1-31-13

12. The K_{sp} expression for the dissociation of $Cd_3(PO_4)_2$

answer: $K_{sp} = [Cd^{2+}]^3[PO_4^{3-}]^2$

The net ionic equation for the following

$(NH_4)_2CO_3(aq) + CaCl_2(aq)$ is:

answer: $CO_3^{2-}(aq) + Ca^{2-}(aq) \rightarrow CaCO_3(s)$

:TURE PRECIPITATION: insoluble solid that forms & drops out of solution

What is soluble? All Na^+, K^+, & NO_3^- salts are soluble; typically K_{sp} values are given for salts which are soluble but seem to be insoluble

calcium chloride

+

Ammonium carbonate

→ when mixed, calcium carbonate precipitated out

$CaCl$ + $(NH_4)CO_3$ →

Potassium Nitrate + Sodium Chloride → Nothing Precipitate out b/c everything in 1A are soluble and nitrates are soluble

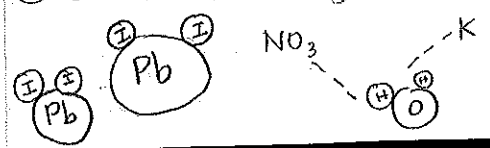
KNO_3 + $NaCl$

Lead chromate + potassium nitrate → Potassium chromate precipitated

Potassium iodide + Lead nitrate → Lead iodide will precipitate

RKSHEET ① $PbNO_3 + KI \rightarrow PbI$

② solution turned yellow when the lead iodide precipitated out of the solution



*show the precipitate clumped together and show the charges on the ion

1-31-13

③ $Pb(NO_3)_2(aq) + KI(aq) \rightarrow PbI_2(s) + 2K^+(aq) + 2NO_3^-(aq)$

$Pb^{2+}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2I^-(aq) \rightarrow PbI_2(s) + 2K^+(aq) + 2NO_3^-(aq)$

④ PbI_2

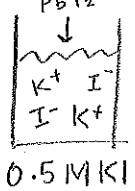
$[x][2x][2x] = 4x^3$ total concentration

$4x^3 = 1.4 \times 10^{-8}$

$\boxed{x = 1.5 \times 10^{-3}}$

* the solubility product is the value of the ion product of the molar concentrations of all the ions in the formula unit at saturation (or equilibrium)

⑤ and ⑥



The K_{sp} of PbI_2 is 1.4×10^{-8} Predict $[Pb^{2+}]$ & $[I^-]$ in when the PbI_2 is added to .5 molar solution of KI?

R $PbI_2 \rightarrow Pb^{2+} + 2I^-$

I	some	∅	0.5
C	−x	+x	+2x
E		+x	0.5+2x

$K_{sp} = [Pb^{2+}][I^-] = x(0.5 + \cancel{2x})$

↑ ignore b/c it is VERY small compared to 0.5

* common ion = dissolution is suppressed

REACTION QUOTIENT, Q

- value of the ion product at any point in a process
- if value of Q_{sp} is > than K, precipitate will form
- if value of Q_{sp} is < than K, precipitate will not form

calculating the value of Q_{sp} for the PbI_2

$Q = [Pb^{2+}][I^-]^2$

$K_{sp} = 1.4 \times 10^{-8}$

$Q_{sp} = 1.0 \times 10^{-3}$; yes a precipitate will form

1-31-13

What is the mass of the PbI_2 that was precipitated?

- go back to original equation and make the assumption that it goes to 100% precipitation

$Pb^{2+} + 2I^- \rightarrow PbI_2$ (s)

↳ limiting reactant product

How much lead is left? HALF b/c of coefficients

How much I^- is left? common ion effect

What concentration will the lead ion need to be dropped to to prevent precipitation?

* for information above, refer to key online for answers

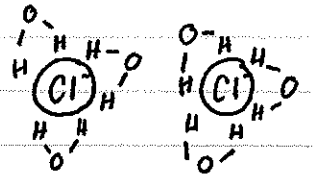
TEMP. ↑ SOLUBILITY

- Solubility ↑ w/ T for ENDOTHERMIC solutions b/c K_{sp} is bigger
- Solubility ↓ w/ T for EXOTHERMIC solutions b/c K_{sp} is smaller

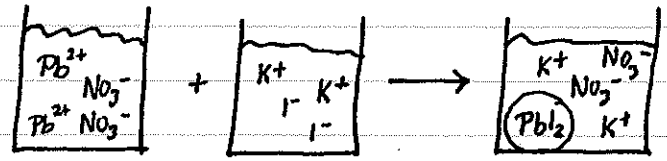
Thinking Like a Chemist About Solubility Equilibrium:

- Precipitation: Insoluble solid that forms and drops out of solution
- Spectator Ions: Ions that don't participate in the chemistry
  - * All Na^+, K^+, and NO_3^- salts are soluble

- Microscopic view of $CaCl_2 \rightarrow Cl_2$ dissolves completely into ions which are surrounded by water



- A solution of lead II nitrate is mixed with a solution of potassium iodide:
  - Net Ionic: $Pb^{2+} + 2I^- \rightarrow PbI_2$
  - Chemical Equation: $Pb(NO_3)_2\,(aq) + 2KI\,(aq) \rightarrow PbI_2\,(s) + 2KNO_3\,(aq)$



R	PbI_2	$\rightarrow Pb^{2+}$	$+ I^-$
I	some	0	0
C	$-x$	$+x$	$+2x$
E		x	$2x$

- K_{sp} of $PbI_2 = 1.4 \times 10^{-8}$ → $[Pb^{2+}] = 1.5 \times 10^{-3}$
  $K_{sp} = [Pb^{2+}][I^-]^2$ → $[I^-] = 3.0 \times 10^{-3}$
- Will the concentration of I^- or Pb^{2+} ion change if molar concentrations are at saturation (equilibrium)?, after adding more iodide ions
  - ~~No~~ Yes R

I	some	0	0.5	$K_{sp} = [Pb^{2+}][I]^2 = x(0.5 + 2x)^2$ → ignore because its very small compared to 0.5
C	$-x$	x	$2x$	$[Pb^{2+}] = 5.6 \times 10^{-8}$
E		x	$0.5 + 2x$	$[I^-] = 0.5$

- Reaction Quotient: Ion product → predicts the formation of precipitate
  - Same form as K_{sp} but different values
  - $Q_{sp} = [Pb^{2+}][I^-]^2$
  - If Q_{sp} is greater than K, the precipitate will form

Determine if precipitate will form:

$Pb(NO_3)_2$
0.2 M

KI
0.2 M
0.2 moles KI

$[Pb^{2+}] = 0.1\ M$
$[I^-] = 0.1\ M$

What is Q?

- $Q = [Pb^{2+}][I^-]^2 = [0.1][0.1]^2 = 1.0 \times 10^{-3}$
- Precipitate will form because $Q > K$

What is the mass of the precipitate that will fall out of solution?

$$\underset{0.2\ mol}{Pb^{2+}} + \underset{0.2\ mol}{2I^-} \rightarrow PbI_2\ (s)$$

] limiting reagent

- Solubility increases with T for endothermic solutions because makes K_{sp} bigger
- Solubility decreases with T for exothermic solutions