Name: ____________________________________

A Greener Le Châtelier's Principle Lab

Background

Chemical equilibrium is a state of dynamic balance where the rate of the forward reaction is the same as the rate of the reverse reaction. Examples of reactions in dynamic equilibrium are:

$$N_2\ (g) \ + \ 3H_2\ (g) \ \leftrightarrow \ 2NH_3\ (g)$$

$$2NO_2\ (g) \ \leftrightarrow \ N_2O_4\ (g)$$

If you look up "equilibrium," you will find it explained using words like "state of balance." A meter stick that is suspended at its center of gravity is said to be balanced or in equilibrium; it remains stationary, or static. Thus, this type of equilibrium is often referred to as ***static equilibrium***. In other words, the entire system is not moving. Consider now the case of a man running on a treadmill. Overall, there is no change in his position. He is running forward at the same speed that the belt is moving in the opposite direction. The two opposing motions balance each other. This is an example of a type of equilibrium called ***dynamic equilibrium***, as the word "dynamic" means "moving." Another example of a dynamic equilibrium is when you walk down an escalator at the same speed as it is moving up. There is no overall change in your position because the two opposing motions are balanced.

Problem

How can Le Châtelier's Principle be used to predict the direction in which a system at equilibrium will shift when conditions are altered? The equilibrium system that we will study in the Pre-Lab is:

$$\underset{\text{green}}{CuCl_2\ (aq)} \ \leftrightarrow \ \underset{\text{blue}}{Cu^{2+}\ (aq)} \ + \ \underset{\text{colorless}}{2Cl^-\ (aq)} \ + \ \text{heat} \qquad (\Delta H < 0)$$

1. Write out the balanced reaction between $AgNO_3$ (aq) and $CuCl_2$ (aq) and identify the precipitate formed.

2. For each change listed, predict the equilibrium shift using the reaction from Question 1 and your knowledge of Le Châtelier's Principle:

Stress	**Direction of shift** (←, →, or *no change*)	**Stress**	**Direction of shift** (←, →, or *no change*)
Raise temperature		Add $AgNO_3$ *(aq)*	
Lower temperature		Add NaCl *(aq)*	

Activity 1: Iodine and Starch

Materials

- Starch solution
- 100 mL graduated cylinder
- 100 mL beaker
- 3 test tubes
- Tincture of iodine
- Plastic pipettes
- Glass stirring rod
- Ice
- 2 (300-400 mL) beakers for cold/hot water baths
- Thermometer
- Hot plate/electric kettle
- Test tube rack

Safety

- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow teacher instructions for clean up of materials and disposal of any chemicals.
- Exercise caution when using a heat source. Hot plates should be turned off and unplugged as soon as they are no longer needed.
- Iodine is a minor eye irritant.

Procedure

1. Measure 60 mL of starch solution using the graduated cylinder and pour into a small beaker.
2. Use the plastic pipette to add 3 drops of tincture of iodine to the starch solution and stir with a glass stirring rod. Note the color of the starch-iodine complex in data table.
3. Pour 20 mL of the starch/iodine solution into each of the three test tubes.
4. Prepare an ice bath with ice cubes and water in a 300 mL beaker.
5. Prepare a hot water bath by heating a 300 mL beaker filled with water on a hot plate until it reaches 80^0C; measure the temperature with a thermometer. Alternatively, obtain pre-heated water from your teacher.
6. Place one test tube in the ice bath, one in the hot water bath, and leave one as a control.
7. Observe and record the changes that occur.

Data and Observations

Iodine (aq) + Starch (aq) ↔ Starch-Iodine Complex (aq)
clear blue/black

Stress	Resulting color
Control	
Raise temperature	
Lower temperature	

Questions

1. What effect did heating the test tube have on the concentration of starch-iodine complex? Explain how you know this by using Le Châtelier's Principle.

2. What effect did cooling the test tube have on the concentration of starch-iodine complex? Explain how you know this by using Le Châtelier's Principle.

3. Which direction is exothermic? Which direction is endothermic? Explain your answer.

Activity 2: Butterfly Pea Tea

Butterfly Pea Tea can act as a base and react with an acidic solution (H^+) to form the conjugate acid, a complex with the tea and hydrogen ion. In this lab, vinegar will be the source of the hydrogen ions. In addition you will observe how the color changes when a base, baking soda, $NaHCO_3$ is added. When $NaHCO_3$ is added, it can accept a hydrogen ion, decreasing its concentration in solution.

Materials

- Butterfly pea tea solution
- 100 mL graduated cylinder
- 3 test tubes
- 1 plastic pipette
- Vinegar
- Baking soda
- Scoopula
- Balance
- Glass stirring rod

Safety

- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow teacher instructions for clean-up of materials and disposal of any chemicals.
- Vinegar can cause skin irritation.

Procedure

1. Measure 60 mL of butterfly pea tea solution into the graduated cylinder.
2. Pour 2 mL of tea into each of the three test tubes.
3. Use a plastic pipette to add 15 drops of vinegar to one of the test tubes, stir with a stirring rod.
4. Use a scoopula to weigh out 1 g of baking soda on a balance. Add 1 g of baking soda to the second test tube, stir with a stirring rod, and label.
5. Leave the third test tube as a control.
6. Observe and record the color changes that occur.

Data and Observations:

$$\underset{\text{green/blue}}{\mathbf{Tea\ (aq)}} + \mathbf{H^+\ (aq)} \leftrightarrow \underset{\text{purple}}{\mathbf{TeaH^+\ (aq)}}$$

Stress	Resulting Color
Control	
Vinegar addition	
Baking soda addition	

Questions

1. For each reaction in Activity 2, demonstrate how each change can be explained by Le Châtelier's Principle. Be specific about where the chemical was added (the stress) and its impact on the other components of the Tea Equilibrium.

2. Traditionally, Le Châtelier's Principle might be demonstrated using cobalt ions. Explain why the activity you completed is a greener reaction. Cite at least one of the 12 green chemistry principles with your justification.