Name: _____
Date: _____
Hour: _____

Topic: Equilibrium Reactions
Content Standard(s):

Equilibrium Lab II

Remind yourself of LeChatelier's principle and write it here:

List the conditions which can disturb a system in dynamic equilibrium.

Procedure-

You will need a warm water bath (75°C). Use a 250 mL beaker with about 100 mL tap water. Start the water bath now.

Part A

1. Put ten drops of 0.2 M $CuSO_4$ (copper (II) sulfate) into each of two test tubes. Label the test tubes #1 and #2. Record your observations.

2. Add two drops of 0.2 M NaOH (sodium hydroxide) into both tube #1 and tube #2. Describe the change you see. What does it mean?

3. Write the equation for the double replacement reaction between NaOH and $CuSO_4$. Balance the equation and provide phase labels.

4. This solid material is not perfectly insoluble in water. It will dissolve somewhat. Write an equilibrium equation for the dissolving of this material by putting the formula for the solid on the left and the ions that form when it dissolves on the right. Since this is at equilibrium, you will use double arrows.

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5. Write the equilibrium constant expression for this equilibrium. Remember the solid will not be included in the expression.

6. We now investigate the effect of temperature on the equilibrium. Put tube #2 in the water bath. Try to maintain the temperature close to 75°C. While the tube in the water bath adjusts to the new temperature, answer these two questions:
   a) Suppose the reaction written in step 4 is exothermic, would the equilibrium shift left or right when the solution is warmed?

   b) Suppose the reaction written in step 4 is endothermic, would the equilibrium shift left or right when the solution is warmed?

7. Once the test tube has been in the water bath long enough to reach 75 °C, looking carefully at the amount of clumped solid in the bottom of the hot test tube compared to the cool tube. Record what you see. Put test tube #2 back into the 75°C bath.

8. Do you think the dissolving of the copper (II) hydroxide is endothermic or exothermic? Why?

9. Rewrite the equilibrium equation from step 4, adding the word "energy" on the appropriate side.

10. Add 6 M NH_3 one drop at a time to the cool test tube. Mix thoroughly. Continue to add drops in this manner until the solution is clear (not cloudy). Record your observations and the number of drops required. Then do the same for the warm test tube.

11. Mix test tubes #1 and #2, and then split them back into two equal portions. (This way the tubes are again identical.) By adding NH_3, we have set up a new equilibrium.

$$Cu^{2+}_{(aq)} + 4\ NH_{3(aq)} \leftrightarrow Cu(NH_3)_4{}^{2+}_{(aq)}$$

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Light blue colorless deep blue

12. Add drops of 6 M HCl to tube #1, swirling, until a noticeable change occurs throughout the tube. Record observations. (Tube #2 is a control.)

13. Which substance was affected by the HCl? The H^+ from the acid combined with the ammonia molecules to form ammonium ions: $H^+ + NH_3 \leftrightarrow NH_4^+$. This reduces the concentration of ammonia molecules in the solution. How would this account for the change that you noticed in the tube when the acid was added. (Use LeChatelier's principle.)

14. Add just a few drops of 6M NaOH while swirling to tube #1 until the deep blue color is returned. What is going on in the tube to allow this change to happen? Use words and the relevant equations to explain what has happened.

15. Continue to add 6 M NaOH while swirling and them some $CuSO_4$ until the original equilibrium is restored. See if you can write some sort of scheme to describe the equilibria involved with the copper-ammonia complex ion, the hydroxide ions, the copper (II) hydroxide solid and the ammonia molecules. Include phase labels and colors.

16. Summarize and list the principles of equilibria that you have seen in the lab today.

17. This activity took place at constant pressure. None of the substances involved would have been affected by a pressure change anyhow. What states of matter in an equilibrium reaction could be influenced by pressure changes? Under what conditions would this happen?