Le Chatelier's Principle and Equilibrium

PRE-LAB DISCUSSION

Le Châtelier's Principle states that "if a system in equilibrium is subject to a change, then processes occur that tend to counteract that change, and the system reaches a new state of equilibrium." In this experiment, three equilibrium systems will be studied to determine the effect of changing concentration and temperature on the position of the equilibrium.

System 1

The first system will involve the equilibrium of a saturated solution. In this experiment, a saturated solution of sodium chloride will be prepared.
This equilibrium can be represented as follows:

$$NaCl\ (s) \leftrightarrow Na+\ (aq) + Cl^-\ (aq)$$

System 2

The second equilibrium system will involve an acid–base indicator. An acid–base indicator is a substance that changes color depending on whether it is in its acidic form (HIn) or its basic form (In–). In this experiment, the acid–base indicator that will be studied is bromothymol blue, which is yellow in its acidic form and blue in its basic form.

This equilibrium can be represented as follows:

$$HIn\ (aq) \leftrightarrow H+\ (aq) + In^-\ (aq)$$
yellow *blue*

System 3

The third equilibrium system will involve the formation of a complex ion. In this experiment, the equilibrium between two different colored complexes of cobalt will be studied.

This equilibrium can be represented as follows:

$$Co(H_2O)_6^{2+}\ (aq) + 4Cl^-\ (aq) + 50\ kJ/mol \leftrightarrow\ CoCl_4^{2-}(aq) + 6H_2O\ (l)$$
pink *blue*

PURPOSE

To apply stress to 3 different systems at Equilibrium to observe how the system reacts.

PROCEDURES:

System 1: Equilibrium in a Saturated Solution

(1) Pour some solid sodium chloride into a large test tube and fill the test tube half full with water.
(2) Stopper the test tube and shake it to form a saturated solution. If all of the sodium chloride dissolves, add some additional sodium chloride, stopper, and shake until a saturated solution with some excess solid remains.
(3) Fold filter paper and place it in a funnel. Put the funnel over a small test tube and pour some of the saturated sodium chloride solution into the funnel. Discard the filter paper.
(4) Add some **concentrated** HCl to the test tube to increase the concentration of Cl^- ion. Observe and record the changes. (Observe from the bottom of the test tube)
(5) Discard the waste in the sink.

System 2: Equilibrium for an Acid-Base Indicator

(1) Fill a small test tube halfway with water. Add several drops of bromothymol blue solution until the water is blue.
(2) To the test tube, add 5 drops of 0.10 M HCl solution, stopper the test tube and shake. This will increase the concentration of H^+ ion.
Observe and record the color.

(3) To the test tube, add 0.10 M NaOH solution, stopper the test tube and shake. Continue until a color change is observed. The OH^- ion will react with the H^+ ion to form water and decrease the concentration of the H^+ ion. Observe and record the color.
(4) Discard the waste in the sink.

System 3: Equilibrium for Complex Ions
(1) Measure approximately 6 mL of ethanol into a large test tube. Add a small amount of cobalt (II) chloride to the test tube. Stopper the test tube and shake.
(2) Put approximately 2 mL of the alcoholic cobalt solution into three small test tubes.
(3) To the first test tube add ten drops of distilled water. Observe and record the color. Set up a hot water bath at your station using your 250 mL beaker and Bunsen Burner or Hot Plate. Place the test tube in the water bath to heat it. Observe and record color after several minutes of heating. Set up a cold water bath at your station using your other 250 mL beaker. Remove the test tube from the hot water bath using tongs and place in the cold water bath. Observe and record color after several minutes of cooling.
(4) To the second test tube add a few drops of **concentrated** HCl to increase the concentration of Cl^- ion. Observe and record the color.
(5) To the third test tube, add five drops of 0.10 M silver nitrate solution. The Ag^+ ion will combine with the Cl^- ion to produce the precipitate silver chloride and decrease the concentration of Cl^- ion. Observe and record the changes.
(6) Discard the waste in the appropriate waste container.

RESULTS
Data

Equilibrium System	Stress	Observations
I. Saturated Solution	Adding concentrated hydrochloric acid	
II. Acid-Base Indicator	Adding 0.10 M HCl solution	
	Adding 0.10 M NaOH solution	
III. Complex Ion	Adding water	
	Heating the alcoholic cobalt solution	
	Cooling the alcohol cobalt solution	
	Adding concentrated hydrochloric acid	
	Adding 0.10 M silver nitrate solution	

Post-Lab Questions:
(1) Use Le Châtelier's principle to explain the observations for the adding concentrated HCl to a saturated sodium chloride solution:

Adding concentrated HCl increased the [_____]. This shifted the equilibrium to the _____ (right or left?), which caused _____ solid to appear.

(2) Use Le Châtelier's principle to explain the observations for the following stresses on the bromothymol blue equilibrium:
(a) *Adding 0.10 M HCl solution:*
Adding HCl caused the [_____] to increase. This shifted the equilibrium to the _____ (right or left?), which caused an increase [_____], resulting in the colour becoming more _____.

(b) *Adding 0.10 M NaOH solution:*
Adding NaOH caused the [_____] to decrease. This shifted the equilibrium to the _____ (right or left?), which caused an increase in [_____], resulting in the colour becoming more _____.

(3) Use Le Châtelier's principle to explain the observations for the following stresses on the cobalt complex equilibrium:
(a) *Adding water:*
Adding water caused equilibrium to shift to the _____ (right or left?), which caused an increase in the [_____], resulting in the color to becoming more _____ .

(b) *Heating the alcoholic cobalt solution:*
Heating the solution caused equilibrium to shift to the _____ (right or left?), which caused an increase in the [_____], resulting in the color becoming more _____ .

(c) *Cooling the alcohol cobalt solution:*
Cooling the solution caused equilibrium to shift to the _____ (right or left?), which caused an increase in the [_____],resulting in the color becoming more _____ .

(d) *Adding concentrated hydrochloric acid:*
Adding concentrated HCl caused the [_____] to increase. This shifted the equilibrium to the _____ (right or left?), which caused an increase [_____], resulting in the color becoming more _____.

(e) *Adding 0.10 M silver nitrate solution:*
Adding silver nitrate caused the [_____] to decrease. This shifted the equilibrium to the _____ (right or left?), which caused an increase [_____], resulting in the color becoming more _____.

(4) Use the word **right** or **left** for the following:

a. When the concentration of a reactant is increased, the equilibrium will shift _____.
b. When the concentration of a reactant is decreased, the equilibrium will shift _____.
c. When the concentration of a product is increased, the equilibrium will shift _____.
d. When the concentration of a product is decreased, the equilibrium will shift _____.
e. When the temperature of an endothermic reaction is increased, the equilibrium will shift _____.
f. When the temperature of an endothermic reaction is decreased, the equilibrium will shift _____.
g. When the temperature of an exothermic reaction is increased, the equilibrium will shift _____.
h. When the temperature of an exothermic reaction is decreased, the equilibrium will shift _____.