

GROUP 2 ELEMENTS - Beryllium to Barium

Introduction

Group I (*alkali metals*) and Group 2 (*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	$1s^2 2s^2$	$[\text{Ne}] 3s^2$	$[\text{Ar}] 4s^2$	$[\text{Kr}] 5s^2$	$[\text{Xe}] 6s^2$

TRENDS IN PHYSICAL PROPERTIES

Atomic Radius **Increases down each group** electrons 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 nuclear charge exceeds the electronic charge

The size of a positive ions is always less than the original atom because the nuclear charge exceeds the electronic charge.

	<i>Be</i> ²⁺	<i>Mg</i> ²⁺	<i>Ca</i> ²⁺	<i>Sr</i> ²⁺	<i>Ba</i> 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 and lower charge density

Each atom contributes two electrons to the delocalised cloud. Melting points tend not to give a decent trend as crystalline structure affects melting points.

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

TRENDS IN CHEMICAL PROPERTIES

Overall

- undergo redox reactions involving the 'loss' of electrons to form 2+ ions
- **reactivity increases down the Group** due to the ease of cation formation

Reason

- **ionisation energies (I.E.) decrease down the group**

REMINDER

1st I.E. The energy required to remove one mole of electrons (to infinity) from one mole of gaseous atoms to form one mole of gaseous positive ions.



2nd I.E. e.g. $\text{Mg}^+(g) \longrightarrow \text{Mg}^{2+}(g) + e^-$

Ionisation Energy **Decreases down the group** atomic size increases

Values for Group I are low because the electron has just gone into a new level and is shielded by filled inner levels. This makes them reactive.

Group 2 values are higher than their Group I equivalents due to the increased nuclear charge.

	<i>Be</i>	<i>Mg</i>	<i>Ca</i>	<i>Sr</i>	<i>Ba</i>
<i>1st I.E. / kJ mol⁻¹</i>	899	738	590	550	500
<i>2nd I.E. / kJ mol⁻¹</i>	1800	1500	1100	1100	1000
<i>3rd I.E. / kJ mol⁻¹</i>	14849	7733	4912	4120	3390

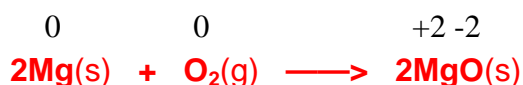
Large increase for 3rd I.E. the electron is now being removed from a **shell nearer the nucleus** and there is **less shielding**.

CHEMICAL PROPERTIES OF THE ELEMENTS

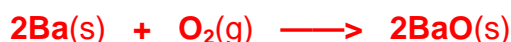
Oxygen

- react with increasing vigour down the group

Mg burns readily with a bright white flame



Ba burns readily with an apple-green flame



In both cases **metal is oxidised** Oxidation No. increases from 0 to +2
 oxygen is reduced Oxidation No. decreases from 0 to -2



Water

- react with increasing vigour down the group

Mg reacts very slowly with cold water



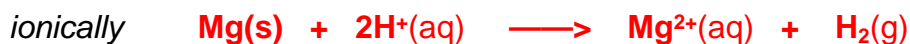
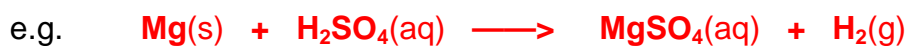
but reacts quickly with steam



Ba react with vigourously with cold water



- Dilute acid*
- react with increasing vigour down the group to produce hydrogen + a salt
 - reactions are more vigorous than with water



OXIDES OF GROUP 2 ELEMENTS

- Properties*
- ionic solids; EXC. beryllium oxide which has covalent character

• BeO	<i>beryllium oxide</i>	MgO	<i>magnesium oxide</i>
CaO	<i>calcium oxide</i>	SrO	<i>strontium oxide</i>
BaO	<i>barium oxide</i>		

Reaction

with water

Most Group 2 oxides react with water to produce the hydroxide



	BeO	MgO	CaO	SrO	BaO
<i>Reactivity with water</i>	NONE	reacts	reacts	reacts	reacts
<i>Solubility of hydroxide g/100cm³ of water</i>	insoluble	sparingly	slightly	quite	very
<i>approx. pH of 0.1M solution</i>	-	10.4	12.5	13.0	13.1

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

Uses

- Ca(OH)₂**
- used in agriculture to neutralise acid soils



- Mg(OH)₂**
- used in toothpaste and indigestion tablets as an antacid



- *both the above are weak alkalis and not as caustic as sodium hydroxide*

CARBONATES OF GROUP 2 ELEMENTS

Properties

- insoluble in water
- undergo thermal decomposition to oxide and carbon dioxide
e.g. $\text{MgCO}_3(\text{s}) \longrightarrow \text{MgO}(\text{s}) + \text{CO}_2(\text{g})$
- ease of decomposition decreases down the group

	MgCO ₃	CaCO ₃	SrCO ₃	BaCO ₃
Solubility (g/100cm ³ of water)	1.5 x 10 ⁻⁴	1.3 x 10 ⁻⁵	7.4 x 10 ⁻⁶	9.1 x 10 ⁻⁶
Decomposition temperature / °C	400	980	1280	1360

SULFATES OF GROUP 2 ELEMENTS

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 x 10 ⁻⁴
CaSO ₄	0.094	-1562	11 x 10 ⁻⁴
SrSO ₄	0.110	-1413	0.62 x 10 ⁻⁴
BaSO ₄	0.134	-1273	0.009 x 10 ⁻⁴

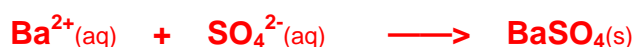
- there is little change in the lattice enthalpy BUT
- as the **cation gets larger** the **hydration enthalpy gets much smaller**
- a **larger cation** has a **lower charge density** so is **less attracted to water**

AGA

Test for sulfates

- **barium sulfate's high insolubility** is the basis for a laboratory **test for sulfates**

- 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 sulfate** confirms presence of sulfate ion



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

Q.1 How is the high insolubility of barium sulfate made use of in hospitals?