بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

(In the Name of Allah, the Most Merciful, the Most Compassionate.)

CHEMISTRY

12

PECTAA
Transformation, Innovation and Excellence

PUNJAB EDUCATION, CURRICULUM,
TRAINING AND ASSESSMENT AUTHORITY

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GROUP 2 ELEMENTS

Student Learning Outcomes [C-12- B-01 to C-12-B-15]

- Describe the properties and trends of Group 2 elements, including their electron configurations, reactivity, and common compounds such as oxides, hydroxides and carbonates.
- Explain the reactivity of Group 2 elements in terms of their electron configuration and valence electrons.
- Explain the chemical reactivity of Group 2 elements, including their reactions with oxygen, water, and acids (Be, Mg, Ca).
- Explain the term reactivity series and its application in predicting the outcome of chemical reactions.
- Explain the term basic oxide and its application in the formation of Group 2 compounds.
- Compare the properties and reactivity of Group 2 elements with group 1 in the periodic table.
- Understand the term thermal decomposition and its application in the analysis of Group 2 compounds especially carbonates and nitrates.
- Use the term thermal decomposition and its application in the analysis of Group 2 compounds especially carbonates and nitrates.
- Describe qualitatively the trend in the thermal stability of the nitrates and carbonates including the effect of ionic radius on the polarization of the large anion.
- Explain the trend in solubility of group 2 sulphates and hydroxides using terms enthalpy of hydration and enthalpy of solution.
- Describe qualitatively the variation in solubility and of enthalpy change of solution, ΔH_{sol}, of the hydroxides and sulphates in terms of relative magnitudes of the enthalpy change of hydration and the lattice energy"
- Explain the term complex ion and its application in the formation of Group 2 compounds.
- Explain the extraction and purification process of Group II elements and their compounds.
- Describe the industrial and everyday uses of Group 2 compounds, including their role in medicine and agriculture.

Group 2 elements are s block elements in Group 2 of the periodic table. They are also called the alkaline earth metals due to their metallic nature and occurrence in the earth crust. These elements present a class of metals having reactivity between highly reactive alkali metals and less reactive transition metals. Ca and Mg are among the eight most widely occurring elements in the earth crust.

Most firework colours are due to Group 2 element

Be is used to make copper alloys harder for aerospace materials, while Mg is an important part of chlorophyll, the green matter in plants. Mg, Ca, Sr, and Ba are essential components of fireworks due to their vibrant flame colours.

17.1 PROPERTIES AND TRENDS OF GROUP 2 ELEMENTS

All these elements have two electrons in their outermost 's' subshells (ns^2), therefore, they exhibit similar chemical properties. However, the properties of the elements vary from top to bottom in the group. Salient characteristics of Group 2 elements are given in **Table 17.1.** The trend in melting point and density are related to the different packing of the metal atoms down the group.

Table 17.1 Properties of Group 2 (Be–Ba)

Property	Beryllium (Be)	Magnesium (Mg)	Calcium (Ca)	Strontium (Sr)	Barium (Ba)
Atomic Number	4	12	20	38	56
Electron Configuration	[He] $2s^2$	[Ne] $3s^2$	[Ar] $4s^2$	[Kr] $5s^2$	[Xe] $6s^2$
Metallic Radius (pm)	112	160	197	215	222
Ionic Radius (M^{2+})	31	65	99	113	135
1st Ionization Energy	900	738	590	550	503
2nd Ionization Energy	1757	1451	1145	1064	965
Electronegativity	1.5	1.2	1.0	1.0	0.9
Melting Point (°C)	1287	650	842	777	727
Density (g/cm^3)	1.85	1.74	1.54	2.64	3.51
Standard Electrode Potential (E°)	-1.97	-2.34	-2.87	-2.89	-2.91

17.1.1 Chemical reactivity of Group 2 Elements

The reactivity of Group 2 elements can be explained based on their electronic configuration. There are two electrons in their outermost subshells (ns^2). After losing these two electrons, they become stable ions with a +2 charge (M^{2+}). This makes them react quickly with other substances. The reactivity increases from Be to Ba due to the increase in size, shielding effect and decrease in the ionization energy down the group. This makes the removal of electrons easier, and the reactivity increases.

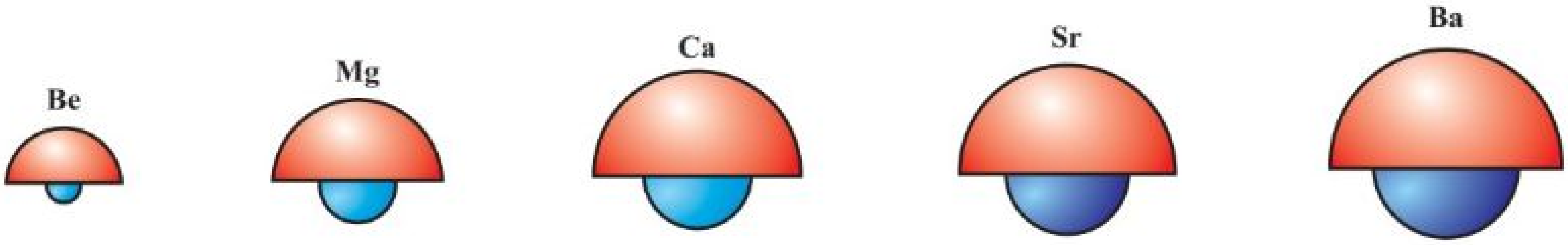


Figure 17.1: Relative sizes of the atoms of the Group 2 elements

Based on the above factors, the reactivity series can be presented in the increasing order from Be to Ba as given below. It shows that Be is the least reactive and Ba is the most reactive element of Group 2.

$$Be < Mg < Ca < Sr < Ba$$

17.2 CHEMICAL REACTIONS OF GROUP 2 ELEMENTS

17.2.1 Reactions with Oxygen

All Group 2 metals burn in oxygen to form metal oxides (MO).

$$2M + O_2 \longrightarrow 2MO$$

Beryllium (Be) reacts with oxygen at high temperatures (above 600 °C) to form (BeO). A thin, strong oxide layer usually protects it, making it less reactive than the other group members.

$$2Be_{(s)} + O_{2(g)} \longrightarrow 2BeO_{(s)}$$

Magnesium (Mg) burns brightly in air or oxygen to form magnesium oxide (MgO). The reaction of calcium (Ca) with oxygen is more vigorous to give a brick red flame.

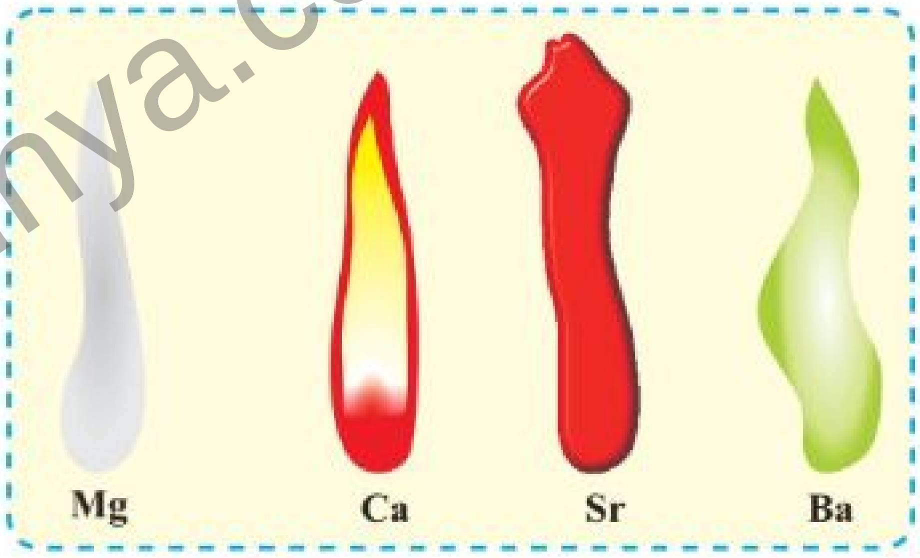


Figure 17.2: Flames of Group 2 elements

The oxides of the Group 2 elements are generally white solids and basic in nature and their basic character increases down the group. The basic character in water is due to the reaction between the oxide ion and water to produce the OH^- ion.

$$O^{2-}_{(s)} + H_2O_{(\ell)} \longrightarrow 2OH^-_{(aq)}$$

17.2.2 Reactions with Water

Except beryllium (Be), other Group 2 metals react with water to produce metal hydroxides, $M(OH)_2$ and hydrogen gas (H_2). Beryllium (Be) does not react with water or steam, even when heated. This is due to its protective oxide layer.

Magnesium (Mg) reacts very slowly with cold water, forming $Mg(OH)_2$ and H_2. With steam, it reacts faster to form magnesium oxide (MgO) and hydrogen.

Using cold water $Mg_{(s)} + 2H_2O_{(\ell)} \longrightarrow Mg(OH)_{2(aq)} + H_{2(g)}$

Using steam $Mg_{(s)} + H_2O_{(g)} \longrightarrow MgO_{(s)} + H_{2(g)}$

Calcium (Ca) reacts with cold water and steam more vigorously than magnesium, forming $Ca(OH)_2$ and H_2. The calcium hydroxide is sparingly soluble, forming a white precipitate.

$$Ca_{(s)} + 2H_2O_{(\ell)} \longrightarrow Ca(OH)_{2(aq)} + H_{2(g)}$$

The hydroxides of Group 2 are less basic than the Group 1 elements. However, the basic character of the hydroxides of Group 2 elements increases down the group due to the increasing solubility.

Figure 17.3 Calcium forms a sparingly soluble hydroxide with water

17.2.3 Reactions with Acids

Group 2 metals react with dilute acids to produce a salt and hydrogen gas (H_2).

$$M_{(s)} + 2HCl_{(aq)} \longrightarrow MCl_{2(aq)} + H_{2(g)}$$

Reactivity increases down the group. Beryllium (Be) reacts with dilute acids to form $BeCl_2$ and hydrogen gas, but its protective oxide layer can slow this reaction.

Magnesium (Mg) reacts readily with dilute acids (e.g., hydrochloric acid, sulphuric acid) to form magnesium salts and hydrogen gas.

$$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

$$Mg_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_{2(g)}$$

Calcium (Ca) reacts vigorously with dilute acids to form calcium salts and hydrogen gas.

$$Ca_{(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_{2(g)}$$

However, with sulphuric acid, the reaction can stop early because the calcium sulphate ($CaSO_4$) formed is sparingly soluble and coats the metal surface with a protective layer.

$$Ca_{(s)} + H_2SO_{4(aq)} \longrightarrow CaSO_{4(s)} + H_{2(g)}$$

Quick Check 17.1 ☑

a) Write equations for the following reactions:
   i) Ca with oxygen   ii). Ba with water
b) Predict the extent of the reactions of Sr and Ba with H_2SO_4.
c) Explain why Group 2 elements are reactive, based on their electron configuration and ion formation.
d Write a balanced equation for calcium and barium burning in air and compare their reactivity.
e) Predict the density and melting point of the radioactive radium (Ra) following the trend in Group 2.

17.3 COMPARISON OF GROUP 2 ELEMENTS WITH GROUP 1 ELEMENTS

Group 1 (alkali metals) and Group 2 (alkaline earth metals) both include highly reactive metals, but they show key differences due to the difference in their ionization energies. Group 1 metals have only one electron to lose, making them extremely eager to react and form a +1 ion.

Group 2 metals lose two electrons, which requires more energy, so they are reactive but generally less so than their Group 1 counterparts in the same period. Both groups show increasing reactivity going down their respective groups due to increasing atomic size, and decreasing ionization energy.

Table 17.2 **Comparison of Group 2 elements with Group 1 elements**

Feature	Group 1 (Alkali Metals)	Group 2 (Alkaline Earth Metals)
Valence Electrons	1 (ns^1)	2 (ns^2)
Ion Formation	Forms +1 ions (M^+)	Forms +2 ions (M^{2+})
Reactivity	More reactive	Less reactive (compared to Group 1 elements in the same period)
Reason for Reactivity	Low ionization energies	Higher ionization energies
Hardness	Very soft (can be cut with a knife).	Harder than Group 1 metals.
Density	Low densities.	Higher densities than Group 1 metals.
Melting/Boiling Points	Lower melting/boiling points.	Higher melting/boiling points.
Reaction with Water	Very vigorous, often explosive (e.g., Na with water).	Less vigorous (e.g., Ca with water, Mg with steam).
Oxides	Form M_2O (e.g., Na_2O); highly basic.	Form MO (e.g., CaO); less basic than Group 1 oxides.
Hydroxides	Highly soluble, strong bases.	Less soluble than Group 1, but solubility increases down the group. Less basic than Group 1 hydroxides

17.4 THERMAL DECOMPOSITION OF CARBONATES AND NITRATES

Thermal decomposition is a chemical reaction, where a single compound breaks down into two or more simpler substances when heated. This process usually requires energy (endothermic) to break the chemical bonds within the compound.

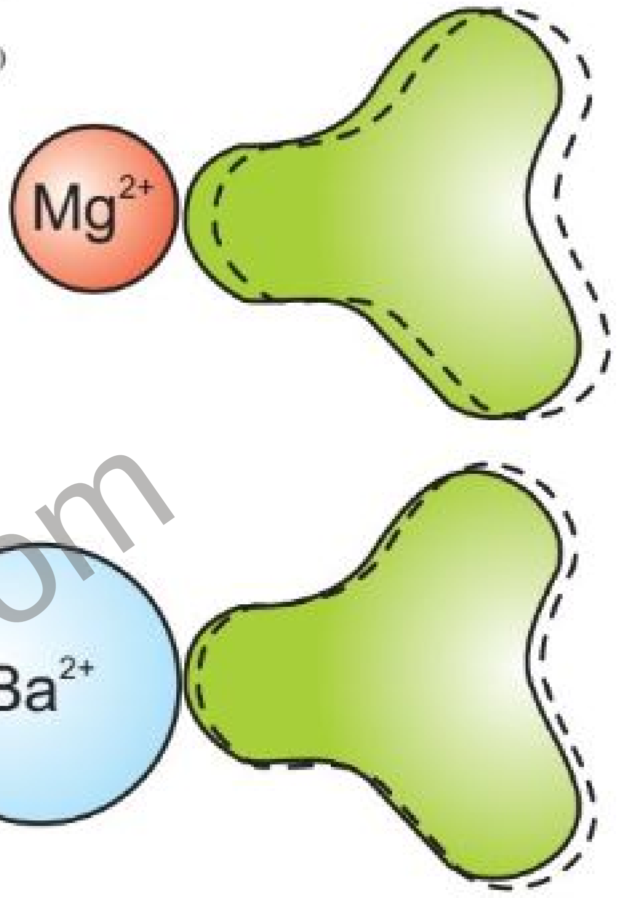
Thermal decomposition is very useful for understanding and analyzing Group 2 carbonates and nitrates because their thermal stability follows a clear trend down the group.

Group 2 carbonates decompose upon heating to form a metal oxide (MO) and carbon dioxide gas (CO_2). The thermal stability of carbonates increases down the group. This means that $BeCO_3$ decomposes at a lower temperature than $MgCO_3$, which decomposes at a lower temperature than $CaCO_3$, and so on.

$$MgCO_{3(s)} \longrightarrow MgO_{(s)} + CO_{2(g)}$$
$$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$$

$BaCO_3$ requires the highest temperature to decompose.

The above discussed trend is due to the size of the M^{2+} ion. Smaller and highly charged cations (like Be^{2+}) have a greater "polarizing power." They distort the large carbonate ion (CO_3^{2-}) to a larger extent, weakening its bonds and making it easier to decompose with heat. As the metal ion gets larger down the group, its polarizing power decreases, leading to more stable carbonates that require more heat for decomposition.



Group 2 nitrates decompose upon heating to form a metal oxide (MO), brown nitrogen dioxide gas (NO_2), and oxygen gas (O_2).

$$2Ca(NO_3)_{2(s)} \longrightarrow 2CaO_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

Similar to carbonates, the thermal stability of nitrates also increases down Group 2. $Be(NO_3)_2$ is the least stable, and $Ba(NO_3)_2$ is the most stable among them.

The same polarizing power argument applies here as well. The smaller M^{2+} ions at the top of the group distort the nitrate ion (NO_3^-) more effectively, making its decomposition easier at lower temperatures.

By observing the temperature at which a Group 2 carbonates or nitrates decompose, chemists can identify the unknown compounds and confirm the presence of specific elements. The decomposition pattern helps to understand the relationship between ionic size, charge density, and thermal stability. The temperatures at which Group 2 carbonates decompose are given in **Table 17.3**

Table 17.3 Temperatures of decomposition of the Group 2 carbonates at 1 atm

Metal Carbonate	Temperature (°C)
$BeCO_3$	250
$MgCO_3$	540
$CaCO_3$	900
$SrCO_3$	1289
$BaCO_3$	1360

Quick Check 17.2

a) State two physical differences between Group 1 and Group 2 metals.

b) State the general formula for a Group 1 oxide and a Group 2 oxide.

c) Write the balanced equation for the thermal decomposition of $SrCO_3$.

d) Explain qualitatively why magnesium carbonate is thermally less stable than calcium carbonate.

e) Write the equations for the thermal decomposition of

i) magnesium nitrate ii) Barium nitrate. Which of these decomposes at a lower temperature?

17.5 SOLUBILITY OF GROUP 2 SULPHATES AND HYDROXIDES

The solubility of an ionic compound in water depends on the balance between two main energy changes:

1. **Enthalpy of Hydration (ΔH_{hyd})** is the energy released when gaseous ions are surrounded and attracted by water molecules (becomes hydrated). This is always exothermic (negative value). Stronger attraction between ions and water molecules means a more negative ΔH_{hyd}. Smaller ions with higher charge density attract water molecules more strongly, leading to a more negative and higher hydration enthalpy. ΔH_{hyd} becomes *less negative* (less energy released) as you go down a group (ions get larger).

2. **Lattice Enthalpy ($\Delta H_{lattice}$)** is the energy required to break apart one mole of a solid ionic compound into its gaseous ions. This is always endothermic. Stronger forces in the crystal lattice imply a higher lattice enthalpy. It depends on the charges and sizes of the ions. As the sizes of the cation and the anion are comparable, the attractive forces become stronger and the lattice energy is higher. When one of the ions is larger and the other much smaller, the forces become weaker and the compound will have lower lattice energy.

The enthalpy of solution (ΔH_{soln}) is the overall energy change when a solid ionic substance is dissolved. A more negative or less positive ΔH_{soln} generally favours higher solubility.

The solubility of Group 2 hydroxides increases down the group (e.g., $Mg(OH)_2$ is sparingly soluble, $Ba(OH)_2$ is quite soluble). Going down Group 2, both ΔH_{hyd} (for M^{2+}) and $\Delta H_{lattice}$ decrease. However, the decrease in lattice enthalpy is more significant than the decrease in hydration enthalpy. With smaller Group 2 metal ions, the lattice energy of hydroxides is higher and vice versa.

The solubility of Group 2 sulphates, (MSO_4) in water decreases down the group (e.g., $MgSO_4$ is soluble and $BaSO_4$ is insoluble).

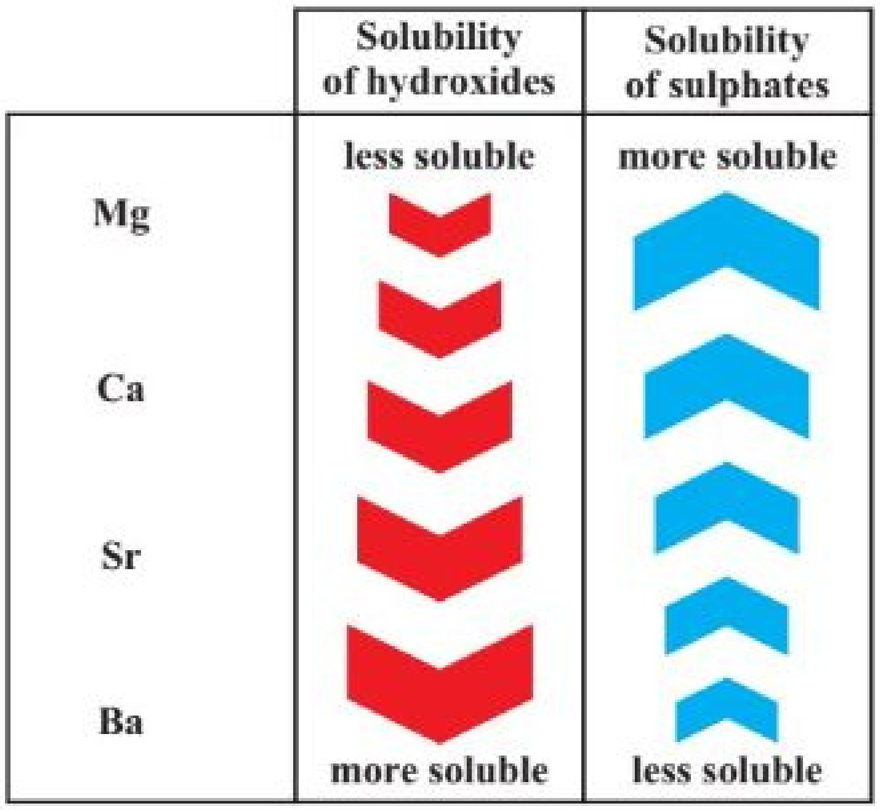


Figure 17.4 Trends in solubility in group 2 hydroxides and sulphates

The sulphate ion (SO_4^{2-}) is relatively larger. While going down Group 2, both ΔH_{hyd} (for M^{2+}) and $\Delta H_{lattice}$ decrease. But, for a large anion like sulphate, the decrease in hydration enthalpy is more significant than the decrease in lattice enthalpy

Table 17.4 **Solubility of Group 2 hydroxides and sulphates**

Group 2 Hydroxides	Solubility at 298K (mol/100 g of water)	Group 2 Sulphates	Solubility at 298K (mol/100 g of water)
$Mg(OH)_2$	2×10^{-5}	$MgSO_4$	1.83×10^{-1}
$Ca(OH)_2$	1.5×10^{-3}	$CaSO_4$	4.66×10^{-3}
$Sr(OH)_2$	3.4×10^{-3}	$SrSO_4$	7.11×10^{-5}
$Ba(OH)_2$	1.5×10^{-2}	$BaSO_4$	9.43×10^{-7}

17.6 COMPLEX ION FORMATION

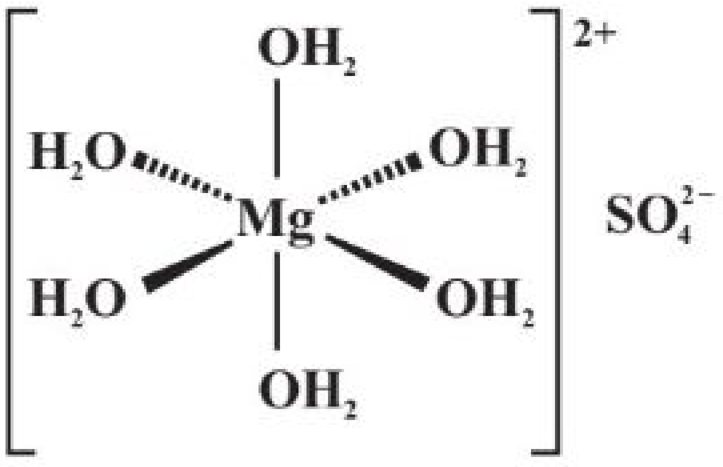
A complex ion is an ion in which a central metal is bonded to a number of surrounding electron donating species.

The central metal ion acts as a Lewis acid (electron pair acceptor), while the molecules or ions with lone pairs of electrons, e.g., H_2O, NH_3, Cl^-, OH^- act as Lewis bases. The number of coordinate bonds formed between the central metal ion and the electron donors is called coordination number. Common coordination numbers are 2, 4, and 6.

While complex ion formation is more typical for transition metals (due to their available d-orbitals for bonding), Group 2 elements can also form complex ions, especially those at the top of the group. Their tendency to form complexes is far less pronounced than that of transition metals, but it's still significant in certain contexts.

The ability of a Group 2 metal ion to form a complex ion depends on its size and charge. Smaller ions have a higher charge density (high charge to size ratio), which makes them better at attracting electron-donating species. All Group 2 ions have a +2 charge, which provides an electrostatic attraction for electron pair donors.

When Group 2 salts dissolve in water, the metal ions become hydrated. These are essentially complex ions where water molecules act as electron pair donors. For example, beryllium, being the smallest Group 2 ion, has a high charge density. It strongly attracts water molecules and forms a hydrated ion with a coordination number of 4 ($[Be(H_2O)_4]^{2+}$). Magnesium ions are larger and usually form hexahydrate complexes, with a coordination number of 6 ($[Mg(H_2O)_6]^{2+}$).



Larger ions like Ca^{2+}, Sr^{2+}, and Ba^{2+} also form hydrated ions, mostly with a coordination number of 6, though the strength of the interaction decreases down the group.

Group 2 ions, especially the smaller ones, can form stable complexes with the donors having more than one donatable electron pairs. These species can form more than one coordinate bonds to the same metal ion, creating a ring-like structure.

Calcium ion forms a complex ring structure with a six electron pair donor, EDTA (ethylenediaminetetraacetic acid).

$$Ca^{2+}_{(aq)} + EDTA^{4-}_{(aq)} \rightarrow [Ca(EDTA)]^{2-}_{(aq)}$$

This complex formation is used in water softening where EDTA removes Ca^{2+} and Mg^{2+} ions from hard water. EDTA can be used to remove toxic metal ions (including sometimes Ca^{2+} if levels are too high) from the body.

Ca-EDTA complex is used in medicines to remove metal ions from the body

Quick Check 17.3

a) Why does $MgSO_4$ dissolve easily as compared to $BaSO_4$?

b) How does lattice energy affect the solubility of Group 2 sulphates?

c) Which hydroxide is more soluble: $Ca(OH)_2$ or $Sr(OH)_2$? Give reason.

17.7 EXTRACTION AND PURIFICATION OF GROUP 2 ELEMENTS AND THEIR COMPOUNDS

17.7.1 Magnesium Production from Seawater (Dow Process)

This is perhaps the most famous and industrially significant process. The "Dow Process" (or variations of it) is a multi-step chemical and electrochemical process used to extract magnesium metal from the vast reserves of magnesium ions (Mg^{2+}) present in seawater.

Seawater is treated with calcium hydroxide ($Ca(OH)_2$), derived from limestone or oyster shells), which precipitates magnesium as insoluble magnesium hydroxide ($Mg(OH)_2$).

$$Mg^{2+}_{(aq)} + Ca(OH)_{2(s)} \longrightarrow Mg(OH)_{2(s)} + Ca^{2+}_{(aq)}$$

Magnesium hydroxide is filtered and then reacted with hydrochloric acid (HCl) to form magnesium chloride ($MgCl_2$).

$$Mg(OH)_{2(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$$

The magnesium chloride solution is then concentrated and dried. The molten $MgCl_2$ is subjected to electrolysis in large electrolytic cells. This is the final step that produces pure magnesium metal at the cathode and chlorine gas at the anode.

$$Mg^{2+}_{(\ell)} + 2Cl^{-}_{(\ell)} \longrightarrow Mg_{(\ell)} + Cl_{2(g)} \qquad \text{(electrolysis)}$$

This process is famous for its ingenuity in extracting a valuable metal from an abundant, low-concentration source (sea water) on a massive industrial scale. It has revolutionized the magnesium production.

17.7.2 Production of Quicklime (CaO) from Limestone ($CaCO_3$)

This is one of the oldest and most fundamental industrial processes involving a Group 2 compound, calcium carbonate (limestone). Quicklime, or calcium oxide, is a vital chemical used in construction (cement, mortar), agriculture (soil treatment), metallurgy, and various chemical industries. Limestone is a naturally abundant sedimentary rock composed primarily of calcium carbonate. The production of quicklime involves heating limestone in a high-temperature furnace (a "lime kiln") to very high temperatures (typically 900-1000°C) in a process called calcination or thermal decomposition as shown in **Figure 17.5**.

$$CaCO_{3(s)} \xrightarrow{\text{heat}} CaO_{(s)} + CO_{2(g)}$$

In modern lime kilns, the ingredients are heated by circulating hot gases at the reaction temperature. The reaction is reversible in the closed container but is made to occur faster by removing CO_2 continuously.

This removal shifts the equilibrium to the right, resulting in a faster production of a large amount of the product.

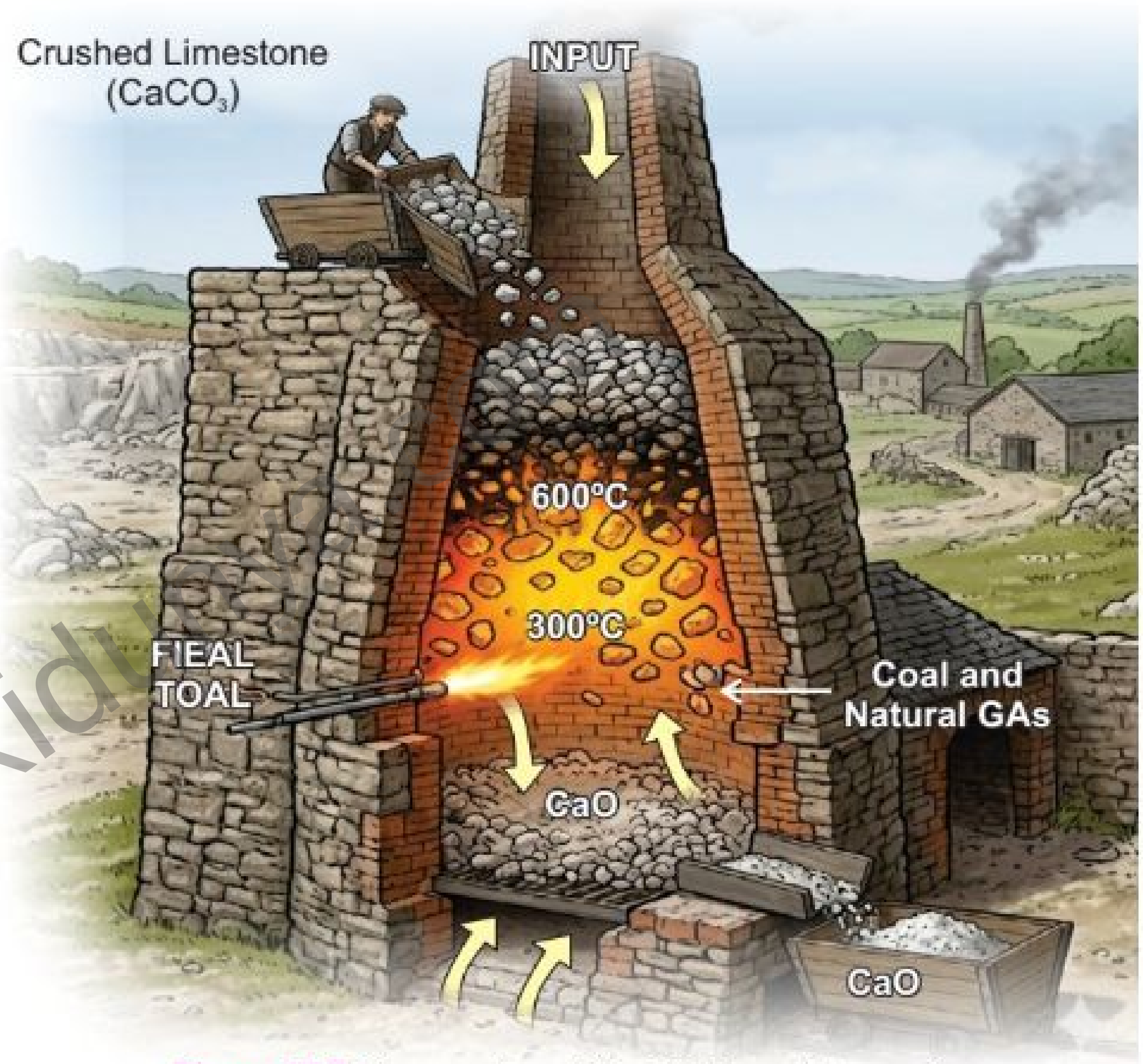


Figure 17.5 The reaction of $CaCO_3$ is used to produce lime (CaO), which has many applications

17.8 USES OF GROUP 2 COMPOUNDS

Group 2 compounds have diverse uses in industries, everyday life, medicine, and agriculture, largely due to their basic nature and varying solubility.

17.8.1 Role of Group 2 Compounds in Industry and Everyday Life

i. Construction

Calcium carbonate ($CaCO_3$) is found as limestone, marble, and chalk. This is widely used as a building material, in cement, concrete, and as a filler in paper and plastics. Calcium oxide (CaO, quicklime) and calcium hydroxide ($Ca(OH)_2$, slaked lime) is used in making cement, mortar, and plaster. Quicklime is also used in the steel production to remove impurities. Calcium sulphate ($CaSO_4{\cdot}2H_2O$, gypsum) is used to make plasterboard (drywall) and plaster of Paris $CaSO_4{\cdot}\frac{1}{2}H_2O$).

ii. Environment

Calcium oxide (CaO) and calcium carbonate ($CaCO_3$) are used in "flue gas desulphurization" (wet scrubbing) to remove acidic sulphur dioxide (SO_2) from power plant emission and preventing acid rain. Magnesium oxide (MgO) is used as a refractory material (lining furnaces) due to its high melting point.

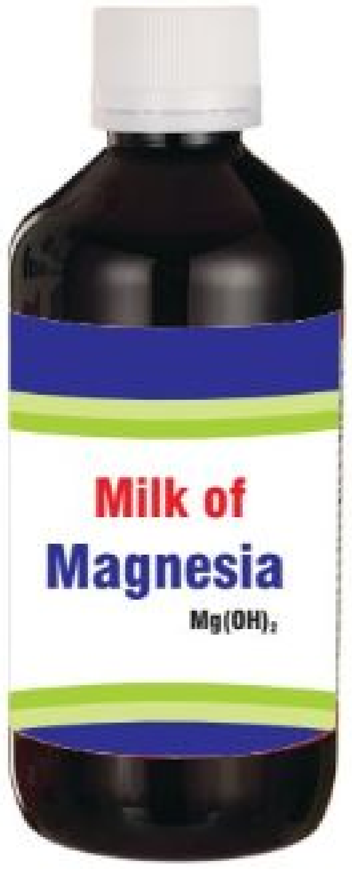
Did You Know?

Magnesium (metal) is used in lightweight alloys (e.g., aerospace, automotive), fireworks, and flares due to its bright burning. Strontium compounds are used to produce red colour in fireworks and flares. Beryllium is used in alloys to increase strength (e.g., in springs, aerospace components) and in X-ray tubes as it is transparent to X-rays.

17.8.2 Medicine

Magnesium hydroxide ($Mg(OH)_2$, "Milk of Magnesia") is used to neutralize excess stomach acid and as a mild laxative. Its low solubility makes it safe to use. Calcium carbonate ($CaCO_3$) is also used in indigestion tablets as an antacid. Calcium compounds (calcium carbonate, calcium citrate, etc.) are essential for strong bones and teeth and are widely used as dietary calcium supplements to prevent osteoporosis. Magnesium compounds (magnesium sulphate, magnesium citrate, etc.) are important for muscle and nerve function and used to treat magnesium deficiencies.

Epsom salts ($MgSO_4 \cdot 7H_2O$) are used as a laxative and in baths. Barium sulphate ($BaSO_4$) is used in "barium meals" for X-ray imaging of the digestive system. It is opaque to X-rays and is safe because it's highly insoluble and passes through the body without being absorbed.



17.8.3 Agriculture

Calcium carbonate ($CaCO_3$) and calcium hydroxide ($Ca(OH)_2$) are added to acidic soils to increase pH (neutralize acidity), making the soil more suitable for crop growth. Calcium and magnesium are essential plant nutrients. Calcium is crucial for cell wall development, while magnesium is a central atom in chlorophyll, which is vital for photosynthesis. Compounds like calcium nitrate or magnesium sulphate (Epsom salts) can be used as fertilizers.

Quick Check 17.4

a) Write the balanced equation for the electrolysis step in the Dow Process.

b) Write the balanced equation for producing quicklime (CaO) from limestone.

c) State one agricultural use of $CaCO_3$ and the chemical principle involved.

Exercise

Q1. MUTIPLE CHOICE QUESTIONS

I) Which Group 2 oxide forms the most alkaline solution in water?

a) Beryllium oxide
b) Magnesium oxide
c) Calcium oxide
d) Strontium oxide

II) Which Group 2 element does not react with water or steam?

a) Beryllium (Be)
b) Magnesium (Mg)
c) Calcium (Ca)
d) All Group 2 metals react

III) What are the products when magnesium reacts with steam?

a) $Mg(OH)_2$ and H_2
b) MgO and H_2
c) $Mg(OH)_2$ only
d) MgO and H_2O

IV) The species formed when a Group 2 basic oxide (e.g., CaO) reacts with water:

a) A salt and hydrogen
b) A metal hydroxide
c) A metal carbonate
d) A salt and water

V) Which Group 2 carbonate is the most thermally stable?

a) $BeCO_3$
b) $MgCO_3$
c) $CaCO_3$
d) $BaCO_3$

VI) What are the products of heating a Group 2 nitrate (e.g., $Ca(NO_3)_2$)?

a) Metal oxide, CO_2, O_2
b) Metal oxide, NO_2, O_2
c) Metal hydroxide, N_2, O_2
d) Metal, NO_2, H_2O

VII) The reason for the increasing thermal stability of Group 2 nitrates down the group is:

a) Smaller cations, higher polarizing power
b) Larger cations, lower polarizing power
c) Larger size of the nitrate ion (NO_3^-)
d) Decrease in the charge on the cation

VIII) Which Group 2 sulphate is the least soluble in water?

a) $MgSO_4$
b) $BaSO_4$
c) $CaSO_4$
d) $BeSO_4$

IX) Which of the following is the least soluble in water?

a) $Mg(OH)_2$
b) $Ba(OH)_2$
c) $MgSO_4$
d) $BaSO_4$

X) Why does Be^{2+} form complexes more easily than Ba^{2+}?

a) Larger size
b) Lower charge density
c) Higher charge density
d) More d-orbitals

Q2. SHORT ANSWER QUESTIONS

a) Exactly 0.1 moles of calcium hydroxide and barium hydroxide are added to separate beakers containing 100 cm^3 of water and stirred to form saturated solutions. Explain which solution has the higher pH value.

b) The size of dichromate ion is larger than the sulphate ion. Following the pattern for the solubilities of Group 2 sulphates, predict which of calcium dichromate and strontium dichromate is more soluble in water?

c) Write balanced equations for the reaction of Ba with cold water.

d) Why does Be metal form a protective layer on reacting with air while other members do not do so? Explain in terms of the strength of bonding between Be^{2+} and oxide ion.

e) Predict the products of the thermal decomposition of barium nitrate. Write the chemical equation.

f) Why does solubility of Group 2 hydroxides increase in terms of the relative changes in ΔH_{hyd} and $\Delta H_{lattice}$?

g) In Dow Process, write the balanced equation for the precipitation of magnesium ions from seawater.

h) State one medical use of $BaSO_4$ and $Mg(OH)_2$ each.

Q3. CONSTRUCTED RESPONSE QUESTIONS

a) Why the melting point and density of beryllium are higher than other Group 2 elements?

b) Why are Group 1 metals more reactive than Group 2 metals in the same period?

c) Explain why calcium hydroxide is used in agriculture.

DESCRIPTIVE QUESTIONS

Q4. Describe the reactivity of Group 2 elements with water and dilute hydrochloric acid. Provide relevant chemical equations and differences in their reactivity.

Q5. Explain the thermal decomposition of carbonates and nitrates of Group 2 elements. Give reason and relative order of the ease of thermal stability.

Q6. Explain the solubility of sulphates and hydroxides of Group 2 elements, and discuss the trend in their solubility down the group with appropriate examples.

Q7. Explain the process of extraction of Mg through Dow's method.