Monday, January 27, 2014
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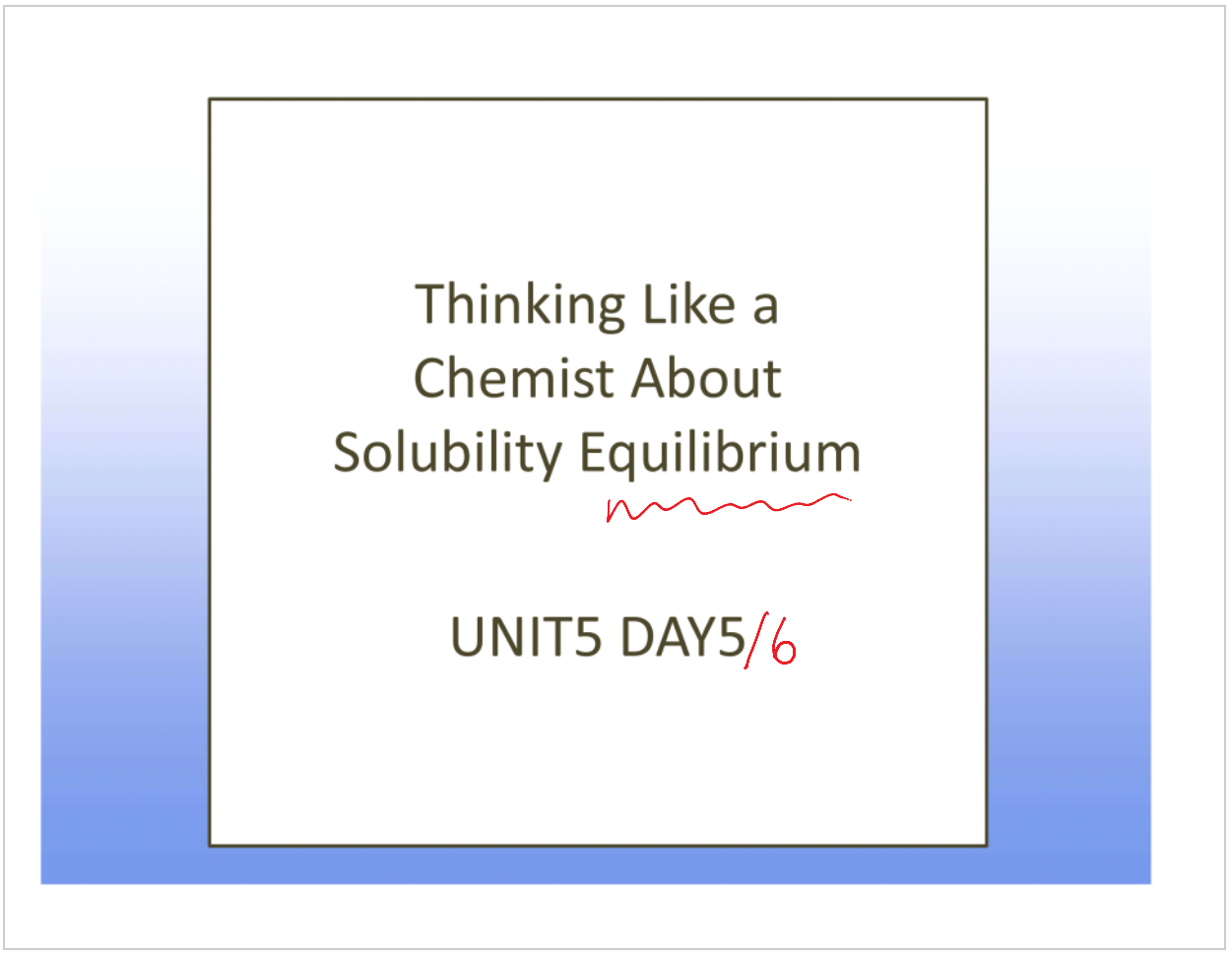


What are we going to learn today?

Thinking Like a Chemist in the Context of the Solution Equilbria

Concept of Solubility
Modeling Ionic Reactions
Solubility Product Constant

LM 10 + 11 last night

IMPORTANT INFORMATION

LM09 and HW2 due this morning

LM10 and LM11 due Th 9AM

LM12 AND HW3 Post Today due Tue 9AM

Looking ahead:

EXAM 1, WED Feb 5th 7 – 9 PM

Details of room assignments will be posted on website next week

Quiz: Clicker Question

When comparing the free energy of the pure solvent to the free energy of a solution formed by dissolving a solid solute in the solvent, the free energy of the solution is:

A. Higher

B. No difference

C. Lower

D. Follows no trend, you need to calculate

Quiz: Clicker Question

Which would you expect to have the lowest vapor pressure?

A. 4 M sugar aqueous solution

B. 0.75 M KCl aqueous solution

C. 0.25 M $CaCl_2$ aqueous solution

D. 1.5 M $MgCl_2$ aqueous solution

E. Are they all the same?

used in de-icing

$i = 3$

$3 \times 1.5 = 4.5\ M$

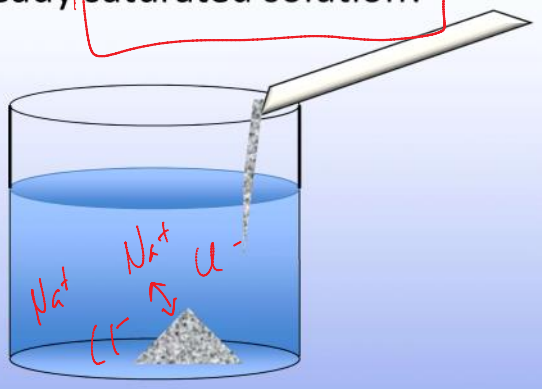
NO

Imagine you have a beaker that contains water and lots of NaCl. You stir for hours to get the salt to dissolve. In the end, the solution still contains some amount of solid NaCl that won't dissolve.

We call such a solution a **saturated solution**.

Poll: Clicker Question 3

What will happen if I add even more solid salt to an already saturated solution?



a. A little more of the salt will dissolve.
b. The solution will become less saturated
c. The concentration of the salt will remain the same.
d. Can't answer without knowing the solubility of the salt.

Solubility

The amount of solute that will dissolve
in a given amount of solvent or solution

We will discuss almost exclusively
the solubility of compounds in water

Solubility: Often given in grams of solute per liter solution
For example: the solubility of KBr in water is 678g/L!

Molar Solubility: is the number of moles of solute that will dissolve in 1 L solvent.
For example: the molar solubility of KBR is 5.7 M.

[KBr] = 5.7 M

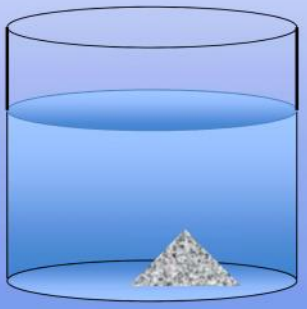
KBr

Solubility

Solubilities are given for saturated solutions
They depend on temperature

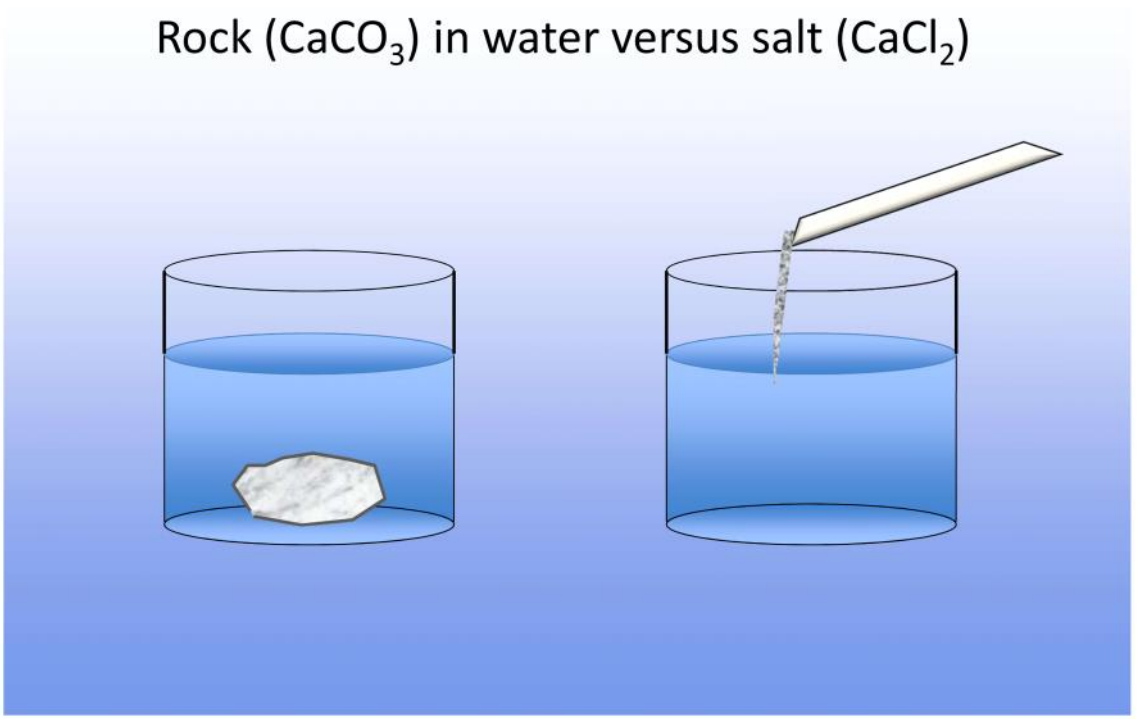
These systems are also in dynamic equilibrium

Rate of solute dissolving = Rate of solute recrystallizing



START WORKING ON ACTIVITY

Rock ($CaCO_3$) in water versus salt ($CaCl_2$)



Poll: Clicker Question

How much of the rock dissolved?

A. None of the rock dissolved

B. All of the rock dissolved

C. A tiny amount dissolved

Compare solubilities… model with reaction:

$CaCl_2(s) \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$

100% to completion

$CaCO_3(s) \leftrightarrows Ca^{2+}(aq) + CO_3^{2-}(aq)$

Equilibrium

Poll: Clicker Question

The molar solubility of $CaCl_2$ is:

A. 0.40 M
B. 0.65 M
C. 3.6×10^{-3} M
D. 1.5 M
E. 5.1 M

$CaCl_2$ $\frac{64.7\ g\ CaCl_2}{100\ g\ H_2O}$

NaCl $\frac{35.72\ g\ NaCl}{100\ g\ H_2O}$

density soln = $1.435\ \frac{g}{mL}$

density soln = $1.199\ \frac{g}{mL}$

molar mass $CaCl_2$ $111.07\ \frac{g}{mol}$

molar mass $58.5\ \frac{g}{mol}$

$$\frac{64.7\ g\ CaCl_2}{(100\ g\ H_2O + 64.7\ g\ (CaCl_2)} \left| \frac{1.485\ g\ soln}{1\ mL\ soln} \right| \frac{1000\ mL\ soln}{1\ L\ soln} \left| \frac{1\ mol\ CaCl_2}{111.07\ g\ CaCl_2} \right. = 5.1\ M$$

(mass soln)

$$\frac{35.72\ NaCl}{100\ g\ H_2O + 35.72\ g\ NaCl} \left| \frac{1.199\ g\ soln}{1\ mL\ soln} \right| \frac{1000\ mL\ soln}{1\ L\ soln} \left| \frac{1\ mol\ NaCl}{58.5\ g\ NaCl} \right. = 5.4\ M$$

Poll: Clicker Question

$K_{sp} = 8.7 \times 10^{-9}$

Limestone rock

$CaCO_3(s) \leftrightarrow Ca^{2+}(aq) + CO_3^{2-}(aq)$

$K_{sp} = [Ca^{2+}][CO_3^{2-}]$

$8.7 \times 10^{-9} = [x][x]$

$[Ca^{2+}] = [CaCO_3]$

Set up the K_{sp} expression.
Solve for molar solubility of $CaCO_3$.

a. 9.3×10^{-5}
b. 9.3×10^{5}
c. 4.4×10^{-9}
d. Not enough information
e. Insoluble means not soluble, so it is 0

[ ] ← symbol for molar concentration

What is the solubility of AgCl?

$$AgCl\ (s) \longleftrightarrow Ag^+(aq) + Cl^-(aq)$$

$$K_{sp} = [Ag^+][Cl^-] = 1.8 \times 10^{-10}$$

Reaction	$AgCl\ (s) \longleftrightarrow Ag^+(aq) + Cl^-(aq)$
Initial	
Change	
Equilibrium	

Poll: Clicker Question

Given a generic formula, AX_2, where A is the cation and X is the anion, and the molar solubility has been determined to be 1 X 10^{-4} M.
Calculate the value of the Ksp.

A. $K_{sp} = 1 \times 10^{-4}$
B. $K_{sp} = 1 \times 10^{-8}$
C. $K_{sp} = 2 \times 10^{-4}$
D. $K_{sp} = 4 \times 10^{-8}$
E. $K_{sp} = 4 \times 10^{-12}$

$[AX_2] = 1 \times 10^{-4}\ M$

$AX_{2(s)} \leftrightarrow 1A^{2+} + 2X^-$

$[AX_2] = [A^{2+}]$ because 1:1 molar ratio

$[A^{2+}] = 1 \times 10^{-4}\ M$

$[X^-] = 2[A^{2+}] = 2 \times 10^{-4}$

Poll: Clicker Question

$K_{sp} = [A^{2+}][X^-]^2$

$K_{sp} = [1 \times 10^{-4}][2 \times 10^{-4}]^2 =$

Which of the following compounds has the lowest molar solubility?

A. AgCl $K_{sp} = 1.8 \times 10^{-10}$
B. FeS $K_{sp} = 8.0 \times 10^{-19}$
C. LiF $K_{sp} = 1.8 \times 10^{-3}$
D. ZnSe $K_{sp} = 2.0 \times 10^{-25}$

All 1:1 ratio of ions

$[C^+][A^-]$

Poll: Clicker Question

Which of the following compounds has the lowest molar solubility?

A.	$AgCl$	$K_{sp} = 1.8 \times 10^{-10}$	$K_{sp} = [Ag^{+}][Cl^{-}]$
B.	$Cd_3(PO_4)_2$	$K_{sp} = \sqrt[5]{2.5 \times 10^{-30}}$	$K_{sp} = [Cd^{2+}]^3[PO_4^{3-}]^2$ 5 ions per unit
C.	$Zn(OH)_2$	$K_{sp} = 3.0 \times 10^{-17}$	$K_{sp} = [Zn^{2+}][OH^{-}]^2$
D.	$ZnSe$	$K_{sp} = \sqrt{2.0 \times 10^{-25}}$	$K_{sp} = [Zn^{2+}][Se^{2-}]$ 2 ions per unit

How did you know that so fast?

Quick way to estimate using your exponent math skills.

CH302 Vanden Bout/LaBrake Spring 2012

Poll: Clicker Question

The net ionic equation for the following is:

$(NH_4)_2CO_{3(aq)} + CaCl_{2(aq)} \rightarrow$

A. $(NH_4)_2CO_3(aq) + CaCl_2(aq) \rightarrow 2NH_4Cl(aq) + CaCO_3(aq)$

B. $(NH_4)_2CO_3(aq) + CaCl_2(aq) \rightarrow 2NH_4Cl(aq) + CaCO_3(s)$

C. $2NH_4^+(aq) + CO_3^{2-}(aq) + Ca^{2+}(aq) + 2Cl^- \rightarrow 2NH_4^+(aq) + 2Cl^-(aq) + CaCO_3(s)$

D. $2NH_4^+(aq) + CO_3^{2-}(aq) + Ca^{2+}(aq) + 2Cl^- \rightarrow CaCO_3(s)$

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

What did we learn today?

Solubility is an equilibrium condition.

Quantify the solubility using equilibrium constant, K.

K is “Ion Product” = product of the ions in solution

Learning Outcomes

Understand the concept of the ion product.

Write formula unit, total ionic and net ionic reactions, and identify spectator ions.