

## 5.R: Le Chatelier's Principle (Lab Report)

Name: \_\_\_\_\_ Lab Partner: \_\_\_\_\_

Date: \_\_\_\_\_ Lab Section: \_\_\_\_\_

### Part A – Equilibrium and an Acid-Base Indicator

Equilibrium system:



#### Observations

Record your results upon completing each of the following steps:

Step 1: Color of bromothymol blue in distilled water
Step 2: Name of reagent “A” causing color change when added
Step 3: Name of reagent “B” causing a return to original color

#### Analysis

- Complete the following:

The acidic form of the bromothymol blue indicator,  $\text{HA (aq)}$ , is \_\_\_\_\_ in color.

The basic form of the bromothymol blue indicator,  $\text{A}^- (\text{aq})$ , is \_\_\_\_\_ in color.

- Explain why reagent A (in Step 2) caused the color change observed.
- Explain why reagent B (in Step 3) caused the color change observed.

### Part B – Solubility Equilibrium and $K_{sp}$

Equilibrium system:



#### Observations

Step 4: Observations upon addition of just 1.0 mL of HCl to the $\text{Pb(NO}_3)_3$ solution	
Step 5: Total volume of HCl required for noticeable precipitation	mL
Step 6: Observations upon placing the test tube with precipitate in hot water	
Step 7: Observations upon placing the test tube with precipitate in cold water	
Step 9: Volume of water added to just dissolve $\text{PbCl}_2$ precipitate	mL
Step 10: Total solution volume upon completion	mL

#### Analysis

- Why didn't any solid  $\text{PbCl}_2$  form immediately upon addition of 1 mL of  $\text{HCl (aq)}$  in Step 4? What condition must be met by  $[\text{Pb}^{2+}]$  and  $[\text{Cl}^-]$  if solid  $\text{PbCl}_2$  is to form?
- Consider your observation in hot water in Step 6:

In which direction did the equilibrium shift? \_\_\_\_\_

Did the value of  $K_{sp}$  get smaller or larger? \_\_\_\_\_

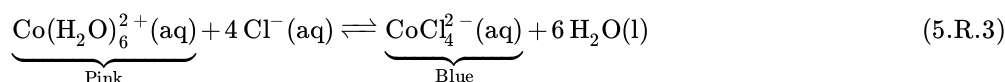
Is the dissolution of  $\text{PbCl}_2$  (s) exothermic or endothermic? \_\_\_\_\_

Explain below.

- Explain why the solid  $\text{PbCl}_2$  dissolved when water was added to it in Step 9. What was the effect of this water on  $[\text{Pb}^{2+}]$ ,  $[\text{Cl}^-]$ , and  $Q_{sp}$ ? In which direction would such a change drive the equilibrium system?
- The point at which the  $\text{PbCl}_2$  precipitate just dissolves in Step 9 can be used to determine the value of  $K_{sp}$  for this equilibrium system, where  $K_{sp} = [\text{Pb}^{2+}][\text{Cl}^-]^2$ . Calculate  $[\text{Pb}^{2+}]$  and  $[\text{Cl}^-]$  in the final solution (consider the “dilution effect”). Then use these equilibrium concentrations to determine the value of  $K_{sp}$  for this system. Show all work below.

## Part C – Complex Ion Equilibria

Equilibrium system:



### Observations

Step 2: Color of solution in 12 M HCl

Step 3: Color of solution upon addition of water

Step 4: Color of solution in hot water

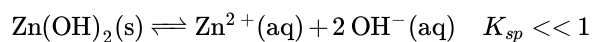
Step 5: Color of solution in cold water

### Analysis

- What form of the complex ion,  $\text{Co}(\text{H}_2\text{O})_6^{2+}(\text{aq})$  or  $\text{CoCl}_4^{2-}(\text{aq})$ , is predominate in:
  - The 12 M HCl (aq) \_\_\_\_\_
  - The diluted solution \_\_\_\_\_
  - The heated solution \_\_\_\_\_
- Explain why you obtained the observed color in 12 M HCl (aq) (Step 2).
- Explain the observed color change that occurred when water was added to the solution in Step 3. Consider how water affects the ion concentrations and  $Q$  in this system.
- Consider your observations in the hot water bath in Step 4.
  - In which direction did the equilibrium shift? \_\_\_\_\_
  - Did the value of K get smaller or larger? \_\_\_\_\_
  - Is the reaction (as written) exothermic or endothermic? \_\_\_\_\_
  - Explain.

## Part D – Dissolving Insoluble Solids

Equilibrium system:



### Observations

Step 1: Adding 1 drop of  $\text{NaOH}(\text{aq})$  to  $\text{Zn}(\text{NO}_3)_2(\text{aq})$

Step 2: Tube A: Effect when  $\text{HCl}(\text{aq})$  is added

Step 3: Tube B: Effect when  $\text{NaOH}(aq)$  is added

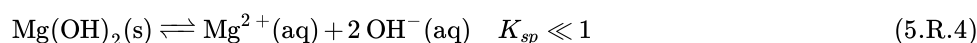
Step 4: Tube C: Effect when  $\text{NH}_3(aq)$  is added

### Analysis

- Explain your observation upon addition of  $\text{HCl}(aq)$  to the precipitate in Tube A. You must consider the various equilibria that are occurring in solution and the effect of  $\text{HCl}$  on  $[\text{OH}^-]$ .
- Explain your observations upon addition of  $\text{NaOH}(aq)$  to the precipitate in Tube B. Consider the various equilibria that are occurring in solution and remember that  $\text{Zn}^{2+}$  forms stable complex ions with  $\text{OH}^-$  at sufficiently high concentrations.
- Explain your observations upon addition of  $\text{NH}_3(aq)$  to the precipitate in Tube C. Consider the various equilibria that are occurring in solution and remember that  $\text{Zn}^{2+}$  forms stable complex ions with  $\text{NH}_3$ .

### Part E

Equilibrium system:



### Observations

Step 1 Adding 1 drop of  $\text{NaOH}(aq)$  to  $\text{Mg}(\text{NO}_3)_2(aq)$

Step 2: Tube A: Effect when  $\text{HCl}(aq)$  is added

Step 3: Tube B: Effect when  $\text{NaOH}(aq)$  is added

Step 4: Tube C: Effect when  $\text{NH}_3(aq)$  is added

### Analysis

- Based on your observations in Steps 3 and 4 do you think that  $\text{Mg}^{2+}$  forms stable complex ions? Explain your reasoning.

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