7. SOLUBILITY EQUILIBRIUM

UNIT 3 – CHEMICAL EQUILIBRIUM

CH40S MR. WIEBE

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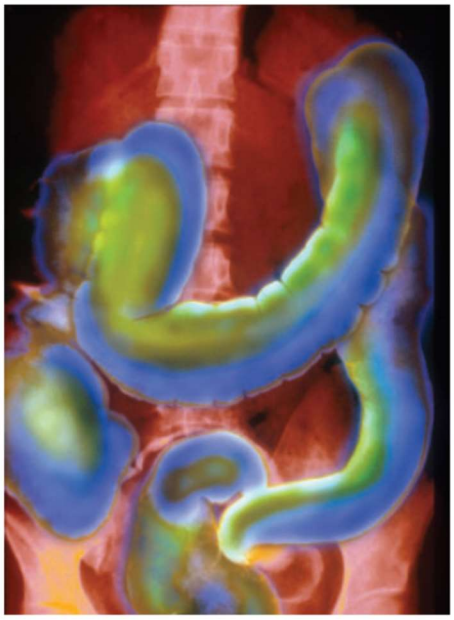
REVIEW – WHAT IS SOLUBILITY?



solubility the quantity of solute that dissolves in a given quantity of solvent at a particular temperature; the concentration of a saturated solution at a particular temperature

Figure 1 Barium sulfate makes the large intestine more visible in this X-ray image. Barium ions are toxic to humans, so the low solubility of barium sulfate also protects the patient from any toxic side effects.

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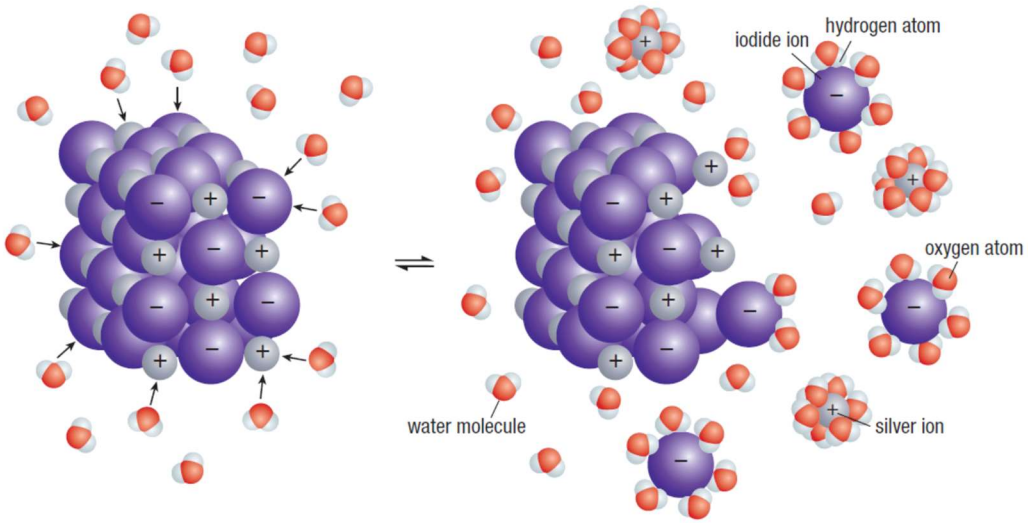
IONIC COMPOUNDS DISSOCIATE IN WATER



$$AgI(s) \rightarrow Ag^{+}(aq) + I^{-}(aq)$$

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GENERAL SOLUBILITY

Your data booklet gives you relative solubility

Low Sol means ≤ .1M

$CaSO_4$ Low

High Sol means > .1 M

Na_3PO_4 High

SOLUBILITY OF COMMON COMPOUNDS IN WATER

The term soluble here means > 0.1 mol/L at 25°C.

Negative Ions (Anions)	Positive Ions (Cations)	Solubility of Compounds
All	Alkali ions: Li^+, Na^+, K^+, Rb^+, Cs^+, Fr^+	Soluble
All	Hydrogen ion: H^+	Soluble
All	Ammonium ion: NH_4^+	Soluble
Nitrate, NO_3^-	All	Soluble
Chloride, Cl^- or Bromide, Br^- or Iodide, I^-	All others	Soluble
	Ag^+, Pb^{2+}, Cu^+	Low Solubility
Sulphate, SO_4^{2-}	All others	Soluble
	Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}	Low Solubility
Sulphide, S^{2-}	Alkali ions, H^+, NH_4^+, Be^{2+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}	Soluble
	All others	Low Solubility
Hydroxide, OH^-	Alkali ions, H^+, NH_4^+, Sr^{2+}	Soluble
	All others	Low Solubility
Phosphate, PO_4^{3-} or Carbonate, CO_3^{2-} or Sulphite, SO_3^{2-}	Alkali ions, H^+, NH_4^+	Soluble
	All others	Low Solubility

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SATURATED SOLUTIONS ARE EQUILIBRIUMS!

This part of the unit is all about the equilibrium that forms when solutes are dissolved in solution…the Ksp and the solubility of saturated solutions.

Unsaturated Solutions

- Not full -more solid dissolves
- The rate of dissolving > the rate of crystallizing
- Not at equilibrium

Saturated Solutions

- Full-more solid doesn't dissolve
- The rate of dissolving = the rate of crystallizing
- At equilibrium

PhET Simulation - Solubility

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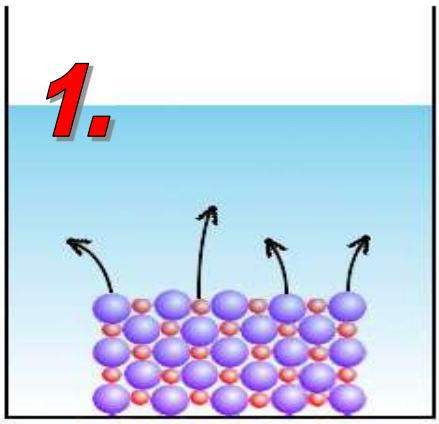
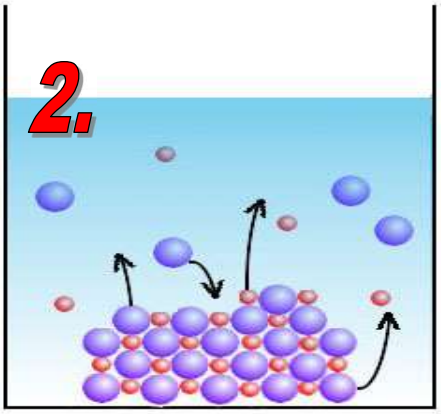
SOLUBILITY EQUILIBRIUM

$AgI(s) \rightarrow Ag^+(aq) + I^-(aq)$



Salt is initially put into the water and begins dissolving.

$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$



Salt continues to dissolve; however, dissolved ions will also precipitate. Because the salt dissolves faster than its ions precipitate, the net movement is towards dissolution.

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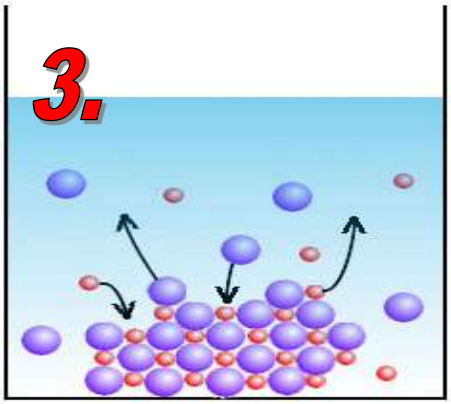
SOLUBILITY EQUILIBRIUM

solubility equilibrium a dynamic equilibrium between a solute and a solvent in a saturated solution in a closed system

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq)$$



Eventually, the rate of dissolution will equal the rate of precipitation. The solution will be in equilibrium, but the ions wil continue to dissolve and precipitate.

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SOLUBILITY PRODUCT CONSTANT (K_{sp})

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq)$$

solubility product constant (K_{sp}) the value obtained from the equilibrium law applied to a saturated solution

$$K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$$K = \frac{[Ag^+(aq)][I^-(aq)]}{[AgI(s)]}$$

$$K_{sp} = [Ag^+(aq)][I^-(aq)]$$

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INTERPRETING K_{sp} VALUES

The larger the Ksp value, the more soluble the solute.

All Ksp values are <1, meaning all solutes with Ksp values are reactant favoured (very low solubility).

Ksp values increase with temperatures.

SOLUBILITY PRODUCT CONSTANTS AT 25°C

Name	Formula	K_{sp}
Silver chloride	AgCl	1.8×10^{-10}
Silver iodate	$AgIO_3$	3.2×10^{-8}
Silver iodide	AgI	8.5×10^{-17}

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq)$$

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EXAMPLE 1: THE EQUILIBRIUM EXPRESSION

Write the solubility product constant equation for a saturated solution of aluminum sulphate, $Al_2(SO_4)_3$, at 25°C.

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EXAMPLE 2: CALCULATING K_{SP}

The solubility of $PbBr_2$ is 0.012 M @ 25 ^{0}C. Calculate the Ksp. Is lead(II) bromide more or less soluble than barium carbonate?

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EXAMPLE 3: CALCULATING SOLUBILITY FROM K_{SP}

Calculate the molar solubility @ 25°C for $Cu(IO_3)_2$. From your ICE table, communicate the molarity of each dissolved ion in this saturated solution.

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