d. NH_4HCO_3

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

Ka of $NH_4^+{}_{(aq)}$ =

Kb of $HCO_3^-{}_{(aq)}$ =

Solution will be basic

P. 424 # 1-4

Calculating pH at Equivalence

Equivalence point

Indicator

$$HIn_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + IN_{(aq)}$$

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 $NH_{3(aq)}$ is titrated against a 0.20 mol/L $HCl_{(aq)}$. Calculate the pH at equivalence. Use figure 9 on p. 425 to select an appropriate indicator.

Chemical equation:

$$NH_{3(aq)} + HCl_{(aq)} \longrightarrow NH_4Cl_{(aq)}$$

volume HCl =

From equation the amount of $NH_4Cl_{(aq)}$ formed = amount of HCl reacted. ∴mol $NH_4Cl_{(aq)}$ = 4.0×10^{-3} mol

$[NH_4Cl_{(aq)}]$ =

$NH_4Cl_{(aq)}$

$NH_4^+{}_{(aq)}$

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

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

$$NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^+_{(aq)}$$

Kb for NH_3 is 1.8 x 10^{-5}
$\therefore$ Ka of NH_4^+ is calculated using Kw = KaKb

Therefore ignore the change in x

$$NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons NH_{3(aq)} + H_3O^+{}_{(aq)}$$

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

$\Delta G = \Delta H - T\Delta S$ ΔG – 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:

$BaSO_{4(s)} \rightleftharpoons Ba_{(aq)} + SO_{4(aq)}$ (dissolution equation)

-

SOLUBILITY PRODUCT CONSTANT

(Ksp)

$BaSO_{4(s)} \rightleftharpoons Ba_{(aq)} + SO_{4(aq)}$ (dissolution equation)

The conc. of $BaSO_4$ as a solid is constant

∴

- Ksp

- Ksp
- Ksp

eg. Write the Ksp for the following:

copper (II) phosphate $Cu_3(PO_4)_2$

1. Write the balanced dissolution equation

$Cu_3(PO_4)_{2(s)} \rightleftarrows$

2. Write the expression for Ksp

p. 432 practice # 9-12

Determining Ksp 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
   $Ag_2CO_{3(s)} \rightleftarrows$

1. Write K_{sp} expression

1. Find the conc. of each ion
   $[Ag^+]$ =

   =

   =

   $[CO_3^{2-}]$ =

1. Substitute numbers into the K_{sp} expression

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

Using the Solubility Product Constant

-

Eg. Calculate the molar solubility of barium ions and sulfate ions in a saturated solution of barium sulfate Ksp = 1.1×10^{-10}

1. write balanced dissolution equation

$$\rightleftharpoons$$

1. Write the expression for K_{sp}

1. Set up ICE table

$BaSO_{4(s)} \rightleftharpoons Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

I		
C		
E		

1. solve for x

Eg. #2 Calculate the conc. of silver and sulfate ions in a saturated solution of silver sulfate ($AgSO_4$) $K_{sp} = 1.2 \times 10^{-5}$

1. $AgSO_{4(s)} \rightleftharpoons$
2.

3. ICE table

$AgSO_{4(s)} \rightleftharpoons 2Ag^{1+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

I		
C		
E		

4. solve for x

$\therefore$ molar solubility of $AgSO_4$ is 1.4×10^{-2} 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?

Eg. $PbCrO_{4(s)} \longrightarrow Pb^{2+}_{(aq)} + CrO_4^{2-}{}_{(aq)}$

-

-

Ksp for $PbCrO_4$

$$Ksp = [Pb^{2+}][CrO_4^{2-}] = 2.3 \times 10^{-13}$$

-

- Demo of PbI_2

The Effect of a Common Ion on Solubility

Eg. The solubility of $PbCrO_{4(s)}$ in water is 4.8×10^{-7} mol/L.

a) How will the equilibrium shift if $PbCrO_{4(s)}$ is added to a 0.10 mol/L solution of sodium chromate, $Na_2CrO_{4(s)}$.

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

a.

$$PbCrO_{4(s)} \rightleftharpoons Pb^{2+}_{(aq)} + CrO_4^{2-}_{(aq)}$$

Ksp = $= 2.3\times10^{-13}$

Set up ICE table

$$PbCrO_{4(s)} \rightleftharpoons Pb^{2+}_{(aq)} + CrO_4^{2-}_{(aq)}$$

I	-		
C	-		
E	-		

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

Ksp =

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}) –>

•

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

$$MgSO_{4(s)} \rightleftharpoons Mg^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \quad Ksp = 5.9 \times 10^{-3}$$

•

•

•

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

Therefore Qsp < Ksp –>

Qsp = Ksp

Qsp > Ksp

Using the Ion Product Expression

-
-
-
- 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.

   $NaCl_{(aq)} \longrightarrow Na^{1+}_{(aq)} + Cl^{1-}_{(aq)}$
   $\therefore [Cl^-] = 0.10$ mol/L

   $AgNO_{3(aq)} \longrightarrow Ag^{1+}_{(aq)} + NO_3{}^{1-}_{(aq)}$
   $[Ag^{1+}] = [AgNO_3]$

2. Determine Q_{sp}

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

p. 446 practice # 29-32

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 $Ca(NO_3)_2$ 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}

$$2NaF_{(aq)} + Ca(NO_3)_{2\ (aq)} \rightleftharpoons 2NaNO_{3(aq)} + CaF_{2(s)}$$

K_{sp} for $CaF_{2(s)}$ is 3.2×10^{-11}

•

n Ca^{2+} = c x v =

n F^- = c x v =

$[Ca^{2+}]$ =

$[F^-]$ =

Balanced dissolution equation

$$CaF_{2(s)} \rightleftharpoons Ca^{2+}{}_{(aq)} + 2F^{1-}{}_{(aq)}$$

Qsp =

p. 447 practice #33-36