COMPOUNDS OF SODIUM AND POTASSIUM

Compounds of Sodium

Due to its pronounced reactivity with other elements, sodium engages in the formation of numerous valuable compounds, all classified as sodium compounds. When reacting with various metals, sodium generates compounds including nitrate, sulfate, halides, carboxylates, and carbonates.

1. Sodium (NA), Natrium

(a) Extraction: Down's Process

By Electrolysis of fused $NaCl + CaCl_2 + NaF$

At cathode (Iron Vessel): $Na^+e^- \rightarrow Na(s)$

At Anode (Graphite): $2Cl^- \rightarrow Cl_2 + 2e^-$

(i) A mixture of ($CaCl_2 + NaF$) is employed to reduce the melting point of NaCl from 800°C to approximately 600°C.

(ii) Electrolysis of aqueous sodium chloride is unsuitable for sodium production, as it would result in the liberation of hydrogen gas at the cathode instead of metallic sodium.

(b) Properties

(i) It possesses a crystalline, malleable structure.

(ii) Due to its high reactivity, it is typically stored in kerosene.

(iii) Sodium dissolves in liquid ammonia to form a blue solution.

(c) Uses

(i) Utilized in the production of sodium amalgam, commonly used as a reducing agent.

(ii) Applied in sodium vapor lamps, which emit a single, yellow-colored wavelength of light.

(iii) Employed as a heat transfer medium within nuclear reactors.

Compounds are basic molecular structures composed of two or more elements. By examining either the name or the chemical formula, it becomes possible to identify the constituent elements within the compound. Sodium oxide serves as an illustrative example of such compounds.

2. Sodium Oxide (Na_2O)

Sodium oxide, characterized by its high insolubility and thermal stability, serves as a valuable source of sodium, particularly in optic, glass, and ceramic applications. Compounds undergoing oxidation often exhibit electrical conductivity, but exceptions exist in the form of certain perovskite structures of oxides that demonstrate electronic conductivity. This unique property positions sodium oxide for applications in cathodes of oxidized solid fuel cells and oxygen generation systems. Essentially, sodium oxide represents a compound containing at least one O2 anion and one metallic cation.

Preparation:

$$2NaNO_3 + 10Na \xrightarrow{\Delta} 6Na_2O + N_2$$

$$2NaNO_2 + 6Na \xrightarrow{\Delta} 4Na_2O + N_2$$

$$3NaN_3 + NaNO_2 \xrightarrow{\Delta} 2Na_2O + 5\,N_2$$

$$Na_2O_2 + 2Na \xrightarrow{\Delta} 2Na_2O$$

Properties:

(i) Sodium oxide is an ionic solid characterized by a colorless appearance.

(ii) The aqueous solution of sodium oxide exhibits strong basic properties, as depicted by the reaction:

$$Na_2O + H_2O \rightarrow 2NaOH$$

(iii) Sodium oxide undergoes a disproportionation reaction at 400°C, leading to the formation of sodium peroxide and sodium:

$$2Na_2O \xrightarrow{400°C} Na_2O_2 + 2Na$$

(iv) Sodium oxide, when reacting with liquid ammonia, produces sodamide:

$$Na_2O + NH_3 \rightarrow NaNH_2 + NaOH$$

3. Sodium Chloride NaCl

(a) Occurrence: Sea water is the main source and also found in salt lakes.

(b) Preparation

It is commonly known as common salt and is found abundantly in nature as rock salt or halite. The primary source with the highest abundance is seawater, where sodium chloride is present in the range of 2.6 to 2.9 percent. The process involves exposing seawater to sunlight and air in large shallow pits. Gradual evaporation of the water results in the formation of salt crystals. To purify it, the salt is dissolved in a minimal amount of water and, if necessary, filtered to eliminate insoluble impurities. The solution is then saturated with a dry hydrogen chloride gas, leading to the formation of pure sodium chloride crystals.

(i) Sea water NaCl (2.7 – 2.9%) $\xrightarrow[\text{By solar heat}]{\text{Evaporation}}$ crude NaCl

(ii) It contains impurities – Na_2SO_4, $MgCl_2$, $CaCl_2$ etc.

(iii) Insoluble impurities removed by filtration.

(iv) Filtrate $\xrightarrow{\text{HClgaspassed}}$ Pure NaCl precipitation (Common ion effect)

$$HCl \rightleftharpoons H^- + Cl^- NaCl \rightleftharpoons Na^+ + Cl^-$$

Ionic product of $[Na^+]$ [Cl–] > solubility product of NaCl hence it precipitates out.

(v) $MgCl_2$ and $CaCl_2$ are more soluble in water so left in solution.

(c) Properties

(i) Common table salt displays slight hygroscopic properties as a result of trace amounts of magnesium and calcium chlorides.

(ii) Interaction with $AgNO_3$ (silver nitrate).

$$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl \text{ (white ppt.)}$$

Reaction with $K_2Cr_2O_7$ + conc. H_2SO_4

(iii) $4NaCl + K_2Cr_2O7 + 5H_2SO_4 \xrightarrow{\triangle} 4NaHSO_4 + K_2SO_4 + 2CrO_2Cl_2 + 3H_2O$ (Orange red)

(iv) NaCl is a colorless crystalline salt with almost no solubility in alcohol, but it is highly soluble in water.

(v) When heated with concentrated sulfuric acid, NaCl produces HCl along with sodium sulfate.

$$NaCl + H_2So_4 \rightarrow NaHSO_4 + HCl \uparrow$$

$$NaHSO_4 + NaCl \rightarrow Na_2SO_4 + HCl \uparrow$$

$$2NaCl + MnO_2 + 2H_2SO_4 \rightarrow MnSO_4 + Na_2SO_4 + 2H_2O + Cl_2 \uparrow$$

(d) Uses

(i) Used as a preservative for pickles, meat, and fish.

(ii) Employed in the preparation of freezing mixtures with ice.

4. Sodium Hydroxide (NaOH), Caustic Soda

(a) Production Method: Through the electrolysis of sodium chloride (NaCl).

(b) Nelson Cell or Diaphragm Cell: The following chemical transformations occur

$$\left.\begin{array}{ll} NaCl(aq.) & \rightleftharpoons Na^+ + Cl^- \\ H_2O & \rightleftharpoons H^+ + OH^+ \end{array}\right\} \rightarrow NaoH + H_2 + Cl_2$$

At cathode (Perforated steel): $2H^+ + 2e^- \rightarrow H_2(g)$

At anode (Carbon): $2Cl - (aq.) \rightarrow Cl_2(g) + 2e^-$

(c) Costner – Keller Cell: (Hg – Cathode Process)

Electrolyte (Brine) $NaCl \rightleftharpoons Na^+ + Cl^-$

On electrolysis –

At Cathode (Hg)

$Na^+ + e^- \rightarrow Na.$ And $Na + Hg \rightarrow Na.Hg$ (amalgam)

At anode (Graphite)

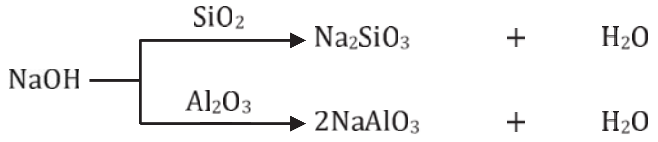
$2Cl- \rightarrow Cl_2(g) + 2e^-$ And $2Na.Hg + 2H_2O \rightarrow 2NaOH + H_2 + 2Hg$

(d) Properties

(i) This is a white crystalline solid with deliquescent properties.

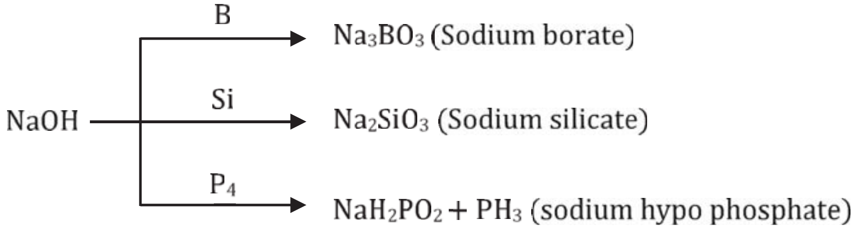
(ii) It has the capability to absorb carbon dioxide (CO_2) from the atmosphere, resulting in the formation of sodium carbonate (Na_2CO_3).

(iii) NaOH is strong base

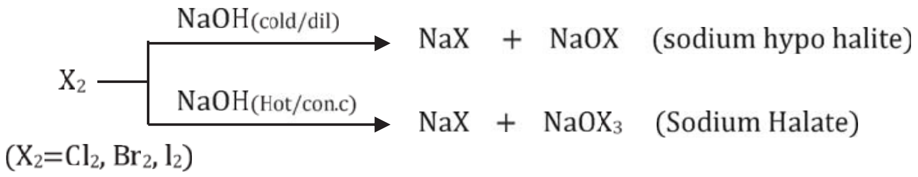


(iv) Reaction with non-metals:

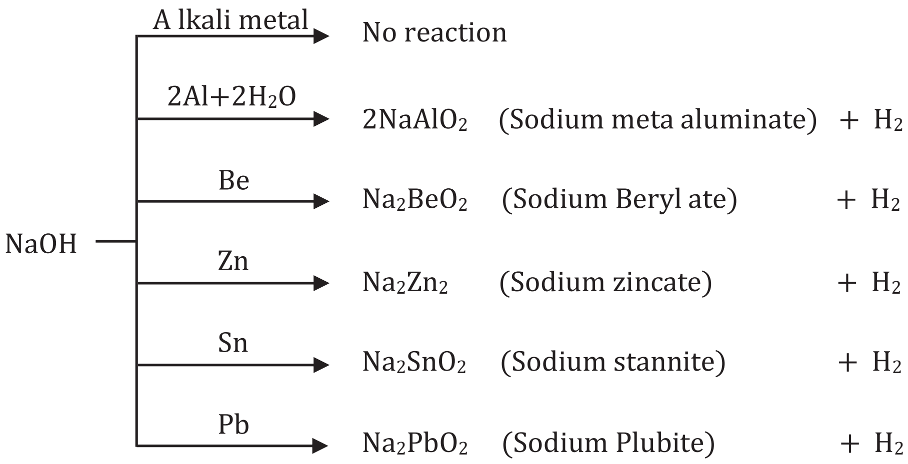
No reaction with H_2, N_2 and C



(v) Reaction with halogens



(vi) Reaction with Metal



(vii) Reaction with $ZnCl_2$ or $ZnSO_4$

$$ZnCl_2 + 2NaOH \rightarrow Zn(OH)_2 + 2NaCl$$

$$Zn(OH) + NaOH \longrightarrow \underset{\text{(Soluble comlex)}}{Na_2[Zn(OH)_4]}$$

(viii) The hydroxides of aluminum, zinc, lead and tin, however, dissolve in excess of sodium hydroxide giving clear solution which can also be obtained when these metals are acted upon by the concentrated solution of sodium hydroxide.

$$Zn(OH)_2 + 2OH^- \longrightarrow \underset{\text{Zincate ion}}{[Zn(OH)_4]^{2-}} \quad Al(OH)_3 + 3OH^- \rightarrow \underset{\text{Aluminate ion}}{[Al(OH)_6]^{3-}}$$

(e) Uses

(i) Used in the production of soap, rayon, dyes, paper, and pharmaceuticals.

(ii) Employed in the petroleum refining process.

5. Sodium Bicarbonate or Baking Soda ($NaHCO_3$)

(a) Preparation:

Sodium bicarbonate is produced through the Solvay process, and it is actually generated during the manufacturing of washing soda.

(i) Aqueous solution gives no colour with phenolphthalein but yellow color with Metyl orange and hence is weakly basic.

(ii) $$2NaHCO_3 \xrightarrow{\triangle} Na_2CO_3 + CO_2 + H_2O$$

(iii) Salts which give basic carbonates with washing soda give normal salts with the bicarbonate.

$$ZnSO_4 + 2NaHCO_3 \rightarrow ZnCO_3 + Na_2SO_4 + H_2O + 2CO_2$$

(iv) It is used as “SODA BICARB” to neutralist stomach acidity.

(v) Baking soda is created by combining the sodium/potassium salt of tartaric acid with $NaHCO_3$.

Solvay process (Commercial Scale)

$$CaCO_3 \rightarrow CaO + CO_2$$

(In brine saturated with NH_3, CO_2 is passed)

$$NH_3 + H_2O + CO_2 \rightarrow NH_4HCO_3$$

$$NaCl + NH_4HCO_3 \rightarrow NH_4Cl + NH_4HCO_3$$

$$2NH_4Cl + CaO \rightarrow CaCl_2 + 2NH_3 + H_2O \text{ (Bye-products)}$$

(b) Properties

Hydrolysis

$$NaHCO_3 + H_2O \rightleftharpoons NaOH + H_2CO_3$$

Effect of heat (temp. $> 100°C$)

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2 \uparrow$$

(Process occurs during preparation of cake)

Reaction with acids – gives CO_2

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2 \uparrow$$

Reaction with base

$$NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$$

(c) Uses

(i) Utilized in the formulation of baking powder.

(ii) Employed in the creation of effervescent beverages.

(iii) Found in fire extinguishers.

(iv) Used as an antacid medication for alleviating acidity.

6. Sodium Carbonate or Washing Soda ($Na_2CO_3.10H_2O$)

(a) Occurrence: Na_2CO_3–Soda ash.

(b) Manufacture: By Solvay process

(i) A concentrated aqueous solution of NaCl is enriched with NH_3 until saturation is achieved.

(ii) The solution is subjected to a stream of CO_2.

(iii) Resulting in the precipitation of $NaHCO_3$.

$$NH_3 + CO_2 + H_2O \rightarrow NH_4HCO_3 \rightleftharpoons NH_4{}^+ + HCO_3^-$$

$$NaCl \rightleftharpoons Na^+ + Cl -$$

$$[Na^+] \times [HCO_3^-] > K_{sp} of NaHCO_3 \quad \text{(So, ppt. forms)}$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

(iv) Potassium bicarbonate ($KHCO_3$) is not obtainable through the Solvay process due to its water solubility.

(c) Leblanc Process

$$NaCl + H_2SO_4(con.\,c) \xrightarrow{\text{midheating}} NaHSO_3 + HCl$$

$$NaCl + NaHSO_4 \xrightarrow[\text{heated}]{\text{strongle}} \underset{\text{salt cake}}{Na_2SO_3} + HCl$$

$$Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO\uparrow$$

$$Na_2S + CaCO_3 \longrightarrow Na_2CO_3 + CaS$$

(d) Properties

(i) Efflorescence

When $Na_2CO_3.10H_2O$ is exposed to the air, it releases nine out of its ten H_2O molecules

$$Na_2CO_3.10H_2O \rightarrow \underset{\text{(Monohydrate)}}{Na_2CO_3.H_2O} + 9H_2O$$

This phenomenon is known as efflorescence, and as a result, washing soda experiences a reduction in weight when exposed to air.

(ii) Hydrolysis

The aqueous solution of Na_2CO_3 exhibits alkaline properties as a result of anionic hydrolysis.

$$Na_2CO_3 \rightarrow 2Na^+ + CO_3^{-2} \text{and} CO_3^{-2} + \underset{\text{(carbonicacid)}}{H_2OCO_3} + 2OH -$$

(e) Uses

(i) Used in the production of a fusion mixture, typically consisting of Na_2CO_3 and K_2CO_3.

(ii) Applied in the manufacturing processes of glass, caustic soda, soap powders, and more.

(iii) Employed in laundries and for water softening purposes.

7. Sodium Peroxide Na_2O_2

(a) Sodium peroxide is produced by heating sodium metal on aluminum trays in an environment free from carbon dioxide (CO2).

$$2Na + O_2 \text{ (air)} \longrightarrow Na_2\,O_2$$

(i) In its pure form, sodium peroxide is colorless, and the faint yellow hue of the typical product results from the presence of a small quantity of NaO_2.

(ii) When sodium peroxide is exposed to moist air, it becomes white due to the formation of NaOH and Na_2CO_3. This transformation is expressed as:

$$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$$

And $$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H2O$$

(iii) Sodium peroxide is a potent oxidizing agent and can oxidize chromium (III) hydroxide to sodium chromate, manganese (II) to sodium manganite, and sulfides to sulfates.

For example:

$$2Cr(OH)_3 + 3O_2{}^{-2} \longrightarrow CrO_4{}^{-2} + 2OH^- + 2H_2O$$

(b) Uses

(i) Sodium peroxide is extensively employed as an oxidizing agent in inorganic chemistry. However, its interaction with organic compounds can be extremely hazardous due to its violent reactivity.

(ii) Sodium readily reacts with carbon dioxide, forming sodium carbonate, and it also combines with oxygen. As a result, it can be utilized for air purification in enclosed spaces like submarines.

(iii) Its strong oxidizing characteristics make sodium peroxide useful as a bleaching agent.

(iv) Sodium peroxide finds applications in the manufacturing of dyes and various other chemicals, including benzoyl peroxide and sodium perborate.

8. Sodium Monoxide (Na_2O)

Preparation:

Sodium peroxide is obtained by heating sodium at 180°C in a controlled oxygen or air atmosphere. The excess sodium is subsequently removed through vacuum distillation, or it can be generated by heating a mixture of sodium peroxide (Na_2O_2), sodium nitrate, and sodium.

$$2Na + \frac{1}{2}O_2 \rightarrow Na_2O$$

$$Na_2O_2 + 2Na \rightarrow 2Na_2O$$
$$2NaNO_3 + 10Na \rightarrow 6Na_2O + N_2$$

Properties

(i) It appears as a colorless, non-crystalline material.

(ii) When it comes into contact with water, it undergoes a vigorous reaction to produce NaOH.

$$Na_2O + H_2O \rightarrow 2NaOH$$

(iii) On heating above 400°C, it disproportionate to give peroxide and metallic sodium.

$$2Na_2O \xrightarrow{400^0C} Na_2O_2 + 2Na$$

(iv) It reacts with liquid ammonia forming so amide and NaOH.

$$Na_2O + NH_2 \rightarrow NaOH + NaNH_2$$

9. Sodium Sulphate (Na_2SO_4)

Preparations

In 1625, Johann Rudolf Glauber made the discovery of sodium sulfate in Austrian spring water, and its hydrate form was consequently named Glauber’s salt. Acknowledging its medicinal properties, he christened it "sal mirabilis" or miraculous salt.

A substantial portion, one-third to be precise, of the global production of sodium sulfate arises as a by-product in various chemical industry processes. This by-product is generated through the reaction between sodium chloride and sulfuric acid.

$$2NaCl + H_2SO_4 \rightarrow 2HCl + Na_2SO_4$$

During the 18th century, Glauber's salt served as a key raw material for the industrial production of soda ash when reacted with potassium carbonate or potash. However, as the demand for soda ash surged in the 19th century, the large-scale Leblanc process, producing synthetic sodium sulfate, emerged as the primary method for soda ash production.

At dietary levels, the excretion of sodium sulfate occurs primarily through urine. Sulphates are present in all body cells, with the highest concentrations found in connective tissues, bone, and cartilage. Sulphates play a crucial role in various physiological processes, including those associated with detoxification.

Properties:

(1) Anhydrous sodium sulfate is commonly referred to as salt cake, and it exhibits hygroscopic properties, meaning it has a tendency to absorb moisture from the surrounding environment.

(2) When an aqueous solution of Na_2SO_4 is cooled below 32°C, Glauber's salt ($Na_2SO_4 \cdot 10H_2O$) precipitates out. Further cooling, below 12°C, results in the formation of $Na_2SO_4 \cdot 7H_2O$ crystals.

Sodium sulfate finds versatile applications, serving multiple purposes:

It is employed to dehydrate organic liquids effectively.

As a filler, sodium sulfate is incorporated into powdered home laundry detergents.

In the glass industry, it acts as a fining agent, eliminating small air bubbles from molten glass during the manufacturing process.

Glauber’s salt, in its decahydrate form, has been historically utilized as a laxative, facilitating the removal of certain drugs such as acetaminophen from the body.

Sodium sulfate is employed for defrosting windows, as an ingredient in carpet fresheners, and in the starch manufacturing process. Additionally, it serves as an additive in cattle feed.

In industrial processes, sodium sulfate is a key component in the manufacture of detergents and plays a role in the Kraft process utilized for paper pulping.

10. Sodium Thiosulfate ($Na_2S_2O_3$) $5H_2O$

Sodium thiosulfate is a salt of an unstable acid (Thiosulphuric acid)

Preparation

(i) Sodium sulfite and flowers of S

$$\underset{\text{Soluble}}{Na_2SO_3} + \underset{\text{Insoluble}}{S} \rightarrow Na_2S_2O_3$$

(ii) Spring's Reaction

$$Na_2S + l_2Na_2So_3 \rightarrow Na_2S_2O_3 + 2Nal \uparrow$$

(iii) Sodium carbonate solution with So_2

$$Na_2S + Na_2CO_3 + SO_2 \rightarrow Na_2S_2O_3 + CO_2 \downarrow$$

(iv) Sulfur and caustic soda

$$4S + 6NaOH \xrightarrow{\triangle} Na_2S_2O_3 + 2Na_2S + 2H_2O$$

With excess pent sulfide forms

$$Na_2S + 4S \rightarrow Na_2S_5$$

Chemical Properties

(i) Heating effect - $Na_2S_2O_3.5H_2O \xrightarrow{215^0C} Na_2S_2O_3 + 5H_2O$

$$4Na_2S_2O_3 \xrightarrow{223^0C} 3Na_2SO_4 + Na_2S_5$$

(ii) Acidification – Liberates SO_2 and S ppt.

$$Na_2S_2O_2 + \text{dil.}\,2HCl \rightarrow 2NaCl + SO_2 + S\downarrow + H_2O$$

$$Na_2S_2O_3 + \text{dil.}\,H_2SO_4 \rightarrow Na_2SO_4 + SO_2 + S\downarrow + H_2O$$

$$Na_2S_2O_3 + \underset{\text{chlorinwater}}{Cl_2 + H_2O} \rightarrow Na_2SO_4 + 2HCl + S$$

(iii) Reduction $Na_2S_2O_3 + \underset{\text{chlorinwater}}{Cl_2 + H_2O} \xrightarrow[\substack{\downarrow(\text{Purple})\\ FeCl_2(\text{green})}]{} Na_2SO_4 + 2HCl + S$

(iv) Oxidation - (oxidizes by I_2 quantitatively)

$$2Na_2S_2O_3 + l_2 \xrightarrow[\substack{\text{sodim}\\ \text{Tetrathionate}}]{} 2Nal + Na_2S_4O_6$$

(v) $AgNo_3$Action

$$2AgNo_3 + Na_2S_2O_3 \rightarrow Ag_2S_2O_3 + 2NaNO_3$$

$$Ag_2S_2O_3 + H_2O \rightarrow Ag_2S + H_2SO_4$$

Thus white ppt. of silver thiosulfate changes as

White → yellow → brown → black

(vi) Silver halide action

$$AgBr + 2Na_2S_2O_3 \rightarrow \underset{\substack{\text{sodium argen}\\ \text{thiosulfate(colourless)}}}{Na_3[Ag(S_2O_3)_2]} + NaBr$$

This property is used in photography fixing.

(vii) Action on $CusO_4$

$$CuSO_4 + Na_2S_2O_3 \rightarrow \underset{\substack{\text{Curpic}\\ \text{Thiosulfate}\\ \text{(colourless)}}}{CuS_2O_3} + Na_2SO_4$$

$$CuS_2O_3 + Na_2S_2O_3 \rightarrow \underset{\text{Cuprous Thiosulfate}}{CuS_2O_3} + \underset{\text{Sodiumtetra Thionate}}{Na_2S_4O_6}$$

$$CuS_2O_3 + Na_2S_2O_3 \xrightarrow[\text{ordy}]{\text{an excess}} \underset{\text{sodium cupro thiosulfate(sol)}}{Na_4[Cu_6(S_2O_3)_5]}$$

Compounds of Potassium

Potassium and its Compounds

1. Atomic Number: 19
2. Electronic Configuration: 2, 8, 8, 1
3. Valence and Oxidation state: + 1
4. Occurrence

   Potassium is an extremely reactive metal and is not naturally found in its free elemental state. Its significant minerals include:

   (a) Pearl ash,
   (b) Sylvine, KCl.
   (c) Indian Salt Petre, KNO_3
   (d) Carnallite, KCl $MgCl_2$. $6H_2O$

5. Extraction

   It can be produced through any of the following techniques:

   (a) Electrolysis of molten potassium cyanide.
   (b) The reaction of potassium fluoride with calcium.
   (c) The heating of potassium carbonate with carbon (coke).
   (d) Electrolysis of molten KCl with a small amount of KF.

6. Properties

   (a) Potassium is a shiny white metal with a melting point of 65°.
   (b) It is lighter and softer than sodium, sharing similar chemical properties with sodium but exhibiting greater reactivity.
   (c) Potassium displays a more vigorous reaction with cold water compared to sodium. The heat generated during this reaction is so intense that the evolved hydrogen gas can ignite when excess metal is burned in the presence of air or oxygen under reduced pressure, forming K_2O. When heated in an excess of air, potassium produces superoxide (KO_2).
   (d) Potassium (with an atomic number of 40) possesses weak radioactivity, emitting beta particles. It has three isotopes with mass numbers of 39, 40, and 41, with the first one being the most abundant. The radioactivity is attributed to the presence of the isotope with a mass number of 40, which constitutes approximately 0.012% of the metal.

7. Uses

   (a) Potassium finds application in photoelectric cells.
   (b) A liquid alloy composed of sodium and potassium is employed in high-temperature thermometers.

Oxides of Potassium

	k_2O_1,	k_2O_2,	k_2O_3,	k_2O,	KO_3
Colors	White	White	Red	Bright Yellow	Orange Solid

Preparation

$$2KNO_3 + 10K \xrightarrow{\text{beating}} 6K_2O + N_2$$

$$\underset{\text{(White)}}{K_2O} \xrightarrow{\text{heating}} \underset{\text{(Yellow)}}{K_2O}$$

$$K_2O + H_2O \rightarrow 2KOH$$

$$2K + O_2 \xrightarrow[\text{airat}300^0C]{\text{Controlled}} K_2O_2 \text{ [Props: Similar with } Na_2O_2\text{]}$$

Passage of O_2 through a blue solution of K in liquid yields oxides (white), (red), and (deep yellow) i.e.

K in liq. $NH_3 \xrightarrow{O_2} \underset{\text{White}}{K_2O_3} \rightarrow \underset{\text{red}}{K_2O_3} \rightarrow \underset{\text{yellow}}{KO_2}$

KO_2 reacts with H_2O and produces H_2O_2 and O_2 both

$$2KO_2 + 2H_2O \xrightarrow{-0^0C} 2KOH + H_2O_2 + O_2$$

KO_3: $\underset{\text{(Drypowedred)}}{KOH} + O_3(\text{Ozonisedoxygen}) \xrightarrow{-10^0\text{to}-15^0C} \underset{\text{(Orangessolidd)}}{KOH}$

Potassium Hydroxide (Caustic Potash) KOH

Preparation

It can be prepared similarly to NaOH, which involves electrolyzing a KCl solution and reacting lime with potassium carbonate. Another method is obtaining it through the reaction of barium hydroxide (Ba $(OH)_2$) with potassium sulfate.

$$k_2SO_4Ba(OH)_2 \rightarrow BaSO_4 \downarrow +2KOH$$

Properties

Its characteristics closely resemble those of sodium hydroxide, but it serves as a more potent alkali and exhibits increased solubility in alcohol. As a result, it is employed in organic reactions in lieu of caustic soda. Additionally, it excels as an absorbent due to its superior solubility, preventing separation. The aqueous solution of this substance is commonly referred to as potash lye.

Potassium Carbonate (K_2CO_3)

It is also known as pearl ash.

Preparation

It is produced by introducing carbon dioxide (CO_2) into a concentrated solution of the chloride, which includes suspended hydrated magnesium carbonate, at a temperature of 20°C. This process results in the precipitation of an insoluble compound known as potassium hydrogen magnesium carbonate.

$$2KCl + 3(MgCO_3.3H_2O) + CO_2 \rightarrow (MgCO_3.KHCO_34H_2O) + MgCl_2$$

The separated precipitate is filtered, and it is subsequently broken down either through heating with pressurized water at 140°C or by reacting it with magnesium oxide at temperatures below 20°C.

$$2(MgCO_3.KHCO_3.4H_2O) \rightarrow 2MgCO_3 + K_2CO_3 + 9H_2O + CO_2$$

$$2(MgCO_3.KHCO_3.4H_2O) + MgO \rightarrow 3(MgCO_3.3H_2O) + K_2CO_2$$

Properties

(i) It is white, deliquescent solid

(ii) k_2CO_3Resembles Na_2CO_3 in properties, but is more alkaline and more soluble than Na_2CO_3

(iii) Potassium carbonate is a finely ground white powder.

Potassium Bicarbonate ($KHCO_3$)

Preparation

In every aspect, it closely resembles sodium bicarbonate, except for its heightened water solubility. It finds applications in medicine and baking powders.

Potassium Sulphate

Preparation

(i) By treating Kcl or KOH with H_2SO_4

$$2KCl + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$$

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

(ii) By treating naturally occurring mineral, stibnite ($k_2SO_4.MgSO_4.6H_2O$) with Sylvine (KCl)

$$k_2SO_4.MgSO_46H_2O + 2KCl \rightarrow 2K_2SO_4 + MgCl_26H_2O$$

Properties

(i) It is a white crystalline solid with a melting point of 1050°C and has limited solubility in water.

(ii) In contrast to sodium sulfate, its crystals lack water of crystallization.

(iii) Upon heating with carbon, it undergoes reduction to yield metallic potassium.

(iv) It can create a range of double salts when combined with trivalent metal sulfates, such as potash alum.

$$K_2SO_4Al_2(SO_4) \rightarrow 24H_2O$$

Potassium Chloride (KCl)

Preparation:

KCl is derived from molten carnallite. Almost pure KCl precipitates from the liquid while the fused $MgCl_2$ remains behind.

$$KCl.MgCl_26H_2O \rightarrow KCl + MgCl_26H_2O$$

Properties:

It exists as colorless cubic crystals that readily dissolve in water. Its solubility in water increases nearly linearly as the temperature rises.

Solubility in Water

(i) $Li_2(CO_3) < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
(ii) $K_2SO_4 < Na_2SO_4 < Li_2SO_4 < Rb_2SO_4 < Cs_2SO_4$
(iii) $NaNO_3 > LiNO_3 > RbNO_3 > KNO_3 > CsNO_3$
(v) $NaI > LiI > RbI > KI > CsI$
(v) $LiBr > RbBr > CsBr > NaBr > KBr$
(vi) $LiOH < NaOH < KOH < RbOH < CsF$
(vii) $KCl < NaCl < LiCl < RbCl < CsCl$
(viii) $LiF < NaF < KF < RbF < CsF$