SI Chemistry – Spring 2008

Disturbing an Equilibrium System

Introduction:

We have seen that reactions can be reversible. The perturbation by the addition of water to the first of two graduated cylinders (either A or B) shifted the new equilibrium state to one in which the second cylinder received the larger portion of the perturbation. In this experiment you will perform perturbations to the equilibrium state of different reactions. You will observe the effect of the perturbation in each case through a change in the color of an aqueous solution of reactants and products.

Procedure:

You will “disturb” the equilibrium in five different reaction systems. Each system is found at a single station in the laboratory. Directions for setting up the equilibrium system at each station are provided below. The perturbations to be induced at each station are also outlined below. You should remember that Le Chatelier's principle provides guidance for both the addition and removal of reactants and products.

At each station you should record the equation for the equilibrium system in the data table of your lab report, and write the color of each reactant and product below it.

For each perturbation, you should enter your observations and the direction of the shift in equilibrium indicated by that observation.

A. The iron (III) thiocynate coordination compound:

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

This reaction is **exothermic**. **The monothiocyano coordination compound produces a red-orange colored solution (**$FeSCN^{+2}$**). Both** OH^{-} **and** PO_4^{-3} **ions react with iron (III) ions.**

This equilibrium system is in the beaker at the station. Using a dropper, place 3-4 drops of the solution in 5 of the cells in the microplate and the same amount in a test tube. Consider the perturbations below:

Cause of Equilibrium Shift	Color change	Shift Toward
Addition of a few crystals KSCN		
Addition of 2 drops of $Fe(NO_3)_3$		
Addition of 2 drops of 1 M NaOH		
Addition of 2 drops of 0.1 M Na_3PO_4		
Addition of heat energy		

Place the contents of all cells in the waste container when you are finished at this station.

B. The copper (II) tetraamine coordination compound:

$$Cu^{+2}(aq) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4^{+2}(aq)$$

The Cu^{+2} ion in solution gives a light blue color while the tetraammine coordination compound is dark blue.

This equilibrium system is in the beaker at the station. Using the dropper, place 3-4 drops of the blue solution in 3 of the cells in the microplate. Consider the perturbations below:

Cause of Equilibrium Shift	Color change	Shift Toward
Addition of a few drops of 6 M HCl		
Addition of a few drops of 6 M $NH_3(aq)$		

Discard solutions in the sink when finished.

C. Dissociation of Acetic Acid:

$$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$$

Place 20 drops of 0.1 M CH_3COOH (acetic acid) in each of two test tubes. (The equilibrium state is already attained in the solution.) Add two drops of methyl orange solution to each of the tubes. **Methyl orange** is an acid-base indicator and does not significantly affect the equilibrium. It **has a red color when many hydrogen ions are present, and an orange-yellow color when there are few hydrogen ions in the solution.** This color indicator may help you judge the state of the equilibrium, since all of the substances involved in the equilibrium are colorless. There is only one perturbation provided at this station. Dispose of the solutions in the sink.

Cause of Equilibrium Shift	Color change	Shift Toward
Addition of 10 drops of 1M Na^+ $CH_3COO^-(aq)$		

D. Ammonium Hydroxide Solution:

$$NH_3(aq) + H_2O \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Place 20 drops of 0.1 M NH_4OH in each of two test tubes. (Again, the equilibrium state is already attained in the solution.) Add two drops of phenolphthalein solution to each of the tubes. **Phenolphthalein is** an acid-base indicator. It does not significantly affect the equilibrium. The indicator is **red-violet when there are many hydroxide ions in the solution and colorless when there are fewer hydroxide ions in the solution.** There is only one perturbation at this station. Discard the solutions in the sink.

Cause of Equilibrium Shift	Color change	Shift Toward
Addition of 20 drops of 1 M NH_4Cl (aq)		

E. NO_2-N_2O_4 Equilibrium

$$NO_2(g) \rightleftharpoons N_2O_4(g)$$

Dinitrogen tetroxide, N_2O_4, is colorless. Nitrogen dioxide, NO_2, is a brownish-red gas. The tetroxide has a heat of formation of 9.2 kJ/mol and the dioxide has a heat of formation of 33.2 kJ/mol. Consider the effect of temperature on the equilibrium using materials provided at this station.

Cause of Equilibrium Shift	Color change	Shift Toward
Removal of heat energy		
Addition of heat energy		