Name: ______________________________ Date ____________________

Lab Partner ____________________________

LE CHATELIER'S PRINCIPLE AND BUFFERS

INTRODUCTION

Read and/or review Sections 14.1, 14.7, 14.8, 14.9, and 16.6 in your textbook.

Chemical equilibrium in a reaction mixture occurs when the rate of the forward reaction is the same as the rate of the reverse reaction.

Once a reaction mixture has reached equilibrium, changes in concentration, temperature, or pressure that are made to the system can cause the system to no longer be at equilibrium. The composition of the reaction mixture will then shift until equilibrium has been reestablished. This is known as Le Chatelier’s principle.

More formally, Le Chatelier's principle states that if a reaction mixture at equilibrium is disturbed by a change, the system will shift its equilibrium composition in a way that tends to counteract the change in an attempt to reestablish equilibrium.

In the first part of the experiment, you will study how changes in concentration and temperature affect an equilibrium reaction mixture.

A buffer is a solution that undergoes a minimal change in pH when small amounts of acid or base are added to it. In the second part of the experiment, the pH of various solutions will be determined both before and after small amounts of acid and base are added to them.

PROCEDURE and DATA REPORT

Dispose of all chemicals according to your teaching assistant's instructions.

Prepare a hot water bath (250 mL beaker) for use later on in the experiment.

Part I.A

1) Place 20 drops of 0.1 M $CuSO_4$ and 20 drops of 0.1 M $NiCl_2$ into separate small test tubes.

Color of the $CuSO_4$ solution: ________________

Color of the $NiCl_2$ solution: ________________

2) Slowly add drops of concentrated NH_3 to each solution until a color change occurs. Do this step in the hood since NH_3 has a strong odor and you should avoid breathing it.

When NH_3 is added to an aqueous solution containing Cu^{2+}, the complex ion $[Cu(NH_3)_4]^{2+}$ forms.

$$Cu^{2+}(aq) + 4\ NH_3(aq) \leftrightarrow [Cu(NH_3)_4]^{2+}(aq)$$

Color of a $[Cu(NH_3)_4]^{2+}$ solution: _________________________

When NH_3 is added to an aqueous solution containing Ni^{2+}, the complex ion $[Ni(NH_3)_6]^{2+}$ forms.

$$Ni^{2+}(aq) + 6\ NH_3(aq) \leftrightarrow [Ni(NH_3)_6]^{2+}(aq)$$

Color of a $[Ni(NH_3)_6]^{2+}$ solution: _____________________________

3) Slowly add drops of 1 M HCl to each solution until the color changes again.

Observations:

Given: $NH_3(aq) + H^+(aq) \rightarrow NH_4^+(aq)$, explain your observations using Le Chatelier's principle.

Part I.B

When a saturated solution of a salt is prepared, an equilibrium is established between the cations and anions that make up the salt and the solid salt. According to the solubility rules given in your textbook, Ag_2CO_3, AgCl, AgI, and Ag_2S are all insoluble salts containing Ag^+. In this part of the experiment, the solubility equilibria of these four salts will be investigated.

****USE THE SAME TEST TUBE WITHOUT POURING OUT THE TEST TUBE CONTENTS IN ALL SIX PROCEDURES IN PART I.B!!!****

1) Ag_2CO_3 is an insoluble salt. In aqueous solution: $2\ Ag^+(aq) + CO_3^{2-}(aq) \leftrightarrow Ag_2CO_3(s)$

In a small test tube add 10 drops of 0.01 M $AgNO_3$ to 10 drops of 0.1 M Na_2CO_3.

Observations and explanation of your observations:

2) Slowly add drops of 6 M HNO_3 until the chemical change that you observe is complete.

Observations:

Given: $2\ H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$, explain your observations using Le Chatelier's principle.

3) AgCl is an insoluble salt. In aqueous solution: $Ag^+(aq) + Cl^-(aq) \leftrightarrow AgCl(s)$

Slowly add drops of 0.1 M HCl until you see evidence of a chemical change.

Observations and explanation of your observations.

4) Slowly add drops of concentrated NH_3 to your assigned solution until the chemical change that you observe is complete. Do this step in the hood since NH_3 has a strong odor and you should avoid breathing it.

Observations:

Given: $Ag^+(aq) + 2\ NH_3(aq) \rightarrow [Ag(NH_3)_2]^+(aq)$, explain your observations using Le Chatelier's principle.

5) AgI is an insoluble salt. In aqueous solution: $Ag^+(aq) + I^-(aq) \leftrightarrow AgI(s)$

Add drops of 0.1 M KI until you see evidence of a chemical change.

Observations and explanation of your observations.

6) Ag_2S is an insoluble salt. In aqueous solution: $2\ Ag^+(aq) + S^{2-}(aq) \leftrightarrow Ag_2S(s)$

Add drops of 0.1 M Na_2S until evidence of a chemical change has occurred.

Observations and explanation of your observations using Le Chatelier's principle.

Part I.C

1) Place a small amount (pea sized) of $CuBr_2$ in a small test tube. Add 5 drops of water.

Color of solution: ______________________

2) Add additional water, 5 drops at a time, until a total of about 2 mL of solution is in the test tube. Note the solution's **color** after each addition.

Observations:

3) Put the test tube in the hot water bath for several minutes.

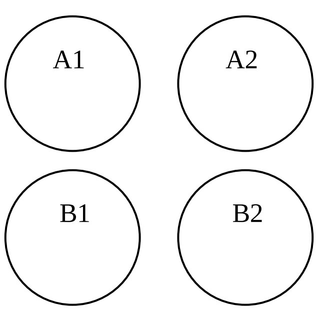
Observations:

4) Is the reaction, $[CuBr_4]^{2-}(aq) + 4\ H_2O(l) \leftrightarrow 4\ Br^-(aq) + [Cu(H_2O)_4]^{2+}(aq)$, endothermic or exothermic as written? Explain your answer using Le Chatelier's principle.

Part II.

The pH of the solutions in this part of the lab is determined by comparing the color of the solution with a universal indicator color chart.

Well plate:



1) Place 20 drops of deionized water in wells A1 and A2 of the well plate. Add 3 drops of universal indicator.

Well A1: color: __________________ pH: __________________

Well A2: color: __________________ pH: __________________

2) Place 10 drops of 0.1 M $HC_2H_3O_2$ in wells B1 and B2 of the well plate. Add 3 drops of universal indicator.

Well B1: color: __________________ pH: __________________

Well B2: color: __________________ pH: __________________

3) Add 10 drops of 0.1 M $NaC_2H_3O_2$ to wells B1 and B2. Use $\Delta pH = pH_{final} - pH_{initial}$

Well B1: color: __________________ pH: __________________ ΔpH: ________________

Well B2: color: __________________ pH: __________________ ΔpH: ________________

4) Add 5 drops of 0.10 M HCl to wells A1 and B1.

Well A1: color: __________________ pH: __________________ ΔpH: ________________

Well B1: color: __________________ pH: __________________ ΔpH: ________________

5) Add 5 drops of 0.10 M NaOH to wells A2 and B2.

Well A2: color: __________________ pH: __________________ ΔpH: ________________

Well B2: color: __________________ pH: __________________ ΔpH: ________________

6) Explain all of your observations and results for this part of the experiment. Pay particular attention to the magnitude of ΔpH in parts 3 through 5.