CHEMICAL FAMILES

The number of valence electrons and the number of occupied energy levels in

an atom of an element determine the position of an element in the periodic

table.i.e

The number of occupied energy levels determine the Period and the valence

electrons determine the Group.Elements with the same number of electrons in the outermost energy level belong to the same group. Electrons in the outermost energy level of an atom is what is called valence electrons.

Elements in the same group have similar physical and chemical properties. The

trends in physical and chemical properties of elements in the same group vary

down the group. Elements in the same group thus constitute a chemical family.

Alkali metals **(**Group I elements)

Group I elements are called ***Alkali metals*** except Hydrogen which is a non metal. The alkali metals include:Lithium,sodium,rubidium,caesium and francium. The properties of the first 3 members of the family are discussed in this chapter.

Element	Symbol	Atomic no.	Electron arrangement	Atomic radius(nm)	Ionic radius(nm)
Lithium	L	3	2.1	0.133	0.060
Sodium	Na	11	2.8.1	0.157	0.095
Potassium	K	19	2.8.8.1	0.203	0.133

-All alkali metals have one electron in the outer energy level. They are therefore

Monovalent. They donate /lose the outer electron to have oxidation state of 1.

The number of energy levels increases down the group from Lithium to Francium. The more the number of energy levels the bigger/larger the atomic size. e.g. The atomic size of Potassium is bigger/larger than that of sodium because Potassium has more/4 energy levels than sodium (3 energy levels).

Atomic and ionic radius The distance between the centre of the nucleus of an atom and the outermost energy level occupied by electron/s is called atomic radius. Atomic radius is measured in nanometers(nm).The higher /bigger the atomic radius the bigger /larger the atomic size.

The distance between the centre of the nucleus of an ion and the outermost energy level occupied by electron/s is called ionic radius..The higher /bigger the ionic radius the bigger /larger the size of the ion. Atomic radius and ionic radius depend on the number of energy levels occupied by electrons. The more the number of energy levels the bigger/larger the atomic /ionic radius. e.g. The atomic radius of potassium is bigger/larger than that of sodium because potassium has more 4energy levels while sodium has 3 energy levels.

Atomic radius and ionic radius of alkali metals increase down the group as the number of energy levels increases.

The atomic radius of alkali metals is bigger than the ionic radius. This is because alkali metals react by losing/donating the outer electron and hence lose the outer energy level.

The atomic radius of sodium is 0.157nM .The ionic radius of Na ion is 0.095nM. This is because sodium reacts by donating/losing the outer electrons and hence the outer energy level. The remaining electrons/energy levels experience more effective / greater nuclear attraction/pull towards the nucleus reducing the ionic radius.

The ease of donating/losing electrons is called electropositivity. All alkali metals are electropositive. Electropositivity increase as atomic radius increase. This is because the effective nuclear attraction on outer electrons decreases with increase in atomic radius. The outer electrons experience less nuclear attraction and can be lost/ donated easily/with ease.

The minimum amount of energy required to remove an electron from an atom of element in its gaseous state is called its first ionisation energy The SI unit of ionization energy is kilojoules per mole.

.Ionization energy depend on atomic radius. The higher the atomic radius, the less effective the nuclear attraction on outer electrons/energy level and thus the lower the ionization energy.

For alkali metals, the 1st ionization energy decrease down the group as the atomic radius increase and the effective nuclear attraction on outer energy level electrons decrease.

e.g. The 1st ionization energy of sodium is 496 kJ/mole while that of potassium

is 419 kJ/mole

.This is because atomic radius increase and thus effective nuclear attraction on outer energy level electrons decrease down the group from sodium to Potassium. It requires the less energy to donate/lose outer electrons in Potassium than in sodium.

Physical properties

1.Soft/Easy to cut: Alkali metals are soft and easy to cut with a knife. The

softness and ease of cutting increase down the group from Lithium to potassium.

This is because an increase in atomic radius leads to decreases in the strength of metallic

bond and the packing of the metallic structure

2.Appearance: Alkali metals have a shiny grey metallic lustre when freshly cut.

The surface rapidly/quickly tarnishes on exposure to air. This is because the

metal surface rapidly/quickly reacts with elements of air/oxygen.

3.Melting and boiling points: Alkali metals have relatively low melting and boiling points as compared to common metals like Iron. This is because alkali metals use only one delocalized electron to form a weak metallic bond/structure.

4.Electrical/thermal conductivity: Alkali metals are good thermal and electrical

conductors. Metals conduct using the outer mobile/ delocalized electrons. The

delocalized electrons move randomly within the metallic structure.

Chemical properties

(i)Reaction with air/oxygen

On exposure to air, alkali metals reacts with the elements in the air.

Example

On exposure to air, Sodium first reacts with Oxygen to form sodium oxide.

$4Na(s) + O2(g) \longrightarrow 2Na2O(s)$

The sodium oxide formed further reacts with water/moisture in the air to form sodium hydroxide solution.

$Na2O(s) + H2O(l) \rightarrow 2NaOH(aq)$

Sodium hydroxide solution reacts with carbon(IV)oxide in the air to form sodium carbonate.

$2NaOH(aq) + CO_2(g) \rightarrow Na_2CO_3(g) + H2O(l)$

(ii)Burning in air/oxygen

Lithium burns in air with a **crimson**/deep red flame to form Lithium oxide

$4Li (s) + O_2(g) \rightarrow 2Li_2O(s)$

Sodium burns in air with a yellow flame to form sodium oxide

$4Na (s) + O_2(g) \rightarrow 2Na_2O(s)$

Sodium burns in oxygen with a golden yellow flame to form sodium peroxide

$2Na (s) + O_2(g) \rightarrow Na_2O_2 (s)$

Potassium burns in air with a lilac/purple flame to form potassium oxide

(iii) Reaction with water:

Experiment

-Measure 500 cm3 of water into a beaker.

-Put three drops of phenolphthalein indicator.

-Put about 0.5g of Lithium metal into the beaker.

-Determine the pH of final product

-Repeat the experiment using about 0.1 g of Sodium

Expected observations

-Lithium Metal floats on water

-rapid effervescence/fizzing/bubbling

-colourless gas produced (that extinguishes burning splint with explosion /“pop” sound)

-resulting solution turn phenolphthalein indicator pink

-pH of solution = 13

conclusion

-Lithium is Moderately vigorous

Sodium -

- floats on water

-darts on water surface producing a hissing sound(colourless gas produced that extinguishes a burning splint with explosion /“pop” sound)

-resulting solution turn phenolphthalein indicator pink

-pH of solution = 14

conclusion

-Reaction of Sodium and water is Very vigorous

NB The reaction of potassium with water is explosive and should not be tried.

Explanation

Alkali metals are less dense than water. They therefore float on water.They react with water to form a strongly alkaline solution(hydroxide) and produces hydrogen gas. The rate of this reaction increase down the group. i.e. Potassium is more reactive than sodium .Sodium is more reactive than Lithium. The reactivity increases as electropositivity increases of the alkali increases. This is because as the atomic radius increases , the ease of donating/losing outer electron increase during chemical reactions.

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(iv) Reaction with chlorine:

Experiment

Cut about 0.5g of sodium and place it on a deflagrating spoon with a lid cover. Warm it on a Bunsen flame until it catches fire. Quickly and carefully lower it into a gas jar containing dry chlorine to cover the gas jar.

Repeat with about 0.5g of Lithium.

Caution: This experiment should be done in fume chamber or in the open because chlorine gas is poisonous /toxic.

Observations

Sodium metal continues to burn in chlorine gas with a yellow flame forming white solid/fumes.

Lithium metal continues to burn with a crimson flame forming white solid / fumes.

NB Alkali metal react with chlorine gas to form the corresponding metal chlorides.

The reactivity increase as electropositivity increase down the group from

Lithium to Francium.The ease of donating/losing the outer electrons increase as

the atomic radius increase and the outer electron is less attracted to the nucleus.

Reactivity increase down the group

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Uses of alkali metals and their compounds

(i)Sodium is used in making sodium cyanide for extracting gold from gold ore.

(ii)Sodium chloride is used in seasoning food.

(iii)Molten mixture of sodium and potassium is used as coolant in nuclear reactors.

(iv)Sodium is used in making sodium hydroxide used in making soapy and soapless detergents.

(v)Sodium is used as a reducing agent for the extraction of titanium from Titanium(IV)chloride.

(vi)Lithium is used in making special high strength glasses

(vii)Lithium compounds are used to make dry cells in mobile phones and laptops.