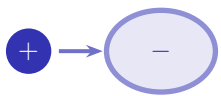
Group 2

A-Level Chemistry ▪ Topic 27

A-Level Chemistry



What we will cover

1. Thermal stability & polarisation
2. Solubility & energetics
3. Why the trends are opposite

1 Group 2 trends

Thermal stability and polarisation

Thermal stability 热稳定性 of the nitrates & carbonates increases down the group.

> A small cation has high charge density, so it **polarises** 极化 the large anion more – weakening it. Larger cations polarise less, so the compound is more stable.

Thermal stability and polarisation, continued

A small, highly charged cation **polarises** 极化 a large anion, distorting it until it decomposes ($CO_3^{2-} \rightarrow CO_2 + O^{2-}$). Down Group 2 the cation gets larger, so it polarises less: carbonates and nitrates become more thermally stable.

> Group 1 carbonates (except Li) do not decompose in a Bunsen flame; Group 2 ones do, more readily at the top of the group.

Solubility and energetics

Two energy changes compete when a solid dissolves:

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

Pull the lattice apart, then **hydrate** 水合 the ions: the **enthalpy change of solution** 溶解焓变 is the sum of the lattice term and the **enthalpy change of hydration** 水合焓变. Down the group both get smaller – but at different rates.

Why the trends are opposite

hydroxides 氢氧化物 ↑

small OH^-: lattice energy falls a lot → more soluble

sulfates 硫酸盐 ↓

large SO_4^{2-}: lattice ≈ constant → less soluble

Solubility of the hydroxides and sulfates

hydroxides
get *more* soluble
down the group

sulfates
get *less* soluble
down the group

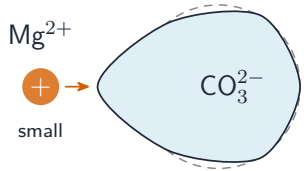
Down Group 2 the hydroxides get more soluble but the sulfates less

Why solubility trends go opposite ways

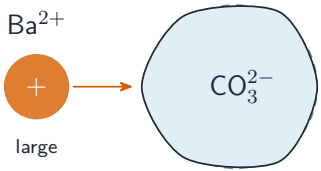
the two energies	the **lattice energy** 晶格能 must be overcome, and the **enthalpy of hydration** 水合焓变 is released as water surrounds the ions
the enthalpy of solution 溶解焓变	the sum of the two – and its sign decides whether dissolving is favourable
down Group 2	the **ionic radius** 离子半径 grows, so both energies fall
the hydroxides	hydration falls faster, so solubility increases down the group
the sulfates	lattice energy falls faster, so solubility decreases down the group
the reason	the sulfate ion is large, so changing the cation size matters less to the lattice than to the hydration

The trends run opposite ways because which of the two energies falls faster depends on the size of the anion. That is the explanation the mark scheme wants.

Thermal stability of the nitrates and carbonates



high charge density —
distorts the anion a lot
less stable: decomposes easily



low charge density —
distorts the anion little
more stable: needs high heat

A small cation has a high charge density, so it distorts (polarises) the large anion more – weakening it, so the compound is less stable

Solubility of the hydroxides and sulfates, continued

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

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

→ **more** soluble

sulfates (large SO_4^{2-}):
lattice energy stays almost constant
$\Rightarrow$ the hydration fall then dominates

→ **less** soluble

Why the trends are opposite: the small OH^- lattice energy falls a lot down the group (hydroxides dissolve more), but the large SO_4^{2-} lattice energy barely changes (sulfates dissolve less)

Exam tips

- Thermal stability of carbonates and nitrates **increases down** the group – larger cations polarise the anion less.
- Give the **decomposition products**: carbonates $\rightarrow$ oxide + CO_2; nitrates $\rightarrow$ oxide + NO_2 + O_2 (brown gas).
- Hydroxides get **more soluble** and sulfates **less soluble** down the group.
- Explain trends with **cation charge density (polarising power)**, not just size.

2 Recap

Worked example – thermal stability

Explain why $BaCO_3$ needs a higher temperature to decompose than $MgCO_3$.

- Decomposition: $MCO_3 \rightarrow MO + CO_2$.
- The cation **polarises** 极化 the carbonate ion, distorting its electron cloud and weakening a C–O bond.
- Mg^{2+} is small with high charge density $\Rightarrow$ polarises strongly $\Rightarrow$ decomposes easily.
- Ba^{2+} is much larger, low charge density $\Rightarrow$ weak polarising $\Rightarrow$ survives to a higher temperature.

Thermal stability rises down Group 2 – the cation gets bigger and polarises less. The same argument works for the nitrates.

Topic 27 – key takeaways

1 Stability

rises down; large cations polarise less

2 Dissolving

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

3 Hydroxides

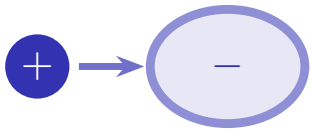
more soluble down (lattice falls a lot)

4 Sulfates

less soluble down (lattice $\approx$ constant)

Check yourself

1. Which way does thermal stability change down Group 2?
2. What does a small cation do to a large anion?
3. Which become more soluble down the group?
4. Which become less soluble down the group?



Answers **1.** increases **2.** polarises (distorts) it **3.** the hydroxides **4.** the sulfates