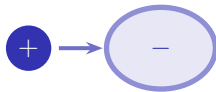


Group 2

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





Thermal stability and polarisation

Thermal stability of the nitrates & carbonates **increases** down the group.

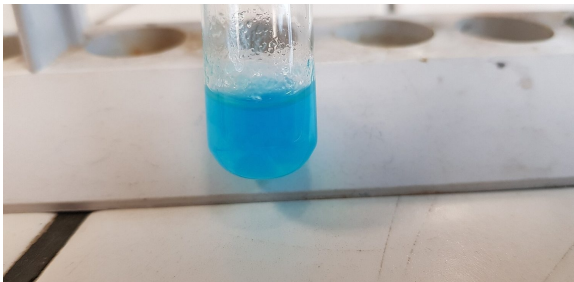
A small cation has high charge density, so it **polarises** the large anion more – weakening it. Larger cations polarise less, so the compound is more stable.

Thermal stability and polarisation, continued

A small, highly charged cation **polarises** a large anion, distorting it until it decomposes ($\text{CO}_3^{2-} \rightarrow \text{CO}_2 + \text{O}^{2-}$). 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** the ions: the **enthalpy change of solution** is the sum of the lattice term and the **enthalpy change of hydration**. Down the group both get smaller – but at different rates.

Why the trends are opposite

hydroxides ↑

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

sulfates ↓

large SO_4^{2-} : lattice $\approx$
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** must be overcome, and the **enthalpy of hydration** is released as water surrounds the ions

the enthalpy of solution

the sum of the two – and its sign decides whether dissolving is favourable

down Group 2

the **ionic radius** grows, so **both** energies fall

the hydroxides

hydration falls **faster**, so solubility **increases** down the group

the sulfates

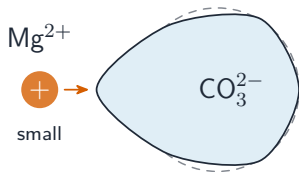
lattice energy falls faster, so solubility **decreases** down the group

the reason

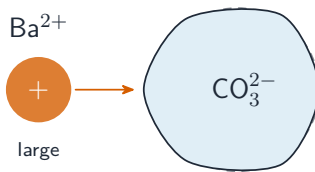
the sulfate ion is large, so changing the cation size matters less to the lattice than to the hydration

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.



Worked example – thermal stability

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

- Decomposition: $\text{MCO}_3 \rightarrow \text{MO} + \text{CO}_2$.
- The cation **polarises** 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

risks 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)

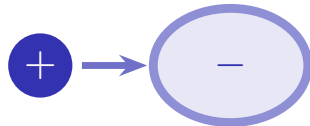
4

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