This page discusses the solubility of the hydroxides, sulfates and carbonates of the Group 2 elements—beryllium, magnesium, calcium, strontium and barium—in water.

Group II metal oxide basicity and hydroxide solubility in water increase as you go down the column. BeO and Be(OH)₂ are amphoteric and react with acids and strong bases such as NaOH. MgO is basic and Mg(OH)₂ is weakly basic and do not dissolve in NaOH solution. The oxides of calcium, strontium, and barium are basic and the hydroxides are strongly basic. The solubilities of the hydroxides in water follow the order: Be(OH)₂ < Mg(OH)₂ < Ca(OH)₂ < Sr(OH)₂ < Ba(OH)₂.

### Metal Oxide Basicity

Group II metal oxides become more basic as you go down the column. This trend is easily seen if you compare the electronegativity of the group II metal to the electronegativity of oxygen.

<table>
<thead>
<tr>
<th>Element</th>
<th>Electronegativity</th>
<th>ΔElectronegativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>3.44</td>
<td></td>
</tr>
<tr>
<td>Be</td>
<td>1.57</td>
<td>1.87</td>
</tr>
<tr>
<td>Mg</td>
<td>1.31</td>
<td>2.13</td>
</tr>
<tr>
<td>Ca</td>
<td>1.00</td>
<td>2.44</td>
</tr>
<tr>
<td>Sr</td>
<td>0.95</td>
<td>2.49</td>
</tr>
<tr>
<td>Ba</td>
<td>0.89</td>
<td>2.55</td>
</tr>
</tbody>
</table>

As you can see the electronegativities of the metals decrease down the column making the change in electronegativities increases down the group. The greater the difference in electronegativity the more ionic the metal-oxygen bond becomes. The more ionic the metal-oxygen bond the more basic the oxide is.

### Solubility of the Hydroxides

Group II metal hydroxides become more soluble in water as you go down the column. This trend can be explained by the decrease in the lattice energy of the hydroxide salt and by the increase in the coordination number of the metal ion as you go down the column.

<table>
<thead>
<tr>
<th>Element</th>
<th>Lattice Energy (kJ/mol)</th>
<th>Coordination Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be</td>
<td>3620</td>
<td>4</td>
</tr>
<tr>
<td>Mg</td>
<td>2998</td>
<td>6</td>
</tr>
<tr>
<td>Ca</td>
<td>2637</td>
<td>6</td>
</tr>
<tr>
<td>Sr</td>
<td>2474</td>
<td>8</td>
</tr>
</tbody>
</table>
The larger the lattice energy the more energy it takes to break the lattice apart into metal and hydroxide ions. Since the atomic radii increase down the group it makes sense that the coordination numbers also increases because the larger the metal ion the more room there is for water molecules to coordinate to it.

The following examples illustrate this trend:

- Magnesium hydroxide appears to be insoluble in water. However, if it is shaken in water and filtered, the solution is slightly basic. This indicates that there are more hydroxide ions in solution than there were in the original water. This is because some magnesium hydroxide has dissolved.
- Calcium hydroxide solution is referred to as "lime water". A liter of pure water will dissolve about 1 gram of calcium hydroxide at room temperature.
- Barium hydroxide is soluble enough to produce a solution with a concentration around 0.1 mol dm\(^{-3}\) at room temperature.

**Solubility of the sulfates**

- The sulfates become less soluble down the group.

This simple trend is true provided hydrated beryllium sulfate is considered, but not anhydrous beryllium sulfate. The Nuffield Data Book quotes anyhydrous beryllium sulfate, BeSO\(_4\), as insoluble, whereas the hydrated form, BeSO\(_4\).4H\(_2\)O is soluble, with a solubility of about 39 g of BeSO\(_4\) per 100 g of water at room temperature. Solubility figures for magnesium sulfate and calcium sulfate also vary depending on whether the salt is hydrated or not, but the variations are less dramatic.

Two common examples illustrate this trend:

1. A familiar reaction is that between magnesium and dilute sulfuric acid, producing hydrogen gas and a colorless solution of magnesium sulfate. Notice that a solution, and not a precipitate, is formed, implying that magnesium sulfate is soluble.
2. Barium sulfate exists as a white precipitate in solution. The ready formation of a precipitate indicates that barium sulfate is quite insoluble. In fact, 1 liter of water dissolves about 2 mg of barium sulfate at room temperature.

**Solubility of the carbonates**

The carbonates become less soluble down the group. All the Group 2 carbonates are very sparingly soluble. Magnesium carbonate, for example, has a solubility of about 0.02 g per 100 g of water at room temperature. There is little data for beryllium carbonate, but as it reacts with water, the trend is obscured. The trend to lower solubility is, however, broken at the bottom of the group: barium carbonate is slightly more soluble than strontium sulfate. There are no simple examples of this trend.
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