- 2.00 g of solid calcium hydroxide is added to 1.00 L of water. What proportion of the calcium hydroxide remains undissolved when the system has reached equilibrium? $K_{sp}(Ca(OH)_2) = 6.5 \times 10^{-6}\ M^3$

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The formula mass of $Ca(OH)_2$ is (40.08 Ca)) + 2 × (16.00 (O) + 1.008 (H)) = 74.096. 2.00 g of $Ca(OH)_2$ therefore corresponds to:

$$\textbf{amount of } Ca(OH)_2 = \frac{\textbf{mass}}{\textbf{formula mass}} = \frac{2.00}{74.096} = 0.0270 \text{ mol}$$

The solubility equilibrium and constant are given by:

$$Ca(OH)_2 \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq) \quad K_{sp} = [Ca^{2+}(aq)][OH^-(aq)]^2$$

If *S* mol dissolves in 1.00 L then $[Ca^{2+}(aq)] = S$ and $[OH^-(aq)] = 2S$. Thus,

$$K_{sp} = (S)(2S)^2 = 4S^3 = 6.5\ 8\ 10^{-6} \quad \text{so } S = 0.0118 \text{ mol}$$

The amount that remains undissolved is (0.0270) – (0.0118) = 0.0152 mol. The proportion that is undissolved is $\frac{0.0152}{0.0270} \times 100\% = 56\%$.

Answer: **56%**

What volume (in mL) of 10.0 M nitric acid must be added to this mixture in order to just dissolve all of the calcium hydroxide? Assume the volume of the nitric acid is small and can be ignored in the calculation of the total volume.

If all of the $Ca(OH)_2$ dissolves then $[Ca^{2+}(aq)] = 0.0270$ M. The [OH(aq)] required to achieve this is given by:

$$K_{sp} = [Ca^{2+}(aq)][OH^-(aq)]^2 = (0.0270) \times [OH^-(aq)]^2 = 6.5 \times 10^{-6}$$

$$[OH^-(aq)] = 0.0155 \text{ M}$$

As dissolution of 0.0270 mol of $Ca(OH)_2$ produces (2 × 0.0270) = 0.0540 mol of OH^-, the remainder has been neutralized by the added nitric acid:

number of moles of nitric acid added = 0.0540 – 0.0155 = 0.0384 mol

The volume of 10.0 M nitric acid which contains this amount is given by:

$$\textbf{volume of nitric acid} = \frac{\textbf{number of moles}}{\textbf{concentration}} = \frac{0.0384}{10.0} = 3.84 \times 10^{-3} \text{ L} = 3.84 \text{ mL}$$

Answer: **3.84 mL**