Lab: Le Chatelier’s Soda

FOR THE TEACHER

Summary
In this lab, students will observe how the equilibrium of a chemical reaction is affected when a change in pressure, temperature, and concentration is applied to the system.

Grade Level
High School

NGSS Alignment
This lab will help prepare your students to meet the performance expectations in the following standards:

- **HS-PS1-6**: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

**Scientific and Engineering Practices**:
- Analyzing and Interpreting Data
- Engaging in Argument from Evidence

**Crosscutting Concepts**:
- Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

AP Chemistry Curriculum Framework
This lab supports the following unit, topics and learning objectives:

- **Unit 7: Equilibrium**
  - **Topic 7.9**: Introduction to Le Châtelier’s Principle
  - **Topic 7.10**: Reaction Quotient and Le Châtelier’s Principle
    - TRA-8.B: Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium.

Objectives
By the end of this lab, students should be able to

- Determine how changing pressure can affect the equilibrium shift of a chemical reaction.
- Analyze how changing temperature can affect the equilibrium shift of a chemical reaction.
- Interpret how changing concentration can affect the equilibrium shift of a chemical reaction.

Chemistry Topics
This lab supports students’ understanding of

- Equilibrium
- Le Chatelier’s Principle
- Chemical Reactions
- Reversible Reactions
- Pressure
- Temperature
- Concentration

Time:
**Teacher Preparation**: 30 minutes
**Lesson**: 50 minutes
Materials
- 1 liter of club soda per class period
- Materials per lab group:
  - Small beaker (100-150ml)
  - Hot plate
  - Universal indicator
  - Dry ice (small piece – approx. size of a golf ball per group)
  - 100ml graduated cylinder

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- Wear gloves. The dry ice is extremely cold and can cause frostbite if directly touched with skin. Only maneuver the dry ice with proper handling equipment.
- Students should wear proper safety gear during chemistry demonstrations. Safety goggles and lab apron are required.

Teacher Notes
- The reaction to be observed during the lab is the reversible reaction:
  \[ \text{CO}_2(g) + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3(aq) + \text{heat} \]
- When universal indicator is added to the system, a distinct difference in color can be observed; depending on the direction equilibrium is shifted.
  \[ \text{CO}_2(g) + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3(aq) + \text{heat} \]
  (green ⇌ yellow green ⇌ yellow ⇌ orange ⇌ red)
- Helpful tips:
  - Procedure A should be done as a whole class teacher led discussion. This procedure and discussion is done when opening the 1L bottle of soda water.
  - The students will then use that opened bottle to do procedure B and procedure C.
  - Using a new bottle of soda for each class will provide the best results.
  - Laboratory burners can be used in lieu of hot plates for procedure B if needed.

FOR THE STUDENT

Lesson

Le Chatelier’s Soda Lab

Background
The reaction to be observed during the lab is the reversible reaction:

\[
\text{CO}_2(g) + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3(aq) + \text{heat}
\]

When universal indicator is added to the system, a distinct difference in color can be observed; depending on the direction equilibrium is shifted.

\[
\text{CO}_2(g) + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3(aq) + \text{heat} \\
\text{(green} \leftrightarrow \text{yellow green} \leftrightarrow \text{yellow} \leftrightarrow \text{orange} \leftrightarrow \text{red})
\]

Le Chatelier’s principle states that when stress is added to a system at equilibrium, the equilibrium will shift in such a way as to relieve that stress. You will be investigating the effects of changing pressure, temperature, and concentration on the equilibrium of the above reaction. Throughout this lab, the color of your solution will indicate the direction of the equilibrium shift.

**Problem**

How does a change in pressure, temperature, or concentration affect the equilibrium of a reversible reaction?

**Materials**

- 1 liter of club soda
- Small beaker (100-150ml)
- Hot plate
- Universal indicator
- Dry ice
- 100ml graduated cylinder

**Safety**

- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- Wear gloves. The dry ice is extremely cold and can cause frostbite if directly touched with skin. Only maneuver the dry ice with proper handling equipment.
- Students should wear proper safety gear during chemistry demonstrations. Safety goggles and lab apron are required.

**Procedure A**

1. Your teacher will demonstrate this procedure.
2. Obtain an unopened container of club soda. Observe the liquid inside.
3. Is liquid inside is under a large or small amount of pressure? Record your answer below:

4. As the container is opened, observe the amount of bubbling. Write your observation below:

5. When the container is opened, does the pressure increase or decrease?

6. Which direction does the reaction shift when the container is opened?
Procedure B
1. Pour about 50ml of the club soda into a small beaker
2. Add 30-40 drops of universal indicator to your club soda
3. What is the color of the solution right now?
4. Place the beaker on a hot plate and heat it for approximately 3 to 5 minutes. What do you observe?
5. Which direction does the reaction shift when the temperature is raised?

Procedure C
1. Remove your beaker from the hot plate.
2. Add a piece of dry ice (frozen CO₂) to the beaker. What happens immediately?
3. Allow the dry ice to bubble through the solution until no further color change is noticed. What color is the final solution?
4. As it bubbles through solution, the dry ice increases the concentration of what substance in the solution?
5. Which direction has the equilibrium shifted?

Conclusion
Write a short paragraph summarizing how a change in pressure, temperature, and concentration will affect a shift in equilibrium.