THE UNIVERSITY OF TENNESSEE KNOXVILLE

Equilibrium and Le Chatelier's Principle

Objectives

- To determine extinction coefficient for $[FeSCN]^{2+}$ and $[CoSCN]^{2+}$
- To calculate equilibrium concentrations
- To calculate the equilibrium constant, K_c
- Explore LeChatelier's Principle

Chemical Equilibrium

- The state where the concentrations of all reactants and products remain constant with time.
- At equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction.

$$a\mathbf{A}(aq) + b\mathbf{B}(aq) \rightleftharpoons c\mathbf{C}(aq) + d\mathbf{D}(aq)$$

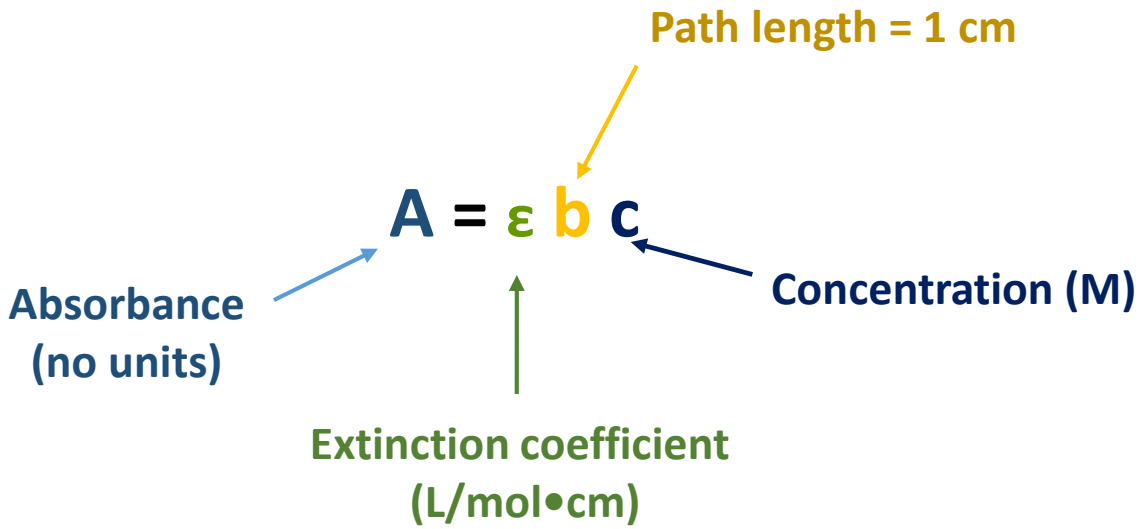
Equilibrium constant K_c

$$K_C = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Equilibrium does NOT depend on the amount of pure solids or pure liquids.

Absorbance and Beer's Law

- **Absorbance**
  - Amount of light absorbed by a particular species
- **Beer's Law**
  - Relates **absorbance to concentration**



The plot of absorbance vs. concentration is linear and the slope is equal to ε b.

Part A: Determining Extinction Coefficient and Equilibrium Concentrations

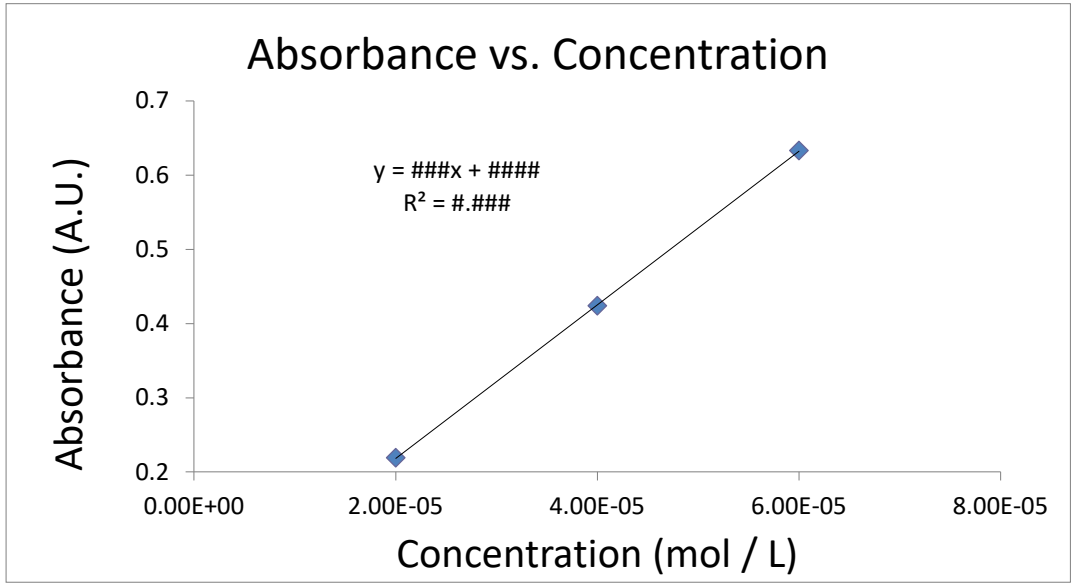
- 1st reaction: complex ion formation

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons [FeSCN]^{2+}(aq)$$

- 2nd reaction: Complex ion formation

$$Co^{2+}(aq) + SCN^{-}(aq) \rightleftharpoons [CoSCN]^{2+}(aq)$$

Part A: Determining ε and Equilibrium Concentrations (cont'd)



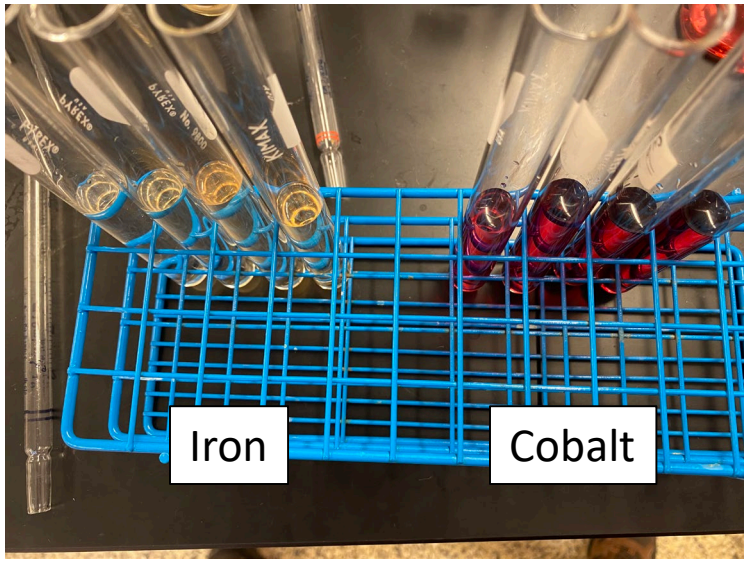
- Use the dilution equation to calculate $[FeSCN]^{2+}$ and $[CoSCN]^{2+}$.
  - (See tables in the procedure)

$Conc._{(start)} \times Volume_{(start)} = Conc._{((final)} \times Volume_{(final)}$

- Plot
  - Absorbance vs. $[FeSCN]^{2+}$
  - Absorbance vs. $[CoSCN]^{2+}$
- Find the Extinction coefficient **ε** for each reaction

LabQuest 3 Colorimeter

- Use 470 nm (**Blue**) LED for both the Iron and the Cobalt Reaction



- **Samples go in *cuvettes***
  - These cost money and can be damaged so handle carefully
  - Each group should only need one *Cuvette* that you will pick up at the back lab bench
  - Use **ONE** *KimWipe* tissue to dry *cuvettes* and/or remove fingerprints
  - Make sure the arrow ◀ is pointing through the clear side of the cuvette and not the side with the ridges.
  - Use the glass pipettes to prepare your samples.

Part B: Determining K_c

- Clean your pipet with DI water.
- Record absorbance for all 7 solutions:
  - 3 at room temperature and 4 at ice bath temperature
- Use **ε** from the previous graph to calculate $[FeSCN^{2+}]_{eq}$
- Use the Table & $M_1V_1=M_2V_2$ equation to find $[Fe^{3+}]_{initial}$ and $[SCN^-]_{initial}$
- Use ICE table to find $[Fe^{3+}]_{eq}$ and $[SCN^-]_{eq}$
- Plug values into the equilibrium expression to find K_c

$$K_C = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

ICE Table

Initial – **C**hange – **E**quilibrium

WRITE THIS DOWN NOW !

	Fe^{3+}	SCN^-	$[FeSCN]^{2+}$
Initial conc. (mol L)	Determined using $C_1V_1 = C_2V_2$		0.00
Change (mol/L)	Related to the stoichiometry of the balanced equation		Difference between **E**quilibrium and **I**nitial values
Equilibrium (mol/L)	Difference between **I**nitial and **C**hange values		Calculated using **ε** and absorbance measurements

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Part C: Le Chatelier's Principle

- A system will shift equilibrium position when disturbed to counteract the effect of the disturbance.
- Potential Disturbances
  - Change in component concentration
  - Change in temperature
  - Change in pressure
- Today's experiment will use solutions of cobalt(II) chloride. The shift in the **equilibrium** is accompanied by a change in color.
- The reaction of hydrated cobalt (II) ion and hydrochloric acid

$$Co(H_2O)_6^{2+}\,(aq) + 4\,Cl^-\,(aq) \rightleftharpoons CoCl_4^{2-}\,(aq) + 6\,H_2O\,(l)$$

Light pink

Purple/blue

Hazards and Waste

- Be very careful when using concentrated HCl. It will VAPORIZE so keep it in the fume hood so you do not inhale it.
- All waste should be placed into Aqueous Waste Container.