

# *Determination of Solubility Product*

**Spoken Tutorial Project**

**<http://spoken-tutorial.org>**

**National Mission on Education through ICT**

**<http://sakshat.ac.in>**

**Snehalatha Kaliappan**

**Madhuri Ganapathi**

**IIT Bombay**

**10 April 2018**



# Learning Objectives



# Learning Objectives

**We will learn to,**



# Learning Objectives

**We will learn to,**

- ▶ **Determine Solubility of salts**



# Learning Objectives

We will learn to,

- ▶ Determine **Solubility** of salts
- ▶ Calculate **Solubility Product** of various sparingly soluble salts



# System Requirement



# System Requirement

- ▶ Mac OS v 10.10.5



# System Requirement

- ▶ **Mac OS v 10.10.5**
- ▶ **ChemCollective Vlabs v 2.1.0**





# System Requirement

- ▶ **Mac OS v 10.10.5**
- ▶ **ChemCollective Vlabs v 2.1.0**
- ▶ **Java v 8**



# Pre-requisites



# Pre-requisites

- ▶ ChemCollective Vlabs interface



# Pre-requisites

- ▶ ChemCollective Vlabs interface
- ▶ If not for relevant tutorials please visit our website  
[www.spoken-tutorial.org](http://www.spoken-tutorial.org)



# Solubility Product



# Solubility Product

- ▶ **Solubility Product** is the mathematical product of its dissolved ion concentrations raised to the power of their stoichiometric coefficients



# Solubility Product - Equation 1



# Solubility Product - Equation 1

- ▶  $AgCl_{(s)} \rightleftharpoons Ag_{(aq)}^{+} + Cl_{(aq)}^{-}$
- ▶  $[Ag^{+}]: [Cl^{-}]$
- ▶ 1: 1
- ▶  $[Ag^{+}] = S, [Cl^{-}] = S$
- ▶  $K_{sp} = [Ag^{+}][Cl^{-}]$
- ▶ *Solubility Product* ( $K_{sp}$ ) =  $S \times S = S^2$





# Solubility Product - Equation 2



# Solubility Product - Equation 2

- ▶  $Ag_2CO_{3(s)} \rightleftharpoons 2Ag_{(aq)}^+ + CO_{3(aq)}^{-2}$
- ▶  $[Ag^+]: [CO_3^{-2}]$
- ▶ 2: 1
- ▶  $[Ag^+] = 2S, [CO_3^{-2}] = S$
- ▶  $K_{sp} = [Ag^+]^2[CO_3^{-2}]$
- ▶  $Solubility\ Product(K_{sp}) = (2S)^2 \times S = 4S^3$



# Solubility Product - Significance



# Solubility Product - Significance

- ▶ **Solubility Product** applies to solutions where salts do not fully dissolve



# Solubility Product - Significance

- ▶ **Solubility Product** applies to solutions where salts do not fully dissolve
- ▶ **Water is generally used as a solvent**



# Solubility Product - Significance

- ▶ **Solubility Product** applies to solutions where salts do not fully dissolve
- ▶ Water is generally used as a solvent
- ▶ **Solubility Product** changes with temperature



# Solubility Product - Significance



# Solubility Product - Significance

- ▶ **Solubility Product** is a heterogeneous equilibrium constant





# Solubility Product - Significance

- ▶ **Solubility Product** is a heterogeneous equilibrium constant
- ▶ **Smaller the Solubility Product of a substance, lower is its Solubility**



# Solubility Product - Significance



# Solubility Product - Significance

**Predicting the precipitation in reactions:**



# Solubility Product - Significance

**Predicting the precipitation in reactions:**

- ▶ Ionic product  $> K_{sp}$  then precipitation will occur



# Solubility Product - Significance

## Predicting the precipitation in reactions:

- ▶ Ionic product  $> K_{sp}$  then precipitation will occur
- ▶ Ionic product  $< K_{sp}$  then precipitation will not occur



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$		



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} \quad [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	





# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} \quad [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	
$\text{SrSO}_4$		



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} \quad [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} \quad [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} \quad [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} \quad [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	
$\text{Ag}_2\text{CO}_3$		



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} \quad [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} \quad [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} \quad [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	
$\text{Sr}(\text{IO}_3)_2$		



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	
$\text{Sr}(\text{IO}_3)_2$	$[\text{Sr}^{+2}] = 4.4 \times 10^{-3} [\text{IO}_3^{-}] = 8.79 \times 10^{-3}$	



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (\text{S}^2)$
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	
$\text{Sr}(\text{IO}_3)_2$	$[\text{Sr}^{+2}] = 4.4 \times 10^{-3} [\text{IO}_3^{-}] = 8.79 \times 10^{-3}$	



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (\text{S}^2)$
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	$3.4 \times 10^{-7} (\text{S}^2)$
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	
$\text{Sr}(\text{IO}_3)_2$	$[\text{Sr}^{+2}] = 4.4 \times 10^{-3} [\text{IO}_3^{-}] = 8.79 \times 10^{-3}$	





# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (\text{S}^2)$
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	$3.4 \times 10^{-7} (\text{S}^2)$
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	$8.1 \times 10^{-12} (4\text{S}^3)$
$\text{Sr}(\text{IO}_3)_2$	$[\text{Sr}^{+2}] = 4.4 \times 10^{-3} [\text{IO}_3^{-}] = 8.79 \times 10^{-3}$	



# Solubility Product Calculations ( $25^{\circ}\text{C}$ )

Salt	Solubility(M)	$K_{sp}$
$\text{AgCl}$	$[\text{Ag}^{+}] = 1.33 \times 10^{-5} [\text{Cl}^{-}] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (\text{S}^2)$
$\text{SrSO}_4$	$[\text{Sr}^{+2}] = 5.83 \times 10^{-4} [\text{SO}_4^{-2}] = 5.83 \times 10^{-4}$	$3.4 \times 10^{-7} (\text{S}^2)$
$\text{Ag}_2\text{CO}_3$	$[\text{Ag}^{+}] = 2.57 \times 10^{-4} [\text{CO}_3^{-2}] = 1.28 \times 10^{-4}$	$8.1 \times 10^{-12} (4\text{S}^3)$
$\text{Sr}(\text{IO}_3)_2$	$[\text{Sr}^{+2}] = 4.4 \times 10^{-3} [\text{IO}_3^{-}] = 8.79 \times 10^{-3}$	$1.14 \times 10^{-7} (4\text{S}^3)$



# Standard Values of Solubility Product



# Standard Values of Solubility Product

Salt	Chemical formula	Solubility Product ( $K_{sp}$ )
Aluminium Hydroxide	$\text{Al}(\text{OH})_3$	$1.8 \times 10^{-33}$
Barium Carbonate	$\text{BaCO}_3$	$8.1 \times 10^{-9}$
Bismuth Sulfide	$\text{Bi}_2\text{S}_3$	$1.6 \times 10^{-72}$
Calcium Carbonate	$\text{CaCO}_3$	$8.7 \times 10^{-7}$
Copper Bromide	$\text{CuBr}$	$4.2 \times 10^{-8}$
Iron(II)hydroxide	$\text{Fe}(\text{OH})_2$	$1.6 \times 10^{-14}$
Lead(II) chloride	$\text{PbCl}_2$	$2.4 \times 10^{-4}$
Magnesium carbonate	$\text{MgCO}_3$	$4.0 \times 10^{-5}$
Silver chloride	$\text{AgCl}$	$1.6 \times 10^{-10}$
Silver Carbonate	$\text{Ag}_2\text{CO}_3$	$8.1 \times 10^{-12}$
Strontium Sulphate	$\text{SrSO}_4$	$3.8 \times 10^{-7}$
Strontium Iodate	$\text{Sr}(\text{IO}_3)_2$	$1.14 \times 10^{-7}$



# Summary



# Summary

We have,

- ▶ Determined **Solubility** of salts
- ▶ Calculated **Solubility Product** of various sparingly soluble salts



# Assignment



# Assignment

**For  $SrSO_4$  and  $Sr(IO_3)_2$ :**

- 1. Write dissociation equation and Solubility Product expression**





# Assignment

For  $SrSO_4$  and  $Sr(IO_3)_2$ :

1. Write dissociation equation and Solubility Product expression
2. Find Solubility Product of these salts at  $35^{\circ}C$



# Assignment

For  $SrSO_4$  and  $Sr(IO_3)_2$ :

1. Write dissociation equation and **Solubility Product** expression
2. Find **Solubility Product** of these salts at  $35^{\circ}C$
3. Observe whether dissolution of these salts is exothermic or endothermic



# About the Spoken Tutorial Project

- ▶ Watch the video available at [http://spoken-tutorial.org/What\\_is\\_a\\_Spoken\\_Tutorial](http://spoken-tutorial.org/What_is_a_Spoken_Tutorial)
- ▶ It summarises the Spoken Tutorial project
- ▶ If you do not have good bandwidth, you can download and watch it



# Spoken Tutorial Workshops

## The Spoken Tutorial Project Team

- ▶ Conducts workshops using spoken tutorials
- ▶ Gives certificates to those who pass an online test
- ▶ For more details, please write to [contact@spoken-tutorial.org](mailto:contact@spoken-tutorial.org)



# Forum for specific questions

- ▶ Do you have questions in **THIS Spoken Tutorial?**
- ▶ Please visit  
<http://forums.spoken-tutorial.org>
- ▶ Choose the minute and second where you have the question
- ▶ Explain your question briefly
- ▶ Someone from our team will answer them



# Acknowledgements

- ▶ **Spoken Tutorial Project is a part of the Talk to a Teacher project**
- ▶ **It is supported by the National Mission on Education through ICT, MHRD, Government of India**
- ▶ **More information on this Mission is available at**

**<http://spoken-tutorial.org /NMEICT-Intro>**

