experiment date:

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:

$$\underset{\text{(red)}}{HMO_{(aq)}} \rightleftharpoons H^+_{(aq)} + \underset{\text{(yellow)}}{MO^-_{(aq)}}$$

What happens to the color when H^+ is added?

What happens to the color when OH^- is then added?

B. Effect of Temperature on Solubility of a Solid

$$MX_{(s)} \rightleftharpoons M^+_{(aq)} + X^-_{(aq)} + \text{heat} \quad (\_\_\_\_\text{thermic})$$

$$MX_{(s)} + \text{heat} \rightleftharpoons M^+_{(aq)} + X^-_{(aq)} \quad (\_\_\_\_\text{thermic})$$

What happens when heat is added to the exothermic process?

What happens when heat is added to the endothermic process?

C. Complex Ion Equilibria

$$\underset{\text{(pink)}}{Co(H_2O)_6^{2+}{}_{(aq)}} + 4\,Cl^-_{(aq)} \rightleftharpoons \underset{\text{(blue)}}{CoCl_4^{2-}{}_{(aq)}} + 6\,H_2O_{(l)}$$

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?

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D. Simultaneous Equilibria

$$Zn(OH)_{2\,(s)} \rightleftharpoons Zn^{2+}{}_{(aq)} + 2\,OH^-{}_{(aq)} \quad K = 5 \times 10^{-17}$$

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: $H^+ + OH^- \longrightarrow H_2O$

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+}

$$Zn^{2+}{}_{(aq)} + 4\,NH_{3\,(aq)} \rightleftharpoons Zn(NH_3)_4{}^{2+}{}_{(aq)} \qquad K = 1 \times 10^{9}$$

$$Zn^{2+}{}_{(aq)} + 4\,OH^-{}_{(aq)} \rightleftharpoons Zn(OH)_4{}^{2-}{}_{(aq)} \qquad K = 3 \times 10^{15}$$

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.