LAB # 7: Equilibrium and Le Chatelier's Principle

Le Chatelier's Principle states:

If an equilibrium system is subjected to a stress, the system will react to remove the stress. In this experiment you will create several equilibrium systems. Then, by putting different stresses on the systems, you will observe how equilibrium systems react to a stress.

A. An Acid-Base Indicator Equilibrium

Acid-base indicators are large organic molecules that can gain and lose hydrogen ions to form substances that have different colours. The reaction of the indicator bromothymol blue (BTB) can be illustrated as follows:

$HBTB_{(aq)}$	$\rightleftharpoons$	$H^+_{(aq)}$	+	$BTB^-_{(aq)}$
yellow				blue

Set up the equilibrium mixture by: filling a test tube about half-full of water. Add a few drops of bromothymol blue indicator solution and stir.

Predictions and Observations:

Equation:

$$HIn_{(aq)} \leftrightarrow H^+_{(aq)} + In^-_{(aq)}$$

Yellow blue

Stress	Predicted shift: Left? Right?	Predicted colour change	Observations
1. Add 5 drops of 0.1M HCl and stir. This will increase the amount of H^+ in solution.			
2. Add 6 drops of 0.1M NaOH and stir. Adding OH^- ions causes the H^+ ion concentration to decrease as the ions combine to form water molecules.			

$Fe^{3+}/FeSCN^{2+}$ Equilibrium

An equilibrium system can be formed in solution with the following ions. NOTE: spectator ions have been removed.

$Fe^{3+}_{(aq)}$	+	$SCN^-_{(aq)}$	$\rightleftharpoons$	$FeSCN^{2+}_{(aq)}$
Gold-coloured		colourless		red-brown

Set up the equilibrium mixture: by adding four full droppers of 0.0020 M KSCN solution (a source of SCN- ion) into a test tube. Add **one drop** of 0.20 M $Fe(NO_3)_3$ solution to the test tube and stir. (See me if the solution doesn't change colour significantly.) Note the following: the colour of the KSCN solution, the color of the $Fe(NO_3)_3$ solution, and the color of the resulting complex ion. Distribute the solution evenly into 4 test tubes. You will stress this equilibrium system in several ways. Keep test tube #1 as a control.

Equation:

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

Golden yellow colourless blood red

Stress	Predicted shift: Left? Right?	Predicted colour change	Observations
Test tube 2: Add a few crystals of KSCN (a source of SCN^-) and stir			
Test tube 3: Add 2 drops of $FeCl_3$ (a source of Fe^{3+}) and stir			
Test tube 4: Add 2-3 drops of $Na_2HPO_{4(aq)}$. Phosphate ions PO_4^{3-}, have the ability to form complex ions with Fe^{3+}, which has the same effect as removing Fe^{3+} from solution.			

Extra: Try restoring the original colour to each test tube.

C. An Equilibrium with Cobalt Complex Ions

In this section we will investigate the equilibrium between two different complex ions of cobalt. The reaction is endothermic:

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

Caution: ***To create the equilibrium mixture, cobalt (II) chloride hexahydrate was dissolved in ethanol. Ethanol is flammable. Turn off all flames. Silver Nitrate causes stains on skin and clothing. Wash off spills with soap and water immediately.***

Set-up: To 5 clean, dry mini-test tubes, add one full dropper of the equilibrium mixture. Keep test tube #1 as a control.

Equation:

$$\underset{\text{Pink}}{Co(H_2O)_6^{2+}(aq)} + 4Cl^-(aq) + \text{heat} \leftrightarrow \underset{\text{blue}}{CoCl_4^{2-}(aq)} + H_2O(l)$$

Stress	Predicted shift: Left? Right?	Predicted colour change	Observations
Test tube 2: Add 1 drop of $AgNO_3$. Note: Ag^+ will precipitate with something on the mixture – use your solubility chart to determine.			
Test tube 3: Add 5-6 drops of 6M HCl. (a source of Cl^-)			
Test tube 4: Add a few drops of water			
Test tube 5: place in a hot water bath			
Test tube 5: place in an ice water bath			

Extra: Place test tubes #2 and 4 into the hot and cold water baths. What happens?