Answer on question #38477, Chemistry, Other

Calculate the molar solubility of Strontium Carbonate in a solution that has been fixed so that its pH is constant and equal to 6.00.

Solution:

Solubility of $SrCO_3$ in pure water at 18 ºC is equal 1,1 mg/100 ml or $7,45 \cdot 10^{-5}$ M.

Acid dissociation constant of H_2CO_3: $pK_{a1} = 6,367$; $pK_{a2} = 10,32$.

Base dissociation constant of $Sr(OH)_2$: $pK_{b2} = 0,82$.

$K_w = [H^+][OH^-]$; $K_w = [H^+][OH^-]$

In water next equilibriums are present:

$SrCO_{3 (s)} \rightleftarrows Sr^{2+}_{(aq)} + CO_3^{2-}$; solubility product: $K_{sp} = [Sr^{2+}][CO_3^{2-}]$;

$CO_3^{2-} + H_2O \rightleftarrows HCO_3^- + OH^-$; first hydrolysis constant $K_1 = \dfrac{K_w}{K_{a2}} = \dfrac{[HCO_3^-][OH^-]}{[CO_3^{2-}]}$,

$pK_1 = 3,68$;

$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$; second hydrolysis constant

$K_2 = \dfrac{K_w}{K_{a1}} = \dfrac{[H_2CO_3][OH^-]}{[HCO_3^-]}$, $pK_2 = 7,633$;

$Sr^{2+} + H_2O \; Sr(OH)^+ + H^+$; first hydrolysis constant $K_1 = \dfrac{K_w}{K_{b2}} = \dfrac{[Sr(OH)^+][H^+]}{[Sr^{2+}]}$,

$pK_1 = 11,18$;

Second step of hydrolysis of CO_3^{2-} and first step of hydrolysis of Sr^{2+} are negligible at pH values near 7 ($K_1/K_2 \approx 10^4$) and can be ignored in further calculations.

In pure water $[Sr^{2+}] = 7,45 \cdot 10^{-5}$ M and $[CO_3^{2-}] + [HCO_3^-] = 7,45 \cdot 10^{-5}$ M.

Let $[HCO_3^-] = [OH^-]$ be equal to "y", then $[CO_3^{2-}] = 7,45 \cdot 10^{-5} - y$.

$K_2 = \dfrac{y*y}{7,45 \cdot 10^{-5} - y} = 2,09 \cdot 10^{-4}$. Solving this equation we get value y = $5,83 \cdot 10^{-5}$.

So, $[HCO_3^-] = 5,82 \cdot 10^{-5}$ M and $[CO_3^{2-}] = 1,62 \cdot 10^{-5}$ M.

Solubility product for $SrCO_3$ is equal: $K_{sp} = [Sr^{2+}][CO_3^{2-}] = 7,45 \cdot 10^{-5}$ M · $1,62 \cdot 10^{-5}$ M = $1,2 \cdot 10^{-9}$ M².

If the value of pH is constant molar fraction of different acid forms is depend on pH and don't depend on general concentration of acids forms. For dibasic acid H_2CO_3:

$\phi(CO_3^{2-}) = \dfrac{[CO_3^{2-}]}{[CO_3^{2-}] + [HCO_3^-] + [H_2CO_3]} = \dfrac{K_{a1} K_{a2}}{K_{a1} K_{a2} + K_{a1}[H^+] + [H^+]^2}$;

If pH = 6, $\phi(CO_3^{2-}) = \dfrac{4,3 \cdot 10^{-5} \cdot 4,79 \cdot 10^{-11}}{4,3 \cdot 10^{-5} \cdot 4,79 \cdot 10^{-11} + 4,3 \cdot 10^{-5} \cdot 10^{-6} + (10^{-6})^2}$ = $1,44 \cdot 10^{-5}$;

So, $K_{sp} = [Sr^{2+}][CO_3^{2-}]$; $[CO_3^{2-}] = c(CO_3^{2-}) \cdot \varphi(CO_3^{2-}) = s \cdot \varphi(CO_3^{2-})$; $[Sr^{2+}] = s$.

$K_{sp} = s \cdot s \cdot \varphi(CO_3^{2-}) = 1,44 \cdot 10^{-5} \cdot s^2 = 1,2 \cdot 10^{-9}$. Hence, molar solubility of $SrCO_3$ in solution with pH = 6 is equal s = $9 \cdot 10^{-3}$ M.

Answer: s = $9 \cdot 10^{-3}$ M