SCH 4U
SOLUBILITY EQUILIBRIUM

Many substances that are insoluble and form precipitates are actually slightly soluble in very tiny amounts in water.

EG. $Ag_2SO_{4(s)} \rightleftharpoons 2Ag^+{}_{(aq)} + SO_4{}^{2-}{}_{(aq)}$ $\qquad K = \frac{\left[Ag^+{}_{(aq)}\right]^2\left[SO_4{}^{2-}{}_{(aq)}\right]}{\left[Ag_2SO_{4(s)}\right]}$

Recall concentration of a ***solid is constant***; therefore, ignore this concentration. This is known as the ***SOLUBILITY PRODUCT CONSTANT***.

Therefore, $K_{sp} = [Ag^+]^2\left[SO_4{}^{2-}\right]$

EG. Write the dissociation of calcium phosphate and its solubility product constant, K_{sp}.

① FIND K_{SP} GIVEN SOLUBILITY of a COMPOUND

EG. If $Ca(OH)_2$ has a solubility of 1.5×10^{-3} mol/L, calculate the K_{sp}.

EG. Lithium carbonate has a solubility of 13.0 g/L at 20°C. Calculate K_{sp}.

② FIND [IONS] GIVEN the K_{SP}

EG. If K_{sp} of silver sulfate is 1.2×10^{-5}, what is the concentration of silver ions and sulfate ions in a saturated solution and the molar solubility of the compound.

EG. What are the ion concentrations and the molar solubility in a saturated solution of iron (III) hydroxide if K_{sp} is 2.80×10^{-39}?

③ THE COMMON ION EFFECT

If a solution is saturated and you add more of one of the ions (from another compound), a precipitate will occur (due to Le Chatelier's Principle).

$$AB_{(s)} \rightleftharpoons A^+_{(aq)} + \mathbf{B^-_{(aq)}}$$

- Add more B^- -- stress is too much product, so equilibrium shifts left, producing more AB precipitate.

EG. Comparing solubility of the same compound in different solutions:

A) What is the solubility of **$PbCl_2$ <u>in water</u>**?

In K_{sp} table, $PbCl_2 = 1.7 \times 10^{-5}$ at 25°C.

$$PbCl_{2(s)} \rightleftharpoons Pb^{2+} + 2Cl^-$$

$K_{sp} = [Pb^{2+}][Cl^-]^2$

$1.7 \times 10^{-5} = (x)(2x)^2$

$1.6 \times 10^{-2} = x$ $\quad \therefore \quad [PbCl_2] = 1.6 \times 10^{-2}\ M$

B) What is the solubility of **$PbCl_2$ <u>in a 0.2 mol/L $NaCl_{(aq)}$ solution</u>**?

	$PbCl_2 \rightleftharpoons Pb^{2+}$	+ 2 Cl^-
I		0	0.2
C		+x	+2x
E		x	0.2+2x

$K_{sp} = [Pb^{2+}] [Cl^-]^2$

$1.7 \times 10^{-5} = (x) (0.2 + 2x)^2$

ignore 2x (approximation method)

$1.7 \times 10^{-5} = 0.04x$

$4.25 \times 10^{-4} = x$

$[PbCl_2] = 4.25 \times 10^{-4}$ mol/L

EG. A) Determine the molar solubility of $PbCrO_{4(s)}$ in water.

B) Determine the solubility of $PbCrO_{4(s)}$ in 0.10 mol/L $Na_2CrO_{4(aq)}$.

④ BUFFERS & the COMMON ION EFFECT

- Solutions that resist changes of pH when acids or bases added.
    - ***weak acid*** and ***salt of conjugate base***

      EG. HCH_3COO and $NaCH_3COO$
    - ***weak base*** and ***salt of conjugate acid***

      EG. NH_3 and NH_4Cl

These buffers have a pH other than 7.

STEPS:

1. [acid] and [ion from salt] in buffer determined by...

   $\frac{V_{initial}}{V_{total}} \times [original] = [buffer]$

2. dissociation equation of acid
3. ICE table
4. K_a expression
5. substitute and solve
6. $pH = -\log[H_3O^+]$

EG. What is the pH at 25°C of a buffer made by mixing equal volumes of 0.20 mol/L acetic acid solution and 0.20 mol/L sodium acetate solution?

EG. Calculate the pH if 200.0 mL of 0.10 mol/L ammonia and 150.0 mL of 0.25 mol/L ammonium chloride are mixed to form a buffer.