5. Based on the solubility product for calcium carbonate, how much calcium (mg/L as $CaCO_3$) should be soluble in this water? Is the water under-saturated or over-saturated with respect to calcium?

$K_s = [Ca^{2+}][CO_3^{2-}]$ ← concentration in mol/L (from 1 = 2×10^{-5})

$10^{-8.305} = [Ca^{2+}][2 \times 10^{-5}]$

$[Ca^{2+}] = 2.48 \times 10^{-4}$ mol/L

$[Ca^{2+}] = 2.48 \times 10^{-4}\ \text{mol/L} \times \frac{40\ g}{mol} \times 1000\ \frac{mg}{g} \times \left(\frac{50}{40_2}\right) = 24.8$ mg/L as $CaCO_3$

∴ Calcium should be soluble in this water = 24.8 mg/L as $CaCO_3$

In reality concentration of Ca^{2+} in this water = 300 mg/L as $CaCO_3$ (from Q. 2)

300 mg/L as $CaCO_3$ > > > 24.8 mg/L as $CaCO_3$

→ over-saturated.

6. Based on the solubility product for magnesium hydroxide, how much magnesium (mg/L as $CaCO_3$) should be soluble in this water? Is water under-saturated or over-saturated with respect to magnesium?

$K_s = [Mg^{2+}][OH^-]^2$ ← unit in mol/L

$10^{-11.25} = [Mg^{2+}][6.17 \times 10^{-7}]^2$ ← from Q. 1

$[Mg^{2+}] = 14.77$ mol/L

$= 14.77\ \text{mol/L} \times \frac{24\ g}{mole} \times 1000\ \frac{mg}{g} \times \left(\frac{50}{94_2}\right) = 1.48 \times 10^6$ mg/L as $CaCO_3$

∴ Magnesium should be soluble in this water = 1.48×10^6 mg/L as $CaCO_3$

From question # 2, concentration of magnesium in this water is only 160.64 mg/L as $CaCO_3$ that is much lower than its ability to be soluble in this water (1.48×10^6 mg/L as $CaCO_3$).

under-saturated.