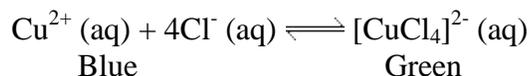
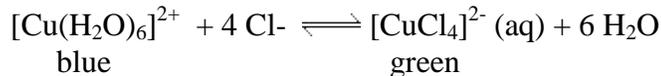


# Observation of LeChatelier's Principle

Copper (II) ions react with halide ions ( $\text{Cl}^-$ ,  $\text{Br}^-$ , and  $\text{I}^-$ ) to form complex ions. While  $\text{Cu}^{2+}$  (aq) ions are blue, the resulting product is green. The following equation can be used to represent this process.



LeChatelier's principle states that "if a stress is applied to an equilibrium system, the system will shift its equilibrium position to relieve that stress." It is possible to use LeChâtelier's principle to predict what should happen as we change the concentration of the ions in solution. Adding more  $\text{Cl}^-$  will shift the equilibrium to the right, so the solution will become more green. One interesting result of this is that the color of copper(II) chloride ( $\text{CuCl}_2$ ) solutions depends on concentration: when dilute there is a smaller amount of  $\text{Cl}^-$  so the color is blue. However, as the concentration increases, the solution becomes more of a green-blue color, rather than a true blue.



In this experiment you will design an experiment to test LeChatelier's Principle on a simple solution equilibrium.

## OBJECTIVES

In this experiment, you will

- Design an experiment to test the effect of stressing an equilibrium system
- Collect data and analyze it to justify claims
- AP Chem Learning Objectives 6.1, 6.8, 6.9; Science Practices 1.4, 2.2, 3.3, 4.2, 5.1, 5.3, 6.2, 7.2

## AVAILABLE MATERIALS:

0.5M $\text{CuCl}_2$ solution	0.1M $\text{AgNO}_3$	50 mL graduated cylinder
Solid $\text{NaCl}$	Solid $\text{Cu}(\text{NO}_3)_2$	ice
0.1M $\text{Pb}(\text{NO}_3)_2$ solution	6M $\text{HCl}$	beakers
Solid $\text{NaC}_2\text{H}_3\text{O}_2$	6 small test tubes	distilled water
Solid $\text{NaNO}_3$	10 mL graduated cylinder	hot tap water

## SAFETY PRECAUTIONS

Copper(II) chloride and copper(II) nitrate are both moderately dangerous (harmful if swallowed, causes irritation to skin, eyes and respiratory tract), so be careful not to ingest these compounds, spill them on your skin, or get them into your eyes. If either compound does come in contact with your skin, wash thoroughly with a lot of water. The other substances used in this experiment are relatively safe; however, you need to observe the normal safety precautions you would for any lab while using them. Wear a lab apron and safety goggles at all times.

## PLANNING THE EXPERIMENT

1. Obtain about 25 mL of a 0.5 M solution of  $\text{CuCl}_2$ . Record the initial color of the solution. To establish an equilibrium system for this reaction, add 6M HCl dropwise to the sample until a teal blue color is observed. Transfer ~2 ml aliquots into 6 different test tubes.

### Part 1: Investigating the Effect of Adding or Removing Reactants and Products

2. Design an experiment that will accomplish each of the following:
  - a) Shift the system left
  - b) Shift the system right
  - c) Cause no shift in the equilibrium position
    - What are your test variables? How will you know if the system has shifted to the left or the right? What will you use as a control? Be prepared to defend your predicted outcomes for each substance chosen.
3. Write out your procedure and consult with your instructor. Incorporate any necessary changes before proceeding.
4. Design an appropriate data table in your notebook.

### Part 2: The effect of temperature on equilibrium position

5. Design an experiment that will allow you to determine whether the reaction
$$\text{Cu}^{2+}(\text{aq}) + 4\text{Cl}^{-}(\text{aq}) \rightleftharpoons \text{CuCl}_4^{2-}(\text{aq})$$
is exothermic or endothermic. Consult with your instructor to be sure that your procedure is safe before beginning your investigation. Design your procedure so that you can conduct this portion of the experiment in 15 minutes or less.
6. Write out your procedure and consult with your instructor. Incorporate any necessary changes before proceeding.
7. Design an appropriate data table in your notebook.
8. Carry out the procedures for both parts 1 and 2 as planned, recording appropriate observations as you work.

## Analyze/Apply

1. Write an equilibrium constant expression for the reaction used in this lab.
2. Did the initial system (sample) favor reactants or product? How do you know?
3. What does it mean, in terms of reactant concentrations, when a system “shifts left?” Describe this in terms of reaction rates.
4. State the color of each experiment you did from part 1, and explain the results in terms of LeChâtelier's principle.
5. The materials did not include solid  $\text{CuSO}_4$  as an option. Explain what you would expect to see if you added solid  $\text{CuSO}_4$  to the initial system.
6. What will happen to the equilibrium position if spectator ions are added to the system? Why?
7. Was the reaction endothermic or exothermic? Justify your response.
8. Which stresses, if any, changed the value of the equilibrium constant? Explain your answer.
9. Attach a summary of your procedures for parts 1 and 2 and attach a copy of your data table to the lab.