

GROUP II ELEMENTS

Beryllium to Barium

Introduction Elements in Group I (*alkali metals*) and Group II (*alkaline earths*) are known as **s-block elements** because their valence (bonding) electrons are in s orbitals.

| | <i>Be</i> | <i>Mg</i> | <i>Ca</i> | <i>Sr</i> | <i>Ba</i> |
|--------------------------|-------------|--------------------|--------------------|--------------------|--------------------|
| Atomic Number | 4 | 12 | 20 | 38 | 56 |
| Electronic configuration | $1s^2 2s^2$ | $[\text{Ne}] 3s^2$ | $[\text{Ar}] 4s^2$ | $[\text{Kr}] 5s^2$ | $[\text{Xe}] 6s^2$ |

PHYSICAL PROPERTIES

Atomic Radius **Increases down each group** electrons are in shells further from the nucleus

| | <i>Be</i> | <i>Mg</i> | <i>Ca</i> | <i>Sr</i> | <i>Ba</i> |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| Atomic radius / nm | 0.106 | 0.140 | 0.174 | 0.191 | 0.198 |

Ionic Size **Increases down the group**
The size of positive ions is less than the original atom because the nuclear charge exceeds the electronic charge.

| | Be^{2+} | Mg^{2+} | Ca^{2+} | Sr^{2+} | Ba^{2+} |
|-------------------|------------------|------------------|------------------|------------------|------------------|
| Ionic radius / nm | 0.030 | 0.064 | 0.094 | 0.110 | 0.134 |

Melting Points **Decrease down each group** metallic bonding gets weaker due to increased size
Each atom contributes two electrons to the delocalised cloud. Melting points tend not to give a decent trend as different crystalline structures affect the melting point.

| | <i>Be</i> | <i>Mg</i> | <i>Ca</i> | <i>Sr</i> | <i>Ba</i> |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| Melting point / °C | 1283 | 650 | 850 | 770 | 710 |

Ionisation Energy **Decreases down the group** atomic size increases
Values are low because the electron has just gone into a new level and is shielded by filled inner levels. This makes them reactive.

| | <i>Be</i> | <i>Mg</i> | <i>Ca</i> | <i>Sr</i> | <i>Ba</i> |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|
| 1st I.E. / kJ mol^{-1} | 899 | 738 | 590 | 550 | 500 |
| 2nd I.E. / kJ mol^{-1} | 1800 | 1500 | 1100 | 1100 | 100 |
| 3rd I.E. / kJ mol^{-1} | 14849 | 7733 | 4912 | | |

There is a **large increase for the 3rd I.E.** as the electron is now being removed from a **shell nearer the nucleus** and there is **less shielding**.

Electronegativity **Decreases down the group**

Increased shielding makes the shared pair less strongly attracted to the nucleus

| | | | | | |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|
| | <i>Be</i> | <i>Mg</i> | <i>Ca</i> | <i>Sr</i> | <i>Ba</i> |
| <i>Electronegativity (Pauling)</i> | 1.5 | 1.2 | 1.0 | 0.95 | 0.89 |

Hydration Enthalpy **Decreases (gets less negative) down each group**

Charge density of the ions decreases thus reducing the attraction for water

| | | | | | |
|---|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | <i>Be</i> ²⁺ | <i>Mg</i> ²⁺ | <i>Ca</i> ²⁺ | <i>Sr</i> ²⁺ | <i>Ba</i> ²⁺ |
| <i>Hydration Enthalpy / kJ mol⁻¹</i> | | -1891 | -1562 | -1413 | -1273 |

CHEMICAL PROPERTIES

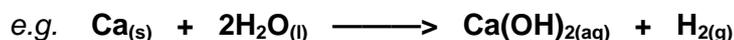
Water • **react with increasing vigour down the group**

Be does not react with water or steam

Mg reacts slowly with cold water and quickly with steam



Ca, Sr, Ba react with cold water with increasing vigour



COMPOUNDS

Hydroxides • white crystalline solids
• solubility in water increases down the Group

Be(OH)₂ *insoluble*

Mg(OH)₂ *sparingly soluble*

Ca(OH)₂ *slightly soluble* - an aqueous solution is known as 'lime water'

Sr(OH)₂ *quite soluble*

Ba(OH)₂ *very soluble*

- **basic strength also increases down group**
- the **metal ions get larger** so charge density decreases
- there is a lower attraction between the OH⁻ ions and larger unipositive ions
- the ions will split away from each other more easily
- there will be a greater concentration of OH⁻ ions in water



'The greater the concentration of OH⁻ ions in water the greater the alkalinity'

Sulphates

- white crystalline solids
- solubility in water decreases down the Group

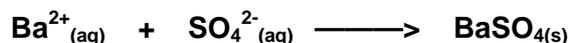
| Salt | Ionic radius (M^{2+}) / nm | Hydration Enthalpy (M^{2+}) / kJ mol^{-1} | Solubility moles/100g |
|-----------------|--------------------------------|--|------------------------|
| MgSO_4 | 0.064 | -1891 | 3600×10^{-4} |
| CaSO_4 | 0.094 | -1562 | 11×10^{-4} |
| SrSO_4 | 0.110 | -1413 | 0.62×10^{-4} |
| BaSO_4 | 0.134 | -1273 | 0.009×10^{-4} |

- reasons for solubility decreasing down the group ...
 - there is little change in the lattice enthalpy BUT
 - as the **cation gets larger** the **hydration enthalpy gets much smaller**
 - a **larger cation** has a **lower charge density** and so is **less attracted to water**

Testing for sulphates

- barium sulphate's insolubility is used as a test for sulphates

- Method
- make up a solution of the compound to be tested
 - acidify it with dilute hydrochloric (or nitric) acid *
 - add a few drops of barium chloride solution
 - white precipitate of barium sulphate confirms the presence of a sulphate



* adding acid prevents the precipitation of other insoluble ions such as carbonate

THE ATYPICAL NATURE OF BERYLLIUM**Theory**

Beryllium differs from the other Group II elements; it has properties closer to that of aluminium - THE DIAGONAL RELATIONSHIP. Being the **head element** of a Group...

- it has*
- a much **smaller ionic size** (a **greater charge/size ratio - highly polarising**)
 - a much **larger ionisation energies** than those elements below it
- so*
- is less likely to form ions
 - compounds (BeCl_2) show covalent character
 - often soluble in organic solvents
 - have lower melting points
 - often hydrolysed by water
 - maximum co-ordination number of 4
 - due to small size
 - beryllium hydroxide is AMPHOTERIC
 - dissolves in both acids and bases

