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Chapter 10

S Block Elements

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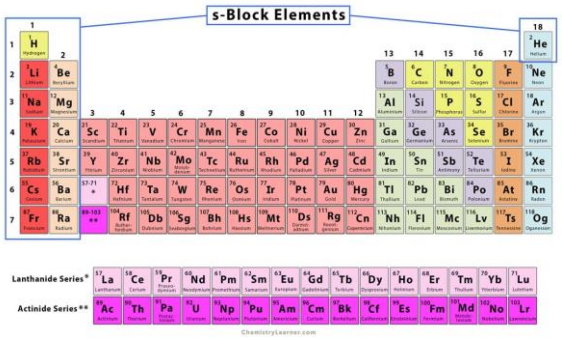
Introduction - The elements in the long form of the periodic table have been divided into four blocks **s**, **p, d** and **f-** block elements. This classification is based on the type of the atomic orbital in which the outermost electron is located. The s orbital can accommodate a maximum of Two electrons, Thus there are two groups of s - block elements Groups 1 and 2 whose electronic configurations are represented as [Noble gas] ns1 and [Noble gas] ns2 respectively.

- The s - block elements are located on the left of the periodic table and comprise of highly reactive metals.
- The last electron enters the S sub-shell.
- All the elements in this block are metals except hydrogen and helium.
- Except for **lithium** and **magnesium,** these do not form complexes ions and their melting and boiling points are very low.
- All these metals are very soft.
- Due to low ionization energy, their electrons get excited easily and they display different colours.

  Example - Li- **Red**, Na-**Yellow**, Ba-**Green** etc.

- he s block elements of the periodic table are shown in the diagram of the periodic table given below.
- S-block contains **12** elements, namely Lithium (**Li**), Sodium (**Na**), Potassium (**K**), Rubidium (**Rb**), Caesium (**Cs**), Francium (**Fr**), Beryllium (**Be**), Magnesium (**Mg**), Calcium (**Ca**), Strontium (**Sr**), Barium (**Ba**), and Radium (**Ra**).
- S block elements include **Group 1** and **Group 2** elements. Group 1 elements have only one electron in their outermost s orbital and are all called Alkali Metals. Group 2 elements have two electrons in their outermost s orbital and are all called Alkaline earth metals.
- Both groups contain **six-six** elements.



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~Group - IA Alkali Metals~

- Group 1 elements include Lithium (**Li**) Sodium (**Na**) Potassium (**K**) Rubedium (**Rb**) Cesuim (**Cs**) and Francium (**Fr**).
- These are collectively known as alkali metals because they react with water to form strongly alkaline hydroxides.

  Example - LiOH, NaOH, KOH, RbOH, CsOH and FrOH.
- The general electronic configuration of the elements of first group (noble gases) is ns1 and the valence shell electronic configuration is ns1.
- Alkali metals are highly reactive and hence they are not found in free state. Na and K are found in abundance in nature in the form of ores. **Francium (Fr)** is rarely found because it is a radioactive element.
- The electronic configurations of the elements included in group one of s block elements are shown below

Atomic number	Symbol	Electronic configuration
3	Li	$1s^2 2s^1$ (or) [He]$2s^1$
11	Na	$1s^2 2s^2 2p^6 3s^1$(or) [Ne]$3s^1$
19	K	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$(or) [Ar]$4s^1$
37	Rb	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 5s^1$(or) [Kr]$5s^1$
55	Cs	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s^1$(or) [Xe]$6s^1$
87	Fr	[Rn]$7s^1$

1. Atomic and Ionic Radius of Alkali Metals - The atomic radius (size) of alkali metals is the largest in any period of the periodic table. The size of their monovalent ion (M+) is smaller than the size of its parent atom. The atomic and ionic radii of alkali metals increase from top to bottom in the group i.e. their size increases from Li to Cs because the number of shells increases.

2. Ionisation Enthalpy - The ionization enthalpy of alkali metals is very low, so they easily lose an electron and attain noble gas configuration. The value of ionization enthalpy decreases as we move down the group from **lithium** to **Cesuim** because the effect of increasing atomic size is greater than that of increasing nuclear charge and the shielding effect also increases. The value of ionization enthalpy of alkali metals is lowest in their period.

3. Hydration Enthalpy -The energy released when a water molecule is added around an ion is called hydration energy. Hydration energy is inversely proportional to ionic radius. In alkali metals, ionic radius increases down the group and hence the value of hydration enthalpy decreases. Therefore, the hydration enthalpy of these ions decreases order –

$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

Due to the smallest size of Li+, its hydration energy is maximum, hence most of the lithium salts are hydrated such as - **$LiCl.2H_2O$**

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Physical Properties of Alkali Metals ~

1. Alkali metals are soft and silvery white. The reason for their softness is that they have weak metallic bonding. On moving from top to bottom in a group, the metallic bonding becomes weaker as the atomic size increases. Therefore, the softness of alkali metals increases, so **Na, K** etc. can be cut only with a knife.
2. Due to the large size of alkali metals, their density is low, hence they are light The value of density decreases as we go down the group because mass

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increases more than volume but the density of K is less than that of Na because K has 8 electrons in its third shell Whereas its capacity is of 18 electrons (2n^2), hence the electrons get spread out and the volume increases more than the mass, hence the order of density of elements of group 1 is - **Li < K < Na < Rb < Cs**

3. **Density -** Alkali metals density are the least abundant among all the metals. **Li, Na**, and **K** have densities less than water. The elements of I A group have lower density as compared to the elements of II A group Because the elements of group II A are smaller in size and have greater mass than those of group I A. But due to the larger atomic size of **K**, its density is less than **Na**.

4. **Melting&Boiling point** - Alkali metals have low melting and boiling points because they have only one electron in their valence shell Therefore the metallic bond between atoms is weak. The strength of metallic bond decreases as we move from top to bottom in a group due to increase in atomic size, hence the values of their melting point and boiling point also decrease.

5. **Metallic Character -** All the elements of the first group are metals. They easily lose their **S electrons** present in their outermost shell. Hence, they are highly electro-rich and reactive elements. The value of ionization enthalpy decreases as we move from top to bottom in a group **(except hydrogen)**, hence their metallic properties **(electro-rich properties)** and reactivity increase.

6. **Oxidation State -** All alkali metals form monovalent cations **(M+)** because they lose one electron to attain stable configuration like noble gases.

7. **Colourless and Diamagnetic -** All alkali metal cations **(M+)** have noble gas configuration and all electrons are paired, so they are colorless and diamagnetic.

8. **Photo - Electric Effect -** The emission of electrons when light falls on the surface of alkali metal is called photoelectric effect and the emitted electrons are called photo electrons. Among the alkali metals, the ionization enthalpy of **K** and **Cs** is very low. They show photoelectric effect.

9. **Flame Test -** Alkali metals and their salts give special colour to the oxidizing flame because the heat of the flame excites their outer electrons to higher energy levels. When this electron returns to its ground state, it emits radiation in the visible region, giving colour to the flame. which is different for different metals.Therefore, alkali metals can be identified by their flame test and their concentration can be determined by flame photometry or atomic absorption spectroscopy.

Metal	Li	Na	K	Rb	Cs
Colour	Crimson red	Yellow	Violet	Red violet	Blue
λ/nm	670.8	589.2	766.5	780.0	455.5

10. **Standard Electrode Potential -** The standard electrode potential of alkali metals is highly negative and hence they are strong reducing agents. Based on ionization enthalpy, lithium should have the lowest reducing property but

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in reality **lithium** is the strongest reducing agent because its standard electrode potential is the most negative. This is because of the small size of **Li+** due to which its hydration enthalpy is very high.

Electrode potential = Hydration enthalpy - (Ionization enthalpy + Sublimation Enthalpy)

Therefore, the order of reducing properties of alkali metals is as follows

Na < K < Rb < Cs < Li

Table : Atomic and Physical properties of the alkali metals ~

Property	Lithium Li	Sodium Na	Potassium K	Rubidium Rb	Caesium Cs	Francium Fr
Atomic number	3	11	19	37	55	87
Atomic mass (g mol^{-1})	6.94	22.99	39.10	85.47	132.91	(223)
Electronic configuration	[He] $2s^1$	[Ne] $3s^1$	[Ar] $4s^1$	[Kr] $5s^1$	[Xe] $6s^1$	[Rn] $7s^1$
Ionization enthalpy / kJ mol^{-1}	520	496	419	403	376	~375
Hydration enthalpy/kJ mol^{-1}	–506	–406	–330	–310	–276	–
Metallic radius / pm	152	186	227	248	265	–
Ionic radius M^+ / pm	76	102	138	152	167	(180)
m.p. / K	454	371	336	312	302	–
b.p / K	1615	1156	1032	961	944	–
Density / g cm^{-3}	0.53	0.97	0.86	1.53	1.90	–
Standard potentials $E^{\ominus}$/ V for (M^+ / M)	–3.04	–2.714	–2.925	–2.930	–2.927	–
Occurrence in lithosphere†	18*	2.27**	1.84**	78-12*	2-6*	~ 10^{-18} *

***ppm (part per million). **percentage by weight: Lithosphere: The Earth's outer layer: its crust and part of the upper mantle**