The pH of surface ocean water is currently 8.10 (having fallen from a pre-industrial era level of 8.16), the concentration of HCO_3^- is 2.5×10^{-3} M, and it is saturated with $CaCO_3$. Calculate the concentration of Ca^{2+} in these conditions.

Marks 4

From 2008-N-2,

$$K_b = \frac{[OH^-(aq)][HCO_3^-(aq)]}{[CO_3^{2-}(aq)]} = 10^{-3.67}$$

If pH = 8.10 then pOH = 14.00 – 8.10 = 5.90 and so $[OH^-(aq)] = 10^{-5.90}$ M.

If $[HCO_3^-] = 2.5 \times 10^{-3}$ M, then

$$[CO_3^{2-}] = \frac{[OH^-(aq)][HCO_3^-(aq)]}{K_b} = \frac{(10^{-5.90})(2.5\times10^{-3})}{(10^{-3.67})} = 1.47 \times 10^{-5}$$

From 2008-N-2, $K_{sp} = [Ca^{2+}(aq)][CO_3^{2-}(aq)] = 3.3 \times 10^{-9}$. Hence,

$[Ca^{2+}(aq)] = K_{sp} / [CO_3^{2-}(aq)] = 3.3 \times 10^{-9} / (1.47 \times 10^{-5}) = 2.2 \times 10^{-4}$ M

$[Ca^{2+}] = 2.2 \times 10^{-4}$ M

The pH is expected to drop to about 7.8 by the end of the century as CO_2 levels increase further. What effect will this have on the solubility of $CaCO_3$ in sea water? Use chemical equations to assist with explaining your answer.

The solubility of $CaCO_3$ will increase.

At a lower pH, $[OH^-(aq)]$ will be lower. The equilibrium below will be shifted to the right:

$$CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + HCO_3^-(aq)$$

With lower $[CO_3^{2-}(aq)]$, $[Ca^{2+}(aq)]$ will increase as $[Ca^{2+}(aq)] = K_{sp} / [CO_3^{2-}(aq)]$. The solubility will be increased.