Solubility Review

Ap Chemistry

1. SIMPLE CONVERSIONS.

Solubility ⟷	Molar Solubility ⟷	Conc of ions ⟷	K_{sp}
g/ L	mol/ L	mol/ L	

2. Problems involving a saturated solution - YOUR IN EQ!! ICE TABLE!!

   a. Calc. molar or gram solubility from K_{sp}

   EX: $Ca(OH)_2 \quad Ca^{2+} + 2\ OH^-$

	$Ca(OH)_2$	Ca^{2+}	OH^-
I	?	0	0
C	-x	+x	+2x
E	? - x	x	2x

$K_{sp} = (x)(2x)^2$....x = mol/L of $Ca(OH)_2$ that actually dissolved = $[Cu(OH)_2]$...convert to g/L!

   b. Common ion effect.

   EX: *Add solid $Ca(OH)_2$ to a 0.1 M OH^-*

	$Ca(OH)_2$	Ca^{2+}	OH^-
I	?	0	0.1
C	-x	+x	+2x
E	? - x	x	0.1 + 2x

$K_{sp} = (x)(0.1 + 2x)^2$....x = mol/L of $Ca(OH)_2$ that actually dissolved = $[Ca(OH)_2]$...convert to g/L!

   c. pH and solubility

   EX: *pH =10.0 for a $Ca(OH)_2$ soln. Molar Sol?*

   NO ICE!!

   $K_{sp} = [Ca^{2+}][OH^-]^2$

   $K_{sp} = [Ca^{2+}][10^{-4}]^2$

   $[Ca^{2+}] =$ _____ $= [Ca(OH)_2]$

3. REACTIONS

   a. Will something ppt? Q PROBLEM!!

      i. The Simple Q problem:

EX: *Will MgF_2 ppt when you mix 100 mL each of 0.5 M $Mg(NO_3)_2$ and 0.5 M NaF?*

step 1: Calculate $[Mg^{2+}]$ and $[F^-]$ taking into account dilution and mixing of solutions.
step 2: Plug into Q expression. Compare Q to K_{sp}

      ii. The More Complex (yet fun!) Q problem - One's involving EQUILIBRIA!!

EX: *Will $Cu(OH)_2$ ppt when 100 mL of 0.5M $Cu(NO_3)_2$ and 100 mL of 0.5 M NH_3 are mixed?*

step 1: Determine $[Cu^{2+}]$ taking into account dilution and mixing of solutions.

step 2: Determine $[OH^-]$ from WB ICE table?

$NH_3 + H_2O \quad NH4^+ + OH^- \quad K_b = 1.8 \times 10^{-5}$

step 3: Plug into Q expression, compare to K_{sp}.

b. Calculating a specific concentration of ions remaining after a D.R. reaction.

EX: *What will be the Mg^{2+} concentration after you mix 100 mL each of 0.5 M $Mg(NO_3)_2$ and 0.5 M NaF???*

step 1: MOLE TABLE. Assume Double Replacement reaction goes to completion. Determine L.R. and what's left over.

	Mg^{2+}	+	$2\ F^-$	------->	MgF_2 (s)
mol_i :					
change:					
mol_f :					
$[\ ]_f$:	y		0		-

step 2: K_{sp} ICE TABLE. Some of the ppt will actually dissolve (reaction will not go all the way). Plug in left over ions from mole table into solubility ice table.

	MgF_2 (s)	Mg^{2+}	+	$2\ F^-$	K_{sp} = ____
I	?	y		0	
C					
E					

4. FACTORS THAT AFFECT SOLUBILITY.

a. Common Ion Effect: $AgCl\ (s) \rightleftharpoons Ag^+ + Cl^-$

EX: *Adding NaCl to a saturated solution of AgCl would shift Eq to the LEFT. Reduce solubility!*

b. Low pH (acidic conditions).

- Low pH INCREASES solubility for salts that contain conjugate bases of WEAK ACIDS!!!

EX:

AgF (s)	*vs*	*AgCl*
$AgF\ (s) \rightleftharpoons Ag^+ + F^-$		$AgCl(s) \rightleftharpoons Ag^+ + Cl^-$
$H^+ + F^- \rightarrow HF$		$H^+ + Cl^- \rightarrow HCl$

c. Complex Ions: INCREASE solubility!!

- Late transition metals - Ag^+, Cu^{2+}, Cd^{2+}, Hg^{2+}, Co^{3+}, Zn^{2+}....
- CN^-, NH_3, I^-, Cl^-, Br^-, OH^-...
- # of molecules/atoms coordinated is 2 times charge....

EX: *Show how sol of $Co(OH)_3$ increases with addition of CN^- ions.*

$Co(OH)_3\ (s) \rightleftharpoons Co^{3+} + 3\ OH^-$

$Co^{3+} + CN^- \rightleftharpoons Co(CN)_6^{-3}$