Ksp: review (grade 11)

1) What is the molar mass of H_2O?
2) How many moles are in 18 g of NaCl?
3) How many g of $CaCl_2$ are found in 2 L of a 3 M solution of $CaCl_2$? (see pg. 130 if you need help)
4) What is the concentration (in mol/L) of K^+ when 2 L of 1.5 M KCl is mixed with 1 L of 3 M K_2SO_4?

Hint: Add together the # mol K^+ from each source to get total # mol K^+. Divide this by total number of L.

Ksp (solubility product) - background

Bottom line: 1) Ksp is similar to Kc, 2) It deals with ions instead of gases, 3) one side of the chem. equation has a solid, which is ignored

We have used Kc in equilibrium problems
"K" indicates an equilibrium
"c" indicates units are mol/L (in this course it will also indicate we are dealing with gases)

There are other types of K: Ksp, Kw, Ka, Kb

Each subscript immediately indicates some detail about the equilibrium

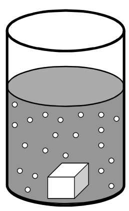
Kw: equilibrium of water, Ka: acid, Kb: base

Ksp: equilibrium between solid and ions

Ksp - background

The equilibrium between solids and ions is different from the equilibrium between gases

The equilibrium between solids and ions is a "phase" equilibrium (e.g. NaCl(aq))



$Na^+(aq) + Cl^-(aq)$
↑↓
NaCl(s)

Ksp deals with a phase equilibrium: (s) ↔ (aq)

Kc - ignoring solids and liquids

Kc calculations involve: 1) Concentrations in mol/L, 2) Gaseous products and reactants

For gases, if mol <u>or</u> L changes so does mol/L

Q - If a gas is 1 mol/L, what is it's new [ ] if it's compressed to 1/2 of its original volume?

A - Now we have 2 mol/L (e.g. 1 mol / 0.5 L)

Conversely, solids and liquids don't compress

Q - If a solid is initially 1 mol/L, what is the concentration if the volume is reduce to 1/2?

A - To get half the volume we must cut it in half … we still have 1 mol/L (e.g. 0.5 mol / 0.5 L)

<u>Concentrations of liquids and solids do not change. Concentrations of ions and gases do.</u>

Why use Ksp instead of Kc?

Read 14.9 (574 - 575), Try PE 13

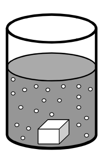
Consider: NaCl ↔ $Na^+(aq) + Cl^-(aq)$

$$\mathbf{K} = \frac{[\mathbf{Na}^+(aq)]\,[\mathbf{Cl}^-(aq)]}{[NaCl(s)]}$$

[NaCl(s)] doesn't change (it's a konstant)

$$\mathbf{K} \cdot [NaCl(s)] = [\mathbf{Na}^+(aq)]\,[\mathbf{Cl}^-(aq)]$$

$$\mathbf{Ksp} = [\mathbf{Na}^+(aq)]\,[\mathbf{Cl}^-(aq)]$$



$Na^+(aq) + Cl^-(aq)$
↑↓
NaCl(s)

We use Ksp because it indicates that the equilibrium is a phase equilibrium (between a solid and it's ions)

Ksp - molar solubility

A solid always dissolves until no more can dissolve - called <u>molar solubility</u> (mol/L or M)

An equilibrium is established when the amount dissolving equals the amount precipitating

This can only be true if there is some solid (thus, we can usually see if there is an equilibrium)

A solution with solid remaining (I.e. in equilibrium) is called "<u>saturated</u>"

Note: adding more solid will not affect equilibrium

Read 14.10 up to PE 14 (575 - 576). Try PE 14

PE 15 - 19 on pg. 578, 580; see examples on 576 - 580 for help

Example 14.12 (pg. 577)

1 L of water dissolves 7.1×10^{-7} mol of AgBr. Ksp?

<u>Step 1</u>: write the balanced chemical equation based on your knowledge of valences:

AgBr(s) ↔ $Ag^+(aq) + Br^-(aq)$

<u>Step 2</u>: solve problem using RICE chart

	AgBr(s)	$Ag^+(aq)$	$Br^-(aq)$
R		1	1
I		0	0
C		7.1×10^{-7}	7.1×10^{-7}
E		7.1×10^{-7}	7.1×10^{-7}

$Ksp = [Ag^+(aq)][Br^-(aq)]$

$Ksp = [7.1 \times 10^{-7}][7.1 \times 10^{-7}] = 5.0 \times 10^{-13}$

Example 14.14 (pg. 577)

The molar solubility of $PbCl_2$ is 1.7×10^{-3} M in a 0.10 M NaCl solution. What is Ksp?

<u>1</u>: write balanced chemical equations:

NaCl(s) ↔ $Na^+(aq) + Cl^-(aq)$ ($[Cl^-]$ = 0.10 M)

$PbCl_2(s)$ ↔ $Pb^{2+}(aq) + 2Cl^-(aq)$

<u>2</u>

	$PbCl_2(s)$	$Pb^{2+}(aq)$	$Cl^-(aq)$
R		1	2
I		0	0.10
C		1.7×10^{-3}	3.4×10^{-3}
E		1.7×10^{-3}	0.1034

$Ksp = [Pb^{2+}(aq)][Cl^-(aq)]^2$

$Ksp = [1.7 \times 10^{-3}][0.1034]^2 = 1.7 \times 10^{-5}$