Group 2

f interpret and explain qualitatively the trend in the thermal stability of the nitrates and carbonates in terms of the charge density of the cation and the polarisability of the large anion ☐

g interpret and explain qualitatively the variation in solubility of the hydroxides and sulfates in terms of relative magnitudes of the enthalpy change of hydration and the corresponding lattice energy ☐

GROUP II

10 Group 2

The physical and chemical properties of the elements of Group 2 (the alkaline Earth metals) are introduced in this topic.

	Learning outcomes Candidates should be able to:
10.1 Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds	a) describe the reactions of the elements with oxygen, water and dilute acids b) describe the behaviour of the oxides, hydroxides and carbonates with water and dilute acids c) describe the thermal decomposition of the nitrates and carbonates d) interpret, and make predictions from, the trends in physical and chemical properties of the elements and their compounds e) state the variation in the solubilities of the hydroxides and sulfates **f) interpret and explain qualitatively the trend in the thermal stability of the nitrates and carbonates in terms of the charge density of the cation and the polarisability of the large anion** **g) interpret and explain qualitatively the variation in solubility of the hydroxides and sulfates in terms of relative magnitudes of the enthalpy change of hydration and the corresponding lattice energy**
10.2 Some uses of Group 2 compounds	a) describe and explain the use of calcium hydroxide and calcium carbonate (powdered limestone) in agriculture

SOLUBILITY OF GROUP II SULFATES

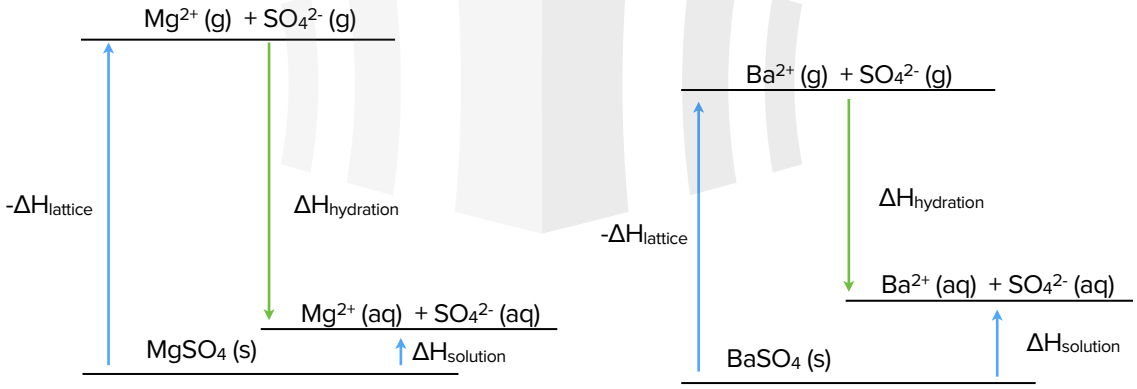
Down the group II sulfates, the solubility decreases.

Going down the group, the size of the cations **increases** (charge is the same). This **decreases** the magnitude of lattice energy and hydration energy. But the decrease in hydration energy is greater.

Thus, (ΔH) solution becomes **endothermic**, and solubility of sulfates **decreases** down the group.

1

BORN-HABER CYCLE OF SOLUBILITY



In this case, $\Delta H_{solution}$ is LESS Endothermic (-), therefore greater solubility.

In this case, $\Delta H_{solution}$ is MORE Endothermic (+), therefore less solubility.

2

SKILL CHECK

Explain qualitatively the variation in solubility of the sulphates of the elements in Group II down the Group from magnesium to barium.

3

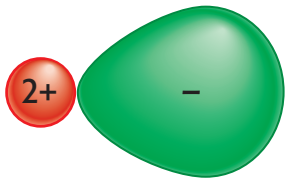
POLARISATION

The positive charge on the cation in an ionic lattice may attract the electrons in the anion towards it.

This results in a distortion of the electron cloud of the anion and the anion is no longer spherical.

We call this distortion, **ion polarisation**.

The ability of a cation to attract electrons and distort an anion is called the **polarising power** of the cation.



4

EFFECT OF CATIONIC RADIUS

The Group II cations increase in ionic radius down the group:
$Mg^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$

The smaller the ionic radius of the cation, the better it is at polarising the carbonate ion.

Therefore the degree of polarisation of the carbonate ion by the Group II cations follows the order:
$Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$

5

THERMAL STABILITY OF GROUP II SALTS

Thermal stability of group 2 nitrates and carbonates increases down the group.

This is because:

as the size of the cation increases down the group,

its charge density decreases

and the polarisation on the anion decreases.

All the carbonates in Group II undergo thermal decomposition to give the metal oxide and carbon dioxide.

$$XCO_3\,(s) \longrightarrow XO\,(s) + CO_2\,(g)$$

6

THERMAL STABILITY OF GROUP II CARBONATES

If this is heated, the carbon dioxide breaks free to leave the metal oxide.

How much you need to heat the carbonate before that happens depends on how polarised the ion was. If it was highly polarised, you need less heat than if it was only slightly polarised.

The smaller the positive ion is, the higher the charge density, and the greater effect it will have on the carbonate ion. As you go down the Group, the positive ions get bigger and have less effect on the carbonate ions near them.

Hence, **polarisation decreases**, and **the thermal stability of the carbonate increases,** and **more heat required to break the lattice**.

7

THERMAL STABILITY OF GROUP II CARBONATES

This O atom & its electrons are pulled towards the Group 2 cation & eventually breaking into O^{2-}

Greater the charge density of the cation, easier to distort the electron cloud of the anion

8

THERMAL STABILITY OF GROUP II NITRATES

All the nitrates in this Group undergo thermal decomposition to give the metal oxide, nitrogen dioxide and oxygen

$$2X(NO_3)_2\ (s) \longrightarrow 2XO\ (s) + 4NO_2\ (g) + O_2\ (g)$$

- As you go down the Group, the nitrates also have to be heated more strongly before they will decompose.
- The nitrates also become more stable to heat as you go down the Group.
- Polarisation deceases= thermal stability inc= more heat required to break the lattice

9

SKILL CHECK

(a) Write an equation representing the action of heat on calcium nitrate, $Ca(NO_3)_2$

(b) Describe and explain the trend in the thermal stabilities of the nitrates of the Group II elements.

10