## Qualitative Observations of an Equilibrium System

Le Chatelier's Principle states that when a system equilibrium is disturbed by a change in an external factor, the net reaction occurs in such a way as to offset the changes, and a new equilibrium is reached. Examples of external changes include changes in temperature, pressure, or concentration. The equilibrium system that you will be using in this investigation is the following:

$$CuCl_4^{2-}(aq) \longleftrightarrow Cu^{2+}(aq) + 4Cl^-(aq) + \text{heat}$$

The net reaction shift to the left or right can be monitored by observing a color change. The tetrachlorocuprate (II) ion, $CuCl_4^{2-}(aq)$, is green; the copper (II) ion, $Cu^{2+}(aq)$, is blue, and the chloride ion, $Cl^-(aq)$, is colorless. Therefore the production of a green color is *net reaction to the left,* and the formation of a blue color is *net reaction to the right.*

**Materials:**
5-6 small tests
test tube rack
hot plate
spot plate
10mL graduate
test tube holder
masking tape
ice

**Reagents:**
1.5M $CuCl_2(aq)$
0.050M $AgNO_3(aq)$
4M $NaCl(aq)$
distilled water

### Part 1:

1. Prepare a boiling-water bath on a hot-plate. Also, prepare an ice-bath (not on the hot-plate).

2. Label two test tubes A-1 and A-2. Into each tube, place 3.0mL of 1.5M copper(II) chloride solution. The tube labeled A-1 will be used as a reference for equilibrium comparisons.

3. Place the tube labeled A-2 in the boiling-water bath. In the space provided on the data table predict on of the following: *net shift left; net shift right; or no net change*

4. After several minutes, remove the test tube A-2 from the boiling water. Record your results in the data table. Compare the results with your prediction.

5. Predict what will happen when you cool the solution and enter your prediction in the data table. Put the test tube labeled A-2 into an ice-water bath. After one minute examine the color. Record your observations.

### Part 2:

1. Obtain a spot plate. Into each of three wells, place 3.0 drops of copper (II) chloride solution. Label the wells B-1, B-2, and B-3. The well labeled B-2 will be used as a reference.

2. Predict what will happen if you increase the chloride concentration in solution. Write your prediction in the data table.

3. Add two drops of 4M sodium chloride solution to the well marked B-3. This will increase the concentration of the chloride ions in solution. Observe the color of the solution in B-3 and compare it to the color of well B-2. Compare the result to your prediction.

4. Predict what will happen if you decrease the chloride concentration in your solution. Record your prediction in the data table.

Add one drop of silver nitrate solution to well B-1. This decreases the concentration of chloride ions because it produces the white solid silver chloride. Compare the color of the solution in B-1 with the color of B-2. Compare your results to your prediction.

**Part 3:**

1. Label two test tubes C-1 and C-2. In each, put 1.0mL of 1.5M copper (II) chloride solution.

2. Design your own experiment in which you alter C-2 with respect to temperature and/or concentration. The experiment must be:
   a. legitimate
   b. testable
   c. measurable

Get approval from the instructor before proceeding.

3. Perform your experiment and enter your results in the data table. Compare your results to your predictions.

**Data Table:**

| Treatment | Prediction | Result |
|---|---|---|
| **Part 1**<br>Heat Solution<br>Cool Solution | | |
| **Part 2**<br>Increase $Cl^-$<br>Decrease $Cl^-$ | | |
| **Part 3** | | |

## Conclusion Questions:

1. Based on the color change, how does a decrease in temperature affect the concentrations of the reactants and products in this reaction?

2. Based on the color change, how does an increase in temperature affect the concentrations of the reactants and products in this reaction?

3. What affect does adding $NaCl_{(aq)}$ have on the color of the solution? Why?