# Chapter 10a (AS-Level)

## Group II

## General properties of group II elements:

- They are all metals
- They are good conductors of electricity
- Their compounds are all white or colourless
- They all have an oxidation number of +2 in their compounds
- They are called the alkaline earth metals because their oxides and hydroxides are basic
- They react with acids to give hydrogen gas

Compared with group I elements:

- They are harder and denser
- Have a higher melting point
- Exhibit stronger metallic bonding due to 2 outer shell electrons

## Uses

### Magnesium

- It is used in flares, incendiary bombs and tracer bullets
- It has a strong reducing power, so is used to protect metals from corrosion. It is also used to extract less electropositive metals like titanium in the Kroll process at 1250K under an argon atmosphere.

$$2\ Mg + TiCl_4 \rightarrow Ti + 2\ MgCl_2$$

- It is found in chlorophyll
- $Mg(OH)_2$ is a weak alkali used in indigestion medicines and toothpastes.

$$Mg(OH)_2 + 2\ H^+ \rightarrow Mg^{2+} + 2\ H_2O$$

- MgO is a refractory material (resistant to heat, melting point over 3000K). It is used as a lining for furnaces
- $MgF_2$ is used to coat the surfaces of camera lenses, to reduce the amount of reflected light (responsible for the violet colour of lens surfaces)

### Calcium

- $CaCO_3$ (limestone) is used to make cement
- CaO (quicklime) is used to purify iron

$$CaO + SiO_2 \rightarrow CaSiO_3$$

- CaO glows with a bright light when heated
- $Ca(OH)_2$ (solid) is used to reduce the acidity of soils

$$Ca(OH)_2 + 2\ H^+ \rightarrow Ca^{2+} + 2\ H_2O$$

- Plaster of Paris (calcium sulphate $2CaSO_4.H_2O$) when mixed with water hydrates to $CaCO_4.2H_2O$ and sets hard. It is used to set broken bones and for modeling
- The hydrogen carbonate of Ca and Mg are responsible for the hardness of water

### Barium

- Barium sulphate is used in the Barium metal, which is insoluble and coats the lining of the alimentary canal to make any imperfections visible for x-ray photographs. It is insoluble so is used as a test for the sulphate ions as it forms a precipitate.

### Strontium

- Strontium has a few uses. $^{90}Sr$ is a product of many nuclear reactions.

## Reactions of group II elements

### With water

All group II elements produce $H_2$ with water reducing it to $H_2$.

- Mg reacts slowly with water to produce an alkaline solution of $Mg(OH)_2$ and $H_2$

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

- Mg reacts with steam to produce MgO, which is a rapid reaction.

$$Mg + H_2O \rightarrow MgO + H_2$$

- The reactivity of the elements with water increase down the group. Ca to Ba reacts readily with water to form a cloudy white precipitate of the hydroxide.

### With oxygen

The reactions are vigorous once started.

$$2\ Mg + O_2 \rightarrow 2\ MgO$$

### Formation of salts with HCl

- All salts of group II elements are crystalline and white. They are prepared by the reaction of the metal, oxide or carbonate with an acid.

- $Mg(s) + 2\ HCl(l) \rightarrow MgCl_2 + H_2$ (rapid with cold HCl)
- $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ (rapid with heating)
- $MgCO_3 + 2\ HCl(aq) \rightarrow MgCl_2 + H_2O + CO_2$ (rapid with cold HCl)

### Reactions of oxides with water

- All are basic and form a solution of the hydroxide (alkaline)

$$MgO + H_2O \rightarrow Mg(OH)_2\ (aq)$$
$$BaO + H_2O \rightarrow Ba(OH)_2\ (aq)$$

- The reaction of MgO with water is slow, others react readily with water
- The solubility of the hydroxides increase down the group and become more alkaline

### Thermal decomposition of Group II nitrates and carbonates

- All nitrates decompose to form metal oxides, nitrogen dioxide and oxygen:

$$2\ Mg(NO_3)_2 \rightarrow 2\ MgO + 4\ NO_2 + O_2$$

- All carbonates decompose to form metal oxide and carbon dioxide:

$$BaCO_3 \rightarrow BaO + CO_2$$

- Decomposition temperature increase down the group

## Chalk and lime industry

- Chalk and limestone are both Calcium Carbonate
- Heating CaCO3 produces CaO (quicklime) and $CO_2$

$$CaCO_3 \rightarrow CaO + CO_2$$

- CaO reacts with $H_2O$ to make $Ca(OH)_2$ (slaked lime)

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

- Adding more water to calcium hydroxide produces lime water (pH 9 -10)
- Adding more $CO_2$ to $Ca(OH)_2$ (aq) form a cloudy precipitate of $CaCO_3$

$$Ca(OH)_2\ (aq) + CO_2 \rightarrow CaCO_3 + H_2O$$

- Adding more $CO_2$ to the lime water after the precipitate, the mixture becomes clear again. The $CaCO_3$ reacts with the water and $CO_2$ (aq) to make Calcium hydrogen carbonate $Ca(HCO_3)_2$

$$CaCO_3 + H_2O + CO_2\ (aq) \rightarrow Ca(HCO_3)_2$$

- Hard water contains $Mg^{2+}$ and $Ca^{2+}$ ions which react with soap to produce scum. These ions are come from the action of $H_2O$ and $CO_2$ with $CaCO_3$. The $CO_2$ (aq) is formed when rainwater dissolves $CO_2$ in the air.

- Flue gas desulphurization (FGD)
  $CaCO_3$ is used to remove $SO_2$ from waste gases produced when coal is burned. These gases are passed through a suspension of $CaCO_3$ forming $CaSO_4$

$$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$$

$$2\ CaSO_3 + O_2 \rightarrow 2\ CaSO_4$$

  The CaSO4 is used to make plaster.

*END OF LESSON*