91392 Demonstrate understanding of equilibrium principles in aqueous systems

SUMMARY

Solubility and Ks

s = solubility

K_s = solubility product expression

Equation for equilibrium - dissolving in water to form a saturated solution: $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

- State symbols
- $\rightleftharpoons$ arrow
- Correct charges!!!

Solubility product expression: $K_s = [Ag^+(aq)]\,[Cl^-(aq)]$

	AB type	AB_2 or A_2B type
example	$CaCO_3$	$Zn(OH)_2$ or Ag_2CrO_4
	$\mathbf{CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)}$	$\mathbf{Zn(OH)_2(s) \rightleftharpoons Zn^{2+}(aq) + 2OH^-(aq)}$
	$\mathbf{K_s = [Ca^{2+}(aq)]\ [CO_3^{2-}(aq)]}$	$\mathbf{K_s = [Zn^{2+}(aq)]\ [OH^-(aq)]^2}$
s (in mol L^{-1})	$s = \sqrt{Ks}$	$s = \sqrt[3]{Ks/4}$
K_s (no units)	$K_s = s^2$	$K_s = 4s^3$

Ionic product and predicting precipitation.

Ionic product is I.P. or Q. (no units needed)

- If I.P. > K_s then a precipitate will form
- If I.P. = K_s then the solution will be a saturated solution (no ppt)
- If I.P. < K_s then a precipitate will not form (and the solution will not be saturated either)

Recognise these questions by…..

"will a precipitate form when ***a*** mL of …. is mixed with ***b*** mL of ….."

"will a precipitate form when **c** g of …… is added to **d** mL of …… "

"what concentration/mass of …… needs to be added to ***e*** mL of …… for a precipitate to form"

"what concentration/mass of …… needs to be added to ***f*** mL of …… to make a saturated solution" etc

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Converting quantities – you might use n=CV and n=m/M

mol $\rightarrow$ g (x M) So mol $L^{-1} \rightarrow$ g L^{-1} (x M)

g $\rightarrow$ mol ($\div$ M) So g $L^{-1} \rightarrow$ mol L^{-1} ($\div$ M)

Common ion and dissolving precipitates

<table>
<tr><th>Common ion effect</th><th colspan="2">Complex ions with (excess)
NaOH(aq) or NH_3(aq)</th></tr>
<tr><td rowspan="2">Dissolving the sparingly soluble solid in a solution that contains one of its ions – i.e. an ion in common (the same ion)

E.g. dissolving $BaSO_4$(s) in Na_2SO_4 solution which contains Na^+(aq) and SO_4^{2-}(aq).

The common ion is the $\mathbf{SO_4^{2-}}$ ion.</td><td colspan="2">Complex ions to know from L2</td></tr>
<tr><td>$[Cu(NH_3)_4]^{2+}$ (aq)
$[Zn(NH_3)_4]^{2+}$ (aq)

$[Ag(NH_3)_2]^{+}$ (aq)</td><td>$[Zn(OH)_4]^{2-}$ (aq)
$[Pb(OH)_4]^{2-}$ (aq)

$[Al(OH)_4]^{-}$ (aq) *maybe schol</td></tr>
<tr><td>$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$

Equilibrium position shifts to the LEFT when $[SO_4^{2-}(aq)]$ is increased – the solubility of sparingly soluble solid ($BaSO_4$) decreases (compared to its solubility in water).</td><td colspan="2">E.g.
1. $Cu(OH)_2(s) \rightleftharpoons Cu^{2+}(aq) + 2OH^-(aq)$
2. $Cu^{2+}(aq) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq)$

Equilibrium position in 1. shifts to the right – as the Cu^{2+}(aq) reacts with NH_3(aq) to form the complex ion in reaction 2. and is removed from the equilibrium. More $Cu(OH)_2$(s) dissolves to re-establish the equilibrium.

The solubility of sparingly soluble solid increases – the precipitate dissolves.</td></tr>
<tr><td colspan="3">"At low pH" or "increased ocean acidification"
Look for an ion(aq) that would react with H_3O^+</td></tr>
<tr><td>A sparingly soluble carbonate

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

CO_3^{2-}(aq) ions will react with H_3O^+ (H^+) to form CO_2 gas and H_2O.

Equilibrium position shifts to the right. Solubility of $CaCO_3$(s) increases so that $[Ca^{2+}][CO_3^{2-}]$ will again equal K_s.</td><td colspan="2">A sparingly soluble hydroxide

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

OH^-(aq) will react with (neutralise) H_3O^+ (H^+) to form H_2O. A decrease in $[OH^-]$ will result in the forward reaction being favoured. Equilibrium position shifts to the right to restore the equilibrium / minimise the change.

Solubility of $Zn(OH)_2$(s) increases so that $[Zn^{2+}][OH^-]^2$ will again equal K_s.</td></tr>
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