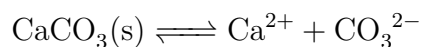


### Find Ksp Given Solubility - Question 1

Find the Ksp for calcium carbonate given that the **solubility** of calcium carbonate is found to be 6.934 p.p.m.  
(note p.p.m. = mg/L)

*Must convert p.p.m. to mol/L first*

$$\frac{6.934 \text{ mg CaCO}_3}{1 \text{ L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol CaCO}_3}{100.09 \text{ g CaCO}_3} = \frac{6.93 \times 10^{-5} \text{ mol CaCO}_3}{1 \text{ L}}$$



$$[\text{Ca}^{2+}] = 6.93 \times 10^{-5} \text{ M}$$

$$[\text{CO}_3^{2-}] = 6.93 \times 10^{-5} \text{ M}$$

$$\begin{aligned} K_{\text{sp}} &= [\text{Ca}^{2+}][\text{CO}_3^{2-}] \\ &= (6.93 \times 10^{-5})^2 \\ &= 4.8 \times 10^{-9} \end{aligned}$$

Please note that solubility must be in mol/L in order to find ion concentrations that can be used to solve for a Ksp value.

## Find Solubility Ksp Given - Question 2

Find equilibrium ion concentrations for a saturated aluminum hydroxided solution and the mass of aluminum hydroxide in mg required to saturate 2500 mL of solution.



Let  $s$  represent the solubility of  $\text{Al(OH)}_3$

$$[\text{Al}^{3+}] = s$$

$$[\text{OH}^{1-}] = 3s$$

$$K_{\text{sp}} = [\text{Al}^{3+}][\text{OH}^{1-}]^3$$

$$3 \times 10^{-33} = (s)(3s)^3$$

$$3 \times 10^{-33} = (s)(27s^3)$$

$$3 \times 10^{-33} = 27s^4$$

$$s = 3.25 \times 10^{-9} \text{ mol/L}$$

$$[\text{Al}^{3+}] = 3.25 \times 10^{-9} \text{ M}$$

$$[\text{OH}^{1-}] = 3 \times (3.25 \times 10^{-9} \text{ M})$$

$$= 9.74 \times 10^{-9} \text{ M}$$

$$2500 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{3.25 \times 10^{-9} \text{ mol}}{1 \text{ L}} \times \frac{78.01 \text{ g Al(OH)}_3}{1 \text{ mol Al(OH)}_3} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 6.34 \text{ mg Al(OH)}_3$$

**Find Maximum Ion Concentration Given a  
Fixed Ion Concentration - Question 3**

Find the maximum concentration of  $\text{Pb}^{2+}$  in p.p.m. that can co-exist in equilibrium with a chloride ion concentration of 0.05 M.



$$K_{\text{sp}} = [\text{Pb}^{2+}][\text{Cl}^{1-}]^2$$

$$[\text{Pb}^{2+}] = \frac{K_{\text{sp}}}{[\text{Cl}^{1-}]^2}$$

$$[\text{Pb}^{2+}] = \frac{1.6 \times 10^{-5}}{(0.05)^2}$$

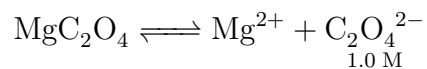
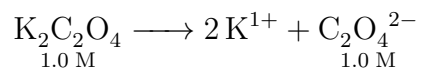
$$[\text{Pb}^{2+}] = 6.4 \times 10^{-3} \text{ M}$$

$$\frac{6.4 \times 10^{-3} \text{ mol Pb}^{2+} \text{ L}}{1 \text{ L}} \times \frac{207.20 \text{ g Pb}^{2+}}{1 \text{ mol Pb}^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{1326 \text{ mg Pb}^{2+}}{1 \text{ L}}$$

$$\therefore [\text{Pb}^{2+}] = 1326 \text{ p.p.m.}$$

**Find Ion Concentration in a Solution of a Soluble Salt (another fixed ion problem) - Question 4**

what is the maximum possible concentration of magnesium ion in p.p.m. that can exist in a 1.0 M  $K_2C_2O_4$  solution



$$K_{sp} = 8.6 \times 10^{-5}$$

$$K_{sp} = [Mg^{2+}][C_2O_4^{2-}]$$

$$[Mg^{2+}] = \frac{K_{sp}}{[C_2O_4^{2-}]^2}$$

$$[Mg^{2+}] = \frac{8.6 \times 10^{-5}}{1.0}$$

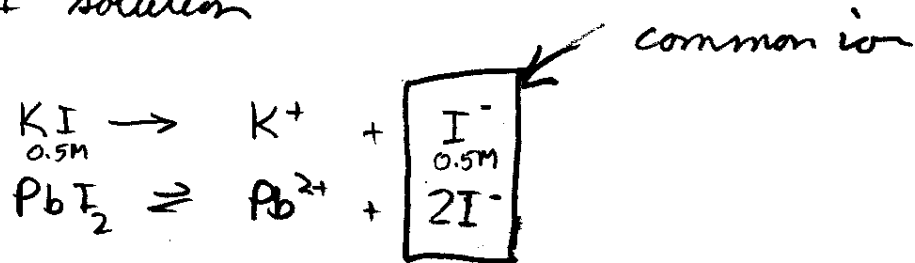
$$[Mg^{2+}] = 8.6 \times 10^{-5} \text{ M}$$

$$\frac{8.6 \times 10^{-5} \text{ mol } Mg^{2+} \text{ L}}{1 \text{ L}} \times \frac{24.31 \text{ g } Mg^{2+}}{1 \text{ mol } Mg^{2+}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = \frac{2.090 \text{ mg } Mg^{2+}}{1 \text{ L}}$$

$$\therefore [Mg^{2+}] = 2.090 \text{ p.p.m.}$$

## K<sub>sp</sub> Problem: Common Ion Effect

Determine the solubility of lead iodide in a 0.5M KI solution



Let  $s$  represent the solubility

$$\therefore [\text{Pb}^{2+}] = s$$

$$[\text{I}^-] = 2s + 0.5$$

↙ contribution from KI

↑ contribution from PbI<sub>2</sub>

$$K_{sp} = [\text{Pb}^{2+}][\text{I}^-]^2$$

$$7.1 \times 10^{-9} = s(2s + 0.5)^2$$

\* use methods to solve a cubic or !!

$$\text{assume } 2s \ll 0.5 \therefore 2s + 0.5 \approx 0.5$$

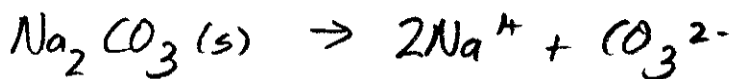
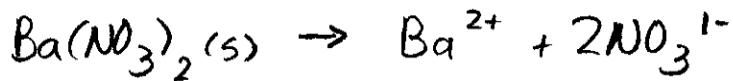
$$7.1 \times 10^{-9} = s(0.5)^2$$

$$s = 2.84 \times 10^{-8} \text{ mol/L} \quad \therefore 2.84 \cdot 10^{-8} \ll 0.5 \text{ (less than 1\%)} \\ \therefore \text{assumption was valid}$$

Note the solubility will be lower than in pure water

Complex Ksp problem - determine mass of ppte formed

400 mL of 0.0001 M  $\text{Ba}(\text{NO}_3)_2$  is mixed with  
500 mL of 0.0003 M  $\text{Na}_2\text{CO}_3$ . What mass of ppte  
forms in mg?



\*  $\text{Na}^+ + \text{NO}_3^{-}$   
are highly soluble  
and hence will  
not be involved  
in a ppte

ppte →  $\text{BaCO}_3(s) \rightleftharpoons \text{Ba}^{2+} + \text{CO}_3^{2-}$

Initial [ ]	N.A.	/	/
Initial amount	0	$n = CV$ $n = 0.0001\text{M} \times 0.4\text{L}$ $n = 4 \times 10^{-5}\text{mol}$	$n = CV$ $n = 0.0003\text{M} \times 0.5\text{L}$ $n = 1.5 \times 10^{-4}\text{mol}$
Final amount	x	$4 \times 10^{-5} - x$	$1.5 \times 10^{-4} - x$
Final [ ]	N.A.	$\frac{4 \times 10^{-5} - x}{0.9}$	$\frac{1.5 \times 10^{-4} - x}{0.9}$

400 mL + 500 mL = 900 mL  
Total Volume: 0.9 L

Let x represent  
the amount of  
 $\text{BaCO}_3$  that forms

$$K_{sp} = [\text{Ba}^{2+}][\text{CO}_3^{2-}]$$

$$4.9 \times 10^{-9} = \left( \frac{4 \times 10^{-5} - x}{0.9} \right) \left( \frac{1.5 \times 10^{-4} - x}{0.9} \right)$$

(from table)

"quadratic"

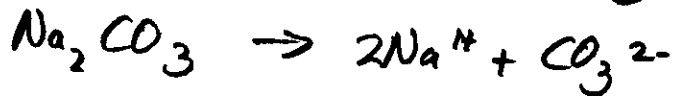
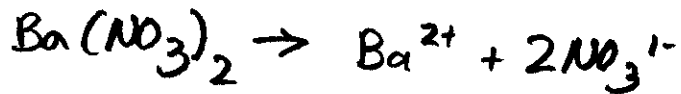
⇒

~~extraneous~~  
 ~~$x = 1.78 \times 10^{-4}\text{mol}$~~   
~~(too big)~~  
or  
 $x = 1.137 \times 10^{-5}\text{mol}$

$$1.137 \times 10^{-5}\text{mol BaCO}_3 \times \frac{197.34\text{g BaCO}_3}{1\text{mol BaCO}_3} \times \frac{1000\text{mg}}{1\text{g}} = 2.244\text{mg BaCO}_3$$

Complex Ksp problem - find Ksp value

eg 400 mL of 0.0001 M  $\text{Ba}(\text{NO}_3)_2$  is mixed with 500 mL of 0.0003 M  $\text{Na}_2\text{CO}_3$ . 2.244 mg of ppt forms. Find Ksp for the ppte produced



Initial [ ]	/	/	/
Initial Amount	0	$n = CV$ $n = 0.0001 \text{ M} \times 0.4 \text{ L}$ $n = 4 \times 10^{-5} \text{ mol}$	$n = CV$ $n = 0.0003 \text{ M} \times 0.5 \text{ L}$ $n = 1.5 \times 10^{-4} \text{ mol}$
Final Amount	$1.137 \times 10^{-5} \text{ mol}$	$4 \times 10^{-5}$ $- 1.137 \times 10^{-5}$ $= 2.863 \times 10^{-5} \text{ mol}$	$1.5 \times 10^{-4}$ $- 1.137 \times 10^{-5}$ $= 1.386 \times 10^{-4} \text{ mol}$
Final [ ]	N.A.	$3.181 \times 10^{-5} \text{ M}$	$1.540 \times 10^{-4} \text{ M}$

400 mL + 500 mL = 900 mL  
 $\therefore$  Total Volume = 0.9 L

$$2.244 \text{ mg BaCO}_3 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol BaCO}_3}{197.34 \text{ g BaCO}_3} = 1.137 \times 10^{-5} \text{ mol BaCO}_3$$

$$K_{sp} = [\text{Ba}^{2+}][\text{CO}_3^{2-}]$$

$$K_{sp} = (3.181 \times 10^{-5})(1.540 \times 10^{-4})$$

$$K_{sp} = 4.9 \times 10^{-9}$$