

# **Descriptive Chemistry of Elements** s-Block

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# 1. The Group 1 elements

Li

Na

K

Rb

Cs

Fr

## Introduction

The elements in the Groups 1 and 2 are called *s*-block elements. The Group 1 elements (formerly Group I or IA) include **lithium** (Li), **sodium** (Na), **potassium** (K), **rubidium** (Rb), **caesium** (Cs) and **francium** (Fr). They are also called "alkali metals". In some Periodic Tables, hydrogen is placed just above Li though its properties are somewhat different to other elements in Group 1. The chemistry of hydrogen will be discussed separately.

#### 1.1 Occurrence and isolation

Alkali metals are reactive and they are not found in nature as free metals. Sodium and potassium are relatively more abundant than the other metals in this group. Na is present as a salt (*e.g.* Sodium chloride, NaCl) in huge quantities in underground deposits (salt mines), in seawater and other natural waters. Potassium salts are found naturally in seawater, and as carnalite, KCl·MgCl<sub>2</sub>·6H<sub>2</sub>O or potash (KOH). The concentrations of Na<sup>+</sup> and K<sup>+</sup> ions in seawater are 10,800 and 590 ppm, respectively.

Sodium and lithium are obtained by electrolysis of their molten chloride. For example,

$$2 \text{ NaCl(l)} \longrightarrow 2 \text{ Na(s)} + \text{Cl}_2(g)$$

During electrolysis Na<sup>+</sup> ions are reduced to Na metal and chloride ions are oxidized to chlorine gas.



### **Activity**

1. Can we obtain Na metal by electrolyzing a concentrated aqueous solution of NaCl?

Potassium is made by the reaction of sodium vapor with molten/fused KCl at 850°C.

$$Na(vapour) + KCl(1) \longrightarrow NaCl(1) + K(1)$$

Rb and Cs are made by the reduction of their chlorides with calcium metal at 800°C.

$$Ca(1) + 2 RbCl(1) \longrightarrow CaCl_2(1) + 2 Rb(1)$$

All isotopes of francium are radioactive.

# 1.2 Some properties of alkali metals

In this lesson, we will mainly concentrate on the chemistry of Na, K and Li. The elements of Group 1 are soft metals and they conduct electricity and heat. Table 1 provides you with some of the physical data of Group 1 elements. As one would expect the ionic radius,  $r(M^+)$ , increases as you go down the group. The melting point (m.p.) decreases from Li to Cs. Alkali metals have low densities and the densities (d) of Li, Na and K are less than that of water; thus these metals float on water.

**Table 1:** Some properties of Group 1 elements

Element	<b>r</b> ( <b>M</b> <sup>+</sup> ) / <b>pm</b>	Electron configuration	m.p./°C	d/gcm <sup>-3</sup>	Eº/v	IE <sub>1</sub> /kJmol <sup>-1</sup>	IE <sub>2</sub> /kJmol <sup>-1</sup>
Li (Lithium)	60	[He] 2s <sup>1</sup>	181	0.53	-3.04	520	7590
Na (Sodium)	95	[Ne] 3s <sup>1</sup>	98	0.97	-2.71	496	4560
<b>K</b> (Potassium)	133	[Ar] 4s <sup>1</sup>	63	0.86	-2.94	418	3060
<b>Rb</b> (Rubidium)	148	[Kr] 5s <sup>1</sup>	39	1.53	-2.94	401	2630
Cs (Caesium)	169	[Xe] 6s <sup>1</sup>	29	1.90	-3.03	376	2430



#### **Activity**

2. Why are alkali metals soft and have low melting points?

The valence electron configuration of these elements can be written as  $\mathbf{ns}^1$  and they have a tendency to lose the single s-electron and attain a noble gas electron configuration.

$$M \longrightarrow M^+ + e$$
 (oxidation)

Therefore, these alkali metals are the most reactive and *electropositive* elements known. This is due to the *low* first ionization energy ( $IE_1$ ) shown by each element. They all form only  $M^+$  ions as the second ionization energy ( $IE_2$ ) is very high when compared to  $IE_1$  (see Table 1).

Q: Write the electron configuration of Na, Na<sup>+</sup> and Ne.

A:

Electron configuration of Na	1s <sup>2</sup> ,2s <sup>2</sup> ,2p <sup>6</sup> ,3s <sup>1</sup>	(11 electrons)
Electron configuration of Na <sup>+</sup>	1s <sup>2</sup> ,2s <sup>2</sup> ,2p <sup>6</sup>	(10 electrons)
Electron configuration of Ne	1s <sup>2</sup> ,2s <sup>2</sup> ,2p <sup>6</sup>	= [Ne] (10 electrons)
Electron configuration of Na	1s <sup>2</sup> ,2s <sup>2</sup> ,2p <sup>6</sup> ,3s <sup>1</sup>	$=$ [Ne] $3s^1$



#### **Activity**

3. Cs has the lowest first ionization energy (see Table 1), explain. Comment on the electropositivity of the cations as you go down the Group.

Group 1 elements form *colorless ionic salts* with common simple anions and the *oxidation state/number* of the metal is always +1. Almost all derivatives of alkali metals are ionic except some lithium compounds. The Group 1 metal ions (M<sup>+</sup>) are quite stable towards reduction to its free elements (M), for example Na<sup>+</sup> is more stable than free Na metal.

Standard reduction electrode potentials (E°) of the Group 1 metals are given in Table 1. The negative values indicate that these elements are *good reducing agents*. Li has a more negative E° value than Na because of its high hydration energy. Simple salts of alkali metals tend to be very

soluble in water, but LiF and Li<sub>2</sub>CO<sub>3</sub> are partially soluble in water. Free alkali metals are normally stored in dry hydrocarbon solvents (paraffin oil) to prevent them from reacting with atmospheric oxygen or moisture.

## 1.3 Compounds of alkali metals

In this section, we will consider some reactions and properties of simple salts of alkali metals: *metal oxides, metal hydroxides* and *metal halides*.

#### Alkali metal oxides

The product(s) obtained due to combustion of Group 1 elements in oxygen vary with the alkali metal and the amount of oxygen used: three different oxygen containing anions (e.g. oxide, peroxide and superoxide) are formed (Table 2). Hydrolysis (reaction with water) of lithiummonoxide gives LiOH. Hydrolysis of sodium peroxide at 0 °C gives NaOH and  $H_2O_2$ , but  $H_2O_2$  is unstable at room temperature and liberates  $O_2$  as the temperature is raised. The corresponding metal hydroxide,  $H_2O_2$  and  $O_2$  are produced when superoxides of K, Rb and Cs are hydrolysed. K, Rb and Cs form all three oxides.

**Table 2:** Stable oxides (main product) obtained by reacting alkali metals with oxygen, and the product(s) due to hydrolysis of the corresponding salt

Metal	Product isolated	Anion type	Product/s due to hydrolysis
Li	Li <sub>2</sub> O	O <sup>2-</sup> (oxide)	OH <sup>-</sup>
Na	Na <sub>2</sub> O <sub>2</sub>	$O_2^{2-}$ (peroxide)	$OH^-$ , $H_2O_2$
K, Rb, Cs	$MO_2$	$O_2^-$ (superoxide)	$OH^{-}, H_{2}O_{2}, O_{2}$

Lithium forms only the monoxide (Li<sub>2</sub>O). Superoxide of sodium is unstable. The superoxide becomes more stable as you go down the group. K, Na and Cs are known to form all three oxides. Large alkali metals form stable superoxides  $MO_2$  (M = K, Rb, Cs), which are ionic and *paramagnetic*. Note that paramagnetic compounds contain *unpaired electrons*, like in the oxygen molecule.



### Activity

4. Write the balanced equations for the reaction of Na with  $O_2$ .

## **Preparation of metal oxides**

The reaction of LiOH with  $H_2O_2$ , generates unstable lithium peroxide [Li<sub>2</sub>O<sub>2</sub>], which decomposes to Li<sub>2</sub>O and O<sub>2</sub>.

$$2 \text{ LiOH(s)} + \text{H}_2\text{O}_2(1) \longrightarrow [\text{Li}_2\text{O}_2] \longrightarrow \text{Li}_2\text{O(s)} + \frac{1}{2} \text{O}_2(g)$$

K<sub>2</sub>O is prepared by reducing KNO<sub>2</sub> or KNO<sub>3</sub> with free metal.

$$2 \text{ KNO}_3(s) + 10 \text{ K}(s) \longrightarrow N_2(g) + 6 \text{ K}_2O(s)$$

$$2 \text{ KNO}_2(s) + 6 \text{ K}(s) \longrightarrow N_2(g) + 4 \text{ K}_2O(s)$$

Sodium peroxide is produced by passing carbon dioxide free dry air over heated Na.

$$2 \text{ Na(s)} + O_2(g) \longrightarrow \text{Na}_2O_2(g)$$

Upon heating, sodium peroxide decomposes to sodium monoxide and oxygen.

$$2 \operatorname{Na_2O_2(s)} \longrightarrow 2 \operatorname{Na_2O(s)} + \operatorname{O_2(g)}$$

These peroxides  $(M_2O_2)$  have ionic structures and they react with cold water  $(0^{\circ}C)$  to give  $H_2O_2$ . (M = Li, Na, K and Cs)

$$M_2O_2(s) + 2 H_2O(1) \longrightarrow H_2O_2(1) + 2 MOH(aq)$$

Alkali metal peroxides are powerful oxidizing agents and they oxidize sulfides to sulfates. Na<sub>2</sub>O<sub>2</sub> absorbs CO<sub>2</sub> and gives out O<sub>2</sub>

$$2 \operatorname{Na_2O_2(s)} + 2 \operatorname{CO_2(g)} \longrightarrow 2 \operatorname{Na_2CO_3(s)} + \operatorname{O_2(g)}$$

These peroxides are used to purify air (by removing CO<sub>2</sub>) in closed spaces such as submarines.

### Alkali metal hydroxides

Alkali metals react with water to give an alkaline solution with hydrogen evolution.

$$2 M(s) + 2 H2O(l) \longrightarrow 2 MOH(aq) + H2(g)$$

Li, Na and K all float on water, Li reacts steadily, Na reacts vigorously and K reacts violently.

NaOH is a very deliquescent white solid. On exposure to air it absorbs moisture. A solid sample of NaOH could combine with CO<sub>2</sub> in air to form a layer of Na<sub>2</sub>CO<sub>3</sub>. This layer protects NaOH from reacting further with moisture and CO<sub>2</sub>. Due to these reactions NaOH cannot be used as a **primary standard** for the standardization of acid solutions. NaOH is produced by electrolyzing NaCl.

Alkali metal hydroxides are used in various acid-base titrations. For example, NaOH can neutralize dilute sulfuric acid giving a salt and water.

$$2 \text{ NaOH(aq)} + \text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2 \text{ H}_2\text{O}(1)$$

Nonmetals such as carbon, nitrogen and oxygen do not react with aqueous NaOH but many other elements do react with NaOH. For example,

$$2 \text{ Al(s)} + 6 \text{ NaOH(aq)} + 6 \text{ H}_2\text{O(l)} \longrightarrow 2 \text{ Na}_3[\text{Al(OH)}_6](\text{aq}) + 3 \text{ H}_2(\text{g})$$
  
 $\text{Si(s)} + 2 \text{ NaOH(aq)} + \text{H}_2\text{O(l)} \longrightarrow \text{Na}_2\text{SiO}_3(\text{s}) + 2 \text{ H}_2(\text{g})$   
 $4 \text{ S(s)} + 6 \text{ NaOH(aq)} \longrightarrow 2 \text{ Na}_2\text{S(aq)} + \text{Na}_2\text{S}_2\text{O}_3(\text{aq}) + 3 \text{ H}_2\text{O(l)}$ 

#### Alkali metal halides

Alkali halides (MX) of sodium and potassium are ionic compounds and readily dissolve in water (a polar solvent). But LiCl, LiBr and LiI have some covalent character and are more soluble in alcohol (a less polar solvent than water). The *covalent* character of lithium compounds is due to the strong *polarizing power* of the Li<sup>+</sup> ion. Large anions are polarized by the Li<sup>+</sup> ion by attracting outermost electrons of the anion and at the same time repelling the positively charged nucleus of the anion. This distortion or polarization of the anion by the cation results in a certain degree of sharing of electrons between ions, *i.e.* the bond would become partially covalent in character. The small fluoride ion resists polarization by the lithium ion thus LiF has more ionic *character*.

The degree of polarization/polarizing power increases as the

- (i) charge of the cation increases,
- (ii) charge of the anion increases,
- (iii) size of the cation decreases, and
- (iv) size of the anion increases.

Q: List the halides in the order of increasing degree of polarization.

A: 
$$F^- < Cl^- < Br^- < \Gamma$$

Q: List the cations of alkali metals in the order of increasing polarizing power.

A: 
$$Cs^+ < Rb^+ < K^+ < Na^+ < Li^+$$

# **Summary**

- Group 1 elements are soft, reactive metals with low melting points; low densities; low first ionization energies; very high second ionization energies; very negative standard reduction potentials. Most simple salts of alkali metals are soluble in water.
- Valence electron configuration of alkali metals (M) is ns<sup>1</sup> and they readily form M<sup>+</sup> ions. Therefore, they are strong reducing agents.
- Na and Li are obtained by electrolyzing of their molten chloride; K is made by reacting molten KCl with sodium vapor.
- They form three types of oxides: monoxide, peroxide and superoxide.
- Alkali metal hydroxides are used in acid-base titrations.



# Learning Outcomes

At the end of this lesson you should be able to

- give the sources and methods used to isolate alkali metals, particularly, Na and K.
- compare the variation in properties of alkali metals such as ionic radius, melting points, density, ionization energies, and standard electrode potentials as you go down the Group.
- write the electron configuration of a Group 1 element or ion.
- mention preparation methods of alkali metal oxides, peroxides and superoxides.
- explain reactions of alkali metal oxides and metal hydroxides.



### Activity

- 5. Determine the oxidation states of the non-metals in the following substances.
  - (i) Na<sub>2</sub>O<sub>2</sub>
- (ii) KClO<sub>4</sub>
- (iii) Na<sub>2</sub>CO<sub>3</sub> (iv) Na<sub>2</sub>SO<sub>4</sub>
- 6. Draw the structures of the following anions NO<sub>3</sub><sup>-</sup>, CO<sub>3</sub><sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, ClO<sub>4</sub><sup>2-</sup> (Hint: Think about the valency and possible oxidation state(s) of atoms/ions)
- 7. What is the order of reactivity of alkali metals towards water?
- 8. Give two organometallic reagents of alkali metals, *i.e.* organic derivatives of alkali metals?
- 9. Which alkali metals form stable superoxides when it is reacted with oxygen?
- 10. Which alkali metals do not form stable superoxides?

# 2. The Group 2 elements

Be

Mg

Ca

Sr

Ba

Ra

#### Introduction

Here we will discuss the properties and chemistry of Group 2 elements and their compounds. The Group 2 (formerly Group II or IIA) elements include **beryllium** (Be), **magnesium** (Mg), **calcium** (Ca), **strontium** (Sr), **barium** (Ba) and **radium** (Ra). They are also called "alkaline earth metals". We will also make an attempt to compare the chemical properties of Group 2 elements with the Group 1 elements.

#### 2.1 Occurrence and isolation

The Group 2 elements are too reactive to occur as free elements in nature. Mg is the second most abundant element in seawater and it occurs as MgCl<sub>2</sub> (0.3%), MgBr<sub>2</sub> (0.04%) and MgSO<sub>4</sub> (0.18%). Magnesium also occurs in *carnalite* deposits, KCl·MgCl<sub>2</sub>·6H<sub>2</sub>O. Dolomite (CaCO<sub>3</sub>·MgCO<sub>3</sub>) is found in Digana (Kandy District) and Rattota (Matale District) which is used in the manufacture of Porcelain and Fertilizer. Limestone, chalk and marble contain CaCO<sub>3</sub>. Calcium also occurs as a sulfate, CaSO<sub>4</sub>·2H<sub>2</sub>O in *gypsum*. *Apatite*, Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> is found in Eppawala (Anuradhapura District). Seawater also contains CaSO<sub>4</sub>. Sr and Ba are rare and Be is even rarer and found as beryl, an aluminosilicate, Be<sub>3</sub>Al<sub>2</sub>(SiO<sub>3</sub>)<sub>6</sub>. The most important source of calcium is the deposits of CaCO<sub>3</sub>, which are the fossilized remains of dead shellfish. Dolomite is the major constituent of the mountain range, the Dolomite Alps in Italy. Ca and Mg are the fifth and sixth most abundant element in the earth's crust. From an Industrial standpoint, Mg is the most important metal.

Group 2 elements are normally prepared by electrolysis of the corresponding fused chlorides. Electrolysis of anhydrous MgCl<sub>2</sub> using a graphite anode and a steel cathode produces Mg at the

cathode. Anhydrous carnalite can be directly used for electrolysis; usually NaCl is added to lower the melting point of MgCl<sub>2</sub>.



## **Activity**

11. Write the half-cell reactions for the above process - electrolysis of anhydrous MgCl<sub>2</sub>.

The anhydrous MgCl<sub>2</sub> can also be prepared by heating magnesite (MgCO<sub>3</sub>) with coke (carbon) and passing chlorine over the mixture.

$$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$$
  
 $MgO(s) + C(s) + Cl_2(g) \longrightarrow MgCl_2(s) + CO(g)$ 

Magnesium can also be obtained from seawater as shown below.

(i)  $Mg(OH)_2$  is precipitated by adding  $Ca(OH)_2$ .

$$Mg^{2+}(aq) + Ca(OH)_2(s) \longrightarrow Mg(OH)_2(s) + Ca^{2+}(aq)$$

(ii) MgO is obtained by heating  $Mg(OH)_2$ .

$$Mg(OH)_2(s) \xrightarrow{2000\,^{\circ}C} MgO(s) + H_2O(g)$$

(iii) MgO is reduced to Mg by heating with carbon (coke).

$$MgO(s) + C(s) \longrightarrow CO(g) + Mg(s)$$

Calcium metal is also obtained by electrolysis of a mixture of CaCl<sub>2</sub> and CaF<sub>2</sub>. CaF<sub>2</sub> is added to lower the melting point of the mixture.

# 2.2 Some properties of Group 2 elements

All Group 2 elements are metals and all are powerful reducing agents. Table 3 provides you with some physical properties of Group 2 elements. The *valence electron configuration* of these elements can be written as  $\mathbf{ns}^2$  and they have the tendency to lose both s-electrons and attain a noble gas electron configuration.

**Table 3:** Some properties of Group 2 elements (E.Con. = Electron configuration; 100 pm (picometres) = 1Å)

Element (name)		E.Con	IE <sub>1</sub> kJmol <sup>-1</sup>	IE <sub>2</sub> kJmol <sup>-1</sup>	IE <sub>3</sub> kJmol <sup>-1</sup>	r(M <sup>2+</sup> ) pm
Be	(Beryllium)	[He] 2s <sup>2</sup>	899	1757	14848	59
Mg	(Magnesium)	[Ne] 3s <sup>2</sup>	738	1451	7733	86
Ca	(Calcium)	[Ar] 4s <sup>2</sup>	590	1145	4912	114
Sr	(Strontium)	[Kr] 5s <sup>2</sup>	549	1064	4207	132
Ba	(Barium)	[Xe] 6s <sup>2</sup>	503	965	3500	149
Ra	(Radium)	[Rn] 7s <sup>2</sup>	-	-	-	-

As seen in the Table 3, the ionic radius of the divalent ions increases as you go down the group. Each free atom has two valence s-electrons (when compared to Group 1 elements) which results in atoms being held together much more strongly in the free metal. Hence *the Group 2 elements* are harder, denser and have a much higher melting point than the corresponding alkali metals (see Table 4).

**Table 4:** Densities and melting points of the elements of Groups 1 and 2

Metal	Li	Be	Na	Mg	K	Ca	Rb	Sr	Cs	Ba
Density (gcm <sup>-3</sup> )	0.53	1.85	0.97	1.75	0.86	1.55	1.53	2.63	1.90	3.62
Melting Point (°C)	181	1287	98	649	63	839	39	768	29	727

Group 2 elements form colorless largely *ionic compounds* in the solid state in which the oxidation state of the metal is always +2. No stable compounds containing  $M^+$  ions are known. All Group 2 metals form only  $M^{2+}$  ions. The *high charge density* of Be<sup>2+</sup> means that the free ions cannot exist, and all its compounds are either covalent or exist as solvated ions such as  $[Be(H_2O)_4]^{2+}$ .

Beryllium thus shows properties markedly different from the other elements in Group 2. The higher charge density of  $M^{2+}$  ions of the Group 2 elements (when compared to  $M^{+}$  ions of the Group 1 elements) results in

- (i) smaller  $M^{2+}$  ions; e.g.  $r(Ca^{2+})$  is 114 pm and  $r(K^{+})$  is 133 pm.
- (ii) strongly hydrated complexes than Group 1 elements
- (iii) higher lattice energies
- (iv) salts which are less soluble in water.



## **Activity**

- 12. Group 2 elements do not form M<sup>3+</sup> ion. Explain.
- 13. Why is IE<sub>3</sub> for Magnesium very large, when compared to its IE<sub>2</sub>?

# 2.3 Compounds of Group 2 elements

In this section, we will discuss the preparation and reactions of Group 2 metal oxides (MO), hydroxides  $M(OH)_2$ , peroxides  $(MO_2)$ , halides  $(MX_2)$ , hydrides  $(MH_2)$ , nitrates  $[M(NO_3)_2]$ , sulfates  $(MSO_4)$  and carbonates  $(MCO_3)$ .

#### **Oxides**

Let us consider preparation of metal oxides. There are three methods to prepare metal oxides: (i) direct reaction with oxygen, (ii) decomposition of metal carbonates, and (iii) direct reaction with water at high temperature.

$$5 \text{ Be(s)} + \underbrace{O_2(g) + N_2(g)}_{\text{Air}} \longrightarrow 2 \text{ BeO(s)} \downarrow + \text{ Be}_3 N_2(s)$$

Similar reactions do occur with Mg, Ca, Sr and Ba. Metal oxides are essentially ionic solids with a divalent cation and an anion (M<sup>2+</sup>O<sup>2-</sup>). Beryllium oxide (BeO) may have some covalent character. This may be due to higher polarizing power of Be<sup>2+</sup> ion.

Group 2 metal oxides are normally prepared by thermal decomposition of the corresponding metal carbonate.

$$MCO_3(s) \longrightarrow MO(s) + CO_2(g)$$

Magnesium reacts with steam to produce MgO and hydrogen.

$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)$$

Some of the reactions of metal oxides are given below.

(i) Group 2 metal oxides have high lattice energies and are less soluble in water compared to those of Group 1 metal oxides. BeO and MgO are quite insoluble in water whilst CaO, SrO and BaO readily react with water giving ionic hydroxides. For example, CaO is a basic oxide and it reacts with water to give Ca(OH)<sub>2</sub>.

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(aq)$$

(ii) CaO reacts with gaseous acidic oxides such as SO<sub>2</sub> to give sulphite.

$$CaO(s) + SO_2(g) \longrightarrow CaSO_3(s)$$

(iii) At higher temperatures, CaO reacts with solid acidic oxides such as silica and P<sub>4</sub>O<sub>10</sub>to give silicate and phosphate, respectively.

$$CaO(s) + SiO_2(s) \longrightarrow CaSiO_3(s)$$
  
 $6 CaO(s) + P_4O_{10}(s) \longrightarrow 2 Ca_3(PO_4)_2(s)$ 

CaO is used in the laboratory as a drying agent in desiccators for drying organic solvent (e.g. ethyl alcohol). During this process Ca(OH)<sub>2</sub> is produced.

#### **Hydroxides**

We know that metal hydroxides can be prepared by hydrating the corresponding metal oxide. The basic character of metal hydroxide increases with the size of the cation, thus basicity increases as shown below.

$$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$$

Be(OH)<sub>2</sub> shows amphoteric properties; it dissolves in mineral acid (HX) to form the corresponding halide (BeX<sub>2</sub>); in alkaline solutions (e.g. NaOH), it produces beryllates, Na<sub>2</sub>[Be(OH)<sub>4</sub>].

$$Be(OH)_2(s) + 2 HCl(aq) \longrightarrow BeCl_2(s) \downarrow + 2 H_2O(l)$$

$$Be(OH)_2(s) + 2 NaOH(aq) \longrightarrow Na_2[Be(OH)_4](aq)$$

An aqueous solution of calcium hydroxide is called limewater; which is used to test for carbon dioxide. When carbon dioxide is passed into limewater, a precipitate of calcium carbonate is formed first.

$$Ca(OH)_2(aq) + CO_2(g) \longrightarrow CaCO_3(s) \downarrow + H_2O(l)$$

Addition of more CO<sub>2</sub> converts the carbonate into more water soluble calcium bicarbonate so that CaCO<sub>3</sub> precipitate dissolves up giving a clear solution.

$$CaCO_3(s) + CO_2(g) + H_2O(l) \longrightarrow Ca(HCO_3)_2(aq)$$

If more limewater is added, CaCO<sub>3</sub> re-precipitates.

$$Ca(HCO_3)_2(aq) + Ca(OH)_2(aq) \longrightarrow 2 CaCO_3(s) \downarrow + 2 H_2O(l)$$

CaCO<sub>3</sub> can be precipitated by boiling a solution of Ca(HCO<sub>3</sub>)<sub>2</sub>

$$Ca(HCO_3)_2(aq) \longrightarrow CaCO_3(s) \downarrow + CO_2(q) \uparrow + H_2O(l)$$

#### **Peroxides**

The formation of metal peroxides  $(MO_2)$  is observed with larger cations.  $BaO_2$  is readily formed when BaO is heated in air or oxygen.

$$2 \operatorname{BaO}(g) + \operatorname{O}_2(g) \longrightarrow 2 \operatorname{BaO}_2(s)$$

SrO<sub>2</sub> is obtained in a low yield by heating SrO in oxygen under pressure at 400°C.

Hydrated peroxides of the type MO<sub>2</sub>·8H<sub>2</sub>O can be obtained by adding H<sub>2</sub>O<sub>2</sub> to a concentrated solution of metal salts.

#### **Halides**

Group 2 metals react directly with halogen to give metal dihalides,  $MX_2$ . M = Be, Mg, Ca and Sr; X = Cl and Br.

$$M(s) + X_2(g) \longrightarrow MX_2(s)$$

The reaction with bromine takes place at higher temperatures. Calcium can react with  $F_2$  and  $I_2$  to give  $CaF_2$  and  $CaI_2$ , respectively.

Beryllium chloride (BeCl<sub>2</sub>) is a *covalent polymer* in the solid state containing Be-Cl-Be bridges. In the vapor phase, the polymer  $[BeCl_2]_n$  is broken into a mixture of the monomer BeCl<sub>2</sub> and the dimer Be<sub>2</sub>Cl<sub>4</sub>.

Some hydrated chlorides are MgCl<sub>2</sub>·6H<sub>2</sub>O, CaCl<sub>2</sub>·6H<sub>2</sub>O and BaCl<sub>2</sub>·H<sub>2</sub>O. Hydrated magnesium chloride decomposes on heating to give a basic chloride.

$$2 \text{ MgCl}_2 \cdot 6H_2O(s) \stackrel{\triangle}{\longrightarrow} \text{ MgO} \cdot \text{MgCl}_2(s) + 2 \text{ HCl}(aq) + 11 \text{ H}_2O(l)$$

Calcium chloride crystallizes as CaCl<sub>2</sub>·6H<sub>2</sub>O. Anhydrous CaCl<sub>2</sub> is used as a drying agent for organic solvents. It also absorbs ammonia and alcohols giving compounds such as CaCl<sub>2</sub>·8NH<sub>3</sub> and CaCl<sub>2</sub>·4CH<sub>3</sub>OH.

## **Hydrides**

Magnesium hydride is formed when Mg powder is reacted with hydrogen under pressure at a high temperature.  $MgI_2$  acts as a catalyst.

$$Mg(s) + H_2(g) \xrightarrow{\Delta} MgH_2(s)$$

MgH<sub>2</sub> reacts with water to give Mg(OH)<sub>2</sub> and hydrogen.

$$MgH_2(s) + 2 H_2O(1) \longrightarrow Mg(OH)_2(s) + 2 H_2(g)$$

Group 2 metal hydrides are thermally more stable than the alkali metal hydrides. CaH<sub>2</sub> is used as a reducing agent and also as a drying agent.

#### **Nitrates**

The reaction of nitric acid with metal oxides, hydroxides or carbonates gives Group 2 metal nitrates.  $Mg(NO_3)_2$  and  $Ca(NO_3)_2$  are very soluble in water. Unlike Group 1 metal nitrates, nitrates of Group 2 metals can be decomposed to their oxides by heating. The thermal stability increases from  $Mg(NO_3)_2$  to  $Ba(NO_3)_2$ .

## **Sulfates**

Be (powdered) and Mg dissolve in dilute H<sub>2</sub>SO<sub>4</sub> to give BeSO<sub>4</sub> and MgSO<sub>4</sub>, respectively.

$$M(s) + H_2SO_4(aq) \longrightarrow M^{2+}(aq) + SO_4^{2-}(aq) + H_2(g)$$

CaSO<sub>4</sub> can be precipitated by adding dilute H<sub>2</sub>SO<sub>4</sub> to a solution of calcium salt.

$$Ca(NO_3)_2 (aq) + H_2SO_4(aq) \longrightarrow CaSO_4(s) + 2 HNO_3(aq)$$

The solubility of sulfates decreases as you go down the group. MgSO<sub>4</sub> is soluble in water but BaSO<sub>4</sub> is insoluble. Thus BaCl<sub>2</sub> is used as a reagent to determine sulfate ions in inorganic analysis,

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$$

#### **Carbonates**

When magnesium salts are treated with a Na<sub>2</sub>CO<sub>3</sub> solution, a precipitate of the basic carbonate, 3MgCO<sub>3</sub>·Mg(OH)<sub>2</sub>·4H<sub>2</sub>O is formed. The composition of the precipitate varies. The normal carbonate (MgCO<sub>3</sub>) can be obtained by adding a solution of NaHCO<sub>3</sub> to a solution of Mg<sup>2+</sup> ions.

$$Mg^{2+}(aq) + NaHCO_3(aq) \longrightarrow MgCO_3(s) + Na^+(aq) + H^+(aq)$$

 $MgCO_3$  is fairly insoluble in water but if  $CO_2$  is bubbled through a suspension of  $MgCO_3$  in water, the soluble bicarbonate is formed.

$$MgCO_3(s) + H_2O(l) + CO_2(g) \longrightarrow Mg(HCO_3)_2(aq)$$

Group 2 metal carbonates react with acids to give the corresponding salt and CO<sub>2</sub>.

$$CaCO_3(s) + 2 HCl(aq) \rightarrow CaCl_2(aq) + H_2O(1) + CO_2(g)$$

Thermal stability of metal carbonates increases with the size of the cation as indicated by their decomposition temperature  $(T_D)$ .

Compound	$MgCO_3$	CaCO <sub>3</sub>	SrCO <sub>3</sub>	BaCO <sub>3</sub>
T <sub>D</sub> / °C	540	900	1290	1360

## Summary

- Group 2 elements are shiny and reactive. They do not occur as free elements in nature.
- Valence electron configuration of alkali earth metal (M) is ns<sup>2</sup> and they readily form M<sup>2+</sup> ions. Therefore, they are strong reducing agents.
- All elements can be obtained by electrolysis of their molten salts.
- The Group 2 elements are harder, denser and have a much higher melting point than the corresponding alkali metals.
- M<sup>2+</sup> ions of the Group 2 elements are (i) smaller (ii) strongly hydrated and (iii) less soluble in water than the M<sup>+</sup> ions of Group 1 elements.
- Metal oxides can be prepared by (i) direct reaction with oxygen, (ii) decomposition of metal carbonates and (iii) direct reaction with water at high temperatures.
- The basic character of metal hydroxide increases with the size of the cation, thus basicity increases from Be(OH)<sub>2</sub> to Ba(OH)<sub>2</sub>.
- Group 2 metals react directly with halogen to give metal dihalides,  $MX_2$ . M = Be, Mg, Ca and Sr and X = Cl and Br.
- Group 2 metal hydrides are thermally more stable than the alkali metal hydrides.



# **Learning Outcomes**

At the end of this session you should be able to

- give the sources and methods used to isolate alkali earth metals, particularly, magnesium.
- compare the variation in properties of alkali earth metals such as ionic radius, melting points, density, and ionization energies, as you go down the Group.
- write the electron configuration of a Group 2 element or ion.
- explain the properties and reactions of alkaline earth metals and their compounds.



### Activity

- 14. Determine the oxidation states of the non-metals in the following substances:
  - (i)  $SiO_3^{2-}$

- (ii)  $SO_3^{2-}$  (iii)  $PO_4^{3-}$  (iv)  $[Be(OH)_4]^{2-}$
- 15. Draw the structures of the following anions:  $SiO_3^{2-}$ ,  $SO_3^{2-}$ ,  $PO_4^{3-}$ ,  $[Be(OH)_4]^{2-}$ (Hint: Think about the valency & possible oxidation state(s) of atoms/ions)
- 16. What do you think about the relative solubility of Mg(OH)<sub>2</sub> and Ca(OH)<sub>2</sub> in water?
- 17. What is the alkaline earth metal which does not react with water?
- 18. Write a balanced equation for the reaction between strontium and bromine.

# 3. Uses and some industries of s-block elements

#### Introduction

In this lesson, we consider uses and some industries based on *s*-block elements. The chloralkali industry refers to the industries that produce chlorine (Cl<sub>2</sub>), sodium hydroxide (NaOH) and sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>). These three chemicals are used in a large number of chemical processes; for example, production of paper, glass, soap, alkaline cleaners and polymers. In industry, Na<sub>2</sub>CO<sub>3</sub> is known as soda ash. In USA, there are deposits called 'trona' which are mixtures of sodium carbonate and bicarbonate, Na<sub>2</sub>CO<sub>3</sub>·NaHCO<sub>3</sub>·2H<sub>2</sub>O. Na, Li and Mg are obtained by the electrolysis of their molten chlorides. Methods for preparation of calcium salts such as CaO, Ca(OH)<sub>2</sub>, CaCl<sub>2</sub>, CaSO<sub>3</sub> and CaSO<sub>4</sub>were discussed in the previous lesson.

#### 3.1 Production of chlorine and NaOH

Chlorine and NaOH are both made by the electrolysis of brine (salt water). There are two types of cells used for this process.

- 1. The diaphragm cell
- 2. The mercury cell

#### The diaphragm cell method

In Sri Lanka at Paranthan, NaOH is produced by the **diaphragm cell** method. In the diaphragm cell the anode (graphite) and the cathode (steel) are separated into two compartments by a diaphragm made of asbestos. A NaCl solution is electrolyzed to produce chlorine, hydrogen and NaOH as shown below.

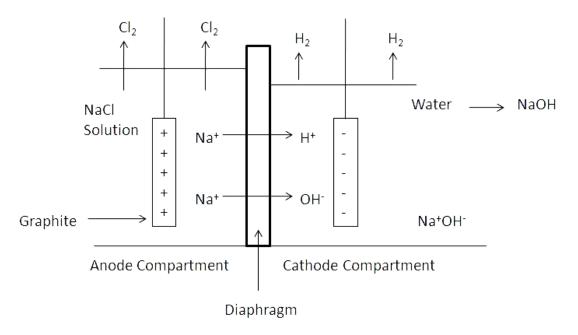


Figure 1: Diagram of a diaphragm cell

#### **Anode reaction**

At the anode, Cl<sup>-</sup> ions are oxidized to chlorine gas.

$$2 \text{ Cl}^-(aq) \longrightarrow \text{Cl}_2(g) + 2e$$

#### **Cathode reaction**

At the cathode, H<sup>+</sup> ions (from water) are reduced to hydrogen gas.

$$2 \text{ H}_2\text{O}(1) + 2e \longrightarrow 2 \text{ OH}^-(aq) + \text{H}_2(g)$$
  
or  
 $2 \text{ H}^+(aq) + 2e \longrightarrow \text{H}_2(g)$ 

During electrolysis, OH<sup>-</sup> ions are produced, therefore the solution becomes increasingly alkaline. Na<sup>+</sup> ions can pass through the diaphragm into the cathode compartment. These Na<sup>+</sup> ions combine with OH<sup>-</sup>ions to form an aqueous solution of NaOH.

$$Na^{+}(aq) + OH^{-}(aq) \longrightarrow NaOH(aq)$$

It is important to maintain the liquid level in the anode compartment higher than that in the cathode compartment. This allows continuous flow of sodium ions into the cathode compartment. Otherwise  $OH^-$  ions may reach the anode and get oxidized to give  $O_2$ .

## The mercury cell method

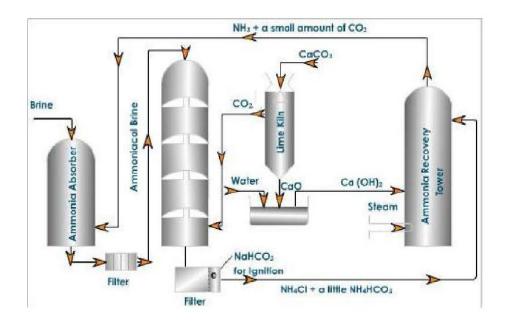
In the **mercury cell** method, brine is continuously passed into a cell that has graphite anodes and a moving layer of mercury as the cathode. As usual, Cl<sup>-</sup> ions are oxidized to give Cl<sub>2</sub>. In contrast to the **diaphragm cell** method, here Na<sup>+</sup> ions are reduced to form sodium amalgam (NaHg) which with unused mercury travels out of the cell into a chamber containing water. In this chamber, NaHg reacts with water to give NaOH, Hg and H<sub>2</sub> as given below.

$$2 \text{ NaHg(s)} + 2 \text{ H}_2\text{O(l)} \longrightarrow 2 \text{ Na}^+(\text{aq}) + 2 \text{ OH}^-(\text{aq}) + 2 \text{ Hg(l)} + \text{H}_2(\text{g})$$

# 3.2 Production of Na<sub>2</sub>CO<sub>3</sub>

Large scale production of Na<sub>2</sub>CO<sub>3</sub> is achieved by the Ammonia-soda or **Solvay** process (see figures 2 and 3). Limestone (CaCO<sub>3</sub>) and NaCl are the starting materials, and the production process consists of the following steps.

- (1) Production of saturated brine solution
- (2) Saturation of brine solution with ammonia
- (3) Production of carbon dioxide by roasting of limestone
- (4) Production of NaHCO<sub>3</sub>
- (5) Conversion of NaHCO<sub>3</sub> to Na<sub>2</sub>CO<sub>3</sub>.



*Figure 2:* Production of  $Na_2CO_3$  by the Solvay process (from reference 7)

Saturated brine solution is made by dissolving NaCl in water (**Step 1**). It is important to have the brine solution free from magnesium and calcium ions; otherwise the final product (Na<sub>2</sub>CO<sub>3</sub>) gets contaminated with CaCO<sub>3</sub> and MgCO<sub>3</sub>. Then, this brine solution is treated with ammonia to saturate the brine with ammonia (**Step 2**).

CO<sub>2</sub> is produced by heating limestone in the column (Step 3).

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

Now, the solution containing brine and ammonia is passed down a tower, against an upward moving current of  $CO_2$  which precipitates  $NaHCO_3$  (Step 4). The reaction can be summarized as given below.

$$NaCl(aq) + NH_3(aq) + CO_2(g) + H_2O(l) \longrightarrow NH_4Cl(aq) + NaHCO_3(s)$$

The resulting NaHCO<sub>3</sub> precipitate is separated and heated in a rotary drier to obtain Na<sub>2</sub>CO<sub>3</sub> (**Step 5**)

2 NaHCO<sub>3</sub>(s) 
$$\stackrel{\triangle}{\longrightarrow}$$
 Na<sub>2</sub>CO<sub>3</sub>(s) + H<sub>2</sub>O(g) + CO<sub>2</sub>(g)

The resulting CaO (in Step 3) is converted into Ca(OH)<sub>2</sub> by adding water.

$$CaO(s)+ H_2O(1) \longrightarrow Ca(OH)_2(aq)$$

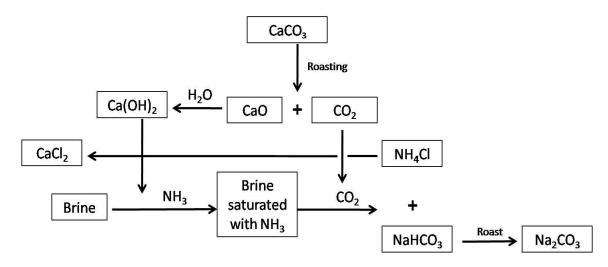
NH<sub>4</sub>Cl(aq) filtrate obtained in (**Step 4**) is reacted with aqueous Ca(OH)<sub>2</sub> to regenerate NH<sub>3</sub> gas. Thus NH<sub>3</sub> is reused during the ammonia-soda process.

$$Ca(OH)_2(aq) + 2 NH_4Cl(aq) \longrightarrow CaCl_2(aq) + 2 H_2O(1) + 2 NH_3(g)$$

The only by-product of this process is CaCl<sub>2</sub>, therefore the overall reaction can be summarized as given below.

$$CaCO_3(s) + 2 NaCl(s) \longrightarrow Na_2CO_3(s) + CaCl_2(s)$$

Sodium carbonate can be crystallized from water as the decahydrate  $Na_2CO_3\cdot 10H_2O$ . An aqueous solution of  $Na_2CO_3$  is alkaline. In the laboratory,  $Na_2CO_3$  is used as a primary standard to standardize acids. In qualitative analysis,  $Na_2CO_3$  is used to precipitate carbonates of  $Ca^{2+}$ ,  $Ba^{2+}$  and  $Sr^{2+}$ . In industry,  $Na_2CO_3$  is used to make glass, caustic soda (NaOH) and other salts.



**Figure 3:** Flow chart of the key stages of the production of  $Na_2CO_3$  by the Solvay process

#### 3.3 Production of NaCl

In Sri Lanka, NaCl is produced by concentrating sea water. As the first step, sea water is collected to a tank. Concentration of the solution is achieved by evaporation of water under the hot sun with the help of blowing wind. Precipitation of CaCO<sub>3</sub> takes place as the concentration of the solution increases. CaCO<sub>3</sub> precipitate is separated by transferring the concentrated solution into a second tank. Further concentration of the solution leads to the precipitation of gypsum (CaSO<sub>4</sub>·2H<sub>2</sub>O). Gypsum is removed by transferring the concentrated solution to a third tank.

Upon further concentration, NaCl crystallizes out leaving MgCl<sub>2</sub>, MgBr<sub>2</sub> and MgSO<sub>4</sub> in the solution, which can be used to extract magnesium. Finally, NaCl crystals are washed with an 8% NaCl solution to get rid of any impurities attached to the solid. A small amount of iodate (IO<sub>3</sub><sup>-</sup>) salts is added as a food supplement (source of iodine) before table salt is marketed for human consumption.

# 3.4 Production of salts of Group 2 elements

Methods for preparation of calcium salts such as CaO, Ca(OH)<sub>2</sub>, CaCl<sub>2</sub>, CaSO<sub>3</sub> and CaSO<sub>4</sub> are given under the topic the Group 2 elements (see section 2.3).

## 3.5 Solubility of salts of s-block elements

Salts of *s*-block elements are used in every laboratory. Your knowledge in solubility of common salts of *s*-block elements in water is important in terms of purification and isolation of products from a reaction mixture. Solubility of common salts of *s*-block elements is given below.

## **Group 1 elements**

Almost all the salts (halides, hydroxides, carbonates, bicarbonates, nitrates, nitrites, sulfides, sulphates, sulphites) of Group 1 elements are soluble in water.

#### **Group 2 elements**

All the halides, sulphides, nitrates, nitrites, and bicarbonates of Group 2 elements are soluble in water.

Be(OH)<sub>2</sub> and Mg(OH)<sub>2</sub> are insoluble in water,  $Ca(OH)_2$  and  $Sr(OH)_2$  are slightly soluble in water and Ba(OH)<sub>2</sub> is soluble in water.

BeSO<sub>3</sub> and MgSO<sub>3</sub> are soluble in water, CaSO<sub>3</sub> is slightly soluble in water, SrSO<sub>3</sub> and BaSO<sub>3</sub> are insoluble in water.

BeSO<sub>4</sub> and MgSO<sub>4</sub> are soluble in water, CaSO<sub>4</sub> is slightly soluble in water, SrSO<sub>4</sub> and BaSO<sub>4</sub> are insoluble in water.

All carbonates of Group 2 elements are insoluble in water.

# 3.6 Uses of s-block elements and their compounds

Some important uses of s-block elements and their compounds are given below.

Li<sub>2</sub>CO<sub>3</sub> is used as an inorganic drug to treat manic-depressive disorders; LiAlH<sub>4</sub>, butyl lithium (BuLi), methyl lithium (MeLi) are used as reagents in organic chemistry; Li and lithium compounds are used in dry cells and storage batteries.

Compounds of sodium including "common salt" (NaCl), "soda ash" (Na<sub>2</sub>CO<sub>3</sub>), "baking soda" (NaHCO<sub>3</sub>), "caustic soda" (NaOH) are important to paper, glass, soap, textile and chemical industries. NaOCl is a bleaching agent.

KNO<sub>3</sub> and KClO<sub>3</sub> are used in fireworks; KMnO<sub>4</sub> is an important oxidizing agent; KOH is used in the preparation of potassium phosphate for liquid detergents.

Soap contains sodium salts (RCO<sub>2</sub>Na) of long chain carboxylic acids. Sodium stearate is produced by reacting NaOH with stearic acid.

Mg(OH)<sub>2</sub> is used to neutralize acids in the mouth and stomach.

Calcium carbide  $(CaC_2)$  is used to generate acetylene  $(C_2H_2)$  which is used to generate oxyacetylene flame. CaO is used for the production of cement.

BaSO<sub>4</sub> is an imaging agent used to detect stomach ulcers.

# **Summary**

- The chloralkali industry refers to the industries that produce chlorine (Cl<sub>2</sub>), sodium hydroxide (NaOH) and sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>).
- Chlorine and NaOH are both made by the electrolysis of brine (salt water).
- In Sri Lanka at Paranthan, NaOH is produced by the diaphragm cell method. In the mercury cell method, brine is continuously passed into a cell that has graphite anodes and a moving layer of mercury as the cathode.
- Large scale production of Na<sub>2</sub>CO<sub>3</sub> is achieved by the Ammonia-soda or Solvay process.
- Methods for preparation of calcium salts such as CaO, Ca(OH)<sub>2</sub>, CaCl<sub>2</sub>, CaSO<sub>3</sub> and CaSO<sub>4</sub> are given in section 2.3.
- Solubility of salts of s-block elements is given in section 3.5.



# **Learning Outcomes**

At the end of this session you should be able to

- describe the production of chlorine, NaOH, NaCl and Na<sub>2</sub>CO<sub>3</sub>
- compare the solubility of salts of *s*-block elements
- list the uses of s-block elements and their salts



#### **Activity**

- 19. What is meant by "Chloralkali industry"?
- 20. Describe the production of NaOH and chlorine using a diaphragm cell.
- 21. What is the starting material used in the production of chlorine in the chemical factory at Paranthan, Sri Lanka. What are the electrodes used for this process? Write the equations for the anodic and cathodic reactions.
- 22. Identify the electrodes used in the mercury cell method? Describe the chemical process which takes place at the cathode.
- 23. How is CO<sub>2</sub> produced for the ammonia soda process?

## **Abbreviations**

(aq) - Aqueous; dissolved in water

(g) - Gas state

 $\Delta$  - Heat

(l) - Liquid state

(s) - Solid state

b.pt./b.p. - Boiling point

C.N. - Coordination number

eV - Electron Volt

IE<sub>i</sub> i<sup>th</sup> ionization energy

J - Joule

L - Ligand

M - Metal

M - Zerovalent metal =  $M(0) = M^{0}$ 

M(g) - Element in gas state

m.pt/m.p - Melting point

 $M^+$  - Monovalent metal =  $M(I) = M^I$ 

 $M^{2+}$  - Divalent metal =  $M(II) = M^{II}$ 

nm - nanometres

O.N. - Oxidation number

pm - picometres

X - Halogen

Z - Atomic number

## **Glossary**

Acid-base titrations : The determination of the concentration of an acid or base by exactly

neutralizing the base/acid with an acid/base of known concentration.

අම්ල-භෂ්ම අනුමාපනය : දන්නා සාන්දුණ සහිත අම්ල/භෂ්ම මඟින් භෂ්ම/අම්ල සම්පූර්ණයෙන්ම

උදාසිනීකරණය කර අම්ලයක හෝ භෂ්මයක සාන්දුණය හරියටම නිර්ණය කිරීම

அமில கார நியமிப்பு : தெரிந்த செறிவுடைய அமில/காரத்தை உபயோகித்து திருத்தமான

நடுநிலையாக்கம் செய்வதன் மூலம் செறிவு அறியப்பட வேண்டிய

அமில/காரத்தின் செறிவை கண்டறிதல்.

Allotropic forms : The property of some chemical elements to exist in two or more different

forms

බහුරූපී ආකාර : සමහර මූලදුවා වලට ආකාර දෙකක් හෝ ඊට වඩා වැඩි ආකාර ගණනකින්

පැවතීමේ ගුණය

பிறதிருப்பம் : சில இரசாயன மூலகங்களின் 2 அல்லது அதற்கு மேற்பட்ட வெளிப்படும்

நிலைகளின் இயல்பு.

Alloys : Metallic substance made by mixing and fusing two or more metals, or a metal

and a nonmetal, to obtain desirable qualities such as hardness, lightness, and

strength, e.g. brass, bronze, and steel, etc.

මිශු ලෝහ : දෘඩතාවය, සැහැල්ලු බව සහ ශකිතිමත් බව යන අභිමත ලක්ෂණ ලබා ගැනීමට

ලෝහ දෙකක් හෝ වැඩි ගණනක්, ලෝහයක් හා අලෝහයක් හෝ විලයනය කර මිශු

කර සාදනු ලබන ලෝහමය දුවා උදාඃ පිත්තල, ලෝකඩ, වානේ

கலப்புலோகம் : இரண்டு அல்லது அதற்கு மேற்பட்ட உலோகங்கள்,அல்லது உலோகம்

மற்றும் அலோகப் பதார்த்தங்களின் சேர்க்கையால் உருவாக்கப்பட்ட உலோகப்

பதார்த்தம்.

Alums : Crystalline double salts of a trivalent metal (such as Al, Cr, or Fe) and a

monovalent metal (such as K or Na).

ඇලම්/සීනක්කාරම් : තිුසංයුජ ලෝහ (Al , Cr හෝ Fe වැනි) සහ ඒක සංයුජලෝහවල (K හෝ Na වැනි)

ස්ඵටිකමය ද්වියෝග ලවණ.

சீனாக்காரம், படிகாரம் : மூவலுவளவுள்ள உலோகத்தினதும் ஒருவலுவளவுள்ளஉலோகத்தினதும்

இரட்டைப் பளிங்குருவுள்ள உப்பு

Amorphous : Not crystalline; lacking definite form; having no specific shape; formless.

අස්එටික : ස්එටික නොවේ; ස්ථීර හැඩයක් හා වූූනයක් නොමැත.

உருவற்ற திண்மம் : பளிங்குருவற்ற, குறிப்பிட்ட உருவமில்லாத, உருவற்ற, திட்டமான,நிலையில்லாத

பதார்த்தம்.

Amphoteric : Capable of functioning either as an acid or as a base.

උභයගුණි : අම්ල හා භෂ්ම ලෙස කිුිිියා කිරීමට හැකියාව ඇත.

ஈரியல்பு : அமிலமாகவும் காரமாகவும் தொழிற்படும் தன்மை

Analogue : One of a group of chemical compounds similar in structure but different in

respect to elemental composition.

සමාකාර : වූහයෙන් සමාන රසායනික සංයෝග වලින් එකක් වන නමුත් මූලදුවා සංයුතිය

අතින් වෙනස් වේ.

: ஓரே கட்டமைப்பையும் வேறுபட்ட மூலகங்களின் அமைப்பும் கொண்ட இரசாயன

சேர்வைகளின் ஒரு கூட்டமாகும்.

Anhydrous : Not containing water, especially water of crystallization

තිර්ජලීය : ජලය අඩංගු තොවේ, විශේෂයෙන්ම ස්ඵටික ජලය.

நீர்ற்ற : நீர் அற்ற நிலை, பளிங்குருவிற்கான நீர் அற்ற நிலை.

Basicity : The state of being a base.

භාෂ්මිකතාවය : භෂ්මයක් ලෙස පැවතීමේ හැකියාව

மூலத்திறன் : மூலமாக தொழிற்படும் நிலை

Brine : Any saline (salt) solution

කරදිය : ලුණු අඩංගු ලවණමය දුාවණයක්

உப்பு : ஏதாவது உவர்ப்பான (உப்பு) கரைசல்.

Chloralkali Industry : An industrial chemical process based on the electrolysis of brine (aqueous

sodium chloride) for the production of caustic soda and chlorine.

ක්ලෝරෝඤාර කර්මාන්ත: කරදිය (NaCl ජලීය දුාවණය) විදුපුත් විච්ඡේදනය කිරීම මඟින් කෝස්ටික් සෝඩා සහ

ක්ලෝරීන් නිපදවීමේ රසායනික කියාවලිය හා බැඳුණු කර්මාන්තයි.

: உப்புக்கரைசலை மின்பகுப்பு செய்வதன் மூலம் எரிசோடாவும், குளோரினும் உந்பத்தி செய்யும் ஒரு தொழிற்சாலை முறை

Coordination number : The number of coordinated atoms surrounding the central metal atom/ion in

a complex or crystal.

සංගත අංකය : සංකීර්ණ සංයෝගයක හෝ ස්එටිකයක මධා ලෝහපරමාණුව/අයනය වටා සංගතව

බැඳී පවතින පරමාණු සංඛ්‍යාව

இணைப்பு எண் : ஒரு சிக்கற் சேர்வையில் அல்லது பளிங்கில் உள்ள மையஅணுவை சூழ

இணைந்துள்ள அணுக்களின் எண்ணிக்கை

Cracking : The process of breaking down complex chemical compounds by heating

them.

බිදීම : සංකීර්ණ රසායනික සංයෝග රත්කිරීම මඟින් බිඳ දුමීමේ කිුයාවලියයි.

உடைதல : வெப்ப சக்தியை வழங்குவதன் மூலம் இரசாயன சிக்கற்சேர்வையை

உடைத்துப் பிரிக்கும் முறை

Degree of polarization : A quantity used to describe the portion of an electromagnetic wave which is

polarized.

ධැවීකරණ පුමාණය : විදාුත් චුම්භක තරංගයක් කොපමණ දුරට ධැවීකරණය වී ඇතිදයි විස්තර කිරීමට

භාවිතා කරනු ලබන පුමාණයයි/මිණුමයි.

முனைவாக்கத்தின் அளவு: முனைவாக்கப்பட்ட மின்காந்த அலையை விபரிப்பதற்கு பிரயோகிக்கப்படும்

அளவுப்பிரமாணம்.

Electrode potential : The measure of individual potential of a reversible electrode at standard

conditions (E°).

ඉලෙක්ටෝඩ විභවය : සම්මත තත්ව යටතේ දී පුතාාවර්ත ඉලෙක්ටෝඩයක විභවය පිළබඳ මිනුමකි.

மின்வாயழுத்தம் : நியம நிலையிலுள்ள மீளும் மின்வாயின் தனிப்பட்ட அழுத்த அளவு

Electron configuration : Specific distribution of electrons in atomic orbitals of atoms or ions.

ඉලෙක්ටෝනික විනාහසය: පරමාණුවක හෝ අයනයක කාක්ෂිකවල ඉලෙක්ටෝන පැතිරී ඇති ආකාරයී

இலத்திரனிலையமைப்பு : அணுக்களினது/அயன்களினது அணுவொழுக்கில் இலத்திரன்களின் குறிப்பிட்ட

பரம்பல்.

Electronegativity : The tendency of an atom to attract shared electrons

විදුපුත් සෘණතාවය : බන්ධනයක ඇති ඉලෙක්ටුෝන තමා දෙසට ඇද ගැනීමේ හැකියාවයි.

மின்னெதிரியல்பு : பங்கிடப்பட்ட இலத்திரன்களை கவரும் அணுக்களின் தன்மை.

Electropositive : The tendency of an atom to remove valence electrons.

විදයුත් ධනතාවය : සංයුජතා කවචයේ පවතින ඉලෙක්ටෝන ඉවත් කිරීමට පරමාණුවක් සතු හැකියාවයි.

மின்னேரியல்பு : வலுவளவு இலத்திரன்களை அகற்றும் அணுக்களின் தன்மை.

Exothermic : Heat energy is transferred to the surroundings during a chemical reaction.

තාපදායක : රසායනික පුතිකියාවක දී බාහිර පරිසරයට තාප ශක්තිය පිට කිරීමේ කිුයාවලිය

புறவெப்பம் : இரசாயன தாக்கத்தின் போது சுற்றுப் புறத்துக்கு வெளிவிடப்படும் வெப்பசக்தி.

Fractional distillation : A process by which components in a chemical mixture are separated

according to their different boiling points.

භාගික ආසවනය : මිශුණයක පවතින සංයෝග ඒවායේ තාපාංක අනුව වෙන් කිරීමේ කිුයාවලියයි.

பகுதிபடகாய்ச்சி வடித்தல் : இரசாயன கலவையிலுள்ள சேர்வைகளை அவற்றின் வேறுபட்ட கொதிநிலைகளின் அடிப்படையில் பிரித்தெடுக்கும் முறை. Furnace : an enclosed chamber in which heat is produced to generate steam, destroy

refuse, smelt or refine ores, etc.

උෟෂ්මකය : නුමාලය නිපදවීමට, අපදුවා විනාශ කිරීමට, විරුවීමට හෝ ශුද්ධ කිරීමට තාපය

නිපදවනු ලබන සංවෘත කුටීරයයි.

உலை : கழிவுகளை நீக்குவதற்கு, உருக்குதல் அல்லது தாதுப்பொருட்களை

சுத்திகரிப்பதற்கு, ஆவியை உருவாக்குவதற்கு தேவையான வெப்பத்தை

உந்பத்தியாக்கும் ஒரு மூடப்பட்ட அதை.

Geometry : The arrangement of a molecule in the space.

ජාාමිතිය : අණුවක තිුමාණ සැකසුම/වාූහය

கேத்திர கணித உருவம்: ஒரு வெளியிலுள்ள மூலக்கூறினுடைய ஒழுங்கமைப்பு.

Group number : The number of a vertical column in the periodic table; there are 18 groups.

කාණ්ඩ අංකය : ආවර්තිතා වඟුවේ සිරස් තීරුවකට අයත් අංකය.එහි කාණ්ඩ 18 කි.

கூட்ட எண் : ஆவர்த்தன அட்டவணையில் நிலைக்குத்து நிரை கூட்டமாகும்

Hydration : The act or process of combining or treating with water.

සජලනය : ජලය සමඟ එකතු වීම හෝ සම්බන්ධ වීමේ කිුිිියාවලිය

நீரேற்றம் : நீருடன் சேர்க்கைஅடையும் தாக்கம்

Hydrolysis : The breaking down of a chemical compound into two or more simpler

compounds by reacting with water.

ජල විච්ඡේදනය : ජලය සමඟ පුතිකිුිිිියා කර රසායනික සංයෝගයක් සරල සංයෝග දෙකක් හෝ

කිහිපයක් බවට බිඳ හෙලීම

நீர்ப்பகுப்பு : நீருடன் தாக்கமடைவதன் மூலம் இரசாயனச் சேர்வைகள் 2 அல்லது அதற்கு

மேற்பட்ட பகுதிகளாக உடையும் பொறிமுறை.

Ionic radius : The radius exhibited by an ion in an ionic crystal where the ions are packed

together to a point where their outermost electronic orbitals are in contact

with each other.

අයනික අරය : අයනික ස්ඵටික දැලිසක වෙනත් අයන සමඟ සම්බන්ධව පවතින බාහිර ඉලෙක්ටුෝන

සහිත කාක්ෂිකයක් ඇති අයනයක අරය

அயன்ஆரை : அயன்கள் தமது வெளியோட்டு இலத்திரனியல் ஒழுக்குகளின் தொடர்பினால்

ஒன்றாக அடுக்கப்பட்டு உருவாக்கப்பட்ட அயனாக்கப்பட்டபளிங்குருவிலுள்ள

அயனால் தோந்றுவிக்கப்பட்ட ஆரை.

Ionization energies : The minimum amount of energy required to remove the most loosely held

electron of an isolated gaseous atom or ion.

අයනීකරණ ශක්තිය : නිදහස් වායුමය අවස්ථාවේ පවතින පරමාණුවක ලිහිල්වම බැඳී ඇති

ඉලෙක්ටෝනයක් ඉවත් කිරීමට අවශා අවම ශක්ති පුමාණය

அயனாக்கற் சக்தி : தனிப்பட்ட வாயு அவத்தையில் உள்ள அணு அல்லது அயனில் வலிமையற்று

பிணைக்கப்பட்டு இருக்கும் ஒரு இலத்திரனை அகற்றுவதற்காக் தேவைப்படும்

மிகக்குறைந்த சக்தி.

Isoelectronic : Several dissimilar atoms or ions with identical electronic configurations.

සමඉලෙක්ටෝනික : එකම ඉලෙක්ටෝනික විනාහසය සහිත විවිධ පරමාණු හෝ අයන

சமவிலத்திரனுக்குரிய : ஒரே மாதிரியான இலத்திரன் நிலையமைப்புக் கொண்ட வேறுபட்ட அணுக்கள்

அல்லது அயன்கள்.

Isotopes : Two or more forms of atoms of the same element with different masses;

atoms containing the same number of protons but different numbers of

neutrons.

සමස්ථානික : එකම මූලදුවායේ විවිධ ස්කන්ධ සහිත පරමාණු; එකම පෝටෝන සංඛාාවක් සහිත

නමුත් විවිධ නිසුටෝන සංඛාහ සහිත පරමාණු

சமதானிகள் : வேறுபட்ட திணிவுடைய ஒரு மூலகத்தினது 2 அல்லது அதற்கு மேற்பட்ட

அணுவமைப்பு அவ்வணுக்கள் ஒரே மாதிரியான புரோத்தன் எண்ணிக்கையையும் வேறுபட்ட நியூத்திரன் எண்ணிக்கையையும்

கொண்டிருக்கும்.

Lattice energy : The energy required to separate completely the ions in an ionic solid.

දැලිස ශක්තිය : අයනික ඝණයක්, අයනවලට සම්පූර්ණයෙන්ම වෙන්කිරීමට අවශා ශක්තිය

சாலகச்சக்தி : ஒரு திண்ம அயன் கட்டமைப்பிலிருந்து அயன்களை முற்றாக பிரிப்பதற்காக

தேவைப்படும் சக்தி.

Magnetic resonance

: A medical imaging technique used in radiology to visualize detailed internal structures.

imaging

චුම්භක අනුනාද දර්ශණය: සවිස්තරාත්මක ලෙස අභාන්තර වහුහ දැක ගැනීමට වෛදා විදාාවේ විකිරණ

විදාහවේ දී භාවිතා කරනු ලබන දර්ශණය කිරීමේ උපකුමයයි.

காந்தப்பிரிவு உருப்படம் : விரிவான அகப்புறக் கட்டமைப்பை பார்வையிட கதிரியல்பை உபயோகித்து

பெறப்படும் மருத்துவ உருவப்படம்.

Melting point : The point at which the crystals of a pure substance are in equilibrium with the

liquid phase at atmospheric pressure.

දුවාංකය : වායුගෝලීය පීඩනය යටතේ දී සංශුද්ධ දුවායක ස්එටික එහි දුව කලාපය සම්ග

සමතුලිතව පවතින උෂ්ණත්වයයි.

உருகு நிலை : பளிங்குருவான தூய பதார்த்தமானது வளிமண்டல அமுக்கத்தில் அதன் திரவ

அவத்தையுடன் சமநிலையில் இருக்கும் புள்ளி.

Molten : The phase change of a substance from a solid to a liquid.

දුව වීම : දුවායක් ඝන අවස්ථාවක සිට දුව අවස්ථාවක් දක්වා කලාප මාරු වීමයි.

உருகுதல் : சில பதார்த்தம் திண்ம அவத்தையிலிருந்து திரவ அவத்தைக்கு மாறும்

செயற்பாடு

Monobasic acid : An acid that has only one hydrogen ion to donate to a base in an acid-base

reaction (e.g. HNO<sub>3</sub>, HCl).

ඒකභාෂ්මික අම්ල :අම්ල භෂ්ම පුතිකිුිිියාවක දී, භෂ්මයකට එක් පුෝටෝනයක් දායක කිරීමට සමත් අම්ල

ஒருமூல அமிலம் : ஒரு அமில கார தாக்கத்தில், காரத்திற்கு வழங்குவதற்கு ஒரு ஐதரசன்

அயனை மட்டுமே கொண்ட அமிலம்  $(\mathsf{HNO_3},\mathsf{HCl})$ 

Monoprotic acid : Acid that can form only one proton (H<sup>+</sup>) per molecule; may be strong or weak.

ඒක පෝටික අම්ල : එක් අණුවක් මඟින් එක් හයිඩොන්නියම් අයණයක් පමණක් සෑදිය හැකි අම්ල; මේවා

පුබල හෝ දුබල අම්ල විය හැකියී

: ஒரு மூலக்கூரிலிருந்து ஒரு புரோத்தனை உருவாக்கக்கூடிய அமிலம். அது

வன்னமிலமாகவோ அல்லது மென்னமிலமாகவோ இருக்கலாம்.

Oxidation state : The state of an element or ion in a compound with regard to the electrons

gained or lost by the element or ion in the reaction that formed the

compound.

ඔක්සිකරණ තත්වය : මුලදවාක හෝ අයනයක අඩංගු ධන හෝ සෘණ ආරෝපිත පුමාණය

ஒட்சியேற்றல் நிலை : தாக்கம் ஒன்றின் ஒரு சேர்வையை உருவாக்குவதற்காக மூலகம்

அல்லது அயன் ஒன்றினால் இலத்திரன்கள் ஏற்கப்படும் அல்லது

இழக்கப்படும் நிலை.

Oxidizing agent : A chemical compound that readily transfers oxygen atoms or a substance that

gains electrons in a redox chemical reaction

ඔක්සිකාරක දුවා : පුතිකිුියාවක දී ඔක්සිජන් පිටකරනු ලබන හෝ ඉලෙක්ටෝන ලබා ගනු ලබන හෝ

රසායනික සංයෝග

ஒட்சியேற்றும் கருவி :இரசாயன தாழ்த்தல் தாக்கத்தில் ஒட்சிசன் அணுவை இடமாற்றும் இரசாயன

சேர்வை அல்லது இலத்திரன்களை வாங்கும் பதார்த்தம்.

Paramagnetic : A substance that shows magnetic properties when placed in a magnetic field.

අනුක්ෂේතු චුම්භක : චුම්භක ක්ෂේතුයක් තුළ තැබූ විට චුම්භක ලක්ෂණ පෙන්වන දුවායි.

பரகாந்தத்திற்குரிய : காந்தப்புலத்திலுள்ள போது காந்த இயல்பைக் காட்டும் ஒரு பதார்த்தம்.

Peroxide : A compound containing the bivalent group  $O_2^{2-}$ , derived from hydrogen

peroxide (H<sub>2</sub>O<sub>2</sub>), sodium peroxide (Na<sub>2</sub>O<sub>2</sub>).

පෙරොක්සයිඩ : H,O,තෝ Na,O,වලින් ඇති වූ ද්විසංයුජ O,²- කාණ්ඩයක් පවතින සංයෝගයකි.

பேரொட்சைட்டு : ஐதரசன் பேரொட்சைட்டு, சோடியம் பேரொட்சைட்டு என்பவற்றிலிருந்து வழிவந்த

இருவலுவளவு கூட்டச் சேர்வை  $(O_2^{2-})$ 

Polarizing power : A charged species such as a proton can attract negatively charged electrons

which causes a shift in the orbital.

ධැවීකරණ බලය : (+) ආරෝපිත අංශුවකට සෘණ ලෙස ආරෝපිත ඉලෙක්ටෝන ආකර්ශණය කර ගත

හැකි අතර මේවා මඟින් කාක්ෂිකවල වෙනසක් ඇති කරනු ලබයි.

முனைவுக்குரிய சக்தி : ஒழுக்குப்பெயர்வு நிகழ்வதற்கு காரணமான எதிரேற்ற இலத்திரன்களை கவரும்

புரோத்தன் போன்ற ஏற்றம்.

Primary standard : A primary standard is a substance from which a standard solution can be

prepared by direct weighing of substance and dissolving in a definite volume

of a solvent.

පුාථමික සම්මතය : කෙලින්ම බර කි්රා එය දන්නා දුාවක පරිමාවක දිය කර ගැනීමෙන් සම්මත

දුාවණයක් සෑදිය හැකි දුවා වේ.

முதனியமம் ்: ஒரு பதார்த்தத்தின் குறித்த நிறையை நேரடியாக நிறுத்து அதை

குறிப்பிட்டளவு கனவளவு கரைசலில் கரைப்பதன் மூலம் நியமக்கரைசலை

தயாரிக்கப் பயன்படுத்தும் பதார்த்தம்.

Reducing agent : A substance that causes another substance to undergo reduction and that is

oxidized in the process.

ඔක්සිහාරක දුවා : වෙනත් දුවායයක් ඔක්සිහරණය කරවනු ලබන සහ එම දුවායයම ඔක්සිකරණය වීම

සිදුවන දුවායන්

தாழ்த்தும் கருவி : இது தான் ஒட்சியேற்றப்படுவதன் மூலம் ஏனையவற்றை தாழ்த்தும் ஒரு

பதார்த்தம்.

Roasting : Cooking (meat or other food) by direct exposure to dry heat, as on a spit.

කර කිරීම : දුවායක් කෙලින්ම තාපයට නිරාවරණය කර පිසීම.

வறுத்தல் : நேரடி வெப்பத்திற்குள்ளாக்கப்பட்டு சமைக்கப்படுதல் (இறைச்சி,உணவு)

Steam : Water in the form of an invisible gas or vapor.

හුමාලය : වායුමය හෝ වාෂ්ප ලෙස පවතින ජලය

ஆவி : கண்ணுக்குப் புலனற்ற வாயு அவத்தையிலுள்ள நீர்.

Superoxide : A compound that possesses the superoxide anion with the formula  $O_2^-$ .

සුපර්ඔක්සයිඩ : 0, යන රසායනික සූතුය සහිත සුපර්ඔක්සයිඩ් ඇනායනය පවතින සංයෝග

மேலொட்சைட்டு : 🔾 எனும் இரசாயன சூத்திரமுடைய அனயன்.

Tetrahedral molecule : A molecule in which the central atom is coordinated to four groups, located in

the four corners of a tetrahedron.

චතුස්තලීය අණුව : චතුස්තලයක කොන් හතරේ පිහිටි කාණ්ඩ 4 ක් මධා පරමාණුවකට සංගත ලෙස

බැඳී ඇති සංයෝගයකි.

நான்முகிக்குரிய மூலக்கூறு : மைய அணுவானது 4 கூட்டங்களுடன் இணைக்கப்பட்டு அவை

நான்முகியின் 4 முனைகளிலும் அமையப்பெற்ற ஒரு மூலக்கூறு.

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