Chapter 5

S-Block Elements (*Alkaline Earth Metal*)

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Group - IIA Alkaline Earth Metal :

- Group 2 elements include Beryllium **(Be)** Magnesium **(Mg)** Calcium **(Ca)** Strontium **(Sr)** Barium **(Ba)** and Radium (**Ra**).

- These elements are called alkaline earth metals because their **oxides** are alkaline and are found in the **soil**..

- The general electronic configuration of the elements of Second group (**noble gases**) is ns2 and the valence shell electronic configuration is **ns2.**

- Among the alkaline earth metals, **Radium** is a **radioactive** element which is not found in free state in nature. Rather, it is found in compounds with other elements, especially in uranium ores.

- The electronic Configuration of the elements included in group one of s block elements are shown below -

Element	Symbol	Atomic Number	Electronic Conf.
Beryllium	Be	4	[He] $2s^2$
Magnesium	Mg	12	[Ne] $3s^2$
Calcium	Ca	20	[Ar] $4s^2$
Strontium	Sr	38	[Kr] $5s^2$
Barium	Ba	56	[Xe] $6s^2$
Radium	Ra	88	[Rn] $7s^2$

1. Atomic and Ionic Radius of Alkaline earths Metals -

Alkaline earth metals have smaller atomic and ionic radii than alkali metals because as we move from left to right in a period in the periodic table, the nuclear charge increases and the force of nuclear attraction increases which decreases the radius. Like the first group, in these also the atomic and ionic radius increases as we move from top to bottom in the group But the value of ionic radius is much smaller than atomic radius, Because when cation **(M2+)** is formed, the outermost shell gets destroyed.

2. Ionisation Enthalpy -

Due to the large atomic size of alkaline earth metals, their ionization enthalpy values are low. Atomic size increases as we move from top to bottom in a group, hence their ionization enthalpy decreases The **first ionization enthalpy** of alkaline earth metals is higher than that of alkali metals This is due to their smaller size compared to alkali metals, but their second ionization enthalpy values are lower than the second ionization enthalpy of alkali metals. Because by losing two electrons we get a stable configuration like noble gases.

3. Hydration Enthalpy

Like alkali metals, in alkaline earth metals also the value of hydration enthalpy decreases as the ionic radius increases from top to bottom in the group.

Be2+ > Mg2 +> Ca2+ > Sr2+ > Ba2+

The hydration enthalpy of alkaline earth metal ions is higher than that of alkali metal ions Because these ions are small in size and have high charge. Compounds of alkaline earth metals are more hydrated than those of alkali metals. For this reason, **NaCl** and **KCl** do not form hydrate whereas **MgCl2** and **CaCl2** are found in the form of hexa hydrate **(MgCl2.6H2O, CaCl2.6H2O)** and **BaCl2** is found in the form of **BaCl2.H2O.**

Physical Properties of Alkaline Earth metals

1. Alkaline earth metals are generally silvery white and lustrous. But **beryllium** and **magnesium** are almost grey in colour. They have metallic luster and

are malleable and ductile. Like alkali metals, they are also good conductors of electricity and heat.

2. Melting and Boiling Point -

The melting and boiling points of alkaline earth metals are higher than those of alkali metals.because their size is small.The value of melting point and boiling point decreases as we move from top to bottom in a group because the strength of metallic bond decreases due to increase in atomic size.But the melting point and boiling point of **calcium** are relatively higher because in it **d-orbitals** are used in forming bonds, due to which the strength of the bond is higher due to their more directional properties. And d orbitals start with calcium only, hence the order of melting point and boiling point of group 2 elements is as follows-

Melting points Be > Ca > Sr > Ba > Mg

Boiling points   Be > Ba > Ca > Sr > Mg

3. Density -

The density of **group 2** elements is higher than that of **group 1** elements because their size is smaller.There is no regularity in the density of alkaline earth metals as we move from top to bottom in a group. The density decreases from **Be** to **Ca** and increases thereafter. The reason for this is the difference in their crystal structure. Hence the order of density of alkaline earth metals is as follows -

Ca < Mg < Be < Sr < Ba

4. Hardness -

Due to the large size of alkaline earth metals, the **metallic bond** in them is weak and hence they are soft. But they are harder than alkali metals because their atomic size is relatively smaller and hence the **bond strength** is higher. Like alkali metals, their hardness also decreases as we move down the group because the bond strength decreases with increase in atomic size.

5. Metallic and Electropositive Character -

Due to low ionization enthalpy, alkaline earth metals are strongly electropositive and electropositive properties increase from top to bottom **(Be to Ba).** Their electrical positive properties **(metallic properties)** are less than those of alkali metals, because due to their small size, their ionization enthalpy is relatively high.

6. Oxidation State -

All alkaline earth metals form divalent cations **(M2+)** because they donate two electrons to attain stable configuration like noble gases.

7. Colourless and Diamagnetic Ion -

The cations **(M2+)** of alkaline earth metals are colourless and diamagnetic. Because they have stable noble gas configuration in which all electrons are paired.

8. Flame Test -

Except **beryllium** and **magnesium**, other alkaline earth metals give flame test Because at high temperature in the flame (in vapour state) the electrons of the outermost shell of alkaline earth metals get excited and move to higher energy levels. When these electrons return to their original state, they emit energy in the form of visible light, which gives the flame its characteristic colour. **Calcium (Ca) Brick red** Calcium gives brick red colour to the flame, **Strontium** gives **crimson red colour** and **Barium** gives **apple green colour** to the flame. This is why in qualitative analysis these radicals are confirmed on the basis of flame test. The electrons of the outermost shells of **beryllium** and **magnesium** are so strongly bound that they cannot be excited by the energy of the flame, so they do not impart any particular colour to the flame.

9. Standard Electrode Potential -

The standard electrode potential of alkaline earth metals is highly negative **(less than that of alkali metals),** hence they are reducing agents. This value keeps on decreasing as we move from top to bottom in a group, hence their reactivity also decreases. For this reason **Be** is the least active alkaline earth metal and **Ba** is the most active.

S block elements availability and extraction in nature -

Due to the high reactivity of **S block elements**, they are not found in free form in nature. Elements of **IA group** are mainly found in the form of **chlorides, sulphates** and **nitrates**. Whereas the elements of **II A group** are mainly found in the form of **silicates,**

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carbides and **sulphates.** They are reduced in metallic form only by **electrolytic** method because due to their high reactivity, their reduction by reducing agents is not possible.

Complexation and Solvation Tendency -

Due to their relatively large size and low charge density, the S block elements have a low tendency to form complex compounds and combine with solvent molecules. Compared to **group IA elements**, **group II A elements** have higher solvation and complexation capacity due to their smaller size and higher charge density.

Solubility of Compounds -

The compounds of **S block elements** are mainly ionic in nature and hence they are soluble in water. Due to the small size and high **polarizability** of lithium and beryllium, their compounds are **covalent** in nature. Due to which their solubility in water is relatively low while it is high in organic compounds. **Sulphates**, **phosphates** and **oxalates** of alkali metals are soluble in water. Whereas **sulphates**, **phosphates** and **oxalates** of alkaline earth metals are insoluble in water due to low value of lattice energy.

Solubility in Liquid ammonia -

All the elements of **I A group** and **Ca**, **Sr** and **Ba** of **II A group** dissolve in **liquid ammonia** to form a **dark blue coloured solution.** This solution is a good conductor of electricity. The solution contains ammonia cations and ammonia electrons. The blue colour of the solution is due to the presence of ammoniated electrons Due to ammoniated cations and ammoniated electrons, this solution behaves as a conductor of electricity, **paramagnetic** and a strong reducing agent.

Eelectronegativity -

The elements of group I A and group II A have lower electronegativities than all other elements. The value of electronegativities decreases as we move from top to bottom in a group whereas electronegativities increase as we move from left to right in a period. Therefore, the electronegativity of the elements of **II A group** is more than that of the elements of **I A group**.

Property	Beryllium Be	Magnesium Mg	Calcium Ca	Strontium Sr	Barium Ba	Radium Ra
Atomic number	4	12	20	38	56	88
Atomic mass (g mol^{-1})	9.01	24.31	40.08	87.62	137.33	226.03
Electronic configuration	[He] $2s^2$	[Ne] $3s^2$	[Ar] $4s^2$	[Kr] $5s^2$	[Xe] $6s^2$	[Rn] $7s^2$
Ionization enthalpy (I) / kJ mol^{-1}	899	737	590	549	503	509
Ionization enthalpy (II) /kJ mol^{-1}	1757	1450	1145	1064	965	979
Hydration enthalpy (kJ/mol)	– 2494	– 1921	–1577	– 1443	– 1305	–
Metallic radius / pm	111	160	197	215	222	–
Ionic radius M^{2+} / pm	31	72	100	118	135	148
m.p. / K	1560	924	1124	1062	1002	973
b.p / K	2745	1363	1767	1655	2078	(1973)
Density / g cm^{-3}	1.84	1.74	1.55	2.63	3.59	(5.5)
Standard potential $E^\ominus$ / V for (M^{2+}/ M)	–1.97	–2.36	–2.84	–2.89	– 2.92	–2.92
Occurrence in lithosphere	2*	2.76**	4.6**	384*	390 *	10^{-6}*

***ppm (part per million), **Percentage by weight, lithosphere : the earth's outer layer : it's crust and part of the upper mentle.**

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