

Salts and Solubility Activity 3

Solution Equilibrium and K_{sp}

Learning Goals: Students will be able to:

- Describe the equilibrium of a saturated solution macroscopically and microscopically with supporting illustrations. (not covered in these questions)
- Write equilibrium expressions for salts dissolving
- Calculate K_{sp} from molecular modeling.

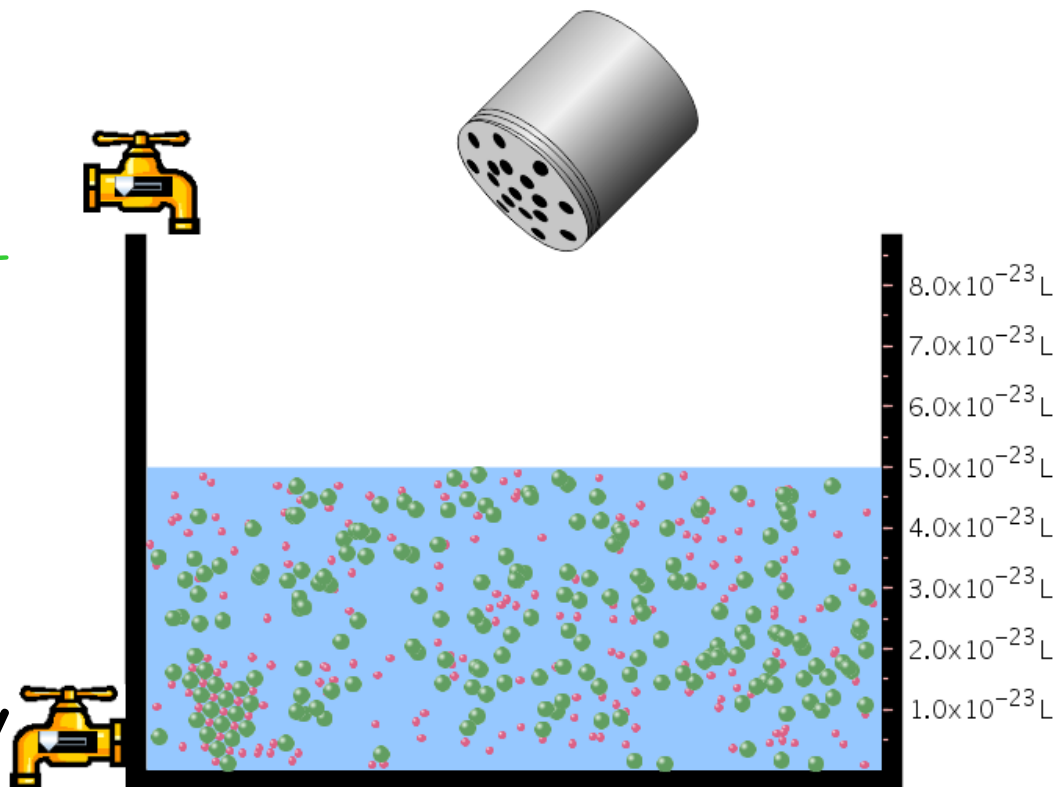
Trish Loeblein updated July 2008

I simplified the reactions by omitting (aq), my students have found this helpful and they know that they must put it on tests.

1. Table salt
dissolves in water:
 $\text{NaCl}(s) \rightleftharpoons \text{Na}^+ + \text{Cl}^-$

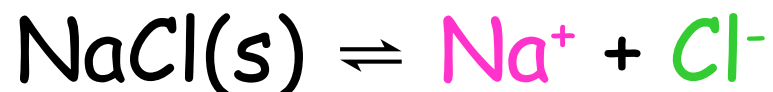
What is the
correct K_{sp}
expression if s is
the molar solubility
Sodium chloride?

- $K_{sp} = s^2$
- $K_{sp} = 2s^2$
- $K_{sp} = s^5$
- $K_{sp} = 4s^4$



Salt		
Ions	● Sodium	● Chloride
Dissolved	181	181
Bound	19	19
Total	200	200
Water		
Volume:	5.00E-23	liters (L)

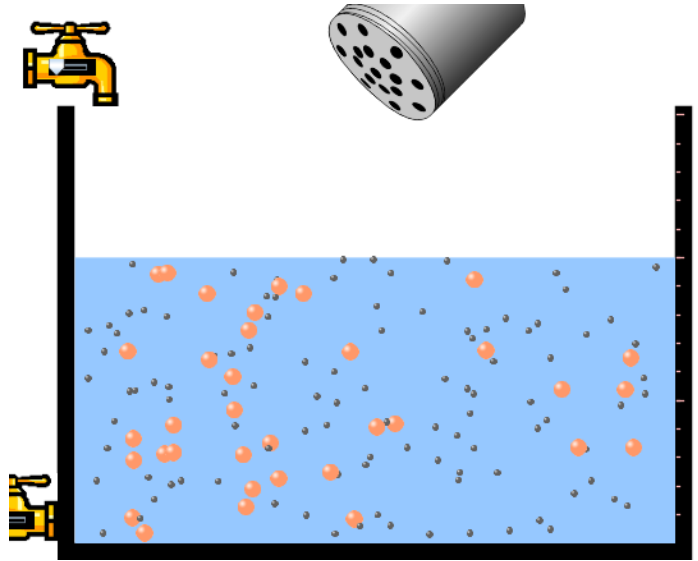
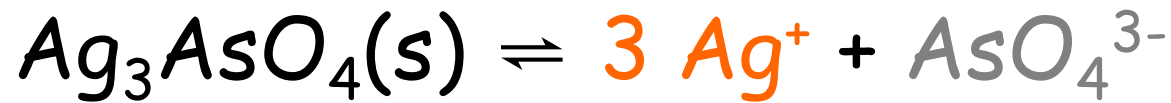
Table salt dissolves in water:



$$K_{\text{sp}} = [\text{Na}^+][\text{Cl}^-]$$

For every NaCl molecule that dissolves there was one Na^+ and one Cl^- put into solution, so if we let s equal the amount of NaCl that dissolved then the expression substitutes to be $K_{\text{sp}} = s^2$

2. Silver arsenate dissolves in water:



What is the correct K_{sp} expression if s is the molar solubility Silver arsenate?

- a. $K_{sp} = s^2$
- b. $K_{sp} = 3s^2$
- c. $K_{sp} = s^4$
- d. $K_{sp} = 3s^4$
- e. $K_{sp} = 27s^4$

Salt		
	Silver Arsenate	
Ions	● Silver	● Arsenate
Dissolved	105	35
Bound	0	0
Total	105	35

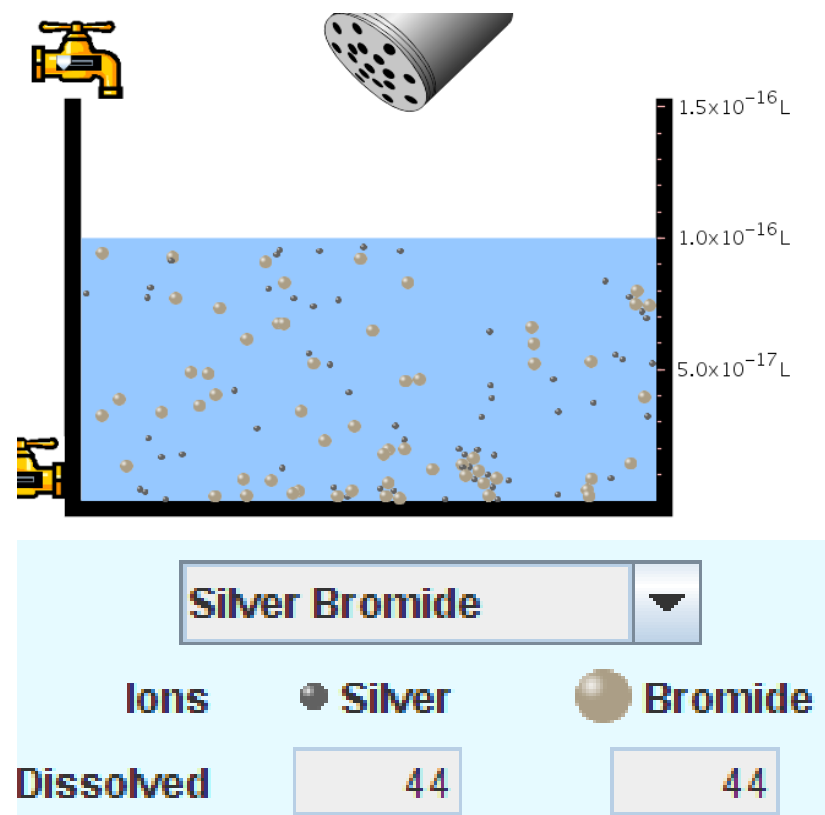
3. What is the proper expression for the molar solubility s of AgCl in terms of K_{sp} ?

a. $s = K_{\text{sp}}$

b. $s = (K_{\text{sp}})^2$

c. $s = (K_{\text{sp}})^{1/2}$

d. $s = K_{\text{sp}}/2$



$$K_{sp} = [\text{Ag}^+][\text{Br}^-]$$

$[\text{Ag}^+] = [\text{Br}^-]$ (44 of each are dissolved)

$$K_{sp} = s^2$$

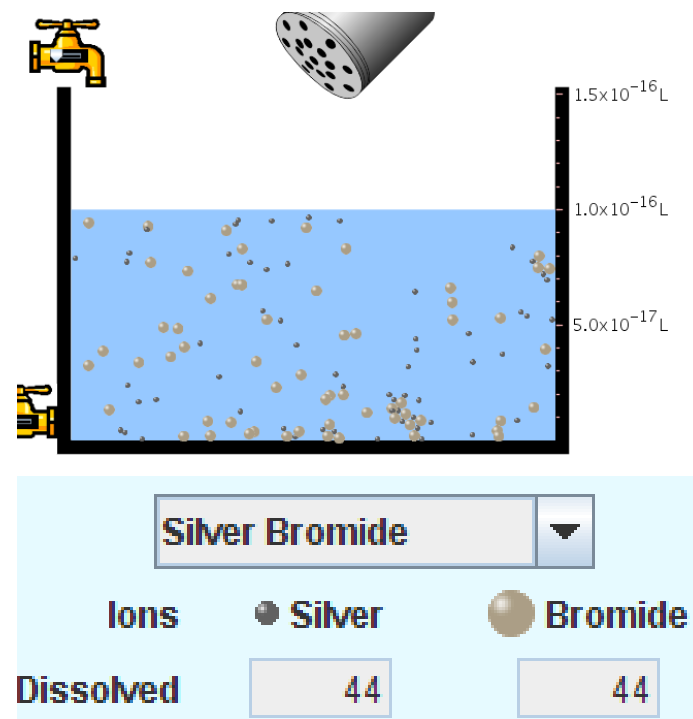
$$s = (K_{sp})^{1/2}$$



$$K_{sp} = 5.0 \times 10^{-13}$$

4. A saturated solution of AgBr in 1×10^{-16} liters of water contains about 44 Ag^+ and 44 Br^- ions as shown.

Suppose that K_{sp} were reduced to 2.5×10^{-13} . How many Ag^+ ions would you expect to see at equilibrium?



a. 11

b. 22

c. 31

d. 44

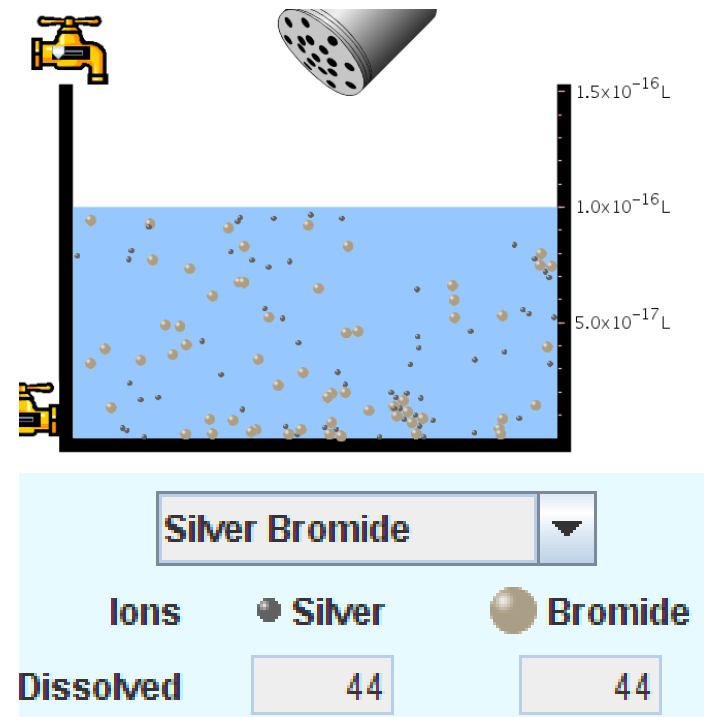
e. 88



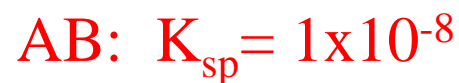
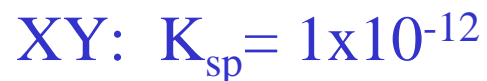
$$K_{sp} = 5.0 \times 10^{-13}$$

Suppose that K_{sp} were reduced to 2.5×10^{-13} . How many Ag^+ ions would you expect to see at equilibrium?

$$\begin{aligned} s &= \sqrt{K_{sp}} \\ &= \sqrt{2.5 \times 10^{-13}} \\ &\approx 31 \end{aligned}$$

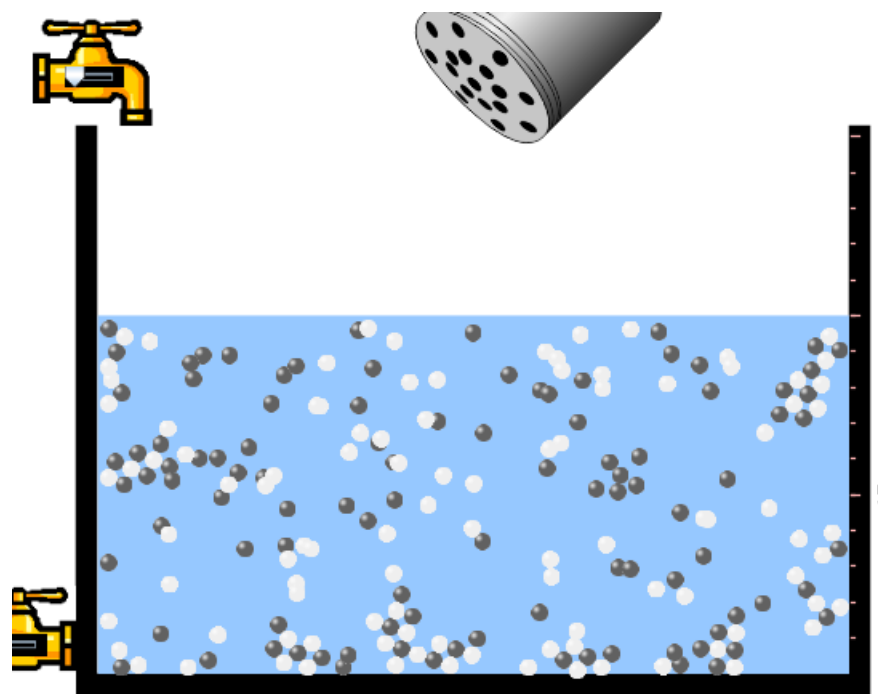


5. Two salts have similar formulas **XY** and **AB**, but they have different solubility product constants.

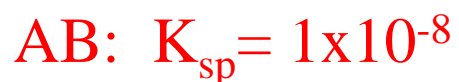
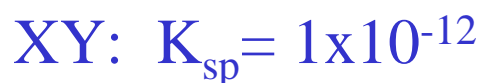


Which one would be more soluble?

- A. **AB**
- B. **XY**
- C. The amount that dissolves would be the same.
- D. Not enough information

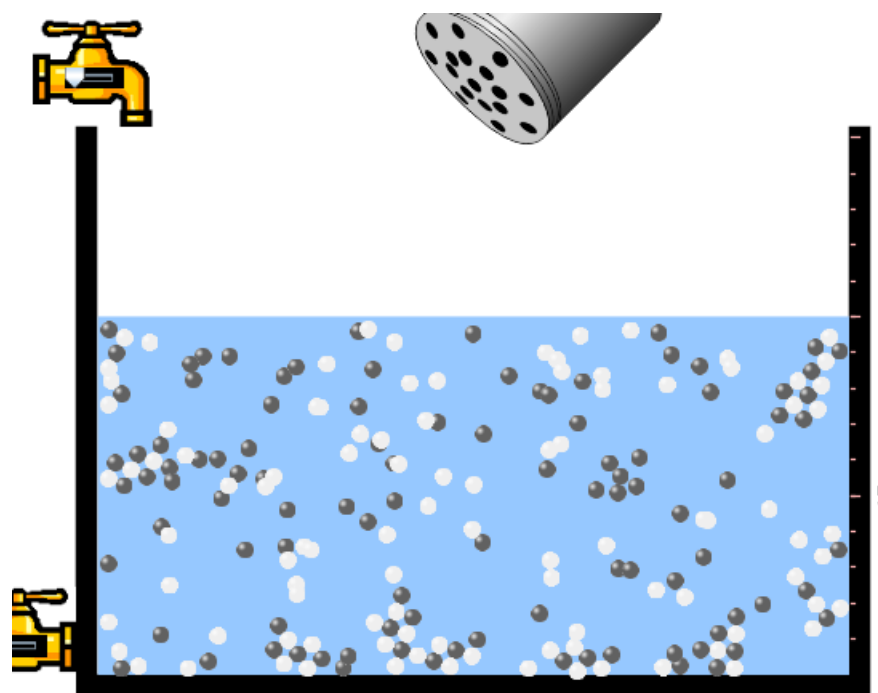


6. Two salts have similar formulas **XY** and **AB**, but they have different solubility product constants.



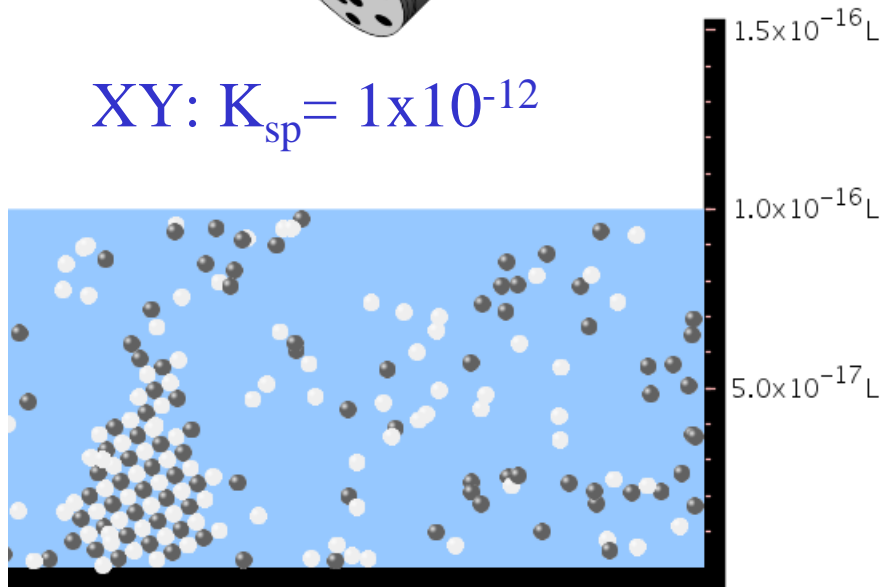
Which one would be more likely to precipitate?

- A. **AB**
- B. **XY**
- C. They behave the same
- D. Not enough information





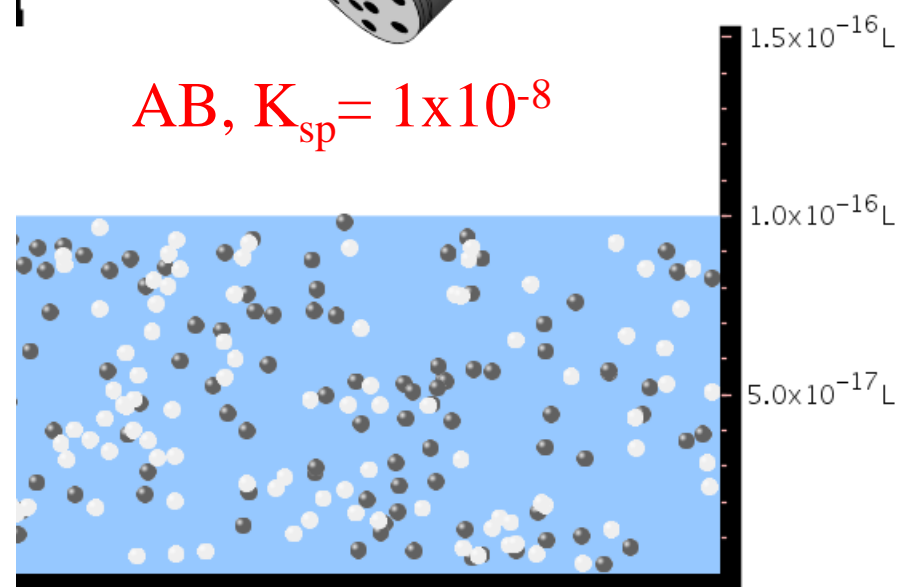
XY: $K_{sp} = 1 \times 10^{-12}$



Salt			
Cation charge:	+1		
Anion charge:	-1		
Ksp	1 E -12		
Ions	● Cation	● Anion	
Dissolved	60	61	
Bound	40	39	
Total	100	100	
Water			
Volume:	1.00E-16 liters (L)		



AB, $K_{sp} = 1 \times 10^{-8}$



Salt			
Cation charge:	+1		
Anion charge:	-1		
Ksp	1 E -8		
Ions	● Cation	● Anion	
Dissolved	100	100	
Bound	0	0	
Total	100	100	
Water			
Volume:	1.00E-16 liters (L)		