Equilibrium and LeChậtelier's Principle Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Purpose:*** To explore LeChatlier’s principle and observe how the system response to various stresses, such as  
 changes in concentration of reactants and products, or to the temperature of the system.

***Introduction***

In most reactions, the conversion of reactants to products is never 100%. This is because most reactions reach equilibrium where the opposing reactions are occurring at equal rates. For the equation

# A + B 🡪 C + D

Initially, the amount of A and B decreases while the amount of C and D increases. After a while, the rate of C + D 🡪 A + B is as fast as A + B 🡪 C + D, and the concentrations of each substance remains constant.

At equilibrium, the equation is written:

# A + B C + D

## **LeChậtelier'sPrinciple**

Chemical equilibrium exists when the rate of the forward reaction equals the rate of the reverse reaction. It is a dynamic process, as collision of molecules still cause reactants to form products and products to form reactants.

If changes cause the rate of the forward reaction to increase, the change favors the forward reaction. Equilibrium therefore shifts to favor the products. This means that when equilibrium is re-established, the new equilibrium concentration of the products is higher than the previous equilibrium concentration of products and the new equilibrium concentration of reactants is lower than the previous equilibrium concentration of reactants. Just the opposite is true if the imposed rate causes the reverse rate to increase.

Changes in concentration, temperature, and pressure (for gases) can stress the system causing a change in equilibrium. If the equilibrium is disturbed, the system will react in such a way as to overcome that stress and establish a new equilibrium. This is LeChậtelier's Principle.

## **Pre-Lab Questions:**

## Restate LeChatlier’s Principle in your own words.

## Explain what happens when equilibrium is reached.

## List the stresses that will be studied in this experiment.

## The formula for solid cobalt (II) chloride is CoCl2 ˑ 6H2O. What is the name given to compounds such as this, which have water as part of their crystal structure?

## Predict the effect on the following equilibrium (shift right or left) under each scenario (a-c). Explain your reasoning for each choice.

## 2CrO4­-2 + 2H+ CrO2-2‑ + H2O (a) Add HCl (b) Add H2O (c) Add NaOH

### Cobalt Chloride System

In the presence of water, cobalt chloride, which is blue when dissolved in alcohol, turns pink. The water displaces the chloride ions to make the pink cobalt complex:

[Co(H2O)6]+2 *(aq)* + 4Cl-1*(aq)* [CoCl4]-2 *(aq)* + 6H2O *(l)*

Pink

Blue

***Procedure:***

1. Obtain seven test tubes. Label them with #1-7, for each of the seven stresses.
2. Obtain two thermometers and two water baths, one hot (~60ᵒC) and one cold (~15ᵒC). Place each thermometer in each water bath and record the temperature in the data table.
3. Obtain a stock solution of cobalt (II) chloride (CoCl2•6H2O) and add approximately 20 drops to each test tube. Record the color of this solution in the “color before the stress” area of the data table.

**You will now stress the system by either changing the concentration of reactants or products, or adjusting the temperature of the system. Make sure to take observations of any changes you see and indicate which direction the system shifted (left or right).**

1. Put test tube #1 in the hot water bath.
2. Put test tube #2 in the cold water bath
3. Add 5 drops of AgNO3 to test tube #3
4. Add 5 drops of HCl to test tube #4
5. Add 5 drops of H2O to test tube #5
6. Add 5 drops of Acetone to test tube #6
7. Add a small amount of solid CaCl2 to test tube #7.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Stress #** | **Color Before Stress** | **Color  After Stress** | **Direction of Shift**  **(Left or Right?)** | **What caused the shift?  What happened in the reaction? (Be specific!)** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |
| **5** |  |  |  |  |
| **6** |  |  |  |  |
| **7** |  |  |  |  |

***Post-Lab Questions:***

Refer to the ionic equation below to answer the following questions:

[Co(H2O)6]+2 *(aq)* + 4Cl-1*(aq)* [CoCl4]-2 *(aq)* + 6H2O *(l)*

1. In what direction was the equilibrium shifted by:
   1. Increasing the temperature
   2. Decreasing the temperature
   3. Adding AgNO3
   4. Adding HCl
   5. Adding H2O
   6. Adding Acetone
   7. Adding CaCl2
2. How do you explain the results describes in answers 1d and 1e using LeChatlier’s Principle?
3. Explain the results observed when AgNO3 was added.
4. Is the reaction endothermic or exothermic? How do you know?
5. Predict how the addition of sodium chloride would affect the equilibrium. Explain your predictions in terms of LeChatlier’s principle.
6. Predict how the addition of sodium hydroxide would affect the equilibrium. Explain your predictions in terms of LeChatlier’s principle.
7. Re-write the equation as a thermochemical reaction, including the energy term where appropriate. The ΔHrxn is +50 kJ/mol.