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(Study notes on Alkaline Earth Metals)

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The Alkaline Earth metals

The alkaline earth metals are chemical elements part of s-block of the periodic table.
The **alkaline earth metals** are six chemical elements in group 2 of the periodic table. They are beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra).

They readily lose their two outermost electrons to form cations with charge +2.

Z	Element	No. of electrons/shell	Electron configuration
4	beryllium	2, 2	[He] $2s^2$
12	magnesium	2, 8, 2	[Ne] $3s^2$
20	calcium	2, 8, 8, 2	[Ar] $4s^2$
38	strontium	2, 8, 18, 8, 2	[Kr] $5s^2$
56	barium	2, 8, 18, 18, 8, 2	[Xe] $6s^2$
88	radium	2, 8, 18, 32, 18, 8, 2	[Rn] $7s^2$

Physical Properties of Alkaline Earth Metals:

- are shiny
- are silvery-white
- are somewhat reactive metals at standard temperature and pressure
- readily lose their two outermost electrons to form cations with a +2 charge
- have low densities
- have low melting points
- have low boiling points

Chemical properties of Alkaline Earth Metals:

All the alkaline earth metals have two electrons in their valence shell, so they lose two electrons to form cations with a +2 charge. Mostly, the chemistry has been observed and studied only for the first five members of the group; whereas, due to the radioactive nature of radium, its chemistry is not well studied.

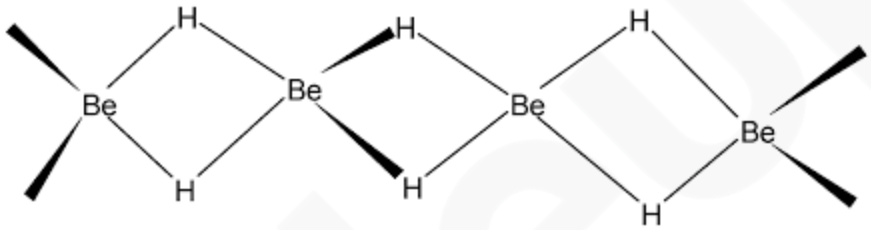
Beryllium is an exception in the group to much extent. It does not react with water or steam, and its halides are covalent. All compounds that include beryllium have a covalent bond. Even beryllium fluoride, which is the most ionic beryllium compound, has a low melting point and a low electrical conductivity when melted.

1. **Hydrides:**

Beryllium does not react with hydrogen directly. Beryllium hydride can be prepared by the reduction of beryllium chloride with lithium aluminium hydride.

$2BeCl_2 + LiAlH_4 \rightarrow 2BeH_2 + LiCl + AlCl_3$

Beryllium and magnesium form covalent hydrides where each hydrogen is connected to two metal atoms. This is an example of 'banana Bond' in which molecules with three centres shares only two electrons.



Hydrides of Alkaline Earth Metals

Calcium, strontium and barium reacts with hydrogen to form metallic hydrides which gives hydride ions.

$M + H_2 \rightarrow 2MH_2 \rightarrow M^+ + 2\ H^-$

Hydrides react violently with water to release hydrogen. Calcium hydride is called 'Hydrolith' and it is used for the production of hydrogen.

$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + H_2$

2. **Reaction of Alkaline Earth Metals with Water**

Beryllium does not react with water even at higher temperatures.
Magnesium reacts with hot water only to form hydroxides and release hydrogen. Magnesium gets a protecting coat of its oxide, that prevents any further attack by the water molecules.
Other alkaline earth metals react even with cold water to liberate hydrogen.

3. **Carbides**

Alkaline earth metals and their oxides, except beryllium, react with carbon to yield carbides. Carbides react with water to liberate acetylene gas and hence they're used as source for the gas.

$M + 2C \rightarrow MC_2$
$MC_2 + 2H_2O \rightarrow M(OH)_2 + C_2H_2$

4. **Oxides**

Beryllium reacts with oxygen only above 600°C. Magnesium and strontium burn in oxygen to form oxides while Barium forms peroxides.
BeO and MgO are more covalent while the other oxides are ionic. Beryllium oxide is amphoteric; while magnesium oxide and calcium oxide are weakly basic, while other oxides are basic.

5. **Hydroxides**

Oxides react with water and forms hydroxide. The basic nature and the thermal stability of hydroxides increases from beryllium to barium.

6. **Carbonates and Bicarbonates**

The hydroxides react with carbon dioxide to form carbonates.

$M(OH)2 + CO_2 \rightarrow MCO_3 + H_2O$

Bicarbonates are soluble in water and exist only in solution. Carbonates exist as solid and are insoluble in water. The solubility of carbonates decreases from Beryllium to Barium.
In the presence of carbon dioxide, carbonates dissolve by forming bicarbonates.
Ionic character and thermal stability of carbonates increases from Beryllium to Barium.

7. **Sulphates**

In contrast to alkali metal sulphates, beryllium sulphate is water-soluble. The smaller size and charge density increases the hydration energy of the beryllium sulphate leading to more solubility.
In other sulphates, increasing lattice energy and the decreasing hydration energy (due to increasing size) decreases their solubility form $BeSO_4$ to $BaSO_4$.

Solubility of $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

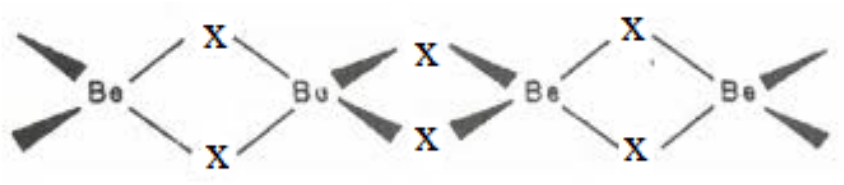
8. **Nitrates**

On reacting the corresponding oxides, hydroxides and carbonates with nitric acid, nitrates can be prepared. Nitrates are soluble in water. On heating, Beryllium nitrate forms nitrite and, other nitrates yield oxide; liberating brown fumes of nitrogen dioxide.

$2M(NO_3)_2 \rightarrow 2MO + 4\ NO_2 + O_2$

9. **Halides**

Alkaline earth metals from calcium to barium react with all halogens to form solid ionic halides with a definite crystal structure. Reactivity decreases from fluorine to iodine.
Beryllium halides are an exception with more covalent bonding because of the high polarization of the small covalent ion on the electron cloud of the halogen anion as indicated by the Fajan's rule.
In the gas phase, Beryllium halides exist as individual molecules and in the solid phase, they form chains of Be-X.



Fluorides are insoluble in water. The solubility of other halides decreases with increase in ionic size i.e. from Mg^{2+} to Ba^{2+}.
Halides are hygroscopic and have the water of crystallization in their solid state ($CaCl_2.6H_2O$).
Fused halides are used as dehydrating agents.

10. **Reaction of Alkaline Earth Metals with Liquid Ammonia**

Alkaline earth metals form ammonia solvated cation and electrons, just like Alkali metals. The solution is electrically conductive, reductive and paramagnetic**.** The solvated electrons are absorbed in the visible region and the solution turns blue in colour. The concentrated solution is bronze in colour. On long standing, it decomposes into amide, ammonia and hydrogen.

$$M + (x + y)\ NH_3 \rightarrow M(NH_3)_x]^+ + [M(NH_3)_y]^- \rightarrow MNH_2 + 1/2H_2$$

11. **Radioactivity:**

All alkaline earth metals, except magnesium and strontium have at least one naturally occurring radioisotope: beryllium-7, beryllium-10, and calcium-41 are trace radioisotopes.
Calcium-48 and barium-130 have very long half-lives and thus occur naturally. All isotopes of radium are radioactive.

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