

Group 2

The physical and chemical properties of the elements of Group 2 (the alkaline Earth metals) are introduced in this topic.

- 10.1 Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds
- 10.2 Some uses of Group 2 compounds



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Learning outcomes

Candidates should be able to:

- 10.1 Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and their compounds
- a) describe the reactions of the elements with oxygen, water and dilute acids
 - b) describe the behaviour of the oxides, hydroxides and carbonates with water and dilute acids
 - c) describe the thermal decomposition of the nitrates and carbonates
 - d) interpret, and make predictions from, the trends in physical and chemical properties of the elements and their compounds
 - e) state the variation in the solubilities of the hydroxides and sulfates
 - f) interpret and explain qualitatively the trend in the thermal stability of the nitrates and carbonates in terms of the charge density of the cation and the polarisability of the large anion**
 - g) interpret and explain qualitatively the variation in solubility of the hydroxides and sulfates in terms of relative magnitudes of the enthalpy change of hydration and the corresponding lattice energy**
- 10.2 Some uses of Group 2 compounds
- a) describe and explain the use of calcium hydroxide and calcium carbonate (powdered limestone) in agriculture

INTRODUCTION

The Group II metals (also known as earth metals) are all elements with similar properties.

Earth Metals comprise of Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra).

They are generally shiny, silvery-white metals with relatively low densities and melting points.

Beryllium (Be)	$1s^2 2s^2$
Magnesium (Mg)	$1s^2 2s^2 2p^6 3s^2$
Calcium (Ca)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
Strontium (Sr)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$
Barium (Ba)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^2$

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PHYSICAL PROPERTIES

	Mg	Ca	Sr	Ba
Melting point/°C	649	839	769	729
Boiling point/°C	1090	1484	1384	1637
First ionisation energy/kJ mol ⁻¹	736	590	548	502
Second ionisation energy/kJ mol ⁻¹	1450	1150	1060	966
Ionic radius of M ²⁺ ion/nm	0.065	0.099	0.113	0.135

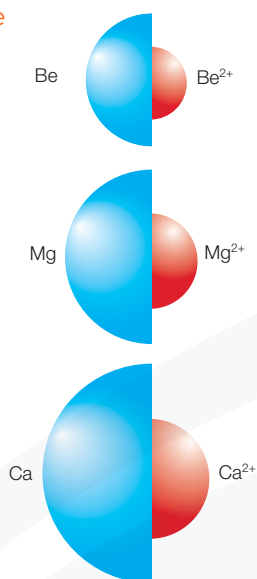
Group 2 metals are reducing agents. They readily give up their two s electrons to form M²⁺ ions (where M represents Mg, Ca, Sr or Ba).

The elements get more reactive as we go down the group as it takes less energy to remove the pair of outer electrons going down Group 2.

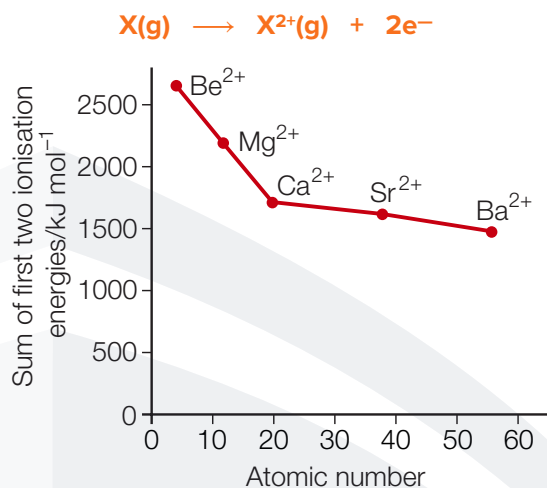
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PHYSICAL PROPERTIES

Relative sizes of the atoms and ions of Group 2 elements.



Graph to show the trend in the sum of the first two ionisation energies of Group 2 metals:



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REACTIONS WITH WATER AND STEAM

The metals Mg to Ba in Group 2 react with water. The reactions are not as vigorous as the reactions of the Group 1 metals, but, as in Group 1, the rate of reaction increases down the group.

Magnesium reacts very slowly with cold water but much more rapidly on heating in steam. It does not give the hydroxide, as magnesium oxide is almost insoluble in water.



Calcium reacts with cold water to produce hydrogen and calcium hydroxide.



Barium reacts even faster with cold water, but its hydroxide is more soluble.

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REACTIONS WITH WATER AND STEAM



Element	Water	Steam
Magnesium	<p>Slow reaction. Bubble of hydrogen form. Produces a hydroxide and hydrogen.</p>	<p>Burns in steam rapidly. Produces white an oxide and hydrogen.</p>
Calcium, Strontium & Barium	<p>Rapid reactions. Vigor increases down the group. Alkaline solution obtained. Produces a hydroxide and hydrogen.</p>	<p>Explosive reaction. Produces white oxide and hydrogen.</p>

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SKILL CHECK

Write balanced equations, including state symbols, for the reaction of:

(a) strontium with water

(b) barium with water

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REACTIONS WITH OXYGEN

Apart from beryllium, the Group 2 metals burn brightly on heating in oxygen to form white ionic oxides, $M^{2+}O^{2-}$.

Magnesium burns very brightly in air, with an intense white flame, to form the white solid magnesium oxide, MgO. For this reason, magnesium powder is an ingredient of fireworks and flares.



Calcium also burns brightly in air, but with a red flame, to form the white solid calcium oxide, CaO.

Strontium burns with a crimson flame and barium with a green flame.

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REACTIONS WITH ACIDS

General Reaction: metal + acid \longrightarrow hydrogen + salt

All Group 2 Metals react with acids to liberate Hydrogen gas. The silver metal is seen dissolving in the metal.

Reactivity increases down the group.

A soluble salt is produced, except in sulfuric acid.

This is due to sulfates being increasingly insoluble down the group.

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GROUP 2 OXIDES

Earth Metals form basic oxides. They have high melting points and are used industrially.

They are normally prepared by heating the hydroxide or carbonate to release water or carbon dioxide gas.



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GENERAL PROPERTIES OF COMPOUNDS

Group II Hydroxides and Oxides are increasingly soluble down the group, making alkaline solutions.

Group II Sulfates are decreasingly soluble down the group.

Group II Carbonates are all insoluble in water, and react with acids to liberate carbon dioxide.



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SKILL CHECK

Write a balanced equation, including state symbols, for the reaction of barium carbonate with dilute nitric acid.

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THERMAL DECOMPOSITION OF CARBONATES

All Carbonates undergo thermal decomposition to give metal oxide and carbon dioxide gas.



Down the group, the carbonates need to be heated strongly to decompose.

Thermal stability of group 2 carbonates increases down the group.

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THERMAL DECOMPOSITION OF NITRATES

All Nitrates undergo thermal decomposition to give metal oxide, nitrogen dioxide (brown gas) and oxygen gas.



Down the group, nitrates also become increasingly stable to heat.

Thermal stability of group 2 nitrates increases down the group.

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SKILL CHECK

Which of the three compounds listed will decompose at the lowest temperature?

(a) calcium carbonate, strontium carbonate, barium carbonate

Q. Write a balanced chemical equation, including state symbols, for the thermal decomposition of:

(a) strontium carbonate

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SKILL CHECK

Which of the three compounds listed will decompose at the lowest temperature?

(a) barium nitrate, calcium nitrate, magnesium nitrate

Write a balanced chemical equation, including state symbols, for the thermal decomposition of:

(a) barium nitrate

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INDUSTRIAL USES

Magnesium Oxide is used to line blast furnaces. It is highly heat resistant and can be used in furnaces where acid isn't present.

Lime (powdered Calcium Carbonate), Quicklime (Calcium Oxide) and Slaked Lime (Calcium Hydroxide) are used to raise the pH of acidic soils by neutralising the acids.

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