

# Group 2

## A-Level Chemistry

### Thermal stability of the nitrates and carbonates

The **thermal stability** 热稳定性 of the Group 2 **nitrates** 硝酸盐 and **carbonates** 碳酸盐 **increases** down the group. Here is the reason, in terms of how the ions affect each other.



*Heating limestone (calcium carbonate) in a kiln decomposes it to calcium oxide — a thermal decomposition*

Image: Martinvl, CC BY-SA 4.0 (commons.wikimedia.org)

A small **cation** 阳离子 with a small **ionic radius** 离子半径 has a high charge density. It pulls on the electrons of the nearby anion and distorts its shape — this is **polarisation** 极化. Distorting the large **anion** 阴离子 (the carbonate or nitrate ion) weakens a bond inside it, so the compound breaks down more easily.

Going down the group, the cation gets larger. Its charge density drops, so it polarises the anion **less**. The anion is less distorted, so the compound is harder to break down — it is more thermally stable and needs a higher temperature to decompose.

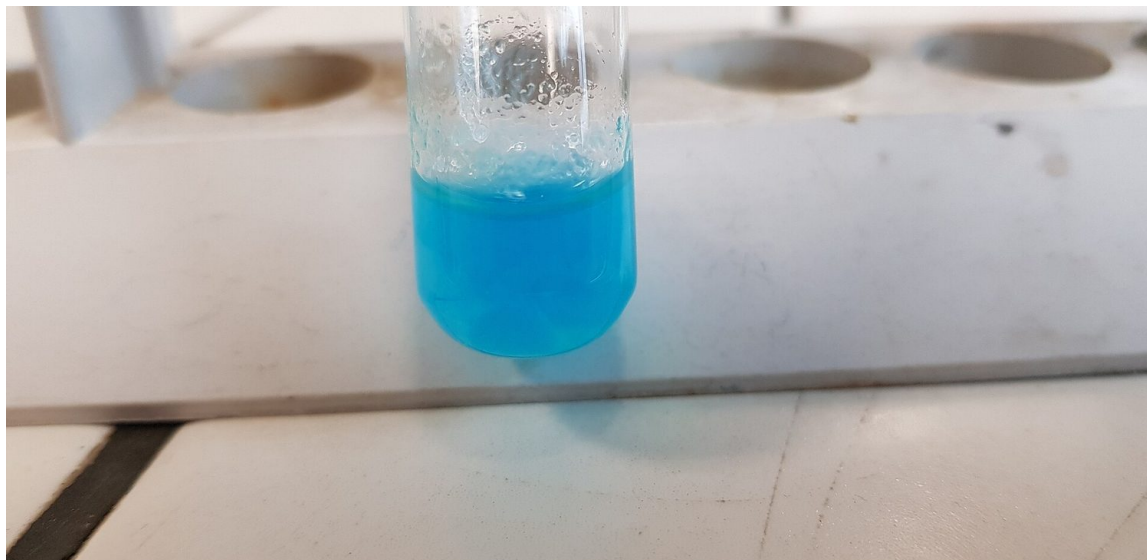
### Solubility of the hydroxides and sulfates

When an ionic solid dissolves, two energy changes compete. The **enthalpy change of solution** 溶解焓变 is the sum of them:

$$\Delta H_{\text{sol}}^{\ominus} = -\Delta H_{\text{latt}} + \Delta H_{\text{hyd}}$$

- you must first pull the lattice apart (this needs the **lattice energy** 晶格能).
- then water surrounds the ions (this releases the **enthalpy change of hydration** 水合焓变).

If the energy released on hydration roughly matches (or beats) the energy needed to break the lattice, the solid dissolves easily.



*An insoluble metal hydroxide forms as a gelatinous precipitate when its lattice energy is too large to be repaid by hydration*

Image: Alvy16, CC BY 4.0 (commons.wikimedia.org)

Going down the group, both the lattice energy and the hydration enthalpy get **smaller** (less negative), because the cation is larger. But they shrink at different rates, and this explains the opposite trends:

$$\Delta H_{\text{sol}} = -\Delta H_{\text{latt}} + \Delta H_{\text{hyd}}$$

**hydroxides** (small  $\text{OH}^-$ ):  
lattice energy falls *a lot* down the group  
⇒ outweighs the smaller hydration fall

→ **more soluble**

**sulfates** (large  $\text{SO}_4^{2-}$ ):  
lattice energy stays almost constant  
⇒ the hydration fall then dominates

→ **less soluble**

*Why the trends are opposite: the small  $\text{OH}^-$  lattice energy falls a lot down the group (hydroxides dissolve more), but the large  $\text{SO}_4^{2-}$  lattice energy barely changes (sulfates dissolve less)*

Compound	Trend in solubility 溶解度 down the group	Why
hydroxides 氢氧化物	increases	the $\text{OH}^-$ ion is small, so the lattice energy falls a lot down the group; this change outweighs the fall in hydration energy
sulfates 硫酸盐	decreases	the $\text{SO}_4^{2-}$ ion is large, so the lattice energy stays almost the same; the fall in hydration energy then dominates, so dissolving becomes less favourable