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.

	Be	*Mg*	*Ca*	*Sr*	*Ba*
Atomic Number	4	12	20	38	56
Electronic configuration	$1s^2 2s^2$	[Ne] $3s^2$	[Ar] $4s^2$	[Kr] $5s^2$	[Xe] $6s^2$

TRENDS

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

	Be	*Mg*	*Ca*	*Sr*	*Ba*
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.

	Be	*Mg*	*Ca*	*Sr*	*Ba*
Melting point / °C	1283	650	850	770	710

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 II elements have higher values than their Group I equivalents due to the increased nuclear charge.

	Be	*Mg*	*Ca*	*Sr*	*Ba*
Ist I.E. / kJ mol $^{-1}$	899	738	590	550	500
2nd I.E. / kJ mol $^{-1}$	1800	1500	1100	1100	1000
3rd I.E. / kJ mol $^{-1}$	14849	7733	4912	4120	3390

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**.

CHEMICAL PROPERTIES OF THE ELEMENTS

Overall Reactivity increases down the Group due to the ease of cation formation

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

Mg burns readily with a bright white flame

$$\overset{0}{2Mg}(s) + \overset{0}{O_2}(g) \longrightarrow \overset{+2\ -2}{2MgO}(s)$$

Ba burns readily with an apple-green flame

$$2Ba(s) + O_2(g) \longrightarrow 2BaO(s)$$

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

$$Mg \longrightarrow Mg^{2+} + 2e^-$$
$$O + 2e^- \longrightarrow O^{2-}$$

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

Mg reacts very slowly with cold water

$$Mg(s) + 2H_2O(l) \longrightarrow Mg(OH)_2(aq) + H_2(g)$$

but reacts quickly with steam

$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$$

Ba react with vigourously with cold water

$$Ba(s) + 2H_2O(l) \longrightarrow Ba(OH)_2(aq) + H_2(g)$$

OXIDES OF GROUP II ELEMENTS

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

- **BeO** *beryllium oxide*
  MgO *magnesium oxide*
  CaO *calcium oxide*
  SrO *strontium oxide*
  BaO *barium oxide*

Reaction with water Most Group II oxides react with water to produce the hydroxide

e.g. **CaO**(s) **+** **H_2O**(l) **——> Ca(OH)$_2$**(s)

	BeO	MgO	CaO	SrO	BaO
Reactivity with water	NONE	reacts	reacts	reacts	reacts
Solubility of hydroxide g/100cm^3 of water	insoluble	sparingly	slightly	quite	very
pH of solution	-		9-10		

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 of hydroxides

Ca(OH)$_2$
- used in agriculture to neutralise acid soils

Ca(OH)$_2$(s) **+** **2H$^+$** (aq) **——> Ca^{2+}**(aq) **+** **2H_2O**(l)

Mg(OH)$_2$
- used in toothpaste and indigestion tablets as an antacid

Mg(OH)$_2$(s) **+** **2H$^+$** (aq) **——> Mg^{2+}**(aq) **+** **2H_2O**(l)

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

CARBONATES

Properties
- insoluble in water
- undergo thermal decomposition to oxide and carbon dioxide

  e.g. **$MgCO_3$**(s) **——>** **MgO**(s) **+** **CO_2**(g)

- ease of decomposition decreases down the group

	$MgCO_3$	$CaCO_3$	$SrCO_3$	$BaCO_3$
Solubility (g/100cm^3 of water)	1.5×10^{-4}	1.3×10^{-5}	7.4×10^{-6}	9.1×10^{-6}
Decomposition temperature / °C	400	980	1280	1360