{(aq)} + FeSCN^{2+}_{(aq)} \quad (2)$$

Or the general reaction

$$aA + bB \Leftrightarrow + cC + dD \quad (3)$$

This is given by the equilibrium expression and in this case the formation constant in the equation as follows

$$H$$
¿
$$+¿$$
$$2+¿$$
$$FeSCN^{¿}$$
¿
$$Fe$$
¿ (4)
$$3+¿$$
¿
¿
¿
¿
$$K_{eq}=¿$$

or the general reaction

$$[C]$$
$$D$$
$$[¿¿c]¿^{d}$$
$$[A]$$
¿ (5)
$$B¿^{b}$$
¿
¿
$$K_{eq}=¿\frac{¿}{¿}$$

This will be used to determine the equilibrium constant by ICE table method which is measured in this lab. Also certain dilutions will happen in this lab. This means adding a different solution to a solution which decreases both solutions concentration. The following equation can be used to determine the concentration.

$$(C_1)(V_1) = (C_2)(V_2) \qquad (6)$$

Where C is concentration and V is volume, 1 is the initial state and 2 is the final state.

Colored solutions have absorbance and thus transmittance. Spectroscopy is a concept in this lab that is used in two very important tests for the determination of certain aspects of this lab. A spectrophotometer is used in this lab to measure the absorbance in order to find a certain max wavelength where a solution absorbs light. The max absorbance wavelength corresponds with a certain compound. The “diode-array” type of instrument, measures the different absorbencies simultaneously. Once this occurs Beer’s law to find the concentration of certain compounds. Epsilon is the constant of proportionality, l is the path length, and A is absorbance. Different compounds absorb different wavelengths of light in the visible spectrum, which correspond to the color they appear. This is the color that is not absorbed. The spectrophotometer measures at a certain wavelength the transmittance then calculates the absorbance from this by the equation of the negative log of percent transmittance over one hundred is equal to absorbance. Absorbance can then be used to calculate the concentrations by knowing the molar extinction constant and the path length the light takes. These concentrations then can be used to plot a working curve, which is a graph of concentration vs. absorbance graph of an unknown sample. It also can be used to calculate the linearity of an instrument.

Le Chatelier's principle is also used in this lab, which states that if either reactants or products are added to a solution, the reaction will run forward or backward until it is in equilibrium again. This is a general principle that is used and known when running these reactions., and is used to find the K_{eq}. Which goes along with equilibrium. The double arrows mean that the reaction is very able to go between both sides of the reaction, in a dynamic equilibrium. It will go forward and reverse for a time, until the forward and reverse are in an equilibrium, like a pendulum.

Spectroscopy is still used in many areas of science. In a recent study of solid dispersions, spectroscopy was used to monitor Curcumin chemical stability. This aided in the determination of the inter and intra molecular strength of curcumin dispersions[2]. In another experiment performed, spectroscopy was used to detect nuclear materials. Nuclear materials have been used an can be used for very dangerous weapons, and certain kinds of spectroscopy can be used to classify, detect and protect from this, as it was in this experiment. In the future it will hopefully deter nuclear terrorism.[3] Finally in another experiment, Stretching of carbon nanotubes were calculated using spectroscopy. This was done in a one-dimensional framework[4].

Materials and Methods

This lab had to be very exact in measurements; therefore there were not many deviations from the lab manual[1]. The Spec 20 was turned on more than a half hour before its use. Solutions were made as stated in the lab manual to exact measurements. This was done by use of a Mohr pipet. Some solutions were spilled in the process. When creating solution 3 of the standard, it was spilled and had to be restarted. A portion of HSCN was contaminated with $Fe(NO_3)_3$ and had to be disposed of. Other than those deviations, everything was measured with exact precision, as far as could be measured. Some cuvettes may not have been exactly three quarters full, but they were close and this should not have