# AP® CHEMISTRY
# 2017 SCORING GUIDELINES

## Question 6

Answer the following questions about $Mg(OH)_2$. At 25°C, the value of the solubility product constant, $K_{sp}$, for $Mg(OH)_2(s)$ is $1.8 \times 10^{-11}$.

(a) Calculate the number of grams of $Mg(OH)_2$ (molar mass 58.32 g/mol) that is dissolved in 100. mL of a saturated solution of $Mg(OH)_2$ at 25°C.

| | |
|---|---|
| $1.8 \times 10^{-11} = [Mg^{2+}][OH^-]^2 = (x)(2x)^2 = 4x^3$<br><br>$x = \sqrt[3]{\frac{1.8 \times 10^{-11}}{4}} = 1.65 \times 10^{-4}\ M = [Mg^{2+}] = [Mg(OH)_2]$<br><br>$0.100\ \text{L} \times \frac{1.65 \times 10^{-4}\ \text{mol}}{1\ \text{L}} \times \frac{58.32\ \text{g}\ Mg(OH)_2}{1\ \text{mol}\ Mg(OH)_2} = 9.6 \times 10^{-4}\ \text{g}\ Mg(OH)_2$ | 1 point is earned for calculating the solubility of $Mg(OH)_2$.<br><br>1 point is earned for calculating the correct mass based on the solubility of $Mg(OH)_2$. |

(b) The energy required to separate the ions in the $Mg(OH)_2$ crystal lattice into individual $Mg^{2+}(g)$ and $OH^-(g)$ ions, as represented in the table below, is known as the lattice energy of $Mg(OH)_2(s)$. As shown in the table, the lattice energy of $Sr(OH)_2(s)$ is less than the lattice energy of $Mg(OH)_2(s)$. Explain why in terms of periodic properties and Coulomb's law.

| Reaction | Lattice Energy (kJ/mol) |
|---|---|
| $Mg(OH)_2(s) \rightarrow Mg^{2+}(g) + 2\ OH^-(g)$ | 2900 |
| $Sr(OH)_2(s) \rightarrow Sr^{2+}(g) + 2\ OH^-(g)$ | 2300 |

| | |
|---|---|
| The $Sr^{2+}$ ion is larger than the $Mg^{2+}$ ion because it has additional occupied energy levels (or shells). Coulomb's law states that the force of attraction between cation and anion is inversely proportional to the square of the distance between them. Since the distance between $Mg^{2+}$ and $OH^-$ is shorter than the distance between $Sr^{2+}$ and $OH^-$, the attractive forces in $Mg(OH)_2$ are stronger and, therefore, its lattice energy is greater. | 1 point is earned for the correct comparison of cation sizes.<br><br>1 point is earned for indicating that smaller interionic distances lead to a greater lattice energy. |