CHEMICAL PROPERTIES OF

GROUPS 1A AND IIA

REACTIVITY OF GROUPS IA AND IIA

Generally Groups IA and IIA metals are very reactive

WHY?

This is due to their high electropositivity

Explanation

The reactivity of a metal is measured by how easily its atom loses its valence electron(s) to achieve a **stable noble gas electron arrangement.**

The **easier** a metal atom **releases its valence electron the more its electropositivity and** the **more reactive** the metal.

TREND IN CHEMICAL REACTIVITY OF GROUPS IA AND IIA

(1) Although metals in each Group exhibit similar chemical properties, they **differ** in **reactivity going down the each group.**

HOW ?

The **reactivity** of alkali metals or alkaline earth metals **increases** down the respective group.

Group IA: **Li< Na<K< Rb < Cs < Fr**

Group IIA: **Be< Mg< Ca< Sr< Ba< Ra**

[This is because electropositivity (ease of losing valence electron) increases down the group]

(2) Group IA metals are more reactive than the corresponding Group IIA metal (same period on the periodic table)

[This is because Group 1A metals are more electropositive (lose valence electron more easily) than their counterpart in Group IIA]

Group IA		Group IA
Li	>	Be
Na	>	Mg
K	>	Ca
Rb	>	Sr
Cs	>	Ba

CHEMICAL REACTIONS OF GROUP IA

Reaction with air

Alkali metal tarnishes rapidly on exposure to air due to formation of oxide at their surfaces. Thus they are kept or preserved under hydrocarbon solvent e.g. kerosene.

- When burnt in oxygen, Li form Lithium oxide (normal oxide) Sodium form peroxide and others form superoxide

$$4Li + O_2 \longrightarrow 2Li_2O$$

$$2Na + O_2 \longrightarrow Na_2O_2$$

$$M + O_2 \longrightarrow MO_2 \quad M=K, Rb, \& Cs$$

$$K + O_2 \longrightarrow KO_2$$

- *The tendency of group IA to form oxygen-rich compound increases down the group because cation radius which helps it in accommodating more oxygen atom increases down the group*
- **Note:** Li burns in air/oxygen to produce Li_2O and little trace of Li_2O_2(peroxide). Na produces Na_2O_2 with a little trace of NaO_2(superoxide).

Reaction with water

Alkali metals react with water to form metal hydroxide and librate hydrogen.

$$2M + 2H_2O \longrightarrow 2MOH + H_2$$

$$2Na + 2H_2O \longrightarrow 2NaOH + H_2$$

[These metal hydroxides are strong bases and dissolve very well in water]

TREND

- They react with water with increasing vigor as we move down the group

  Li- reacts quietly

  Na reacts vigorously

  K reacts very vigorously

  Rb & Cs react with exceptional violence

Reaction with Acids

Alkali metals react with strong acids (HCl , HNO_3 , H_2SO_4) to produce relevant alkali metal salt and librate hydrogen gas.

$$\mathbf{2Na + 2HCl = 2NaCl + H_2}$$

$$\mathbf{2K + H_2SO_4 = K_2SO_4 + H_2}$$

- **Reaction with Halogen**
- Alkali metals react with halogen to form alkali metal halides.
- $2M + X_2 \longrightarrow 2MX$

- **Reaction with Nitrogen**

Only Li reacts with nitrogen i.e.

- $6Li + N_2 \longrightarrow 2Li_3N$

(Lithium shares this nature with GROUP IIA metals)

Reaction with Hydrogen

Alkali metals react with hydrogen to form Metal hydrides (MH) e.g.

$$2Na + H_2 = 2NaH$$

USES

LITHIUM

1. Production of low density aluminum alloy for aircraft construction.
2. Use in metallurgical process as a scavenger (remover of impurities) i.e refining of metals like Fe, Ni, and Zn.
3. It is used in organic synthesis
4. Lithium compound is used as catalyst in synthetic rubber manufacture.

SODIUM

1. Na is used as a strong reducing agent i.e. in the production of titanium and Zirconium from their coonhounds
2. Na is used in making Na light used in the high ways becomes its yellow light can penetrate fug very well
3. It is used in the production of synthetic rubber
4. Na is used to cool fuel in nuclear reactor because of its low melting and high conductivity
5. Sodium-lead alloy is used to make tetra ethyl lead which is added to petrol as an antiknock agent.

POTASIUM

The metal itself is not of much use but can be to prepare compound like KO_2 and alloy i.e NaK

1. Potassium superoxide (KO_2) is used in space capsule, submarine and in some types of self-contained breeding equipment because it absorbed exhaled CO_2 and moisture to release O_2 in the mask

$$4K + 2H_2O \longrightarrow 4KOH + 3O_2$$

$$KOH + CO_2 \longrightarrow KHCO_3(s)$$

2. Alloy of Potassium with sodium NaK) is used as a heat-transfer medium in nuclear reactor

Rubidium and Cesium

1. Both Rb and Cs used in photoelectric cells (devices for converting light signal to electric signal)
2. Rb is used as oxygen removal in vacuum tubes
3. Cs is in atomic clocks

CHEMICAL REACTIONS OF GROUP IIA

REMINDER: **A**lkaline earth metals are very reactive but less reactive than the corresponding alkali metals.

- Due to the extremely small size of Be, it has a unique chemical behaviour different from the other members of the group. Its compounds are more of covalent nature.
- Magnesium compound are both ionic and covalent in nature
- The rest in the group(**Ca, Sr and Ba)** have ionic nature compounds.

Some important chemical properties of Group IIA

Reaction with air

- All Group IIA metals reacts with oxygen to form oxides at room temperature except Be.

$2M + O_2 \longrightarrow 2MO$ e.g.

$2Ca + O_2 \longrightarrow 2CaO$

Trend

- Oxides are formed only on the surface of magnesium and calcium
- $2Mg + O_2 \longrightarrow 2MgO$

- But Ba reacts vigorously with air such that it must be stored under oil

Sr and Ba form peroxide (MO_2) on prolong heating, particularly if pressure is used.

Reaction with water

- Be does not react with water

- Mg reacts with boiling water to form oxide

$$Mg + H_2O \longrightarrow MgO + H_2$$

Ca, Sr, and Ba react readily

$$M + H_2O \longrightarrow M(OH)_2 + H_2$$

M = Ca, Sr and Ba

Reaction with acids

- All alkaline earth metals react with dilute acids to liberate H_2 but **Be reacts very slowly**

- $M + 2HCl \longrightarrow MCl_2 + H_2$

M = all alkaline earth metal

Reaction with halogen

- All react with halogen at elevated temperatures

$M + X_2 \longrightarrow MX_2$

- BeX are covalent in nature
- Other MX are ionic and soluble in water

Reaction with Hydrogen

- Ca, Sr and Ba react with H_2 at elevated temperature to form hydride
- $Ca + H_2 \longrightarrow CaH_2$

Reaction with nitrogen

- All react with N_2 at elevated temperature to form nitride
- e.g $3Mg + N_2\ (s) \longrightarrow Mg_3N_2$

Reaction with CO_2

- Mg, reduces CO_2
- $2Mg + CO_2 \longrightarrow 2MgO + C$
- Thus Mg fire can not be put off by CO_2

Uses

Be

- X-ray window
- Scavenger in alloys

Mg

- Use in making light weight alloy because of its lightness
- use in making photographic flash light and other fire works- Mg metal burns with a brilliant white light in oxygen
- Use in man for metabolic processes

Ca

- use in making alloy
- Use as reducing agent in the production of metals i.e.Cr, Zn, Th, Au
- Use in the removal of O2 and N2 from electronic tubes

Sr

Of little commercial demand since Ba and Ca are readily available to fulfill the same purpose

Ba

Use as scavenger of removal of gases in electronic vacuum tubes

Anomalous behaviour of Beryllium

Beryllium has more covalent nature due to its smallest size, Highest ionization energy, high electropositive nature and strongest polarizing nature. Because of these, **Beryllium differs from other alkaline earth metal properties.**

1. It is the hardest metal among alkaline earth metals
2. Melting and boiling point of beryllium is **maximum**.
3. It does not react with atmospheric oxygen.
4. Beryllium nitride is volatile.
5. Does not react with water even at red hot conditions.
6. It does not react directly with hydrogen to form hydride.
7. Unlike other alkaline earth metals, **does not liberate hydrogen** from acid because of higher electrode potential. Concentrate nitric acid form a coating of oxide, which makes it passive.
8. Beryllium oxide and hydroxide are amphoteric. Dissolves in acids to form salts and in bases to form beryllate.
9. Beryllium **forms carbide of a different formula** and **yields methane** and not acetylene like other metal on reaction with water.

Diagonal Relationship of Beryllium with Aluminium

Beryllium of group two resembles more with Aluminum of group three because their atomic sizes are similar. This relationship is referred to as **diagonal relationship**

Both beryllium and aluminium occur together in the mineral, “Beryl” $3BeO\ Al_2O_3\ 6SiO_2$

1. Both of them do not react with atmospheric oxygen and nitrogen.
2. Both of them do not react with water even at high temperatures.
3. They do not liberate hydrogen from acid. On treatment with concentrated nitric acid, they become passive.
4. Water hydrolyzes both nitrides liberate ammonia.
5. Oxides and hydroxides of Be and Al are amphoteric. So, they react with acid as well base.
6. Both form carbide, that on hydrolysis yields Methane.
7. Carbonates of beryllium and Aluminum are unstable.