

CAIE Chemistry A-level

10: Group 2 Notes

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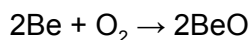


Trends in the Properties of Group 2 Metals, Magnesium to Barium, and their Compounds

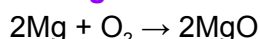
Group 2 Metals and Oxygen

Generally, the Group 2 metals burn in oxygen to form a **metal oxide**.

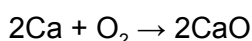
- **Beryllium** is coated in a thin layer of **beryllium oxide** which **inhibits** the reaction meaning it only reacts in a powder form.



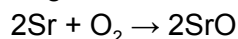
- **Magnesium** burns in oxygen with a **bright white flame**.



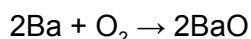
- **Calcium** burns with an orange/**red flame**.



- **Strontium** is reluctant to start burning but burns intensely with a **red flame**.



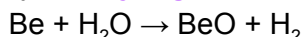
- **Barium** burns in oxygen with **green flame**.



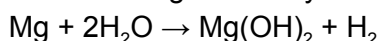
Group 2 Metals and Water

The reactions of the Group 2 metals with water or steam can be used to see the **trend in reactivity** down the group.

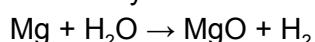
- **Beryllium** reacts with steam only at **very high temperatures**.



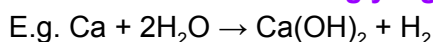
- **Magnesium** has a very **slight reaction** with **cold water**. The reaction stops due to the production of an insoluble coat of magnesium hydroxide.



Magnesium burns in **steam** more readily than cold water:



- **Calcium, strontium** and **barium** all react in cold water to produce their hydroxide and hydrogen gas. The reactions become **increasingly vigorous** down the group.

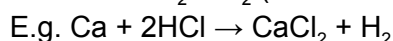


Beryllium only reacts with steam at high temperatures but, going down Group 2, the metals react more readily and rapidly with cold water, with barium reacting the fastest. This shows that **reactivity increases down the group**.

Group 2 Metals and Dilute Acids

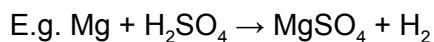
Hydrochloric acid

All Group 2 metals react with dilute hydrochloric acid to produce a **metal chloride** and **hydrogen** gas. The reactions get **more vigorous** as you go down the group. The general equation for this reaction is: $\text{X} + 2\text{HCl} \rightarrow \text{XCl}_2 + \text{H}_2$ (where X is a Group 2 metal).



Sulfuric acid

Dilute sulfuric acid reacts with Group 2 metals to produce a **metal sulfate** and **hydrogen**. The general equation for this reaction is: $X + H_2SO_4 \rightarrow XSO_4 + H_2$ (where X is a Group 2 metal).



The reactions with dilute sulfuric acid **do not get more vigorous** down the group due to the **solubility of the sulfates** produced. Beryllium and magnesium produce soluble sulfates so their reactions with sulfuric acid are similar to their reactions with hydrochloric acid.

Calcium produces a **sparingly soluble** sulfate. **Strontium** and **barium** produce **insoluble sulfates**. This means calcium, strontium and barium will only react with sulfuric acid for a short period of time because the **reaction will stop** once the **insoluble sulfate forms on the metal**.

Group 2 Oxides

Reactions with water

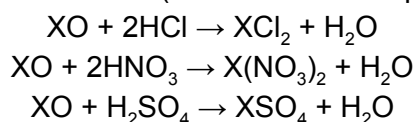
Apart from **beryllium**, all Group 2 oxides react with water to produce hydroxides.

- **Magnesium oxide** produces a solution that is around **pH 9**. This is because the **magnesium hydroxide** is only **sparingly soluble** so not many OH^- ions are released into the solution.
 $MgO + H_2O \rightarrow Mg(OH)_2$
- **Calcium oxide** (quicklime) undergoes an **exothermic** reaction to produce calcium hydroxide (also known as slaked lime or lime water). **Calcium hydroxide** is **partially soluble** so the resulting solution is **pH 12**.
 $CaO + H_2O \rightarrow Ca(OH)_2$
- **Strontium oxide** and **barium oxide** produce hydroxides which are **increasingly soluble**. They react in the same way as calcium but produce solutions with a **higher pH** as more OH^- ions get released into the solution.

Reactions with dilute acids

All Group 2 oxides react with dilute acids to produce **salt and water**.

The general equations for these reactions (where X is a Group 2 metal) are:



The reactions with **hydrochloric and nitric acid are standard** and reactivity increases down the group.

The reactions with **sulfuric acid are different** due to the different **solubilities** of the products. Magnesium and beryllium oxides react as expected. **Calcium, barium** and **strontium** oxides react differently because their sulfates are **increasingly insoluble**. The sulfate formed during the reaction coats the metal oxide, **slowing or stopping** the reaction.



Group 2 Hydroxides

Reactions with water

The Group 2 hydroxides **do not react** with water.

Reactions with dilute acids

The Group 2 hydroxides react with dilute acids in the **same way as the metal oxides** (explained on the previous page). The only difference is that two water molecules are produced rather than one.



Metal Carbonates

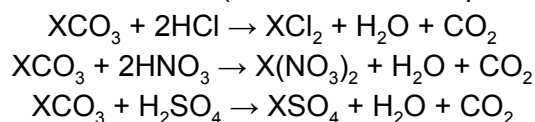
Reactions with water

The Group 2 metal carbonates are insoluble so they **do not react** with water.

Reactions with dilute acids

Group 2 carbonates react with dilute acids to produce a **salt, water** and **carbon dioxide**.

The general equations for these reactions (where X is a Group 2 metal) are:



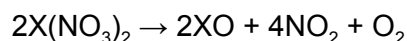
The reactions with **hydrochloric and nitric acid are standard** and **reactivity increases** down the group.

The reactions with **sulfuric acid are different** due to the different **solubilities** of the products. Magnesium and beryllium carbonates react as expected. **Calcium, barium** and **strontium** carbonates react differently because their sulfates are **increasingly insoluble**. The sulfate formed during the reaction coats the metal carbonate, **slowing or stopping** the reaction.

Thermal Decomposition of the Nitrates and Carbonates

Nitrates

All Group 2 nitrates undergo **thermal decomposition** to produce a **metal oxide, oxygen** and **nitrogen dioxide**. The nitrates are **heated more strongly** as you go down the group. The general equation for this reaction (where X is the Group 2 metal) is:

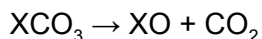


Observations: The nitrate and the oxide are both **white solids**. Nitrogen dioxide is a **brown gas**.



Carbonates

All Group 2 carbonates undergo **thermal decomposition** to produce a **metal oxide** and **carbon dioxide**. The carbonates are **heated more strongly** as you go down the group. The general equation for this reaction (where X is the Group 2 metal) is:



Observations: The carbonate and the oxide are both **white solids**. Carbon dioxide is a **colourless gas**.

Both Group 2 carbonates and nitrates become **more stable to heat** as you go down the group. This means as you go down the group, the nitrates and carbonates have to be **heated more strongly** for thermal decomposition to occur.

Predicting Trends

The reactions of Group 2 metals, metal oxides, metal hydroxides and metal carbonates generally indicate that **reactivity increases as you go down Group 2**.

Reactivity increases down the group because **ionisation energy decreases** due to the **increasing atomic radius** and the **shielding effect** of electrons. This means further down the group, the electrons become easier to remove so reactivity increases.

Some **exceptions** to this trend can be seen when **sulfates and hydroxides are produced**, however this is due to the **insolubility** of some sulfates and hydroxides inhibiting reactions.

Solubility of Hydroxides and Sulfates

The **solubilities** of the Group 2 metal **hydroxides** and **sulfates** show trends in the group. The trend in the solubility of sulfates is **opposite** to the trend in the hydroxides:

Group 2 element - X	Hydroxide - X(OH) ₂	Sulfate - XSO ₄
Magnesium	Least soluble	Most soluble
Calcium		
Beryllium		
Barium	Most soluble	Least soluble

Compounds with very **low solubilities**, like magnesium hydroxide, are often said to be **sparingly soluble**. Most sulfates are soluble in warm water except barium sulfate which is insoluble.



Uses of Group 2 Compounds

Calcium hydroxide and **calcium carbonate** are both compounds used in **agriculture**. Calcium carbonate is **powdered limestone**. Calcium hydroxide is formed when calcium oxide is added to water. Calcium oxide and calcium hydroxide are often referred to as **lime** and **slaked lime**, respectively.

Crops grow best in soil around **pH 6**. If soil becomes **too acidic**, calcium carbonate or calcium hydroxide can be added to raise the pH. This is because both compounds **react with and neutralise acids**.

Calcium carbonate **reacts more slowly** than calcium hydroxide since it is **not water soluble**, however it is used more often as it is **cheaper** and **easier to handle**.

