

## Ch # 15 Halogens

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### INTRODUCTION

Halogens are the elements of VII – A group of the periodic table. They include fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I) and Astatine (At). A name derived from Greek word meaning “Salt Producing” (Halo means salt; gene means producing), because these elements combine readily with metals to form salts. These are strong oxidizing agents. The last member of the family is Astatine, which is radioactive, shows different behavior and is rather unstable. They exhibit variable oxidation states in their compounds except fluorine which shows an oxidation state -1 always. Halogens exist as diatomic molecule; F<sub>2</sub>, Cl<sub>2</sub>, Br<sub>2</sub> and I<sub>2</sub>. Fluorine and chlorine are gases. F<sub>2</sub> is pale yellow in color; chlorine is of greenish yellow gas or pale green in color. Bromine (Br<sub>2</sub>) is volatile reddish brown liquid. Iodine (I<sub>2</sub>) is shiny black solid that sublimes readily.

### PREPARATION OF CHLORINE GAS (Cl<sub>2</sub>)

#### a. Laboratory Method For Preparation Of Cl<sub>2</sub> Gas

Chlorine is usually prepared in the laboratory from hydrochloric acid. When conc: HCl is gently heated with MnO<sub>2</sub> or KMnO<sub>4</sub>, chlorine gas is produced.



#### **Procedure:**

In this method MnO<sub>2</sub> is taken in round bottomed flask with conc: HCl, fitted with a cork greenish yellow chlorine gas comes out which is collected by the upward displacement of air in a gas jar through the delivery tube.

Since it is a poisonous gas so efficient ventilation in the laboratory is necessary.

(fig)

#### b. Industrial Preparation Of Cl<sub>2</sub> Gas:

On large scale chlorine gas is manufactured by the electrolysis of sodium chloride solution in two types of cells.

- Nelson's Cell
- Castner Kellner's Cell

### NELSON'S CELL

#### **Construction:**

- Nelson's cell consists of a U – shaped perforated steel vessel, which acts as cathode.
- The graphite anode is dipped in the salt solution, taken in the U – shaped vessel.
- The U – tube is separated from anode by a diaphragm, deposited on inner wall of the perforated U – tube.
- The U – tube is known as anode compartment and this U – tube is fixed in an outer compartment, known as cathode compartment.

#### **Working:**

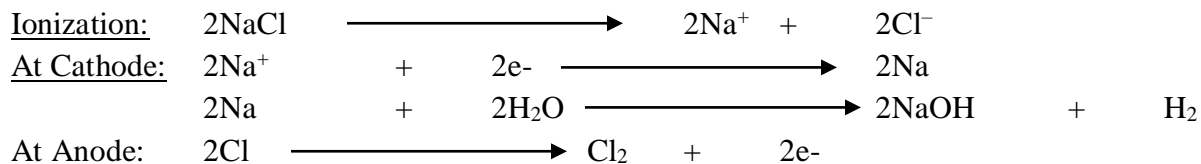
On passing electric current through the solution, chlorine gas is produced at anode, which rises into the dome at the top of the anode and is drawn away. Na metal is produced at cathode which interacts with water of the solution seeping through the diaphragm to release hydrogen (H<sub>2</sub>) gas

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with the formation of sodium hydroxide solution, which is collected at the bottom of the cathode compartment in a catch basin.

(Figure)

### Cell Reaction:



### CASTNER – KELLNER'S CELL

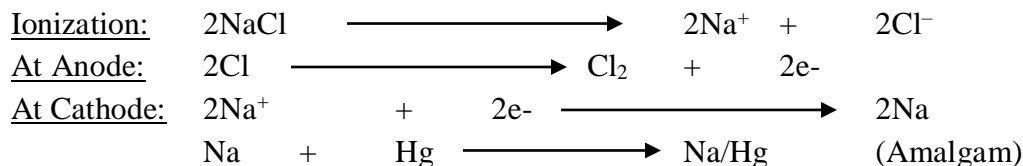
#### Construction:

- Castner Kellner's cell consists of two compartments. First cell is called electrolyzer and second cell is called soda cell or denuder.
- First cell consists of a steel tank. A number of graphite or titanium blocks acts as anode and a stream of mercury flowing across the bottom of the cell acts as cathode. (It is called moving mercury cathode).

#### Working:

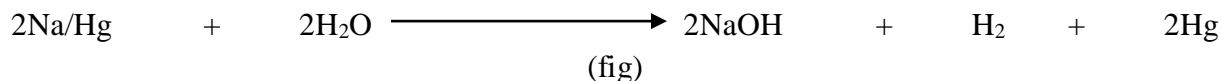
On passing electric current, chlorine is discharged at the anode and sodium at cathode, where it is dissolved in the Hg to form sodium amalgam. The sodium amalgam is removed from the cell.

The following reactions take place.



#### Reaction In Soda Cell:

The sodium amalgam flows into a separate chamber called soda cell. In this cell the amalgam mixed with water, producing sodium hydroxide and releases H<sub>2</sub> gas. Pure mercury is regenerated and recycled through mercury pump.



#### Advantages Of The Process:

- The process is very efficient.
- The process gives product of high purity.
- The possible reaction between NaOH and Cl<sub>2</sub> gas is avoided by obtaining NaOH and Cl<sub>2</sub> gas in the separate chambers.

#### Disadvantages Of The Process:

- The process consumes large amount of current.

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- In spite of its strict control, some mercury vapors escape from the factory. This mercury contaminates sea water. As a result mercury becomes part of tissues of marine animals and plants resulting in pollution of food chain.

### **PHYSICAL PROPERTIES OF CHLORINE GAS:**

- Chlorine is greenish yellow gas.
- It has sharp, pungent disagreeable and irritating choking smell.
- It produces inflammation in the nose and throat, if inhaled in considerable quantity and cause congestion in the lung tissues.
- It is fairly soluble in water and its solution is called chlorine water.
- Its density is  $3.214\text{g/cm}^3$  at S.T.P.
- It is 2.5 times heavier than air.
- It shows variable oxidation states in its compounds such as  $-1$  (the most common oxidation state),  $+1$ ,  $+3$ ,  $+5$  and  $+7$ .
- Its boiling point is  $-34.5^\circ\text{C}$ .
- Its freezing point is  $-102^\circ\text{C}$ .

### **CHEMICAL PROPERTIES OF CHLORINE GAS:**

#### **1. Reaction With Halogens:**

Chlorine undergoes addition reaction with Hydrogen gas quickly in the presence of Hydrogen chloride gas



#### **2. Reactions With Metals:**

Practically all metals (except noble metals) combines with chlorine gas on heating to form their chlorides

For Example:

- $2\text{Na} + \text{Cl}_2 \xrightarrow{\Delta} 2\text{NaCl}$
- $\text{Zn} + \text{Cl}_2 \xrightarrow{\Delta} \text{ZnCl}_2$
- $2\text{Sb} + 3\text{Cl}_2 \xrightarrow{\Delta} 2\text{SbCl}_3$
- $2\text{Fe} + 3\text{Cl}_2 \xrightarrow{\Delta} 2\text{FeCl}_3$
- $\text{Sn} + 2\text{Cl}_2 \xrightarrow{\Delta} \text{SnCl}_4$

#### **3. Reactions With Nonmetals:**

##### **a. With Phosphorous:**

- $2\text{P} + 3\text{Cl}_2 \xrightarrow{\Delta} 2\text{PCl}_3$
- $2\text{P} + 5\text{Cl}_2 \xrightarrow{\Delta} 2\text{PCl}_5$

##### **b. With Sulphur:**



#### **4. Addition Reaction:**

- $\text{CH}_2=\text{CH}_2 + \text{Cl}_2 \xrightarrow{\quad\quad\quad} \begin{array}{c} \text{Cl} \quad \text{Cl} \\ | \quad | \\ \text{CH}_2-\text{CH}_2 \end{array}$
- $\text{CO} + \text{Cl}_2 \xrightarrow{\quad\quad\quad} \text{COCl}_2$

$\text{COCl}_2$  is a poisonous gas and is used as a chemical weapon in wars.

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### 5. Substitution Reaction:

Chlorine undergoes addition reaction with a lot of compounds.

For Example

### 6. Reaction With Alkali:

### 7. Reaction With Ammonia:

### 8. Reaction With Lime Water:

### 9. Reaction With Water (Bleaching Action):

### **USES OF CHLORINE GAS:**

The production and consumption of  $\text{Cl}_2$  on large scale make it one of the most important chemical.

1. It is used in the

2. It is used in the

3. It is used

4. It is used

5. It is used

6. It is used

7. Chlorine is used extensively in the

8. It is also used in the layer test for the identification of bromide and iodide ions.

### **HYDROCHLORIC ACID (HCL)**

1. Laboratory preparation:

2. Industrial preparation:

a. By direct combination of  $\text{H}_2$  and  $\text{Cl}_2$ :

b. By Hydrolysis of  $\text{PCl}_3$ :

c. By action  $\text{Cl}_2$  on  $\text{H}_2\text{S}$  and  $\text{H}_2\text{O}$

### **PHYSICAL PROPERTIES:**

1. Hydrogen chloride

2. It is highly

3. It is slightly

### **CHEMICAL PROPERTIES:**

i. Reaction With Water:

ii. Reaction With Alkalis

iii. Reaction With Ammonia

iv. Reaction With Less Electropositive Metals:

v. Reaction With Metal Carbonates And Bicarbonates:

vi. Reaction With  $\text{AgNO}_3$  And  $\text{Pb}(\text{NO}_3)_2$  (Precipitation)

### **USES:**

1. Hydrochloric acid is used

2. It is used in the manufacture

3. It is used as chemical reagent in the laboratory.

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4. It is used to remove  $\text{CaCO}_3$  deposits from sanitary wares and floors.

### **BLEACHING POWDER**

#### **INTRODUCTION:**

Bleaching powder is a mixed salt

#### **PREPARATION:**

- a. Laboratory Preparation:
- b. Commercial Preparation:

#### **PHYSICAL PROPERTIES:**

1. Bleaching powder
2. It is soft powder.
3. It gives a strong smell of chlorine.

#### **CHEMICAL PROPERTIES:**

- i. Reaction With Water:
- ii. Reaction With Strong Acids:
- iii. Reaction With  $\text{CO}_2$  In The Presence Of Moisture
- iv. Reaction With Ammonia:

#### **USES:**

1. Bleaching powder is used for sterilization of drinking water and disinfecting drainages and sewers.
2. It is used for bleaching of cotton, linen and paper pulp.
3. It is used for the quick preparation of  $\text{Cl}_2$  gas which is a powerful oxidizing agent.
4. It is also used to prepare hypochlorous acid ( $\text{HClO}$ )