Exercise walk-through

Similarities and trends in the properties of the Group 2 metals, magnesium ▪ 27.1

eXercise

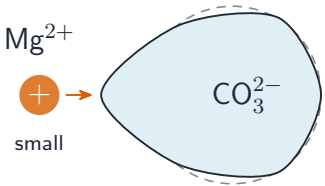
You must be able to

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

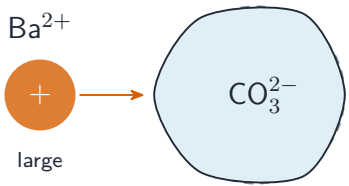
Method — Thermal stability and polarisation

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

Method — 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 Mg^2 strongly distorting the carbonate anion; a large Ba^2 barely distorting it

Method — Solubility energetics

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.

Method — Solubility energetics

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

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

Comparing lattice energy and hydration enthalpy to explain ΔHsol trends

Practice 2.1 ▪ 1 mark

State the trend in thermal stability of the Group 2 carbonates down the group.

Solution 2.1

Method: Thermal stability and polarisation

Worked steps

it increases down the group B1.

Practice 2.2 ▪ 1 mark

State the trend in solubility of the Group 2 sulfates down the group.

Solution 2.2

Method: Solubility energetics

Worked steps

it decreases down the group B1.

Exam-style 3.1 ▪ 1 mark

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

A is larger

B has a higher charge density and polarises the carbonate more

C has a lower charge

D is more soluble

Solution 3.1

Method: Thermal stability and polarisation

A is larger

B has a higher charge density and polarises the carbonate more ✓

C has a lower charge

D is more soluble

Worked steps

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

Exam-style 3.2 ▪ 1 mark

The increasing thermal stability of the nitrates down Group 2 is explained by:

A increasing cation charge

B decreasing polarisation of the anion by the larger cation

C increasing anion size

D decreasing temperature

Solution 3.2

Method: Thermal stability and polarisation

A increasing cation charge

B decreasing polarisation of the anion by the larger cation ✓

C increasing anion size

D decreasing temperature

Worked steps

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

Exam-style 3.3 ▪ 3 marks

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

Solution 3.3

Method: Thermal stability and polarisation

Worked steps

down the group the cation gets larger, so its charge density falls M1; it polarises/distorts the large nitrate ion less M1; so the N–O bonds are weakened less and a higher temperature is needed to decompose it A1.

Exam-style 3.4 ▪ 2 marks

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

Solution 3.4

Method: Solubility energetics

Worked steps

down the group the cation is larger M1; so both the lattice energy (ions further apart) and the hydration enthalpy (lower charge density, weaker attraction to water) become less exothermic A1.