

# **CHEMISTRY 1220**

## **SOLUBILITY**

### **STUDY SESSION**

- ☐  **$K_{sp}$  & MOLAR SOLUBILITY**
- ☐ **FACTORS INFLUENCING SOLUBILITY**
- ☐ **COMMON ION EFFECT**
- ☐ **pH & SOLUBILITY**
- ☐ **COMPLEX ION FORMATION**
- ☐ **PRECIPITATION AND SEPARATION OF IONS**
- ☐ **EXAM PREP**

# $K_{sp}$ & MOLAR SOLUBILITY

## Question #1

The solubility product expression for  $\text{La}_2(\text{CO}_3)_3$  is  $K_{sp} = ?$

## Question #2

The solubility of  $\text{BaF}_2$  is 1.3 g/L. What is the solubility product constant?

## Question #3

Which compound is the **least** soluble (mol/L) in water?

- (a)  $\text{CaCO}_3$   $K_{sp} = 2.8 \times 10^{-9}$
- (b)  $\text{PbI}_2$   $K_{sp} = 8.7 \times 10^{-9}$
- (c)  $\text{AgBr}$   $K_{sp} = 5.0 \times 10^{-13}$
- (d)  $\text{Fe}(\text{OH})_2$   $K_{sp} = 8.0 \times 10^{-16}$
- (e)  $\text{Co}(\text{OH})_2$   $K_{sp} = 1.6 \times 10^{-15}$

## Question #4

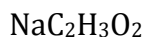
Which of the following salts has the highest concentration of silver ion when dissolved in water?

$\text{AgCl}$	$K_{sp} = 1.6 \times 10^{-10}$
$\text{Ag}_2\text{CO}_3$	$K_{sp} = 8.1 \times 10^{-12}$
$\text{AgBr}$	$K_{sp} = 5.0 \times 10^{-13}$

# FACTORS INFLUENCING SOLUBILITY

## Question #1

A solution is saturated with silver acetate,  $\text{AgC}_2\text{H}_3\text{O}_2$  ( $K_{\text{sp}} = 1.9 \times 10^{-3}$ ). Which of the following reagents will increase the solubility of silver acetate?



## Question #2

How many of the following salts would be more soluble in acidic solution than in pure water?



## Question #3

Would each of the following reagents increase, decrease, or have no effect on the solubility of  $\text{Cu}(\text{OH})_2$ ?



## Question #4

Which salt solubility would be most sensitive to pH?



## Question #5

The solubility of which of the listed salts would be unaffected by the presence of a strong acid?



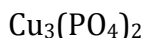
## Question #6

How many of the following reagents, when added to a solution in contact with solid  $\text{NiCO}_3$  would change the solubility of  $\text{NiCO}_3$ ?



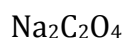
## Question #6

The solubility of how many of the following salts will be affected by strong acid?



## Question #8

Zinc oxalate is a slightly soluble salt. How many of the following reagents would be expected to decrease the solubility of  $\text{ZnC}_2\text{O}_4$ ?



# COMMON ION EFFECT

## Question #1

What is the molar solubility of  $\text{MgF}_2$  in 0.40 M  $\text{F}^-$ ?  $K_{\text{sp}} \text{MgF}_2 = 6.4 \times 10^{-9}$

## Question #2

The solubility product constant for  $\text{BiI}_3$  is  $8.1 \times 10^{-19}$ . Calculate the molar solubility of  $\text{BiI}_3$  in 0.20 M  $\text{Bi}(\text{NO}_3)_3$ .

# pH & SOLUBILITY

## Question #1

The  $K_{sp}$  for  $Zn(OH)_2$  is  $5.0 \times 10^{-17}$ . Determine the molar solubility of  $Zn(OH)_2$  in buffered solution with a pH of 11.50?

## Question #2

What is the pH of a saturated solution of  $Cu(OH)_2$  ( $K_{sp} = 2.6 \times 10^{-19}$ )?

## Question #3

What is the molar solubility (mol/L) of  $Cr(OH)_3$  at pH = 10.00?  $K_{sp}$  for  $Cr(OH)_3$  is  $6.3 \times 10^{-31}$  and  $K_f$  for  $Cr(OH)_4^-$  is  $8 \times 10^{29}$ .

Assume the soln is buffered at pH = 10.00.  
The solution to this problem assumes this.

# COMPLEX ION FORMATION

## Question #1

Calculate the concentration of free cadmium ion,  $[\text{Cd}^{2+}]$ , in a solution that contains 0.20 M  $\text{Cd}(\text{NO}_3)_2$  in 2.0 M NaCN. Cadmium ion forms the complex ion,  $\text{Cd}(\text{CN})_4^{2-}$  for which  $K_f$  is  $6.0 \times 10^{18}$ .

## Question #2

Calculate the molar solubility of  $\text{CdCO}_3$  in 1.5 M  $\text{NH}_3$ . Note that  $\text{Cd}^{2+}$  forms the  $\text{Cd}(\text{NH}_3)_4^{2+}$  complex ion for which  $K_f$  is  $1.3 \times 10^7$ .  $K_{sp}$  for  $\text{CdCO}_3$  is  $5.2 \times 10^{-12}$ .

## Question #3

Calculate the molar solubility of AgCl in 12 M  $\text{NH}_3$ .

$$K_{sp} \text{ AgCl} = 1.8 \times 10^{-10} \quad K_f \text{ Ag}(\text{NH}_3)_2 = 1.7 \times 10^7$$

## Question #4

The  $\text{Ag}^+$  ion forms the complex ion  $\text{AgCl}_2^-$  for which  $K_f = 2.5 \times 10^5$ . Determine the equilibrium constant for the solubility of AgCl in the presence of excess chloride ion.  $K_{sp}$  of AgCl is  $1.8 \times 10^{-10}$ .

## Question #5

Use the information from the previous problem to calculate the molar solubility of AgCl in 8.5 M HCl.

# PRECIPITATION AND SEPARATION OF IONS

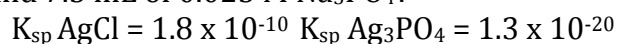
## Question #1

A solution contains  $\text{Ca}^{2+}$  at a concentration of  $2.0 \times 10^{-4}$  M. If 40.0 mL of this solution is added to 25.0 mL of  $5.0 \times 10^{-3}$  M NaF, will a precipitate form? If 40.0 mL of the  $\text{Ca}^{2+}$  solution is added to 25.0 mL of  $5.0 \times 10^{-3}$  M  $\text{Na}_3\text{PO}_4$  will a precipitate form?



## Question #2

Which salt precipitates first and what is the minimum concentration of  $\text{Ag}^+$  necessary to cause this precipitation in a solution containing 7.5 mL of 0.025 M NaCl and 7.5 mL of 0.025 M  $\text{Na}_3\text{PO}_4$ ?



## Question #3

A solution contains 0.10 M  $\text{Mg}(\text{NO}_3)_2$  and 0.10 M  $\text{Ca}(\text{NO}_3)_2$ . If solid sodium oxalate,  $\text{Na}_2\text{C}_2\text{O}_4$ , is added to the solution, what is  $[\text{Ca}^{2+}]$  (M) when  $\text{MgC}_2\text{O}_4$  begins to precipitate? (Assume no volume changes.) At 25 °C,  $K_{\text{sp}}$  of  $\text{CaC}_2\text{O}_4$  is  $2.3 \times 10^{-9}$  and  $K_{\text{sp}}$  of  $\text{MgC}_2\text{O}_4$  is  $8.6 \times 10^{-5}$ .

## Question #4

A solution contains 0.010 M  $\text{Al}^{3+}$  and 0.010 M  $\text{Ag}^+$ . Solid  $\text{Na}_3\text{PO}_4$  is slowly added to separate the two cations.  $K_{\text{sp}}$  for  $\text{AlPO}_4$  is  $1.3 \times 10^{-20}$  and  $K_{\text{sp}}$  for  $\text{Ag}_3\text{PO}_4$  is  $1.3 \times 10^{-20}$ . Which cation would precipitate first, and after it precipitates, what concentration of  $\text{PO}_4^{3-}$  ion should be obtained in the solution for the best separation?