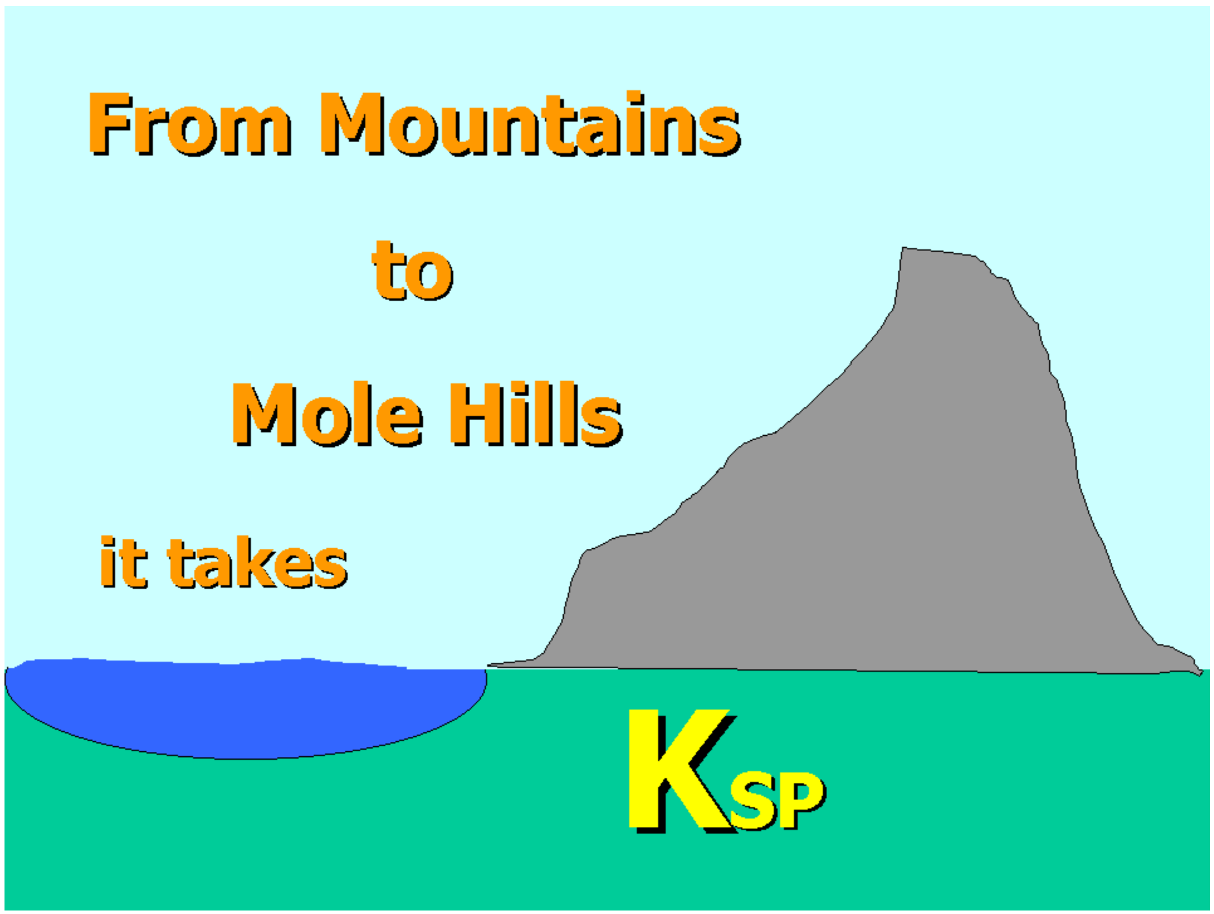
Notes 9 -The Solubility Product Constant



The Solubility Product Constant

Some ionic compounds dissolve readily in water, and some barely dissolve at all.

The equilibrium constant expression for the dissolving of a sparingly soluble compound is called the solubility product constant, K_{sp}.

The Solubility Product Constant

Write a solubility product constant K_{sp} expression for this reaction:

$$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$$

$$K_{sp} = [Mg^{2+}][OH^-]^2$$

The Solubility Product Constant

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Table 17.3 Solubility Product Constants at 298 K

Compound	K_{sp}	Compound	K_{sp}	Compound	K_{sp}
Carbonates		**Halides**		**Hydroxides**	
$BaCO_3$	2.6×10^{-9}	CaF_2	3.5×10^{-11}	$Al(OH)_3$	4.6×10^{-33}
$CaCO_3$	3.4×10^{-9}	$PbBr_2$	6.6×10^{-6}	$Ca(OH)_2$	5.0×10^{-6}
$CuCO_3$	2.5×10^{-10}	$PbCl_2$	1.7×10^{-5}	$Cu(OH)_2$	2.2×10^{-20}
$PbCO_3$	7.4×10^{-14}	PbF_2	3.3×10^{-8}	$Fe(OH)_3$	4.9×10^{-17}
$MgCO_3$	6.8×10^{-6}	PbI_2	9.8×10^{-9}	$Fe(OH)_3$	2.8×10^{-39}
Ag_2CO_3	8.5×10^{-12}	$AgCl$	1.8×10^{-10}	$Mg(OH)_2$	5.6×10^{-12}
$ZnCO_3$	1.5×10^{-10}	$AgBr$	5.4×10^{-13}	$Zn(OH)_2$	3×10^{-17}
Hg_2CO_3	3.6×10^{-17}	AgI	8.5×10^{-17}	**Sulfates**	
Chromates		**Phosphates**		$BaSO_4$	1.1×10^{-10}
$BaCrO_4$	1.2×10^{-10}	$AlPO_4$	9.8×10^{-21}	$CaSO_4$	4.9×10^{-5}
$PbCrO_4$	2.3×10^{-13}	$Ca_3(PO_4)_2$	2.1×10^{-33}	$PbSO_4$	2.5×10^{-8}
Ag_2CrO_4	1.1×10^{-12}	$Mg_3(PO_4)_2$	1.0×10^{-24}	Ag_2SO_4	1.2×10^{-5}

The Solubility Product Constant

Use the K_{sp} value from Table 3 to calculate the solubility in mol/L of copper (II) carbonate, $CuSO_4$ at 298 K.

$$CuCO_3(s) \rightleftharpoons Cu^{2+}(aq) + CO_3^{2-}(aq)$$

$$K_{sp} = [Cu^{2+}][CO_3^{2-}] = 2.5 \times 10^{-10}$$

The Solubility Product Constant

Let s represent the solubility of $CuSO_4$, that is, the number of moles of $CuSO_4$ that dissolves in 1 L of solution. For every mole of $CuSO_4$ that dissolves, an equal number of moles of Cu^{2+} ions forms in solution.

$$CuCO_3(s) \rightleftharpoons Cu^{2+}(aq) + CO_3^{2-}(aq)$$

Therefore, $[Cu^{2+}.] = s$.

The Solubility Product Constant

Every Cu^{2+} has an accompanying CO_3^{2-} ion, so $[CO_3^{2-}]$ also equals s. Substituting s for $[Cu^{2+}]$ and $[CO_3^{2-}]$, the K_{sp} expression becomes the following:

$$s = [Cu^{2+}] = [CO_3^{2-}]$$

$$(s)(s) = s^2 = 2.5 \times 10^{-10}$$

$$s = \sqrt{2.5 \times 10^{-10}} = \mathbf{1.6 \times 10^{-5}\ mol/L}$$