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

Name: _____ Lab Partner: _____

Date: _____ Lab Section: _____

Part A – Equilibrium and an Acid-Base Indicator

Equilibrium system:

$$\mathrm{HA(aq)} \rightleftharpoons \mathrm{H^+(aq) + A^-(aq)} \tag{5.R.1}$$

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, HA (*aq*), is _____ in color.
The basic form of the bromothymol blue indicator, $\mathrm{A^-}$ (*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:

$$\mathrm{PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2\,Cl^-(aq)} \tag{5.R.2}$$

Observations

Step 4: Observations upon addition of just 1.0 mL of HCl to the $\mathrm{Pb(NO_3)_3}$ 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 $\mathrm{PbCl_2}$ precipitate	mL
Step 10: Total solution volume upon completion	mL

Analysis

- Why didn't any solid $\mathrm{PbCl_2}$ form immediately upon addition of 1 mL of HCl (*aq*) in Step 4? What condition must be met by $[\mathrm{Pb^{2+}}]$ and $[\mathrm{Cl^-}]$ if solid $\mathrm{PbCl_2}$ 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 $PbCl_2$ (s) exothermic or endothermic? _____

Explain below.

- Explain why the solid $PbCl_2$ dissolved when water was added to it in Step 9. What was the effect of this water on $[Pb^{2+}]$, $[Cl^-]$, and Q_{sp}? In which direction would such a change drive the equilibrium system?
- The point at which the $PbCl_2$ precipitate just dissolves in Step 9 can be used to determine the value of K_{sp} for this equilibrium system, where $K_{sp} = [Pb^{2+}][Cl^-]^2$. Calculate $[Pb^{2+}]$ and $[Cl^-]$ 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:

$$\underbrace{Co(H_2O)_6^{2+}(aq)}_{\text{Pink}} + 4\,Cl^-(aq) \rightleftharpoons \underbrace{CoCl_4^{2-}(aq)}_{\text{Blue}} + 6\,H_2O(l) \qquad (5.R.3)$$

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, $Co(H_2O)_6^{2+}$ (*aq*) or $CoCl_4^{2-}$ (*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:

$$Zn(OH)_2(s) \rightleftharpoons Zn^{2+}(aq) + 2\,OH^-(aq) \quad K_{sp} << 1$$

Observations

Step 1: Adding 1 drop of NaOH(*aq*) to $Zn(NO_3)_2$ (*aq*)	
Step 2: Tube A: Effect when HCl (*aq*) is added	

Step 3: Tube B: Effect when $\mathrm{NaOH}(aq)$ is added	
Step 4: Tube C: Effect when $\mathrm{NH_3}$ (aq) is added	

Analysis

- Explain your observation upon addition of HCl (aq) to the precipitate in Tube A. You must consider the various equilibria that are occurring in solution and the effect of HCl on $[\mathrm{OH^-}]$.
- Explain your observations upon addition of NaOH (aq) to the precipitate in Tube B. Consider the various equilibria that are occurring in solution and remember that $\mathrm{Zn^{2+}}$ forms stable complex ions with $\mathrm{OH^-}$ at sufficiently high concentrations.
- Explain your observations upon addition of $\mathrm{NH_3}$ (aq) to the precipitate in Tube C. Consider the various equilibria that are occurring in solution and remember that $\mathrm{Zn^{2+}}$ forms stable complex ions with $\mathrm{NH_3}$.

Part E

Equilibrium system:

$$\mathrm{Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\,OH^-(aq)} \quad K_{sp} \ll 1 \tag{5.R.4}$$

Observations

Step 1 Adding 1 drop of $\mathrm{NaOH}(aq)$ to $\mathrm{Mg(NO_3)_2}$ (aq)	
Step 2: Tube A: Effect when HCl (aq) is added	
Step 3: Tube B: Effect when $\mathrm{NaOH}(aq)$ is added	
Step 4: Tube C: Effect when $\mathrm{NH_3}$ (aq) is added	

Analysis

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