Solubility

ch 14

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SOLUBILITY

- *generally, a solute is considered "soluble" if more than 1 gram dissolves in 100 ml of water*
- *soluble salts are* ***assumed*** *to dissolve 100% in aqueous solns*
- *generally, solubility increases for solids in solvents with temperature*

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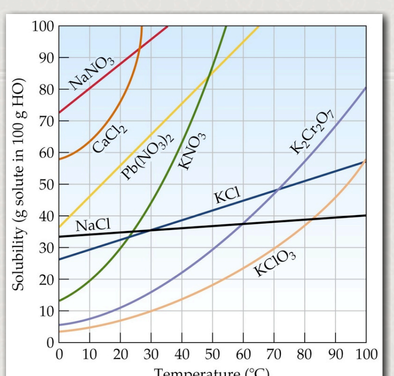

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Solubility Product

- *what about those that sorta kinda dissolve just a little bit???*
- *there is a way to measure how much; called **solubility product (K_{sp})***
- *the greater the value the more soluble it is...*

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- *For this reaction:*

$$A_aB_{b(s)} \leftrightarrow aA^+_{(aq)} + bB^-_{(aq)}$$

- ***$K_{sp} = [A]^a[B]^b$***
- *remember: [x] means "concentration of x"*
- *the **lower** the Ksp, the **less** soluble it is, and vice versa*

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Solubility to K_{sp}

- *The solubility of a salt can be used to determine the Ksp value for the salt:*
- *for example...*

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- ***The solubility of $Pb_3(PO_4)_2$ is 6.2×10^{-12} M. Calculate the Ksp value for the solid.***
- *STEP 1: Write the reaction.*

$$Pb_3(PO_4)_2 \rightleftharpoons 3Pb^{2+} + 2PO_4^{3-}$$

- *Make an ICE chart...*

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	$Pb_3(PO_4)_2$ ⇋	$3Pb^{2+}$ +	$2PO_4^{3-}$
Initial		0	0
Change		+3x	+2x
Equilibrium		3x	2x

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- ***$Ksp = [Pb^{2+}]^3[PO_4^{3-}]^2$***
- *$Ksp = (3x)^3 (2x)^2 = 108x^5$*
- *now x has to equal the solubility of the salt, 6.2×10^{-12} M*
- *$Ksp = 108(6.2 \times 10^{-12})^5$*
- *$Ksp = 9.9 \times 10^{-55}$*
- *kinda small, eh?*

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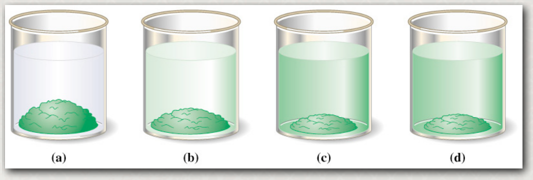
Common Ion Effect

- *those Ksp values assume you have reached a nice equilibrium, where the amount dissolving equals the amount coming back (c and d below)*



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- *but what if we mess with that equilibrium, what about when we **add** a load of just **one** of the player ions into the mix? does it affect the equilibrium?*
- *you betcha...*

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example

- *solubility expression for AgCl is*
- *Ksp = $[Ag^+][Cl^-] = 1.6 \times 10^{-10}$*
- *which means that normally $[Ag^+]$ and $[Cl^-]$ are 1.3×10^{-5} M (do you see that?)*
- *throw something with a **common ion** in there like Na**Cl** and things change...*

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- *add 0.10 mol NaCl to a liter of that soln.*
- *that means you've just upped the $[Cl^-]$ an extra 0.10 M, so...*
  - *$[Ag^+][Cl^-] = 1.6 \times 10^{-10}$*
  - *$[Ag^+][0.00013 + 0.10] = 1.6 \times 10^{-10}$*
  - *$[Ag^+][$~~0.00013~~$ + 0.10] = 1.6 \times 10^{-10}$*
  - *$[Ag^+][0.10] = 1.6 \times 10^{-10}$*
  - *$[Ag^+] = 1.6 \times 10^{-9}$ M*
- ***a LOT smaller that it was before***

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eocs

- *15.91*

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Ppt formation

- *How do you know if a ppt will form when you add some ions into a solution?*
- *Depends!..*

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Ion Product

- remember Q? It is the same as K, just for any time, not just equilibrium
- So, if...
  - Q > Ksp precipitation!
  - Q < Ksp no ppt!
  - Q = Ksp it is saturated

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example

- You put 100.0 ml of 4.0×10^{-4} M $Mg(NO_3)_2$ to 100.0 mL 2.0×10^{-4} M NaOH. Any precipitate from this???
- 1) What will form, if anything?
  - $Mg(OH)_2$ ***might!*** The other possibility, $NaNO_3$ is soluble....

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- 2) What is the concentration of those ions as you dump them together?
  - $[Mg^{2+}]$ = mol/L = (0.1000 L x 4.0×10^{-4} mol/L) / 0.2000 L
    - = 2.0×10^{-4} M
  - $[OH^-]$ = = mol/L = (0.1000 L x 2.0×10^{-4} mol/L) / 0.2000 L
    - = 1.0×10^{-4} M

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- 3) Write the ion product expression and compare it to Ksp (here $K_{sp} = 8.8 \times 10^{-12}$)
  - $Q = [Mg^{2+}][OH^-]^2 = (2.0 \times 10^{-4}\ M)(1.0 \times 10^{-4})^2 = 2.0 \times 10^{-12}$
- **Q < Ksp so no ppt forms**

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Selective ppt

- There are times in chem when you want to get rid of an ion.
- e.g. if you can get Pb ions - or any other "heavy metals" - out of water without disrupting anything else, that would be good

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example

- We have a solution: 0.25 M $Ni(NO_3)_2$ and 0.25 M $Cu(NO_3)_2$.
  Someone now adds some Na_2CO_3!!!
  What happens, if anything?
- Will $NiCO_3$ ($K_{sp} = 1.4 \times 10^{-7}$) or $CuCO_3$ ($K_{sp} = 2.5 \times 10^{-10}$) precipitate first?
- $CuCO_3$ because it has a smaller Ksp!!!

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Qualitative Analysis

- *Sometimes in real chem we have to separate out several ions based on their solubilities*
- *This is where "they" expect you to know the basic rules of solubility (!)*
- *like this...*

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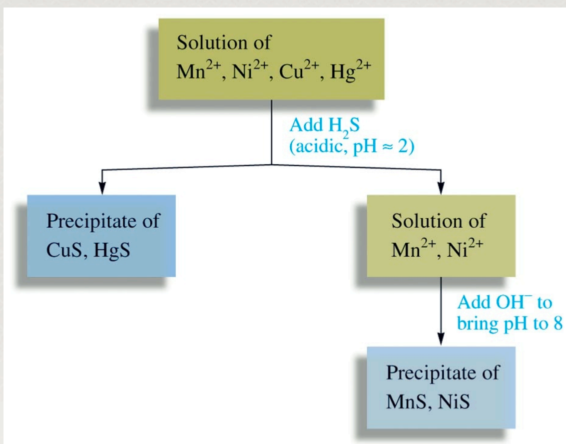

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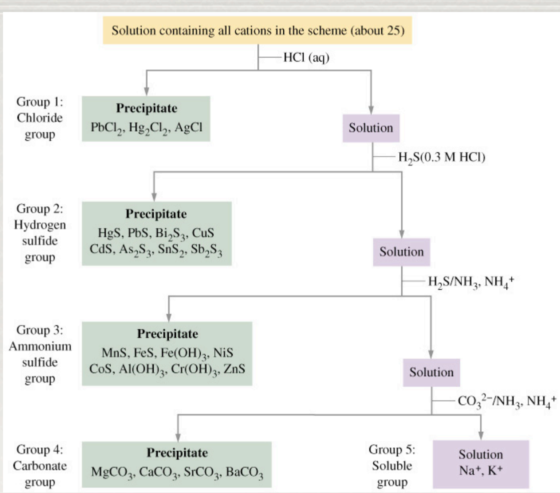

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