Unit 9: Chemical Kinetics & Equilibrium

Chemist: _____

Investigating Chemical Equilibrium

Part 1

Introduction:

Le Châtelier's principle allows us to predict the effects of a stress placed on an equilibrium system. The stress produces a shift in concentrations that may be recognized by changes in the macroscopic properties of the system.

The reaction presented in this investigation demonstrates observable reversibility. Under changing conditions the systems will respond to counteract any stress placed upon the equilibrium state. A change in appearance provides observable evidence that a shift has occurred in the equilibrium concentrations.

The system you will study is the conversion of the indicator Phenolphthalein (Dropper Bottle Hln) from its pink form to its clear form. The extent to which the forward reaction is favored depends upon the concentration of the hydrogen ions in solution.

$$\text{Phenolphthalein (pink form)} + H^+ \leftrightarrow \text{Phenolphthalein}^+ \text{ (clear form)}$$

Procedure:

1. Obtain 2 clean test tubes.

2. Fill each test tube with 10mL of water and 8-10 drops of Phenolphthalein indicator (Dropper bottle Hln). You will run steps 3 – 5 on test tube 1. Test tube 2 will not have anything added to it after this part - Test tube 2 should be used as a control for comparison

3. Add 0.1M NaOH (count the number of drops!) to test tube 1 until you see a permanent change in color. Gently mix the test tube using a stirring rod or stopper so that it is mixed throughout. Record the number of drops and your observations in the table for "Stress 1"

4. Add 0.1M HCl (count the number of drops!) to test tube 1 until you see a permanent change in color. Gently mix the test tube using a stirring rod or stopper so that it is mixed throughout. Record the number of drops and your observations in the table for "Stress 2"

5. Add 0.1M NaOH (count the number of drops!) to test tube 1 until you see a permanent change in color. Record the number of drops and your observations in the table for "Stress 3"

6. Rinse the used test tubes with water, the solutions can be poured down the sink.

Part 2

Introduction:

Le Châtelier's principle allows us to predict the effects of a stress placed on an equilibrium system. The stress produces a shift in concentrations that may be recognized by changes in the macroscopic properties of the system.

The reaction presented in this investigation demonstrates observable reversibility. Under changing conditions the systems will respond to counteract any stress placed upon the equilibrium state. A variation in appearance provides observable evidence that a shift has occurred in the equilibrium concentrations.

The system you will study is the conversion of copper and chlorine ions into a copper chlorine complex ion:

$$Cu^{2+}\ (aq)\ (\text{blue form}) + 2Cl^{-}\ (aq) \leftrightarrow\ CuCl_2^{2-}\ (aq)\ (\text{green form})$$

Procedure for Part A: (adjusting concentrations)

1. Obtain 3 clean test tubes.
2. Fill each test tube with 3.0 mL of 0.3 M $CuCl_2$.
3. Test tube 1 is a control used for comparison.
4. Add 0.8 g of NaCl to test tube 2. Use a stirring rod or stopper to gently mix the contents. Not all of the NaCl will dissolve. Record your observations in the table for "Stress 1"
5. Add 20 drops of NaOH to test tube 2. Do not mix the test tube until you have observed what is happening at the top of the solution. Record your observations in the table for "Stress 2"
6. Add 10 drops of $NaC_2H_3O_2$ to test tube 3. Record your observations in the table for "Stress 3"
7. Keep all of your test tubes for Part B.

Procedure for Part B: (adjusting temperature)

Goal: Investigate the effect of temperature on this reaction. You must determine if the reaction from Part A is endothermic or exothermic.

1. **GENTLY** heat test tube 2 from part A in a Bunsen burner until bubbles form. Remove the test tube from the flame and record observations for "stress 1."
2. Heat the control test tube from part A (the one with nothing placed in it) as in step 3. Record observations for "stress 2."
3. Dispose of all test tubes (from BOTH parts) in the drain with plenty of water, make sure to use the test tube brush to clean the test tubes before placing them upside down on the test tube holder to dry.

Unit 9: Chemical Kinetics & Equilibrium

Chemist: _____

Investigating Chemical Equilibrium

PART 1

Phenolphthalein (pink form) + H^+ ↔ Phenolphthalein$^+$ (clear form)

Part 1 Data Table:

Stress #	Stress added	Number of drops required	Color observation	Direction of equilibrium shift (Right? Left? None?)
1	*NaOH*			
2	*HCl*			
3	*NaOH*			

Analysis Questions:

1. Investigate stress #1. Phenolphthalein (pink form) + H^+ ↔ Phenolphthalein$^+$ (clear form)

   a. What are the **two ions** you added in stress #2?

   b. Which way did the reaction shift based on your observations?

   c. Remember there are two methods for creating stress on the system: you can **add** more reactants/products OR you can create stress by **removing** reactants/products. Explain what happened when you added NaOH to cause the observed shift. (**AKA**: why did the solution change color even though there isn't any NaOH in the reaction?)

2. Investigate stress #2. Phenolphthalein (pink form) + H^+ ↔ Phenolphthalein$^+$ (clear form)

   a. Is the stress a reactant or a product? _____ Circle the stress in the equation.

   b. Which way must the reaction shift to release the stress? What observation supports this?

3. Does the K_{eq} value of this reaction change when you add NaOH or HCl? Why or why not?

PART 2

Cu^{2+} (aq) (blue form) + $2Cl^-$ (aq) ↔ $CuCl_2^{2-}$ (aq) (green form)

Part 2-A Data Table:

Stress #	Stress added (list the ion that is adding stress to the reaction…none is an option…)	Color observation	Direction of equilibrium shift (Right? Left? None?)
1			
2			
3			

Analysis Questions Part A:

1. Write the equilibrium constant expression for the system studied in this lab.

2. Apply Le Chatelier's principle to ***explain*** the results obtained when NaCl is added to the copper (II) chloride solution.

3. Explain WHY stress #3 did not cause a shift in the reaction.

4. What would happen if the pressure on the system was increased? Why?

Cu^{2+} (aq) (blue form) + $4Cl^-$ (aq) ↔ $CuCl_4^{2-}$ (aq) (green form)

Part 2-B Data Table:

Stress #	Stress added	Color observation	Direction of equilibrium shift (Right? Left? None?)
1			
2			

Analysis Questions Part B:

1. Is the reaction endothermic or exothermic? Explain how you know based on your observations.