Name _____ Date _____ Class _____

Observing Chemical Equilibrium

Lab 46

Text reference: ***Chapter 16***

Introduction

Some types of eyeglasses get darker when light shines on them. This is because a silver compound (AgCl) present in the lenses undergoes a chemical reaction when exposed to light. The products of the reaction (silver and chlorine atoms) are more opaque than the reactant. The reaction can be reversed by decreasing the amount of light, returning the sunglasses to a lighter tint:

$$\underset{\text{(transparent)}}{AgCl(s)} + \text{light} \rightleftharpoons \underset{\text{(dark)}}{Ag^{\circ}(s) + Cl^{\circ}(s)}$$

This reaction is an example of an equilibrium reaction since, assuming the amount of light remains constant, the rate of the forward reaction is equal to the rate of the reverse reaction. In this example, light energy is considered to be a reactant.

In this investigation, you will examine three other examples of equilibrium reactions. In each case, you will establish equilibrium in the system. Then you will disturb the equilibrium by changing either the concentration of a reactant, the acid/base level, or the temperature. The effects on the equilibrium of each system will be observed.

Pre-Lab Discussion

Read the entire laboratory investigation and the relevant pages of your textbook. Then answer the questions that follow.

1. What is meant by the statement "The reaction is in equilibrium"?

   _____

2. How can equilibrium be compared to passengers entering and leaving an elevator as it changes floors? _____

   _____

   _____

3. What is meant by the term *dynamic equilibrium*? _____

   _____

   _____

4. What are some safety hazards associated with sodium hydroxide solutions? _____

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Problem

What are some of the factors that affect the equilibrium of a chemical system?

Materials

chemical splash goggles
laboratory apron
2 beakers, 600-mL
hot plate
graduated cylinder, 10-mL
sodium chloride (NaCl)
laboratory balance
3 test tubes
3 stoppers to fit the test tubes
test-tube rack
5 micropipets, containing the following solutions:
- hydrochloric acid (HCl), 1.0 *M*
- bromthymol blue indicator
- hydrochloric acid (HCl), 0.1 *M*
- sodium hydroxide (NaOH), 0.1 *M*
- copper(II) sulfate ($CuSO_4$), 0.1 *M*

marking pen
distilled water

Safety

Wear your goggles and lab apron at all times during the investigation. Hot plates get very hot, so do not touch them with bare hands. Hydrochloric acid and sodium hydroxide solutions are irritating to skin and will damage clothing. If you spill any of these, immediately wash the area with plenty of cold water and notify your teacher. Copper(II) sulfate is poisonous. Avoid contact with it.

Note the caution alert symbols here and with certain steps of the Procedure. Refer to page *xi* for the specific precautions associated with each symbol.

Procedure

Part A

1. Put on your goggles and lab apron. Place a beaker containing about 300 mL of water on a hot plate. Set the hot plate to a moderate setting. You do not want the water to boil. **CAUTION:** *The water and hot plate will become very hot. Do not touch them with bare hands.* Go on to the next steps while you are waiting for the water to heat.

2. Put 10.0 mL of water into a test tube. Create a saturated solution of sodium chloride by adding 4.0 g NaCl to the test tube, inserting a stopper, and shaking. Remove the stopper, allow the solution to rest for 1 minute, and then, using a micropipet, add 1.0 *M* HCl a few drops at a time. **CAUTION:** *Hydrochloric acid is corrosive. Avoid spilling it on your skin or clothing.* Keep adding drops until you observe a change. Record your observations.
3. Rinse the contents of the tube down the drain with plenty of water. Set the tube upside down in the test-tube rack to drain.

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Part B

4. Label three test tubes *1–3*. Half-fill them with distilled water. Add three drops of bromthymol blue indicator solution to each tube. Insert stoppers into each tube and shake.

5. Add two drops of 0.1 *M* HCl to test tube 1. Observe and record.

6. Add two drops of 0.1 *M* NaOH to test tube 2. **CAUTION:** *Sodium hydroxide is caustic. Avoid spilling it on your skin or clothing.* Observe and record.

7. Add two drops of 0.1 *M* HCl to test tube 3. Then add two drops of 0.1 *M* NaOH to the test tube. Observe and record.

8. Rinse out the test tubes with plenty of water.

Part C

9. Place 3.0 mL 0.1 *M* copper(II) sulfate solution in each of two test tubes. Add an equal number of drops of 0.1 *M* NaOH to each test tube until a thick blue-white precipitate forms.

10. Place one of the tubes into the hot-water bath. After four minutes, observe and record any changes. Use the other tube for comparison.

11. Rinse the test tubes out with plenty of water. Turn off the hot plate. Clean up your work area and wash your hands before leaving the laboratory.

Observations

HCl added to saturated NaCl solution _____

0.1 *M* HCl added to bromthymol blue _____

0.1 *M* NaOH added to bromthymol blue _____

0.1 *M* HCl then 0.1 *M* NaOH added to bromthymol blue _____

0.1 *M* NaOH added to 0.1 *M* $CuSO_4$ in hot water _____

Critical Thinking: Analysis and Conclusions

1. Write a chemical equation showing solid sodium chloride in equilibrium with aqueous sodium and chloride ions. *(Making inferences)*

_____

2. In Part A, how did the addition of HCl change the concentration of ions in solutions? Speculate on the identity of the white precipitate.

(Making inferences) _____

_____

3. Write a rule that describes how the equilibrium of a system is shifted when the concentration of a substance in the reaction is increased. *(Drawing conclusions)* _____

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4. In Part B, does the NaOH counteract the effects of the HCl? Explain. *(Interpreting data)* _____

5. Write the chemical equation showing the reaction in Part C. Include heat as a term in the equation. Is this an exothermic or endothermic reaction? *(Making inferences)* _____

6. Write a rule that describes how the equilibrium is shifted when the temperature of an endothermic reaction, such as this, is increased. (Hint: Look at the answer to Analysis and Conclusions Question 3.) *(Drawing conclusions)* _____

Critical Thinking: Applications

1. Write a rule that describes the effect on the equilibrium of a system when the concentration of a substance in the reaction is decreased. *(Making predictions)* _____

2. Are the rates of the forward and reverse reactions still equal immediately after a disturbance is introduced to a system at equilibrium? Explain. *(Applying concepts)* _____

3. Write a general rule covering all of the types of disturbances to equilibrium observed in this investigation. *(Developing hypotheses)* _____

Going Further

1. Investigate and report on the effect of pressure on a system in which gases are involved in a chemical reaction. Give examples of equilibrium systems that would be affected by pressure.
2. Equilibrium can be shifted by decreasing the concentration of a substance. Suggest how this might be done. Devise an experiment to test your idea. Have your teacher approve your experimental design before you begin. Perform the experiment only under your teacher's supervision.