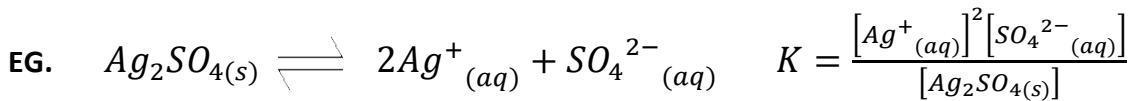


## SCH 4U SOLUBILITY EQUILIBRIUM

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



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

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

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  $1.5 \times 10^{-3}$  mol/L, calculate the  $K_{sp}$ .

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

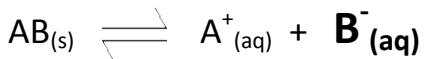
## (2) FIND [IONS] GIVEN the $K_{sp}$

EG. If  $K_{sp}$  of silver sulfate is  $1.2 \times 10^{-5}$ , 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  $2.80 \times 10^{-39}$ ?

## (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).

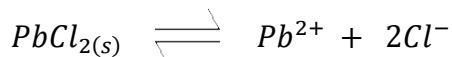


- Add more  $B^-$  -- stress is too much product, so equilibrium shifts left, producing more  $AB$  precipitate.

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

A) What is the solubility of  $PbCl_2$  in water?

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



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

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

$$1.6 \times 10^{-2} = x$$

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

B) What is the solubility of  $\text{PbCl}_2$  in a 0.2 mol/L  $\text{NaCl}_{(\text{aq})}$  solution?

	$\text{PbCl}_2 \rightleftharpoons \text{Pb}^{2+} + 2 \text{Cl}^-$	
I	0	0.2
C	+x	+2x
E	x	0.2+2x

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

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

ignore 2x (approximation method)

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

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

$$[\text{PbCl}_2] = 4.25 \times 10^{-4} \text{ mol/L}$$

EG. A) Determine the molar solubility of  $\text{PbCrO}_{4(\text{s})}$  in water.

B) Determine the solubility of  $\text{PbCrO}_{4(\text{s})}$  in 0.10 mol/L  $\text{Na}_2\text{CrO}_{4(\text{aq})}$ .

## 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.  $\text{HCH}_3\text{COO}$  and  $\text{NaCH}_3\text{COO}$

- ***weak base*** and ***salt of conjugate acid***

EG.  $\text{NH}_3$  and  $\text{NH}_4\text{Cl}$

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.  $pH = -\log[\text{H}_3\text{O}^+]$

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.