

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



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 (25⁰ C)

Salt	Solubility(M)	K_{sp}



Solubility Product Calculations (25°C)

Salt	Solubility(M)	K_{sp}
<i>AgCl</i>		



Solubility Product Calculations (25°C)

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



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5}$ $[Cl^-] = 1.33 \times 10^{-5}$	
$SrSO_4$		



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
<i>AgCl</i>	$[Ag^+] = 1.33 \times 10^{-5}$ $[Cl^-] = 1.33 \times 10^{-5}$	
<i>SrSO₄</i>	$[Sr^{+2}] = 5.83 \times 10^{-4}$ $[SO_4^{-2}] = 5.83 \times 10^{-4}$	



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5}$ $[Cl^-] = 1.33 \times 10^{-5}$	
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4}$ $[SO_4^{-2}] = 5.83 \times 10^{-4}$	
Ag_2CO_3		



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5} [Cl^-] = 1.33 \times 10^{-5}$	
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4} [SO_4^{-2}] = 5.83 \times 10^{-4}$	
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4} [CO_3^{-2}] = 1.28 \times 10^{-4}$	



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5} [Cl^-] = 1.33 \times 10^{-5}$	
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4} [SO_4^{-2}] = 5.83 \times 10^{-4}$	
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4} [CO_3^{-2}] = 1.28 \times 10^{-4}$	
$Sr(IO_3)_2$		



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5} [Cl^-] = 1.33 \times 10^{-5}$	
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4} [SO_4^{-2}] = 5.83 \times 10^{-4}$	
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4} [CO_3^{-2}] = 1.28 \times 10^{-4}$	
$Sr(IO_3)_2$	$[Sr^{+2}] = 4.4 \times 10^{-3} [IO_3^-] = 8.79 \times 10^{-3}$	



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5}$ $[Cl^-] = 1.33 \times 10^{-5}$	1.77×10^{-10} (S^2)
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4}$ $[SO_4^{-2}] = 5.83 \times 10^{-4}$	
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4}$ $[CO_3^{-2}] = 1.28 \times 10^{-4}$	
$Sr(IO_3)_2$	$[Sr^{+2}] = 4.4 \times 10^{-3}$ $[IO_3^-] = 8.79 \times 10^{-3}$	



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5} [Cl^-] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (S^2)$
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4} [SO_4^{-2}] = 5.83 \times 10^{-4}$	$3.4 \times 10^{-7} (S^2)$
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4} [CO_3^{-2}] = 1.28 \times 10^{-4}$	
$Sr(IO_3)_2$	$[Sr^{+2}] = 4.4 \times 10^{-3} [IO_3^-] = 8.79 \times 10^{-3}$	



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5} [Cl^-] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (S^2)$
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4} [SO_4^{-2}] = 5.83 \times 10^{-4}$	$3.4 \times 10^{-7} (S^2)$
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4} [CO_3^{-2}] = 1.28 \times 10^{-4}$	$8.1 \times 10^{-12} (4S^3)$
$Sr(IO_3)_2$	$[Sr^{+2}] = 4.4 \times 10^{-3} [IO_3^-] = 8.79 \times 10^{-3}$	



Solubility Product Calculations (25⁰ C)

Salt	Solubility(M)	K_{sp}
$AgCl$	$[Ag^+] = 1.33 \times 10^{-5} [Cl^-] = 1.33 \times 10^{-5}$	$1.77 \times 10^{-10} (S^2)$
$SrSO_4$	$[Sr^{+2}] = 5.83 \times 10^{-4} [SO_4^{-2}] = 5.83 \times 10^{-4}$	$3.4 \times 10^{-7} (S^2)$
Ag_2CO_3	$[Ag^+] = 2.57 \times 10^{-4} [CO_3^{-2}] = 1.28 \times 10^{-4}$	$8.1 \times 10^{-12} (4S^3)$
$Sr(IO_3)_2$	$[Sr^{+2}] = 4.4 \times 10^{-3} [IO_3^-] = 8.79 \times 10^{-3}$	$1.14 \times 10^{-7} (4S^3)$



Standard Values of Solubility Product



Standard Values of Solubility Product

Salt	Chemical formula	Solubility Product (K_{sp})
Aluminium Hydroxide	Al(OH)_3	1.8×10^{-33}
Barium Carbonate	BaCO_3	8.1×10^{-9}
Bismuth Sulfide	Bi_2S_3	1.6×10^{-72}
Calcium Carbonate	CaCO_3	8.7×10^{-7}
Copper Bromide	CuBr	4.2×10^{-8}
Iron(II)hydroxide	Fe(OH)_2	1.6×10^{-14}
Lead(II) chloride	PbCl_2	2.4×10^{-4}
Magnesium carbonate	MgCO_3	4.0×10^{-5}
Silver chloride	AgCl	1.6×10^{-10}
Silver Carbonate	Ag_2CO_3	8.1×10^{-12}
Strontium Sulphate	SrSO_4	3.8×10^{-7}
Strontium Iodate	$\text{Sr(IO}_3)_2$	1.14×10^{-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
- ▶ 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



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>

