Experiment 20 - LeChatelier's Principle

Goal: To test LeChatelier's Principle through performance of a series of experiments.

LeChatelier's Principle - When stress is put on a system at equilibrium, the system responds to relieve the stress.

A. Use of Acid-Base Indicators

For example, we have an indicator dye called methyl orange (HMO). When dissolved in water, its color is yellow:

\[
\text{HMO}_{(aq)} \rightleftharpoons \text{H}^+_{(aq)} + \text{MO}^-_{(aq)}
\]

What happens to the color when \( \text{H}^+ \) is added?

What happens to the color when \( \text{OH}^- \) is then added?

B. Effect of Temperature on Solubility of a Solid

\[
\text{MX}_{(s)} \rightleftharpoons \text{M}^+_{(aq)} + \text{X}^-_{(aq)} + \text{heat} \quad (\text{thermic})
\]

\[
\text{MX}_{(s)} + \text{heat} \rightleftharpoons \text{M}^+_{(aq)} + \text{X}^-_{(aq)} \quad (\text{thermic})
\]

What happens when heat is added to the exothermic process?

What happens when heat is added to the endothermic process?

C. Complex Ion Equilibria

\[
\text{Co(H}_2\text{O)}_{6}^{2+} \quad + \quad 4 \text{Cl}^-_{(aq)} \rightleftharpoons \text{CoCl}_4^{2-} \quad + \quad 6 \text{H}_2\text{O} \quad (\text{blue})
\]

To initially set up the equilibrium we add concentrated HCl to a solid sample of Co(NO_3)_2. What color do you expect to see?

Next, excess H_2O is added to the mixture. What color do you expect to see?
experiment date:

**D. Simultaneous Equilibria**

\[ \text{Zn(OH)}_2(\text{s}) \rightleftharpoons \text{Zn}^{2+}(\text{aq}) + 2 \text{OH}^- (\text{aq}) \quad K = 5 \times 10^{-17} \]

The K value tells us the reaction strongly favors the reactants, and that Zn(OH)$_2$ is essentially insoluble.

There are two possible ways to dissolve this solid (shift the equilibrium to the right), using LeChatelier's Principle: decrease the [Zn$^{2+}$] or decrease the [OH$^-$],

1. How could we decrease the [OH$^-$]?

   Add acid: $\text{H}^+ + \text{OH}^- \longrightarrow \text{H}_2\text{O}$

   The effect on original equilibrium reaction is to decrease [OH$^-$], rxn shifts right to make more OH$^-$, solid Zn(OH)$_2$ dissolves.

2. How to decrease [Zn$^{2+}$]:

   Add ligand(s) that will form complex ions with Zn$^{2+}$

   \[ \text{Zn}^{2+}(\text{aq}) + 4 \text{NH}_3(\text{aq}) \rightleftharpoons \text{Zn(NH}_3)_4^{2+}(\text{aq}) \quad K = 1 \times 10^9 \]

   \[ \text{Zn}^{2+}(\text{aq}) + 4 \text{OH}^- (\text{aq}) \rightleftharpoons \text{Zn(OH)}_4^{2-}(\text{aq}) \quad K = 3 \times 10^{15} \]

   Both of the above reactions (based on value of K), favor the products. The effect on the original equilibrium is to decrease [Zn$^{2+}$], rxn shifts right to make more Zn$^{2+}$, solid Zn(OH)$_2$ dissolves.

**ASA:** all of it

**Procedure:** all of it

**Waste Disposal:** Pour all liquids and rinse all solids into the HEAVY METAL INORGANIC waste container.