

d. NH_4HCO_3

Whichever value of K is bigger will determine if acidic or basic.

K_a of $\text{NH}_4^+_{(\text{aq})} =$

K_b of $\text{HCO}_3^-_{(\text{aq})} =$

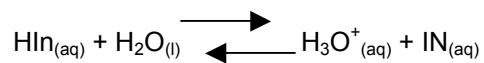
Solution will be basic

P. 424 # 1-4

Calculating pH at Equivalence

Equivalence point

Indicator



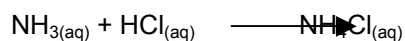
End Point

to determine which indicator to use we need to know if the pH at equivalence

e.g.

2.0×10^1 mL of a 0.20 mol/L $\text{NH}_{3(\text{aq})}$ is titrated against a 0.20 mol/L $\text{HCl}_{(\text{aq})}$. Calculate the pH at equivalence. Use figure 9 on p. 425 to select an appropriate indicator.

Chemical equation:



volume HCl =

From equation the amount of $\text{NH}_4\text{Cl}_{(\text{aq})}$ formed = amount of HCl reacted. $\therefore \text{mol NH}_4\text{Cl}_{(\text{aq})} = 4.0 \times 10^{-3} \text{ mol}$

$[\text{NH}_4\text{Cl}_{(\text{aq})}] =$

$\text{NH}_4\text{Cl}_{(\text{aq})}$

$\text{NH}_4^+_{(\text{aq})}$

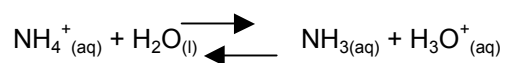
$\text{Cl}^-_{(\text{aq})}$

pH of the final solution will depend on the following reaction:



K_b for NH₃ is 1.8×10^{-5}
 \therefore K_a of NH₄⁺ is calculated using K_w = K_aK_b

Therefore ignore the change in x



I			
C			
E			

methyl red is a good choice pH 4.2-6.2

p. 428 practice # 5-8

Hydrolysis Activity

9.2 SOLUBILITY EQUILIBRIUM

- saturated solution is an example of a system at equilibrium
- solubility =

Three factors determine if a change is favoured:

ΔH :

ΔS :

T:

Same factors determine how much salt will dissolve

$$\Delta G = \Delta H - T\Delta S \quad \Delta G - \text{Free energy}$$

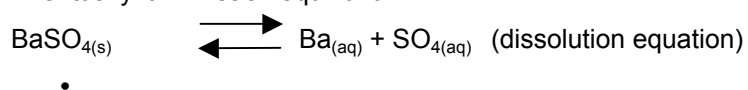
Dissolving - ΔS is always positive $\therefore -T\Delta S$ is neg.

\therefore

HETEROGENEOUS EQUILIBRIUM

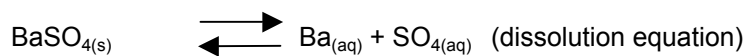
Eg. BaSO_4 solution is sparingly soluble

Eventually it will reach equilibrium:



SOLUBILITY PRODUCT CONSTANT

(K_{sp})



The conc. of BaSO_4 as a solid is constant

\therefore

- K_{sp}

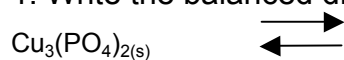
- K_{sp}

- K_{sp}

eg. Write the K_{sp} for the following:

copper (II) phosphate $\text{Cu}_3(\text{PO}_4)_2$

1. Write the balanced dissolution equation



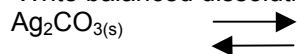
2. Write the expression for K_{sp}

p. 432 practice # 9-12

Determining K_{sp} from Measured Solubilities

A chemist finds that the solubility of silver carbonate Ag_2CO_3 , is 1.3×10^{-4} mol/L at 25°C . Calculate K_{sp} for silver carbonate.

1. Write balanced dissolution equation



1. Write K_{sp} expression

1. Find the conc. of each ion

$$[\text{Ag}^+] =$$

=

=

$$[\text{CO}_3^{2-}] =$$

1. Substitute numbers into the K_{sp} expression

p. 433 practice # 13-16 (ppm = mg/L)
(formula unit = molecule with ionic compounds)

Using the Solubility Product Constant

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Eg. Calculate the molar solubility of barium ions and sulfate ions in a saturated solution of barium sulfate
 $K_{sp} = 1.1 \times 10^{-10}$

1. write balanced dissolution equation



1. Write the expression for K_{sp}

1. Set up ICE table

$$\text{BaSO}_{4(s)} \rightleftharpoons \text{Ba}^{2+}_{(aq)} + \text{SO}_4^{2-}_{(aq)}$$

I		
C		
E		

1. solve for x

Eg. #2 Calculate the conc. of silver and sulfate ions in a saturated solution of silver sulfate (Ag_2SO_4) $K_{sp} = 1.2 \times 10^{-5}$



- 2.

3. ICE table

$$\text{Ag}_2\text{SO}_{4(s)} \rightleftharpoons 2\text{Ag}^{1+}_{(aq)} + \text{SO}_4^{2-}_{(aq)}$$

I		
C		
E		

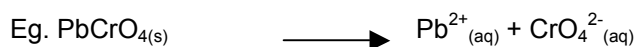
4. solve for x

∴ molar solubility of AgSO_4 is $1.4 \times 10^{-2} \text{ mol/L}$

p. 436 practice # 17-20

Common Ion effect

What happens to the solubility of an ionic compound when it is added to a solution that already contains one of its ions?



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K_{sp} for PbCrO₄

$$K_{sp} = [\text{Pb}^{2+}][\text{CrO}_4^{2-}] = 2.3 \times 10^{-13}$$

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- Demo of PbI_2

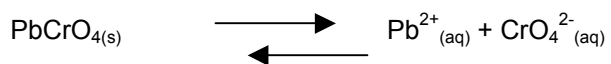
The Effect of a Common Ion on Solubility

Eg. The solubility of $\text{PbCrO}_{4(s)}$ in water is $4.8 \times 10^{-7} \text{ mol/L}$.

a) How will the equilibrium shift if $\text{PbCrO}_{4(s)}$ is added to a 0.10 mol/L solution of sodium chromate, $\text{Na}_2\text{CrO}_{4(s)}$.

b) K_{sp} for $\text{PbCrO}_{4(s)}$ 2.3×10^{-13} . Determine the solubility of $\text{PbCrO}_{4(s)}$ in a 0.10 mol/L solution of Na_2CrO_4 .

a.



$$K_{sp} = 2.3 \times 10^{-13}$$

Set up ICE table



I	-		
C	-		
E	-		

Assume that x is small due to such a small K_{sp} ignore +x

$$K_{sp} =$$

p. 439 practice # 21-24

Buffers and the Common Ion Effect

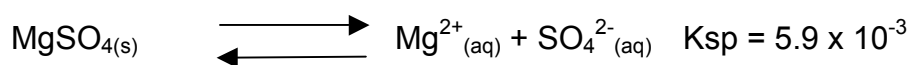
9.3 PREDICTING THE FORMATION OF A PRECIPITATE

Based on concentrations of ions in solutions

ION PRODUCT (Q_{sp}) →

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e.g. Slowly add $MgSO_4$ to the water



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-

$$Q_{sp} = [Mg^{2+}_{(aq)}][SO_4^{2-}_{(aq)}]$$

Therefore $Q_{sp} < K_{sp}$ →

$$Q_{sp} = K_{sp}$$

$$Q_{sp} > K_{sp}$$

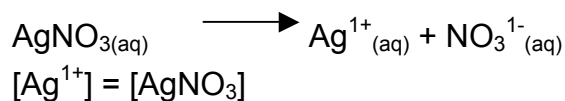
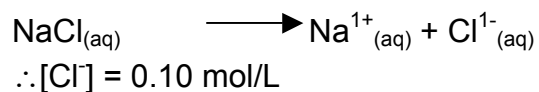
Using the Ion Product Expression

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-
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- K_{sp} is the point at which formation of ppt. is balanced with formation of ions. Therefore if there is an excess of ions that would mean that Le Chat, would have reaction pushed to left therefore ppt. forms.

e.g. A common test for the presence of chloride ions is the silver nitrate test. If chloride is present in sufficient quantity, a ppt. will form. K_{sp} for silver chloride is 1.8×10^{-10}

A drop (0.050 mL) of 6.0 mol/L silver nitrate is added to 1.0 L of 0.10 mol/L sodium chloride. Does a precipitate form?

1. Determine the concs. of ions in solution. Ignore the amount of silver chloride for total volume. I.e. total volume is 1.0 L.



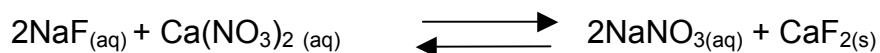
2. Determine Q_{sp}

3. Compare Q_{sp} and K_{sp} to determine ppt.?

The next example shows what will happen if significant volumes of reactants are mixed.

e.g. A chemist mixes 100.0mL of 0.25 mol/L $\text{Ca}(\text{NO}_3)_2$ with 200.0mL of 0.070 mol/L NaF. Does a ppt. form?

1. Determine if an insoluble compound is formed when these 2 ionic solutions react.
2. If an insoluble compound forms, write the dissolution equation and determine its K_{sp}
3. Determine the concs. of the ions that make up the compound.
4. Determine Q_{sp}
5. Compare Q_{sp} and K_{sp}



K_{sp} for $\text{CaF}_{2(\text{s})}$ is 3.2×10^{-11}

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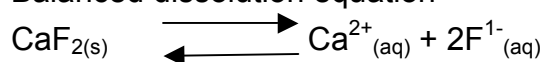
$$n \text{ Ca}^{2+} = c \times v =$$

$$n \text{ F}^{-} = c \times v =$$

$$[\text{Ca}^{2+}] =$$

$$[\text{F}^{-}] =$$

Balanced dissolution equation



$$Q_{\text{sp}} =$$