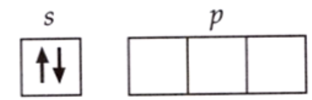
# Group II Elements (Mg to Ba)

# General Characteristics

- Have 2 electrons in outer shell.




- White metal
- **Low** melting points and boiling points
- Good **conductors** of heat and electricity

consist of sea of delocalised electron

- Have large atomic radius.
- Have relatively **low ionisation energy**
- Small electronegativity

shell number increase,shielding effect increase.atomic size increase,nuclear change increase...but both above character overpowered nucler charge.so,ionisation decrease when going down the group

# General Characteristics

- Usually form **$M^{2+}$ ions** in compounds (most compounds are ionic)
- Have only oxidation state of **+2** in compounds.
- Oxides of Group II elements are all **basic** (except beryllium oxide – amphoteric)
- Powerful **reducing agents** – react readily to give up electrons to form $M^{2+}$ ions.
- React with acid to give hydrogen gas.

- Going down the group :

  a) **atomic radius increases**

  b) **ionisation energy decreases**

  c) **reducing power increases**. (<u>atomic radius increase, easier to lose electron</u>).

∴ Going down the group, elements become **more reactive** and more powerful reducing agents.

# Group II

## Reaction with **OXYGEN**

- The Group 2 metals react vigorously with oxygen.
- Burns to give bright flame.
- Each element forms the expected ionic formula oxide with general formula MO
- $2M(s) + O_2(g) \rightarrow 2MO(s)$.
- Reactivity **increases** from Mg to Ba

# Reaction with oxygen and water

- Elements burns in $\mathbf{O_2}$ with a bright flame.

  $2M + O_2 \rightarrow 2MO$

- Reactivity **increases** from Mg to Ba, so Ca and Ba is stored under **oil** to protect them from reacting with oxygen and water vapour in the air.
- Elements except Be react with cold water to produce $\mathbf{H_2(g)}$ and **metal hydroxides**.

  $M + 2H_2O \rightarrow M(OH)_2 + H_2$

- Mg react very slowly with cold water. Little $H_2$ gas only formed after a few days.

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

- But heated Mg reacts rapidly with steam.

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

- Reactivity of elements with water **increases** down the Group.

# Reaction with oxygen

| | Reaction with oxygen | Colour of flame |
|---|---|---|
| **Mg** | $2Mg(s) + O_2(g) \rightarrow 2MgO$ | White |
| **Ca** | $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$ | Brick red |
| **Sr** | $2Sr(s) + O_2(g) \rightarrow 2SrO(s)$ | Red |
| **Ba** | $2Ba(s) + O_2(g) \rightarrow 2BaO(s)$ | Green |

- Sr and Ba form peroxides on prolonged heating in the presence of high pressure of $O_2(g)$.

# Nature of Group II Oxides

| BeO | MgO | CaO | SrO | BaO |
|---|---|---|---|---|
| Amphoteric<br>(can react with both acid and base)<br><br>$BeO + HCl \rightarrow BeCl_2 + H_2O$<br><br>$BeO + 2OH^- + H_2O \rightarrow Be(OH)_4^{2-}$<br>beryllate<br><br>• BeO is amphoteric because **$Be^{2+}$** has **high charge density**, polarising the $O^{2-}$ anion → cause the bonding in BeO to have some degree of covalent character.<br>• The acidic character in BeO is due to the covalent nature of the bonding in BeO. | Basic<br>(can react with acids to give salts and water)<br><br>Eg. $MgO + 2HCl \rightarrow MgCl_2 + H_2O$<br><br>$CaO + 2HCl \rightarrow CaCl_2 + H_2O$<br><br>$SrO + 2HCl \rightarrow SrCl_2 + H_2O$<br><br>$BaO + 2HCl \rightarrow BaCl_2 + H_2O$ | | | |

# Nature of Group II Oxides

- Going down the group, **solubility in water increases**.
- Going down the group, ionic radius increase → strength of ionic bond decrease → easier for water molecules to penetrate the lattice structure.

| Oxide | Ionic radius of cation/nm | Reaction with water | Reaction equation | pH of solution |
|---|---|---|---|---|
| MgO | 0.065 | Partially soluble in water (strong ionic bond) | $MgO + H_2O \leftrightarrow Mg(OH)_2$ | 9 |
| CaO | 0.099 | React vigorously with cold water to form alkaline solution | $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$ | 10 |
| SrO | 0.113 | | $SrO + H_2O \rightarrow Sr(OH)_2$ | 11 -12 |
| BaO | 0.135 | | $BaO + H_2O \rightarrow Ba(OH)_2$ | 12 - 13 |

## Reaction with WATER

- Elements except Be react with cold water to produce **$H_2$(g)** and **metal hydroxides**.
- Reactivity with water increases down the group.
- This reflects the increasing ease with which electrons can be lost.
- $M(s) + 2H_2O(l) \rightarrow M(OH)_2(aq) + H_2(g)$

- $Mg(s) + 2H_2O(g) \rightarrow Mg(OH)_2(aq) + H_2(g)$
- Mg react very slowly with cold water. Little $H_2$ gas only formed after a few days.

- But heated Mg reacts rapidly with steam.

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

# Reaction with **WATER**

E.g :

- $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$

- $Sr(s) + 2H_2O(l) \rightarrow Sr(OH)_2(aq) + H_2(g)$

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

# Carbonates and Nitrates of Group II Elements

| Carbonates | Nitrates |
|---|---|
| General formula : $MCO_3$ | General formula $M(NO_3)_2$ |
| Insoluble in water | Soluble in water |
| Decompose on heating to leave a metal oxide residue and $CO_2$(g)<br>**$MCO_3 \rightarrow MO + CO_2$** | Decompose on heating to leave a metal oxide residue, NO(g) & $O_2$(g).<br>**$M(NO_3)_2 \rightarrow MO + 2NO_2 + ½O_2$** |

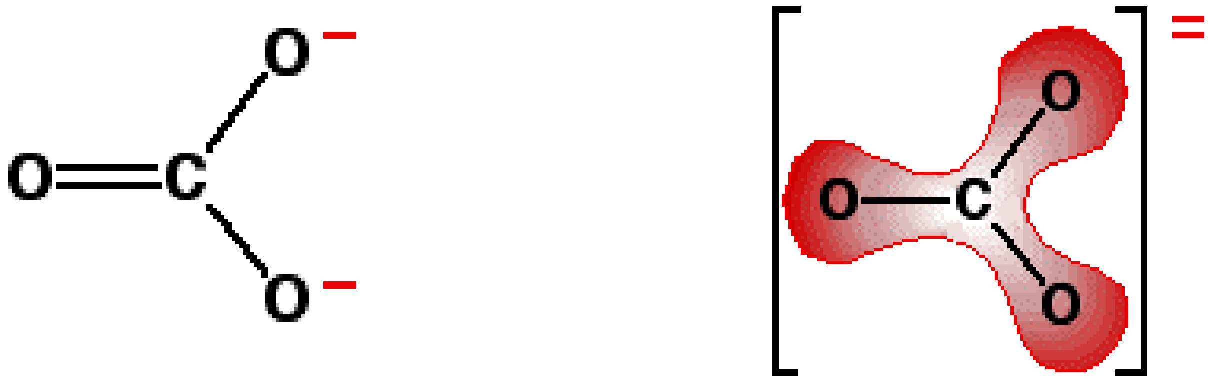
- **Decomposition temperature** of Group II compounds **increases** down the group (Ca to Ba).

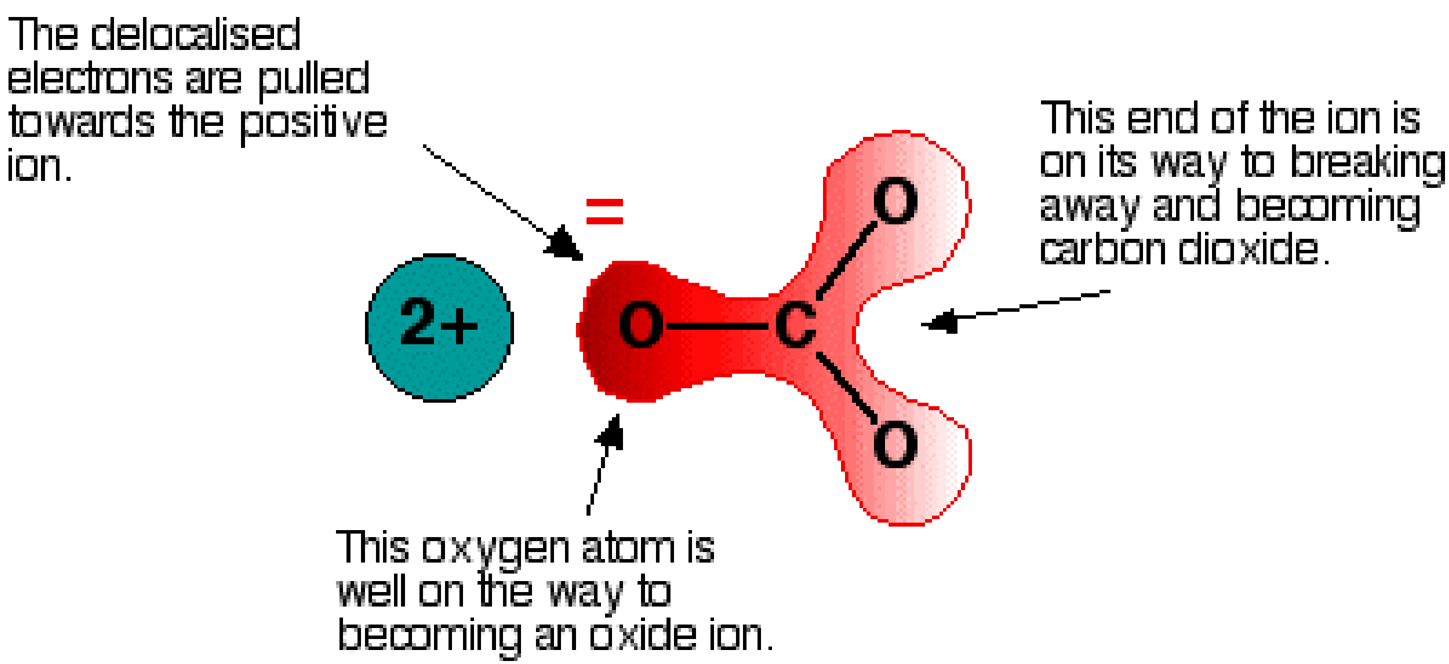
# Thermal stability of Group II carbonates and nitrates.

$MgCO_3$ , $Mg(NO_3)_2$
$CaCO_3$ , $Ca(NO_3)_2$
$SrCO_3$ , $Sr(NO_3)_2$
$BaCO_3$ , $Ba(NO_3)_2$

**- Decomposition temperature increase.**
**Thermal stability increase**, more difficult to decompose.

**- Ionic radius increase,**
**- charge density decrease, polarizing power decrease**.
- more difficult to distort the large $CO_3^{2-}$ and $NO_3^-$ anion.
- $\therefore$ Compound more difficult to decompose.


O
C
O
O
O
C
O
O


The delocalised electrons are pulled towards the positive ion.
2+
O
C
O
O
This end of the ion is on its way to breaking away and becoming carbon dioxide.
This oxygen atom is well on the way to becoming an oxide ion.

# Uses of Magnesium Oxide

Magnesium compounds, primarily **magnesium oxide**, are used mainly as **refractory** material in **furnace** linings for producing **iron**, **steel**, nonferrous metals, **glass** and **cement**. What property makes it suitable to be used in furnace linings?

A Furnace

# Uses of Calcium Carbonate

Calcium carbonate is mainly used to manufacture **cement.**

Cement is made by heating a mixture of limestone and clay in a sloping rotating cylinder which is heated on the inside by burning coal dust in a blast of air.

Lumps of clinkers are formed, which are ground to powder. This is cement.

When it is thoroughly mixed with sand and water, the slurry so formed sets in a few hours.

# Uses of lime in agriculture

- Slaked lime [$Ca(OH)_2$]

  $CaO + H_2O \rightarrow Ca(OH)_2$

  Used in agriculture to reduce soil acidity.

# Uses of Group II Compounds

| compound | use | reason for use |
|---|---|---|
| magnesium oxide | refractory (heat resistant) lining of furnaces | magnesium oxide has a very high melting point |
| calcium oxide and calcium hydroxide | spread onto agricultural land to neutralise excess acidity | calcium oxide and hydroxide are alkaline |
| calcium carbonate (marble and limestone) | used to make cement for concrete in buildings | — |
| calcium sulphate $CaSO_4 \cdot \frac{1}{2}H_2O$ | plaster casts for broken limbs | absorbs water and sets to a hard solid |

# Uses of Group II Compounds

| **Compound** | **Use** | **Reason of Use** |
|---|---|---|
| Magnesium metal | -used to protect steel objects (ships,bridges) from corrosion.<br>-Used to extract less electropositive metals (Titanium in Kroll process).<br>- Used in flare guns and tracer bullets. | -Strong reducing agent.<br>- Burns with bright white flame. |
| $MgF_2$ | Used to coat surface of camera lenses to reduce amount of reflected lights. | - |
| $Mg(OH)_2$ | Used in indigestion remedies and toothpaste. | Weak alkali |