CHAPTER 1

CHEMISTRY OF REPRESENTATIVE ELEMENTS

Teaching Periods	22	Assessment	02	Weightage %	18

1 IA 1A	2 IIA 2A	13 IIIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.008							2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.972	35 Br Bromine 79.904	36 Kr Krypton 84.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	113 Nh Nihonium unknown	114 Fl Flerovium [289]	115 Mc Moscovium unknown	116 Lv Livermorium [298]	117 Ts Tennessine unknown	118 Og Oganesson unknown

Alkali Metal | Alkaline Earth Metal | Basic Metal | Semimetal | Nonmetal | Halogen | Nobel Gas

Students will be able to:

- ✓ Recognize the demarcation of the Periodic Table into s-block, p-block, d-block, and f-block. (Understanding)
- ✓ Describe physical properties like atomic radius, ionization energy, electronegativity, electrical conductivity, oxidation states of elements and melting and boiling points of elements change within groups of representative elements. (Analyzing)
- ✓ Explain reactions of s-Block elements with oxygen, water, Halogens, nitrogen, hydrogen, alcohol and acids. (Understanding)
- ✓ Enlist flame test of s-Block Elements. (Applying)
- ✓ Explain Chemistry of Sodium Hydroxide and bleaching powder. (Understanding)
- ✓ Enlist functions of s-Block Elements and their important compounds in tabular form. (Understanding)
- ✓ Explain reactions of p-Block elements with oxygen, water, Halogens, nitrogen and hydrogen. (Understanding)
- ✓ Differentiate beryllium from other members of its group. (Analyzing)
- ✓ Explain the relative behaviour of halogens as oxidizing agents and reducing agents. (Applying)
- ✓ Compare the acidity of hydrogen halides. (Analyzing)
- ✓ Distinguish between an oxide and a peroxide. (Understanding)
- ✓ Write representative equations for the formation of oxides and sulphides. (Applying)
- ✓ Explain Chemistry of Sulphuric acid (Understanding)
- ✓ Enlist functions of some p-block elements and their important compounds in tabular form (Understanding)

Introduction

Periodic table is a systematic arrangement of elements based on their atomic numbers, electronic configuration and properties.

The long form of periodic table consists of seven horizontal rows known as periods and eighteen vertical columns known as groups. There are two types of groups in the periodic table. Sub group A, referred to as representative elements, and sub group B is known as transition elements. The block in the periodic table refers to specific sections based on the type of orbitals being filled by valence electrons. There are four blocks in the modern periodic table named as s-block, p-block, d-block and f-block. The elements of s-block are located on extreme left in the periodic table. It consists of groups IA and IIA. The valence shell electronic configuration of the elements of this block is ns^1 for alkali metals and ns^2 for alkaline earth metals. The p-block is found on extreme right of the periodic table and includes groups IIIA to VIIIA. Elements belong to this block possess a valence shell electronic configuration of ns^2, np^1 to ns^2, np^6. The d-block elements are located in the middle of the periodic table and cover up all sub group B. The general valence shell electronic configuration of these elements is ns^2, $(n-1)\ d^1$ to ns^2, $(n-1)\ d^{10}$. The f-block elements are located below the main body of periodic table and exist in two horizontal series of fourteen elements each, generally known as lanthanides and actinides. The valence configuration of f-block elements is $ns^{1,2}$, $(n-2)\ f^1$ to $ns^{1,2}$, $(n-2)\ f^{14}$.

The position of each element in a particular group, period and block can be identified by its electronic configuration. The principal quantum number (n) of the valence electrons represents the period of an element. While the group of an element is predicted from the number of electrons in the valence shell. For example, the atomic number of sulphur is 16 ($1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^4$), therefore it is predicted that sulphur belongs to third period and VIA group. Another feature of the long form of periodic table is the regular changes in the physical properties of elements downward in the group and along with the period except ignoring anomalies in certain places.

1.1 GENERAL GROUP TRENDS OF REPRESENTATIVE ELEMENTS

Elements in the long form of periodic table are arranged according to their increasing atomic number and electronic configuration in such a manner that their general properties are correlated to each other. They exhibit a regular trend in properties within each group, with some exceptions or anomalies occurring in specific positions.

"The regular variations in the properties of elements in a group of periodic table is called group trend". In this section we will discuss the group trends of various physical properties of s-block and p-block elements.

Atomic Radii

"Atomic radius is the distance between the nucleus of an atom to its outermost electron shell".

Group Trends

IA and IIA Groups

Elements of group IA are termed as alkali metals. They possess the largest atomic radii in their respective periods. However the atomic radii increase regularly from lithium to francium. It is because the number of energy levels occupied by electrons increases, resulting in an increase in the distance between the nucleus and the outermost electronic shell.

Similarly, the same trend applies to the elements of group IIA (Be to Ra). That means beryllium is the smallest alkaline earth metal (IIA) and barium is the largest, as shown in Table 1.1.

Table 1.1 Atomic radii of group IA and IIA in picometer (pm)

Alkali Metals (Group IA)	Atomic Radii (pm)	Alkaline earth Metals (Group IIA)	Atomic Radii (pm)
Li	152	Be	112
Na	186	Mg	145
K	227	Ca	194
Rb	248	Sr	219
Cs	265	Ba	253
Fr	348	Ra	215

Increase ↓

IIIA Group

Atomic radii of the elements of Boron family (Group IIIA) generally increase down the group (from boron to thallium). However, there is an exception to the trend between aluminum and gallium. Gallium has slightly smaller atomic radii than aluminum despite being located below it in the group. It is because of poor shielding effect caused by electrons of d-orbitals.

IVA to VIIIA Groups

The atomic radii of elements of Group IVA to Group VIIIA follow the similar group trend, increasing regularly from top to bottom within the group as shown in Table 1.2. The same reason for this trend is discussed as in the group trend of alkali metals.

Table 1.2 Trend in the atomic radii of p-block elements in Picometer (pm)

IIIA	IVA	VA	VIA	VIIA	VIIIA
B (85)	C (77)	N (75)	O (73)	F (72)	Na (71)
Al (143)	Si (118)	P (110)	S (103)	Cl (100)	Ar (98)
Ga (135)	Ge (122)	As (120)	Se (119)	Br (114)	Kr (112)
In (167)	Sn (140)	Sb (140)	Te (142)	I (133)	Xe (131)
Tl (170)	Pb (146)	Bi (150)	Po (168)	At (140)	Rn (141)

Increase (down the group)

Decrease (across the period)

Ionization Energy

"It is the energy needed to remove an electron from a neutral atom in the gas phase".

Group Trends

IA and IIA Groups

The ionization energy of alkali metals (Group IA) and alkaline earth metals (Group IIA) decreases as we move down the group. This is because the outermost electrons of these elements are located farther away from the nucleus as we go from top to bottom, leading to weaker attractive forces between the electrons and the nucleus. As a result, it requires less energy to remove the outer shell electrons from the atom, that is why the ionization energy decreases.

IIIA Group

The ionization energy (IE) trend in group IIIA elements has irregularities as we move down the group. Two exceptions highlight this irregularity. Firstly, gallium (Ga) has a higher ionization energy than aluminum (Al). Secondly, thallium (Tl) exhibits a higher ionization energy than indium (In). These irregularities occur due to insufficient shielding of the nuclear charge in gallium by 3d electrons and in thallium by 4f electrons.

IVA Group

The ionization energy of group IVA elements generally decreases from top to bottom in the group. However, there are irregularities observed between Tin (Sn) and Lead (Pb). This is because both tin and lead have nearly the same atomic radii, which is a result of the lanthanide contraction. Due to this, the attraction between the nucleus and the outer electrons becomes stronger and requires more energy to remove these electrons.

VA, VIA, VIIA and VIIIA Groups

The ionization energy of the remaining groups of representative elements (group VA, VIA, VIIA, VIIIA) follows a regular pattern. It decreases progressively from top to bottom as the atomic radii increase, as shown in Table 1.3.

Table 1.3 First ionization energies of representative elements in KJ/mol

Group IA	Group IIA	Group IIIA	Group IVA	Group VA	Group VIA	Group VIIA	Group VIIIA
Li (520)	Be (900)	B (800)	C (1090)	N (1400)	O (1310)	F (1680)	Ne (2080)
Ne (490)	Mg (730)	Al (577)	Si (780)	P (1060)	S (1001)	Cl (1250)	Ar (1520)
K (420)	Ca (590)	Ga (580)	Ge (762)	As (960)	Se (950)	Br (1140)	Kr (1350)
Rb (400)	Sr (550)	In (560)	Sn (700)	Sb (830)	Te (870)	I (1010)	Xe (1170)
Cs (380)	Ba (500)	Tl (590)	Pb (710)	Bi (800)	Po (810)	At (920)	Rn (1030)

Decrease

Increase

Electronegativity (EN)

"It is the measure of the tendency of an atom to attract the shared pair of electrons towards itself when it is involved in a covalent bond".

Group Trends

IA and IIA Groups

The electronegativity (EN) of alkali metals (Group IA) and alkaline earth metals (Group IIA) follows a regular decreasing trend from top to bottom. This trend can be explained by the regular increase in atomic radii as we move down the group. The larger atomic size results in a decreasing tendency for the atom to attract the shared pair of electrons towards itself.

IIIA Group

The electronegativity (EN) of group III elements initially decreases from Boron (B) to Aluminum (Al) and then increases from gallium (Ga) to tellurium (Te). This irregular increase in EN can be attributed to the poor shielding effect of the electrons in the d-orbital and f-orbitals, respectively.

IVA, VA, VIA and VIIA Groups

The electronegativity of groups IVA, VA, VIA, and VIIA decreases regularly from top to bottom. This trend can be explained by the same reason as discussed for alkali metals as shown in Table 1.4.

Table 1.4 **Electronegativity value of representative elements**

Group IA	Group IIA	Group IIIA	Group IVA	Group VA	Group VIA	Group VIIA
Li (1.0)	Be (1.5)	B (2.0)	C (2.5)	N (3.0)	O (3.5)	F (4.0)
Na (0.9)	Mg (1.2)	Al (1.5)	Si (1.9)	P (2.1)	S (2.5)	Cl (3.0)
K (0.8)	Ca (1.0)	Ga (1.6)	Ge (1.8)	As (2.0)	Se (2.4)	Br (2.8)
Rb (0.8)	Sr (0.95)	In (1.7)	Sn (1.8)	Sb (1.9)	Te (2.1)	I (2.5)
Cs (0.7)	Ba (0.9)	Tl (1.8)	Pb (1.8)	Bi (1.9)	Po (2.0)	At (2.2)

Decrease (down the groups)

Increase (across the rows)

Electrical Conductivity

"Electrical conductivity is the measurement of a material's capability to conduct electric current". It is a measure of how easily electric charges, such as electrons, can flow through a substance. Materials with high electrical conductivity allow electric current to pass through them easily, while materials with low electrical conductivity hinder the flow of electric charges.

The electrical conductivity of representative elements can vary widely. Alkali metals and alkaline earth metals generally exhibit high electrical conductivity due to their ability to easily transfer electrons. Group IIIA elements display moderate electrical conductivity, while elements in Group IVA can have variable conductivity ranging from poor (e.g., carbon and lead) to moderate (e.g., silicon and tin). Group VA, VIA, and VIIA elements typically have poor electrical conductivity. Noble gases, on the other hand, have extremely low electrical conductivity as shown in Table 1.5.

Table 1.5 Electrical conductivity trends of representative elements

Group Number	Trend of Electrical Conductivity
Group I and IIA	High electrical conductivity
Group IIIA	Moderate electrical conductivity
Group IVA	Variable electrical conductivity (Carbon: poor, Silicon: moderate, Germanium: moderate, Tin: moderate, Lead: poor)
Group VA	Moderate electrical conductivity
Group VIA	Poor electrical conductivity
Group VIIA (Halogens)	Poor electrical conductivity
Group VIIIA (Noble gases)	Extremely low electrical conductivity

Oxidation State

"An oxidation number is a value assigned to an element in a chemical compound or combined state.

The oxidation states of representative elements depend on their position in a particular group of periodic table. Some oxidation states are shown in Table 1.6.

Table 1.6 Oxidation states of representative elements

Group	Elements	Oxidation States
IA (Alkali Metals)	Li, Na, K, Rb, Cs	+1
IIA (Alkaline Earth Metals)	Be, Mg, Ca, Sr, Ba	+2
IIIA	B, Al, Ga, In, Tl	+3
IVA	C, Si, Ge, Sn, Pb	-4, -2, +2, +4
VA	N, P, As, Sb, Bi	-3, -2, +3, +5
VIA	O, S, Se, Te, Po	-2, +2, +4, +6
VIIA (Halogens)	F, Cl, Br, I, At	-1, +1, +3, +5, +7
VIIIA (Noble Gases)	He, Ne, Ar, Kr, Xe, Rn	0

Melting and Boiling Point

The melting and boiling points of representative elements can vary widely across the periodic table. Alkali metals have low melting and boiling points due to weak metallic bonding, while alkaline earth metals have higher melting and boiling points due to stronger metallic bonding as shown in Table 1.7. Moving across the p-block elements, the melting and boiling points generally increase gradually.

However, there are exceptions in groups IVA and VA. Carbon has a high melting point due to strong covalent bonds, while nitrogen has low melting and boiling points because it exists as diatomic molecules with weak intermolecular forces. Halogens have low melting and boiling points due to weak intermolecular forces, and noble gases have extremely low melting and boiling points due to weak interatomic forces.

The melting and boiling points of representative elements reflect the different bonding types and intermolecular forces within each group, resulting in a wide range of physical properties.

Table 1.7 Melting point of representative element in °C

IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
Li (180)	Be (1278)	B (2300)	C (3700)	N (-210)	O (-219)	F (-220)	Ne (-248)
Na (97.8)	Mg (651)	Al (658)	Si (1410)	P (34)	S (119)	Cl (-102)	Ar (-186)
K (63.7)	Ca (843)	Ga (297)	Ge (937)	As (814)	Se (217)	Br (-7.2)	Kr (-157)
Rb (39.0)	Sr (769)	In (155)	Sn (232)	Sb (630)	Te (450)	I (114)	Xe (-112)
Cs (28.6)	Ba (725)	Tl (303)	Pb (327)	Bi (271)	Po --	At (302)	Rn (-71)

Self Assessment

Boiling points of alkali metal decreases regularly and the boiling point of halogens increase regularly in going from top to bottom in their respective groups. How can you explain this behavior?

Unique behavior of Beryllium in group IIA

Beryllium differs markedly from its other members because of its smaller atomic radii and high electronegativity. Some unique characteristics shown by beryllium in comparison to other elements of group IIA are given as:

- Beryllium is harder and more rigid than other members of group IIA.
- Beryllium has relatively low density and high melting point compared with other group members.
- Beryllium exhibits chemical stability due to the formation of protective oxide layer on its surface which prevents further oxidation and corrosion.
- Beryllium has tendency to form covalent bonds with other elements due to its smaller atomic size while other members of the group form ionic bonds.

1.2 REACTIONS OF REPRESENTATIVE ELEMENTS

1.2.1 s-block elements

Alkali metals (group IA) and alkaline earth metals (group IIA) are highly reactive because they can easily lose their valence electrons due to low ionization energy (IE). Some common reactions of the elements of group IA and IIA are given as.

1.2.1.1 With oxygen

Alkali metals rapidly react with oxygen to produce oxides. Lithium forms normal oxide (oxidation state of oxygen is -2), sodium forms peroxide (oxidation state of oxygen is -1) in excess of air while the rest of the elements of group IA form superoxides (oxidation state of oxygen is $-\frac{1}{2}$).

$$4Li_{(s)} + O_{2(g)} \longrightarrow 2Li_2O_{(s)} \quad \text{(Normal oxide)}$$

$$2Na_{(s)} + O_{2(g)} \xrightarrow{\text{(Excess)}} Na_2O_{2(s)} \quad \text{(Per oxide)}$$

$$K_{(s)} + O_{2(g)} \longrightarrow KO_{2(s)} \quad \text{(Super oxide)}$$

$$Rb_{(s)} + O_{2(g)} \longrightarrow RbO_{2(s)} \quad \text{(Super oxide)}$$

$$Cs_{(s)} + O_{2(g)} \longrightarrow CsO_{2(s)} \quad \text{(Super oxide)}$$

The reaction of alkaline earth metals with oxygen takes place at high temperature. However, on oxidation, beryllium, magnesium and calcium form normal oxides while strontium and barium form peroxides.

$$2M + O_2 \longrightarrow 2MO \text{ (Where M = Be, Mg, Ca)}$$

$$M + O_2 \longrightarrow MO_2 \text{ (Where M = Sr, Ba)}$$

1.2.1.2 With water

Alkali metals react with water to produce metal hydroxides with the liberation of hydrogen gas. The intensity of reaction increases from lithium to cesium, until a violent reaction is observed often accompanied by an explosion when cesium is put into water.

$$2M_{(s)} + 2H_2O_{(\ell)} \longrightarrow 2MOH_{(aq)} + H_{2(g)}\uparrow$$

(Where M = Li, Na, K, Rb, Cs).

Among alkaline earth metals beryllium does not react with either cold or steam, but magnesium reacts with steam. The reason is that these two elements form a stable oxide layer that acts as a barrier preventing direct contact between water and metal. The rest of the members of this group react with water easily and form hydroxides.

DO YOU KNOW?
Alkali metals are highly reactive, they react vigorously with water and moist air and can cause fire or explosion that is why they keep in kerosene oil.

$$M_{(s)} + 2H_2O_{(\ell)} \longrightarrow M(OH)_{2(aq)} + H_2\uparrow$$

(Where M = Mg, Ca, Sr and Ba).

1.2.1.3 With halogens

Alkali metals react vigorously with halogens to form metal halides. The reaction involves the transfer of electron from an alkali metal to a halogen.

$$2M_{(s)} + X_{2(g)} \longrightarrow 2MX_{(s)}$$

(Where M = Li, Na, K, Rb, Cs)

Alkaline earth metals also react with halogens although to a lesser extent when compared with alkali metals.

$$M_{(s)} + X_{2(g)} \longrightarrow MX_{2(s)}$$

(Where M = Be, Mg, Ca, Sr, Ba)

1.2.1.4 With nitrogen

Nitrides are formed when both alkali metals and alkaline earth metals react with nitrogen. The general formula for the nitrides of alkali metals is M_3N and for the nitrides of alkaline earth metals is the formula M_3N_2.

$$6M_{(s)} + N_{2(g)} \longrightarrow 2M_3N_{(s)} \text{ (M = Li, Na, K, Rb, Cs)}$$

$$3M_{(s)} + N_{2(g)} \longrightarrow M_3N_{2(s)} \text{ (M = Be, Mg, Ca, Sr, Ba)}$$

1.2.1.5 With hydrogen

Alkali and alkaline earth metals react with hydrogen at different temperatures to produce ionic hydrides.

$$2M_{(s)} + H_{2(g)} \longrightarrow 2MH_{(s)} \text{ (M = Li, Na, K, Rb, Cs)}$$

$$M_{(s)} + H_{2(g)} \longrightarrow MH_{2(s)} \text{ (M = Ca, Sr, Ba)}$$

1.2.1.6 With alcohols

Elements of group IA react vigorously with alcohols to form metal alkoxide with the liberation of hydrogen gas.

$$2M_{(s)} + 2C_2H_5OH_{(aq)} \longrightarrow 2C_2H_5OM_{(aq)} + H_{2(g)} \text{ (M = Li, Na, K, Rb, Cs)}$$

Alkaline earth metals have a very limited reactivity with alcohols.

1.2.1.7 With acids

Alkali metals react vigorously with acids to produce salt with the liberation of hydrogen gas. This reaction is highly exothermic and violent.

$$2M_{(s)} + 2HCl_{(aq)} \longrightarrow 2MCl_{(s)} + H_{2(g)} \text{ (Where M = Li, Na, K, Rb, Cs)}$$

Alkaline earth metals can react with acids but their reactivity is generally lower compared to alkali metals.

Self Assessment

Complete and balance the following reactions:

$Mg + N_2 \longrightarrow$

$Na + C_2H_5OH \longrightarrow$

$K + H_2SO_4 \longrightarrow$

$Ba + O_2 \longrightarrow$

$Ca + H_2O \longrightarrow$

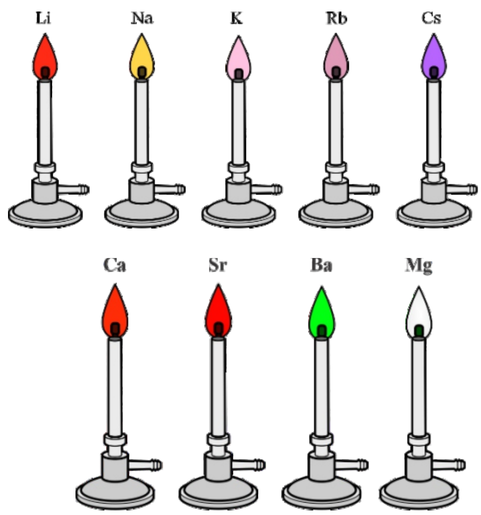
1.3 FLAME TEST FOR S-BLOCK ELEMENTS

"Flame test is a qualitative method used to identify the presence of alkali metals based on their characteristic flame colours".

When an alkali metal or its compound burn in flame, the electron in the lower energy orbital jumps to higher energy orbital due to the absorption of energy from the flame. This electron upon returning to lower energy orbital, releases energy in the form of light of a specific colour which can be observed as a colour flame.

Table 1.8 Colour flames of alkali and alkaline earth metals

Elements	Flame Colour
Lithium	Red
Sodium	Yellow
Potassium	Violet
Rubidium	Red Violet
Cesium	Blue Violet
Beryllium	No characteristic flame colour
Magnesium	Silver white
Calcium	Orange red
Strontium	Deep Red
Barium	Pale Green



1.4 CHEMISTRY OF IMPORTANT COMPOUNDS OF S-BLOCK ELEMENTS

There are various naturally occurring compounds of alkali and alkaline earth metals found in the earth's crust in the form of minerals and ores. However, many useful compounds of s-block elements are synthesized in industries, such as caustic soda, soda ash, bleaching powder etc.

1.4.1 Sodium Hydroxide (NaOH)

Sodium hydroxide is a highly versatile and widely used chemical compound. It is commonly known as caustic soda due to its ability to cause burns and damage tissues severely.

Caustic soda is manufactured by an electrolytic process in a specially designed cell known as Castner Kellner cell. The cell consists of an upper rectangular vessel and a lower pipe like portion. In the upper part, there are titanium blocks which are submerged in an aqueous solution of sodium chloride acting as an anode as shown in figure 1.1. The lower section is filled with mercury which circulates constantly with the help of a pump and serves as cathode. The upper part of the cell is connected to the lower part by a graphite made chamber known as denuder where the separation of sodium from amalgam takes place.

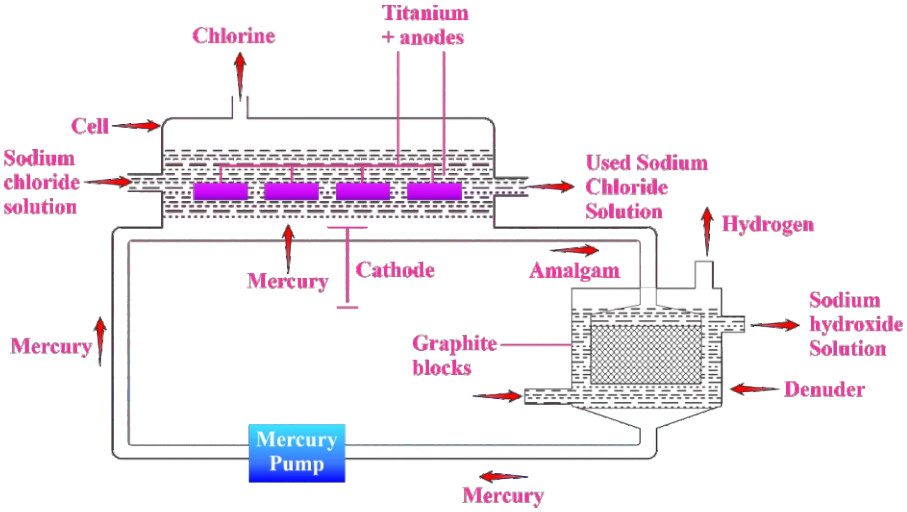


Fig 1.1: Structure of Castner Kellner cell

The aqueous solution of sodium chloride in the upper portion consists of mainly sodium ions (Na^+) and chloride ions (Cl^-). On passing electricity through the cell, all Cl^- ions migrate toward titanium anode where they get oxidized. The chlorine gas liberated in this electrolytic process is collected as a by-product.

$$2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^- \quad \text{(Oxidation)}$$

$O\bar{H}$ ions of water which are in very low quantities, are also oxidized on titanium anode.

$$4O\bar{H}_{(aq)} \longrightarrow 2H_2O_{(\ell)} + O_{2(g)} \quad \text{(Reduction)}$$

Sodium ions on the other hand discharge over mercury surface where an amalgam of Na/Hg (alloy) is formed.

$$2Na^+_{(aq)} + 2\bar{e} \longrightarrow 2Na_{(aq)}$$

$$Na_{(l)} + Hg_{(\ell)} \longrightarrow Na/Hg_{(\ell)}$$

Amalgam is then sent to denuder where sodium reacts with water to form sodium hydroxide.

$$2Na/Hg + 2H_2O_{(\ell)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)} + Hg_{(\ell)}$$

The mercury is recycled to dissolve more sodium and the sodium hydroxide is collected for marketing.

Compared with other processes for the preparation of caustic soda, the Castner Kellner process is more preferable because the two products of the process, sodium hydroxide and chlorine are obtained in separate portions of the cell, which prevents them to react with each other. However, one disadvantage of the process is that, in spite of strict control some mercury vapours escape from the factory. This mercury contaminates seawater. As a result mercury becomes part of tissues of marine animals and plants and thus pollutes the food chain.

Physical Properties

- **State**: It is a solid at room temperature, typically appearing as white pellets, flakes, or granules.
- **Odor**: It is odorless.
- **Melting Point**: Its melting point is approximately 318 °C (604 °F). At this temperature, it melts and forms a liquid.
- **Solubility**: It is highly soluble in water.

- **Density**: The density of NaOH depends on its concentration and temperature. For a 50% concentration at room temperature, the density is approximately 1.52 g/cm³.
- **Corrosiveness**: It is highly corrosive and can cause burns and irritation to the skin, eyes, and respiratory system.

Chemical Properties

Reaction with acids

Being a strong base, it reacts with all acids to produce sodium salt and water.

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(\ell)}$$

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(\ell)}$$

Reaction with Ferric Chloride

On reaction with aqueous ferric chloride, it gives brown ppt of ferric hydroxide.

$$3NaOH_{(aq)} + FeCl_{3(aq)} \longrightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

Reaction with Aluminum and Zinc

Caustic soda can react with aluminum and zinc to form aluminate and zincate salts.

$$2NaOH_{(aq)} + 2Al_{(s)} + 2H_2O_{(\ell)} \longrightarrow 2NaAlO_{2(s)} + 3H_{2(g)}$$

$$2NaOH_{(aq)} + Zn_{(s)} \longrightarrow Na_2ZnO_{2(s)} + H_{2(g)}$$

Reaction with Chlorine

The reaction of hot aqueous sodium hydroxide with chlorine gas gives sodium chloride and sodium chlorate.

$$6NaOH_{(aq)} + 3Cl_{2\,(g)} \longrightarrow NaClO_{3(aq)} + 5NaCl_{(aq)} + 3H_2O_{(l)}$$

Uses of Sodium Hydroxide

- It is a key ingredient in the production of detergents and soaps.
- It is utilized in the production of bleach, such as chlorine bleach, which is commonly used as a disinfectant and stain remover.
- Its strong alkaline nature makes it effective for unclogging drains and pipes by breaking down organic matter.
- It is used to remove heavy metals and adjust pH levels in water, ensuring safe and clean drinking water.
- It is used as a food preservative to prevent bacterial and mold growth, enhancing the shelf life of certain food products.

- It is utilized in the canning process to remove the outer skin of fruits and vegetables, ensuring food safety and quality.
- It plays a role in the paper making industry, where it is used for pulping wood fibers and paper recycling processes.

1.4.2 Bleaching Powder($CaOCl_2$)

Bleaching powder, also known as calcium hypochloride ($CaOCl_2$), is a chemical compound widely used as a bleaching agent and disinfectant.

Commercially, it is prepared by Hasenclever Process, as shown in figure 1.2. Dry slaked lime is fed into the Hasenclever plant from the most upper cylinder. The slaked lime is moved forward by revolving blades of rotating shaft. Chlorine gas is passed from the lower cylinder which rises upto upper cylinder and reacts with slaked lime to form bleaching powder.

DO YOU KNOW?

Sometimes accidently bleach ingestion occurs in children and adults by instead of water due to its clear color, especially when stored in unmarked containers. Common symptoms include sore throat, nausea, vomiting, and difficulty in swallowing. Immediate give them some water to drink and then medical attention is necessary when bleach is ingested.

$$Ca(OH)_{2(aq)} + Cl_{2(aq)} \longrightarrow CaOCl_{2(s)} + H_2O_{(l)}$$

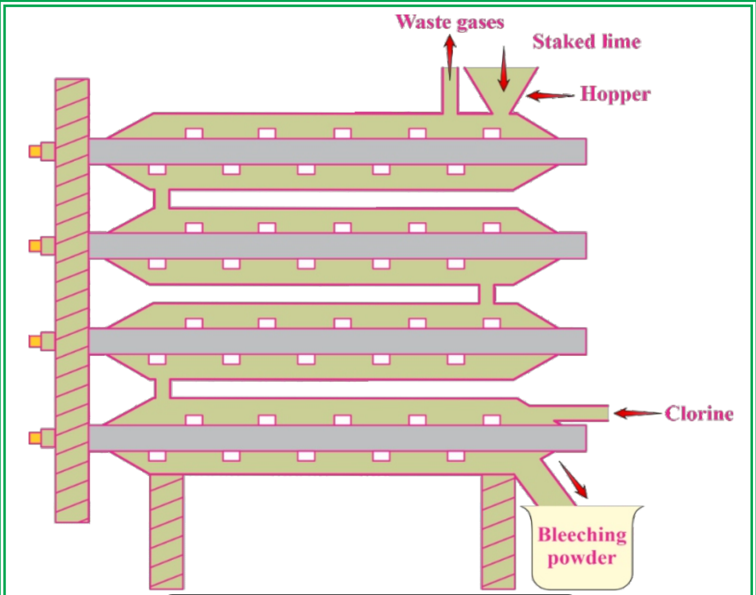


Fig 1.2: Structure of Hasenclever process

Physical Properties of Bleaching Powder

- Bleaching powder has a dirty white appearance.
- It has a distinct chlorine odour.
- It is soluble in water.

Chemical Properties of Bleaching Powder

(i) Reaction with Water

Bleaching powder when dissolves in water, it produces calcium hydroxide and hypochlorous acid (HOCl). Hypochlorous acid is a weak acid and commonly used for bleaching and sanitizing.

$$CaOCl_{2(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + 2HOCl_{(aq)}$$

(ii) Reaction with Acids

The reaction of bleaching powder with hydrochloric acid produces calcium chloride and chlorine gas.

$$CaOCl_{2(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(s)} + 2H_2O_{(l)} + Cl_{2(g)}$$

Uses of Bleaching Powder

- It is used for sterilization of water.
- It is used for bleaching of cotton, linen and paper.
- It is used for the preparation of chlorine gas and chloroform.

Table 1.9 Functions of some elements and compounds of s-block elements.

Selected s-block elements and their compounds	Significant Uses
Sodium (Na)	It helps to regulate the balance of fluids inside and outside our tissues and facilitates the absorption of various nutrients.
Potassium (K)	It helps to balance the pH level in the body.

Magnesium (Mg)	It helps in muscle contraction and maintain the bones and heart functions.
Calcium (Ca)	It is essential for the growth of bones and teeth.
Common Salt (NaCl)	It is a raw material for the synthesis of various chemicals such as soda ash, caustic soda and chlorine gas etc. It plays a vital role in maintaining electrolyte balance in the body.
Washing Soda ($Na_2CO_3.10H_2O$)	It is used in the manufacturing of glass, soap and borax. It is also used for laundry purpose.
Backing Soda ($NaHCO_3$)	It is used in bakeries to prepare various food items.
Potassium Nitrate (KNO_3)	It is used in fireworks and fertilizer.

1.5 REACTIONS OF p-BLOCK ELEMENTS

Elements of group IIIA to VIIA in the periodic table exhibit diverse chemical behavior. They can participate in various types of chemical reactions based on their unique properties. Some important chemical reactions involving p-block elements are given below.

1.5.1 With oxygen

The reactions of p-block elements with oxygen produce either normal oxides or in some cases peroxides.

Elements of group IIIA react with oxygen to produce oxides of the formula M_2O_3.

$$4B_{(s)} + 3O_{2(g)} \longrightarrow 2B_2O_{3(s)}$$

$$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$$

- In group IVA, carbon forms carbon monoxide and carbon dioxide when it reacts with oxygen while silicon form only one stable silicon oxide(SiO_2).

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

$$2C_{(s)} + O_{2(g)} \longrightarrow 2CO_{(g)}$$

$$Si_{(s)} + O_{2(g)} \xrightarrow{\text{above } 900°C} SiO_{2(s)}$$

- In group VA, nitrogen forms NO, N_2O and NO_2 when reacts with oxygen depending upon the conditions applied. Phosphorus may form P_2O_3 in limited supply of oxygen whereas P_2O_5 in excess of oxygen.

$$N_{2(g)} + O_{2(g)} \xrightarrow{\text{High temp.}} 2NO_{(g)}$$
$$2N_{2(g)} + O_{2(g)} \xrightarrow{\text{Catalyst}} 2N_2O_{(g)}$$
$$4P_{(s)} + 3O_{2(g)} \xrightarrow{\text{Limited oxygen}} 2P_2O_{3(s)}$$
$$4P_{(s)} + 5O_{2(g)} \xrightarrow{\text{Excess oxygen}} 2P_2O_{5(s)}$$

- In group VIA, sulphur oxidized in air to give sulphur dioxide.

$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$$

- Halogens can also react with oxygen however their oxides are mostly highly reactive. For example the oxide of fluorine is a highly reactive yellow gas.
- The oxides of halogens are very unstable.

$$2F_{2(g)} + O_{2(g)} \longrightarrow 2OF_{2(g)}$$

DO YOU KNOW?

Aluminum is generally considered safe metal for cooking and food storage purposes. It is widely used in kitchen wares due to its light weight. However, it is recommended to avoid cooking or storing highly acidic or alkaline foods in aluminum containers.

1.5.2 With water

- The reaction of p-block elements with water depends on the nature of element and the group to which it belongs.
- Aluminum reacts with water but the reaction is slow due to the presence of a thin oxide film on its surface.

$$2Al_{(s)} + 6H_2O_{(l)} \longrightarrow 2Al(OH)_{3(s)} + 3H_{2(g)}$$

- Silicon reacts with steam and forms slicondioxide.

$$Si_{(s)} + 2H_2O_{(g)} \longrightarrow SiO_{2(s)} + 2H_{2(g)}$$

- Phosphorus reacts vigorously with water to produce phosphoric acid and phosphine.

$$2P_{4(s)} + 12H_2O_{(l)} \longrightarrow 3H_3PO_{4(aq)} + 5PH_{3(g)}$$

- Sulphur reacts if it is heated to a high temperature.

$$S_{(s)} + 2H_2O_{(l)} \xrightarrow{\text{high temp.}} SO_{2(g)} + 2H_{2(g)}$$

- Halogens such as chlorine and bromine react with water to form a mixture of two acids.

$$Cl_{2(g)} + H_2O_{(l)} \longrightarrow HCl_{(aq)} + HOCl_{(aq)}$$
$$Br_{2(l)} + H_2O_{(l)} \longrightarrow HBr_{(aq)} + HOBr_{(aq)}$$

1.5.3 With halogens

Majority of p-block elements have the capability to react with halogens, resulting in the formation of binary compounds.

$$2Al_{(s)} + 3Cl_{2(g)} \xrightarrow{\Delta} 2AlCl_{3(s)}$$

$$C_{(s)} + 2Cl_{2(g)} \longrightarrow CCl_{4(l)}$$

$$N_{2(g)} + 3Cl_{2(g)} \longrightarrow 2NCl_{3(g)}$$

$$O_{2(g)} + 2F_{2(g)} \longrightarrow 2OF_{2(g)}$$

1.5.4 With nitrogen

The reaction of p-block elements with nitrogen can vary depending on the specific element and the reaction conditions. For example

- Boron and aluminum react with nitrogen to form their nitrides.

$$2B_{(s)} + N_{2(g)} \xrightarrow{\Delta} 2BN_{(s)}$$

$$2Al_{(s)} + N_{2(g)} \xrightarrow{\Delta} 2AlN_{(s)}$$

- Carbon and Silicon can form nitrides when heated with nitrogen at high temperatures.

$$3C_{(s)} + 2N_{2(g)} \xrightarrow{\Delta} C_3N_{4(s)}$$

$$3Si_{(s)} + N_{2(g)} \xrightarrow{\Delta} Si_3N_{4(s)}$$

- Phosphorus reacts with nitrogen at high temperatures to form phosphorus nitride (P_3N_5).

$$6P_{(s)} + 5N_{2(g)} \xrightarrow{\Delta} 2P_3N_{5(s)}$$

- Halogen (Cl_2, Br_2) can react with nitrogen to form nitrogen trihalide.

$$3Cl_{2(g)} + N_{2(g)} \longrightarrow 2NCl_{3(s)}$$

1.5.5 With hydrogen

- Elements of group IIIA and IVA do not directly react with hydrogen, however silicon at high temperatures may form silicon hydrides.

$$Si_{(s)} + 2H_{2(g)} \xrightarrow{\text{High Temperature}} SiH_{4(s)}$$

- Nitrogen reacts with hydrogen under high pressure to form ammonia.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow{400 - 450°C} 2NH_{3(g)}$$

- Sulphur reacts with hydrogen at high temperatures to form hydrogen sulphide.

$$S_{(s)} + H_{2(g)} \xrightarrow{850°C} H_2S_{(g)}$$

- The reaction of halogen with hydrogen can result in the formation of hydrogen halides.

$$Cl_{2(g)} + H_{2(g)} \longrightarrow 2HCl_{(g)}$$

Self Assessment

Write the equations for the following chemical processes.

- Silicon is put into steam.
- Phosphorus burns in excess of oxygen.
- Nitrogen gas is passed through hot piece of phosphorus.
- Carbon is heated with nitrogen.
- Aluminum is treated with chlorine gas.

1.6 CHEMICAL BEHAVIOR OF HALOGENS

Halogens include fluorine (F), chlorine (Cl), bromine (Br), iodine (I) and astatine (At). The reactivity of halogens is determined by their bond enthalpies and their ability to undergo redox reactions.

1.6.1 Bond enthalpies in halogens

The enthalpy is required for the dissociation of halogen-halogen bond in gaseous state and it varies according to size of halogen atom, bond length and the intermolecular attraction.

Table 1.10 Bond enthalpies of halogens

Halogens	Atomic radii (pm)	Bond length (in gaseous phase) (pm)	Bond enthalpies (KJ/mole)
F – F	72	143	159
Cl – Cl	100	199	242
Br – Br	114	228	193
I – I	133	266	151

It is noted from the Table 1.10 that the bond enthalpies of halogens decrease from chlorine to iodine due to the increase in bond length but fluorine is an exception to this trend. This is due to the large repulsion between the non-bonding electrons of small sized atom in the fluorine molecule.

1.6.2 Acidity of Hydrogen Halides

Hydrogen halides (HX) are strong mineral acids and their acidity follows an increasing trend from HF to HI (HF < HCl < HBr < HI). The increasing order of acidity of hydrogen halides can be attributed to their bond energies. Since the bond energy of H-I is the smallest, it can easily donate a proton and serves as the strongest acid compared to other halogen acids.

Halogen acids (HX)	H-F	H-Cl	HBr	HI
Bond energies (KJ/mol)	565	432	366	299

Decrease →

1.6.3 Strength of Halogens as oxidizing agent

Halogens are good oxidizing agents due to their high electronegativities and ability to readily accept electrons. The strength of halogens as oxidizing agent decreases from top to bottom in group VIIA.

$$F_2 > Cl_2 > Br_2 > I_2$$

Fluorine is the strongest oxidizing agent due to its highest electronegativity and smallest atomic size allowing it to readily accept electron and attain a negative charge.

1.6.4 Halide ions as a reducing agent

Halide ions (Cl^-, Br^-, I^-) can serve as reducing agents in chemical reactions due to their ability to readily donate electron to an oxidizing species thereby undergoing oxidation.

Among halide ions, there is a trend in relative strength of reducing agents $I^- > Br^- > Cl^- > F^-$. This means that iodide ion is the strongest reducing agent while fluoride ion is the weakest.

Based on this information, we can infer that chlorine has the ability to displace bromine and iodine from their salts.

$$2NaBr_{(s)} + Cl_{2(g)} \longrightarrow 2NaCl_{(s)} + Br_{2(l)}$$

$$2NaI_{(s)} + Cl_{2(g)} \longrightarrow 2NaCl_{(s)} + I_{2(s)}$$

Similarly bromine has the ability to displace iodine from its salt.

$$2NaI_{(s)} + Br_{2(l)} \longrightarrow 2NaBr_{(aq)} + I_{2(s)}$$

DO YOU KNOW?

The deficiency of iodine in the diet can lead to the development of goiter, which is an enlargement of the thyroid gland. To control the deficiency of iodine in the body an efficient is way to intake iodide salt and food supplements i.e., Kelp or Seaweed, fish and other sea foods etc.

Chlorine as an auto oxidizing and reducing agent

Chlorine reacts with water to form hydrochloric acid and hypochlorous acid. In this reaction chlorine itself reduces into hydrochloric acid and oxidizes into hypochlorous acid and hence serves as auto oxidizing and reducing agent.

$$\underset{\text{(Chlorine)}}{Cl_{2(g)}} + H_2O_{(l)} \longrightarrow \underset{\text{(Hydrochloric acid)}}{HCl_{(aq)}} + \underset{\text{(Hypochlorous acid)}}{HOCl_{(aq)}}$$

Self Assessment

Chlorine can displace bromide and iodide from their salts but fluorine cannot why?

1.7 CHEMISTRY OF SULPHURIC ACID (Contact Process)

Sulphuric acid is a highly corrosive and colourless liquid with a viscous texture. It is one of the most widely used and important industrial chemical compound due to its versatile nature and unique properties. It is often called oil of vitriol because in past it was obtained through the distillation of green vitriol. Sulphuric acid is produced worldwide by Contact process, which involves a series of essential steps.

Step 1: Oxidation of Sulfur to Sulfur Dioxide

Sulfur (S) is burned in the presence of air or oxygen to produce sulfur dioxide (SO_2). The reaction can be represented as follows:

$$S_{(s)} + O_{2(g)} \xrightarrow{400\text{-}500°C} SO_{2(g)}$$

SO_2 gas which is produced in "Sulphur Burner" may contains some impurities of "Arsenic", "Silica" and "CO_2". These impurities must be removed from SO_2 gas before entering it into catalytic chamber because catalyst (V_2O_5) get poisoned in the presence of these impurities and hence decreases the rate of formation of SO_3.

Step 2: Conversion of Sulfur Dioxide into Sulfur Trioxide

Sulfur dioxide (SO_2) is then reacted with oxygen (O_2) in the presence of a catalyst (usually vanadium pentoxide, V_2O_5) to form sulfur trioxide (SO_3). This reaction is carried out at high temperatures:

$$2SO_{2(g)} + O_{2(g)} \underset{1\text{-}2\ atm}{\overset{V_2O_5\ \ 400\text{-}500°C}{\rightleftharpoons}} 2SO_{3(g)}\ (\Delta H = -45\ Kcal/mol)$$

Step 3: Absorption of Sulfur Trioxide to Sulphuric acid

Sulfur trioxide (SO_3) is dissolved in concentrated sulphuric acid (H_2SO_4) to produce oleum, also known as fuming sulphuric acid ($H_2S_2O_7$). This is an exothermic reaction, and it needs to be carefully controlled to avoid excessive heat release.

$$SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2O_{7(l)}$$

Step 4: Dilution of Oleum to Sulphuric acid

Finally, the oleum ($H_2S_2O_7$) is diluted with water to obtain the desired concentration of sulphuric acid. The reaction is highly exothermic and must be performed slowly and with caution:

$$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$$

Sulphuric acid obtained through the contact process as shown in figure1.3 is typically of high purity, often reaching a concentration of 98%. The high purity is achieved through careful control including the purification steps.

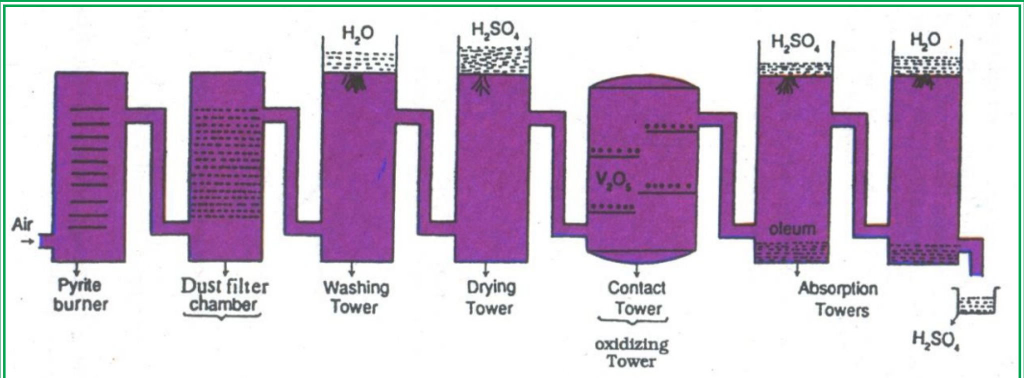


Fig 1.3: Flow diagram of contact process

Physical Properties

- **Density:** Sulphuric acid has a high density, typically around 1.84 g/cm3.
- **Melting Point:** Sulphuric acid has no distinct melting point since it can supercool below its freezing point. The freezing point of sulphuric acid is approximately 10ºC but it can vary depending on the concentration.
- **Boiling Point:** Commercial sulphuric acid has a boiling point of 290ºC. However, the boiling point increases with increasing concentration.
- **Solubility:** Sulphuric acid is highly soluble in water.
- **Corrosive Nature:** Sulphuric acid is a highly corrosive substance and can react with metals and organic compounds etc.

Chemical Properties

An oxidizing agent

In sulphuric acid, sulphur exists in its highest oxidation state of +6. This highest oxidation state of sulphur makes the sulphuric acid to serve as an oxidizing agent when reacts with metals and non metals.

$$C_{(s)} + 2H_2SO_{4(aq)} \longrightarrow CO_{2(g)} + 2SO_{2(g)} + 2H_2O_{(\ell)}$$

$$S_{(s)} + 2H_2SO_{4(aq)} \longrightarrow 3SO_{2(g)} + 2H_2O_{(\ell)}$$

$$Cu_{(s)} + 2H_2SO_{4(aq)} \xrightarrow{\text{(conc.)}} CuSO_{4(aq)} + SO_{2(g)} + 2H_2O_{(\ell)}$$

$$2Al_{(s)} + 6H_2SO_{4(aq)} \xrightarrow{\text{(conc.)}} Al_2(SO_4)_3 + 3SO_{2(g)} + 6H_2O_{(\ell)}$$

A dehydrating agent

The dehydrating ability of sulphuric acid can be attributed to its capability to extract water molecules from other substances.

$$\underset{\text{(glucose)}}{C_6H_{12}O_{6\,(s)}} \xrightarrow{H_2SO_{4(conc.)}} 6C_{(s)} + 6H_2O_{(l)}$$

$$\underset{\text{(sugar)}}{C_{12}H_{22}O_{11(S)}} \xrightarrow{H_2SO_{4(conc.)}} 12C_{(s)} + 11H_2O_{(\ell)}$$

$$\underset{\text{(wood)}}{(C_6H_{12}O_5)_n} \xrightarrow{H_2SO_{4(conc.)}} 6nC_{(s)} + 5nH_2O_{(\ell)}$$

A sulphonating agent

Sulphonation involves the introduction of sulphonic group (SO_3H) into a molecule. Sulphuric acid serves as a source of sulphonic group which can be added to organic compounds to create new molecules.

$$\underset{\text{(Benzene)}}{C_6H_{6(l)}} + H_2SO_{4(aq)(conc.)} \longrightarrow \underset{\text{(Benzene sulphonic acid)}}{C_6H_5SO_3H_{(l)}} + H_2O_{(l)}$$

$$\underset{\text{(Toluene)}}{C_7H_{8(l)}} + H_2SO_{4(conc.)} \longrightarrow \underset{\text{(p-toluene sulphonic acid)}}{C_6H_4(CH_3)SO_3H_{(l)}} + H_2O_{(l)}$$

A dibasic acid

Sulphuric acid has the ability to donate two protons in water in two dissociation steps and serves as dibasic acid.

$$H_2SO_{4(aq)} \rightleftharpoons H_3O^+ + HSO^-_{4(aq)}$$

$$HSO^-_{4(aq)} \rightleftharpoons H_3O^+ + SO^{-2}_{4(aq)}$$

Uses of Sulphuric acid

Sulphuric acid is used in various industries for:

- Producing fertilizers, dyes, pigments, detergents, pharmaceuticals, and synthetic fibers.
- Refining petroleum to make high-octane gasoline additives.
- Processing and purifying metals, including removing rust and scale.
- Etching and electroplating processes.
- Manufacturing lead-acid batteries.
- Cleaning and descaling due to its strong acidic properties.

1.8 DIAGONAL RELATIONSHIP OF REPRESENTATIVE ELEMENTS

The diagonal relationship refers to the resemblance in the properties exhibited by certain pairs of elements that are located diagonally to each other within the periodic table.

There are three pairs of elements that exhibit the diagonal relationship in the second and third periods of representative elements.

Table 1.11 Diagonal relationships of three pairs of elements in groups

Periods	Groups			
	IA	IIA	IIIA	IVA
Second	Li	Be	B	C
Third	Na	Mg	Al	Si

1.8.1 Diagonal relationship between lithium and magnesium, Beryllium and Aluminum, Boron and Silicon

- **Li and Mg**

i. Both have almost similar atomic radii (Li = 152pm and Mg =160pm).
ii. Both have almost similar electronegativities (Li = 1.0 and Mg 1.2)
iii. Both are lighter in their respective group.
iv. Oxide of both Li and Mg are very less soluble in water compared to other elements of the respective group.

➢ Be and Al

i. Both Be and Mg have same EN (1.5).

ii. Both show passivity with conc. Nitric acid.

iii. $BeCl_2$ and $AlCl_3$ both acts as Lewis acid.

➢ B and Si

i. Both B and Si have closer EN (B = 2.0 and Si 1.8).

ii. Both B and Si have nearly same density (B = 2.35g/cm^3 , Si = 2.34g/cm^3).

iii. Both B and Si are metalloids and both of these do not form cation.

Table 1.12 **Important functions of selected elements and compounds of representative elements**

Element/Compound	Significant Uses
Aluminum	It is used in making coils, alloys, kitchen utensils, window frames, chocolate foils etc.
Sulphur	It is used in the manufacturing of sulphuric acid, hydrogen sulphide and pesticides.
Chlorine	It is used in the manufacturing of plastic, bleaching powder and in the purification of drinking water.
Borax ($Na_2B_4O_7.10H_2O$)	It is used in cleaning, laundry, cosmetics and as flux in welding.
Alum ($K_2SO_4.Al_2SO_4.24H_2O$)	It is used for the purification of water, tanning of leather, fire extinguishers and as an antiseptic for minor cuts and wounds.
Ammonia (NH_3)	It is used in the manufacturing of fertilizers, nitric acid and refrigeration.

SOCIETY, TECHNOLOGY AND SCIENCE

Fluoride Toxicity and Deficiency

Fluoride is an essential mineral. It plays a significant role in maintaining the dental and skeletal health of our bodies. It is obtained from water, tea, fish and certain fruits and vegetables.

The deficiency of fluoride increases the risk of dental cavities, brown colouration of teeth, weakening of teeth and bones etc.

An excessive intake of fluoride over a prolong period may cause a condition known as fluorosis or fluoride toxicity. It causes white or brown spotting on teeth, pitting of teeth and irregular appearance of teeth etc.

SUMMARY

- Atomic radii of representative elements generally increase downward in the group.
- Melting point and boiling point of alkali metals decrease regularly down the group while the elements of other groups have variations depending upon their position in the periodic table.
- Ionization energy of s-block elements decreases down the group with increasing atomic radii.
- Electronegativities of the elements of group IA and IIA decrease regularly from top to bottom while the EN of the elements of remaining group varies depending upon shielding effect.
- Beryllium differs markedly from other members of group IIA on the basis of its smaller atomic radii, hardness and high melting point.
- Lithium forms normal oxide, sodium forms peroxide while the rest of alkali metals form super oxide when come in contact with air.
- Alkali metals and alkaline earth metals can be identified by flame test. Lithium gives red, sodium yellow and potassium shows violet colour when comes in contact with the flame.

- Castner Kellner process is used for preparation of caustic soda.
- Bleaching powder is prepared by the reaction of lime water with chlorine gas.
- The order of acidic strength of hydrogen halides is HI > HBr > HCl > HF.
- Chlorine acts as auto oxidizing and reducing agent in certain chemical reactions.
- Sulphuric acid is a good dehydrating agent.
- Sulphuric acid reacts with metals and non metals, it acts as an oxidizing agent.
- Similarities in the properties exhibited by certain pairs of elements among the groups of representative elements are known as diagonal relationship.

EXERCISE

Multiple Choice Questions

(i) Melting and boiling points regularly decrease down the group in:
(a) Group IA (b) Group IIIA
(c) Group VIIA (d) Group VIIIA

(ii) The s-block element forms super oxide when burned in air is:
(a) Li (b) Na
(c) K (d) Mg

(iii) The general formula of nitrides for alkaline earth metal is:
(a) MN_3 (b) M_2N_3
(c) M_3N (d) M_3N_2

(iv) The alkali metal that gives a yellow color during a flame test is:
(a) Na (b) K
(c) Rb (d) Cs

(v) The chemical commonly used in fireworks is:
(a) Sodium bicarbonate (b) Bleaching powder
(c) Potassium nitrate (d) Potash Alum

(vi) Cathode in Castner Kellner cell is:
(a) Titanium blocks (b) Carbon rods
(c) Mercury (d) Iron container

(vii) The diagonal member of beryllium is:

(a) Mg (b) Al

(c) Si (d) C

(viii) The catalyst commonly used in the conversion of sulfur dioxide to sulfur trioxide during the preparation of sulphuric acid is:

(a) Vanadium pentoxide (V_2O_5) (b) Copper (Cu)

(c) Iron (Fe) (d) Nickel (Ni)

(ix) Oil of vitriol refers to:

(a) Borax (b) Sulphuric acid

(c) Alum (d) Caustic soda

(x) The best oxidizing agent among halogens is:

(a) F_2 (b) Cl_2

(c) Br_2 (d) I_2

Short Questions

1. Give reasons for the following:

(i) Ionization energy decreases from top to bottom in s-block elements?

(ii) Boiling point of halogens increase down the group in the periodic table?

(iii) Gallium has smaller atomic radii than aluminum despite being below the aluminum in group IIIA?

(iv) Electronegativities of alkali metals decrease from Li to Cs?

(v) Alkali metals are good conductor of electricity?

(vi) Acidity of hydrogen halides increase from HF to HI?

(vii) Fluorine is the strongest oxidizing agent?

2. What is flame test? Mention the colour of flame of alkali metals.
3. Explain the auto oxidizing and reducing properties of chlorine.
4. What is meant by a diagonal relationship? Mention three pairs of representative elements that show diagonal relationship.
5. Discuss the group trend of Ionization energy in group IIIA of periodic table.
6. Write down three properties of beryllium that show its unique behavior in group IIA.

Descriptive Questions

1. Draw a flow diagram of contact process and describe various steps involved in the manufacturing of sulphuric acid.
2. Explain with the help of a diagram of Castner Kellner cell, how caustic soda is obtained by the electrolysis of aqueous sodium chloride?
3. Write the balance equations for the following chemical process.
   (i) A piece of aluminum is dipped into concentrated sulphuric acid.
   (ii) Ferric chloride is mixed with an aqueous solution of caustic soda.
   (iii) Sodium burns in excess of air.
   (iv) Magnesium is heated with nitrogen gas.
   (v) Potassium is put into ethyl alcohol.
   (vi) Chlorine gas is passed through an aqueous solution of caustic soda.
4. What is bleaching powder? How is it prepared? Give the reaction of bleaching powder with water and hydrochloric acid.
5. Discuss the group trend of atomic radii, ionization energy and electronegativity of alkali metals.