Marks 6

- All forms of life depend on iron and the concentration of iron in the oceans and elsewhere is one of the primary factors limiting the growth rates of the most basic life forms. One reason for the low availability of iron(III) is the insolubility of the hydroxide, $Fe(OH)_3$, which has a K_{sp} of only 2×10^{-39}.

  Calculate the maximum possible concentration of $Fe^{3+}(aq)$ in the pre-industrial era ocean which had a pH of about 8.2.

When pH = 8.2, pOH = 14.0 – 8.2 = 5.8. As $pOH = -\log_{10}[OH^-(aq)]$:

$[OH^-(aq)] = 10^{-5.8}$ M

$Fe(OH)_3(s)$ dissolves according to the chemical equation:

$$Fe(OH)_3(s) \rightleftharpoons Fe^{3+}(aq) + 3OH^-(aq)$$

The solubility product is therefore given by:

$$K_{sp} = [Fe^{3+}(aq)][OH^-(aq)]^3$$

As $[OH^-(aq)] = 10^{-5.8}$ M:

$$[Fe^{3+}(aq)] = K_{sp} / [OH^-(aq)]^3 = 2 \times 10^{-39} / (10^{-5.8})^3 \text{ M} = 5 \times 10^{-22} \text{ M}$$

$[Fe^{3+}(aq)] = \mathbf{5 \times 10^{-22}\ M}$

How many $Fe^{3+}(aq)$ ions are present in a litre of seawater at this pH?

From above, $[Fe^{3+}(aq)] = 5 \times 10^{-22}$ M $= 5 \times 10^{-22}$ mol L^{-1}. Hence, a litre of seawater contains 5×10^{-22} mol.

The number of ions of Fe^{3+} is therefore:

$$\text{number of ions} = (5 \times 10^{-22}\ \text{mol}) \times (6.022 \times 10^{23}\ \text{mol}^{-1}) = 300$$

Answer: **300**

The pH of the ocean is predicted to drop to 7.8 by the end of this century as the concentration of CO_2 in the atmosphere increases. What percentage change in the concentration of $Fe^{3+}(aq)$ will result from this fall in pH?

When pH = 7.8, pOH = 14.0 – 7.8 = 6.2 and $[OH^-(aq)] = 10^{-6.2}$ M. Hence:

$$[Fe^{3+}(aq)] = K_{sp} / [OH^-(aq)]^3 = 2 \times 10^{-39} / (10^{-6.2})^3 \text{ M} = 8 \times 10^{-21} \text{ M}$$

The percentage increase is therefore:

$$\text{percentage change} = \frac{(8 \times 10^{-21} - 5 \times 10^{-21})}{5 \times 10^{-21}} \times 100\ \% = 1500\ \%$$

Answer: **1500 %**