

## 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.

	$\text{Be}^{2+}$	$\text{Mg}^{2+}$	$\text{Ca}^{2+}$	$\text{Sr}^{2+}$	$\text{Ba}^{2+}$
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. / $\text{kJ mol}^{-1}$	899	738	590	550	500
2nd I.E. / $\text{kJ mol}^{-1}$	1800	1500	1100	1100	100
3rd I.E. / $\text{kJ mol}^{-1}$	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<sup>2+</sup></i>	<i>Mg<sup>2+</sup></i>	<i>Ca<sup>2+</sup></i>	<i>Sr<sup>2+</sup></i>	<i>Ba<sup>2+</sup></i>
<i>Hydration Enthalpy / kJ mol<sup>-1</sup></i>		-1891	-1562	-1413	-1273

## CHEMICAL PROPERTIES

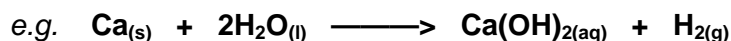
**Water** • **react with increasing vigour down the group**

*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)<sub>2</sub>* *insoluble*

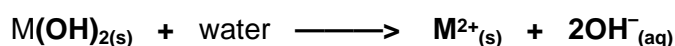
*Mg(OH)<sub>2</sub>* *sparingly soluble*

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

*Sr(OH)<sub>2</sub>* *quite soluble*

*Ba(OH)<sub>2</sub>* *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<sup>-</sup> ions and larger unipositive ions
- the ions will split away from each other more easily
- there will be a greater concentration of OH<sup>-</sup> ions in water



*'The greater the concentration of OH<sup>-</sup> ions in water the greater the alkalinity'*

**Sulphates**

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

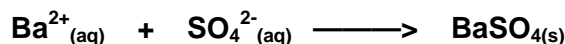
Salt	Ionic radius ( $M^{2+}$ ) / nm	Hydration Enthalpy ( $M^{2+}$ ) / $\text{kJ mol}^{-1}$	Solubility moles/100g
$\text{MgSO}_4$	0.064	-1891	$3600 \times 10^{-4}$
$\text{CaSO}_4$	0.094	-1562	$11 \times 10^{-4}$
$\text{SrSO}_4$	0.110	-1413	$0.62 \times 10^{-4}$
$\text{BaSO}_4$	0.134	-1273	$0.009 \times 10^{-4}$

- 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 ( $\text{BeCl}_2$ ) 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

