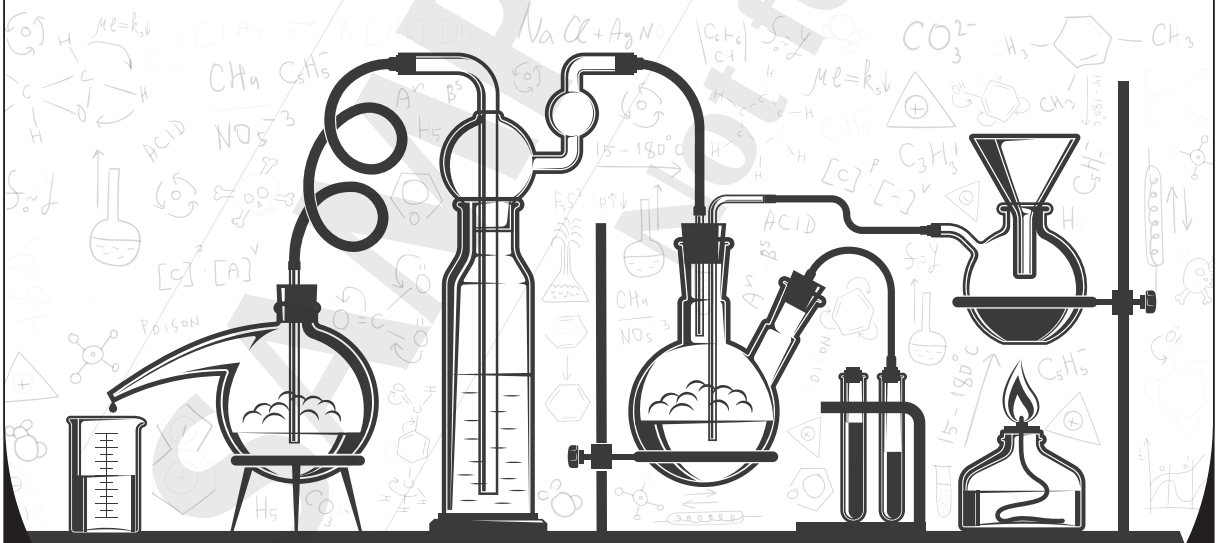
SLO-Based

Class 12th

Unique Notes

CHEMISTRY

Prepared for the Session 2026-27
According to the New Curriculum of PECTAA 2025-26



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UNIQUE NOTES, CHEMISTRY 12th

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Chapter 17

GROUP 2 ELEMENTS

20 Ca Calcium 40.078

i. Properties and trends of Group 2 elements
ii. Chemical reaction of Group 2 elements
iii. Comparison of Group 2 elements with Group 1 elements
iv. Thermal decomposition of carbonates and nitrates
v. Solubility of Group 2 Sulphates and Hydroxide
vi. Complex ion formation
vii. Extraction and purification of Group 2 elements
viii. Uses of Group 2 compounds

DESCRIPTIVE QUESTIONS

Q.1 What do you know about group-2 elements? 12217001

Ans. Key points: Alkaline Earth Metals | Occurrence | Reactivity | Use in Daily Life

The elements of s-block present in Group 2 of modern periodic table are Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra).

Alkaline Earth Metals

They are also called the alkaline earth metals because aqueous solutions of their oxides and hydroxides are basic in nature and are found in Earth crust.

Occurrence

Ca and Mg are among the eight most widely occurring elements in the Earth crust in the form of silicates and carbonates.

Reactivity

These elements present a class of metals having reactivity between highly reactive alkali metals and less reactive transition metals.

Use in DailyLife

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



Most firework colours are due to Group 2 element

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PROPERTIES AND TRENDS OF GROUP ELEMENTS

Q.2 What is the general trend in properties of Group-2? Discuss the chemical reactivity of Group-2 on the basis of electronic configuration. 12217002

Ans. Key points: General Trend in Properties of Group 2 Elements | Chemical Reactivity of Group 2 Elements

General trend in properties 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^o)	-1.97	-2.34	-2.87	-2.89	-2.91

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.

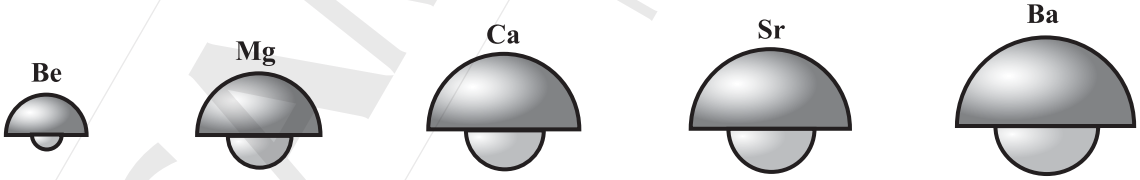


Figure 17.1: Relative sizes of the atoms of the Group 2 elements

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.

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

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CHEMICAL REACTIONS OF GROUP 2 ELEMENTS

Q.3 How do alkaline earth metals react with: 12217003

(a) oxygen (b) water (c) acids?

Ans. Key Points: Reaction with oxygen | Reactions with water | Reactions with acids

(a) Reaction with oxygen

All Group 2 metals react with oxygen to form normal metal oxides (MO) on heating. These oxides are obtained by heating the metal in oxygen.

$$2M_{(s)} + O_{2(g)} \longrightarrow 2MO_{(s)}$$

Reaction of Be with oxygen

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. Be is least reactive metal in Group-2

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

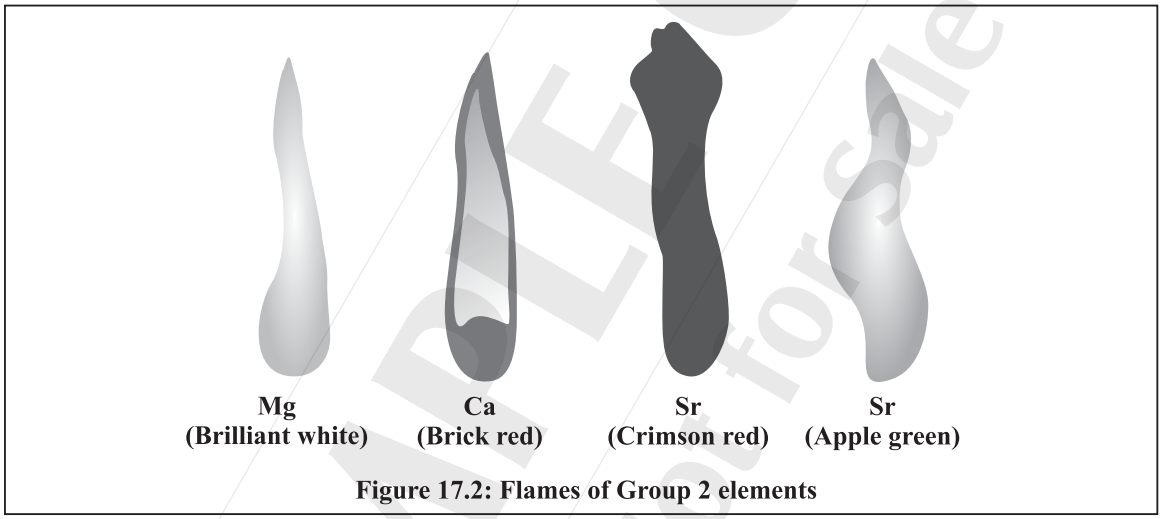


Figure 17.2: Flames of Group 2 elements

Reaction of Mg and Ca with oxygen

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.

$$2Mg_{(s)} + O_{2(g)} \longrightarrow 2MgO_{(s)}$$

$$2Ca_{(s)} + O_{2(g)} \longrightarrow 2CaO_{(s)}$$

Nature of Oxides

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.

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

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(b) 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).

Non-reactivity of Be with H_2O

Beryllium (Be) does not react with water or steam, even when heated. This is due to its protective oxide layer. This is called passivity of beryllium

Reaction of Mg with H_2O

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

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

Reaction of Ca with H_2O

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.

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



Figure 17.3 Calcium forms a sparingly soluble hydroxide with water

Nature of hydroxides of Group 2

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

(c) Reactions with acids

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

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

Reaction of Be with dilute acids

Reactivity of Group 2 elements with acids 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.

Reaction of Mg with acids

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

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

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

Reaction of Ca with acids

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.

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Quick Check 17.1

(a) **Write equations for the following reactions:** 12217003a

(i) Ca with oxygen (ii). Ba with water

Ans. (i) Ca with oxygen

$$2Ca_{(s)} + O_{2(g)} \longrightarrow 2CaO_{(s)}$$

(ii) Ba with water

$$Ba_{(s)} + 2H_2O_{(l)} \longrightarrow Ba(OH)_2 + H_{2(g)}$$

(b) **Predict the extent of the reactions of Sr and Ba with H_2SO_4** 12217003b

Ans. Ba and Sr react with sulfuric acid initially to give their respective sulfate and H_2 gas. Both sulfates of Barium and Strontium are insoluble in water and form coating over the metal surface which stop further reaction. So the extent of chemical reaction is very limited for the metals Ba and Sr with sulfuric acid.

$$Ba_{(s)} + H_2SO_{4(aq)} \longrightarrow BaSO_{4(s)} + H_{2(g)}$$

$$Sr_{(s)} + H_2SO_{4(aq)} \longrightarrow SrSO_{4(s)} + H_{2(g)}$$

(c) **Explain why Group 2 elements are reactive, based on their electron configuration and ion formation.** 12217003c

Ans. 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.

(d) **Write a balanced equation for calcium and barium burning in air and compare their reactivity.** 12217003d

Ans. **Reaction of Ca and Ba with air (oxygen)**

$$2Ca_{(s)} + O_{2(g)} \xrightarrow{\Delta} 2CaO_{(s)}$$

$$2Ba_{(s)} + O_{2(g)} \xrightarrow{\Delta} 2BaO_{(s)}$$

Both metals form white metal oxides on burning in air. Ba burns more vigorously than Ca as reactivity increases down the group.

(e) **Predict the density and melting point of the radioactive radium (Ra) following the trend in Group 2.** 12217003e

Ans. Group 2 trend indicates, density increases, melting point decreases down the group. So the density of Ra (Radium) will be higher than Ba and melting point will be low as compared to Ba.

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COMPARISON OF GROUP 2 ELEMENTS WITH GROUP 1 ELEMENTS

Q.4 Why are Group-1 metal more reactive than the Group-2 metals in the same period? 12217004

Ans. Key Points: Reactivity of Group 2 Metals

Reactivity of Group 2 Metals

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 M^{1+} ion.

Loss of 2 electrons from Group 2 metals

Group 2 metals lose two electrons, which requires more energy, so they are reactive but are generally lesser reactive 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.

Q.5 Give a brief comparison of Group 2 elements with Group 1 elements. 12217005

Ans. Key Points: Comparison of Group 2 Elements with Group 1 Elements

Table 17. 2 **Comparison of Group 2 Elements with Group 1 Elements**

Feature	Group 1 (Alkali Metals)	Group 2 (Alkaline Earth Metals)
Valence Electrons	Group 1 metals have one electron in valence shell (ns^1)	Group 2 metals have two electrons in valence shell (ns^2)
Ion Formation	These metal form +1 ions (M^+)	These metal form 2+ ions (M^{2+})
Reactivity	These metals are more reactive.	These metals are less reactive. (compered to Group 1 elements in the same period).
Reason for Reactivity	These metals have low ionization energies.	These metal have higher ionization energies.
Hardness	These metals are very soft (can be cut with a knife).	These metals are harder than group 1 metals.
Density	These metals have low densities.	These metals have higher densities than group 1 metals.
Melting/Boiling Points	These metals have lower melting / boiling points.	These metals have higher melting / boiling points.

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Reaction with Water	These metals react with water very vigorously. (e.g, Na with water)	These metals react with water less vigorously. (e.g, Ca with water, Mg with steam).
Oxides	These metals form M_2O (e.g., Na_2O) highly basic.	These metals form MO (e.g., CaO) less basic than group 1 oxides..
Hydroxides	These are highly soluble strong bases.	These are less soluble than group1 but solubility increases down the group. These are less basic than group 1 hydroxides.

THERMAL DECOMPOSITION OF CARBONATES AND NITRATE

Q.6 Explain the thermal decomposition of carbonates and nitrates of Group 2 elements. Give reason and relative order of the ease of thermal stability.

12217006

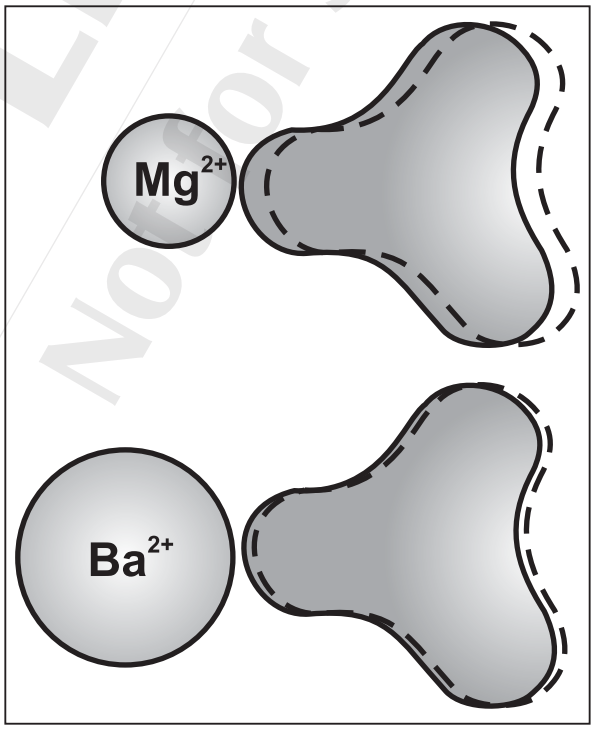
Ans. Key Points: Thermal Decomposition | Thermal Decomposition of Carbonates and Nitrate | Order of Increasing Thermal Stability

Thermal Decomposition

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 of Group 2 Compounds

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.



Order of Increasing Thermal Stability of Group 2 Compounds

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, 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.

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Reason

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 on heating. As the metal ion gets larger down the group, its polarizing power decreases, leading to more stable carbonates that require more heat for decomposition.

Thermal Decomposition of Nitrates

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

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

Trend in Thermal Stability of Nitrates

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 too.

Order of thermal stability of nitrates

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.

Importance of thermal decomposition of carbonates / nitrates

- 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. 12217006a

Ans.

Property	Group 1 Metals	Group 2 Metals
Hardness	These metals are very soft (can be cut with a knife).	These metals are harder than group 1 metals.
Density	These metals have low densities.	These metals have higher densities than group 1 metals.
Melting/Boiling Points	These metals have lower melting / boiling points.	These metals have higher melting / boiling points.

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(b) State the general formula for a Group 1 oxide and a Group 2 oxide. 12217006b

Ans. General formula for Group 1 metal oxide

M_2O e.g. Na_2O, K_2O

Group 2 Metal oxide:

MO e.g. MgO, CaO

Reason: Group 1 metals have one electron in valence shell and forms M^{1+} ion and group 2 metals form M^{2+} ion.

(c) Write the balanced equation for the thermal decomposition of $SrCO_3$. 12217006c

Ans. Thermal decomposition of $SrCO_3$

$$SrCO_{3(s)} \xrightarrow{\Delta} SrO_{(s)} + CO_{2(g)}$$

Strong heating is required because $SrCO_3$ is quite stable

(d) Explain qualitatively why magnesium carbonate is thermally less stable than calcium carbonate. 12217006d

Ans. As we know cation size increases as we move down the group So $Mg^{2+} < Ca^{2+}$. Smaller Mg^{2+} ion has higher charge density. It polarizes CO_3^{2-} ion more strongly, which weakens C and O bond more easily. Thus $MgCO_3$ decomposes at lower temperature.

Trend: Thermal stability of carbonates increases down the group.

(e) **Write the equations for the thermal decomposition of magnesium nitrate ii) Barium nitrate. Which of these decomposes at a lower temperature?** 12217006e

Ans. Thermal decomposition of nitrates.

(i) Magnesium nitrate

$$2Mg(NO_3)_{2(s)} \xrightarrow{\Delta} 2MgO_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

(ii) Barium nitrate

$$2Ba(NO_3)_{2(s)} \xrightarrow{\Delta} 2BaO_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

Magnesium nitrate decomposes at lower temperature.

Reason: Like carbonate trend, Mg^{2+} is smaller in size and has higher charge density. Therefore it polarizes NO_3^- more and the bond becomes less stable.

SOLUBILITY OF GROUP 2 SULPHATES AND HYDROXIDES

Q.7 Explain the solubility of sulphates and hydroxides of Group 2 elements, and discuss the trend in their solubility down the group with appropriate examples. 12217007

Ans. Key Points: Solubility of Sulphates and Hydroxides of Group 2 Elements | Trend of solubility of Sulphates and Hydroxides

Solubility of Sulphates and Hydroxides of Group 2 Elements

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

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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.

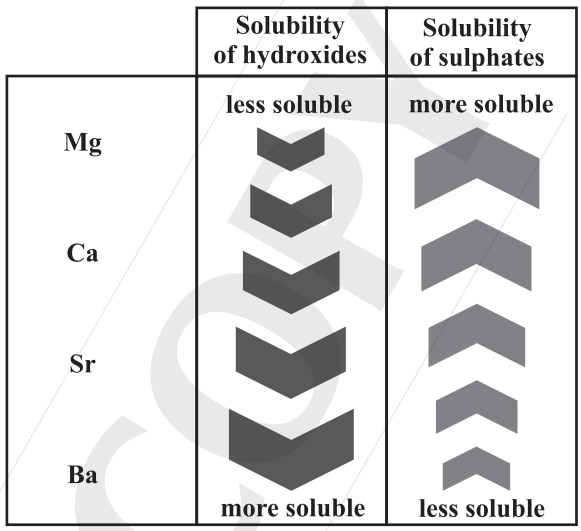


Figure 17.4 Trends in solubility in Group 2 hydroxides and sulphates

Enthalpy of solution

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.

Trend of solubility of Group 2 Sulphates and Hydroxides

(a) Hydroxides

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.

(b) Solubility of Group 2 Sulphates

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).

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 hydroxide 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}

COMPLEX ION FORMATION

Q.8 What do you know about complex ion. Discuss complex ion formation of Group 2 metals? 12217008

Ans. Key Points: Complex ion | Complex ion Formation of Group 2 Metals

Complex ion

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

- **Lewis acids:** The central metal ion acts as a Lewis acid (electron pair acceptor).
- **Lewis base:** The molecules or ions with lone pairs of electrons, e.g., H_2O, NH_3, Cl^-, OH^- act as Lewis bases.
- **Coordination number:** 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.

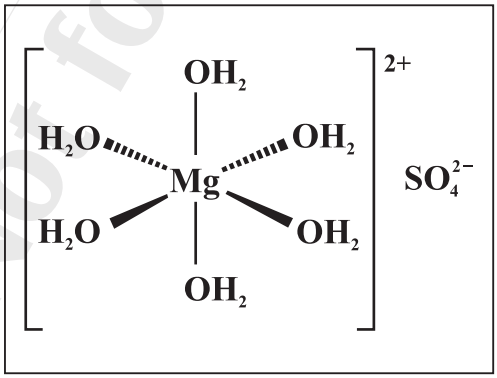
Complex ion Formation of Group 2 Metals

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.

Factors affecting the formation of complex ions

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.

Hydrated complexes of Be and Mg



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, only 4 water molecules can fit it and 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, 6 water molecules can surround it and usually form hexahydrate complexes, with a coordination number of 6 ($[Mg(H_2O)_6]^{2+}$).

Complexes of larger ions

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.

Ring like structure of Group-2 complexes

Group 2 ions, especially the smaller ones, can form stable complexes with the donors having

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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).

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



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

Use in water softening

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.

Quick Check 17.3

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

Ans. $MgSO_4$ (magnesium sulphate) dissolves much more easily in water than $BaSO_4$ (barium sulphate) because of the balance between lattice energy and hydration energy. **12217009**

The small Mg^{2+} ion is strongly attracted to water, making $MgSO_4$ dissolve easily. The larger Ba^{2+} ion is less attracted to water, so $BaSO_4$ remains mostly undissolved.

(b) How does lattice energy affect the solubility of Group 2 sulphates? **12217010**

Ans. The solubility of Group 2 sulfates decreases down the group because of the effect of lattice energy and hydration energy. As we move down the group from MgSO4 to BaSO4, the metal ions become larger, the lattice energy decreases. However, the hydration energy decreases much more rapidly. So there is not enough energy released to overcome the lattice energy therefore, solubility of Group 2 sulfate decreases down the group.

$$MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$$

(c) Which hydroxide is more soluble: $Ca(OH)_2$ or $Sr(OH_2$? Give reason. **12217011**

Ans. $Sr(OH)_2$ is more stable than $Ca(OH)_2$ because the large Sr^{2+} ion polarizes the OH^- ion less strongly than smaller group 2 cations.

$$Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$$

EXTRACTION AND DPURIFICTION OF GROUP 2 ELEMENTS AND THEIR COMPOUNDS

Q.9 Explain the process of extraction Mg through Dow's method. **12217012**

Ans. Key Points: Magnesium Production from Seawater (Dow's Process) | Steps Involved in Dow's Process | Importance of Dow's Method

Magnesium Production from Seawater (Dow's Process)

Introduction: This is the most famous and industrially significant process. The "Dow's Process" 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.

Steps Involved in Dow's Process

(i) Formation of insoluble Mg $(OH)_2$ (Precipitation)

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

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

(ii) Formation of $MgCl_2$ (Acid treatment)

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

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

(iii) Electrolysis of $MgCl_2$ (Electrolysis)

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.

$$Mg^{2+}_{(l)} + 2Cl^{-}_{(l)} \longrightarrow Mg_{(l)} + Cl_{2(g)}$$

Importance of Dow's Method

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

Q.10 How quicklime (CaO) is produced from limestone ($CaCO_3$) 12217013

Ans. Key Points: Production of Quicklime (CaO) from Limestone ($CaCO_3$) | Calcination / Thermal decomposition

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

Introduction: This is one of the oldest and most fundamental industrial processes involving a Group 2 compound, calcium carbonate (limestone).

Importance of quicklime

Quicklime, or calcium oxide, is a vital chemical used in:

- Construction (cement, mortar),
- Agriculture (soil treatment),
- Metallurgy, and various chemical industries.

Calcination / Thermal decomposition

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**.

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

Modern Lime Kiln

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

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

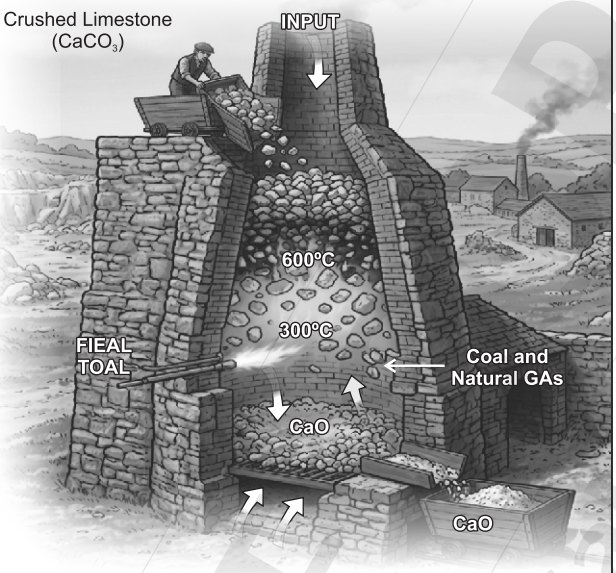


Figure 17.5 The reaction of $CaCO_3$ is used to produce lime (CaO), which has many applications

USES OF GROUP 2 COMPOUNDS

Q.11 Write role of group 2 compounds in construction and environment. 12217014

Ans. Key Points: Role of Group 2 Compounds in Construction | Role of Group 2 Compounds in Environment

Role of Group 2 Compounds in Construction

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

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 sulfate ($CaSO_4 \cdot 2H_2O$, gypsum) is used to make plasterboard (drywall) and plaster of Paris $CaSO_4.\frac{1}{2}H_2O$) or $(CaSO_4)_2.H_2O$ Calcium sulfate hemihydrate

Role of Group 2 Compounds in Environment

- **Flue gas desulphurization**
  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.
- **MgO as a refractory material**
  Magnesium oxide (MgO) is used as a refractory material (lining furnaces) due to its high melting point.

Did you know?

Q. Write a few uses of Mg, Sr, Be in daily life. 12217015

Ans. Uses of metals

- **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.

Q.12 Write uses of Group 2 compounds in medicine and agriculture. 12217016

Ans. Key Points: **Uses of Group 2 Compounds in Medicine | Uses of Group 2 Compounds in Agriculture**



Uses of Group 2 Compounds in Medicine

- **Milk of magnesia**
  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**
  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.
- **Other magnesium compounds**
  Magnesium compounds (magnesium sulphate, magnesium citrate, etc.) are important for muscle and nerve function and used to treat magnesium deficiencies.
- **Epsom salts**
  Epsom salts ($MgSO_4,7H_2O$) are used as a laxative and in baths soaps.
- **Barium meals**
  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 is highly insoluble and passes through the body without being absorbed.

Uses of Group 2 Compounds in 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.

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Quick Check 17.4

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

Ans. $Mg^{2+}_{(l)} + 2Cl^{-}_{(l)} \longrightarrow Mg_{(l)} + Cl_{2(g)}$ 12217017

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

Ans. $CaCO_{3(s)} \xrightarrow{heat} CaO_{(s)} + CO_{2(g)}$ 12217018

(c) State one agricultural use of $CaCO_3$ and the chemical principle involved. 12217019

Ans. Calcium carbonate ($CaCO_3$) are added to acidic soils to increase pH (neutralize acidity, making the soil more suitable for crop growth.

MULTIPLE CHOICE QUESTIONS (EXERCISE)

Encircle the most suitable answer.

1. Which Group 2 oxide forms the most alkaline solution in water? 12217020
(a) Beryllium oxide
(b) Magnesium oxide
(c) Calcium oxide
(d) Strontium oxide

2. Which Group 2 element does not react with water or steam? 12217021
(a) Beryllium (Be)
(b) Magnesium (Mg)
(c) Calcium (Ca)
(d) All Group 2 metals react

3. What are the products when magnesium reacts with steam? 12217022
(a) $Mg(OH)_2$ and H_2
(b) MgO and H_2
(c) $Mg(OH)_2$ only
(d) MgO and H_2O

4. The species formed when a Group 2 basic oxide (e.g., CaO) reacts with water:
(a) A salt and hydrogen 12217023
(b) A metal hydroxide
(c) A metal carbonate
(d) A salt and water

5. Which Group 2 carbonate is the most thermally stable? 12217024
(a) $BeCO_3$ (b) $MgCO_3$
(c) $CaCO_3$ (d) $BaCO_3$

6. What are the products of heating a Group 2 nitrate (e.g., $Ca(NO_3)_2$)? 12217025
(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

7. The reason for the increasing thermal stability of Group 2 nitrates down the group is: 12217026
(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

8. Which Group 2 sulphate is the least soluble in water? 12217027
(a) $MgSO_4$ (b) $BaSO_4$
(c) $CaSO_4$ (d) $BeSO_4$

9. Which of the following is the least soluble in water? 12217028
(a) $Mg(OH)_2$
(c) $MgSO_4$
(b) $Ba(OH)_2$
(d) $BaSO_4$

10. Why does Be^{2+} form complexes more easily than Ba^{2+}? 12217029
(a) Larger size$_2$
(b) Lower charge density
(c) Higher charge density
(d) More d-orbitals

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MULTIPLE CHOICE QUESTIONS (ADDITIONAL)

Properties and Trends of Group 2 Elements

11. The order of increasing radius of Group 2 elements is: 12217030
(a) Ba < Sr < Ca < Mg < Be
(b) Be < Mg < Ca < Sr < Ba
(c) Mg < Be < Ca < Sr < Ba
(d) Be < Ca < Mg < Sr < Ba

12. The valence shell electronic configuration of alkaline earth metals is: 12217031
(a) ns^1 (b) ns^2
(c) ns^2p^1 (d) ns^2p^2

13. What is the trend in 1st ionization energy of group 2 elements from Be to Ba: 12217032
(a) Increases from Be to Ba
(b) Decreases from Be to Ba
(c) Remain constants
(d) First increases then decreases

Chemical Reactions of Group 2 Elements

14. The order of reactivity of Group 2 elements is: 12217033
(a) Ba < Sr < Ca < Mg < Be
(b) Be < Mg < Ca < Sr < Ba
(c) Mg < Be < Ca < Sr < Ba
(d) Be < Ca < Mg < Sr < Ba

15. Group 2 metals react with oxygen to form: 12217034
(a) Peroxides (b) Hydroxides
(c) Oxides (MO) (d) Carbonates

16. The general equation for reaction of Group 2 metals with oxygen is: 12217035
(a) $M + O_2 \rightarrow MO_2$
(b) $2M + O_2 \rightarrow 2MO$
(c) $M + O \rightarrow MO$
(d) $2M + O \rightarrow M_2O$

17. Beryllium reacts with oxygen: 12217036
(a) At room temperature
(b) Only above 600°C
(c) Below 100°C
(d) Does not react

18. Beryllium is less reactive because:
(a) Large atomic size 12217037
(b) High density
(c) Protective oxide layer
(d) Low melting point

19. Magnesium burns in air with: 12217038
(a) Yellow flame
(b) Blue flame
(c) Bright white flame
(d) Green flame

20. Which Group 2 element does not react with water or steam? 12217039
(a) Mg (b) Ca
(c) Be (d) Sr

21. Magnesium reacts with steam to form:
(a) $Mg(OH)_2 + H_2$ 12217040
(b) $MgO + H_2$
(c) $MgO + O_2$
(d) $Mg(OH)_2 + O_2$

22. Calcium reacts with cold water to form: 12217041
(a) $CaO + H_2$
(b) $Ca(OH)_2 + H_2$
(c) $CaO + H_2O$
(d) $CaCl_2 + H_2$

23. Group 2 metals react with dilute acids to produce: 12217042
(a) Salt and oxygen
(b) Salt and hydrogen
(c) Oxide and hydrogen
(d) Hydroxide and oxygen

24. Which hydroxide of group 2 metals is sparingly soluble in water? 12217043
(a) $Mg(OH)_2$ (b) $Ba(OH)_2$
(c) $Ca(OH)_2$ (d) $Sr(OH)_2$

Comparison of Group 2 Elements with Group 1 Elements

25. How many electrons are lost by group 2 metals? 12217043a
(a) 1 (b) 2
(c) 3 (d) 4

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26. Down a Group, reactivity of Group 2 metals: 12217044
(a) Decreases (b) Increases
(c) Remains constant
(d) First increases then decreases

27. Hydroxides of Group 2 metals are:
(a) More soluble than group 1 12217045
(b) Less soluble than group 1
(c) Insoluble
(d) Have same solubility

28. Nature of reaction of Group 2 metals with water is: 12217046
(a) More vigorous than group 1
(b) Less vigorous than group 1
(c) Explosive reaction
(d) Does not occur

29. Which Group has higher melting / boiling points? 12217047
(a) Group 1 (b) Group 2
(c) Both same
(d) Depends on the element

30. Why Group 2 metals are less reactive as compared to Group 1: 12217048
(a) Lower ionization energy
(b) Higher ionization energy
(c) Smaller atomic size
(d) Higher density

Thermal Decomposition of Carbonates and Nitrates

31. On heating, Group 2 carbonates decompose into: 12217049
(a) Metal + CO_2
(b) Metal oxide + CO_2
(c) Metal hydroxide + CO_2
(d) Metal oxide + O_2

32. The thermal stability of Group 2 carbonates: 12217050
(a) Decreases down the group
(b) Remains constant
(c) Increases down the group
(d) First increases then decreases

33. Which carbonate decomposes at the lowest temperature? 12217051
(a) $BaCO_3$ (b) $SrCO_3$
(c) $CaCO_3$ (d) $BeCO_3$

34. Which carbonate is the most thermally stable? 12217052
(a) $BeCO_3$ (b) $MgCO_3$
(c) $CaCO_3$ (d) $BaCO_3$

35. The decomposition product of $MgCO_3$ is: 12217053
(a) Mg + CO_2
(b) MgO + CO_2
(c) $Mg(OH)_2$ + CO_2
(d) MgO + O_2

36. The thermal stability of Group 2 nitrates: 12217054
(a) Decreases down the group
(b) Increases down the group
(c) Remains constant
(d) Has no trend

37. On heating, Group 2 nitrates produce:
(a) Metal oxide, NO_2 and O_2 12217055
(b) Metal nitrite and O_2
(c) Metal oxide and N_2
(d) Metal hydroxide and NO_2

38. Which nitrate is least thermally stable? 12217056
(a) $Ba(NO_3)_2$ (b) $Sr(NO_3)_2$
(c) $Ca(NO_3)_2$ (d) $Be(NO_3)_2$

Solubility of Group 2 Sulphates and Hydroxide

39. The solubility of an ionic compound depends mainly on: 12217057
(a) Atomic mass and density
(b) Hydration enthalpy and lattice enthalpy
(c) Melting point and boiling point
(d) Atomic radius and ionization energy

40. Hydration enthalpy is: 12217058
(a) Always positive
(b) Always negative (exothermic)
(c) Zero
(d) Independent of ion size

41. Smaller ions have: 12217059
(a) Lower charge density
(b) Higher charge density
(c) No hydration enthalpy
(d) Lower attraction for water molecules

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42. Going down Group 2, hydration enthalpy is: 12217060
(a) More negative
(b) Less negative
(c) Constant (d) Positive

43. Lattice enthalpy is: 12217061
(a) Energy released when ions dissolve
(b) Energy required to separate ionic solid into gaseous ions
(c) Energy released during hydration
(d) Heat absorbed during neutralization

44. Lattice enthalpy is always: 12217062
(a) Exothermic (b) Negative
(c) Endothermic (d) Zero

45. Which hydroxide is most soluble in water? 12217063
(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Sr(OH)_2$ (d) $Ba(OH)_2$

46. Barium sulphate is: 12217064
(a) Highly soluble
(b) Slightly soluble
(c) Insoluble in water
(d) Hygroscopic

47. The solubility of Group 2 hydroxides:
(a) Decreases down the group 12217065
(b) Increases down the group
(c) Remains constant
(d) First increases than decreases

48. The solubility of Group 2 sulphates:
(a) Increases down the group 12217066
(b) Decreases down the group
(c) Remains constant
(d) Is unpredictable

Complex Ion Formation

49. EDTA is mainly used for: 12217067
(a) Water purification
(b) Water softening
(c) Bleaching
(d) Fertilizer preparation

50. EDTA removes hardness by complexing: 12217068
(a) Na^+ and K^+
(b) Ca^{2+} and Mg^{2+}
(c) Cl^- and SO_4^{2-}
(d) H^+ and OH^-

51. EDTA is an example of a: 12217069
(a) Monodentate ligand
(b) Bidentate ligand
(c) Hexadentate ligand
(d) Unidentate ligand

52. Be^{2+} forms complexes more readily because of: 12217070
(a) Larger size
(b) Lower charge density
(c) Higher charge density
(d) Presence of d-orbitals

53. Which ion forms the most stable complexes among Group 2 elements? 12217071
(a) Ba^{2+} (b) Sr^{2+}
(c) Ca^{2+} (d) Be^{2+}

Extraction and Purification of Group 2 Elements and their Compounds

54. Magnesium is extracted industrially from: 12217072
(a) Limestone
(b) Sea water
(c) Dolomite only
(d) Magnesite only

55. In Dow's process, magnesium ions are precipitated as: 12217073
(a) $MgCl_2$ (b) $MgCO_3$
(c) $Mg(OH)_2$ (d) $MgSO_4$

56. The reagent used to precipitate Mg^{2+} from sea water is: 12217074
(a) HCl (b) $Ca(OH)_2$
(c) NaOH (d) H_2SO_4

57. Magnesium hydroxide reacts with HCl to produce: 12217075
(a) MgO (b) $MgSO_4$
(c) $MgCl_2$ (d) $MgCO_3$

58. Electrolysis of molten $MgCl_2$ produces: 12217076
(a) Mg and O_2 (b) Mg and Cl_2
(c) MgO and Cl_2
(d) MgH_2 and Cl_2

59. During electrolysis of molten $MgCl_2$, magnesium is formed at the: 12217077
(a) Anode (b) Cathode
(c) Electrolyte (d) Salt bridge

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60. During electrolysis of molten $MgCl_2$ chlorine gas is liberated at the: 12217078
(a) Cathode (b) Anode
(c) Both electrodes (d) None

61. Quicklime is produced by heating: 12217079
(a) $Ca(OH)_2$ (b) $CaCO_3$
(c) $CaSO_4$ (d) $MgCO_3$

62. The chemical formula of quicklime is: 12217080
(a) $CaCO_3$ (b) $Ca(OH)_2$
(c) CaO (d) MgO

63. Limestone mainly consists of: 12217081
(a) $MgCO_3$ (b) $CaCO_3$
(c) CaO (d) $CaSO_4$

64. The process of converting limestone into quicklime is called: 12217082
(a) Hydration
(b) Neutralization
(c) Calcination
(d) Crystallization

65. The by-product formed during the production of quicklime is: 12217083
(a) SO_2 (b) H_2
(c) CO_2 (d) O_2

Uses of Group 2 Compounds

66. Which Group 2 compound is used in cement and mortar? 12217084
(a) CaO (b) $BaSO_4$
(c) $MgSO_4$ (d) $Mg(OH)_2$

67. Gypsum has the formula: 12217085
(a) $CaSO_4 \cdot 2H_2O$ (b) $CaCO_3$
(c) $MgSO_4 \cdot 7H_2O$ (d) CaO

68. Which compound is used for flue gas desulphurization? 12217086
(a) $MgSO_4$ (b) $BaSO_4$
(c) CaO (d) $MgCl_2$

69. Milk of Magnesia is: 12217087
(a) $MgCO_3$ (b) $Mg(OH)_2$
(c) MgO (d) $Ca(OH)_2$

70. $BaSO_4$ is used in medicine because it is: 12217088
(a) Highly soluble (b) Toxic
(c) Insoluble and X-ray opaque
(d) Radioactive

71. Epsom salt is: 12217089
(a) $CaSO_4 \cdot 2H_2O$
(b) $MgSO_4 \cdot 7H_2O$
(c) $BaSO_4$ (d) $CaCO_3$

72. Calcium carbonate is added to acidic soil to: 12217090
(a) Decrease pH
(b) Increase pH
(c) Produce fertilizer
(d) Remove nitrogen

ANSWER KEY

1	d	2	a	3	b	4	b	5	d
6	b	7	b	8	b	9	d	10	c
11	b	12	b	13	b	14	b	15	c
16	b	17	b	18	c	19	c	20	c
21	b	22	b	23	b	24	c	25	b
26	b	27	b	28	b	29	b	30	b
31	b	32	c	33	d	34	d	35	b
36	b	37	a	38	d	39	b	40	b
41	b	42	b	43	b	44	c	45	d
46	c	47	b	48	b	49	b	50	b
51	c	52	c	53	d	54	b	55	c
56	b	57	c	58	b	59	b	60	b
61	b	62	c	63	b	64	c	65	c
66	a	67	a	68	c	69	b	70	c
71	b	72	b						

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SHORT ANSWER QUESTIONS (EXERCISE)

Q.1 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. 12217091

Ans. $Ba(OH)_2$ will form the solution with the higher pH value, because the solubility of Group 2 hydroxides increases down the group. ($Ba(OH)_2 > Ca(OH)_2$. 0.1 moles of $Ba(OH)_2$ is significantly more soluble than $Ca(OH)_2$ and dissociates, completely in 100 cm^3 of water.

$$Ba(OH)_2 \rightarrow Ba^{+2} + 2OH^-$$

This releases a high concentration of OH^- ions, making the solution more basic and has the higher pH value.

Q.2 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? 12217092

Ans. Calcium dichromate is more soluble than strontium dichromate because dichromate $\left(Cr_2O_7^{2-}\right)$ anions are large like sulphate ions $\left(SO_4^{2-}\right)$ so the solubility of dichromate also decreases down the group. As we move down the group 2) cation size increases hydration enthalpy (ΔH_{hyd}) decreases while the lattice energy remains relatively unchanged due to the already massive size of the anion. Following this sulphate trend the smaller cation (Ca^{2+}) yields higher solubility than the larger cation Sr^{2+}.

Q.3 Write balanced equations for the reaction of Ba with cold water. 12217093

Ans. $Ba_{(s)} + 2H_2O_{(\ell)} \longrightarrow Ba(OH)_{2(aq)} + H_{2(g)}$

Q.4 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. 12217094

Ans. Beryllium forms a protective oxide layer because BeO is very strong and adherent due to the high charge density of Be^{2+}. This layer prevents further reaction with air. Be^{2+} and O^{2-} ions due to strong electrostatic attraction creates an exceptionally strong and tightly packed crystal lattice. This forms an impermeable layer on the metal surface that prevent further oxygen from penetrating. This is called passivity of beryllium.

Q.5 Predict the products of the thermal decomposition of barium nitrate. Write the chemical equation. 12217095

Ans. Thermal decomposition of barium nitrate oxygen. (BaO, NO_2, O_2)

$$2Ba(NO_3)_2 \xrightarrow{\Delta} 2BaO + 4NO_2 + O_2$$

Q.6 Why does solubility of Group 2 hydroxides increase in terms of the relative changes in ΔH_{hyd} and $\Delta H_{lattice}$? 12217096

Ans. As size of metal cation increases down the group 2, while hydroxide ion (OH^-) is relatively smaller ,the lattice energy drops more rapidly than the hydration enthalpy. It becomes easier for water to separate the ions, so more readily the hydroxides dissolve and the solubility increases down the group.

Q.7 In Dow Process, write the balanced equation for the precipitation of magnesium ions from seawater. 12217097

Ans. In Dow's process magnesium ions are precipitated as magnesium hydroxide $Mg(OH)_2$:

(i) By adding $Ca(OH)_2$

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

(ii) Using the chloride

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

Q.8 State one medical use of $BaSO_4$ and $Mg(OH)_2$ each. 12217098

Ans.

- Barium sulphate ($BaSO_4$) commonly known as "Barium meal" used as X–ray contrast medium.
- Magnesium hydroxide ($Mg(OH)_2$) used as an antacid (milk of magnesia). It is used to neutralize excess stomach acid and relieve indigestion.

SHORT ANSWER QUESTIONS (ADDITIONAL)

Properties and Trends of Group 2 Elements

Q.9 Why are group 2 metals less reactive than group 1 metal in the same period? 12217099

Ans. Group 2 metals are regarded less reactive as compare to group 1 metals in the same period due to higher ionization energy values. Group 2 needs more energy to lose 2 electrons as compared to group 1 metals losing one electron only.

Q.10 What is the relation between the values of 1st ionization energy and 2nd ionization energy of group 2 metals. 12217100

Ans. Both the values decrease from Be to Ba down the group because the size of metals increases down the group.

Q.11 How does solubility and basicity of group 2 hydroxides change down the group? 12217101

Ans. Solubility increases down the group. Basicity also increases down the group but they are less basic than group 1 metals.

Q.12 Compare the melting points and hardness of group 1 and group 2 metals. 12217102

Ans. Group 2 metals have higher melting and boiling points and are harder than group 1 metals because of strong metallic bonds.

Q.13 What is the general trend in properties of group 2 elements? 12217103

Ans. 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.

Q.14 How the reactivity of group 2 elements can be explained on the basis of electronic configuration? 12217104

Ans. 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+}).

Q.15 Why does the reactivity of group 2 increase from Be to Ba. 12217105

Ans. 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.

Chemical Reactions of Group 2 Elements

Q.16 State the order of reactivity of Group 2 elements. Why is beryllium the least reactive element of Group 2? 12217106

Ans. Be < Mg < Ca < Sr < Ba

Beryllium is least reactive because it has the smallest atomic radius and the highest ionization energy in Group 2. Its valence electrons are very tightly held by the nucleus, making it exceedingly difficult for beryllium to lose electrons and form chemical bonds compared to the other elements. 12217107

Q.17 Why are Group 2 oxides basic in nature? Write the ionic equation showing the formation of hydroxide ions from oxide ions?

Ans. Group 2 oxides are basic because they react with water to yield metal hydroxides, which release hydroxide ions (OH^-) into the solution, raising the pH. $O^{2-} + H_2O \rightarrow 2OH^-$

Q.18 Why does magnesium burn with a bright white flame? 12217108

Ans. When magnesium burns in oxygen, it undergoes a highly exothermic reaction to form magnesium oxide (MgO). The intense heat generated excites electrons to higher energy levels. As these electrons fall back to their ground state, they release energy across the entire visible spectrum, which our eyes perceive as a brilliant white light.

Q.19 Why does beryllium not react with water? 12217109

Ans. As Beryllium has an exceptionally high ionization energy and strong metallic bonding and It also forms a tough, impervious, and protective oxide layer (BeO) on its surface that completely passivates the metal, preventing water molecules from reaching the underlying element, due to these

it doesn't react with water or steam. This is called passivity of Beryllium.

Q.20 Why does calcium react more vigorously with water than magnesium? 12217110

Ans. Calcium has a larger atomic radius and lower ionization energy than magnesium. Consequently, calcium loses its two valence electrons much more easily than magnesium.

Magnesium also forms a slightly protective layer of insoluble magnesium hydroxide during the reaction, which slows it down, whereas calcium's reaction proceeds rapidly and vigorously at room temperature.

Comparison of Group 2 Elements with Group 1 Elements

Q.21 What is the difference between the reaction of group 1 and 2 metals with water? 12217111

Ans. Group 1 metals react very vigorously with water causing explosive reactions. e.g., reaction.

$$Na_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + H_{2(g)} + heat$$

Group 2 elements: react with water less vigorously. e.g.,

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

Q.22 Compare the nature of oxides and hydroxides of Group 1 and Group 2 elements. 12217112

Ans. Group 1 metals form oxides of M_2O type which are highly basic in nature. Their hydroxides are highly soluble and are strong bases. e.g., NaOH, KOH.

Group 2 metals form oxides of MO-type which are less basic than group 1 oxide. Their hydroxides are less soluble than Group 1 and are comparatively weaker bases. e.g., $Ca(OH)_2$, $Mg(OH)_2$.

Thermal Decomposition of Carbonates and Nitrates

Q.23 What is thermal decomposition? Write the general equation for decomposition of Group 2 carbonates? 12217113

Ans. Thermal decomposition is a chemical reaction where a single substance breaks down into two or more simpler substances upon heating. $MCO_3 \xrightarrow{\Delta} MO + CO_2$

(Where M represents any Group 2 element: Be, Mg, Ca, Sr, Ba)

Q.24 State the trend in thermal stability of Group 2 carbonates? 12217114

Ans. The thermal stability of Group 2 carbonates increases down the group from beryllium to barium.

$BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

Beryllium carbonate decomposes at a low temperature of 250°C, while barium carbonate requires exceptionally high temperatures of 1360°C to decompose.

Q.25 What is meant by polarizing power? Why do smaller cations have greater polarizing power? 12217115

Ans. Polarizing power is the ability of a cation to polarize the electron cloud of an adjacent anion.

Polarizing power depends on charge density charge/size ratio. A smaller cation concentrates its positive charge into a much smaller surface area. This high concentration of positive charge exerts a stronger electrostatic pull on the outer electrons of a nearby anion, distorting its electron cloud more effectively.

Q.26 Why does $BeCO_3$ decompose more easily than $BaCO_3$? 12217116

Ans. The Be^{2+} ion is exceptionally small, giving it a very high charge density and immense polarizing power compared to the large Ba^{2+}ion.Be^{2+} strongly pulls and distorts the electronic cloud of the large, easily polarizable carbonate ion.This distortion weakens the internal carbon-oxygen (C-O) covalent bonds within the carbonate group, so much less heat energy is required to break the bonds and split it into its oxide and carbon dioxide, making $BeCO_3$ far less thermally stable than $BaCO_3$.

Solubility of Group 2 Sulphates and Hydroxides

Q.27 Define hydration enthalpy (ΔH_{hyd}). How does hydration enthalpy change down Group 2? 12217117

Ans. Hydration enthalpy is the amount of

energy released when one mole of gaseous ions are completely dissolved in water to form infinitely dilute aqueous ions. This is always exothermic (−ve value).

Hydration enthalpy decreases (becomes less negative) down the group 2. As ionic radius increases from Mg^{2+} to Ba^{2+}, the charge density decreases, weakening the electrostatic attraction between the metal cation and water molecules.

Q.28 Define lattice enthalpy ($\Delta H_{lattice}$). Why is lattice enthalpy always positive? 12217118

Ans. Lattice enthalpy is the energy required to completely separate one mole of a solid ionic compound into its gaseous constituent ions under standard conditions. This is always endothermic (+ve value).

Breaking an ionic lattice requires overcoming the strong electrostatic forces of attraction holding the oppositely charged ions together. Because bond-breaking is an endothermic process, energy must be absorbed, making the enthalpy change strictly positive.

Q.29 What is meant by enthalpy of solution (ΔH_{soln})? 12217119

Ans. Enthalpy of solution is the enthalpy change when one mole of a solute is completely dissolved in a solvent under standard conditions to form an infinitely dilute solution. It depends on the balance between lattice enthalpy and hydration enthalpy:

$\Delta H_{soln} = \Delta H_{lattice} + \Delta H_{hyd}$

Q.30 State the trend in solubility of Group 2 hydroxides. 12217120

Ans. The solubility of Group 2 hydroxides increases down the group. As we move down the group, both lattice enthalpy and hydration enthalpy decrease. However, because the hydroxide ion is relatively smaller, the lattice enthalpy decreases much more faster than the hydration enthalpy. This makes ΔH_{soln} less endothermic down the group, increasing their solubility.

Q.31 State the trend in solubility of Group 2 sulphates. 12217121

Ans. The solubility of Group 2 sulphates decreases down the group.

As the sulphate ion is exceptionally large, that's why, down the group, the lattice enthalpy remains relatively constant, while the hydration enthalpy of the cation drops significantly due to increasing size. This causes ΔH_{soln} to become more endothermic, and solubility decreases from $MgSO_4$ to $BaSO_4$.

Complex Ion Formation

Q.32 What is EDTA? 12217122

Ans. EDTA stands for Ethylenediaminetetraacetic acid. It is a polydentate (specifically a hexadentate) chelating ligand. It possesses six donor atoms (two nitrogen atoms and four oxygen atoms) that allow it to wrap around a single metal cation, forming a highly stable, ring-like complex structure called a chelate.

Q.33 Give one use of EDTA in medicine. 12217123

Ans. EDTA is primarily used in Chelation Therapy to treat heavy metal poisoning such as Pb^{2+}, Hg^{2+} or As^{3+} poisoning. It binds to the toxic metal ions in the blood stream, forming a stable, non-toxic complex that the kidneys can safely filter out and excrete through urine.

Q.34 Why is EDTA used for water softening? 12217124

Ans. Hard water contains dissolved calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions that form scum with soap and cause limescale in pipes. EDTA is added to soften water because it binds with these specific ions, forming stable water soluble complexes. So they can no longer react with soap molecules or precipitate out as scale.

Q.35 Why does EDTA remove Ca^{2+} and Mg^{2+} ions from hard water? 12217125

Ans. EDTA acts as a powerful chelating

agent. When added to hard water, its six donor atoms form strong coordinate covalent bonds with a single Ca^{2+} or Mg^{2+} ion, completely surrounding it to form a highly stable, water-soluble complex. This effectively "masks" or sequesters the ions, preventing them from causing hardness

Q.36 Why does Be^{2+} form complexes more readily than Ba^{2+}? 12217126

Ans. Complex formation depends heavily on the charge density of the metal cation.

Both ions have the same charge (+2), but the Be^{2+} ion is exceptionally small, giving it a much higher charge density than the large Ba^{2+}ion.This high charge density allows Be^{2+} to exert a much stronger electrostatic attraction on the lone pairs of incoming ligands, drawing them into coordinate bonds far more readily.

Extraction and Purification of Group 2 Elements and their Compounds

Q.37 What is Dow's process? 12217127

Ans. The Dow's process is an industrial method used to extract magnesium metal from seawater via electrolysis. It involves precipitation of magnesium from seawater as magnesium hydroxide, converting it to magnesium chloride, and finally performing electrolysis on the molten salt to obtain pure magnesium metal.

Q.38 Why is seawater a suitable source for magnesium extraction? 12217128

Ans. Seawater is an excellent and highly suitable source for magnesium because magnesium ions (Mg^{2+}) are the second most abundant dissolved cations in the ocean (ranking second after sodium). This provides a virtually inexhaustible, cheap, and easily accessible raw material.

Q.39 Write the equation for precipitation of magnesium hydroxide in Dow's process. 12217129

Ans. When calcium hydroxide is added to seawater, it reacts with the dissolved magnesium ions to form an insoluble precipitate of magnesium hydroxide:

$$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$$

Q.40 Why is $Ca(OH)_2$ added to sea water during Dow's process? 12217130

Ans. Calcium hydroxide ($Ca(OH)_2$) is added because it provides a cheap and abundant source of hydroxyl ions (OH-). Since magnesium hydroxide is highly insoluble in water compared to calcium hydroxide, the addition of $Ca(OH)_2$ successfully forces selective precipitation of magnesium out of the seawater.

Q.41 Why is molten $MgCl_2$ used instead of aqueous $MgCl_2$ for electrolysis? 12217131

Ans. If an aqueous solution of magnesium chloride ($MgCl_2$) is electrolyzed, water molecules are reduced at the cathode instead of magnesium ions because hydrogen has a lower reduction potential than magnesium.

In aqueous solution we get hydrogen gas (H_2) at the cathode. While in molten state there is no water present, allowing the magnesium ions to successfully gain electrons and deposit as pure magnesium metal (Mg).

Q.42 Define calcination. 12217132

Ans. Calcination is a thermal treatment process in which a solid chemical compound (often an ore or carbonate) is heated to a high temperature below its melting point in the absence or limited supply of air and get solid main product. The primary goal is to drive off volatile fractions, remove moisture, or cause chemical decomposition.

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

Q.43 Why is CO_2 continuously removed during the manufacture of quicklime? 12217133

Ans. The decomposition of limestone is a reversible reaction that establishes a chemical equilibrium in a closed system:

$$CaCO_3 \rightleftharpoons^{\Delta} CaO + CO_2$$

According to Le Chatelier's Principle, continuously removing the carbon dioxide (CO_2) gas shifts the equilibrium position to

the forward direction (right). This ensures a maximum yield of quicklime (CaO) and prevents the reverse reaction from turning it back into limestone.

Uses of Group 2 Compounds

Q.44 What is the difference between quick lime and slaked lime? Write formulas and uses. 12217134

Ans. Quicklime CaO obtained by the thermal decomposition (calcination) of limestone ($CaCO_3$). Used in steel manufacturing, production of high-grade glass, and as a drying agent.

Calcium Hydroxide $Ca(OH)_2$ obtained by reacting quicklime with water (a process called "slaking"). Used in water treatment, soil stabilization, mortar/plaster preparation, and bleaching powder production.

Q.45 Mention one use of gypsum. 12217135

Ans. Gypsum ($CaSO_4.\ 2H_2O$) is primarily used in the construction industry to manufacture Plaster of Paris and wallboards/drywall. It is also added 2% to Portland cement to react as a retarder, slowing down its setting time so workers have more time to mold or pour it.

Q.46 What is flue gas desulphurization? 12217136

Ans. Flue Gas Desulfurization (FGD) is an environmental technology used to remove sulfur dioxide (SO_2) from the exhaust emissions (flue gases) of fossil-fuel power plants and industrial boilers. This is typically done by spraying the exhaust with an alkaline slurry—usually made of limestone ($CaCO_3$) or slaked lime ($Ca(OH)_2$ which reacts with the SO_2 to form calcium sulfate (gypsum), preventing the formation of acid rain.

Q.47 Why is MgO used as a refractory material? 12217137

Ans. Magnesium oxide (MgO) is an excellent refractory material (a material that maintains its strength and structure at extremely high temperatures) due to two main properties:

1. Exceptionally High Melting Point roughly 2852°C.
2. It is highly stable and does not easily break down or react with basic slags during high-temperature metallurgical processes, making it ideal for lining industrial furnaces and crucibles.

Q.48 What is Milk of Magnesia? State one use. 12217138

Ans. Milk of Magnesia is an aqueous suspension of magnesium hydroxide ($Mg(OH)_2$. Because it looks white and creamy like milk, it got this common name.

USE. It is widely used medicinally as an antacid to neutralize excess stomach acid and relieve indigestion, or as a laxative to treat temporary constipation

Q.49 Why is $BaSO_4$ used in X-ray imaging? 12217139

Ans. Even though barium ions are highly toxic to humans, Barium sulfate ($BaSO_4$) is safely used as a contrast agent (often called a "barium meal") for X-ray imaging of the gastrointestinal tract because it is completely insoluble in water and stomach acid, meaning the body cannot absorb it, so it is excreted unchanged without causing poisoning.

Additionally Barium has a high atomic number, making it excellent at absorbing X-rays. This causes the stomach and intestines to stand out clearly as bright white structures on the X-ray film.

Q.50 State two medicinal uses of Group 2 compounds. 12217140

Ans.

1. Magnesium Sulfate ($MgSO_4.\ 7H_2O$, Epsom salt): Used intravenously to prevent seizures in pregnant women with preeclampsia and as a muscle relaxant.
2. Calcium Carbonate ($CaCO_3$), used as an oral calcium supplement to treat or prevent osteoporosis (bone thinning) and antacid relief.

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Q.51 How do $CaCO_3$ and $Ca(OH)_2$ help agriculture? 12217141

Ans. Both compounds are widely used in agriculture for soil treatment, a process commonly known as "liming". They are basic in nature, so they are added to fields to neutralize highly acidic soils, raising the pH to an optimal level for crop growth. They also improve soil structure and supply essential calcium nutrients, which enhances root development and overall plant health.

Q.52 Why is magnesium essential for plants? 12217142

Ans. Magnesium (Mg) is the central atom in the chlorophyll molecule the green pigment that plants use to trap sunlight. Without magnesium, plants cannot synthesize chlorophyll, meaning they cannot perform photosynthesis to create food, resulting in a condition called chlorosis (yellowing of the leaves) and stunted growth.

CONSTRUCTED RESPONSE QUESTIONS

Q.1 Why the melting point and density of beryllium are higher than other Group 2 elements? 12217143

Ans. Smallest atomic radius and highest charge density are responsible to allow Be atom to pack very tightly in a metallic lattice which strong metallic bonding (Stronger attraction between small nuclei and delocalized valence electrons). These strong bonds require more energy to break, resulting in higher melting point. Exceptionally small atomic volume results in a tightly pack structure with high density (d = m/V) relative to its mass.

Q.2 Why are Group 1 metals more reactive than Group 2 metals in the same period? 12217144

Ans. Group 1 elements have larger atomic radii and lower nuclear charges than Group 2 elements in the same period. Group 1 metals have only one valence electron which is removed more easily than 2 valence electrons of Group 2 metals. They have lower ionization energies, so they lose electrons more readily than those of Group 1 metals.

Q.3 Explain why calcium hydroxide is used in agriculture. 12217145

Ans. Calcium hydroxide $Ca(OH)_2$ known as slaked lime is used to treat acidic soils. It is basic in nature, neutralizes excess acidity and raises soil pH thus improves soil structure. It also provides essential calcium (Ca) nutrients to crops.

DESCRIPTIVE QUESTIONS (EXERCISE)

Q.4 Describe the reactivity of Group 2 elements with water and dilute hydrochloric acid. Provide relevant chemical equations and differences in their reactivity. 12217146

Ans. See (L.Q. 3 Parts b and c)

Q.5 Explain the thermal decomposition of carbonates and nitrates of Group 2 elements. Give reason and relative order of the ease of thermal stability. 12217147

Ans. See (L.Q. 6)

Q.6 Explain the solubility of sulphates and hydroxides of Group 2 elements, and discuss the trend in their solubility down the group with appropriate examples. 12217148

Ans. See (L.Q. 7).

Q.7 Explain the process of extraction of Mg through Dow's method. 12217149

Ans. See (L.Q. 9).

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