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**Lab: Equilibrium and Le Chatelier’s Principle**

**Introduction:** According to your text, Le Chatelier’s Principle describes the effect that applying various types of stress will have on the position of equilibrium. As you know, stresses include things like variations in concentrations of reactants or products, temperature of the system, and (for reactions involving gases) the pressure.

Most of our investigations are done with systems in water solution. This sort of system permits us to simplify Le Chatelier’s Principle to read:

***For any system at equilibrium in solution:***

***If you add anything to the system, it will try to consume whatever was added;***

***If you remove anything from the system, it will try to replace whatever was removed.***

It is the purpose of this experiment to let you observe for yourself what Le Chatelier’s Principle means. Your investigation will deal with two complexes of cobalt (II) ions. When we have finished, you will talk about what you saw with your group and what it signifies in terms of the reaction system being investigated. You will need to take good notes during both the experiment and the post lab session, since those notes will form the basis for your answers to the questions which you will be expected to answer. Sample data can be observed at <https://youtu.be/cWr3UDo-WeU>

**The Reaction we will be observing is:**

“The Blue Ion” + “Water” 🡨 🡪 “The Pink Ion” + “chloride ion”

CoCl4-2(aq) **+** 6H2O (aq) **←→**[Co·(H2O)6]+2(aq) + Cl -1(aq)

**Blue Pink**

**Procedure:**

1. Place a small amount (20-25 drops) of the cobalt solution into five different areas of a spot plate.
2. Add 1 drop of distilled water to each spot (all five wells) and record your observation. Use four of the five spots for the following steps and keep one as a control.
3. Use a dropper and carefully add 1-2 drops of 12 M hydrochloric acid solution to the solution. Record your observations.
4. To the second sample of solution, add two small lumps of solid calcium chloride. Record your observations.
5. To the third sample, add 10 drops of acetone. Record your observations.
6. To the fourth sample, add 3-4 drops of 0.1 M silver nitrate, AgNO3, one drop at a time.
7. Take a small test tube and fill it about halfway with the solution. Place this in an ice bath and record your observations.
8. Take a small test tube and fill it about halfway with solution. Place this in a hot water bath and record your observations.

**Observations of Stresses Data Table:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Stresses** | **Before Observations** | **After Observations** |
| **b)** | **Adding H2O** |  |  |
| **c)** | **Adding HCl** |  |  |
| **d)** | **Adding CaCl2** |  |  |
| **e)** | **Adding Acetone** |  |  |
| **f)** | **Adding AgNO3** |  |  |
| **h)** | **Heating (Adding Heat)** |  |  |
| **g)** | **Cooling (Removing Heat)** |  |  |

**Conclusions:**

**The net-ionic equation for the equilibrium reaction you have been investigating is:**

“The Blue Ion” + “Water” 🡨 🡪 “The Pink Ion” + “chloride ion”

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

**Blue Pink**

1. a. Which cobalt complex (see equation) was favored by addition of water?

b. Use Le Chatelier’s Principle to explain the color change you saw.

1. a. Which cobalt complex was favored with the addition of HCl? With CaCl2?
2. What ion is common to both of the reagents you used to bring about the color changes in these two steps?
3. Use Le Chatelier’s Principle to explain why the color changes occurred in each case.

“The Blue Ion” + “Water” 🡨 🡪 “The Pink Ion” + “chloride ion”

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

**Blue Pink**

1. You added acetone to the mixture. Acetone is known to absorb water. Use this fact and Le Chatelier’s Principle to explain the color change you saw when you added acetone.
2. Silver chloride, AgCl, is a white solid. For the equilibrium

Ag+1 (aq) + Cl-1 (aq) ←→ AgCl (s)

The value of the equilibrium constant is K = 6 x 109 (or 6,000,000,000)

1. Based on the value of K for this reaction, at equilibrium, would you expect to have mostly silver and chloride ions in solution, or mostly solid silver chloride? Explain.
2. What color was the solid you formed when you added silver nitrate? What must it have been?
3. What color did the liquid in the spot plate turn when you added silver nitrate? Which complex of cobalt was favored (reactants or products)? Explain your answer.
4. Use Le Chatelier’s Principle to explain why the liquid in the spot plate underwent the color change you observed.
5. a. Which cobalt complex was favored by addition of heat? Which complex was

favored by cooling?

b. Rewrite the equation for the reaction, including the energy term directly in the

equation. The value for ΔH for the process is 50 kJ. (Hint: Use the color change

to figure out if the reaction is exothermic or endothermic. You do not know yet

whether the ΔH value is negative or positive until you figure this out.)

1. Use Le Chatelier’s Principle and the equation you just wrote to explain the color

changes that resulted from the heating and cooling.