A-LEVEL CHEMISTRY • EXERCISE SHEET

27.1 Group 2 trends in thermal stability and solubility

Name: _____ Class: _____ Date: _____ **Total: 9 marks**

Objective

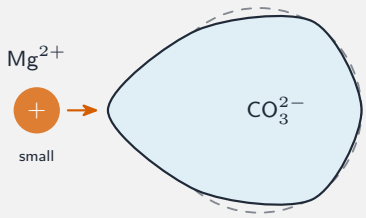
Build the skills to answer exam questions on the **Group 2 trends** —the **thermal stability** 热稳定性 of the nitrates and carbonates, and the **solubility** 溶解度 of the hydroxides and sulfates.

You must be able to:

- explain the thermal-stability trend using ionic radius and **polarisation** 极化
- explain the solubility/ΔH_{sol} trends using lattice energy and hydration enthalpy

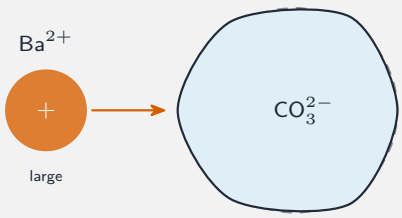
1 Worked examples

■ Thermal stability and polarisation



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 (high charge density) polarises the large anion more, weakening it — so stability rises down the group

Down the group the cation gets larger → lower charge density → polarises the anion **less** → the carbonate/nitrate is harder to decompose (more stable).

■

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

hydroxides (small OH^-):
lattice energy falls *a lot* down the group
⇒ outweighs the smaller hydration fall
→ **more** soluble

sulfates (large SO_4^{2-}):
lattice energy stays almost constant
⇒ the hydration fall then dominates
→ **less** soluble

ΔH_{sol} depends on the balance of lattice energy and hydration enthalpy as both change down the group

Hydroxides become **more soluble**, sulfates **less soluble** down the group —because the lattice energy and hydration enthalpies change at different rates as the cation grows.

2 Practice

2.1 State the trend in thermal stability of the Group 2 carbonates down the group. [1]

2.2 State the trend in solubility of the Group 2 sulfates down the group. [1]

3 Exam-style questions

3.1 Magnesium carbonate decomposes at a lower temperature than barium carbonate because the Mg^2 ion: [1]

- **A** is larger
- **B** has a higher charge density and polarises the carbonate more
- **C** has a lower charge
- **D** is more soluble

3.2 The increasing thermal stability of the nitrates down Group 2 is explained by: [1]

- **A** increasing cation charge

- **B** decreasing polarisation of the anion by the larger cation
- **C** increasing anion size
- **D** decreasing temperature

3.3 Explain, in terms of polarisation, why the thermal stability of the Group 2 nitrates increases down the group. [3]

3.4 ΔH_{sol} depends on the lattice energy and the hydration enthalpies. Explain why both quantities become **less** exothermic down Group 2. [2]

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4 Go further

You are now ready for the real exam questions on this subtopic. Open the **27.1 Group 2 trends** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/42 N25 —Q4 (group 2 trends in thermal stability and solubility)

Solutions

2.1 it increases down the group.

2.2 it decreases down the group.

3.1 B. The small Mg^2 has a high charge density and polarises the carbonate more.

3.2 B. The larger cation polarises the anion less, so the nitrate is more stable.

3.3 down the group the cation gets larger, so its charge density falls; it polarises/distorts the large nitrate ion less; so the N–O bonds are weakened less and a higher temperature is needed to decompose it.

3.4 down the group the cation is larger; so both the lattice energy (ions further apart) and the hydration enthalpy (lower charge density, weaker attraction to water) become less exothermic.