s – Block Elements

Alkali Metals and Their Compounds

The group 1 of the periodic table contains six elements, namely lithium (*Li*), sodium (*Na*), potassium (*K*), rubidium (*Rb*), caesium (*Cs*) and francium (*Fr*).

(1) Electronic configuration

Elements	Discovery	Electronic configuration (ns^1)
$_3Li$	Arfwedson (1817)	$[He]^2 2s^1$
$_{11}Na$	Davy (1807)	$[Ne]^{10} 3s^1$
$_{19}K$	Davy (1807)	$[Ar]^{18} 4s^1$
$_{37}Rb$	Bunsen (1861)	$[Kr]^{36} 5s^1$
$_{55}Cs$	Bunsen (1860)	$[Xe]^{54} 6s^1$
$_{87}Fr$	Percy (1939)	$[Rn]^{86} 7s^1$

Occurrence: Alkali metals: Li, Na, K, Rb, Cs

They readily form oxides and hydroxides which are strongly alkaline.

(i) ***Lithium:*** Triphylite, Petalite, lepidolite, Spodumene [$LiAl(SiO_3)_3$], Amblygonite [$Li(Al\ F)PO_4$]
(ii) ***Sodium***: Chile salt petre ($NaNO_3$), Sodium chloride ($NaCl$), Sodium sulphate (Na_2SO_4), Borax ($Na_2B_4O_7 10H_2O$), Glauber salt ($Na_2\ SO_4.10H_2O$)
(iii) ***Potassium***: Sylime (KCl), carnallite ($KCl.MgCl_2.6H_2O$) and Felspar ($K_2O.Al_2O_3.6SiO_2$)
(iv) ***Rubidium***: Lithium ores Lepidolite, triphylite contains 0.7 to 3% Rb_2O
(v) ***Caesium***: Lepidolite, Pollucite contains 0.2 to 7% Cs_2O

Physical properties

Physical state

(i) All are silvery white, soft and light solids. These can be cut with the help of knife. When freshly cut, they have bright lustre which quickly tarnishes due to surface oxidation.

Atomic and ionic radii

(i) The alkali metals have largest atomic and ionic radii than their successive elements of other groups belonging to same period.

Density

(i) All are light metals, *Li*, *Na* and *K* have density less than water.

Melting point and Boiling point

(i) All these elements possess low melting point and boiling point in comparison to other group members.

Ionisation energy and electropositive or metallic character

Decreases from top to bottom.

Oxidation number and valency

Alkali metals are univalent in nature due to low ionisation energy.

Electronegativity, Electro positivity and metallic character.

Increases down the group due to the decrease in ionization energy.

Characteristic flame colours:

The alkali metals and their salts give characteristic colour to Bunsen flame.

Chemical properties

Formation of oxides and hydroxides

$$M + O_2 \rightarrow \underset{\text{Oxide}}{M_2O} \longrightarrow \underset{\text{Peroxide}}{M_2O_2}$$

$M + H_2O \longrightarrow$

$M(OH)_2 + H_2$

Hydrides

(i) These metals combine with *H* to give white crystalline ionic hydrides of the general of the formula *MH*.

(ii) The tendency to form their hydrides, basic character and stability decreases from *Li* to *Cs* since the electropositive character decreases from *Cs* to *Li*.

$2M + H_2 \rightarrow 2MH$; Reactivity towards H_2 is $Cs < Rb < K < Na < Li$.

Carbonates and Bicarbonates

(i) The carbonates (M_2CO_3) & bicarbonates ($MHCO_3$) are highly stable to heat, where M stands for alkali metals.

(ii) The stability of these salts increases with the increasing electropositive character from *Li* to *Cs*.

Halides

(i) Alkali metals combine directly with halogens to form ionic halide M^+X^-.

Solubility in liquid NH_3

(iii) The metal atom is converted into ammoniated metal in i.e. $M^+(NH_3)$ and the electron set free combines with NH_3 molecule to produce ammonia solvated electron.

$$Na + (x+y)NH_3 \rightarrow \underset{\text{Ammoniated cation}}{[Na(NH_3)_x]^+} + \underset{\text{Ammoniated electron}}{[e(NH_3)_y]^-}$$

Nitrates: Nitrates of alkali metals (MNO_3) are soluble in water and decompose on heating. $LiNO_3$ decomposes to give NO_2 and O_2 and rest all give nitrites and oxygen.

$$2MNO_3 \rightarrow 2MNO_2 + O_2 \text{ (except } Li\text{)}$$

$$4\,LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$$

Sulphates

(i) Alkali metals' sulphate have the formula M_2SO_4.

(ii) Except Li_2SO_4, rest all are soluble in water.

Reaction with non-metals

(i) These have high affinity for non-metals. Except carbon and nitrogen, they directly react with hydrogen, halogens, sulphur, phosphorus etc. to form corresponding compounds on heating.

$$2Na + H_2 \xrightarrow{300^0C} 2NaH \quad ; \quad 2K + H_2 \rightarrow 2KH$$

$$2Na + Cl_2 \rightarrow 2NaCl \quad ; \quad 2K + Cl_2 \rightarrow 2KCl$$

$$2Na + S \rightarrow Na_2S \quad ; \quad 2K + S \rightarrow K_2S$$

$$3Na + P \rightarrow Na_3P \quad ; \quad 3K + P \rightarrow K_3P$$

Reaction with acidic hydrogen : Alkali metals react with acids and other compounds containing acidic hydrogen (*i.e*, H atom attached on F,O, N and triply bonded carbon atom, for example, HF, H_2O, ROH, RNH_2, $CH \equiv CH$) to liberate H_2 .

$M + H_2O \rightarrow MOH + \frac{1}{2}H_2$; $M + HX \rightarrow MX + \frac{1}{2}H_2$

$M + ROH \rightarrow ROH + \frac{1}{2}H_2$; $M + RNH_2 \rightarrow RNHNa + \frac{1}{2}H_2$

Alkaline Earth Metals and Their Compounds

The group 2 of the periodic table consists of six metallic elements. These are beryllium (*Be*), magnesium (*Mg*), calcium (*Ca*), strontium (*Sr*), barium (*Ba*) and radium (*Ra*). These (except *Be*) are known as alkaline earth metals as their oxides are alkaline and occur in earth crust.

Electronic configuration

Element	Electronic configurations (ns^2)
$_4Be$	$[He]2s^2$
$_{12}Mg$	$[Ne]3s^2$
$_{20}Ca$	$[Ar]4s^2$
$_{38}Sr$	$[Kr]5s^2$
$_{56}Ba$	$[Xe]6s^2$
$_{88}Ra$	$[Rn]7s^2$

Radium was discovered in the ore pitch blende by madam Curie. It is radioactive in nature.

Occurrence: These are found mainly in combined state such as oxides, carbonates and sulphates *Mg* and *Ca* are found in abundance in nature. *Be* is not very abundant, *Sr* and *Ba* are less abundant. *Ra* is rare element. Some important ores of alkaline earth metals are given below,

(i) ***Baryllium***: Beryl ($3BeO.Al_2O_3.6SiO_2$); Phenacite (Be_2SiO_4)

(ii) ***Magnesium***: Magnesite ($MgCO_3$); Dolomite ($CaCO_3.MgCO_3$); Epsomite($MgSO_4.7H_2O$); Carnallite ($MgCl_2.KCl.6H_2O$); Asbestos [$CaMg_3(SiO_3)_4$]

(iii) ***Calcium***: Limestone ($CaCO_3$); Gypsum : ($CaSO_4.2H_2O$), Anhydrite ($CaSO_4$); Fluorapatite [($3Ca_3(PO_4)_2.CaF_2$)] Phosphorite rock [$Ca_3(PO_4)_2$]

(iv) ***Barium***: Barytes ($BaSO_4$) ; witherite ($BaCO_3$)

(v) ***Radium***: Pitch blende (U_3O_8); (*Ra* in traces); other radium rich minerals are carnotite [K_2UO_2)] $(VO_4)_2\ 8H_2O$ and antamite [$Ca(UO_2)_2$]

Extraction of alkaline earth metals

(i) *Be* and *Mg* are obtained by reducing their oxides carbon,

$$BeO + C \rightarrow Be + CO \ ; \ MgO + C \rightarrow Mg + CO$$

Physical state: All are greyish-white, light, malleable and ductile metals with metallic lustre. Their hardness progressively decrease with increase in atomic number. Although these are fairly soft but relatively harder than alkali metals.

Atomic and ionic radii

(i) The atomic and ionic radii of alkaline earth metals also increase down the group due to progressive addition of new energy shells like alkali metals.

	Be	*Mg*	*Ca*	*Sr*	*Ba*	*Ra*
Atomic radius (pm)	112	160	197	215	222	–
Ionic radius of M^{2+} ion (pm)	31	65	99	113	135	140

Density

(i) Density decreases slightly upto *Ca* after which it increases. The decrease in density from *Be* to *Ca* might be due to less packing of atoms in solid lattice of *Mg* and *Ca*.

Be	*Mg*	*Ca*	*Sr*	*Ba*	*Ra*
1.84	1.74	1.55	2.54	3.75	6.00

Melting point and Boiling point

(i) Melting points and boiling points of alkaline earth metals do not show any regular trend.

	Be	*Mg*	*Ca*	*Sr*	*Ba*	*Ra*
melting points (K)	1560	920	1112	1041	1000	973
Boiling point (K)	2770	1378	1767	1654	1413	–

Ionisation Energy and electropositive or metallic character

Since, the atomic size decreases along the period and the nuclear charge increases and thus the electrons are more tightly held towards nucleus. It is therefore alkaline earth metals have higher ionisation energy in comparison to alkali metals but lower ionisation energies in comparison to p-block elements.

Oxidation number and valency

The IE_1 of these metals are much lower than IE_1 and thus it appears that these metals should form univalent ion rather than divalent ions but in actual practice, all these give bivalent ions.

Hydration of ions

The hydration energies of alkaline earth metals divalent cation are much more than the hydration energy of monovalent cation.

Mg^{+}

Mg^{2+}

Hydration energy or Heat of hydration ($kJ\ mol^{-1}$) 353 1906

Electronegativities

The electronegativities of alkaline earth metals are also small but are higher than alkali metals.

Characteristic flame colours

The characteristic flame colour shown are: *Ca* - brick red; *Sr* –crimson; *Ba*-apple green and *Ra*- crimson.

Chemical Properties

Formation of oxides and hydroxides

(i) The elements (except *Ba* and *Ra*) when burnt in air give oxides of ionic nature $M^{2+}O^{2-}$ which are crystalline in nature. *Ba* and *Ra* however give peroxide. The tendency to form higher oxides increases from *Be* to *Ra*.

$2M + O_2 \rightarrow 2MO$ (*M* is *Be*, *Mg* or *Ca*)

$2M + O_2 \rightarrow MO_2$ (*M* is *Ba* or *Sr*)

Hydrides

(i) Except *Be*, all alkaline earth metals form hydrides (MH_2) on heating directly with H_2 .

$$M + H_2 \rightarrow MH_2.$$

Carbonates and Bicarbonates

All these metal carbonates (MCO_3) are insoluble in neutral medium but soluble in acid medium. These are precipitated by the addition of alkali metal or ammonium carbonate solution to the solution of these metals.

Halides

The alkaline earth metals combine directly with halogens at appropriate temperatures forming halides, MX_2. These halides can also be prepared by the action of halogen acids (HX) on metals, metal oxides, hydroxides and carbonates.

Solubility in liquid ammonia:

Like alkali metals, alkaline earth metals also dissolve in liquid ammonia to form coloured solutions When such a solution is evaporated, hexammoniate, $M(NH_3)_6$ is formed.

Nitrides

All the alkaline earth metals direct combine with N_2 give nitrides, M_3N_2.

Sulphates

All these form sulphate of the type $M\ SO_4$ by the action of $H_2\ SO_4$ on metals, their oxides, carbonates or hydroxides.

Nitrates: Nitrates of these metals are soluble in water On heating they decompose into their corresponding oxides with evolution of a mixture of nitrogen dioxide and oxygen.

$$M(NO_3)_2 \rightarrow MO + 2NO_2 + \left(\frac{1}{2}\right)O_2$$