

## Solubility - Model exercise

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### Exercise

At a given temperature, the solubility of aluminum hydroxide is 1 mg/L.

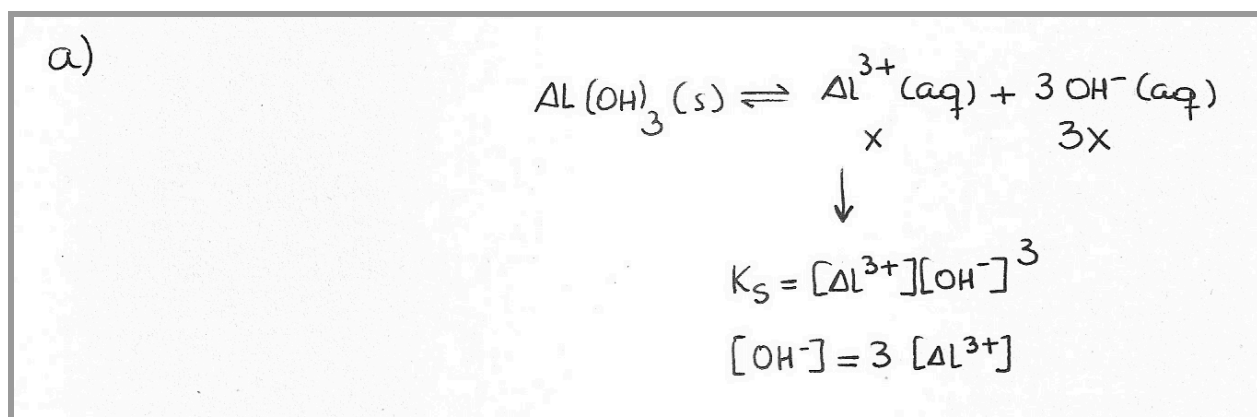
(a) Determine the solubility product constant ( $K_s$ )

(b) 2 liters of NaOH 0.05 M and 6 liters of  $\text{AlCl}_3$  0.001 M are added: will a precipitate of aluminum hydroxide appear?

### Resolution

#### SECTION A

First, we will write the dissociation equation for aluminum hydroxide:



This way, we will know: (1) what is the expression of  $K_s$ , and (2) that the concentration of hydroxide ions is three times that of aluminum ions.

Next, we will determine the molarity of aluminum hydroxide in a saturated solution. Next, we will determine the concentrations of both ions (aluminum and hydroxide ions) and determine the value of  $K_s$ .

$$Mm(Al(OH)_3) = 27 + (3 \times 16) + (3 \times 1) = 78 \text{ g/mol}$$

$$[Al(OH)_3] = 1 \frac{\text{mg}}{\text{L}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol}}{78 \text{ g}} = 1.28 \times 10^{-5} \text{ M}$$

$$\rightarrow [Al^{3+}] = [Al(OH)_3] = 1.28 \times 10^{-5} \text{ mol/L}$$

$$\rightarrow [OH^-] = 3 \times [Al(OH)_3] = 3.84 \times 10^{-5} \text{ mol/L}$$

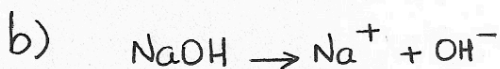
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$$K_s = [Al^{3+}][OH^-]^3 = (1.28 \times 10^{-5}) \times (3.84 \times 10^{-5})^3 =$$

$$= \boxed{7.25 \times 10^{-19}}$$

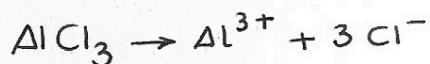
#### SECTION B

When two solutions are mixed, we should (1) determine the ionic product ( $Q = [Al^{3+}][OH^-]^3$ ) and (2) compare it against the value of  $K_s$ , in order to know if a precipitate will be formed.



$$n(OH^-) = 2 \text{ L} \times \frac{0.05 \text{ mol NaOH}}{1 \text{ L}} \times \frac{1 \text{ mol OH}^-}{1 \text{ mol NaOH}} = 0.1 \text{ mol OH}^-$$

$$[OH^-] = \frac{0.1 \text{ mol OH}^-}{8 \text{ L}} = 0.0125 \text{ M OH}^-$$



$$n(Al^{3+}) = 6 \text{ L} \times \frac{0.001 \text{ mol AlCl}_3}{1 \text{ L}} \times \frac{1 \text{ mol Al}^{3+}}{1 \text{ mol AlCl}_3} = 0.006 \text{ mol Al}^{3+}$$

$$[Al^{3+}] = \frac{0.006 \text{ mol Al}^{3+}}{8 \text{ L}} = 7.5 \times 10^{-4} \text{ M Al}^{3+}$$

The comparison of both values gives this result:  $Q > K_s$ . Thus, a precipitate will be formed.

$$Q = [\text{Al}^{3+}][\text{OH}^-]^3 = (7.5 \times 10^{-4}) \times (1.25 \times 10^{-2})^3 = 1.46 \times 10^{-9}$$

