4.9: Disrupting Equilibrium Systems: Lab Activity

Introduction

Le Châtelier's principle describes the effect that applying various types of stresses will have on the position of equilibrium—whether or not it will shift to increase or decrease the concentration(s) of products in the equilibrium system. These stresses include changes in factors such as concentrations of reactants or products, temperature of the system, and, for reactions involving gases, pressure.

Some investigations are done with systems in a water solution. In these systems, where gases are not involved, the volume of the system is generally defined by the volume of the solution, and pressure is of little or no consequence.

Purpose

The purpose of this experiment is to let you observe for yourself what Le Châtelier's principle means.

Apparatus

- fume hood
- 50 mL beaker
- well plate (12 wells)
- scoopula
- 10 mL graduated cylinder
- eyedropper pipettes
- hot plate
- ice bath

Materials

- distilled water
- solid cobalt(II) chloride ($CoCl_2 \cdot 6H_2O_{(s)}$)
- solid calcium chloride ($CaCl_{2(s)}$)
- 0.1 mol/L silver nitrate ($AgNO_3$)
- 12 mol/L hydrochloric acid (HCl)
- ethanol

Procedure

1. Gather all equipment.
2. Measure out 10 mL of ethanol and place it in the 50 mL beaker.
3. Place several pieces of the solid cobalt(II) chloride in one of the wells in your well plate. Note both its colour and the formula for the compound, as shown on the label of the stock bottle.
4. Add 4 or 5 crystals of the cobalt(II) chloride to the ethanol in the beaker until a blue solution results. Add more crystals, if necessary.
5. Using an eyedropper pipette, transfer one-fifth of the blue solution to four of the wells in the well plate. Be sure to leave a small amount in the beaker.
6. To one of the wells from step 5, add 5 drops of distilled water, one drop at a time. Record your observations after each drop. Repeat this step in two more wells so that all three of them exhibit the same colour.
7. Take your well plate to the fume hood. Use the eyedropper pipette provided in the acid bottle of 12 mol/L hydrochloric acid and carefully add one drop at a time until you have added 5 drops to the first well from step 6.

Warning:
Hydrochloric acid is caustic and corrosive. Avoid contact, and immediately rinse all spills with copious amounts of water.

8. To the second well from step 6, add 2 small lumps of solid calcium chloride.
9. To the third well from step 6, add 10 drops of 0.1 mol/L silver nitrate.

Caution:
Silver nitrate will stain your skin and clothing.

10. Retain the solution in the fourth well to use for comparison purposes.
11. To the remaining solution in the beaker, add just enough distilled water to get a purple colour that is about halfway between the blue and pink shades. Place the beaker on a hot plate and warm the beaker until a colour change occurs. Make sure you do not let the ethanol come to a boil.
12. Chill the beaker in an ice bath to see if the colour change in step 11 is reversible.

Observations

Before Reactions	
	Colour
Distilled water	
$CoCl_2 \cdot 6H_2O_{(s)}$	
$CaCl_{2(s)}$	
0.1 mol/L $AgNO_3$	
12 mol/L HCl	
Ethanol	

After Reactions	
	Colour
Add distilled water (H_2O)	
Add hydrochloric acid (HCl)	
Add calcium chloride ($CaCl_{2(s)}$)	
Add silver nitrate ($AgNO_3$)	
Add heat	
Remove heat	

Analysis

1. The net ionic equation for the equilibrium reaction you have been investigating is

$$Co(H_2O)_6^{2+} + 4Cl^- \rightleftharpoons CoCl_4^{2-} + 6H_2O$$

pink blue

On the reagent bottle, the formula for the solid cobalt(II) chloride is $CoCl_2 \cdot 6H_2O$. What name do we give to compounds that have water molecules bound to their structure?

2. Which cobalt complex was favoured by the addition of water in step 6 of the procedure? Use Le Châtelier's principle to explain the colour change.

3. Which cobalt complex was favoured in both steps 7 and 8 of the procedure? What ion is common to both of the reagents that caused the colour changes? Use Le Châtelier's principle to explain why the colour change occurred in each case.

4. What colour was the solid you formed in step 9 of the procedure? Why must it have been this colour? To what colour did the liquid in the well turn? Which complex of cobalt was favoured? Explain. Use Le Châtelier's principle to explain why the liquid in the well underwent the colour change that you observed.

5. Which cobalt complex was favoured by the addition of heat in step 11 of the procedure? Rewrite the equation for the reaction, including the energy term directly in the equation. The value of ΔH for the process is +50 kJ/mol. Use Le Châtelier's principle and the equation that you just wrote to explain the colour changes that resulted from the heating and cooling.

Discussion

Provide two sources of error. If any of your results do not match what the colour change should have been, talk about it in your discussion.

Conclusion

State what the colour change should be—not necessarily what you saw.

"Stress"	Colour Change	Shift
Addition of H_2O		
Addition of HCl		
Addition of $CaCl_2$		
Addition of $AgNO_3$		
Addition of heat		
Removal of heat		