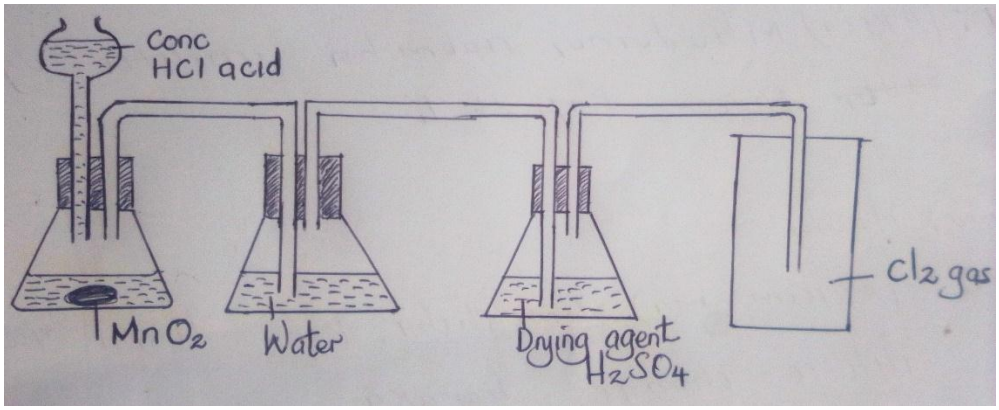
CHLORINE AND ITS COMPOUNDS.

Laboratory preparation of chlorine.

- ☆ Chlorine is prepared by oxidation of concentrated Hydrochloric acid.
- ☆ The common oxidising agent used are potassium manganate $KMnO_4$ and manganese oxide MnO_2.



$MnO_{2\,(S)} + 4HCL_{\,(aq)} \longrightarrow MnCl_{2\,(aq)} + 2H_2O_{\,(l)} + Cl_{2\,(g)}.$

- ☆ Chlorine gas is collected by downward delivery as it is denser than air.
- ☆ Chlorine gas is fairly soluble in water hence should not be collected over water, however it can be collected over concentrated sodium chloride $NaCl_{\,(aq)}$
- ☆ $NaOH_{(aq)} + Cl_2(g) \longrightarrow NaOCl_{\,(aq)} + NaCl_{\,(aq)} + H_2O_{\,(l)}$

Preparation of chlorine by oxidation of HCl using potassium permanganate ($KMnO_4$)

- ◊ This reaction is vigorous and heating is not required.

$2KMnO_4 + 16HCL_{\,(aq)} \longrightarrow 2KCl + 2MnCl_{2\,(aq)} + 5Cl_{2\,(g)} + 8H2O_{\,(l)}$

Other methods of chlorine preparation

- ✔ **From bleaching powder (**$CaOCl_2$)

$CaOCl_{2(s)} + 2HNO_{3\,\mathbf{(aq)}} \longrightarrow Ca(NO_3)_{2\,(aq)} + H_2O_{\,(l)} + Cl_{2\,(g)}$

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

NOTE: sulphuric acid should not be used in this case as the reaction stops after a while. This is because of the formation of an insoluble layer on $CaOCl_2$ which prevents further reaction.

Preparation of chlorine from sodium chloride NaCl, sulphuric acid and Manganese (IV) oxide

◊ The mixture is heated to generate chlorine gas.
$2NaCl_{(s)} + 2H_2SO_4\ (l) + MnO_2(s) \longrightarrow Na_2SO_{4\ (aq)} + MnSO_4 + H_2O + Cl_{2\ (g)}$

◊ The role of concentrated sulphuric acid is to generate hydrochloric acid by reacting with sodium chloride.
$NaCl_{(s)} + H_2SO_{4\ (l)} \longrightarrow NaHSO_{4\ (aq)} + HCl_{(aq)}$

◊ The role of manganese oxide or potassium manganate is to oxidise the concentrated hydrochloric acid to produce chlorine gas.
$MnO_{2(s)} + 4HCl_{(aq)} \longrightarrow MnCl_{2\ (aq)} + H_2O_{(l)} + Cl_{2\ (g)}$

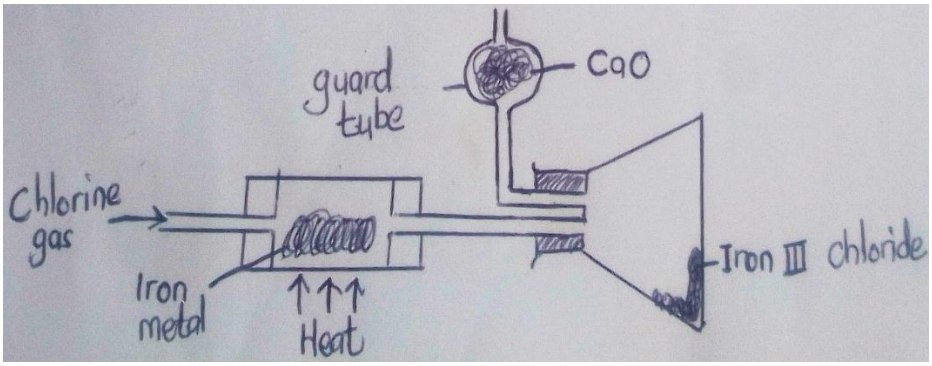
Physical properties of chlorine gas.

◊ Greenish yellow gas with unpleasant chocking and irritating smell.
◊ It is denser than air hence collected by downward delivery.
◊ It is fairly soluble in water and reacts with water to form chlorine water.
◊ It occurs as a diatomic molecule.

Physical properties of chlorine gas

❖ **Reaction of chlorine with iron wool (metals)**

~ Chlorine reacts with heated iron to form iron III chloride which sublimes.



~ The reaction is as follows
$2Fe_{(s)} + 3Cl_{2\ (g)} \longrightarrow 2FeCl_3$

~ reaction in the guard tube
$CaO_{(s)} + H_2O \longrightarrow Ca(OH)_{2\ (s)}$
$CaO_{(s)} + Cl_{2\ (g)} \longrightarrow CaOCl_{2(s)}$
Bleaching powder.

What is the role /function of Cao/$CaCl_2$ in the guard tube?

~ It absorbs moisture from air and keeps the apparatus dry.
~ It prevents hydrolysis of iron III chloride, $FeCl_3$.

Why CaO is preferred compared to CaCl2 in the guard tube?

~ It absorbs both moisture and excess chlorine gas.

Note:

- ☆ This experiment should be conducted in the fume chamber as chlorine gas is poisonous.
- ☆ It is necessary to pass chlorine gas through the apparatus before heating begins-this is to expel air which would otherwise oxidize iron before the reactions starts.
- ☆ Iron III chloride is collected using the method above because it sublimes on heating hence collected far away from the heating point.

❖ **Chlorine is a bleaching agent.**

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

$HOCl_{(aq)}$ + dye (coloured) $\longrightarrow$ $HCl_{(aq)}$ + Dye (colourless)

~ Chlorine reacts with water to form hypochlorous acid which bleaches by oxidation.

❖ **Reaction of chlorine gas with dilute and cold sodium hydroxide solution.**

~ When chlorine gas is bubbled through cold and dilute NaOH solution, the resulting solution acts as a bleaching agent due to pressure sodium hypochlorite which is bleached by oxidation.

$NaOH_{(s)} + Cl_{2\,(g)} \longrightarrow NaCl + NaOCl + H_2O$

Explain how the resulting solution acts as a bleaching agent.

~ Due to the presence of NaOCl which bleaches by oxidation.

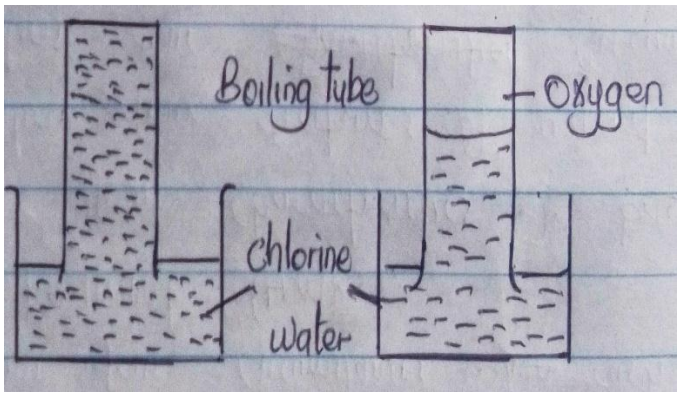
❖ **Reaction between chlorine gas and concentrated NaOH (hot and conc NaOH)**

~ Excess chlorine reacts with hot concentrated solution of NaOH to form chloride, sodium chlorate and water.

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

Sodium chlorate.

Exposure of chlorine water to sunlight.



❖ **Test for chlorine gas.**

~ It is a greenish yellow gas with a pungent smell.

~ It bleaches dump litmus papers.

Observation.

~ Red litmus paper is bleached.
~ Blue litmus paper changes to red and then it is bleached.

❖ **Uses of chlorine gas.**

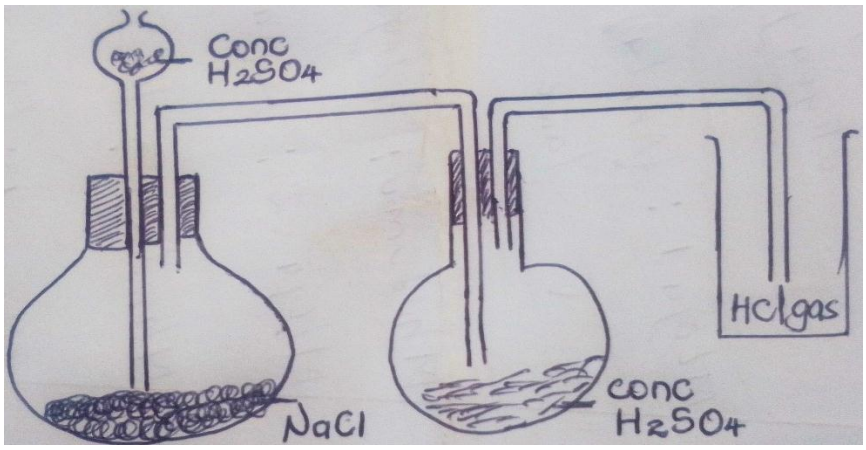
~ Industrial manufacture of hydrochloric acid.
~ Used in water treatment to kill germs.
~ Manufacture plastics like PVC(poly vinyl chloride)
~ Manufacture of herbicides and insecticides.
~ Manufacture of sodium hypochlorite used in sewage treatment.

Chlorine gas is poisonous yet it is used in water treatment, expain.

~ Used in wider proportion and it reacts with water to form a harmless HCL acid (HOCl).

HYDROGEN CHLORIDE GAS

~ It is prepared by heating metal chloride with concentrated sulphuric (VI) acid.
~ The common chloride used is sodium chloride.



$NaCl_{(s)} + H_2SO_{4(l)} \longrightarrow NaHSO_4(s) + HCL_{(g)}$

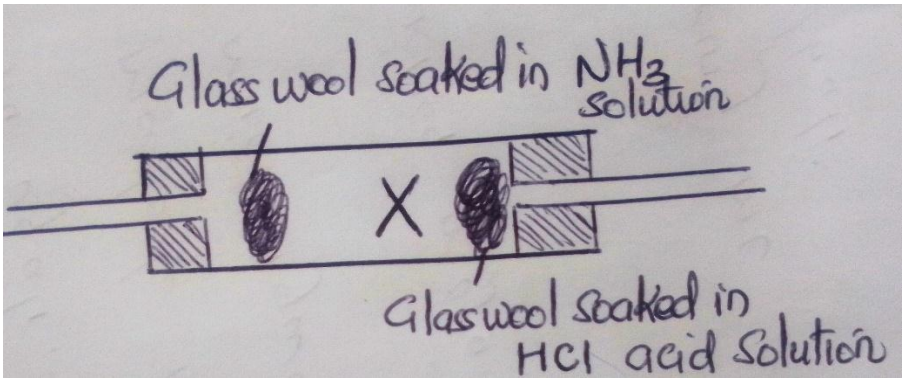
Properties of hydrogen chloride gas.

❖ **Physical properties.**

~ It is denser than air hence it is collected by upward displacement or downward delivery.
~ It is highly soluble in water thus could be collected over water.
~ It has a low boiling point
~ Has a strong pungent and irritating smell.

Chemical properties.

❖ **Reaction with ammonia**



~ Hydrogen chloride gas form white cloud/ ring when reacted with ammonia gas. The white ring or clod formed is ammonium chloride.

$NH3_{(g)} + HCl_{(g)} \longrightarrow NH_4Cl_{(s)}$

Colourless colourless white.

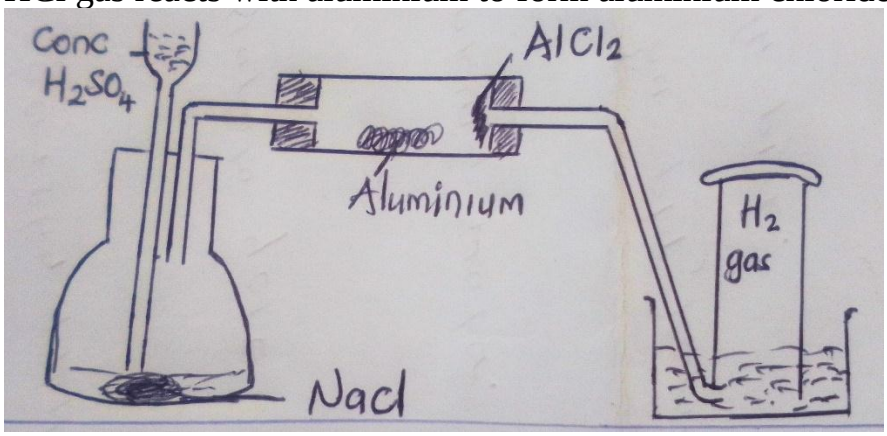
❖ **Reaction with metals.**

~ It is a reducing agent and it reacts with metals to liberate hydrogen gas.

Aluminium

$2Al_{(s)} + 6HCl_{(g)} \longrightarrow 2AlCl_3 + 3H_{2(g)}$

~ HCl gas reacts with aluminium to form aluminium chloride and hydrogen gas.



~ $AlCl_3$ forms far away from hear as it sublimes when heated.

❖ **Reaction of hydrogen chloride gas with carbonates and bicarbonates.**

~ Hydrogen chloride gas reacts to form metal chlorides, water and carbon (IV) oxide gas.

$Na_2CO_{3(s)} + 2HCl_{(g)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

$CaCO_{3(s)} + 2HCl_{(g)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

❖ **Oxidation of Hydrogen chloride gas**

~ The gas is oxidised by oxidising agents such as mno_2 and $kmno_4$ to liberate chlorine gas.

$MnO_{2(s)} + 4HCl_{(g)} \longrightarrow MnCl_{2(aq)} + 2H_2O_{(l)} + Cl_{2(g)}$

Note:

- ✔ Hydrogen chloride gas reacts with iron (Fe) to form Iron (II) chloride and chlorine reacts with iron (Fe) to form Iron (III) chloride.

$Fe_{(s)} + HCl_{(g)} \longrightarrow \underset{\text{Green}}{FeCl_{2(s)}} + H_2O_{(s)}$

$2Fe_{(s)} + Cl_{2\,(g)} \longrightarrow \underset{\text{Brown}}{2FeCl_{3(s)}}$

Industrial manufacture of Hydrochloric acid.

~ HCL acid id manufactured by direct synthesis where hydrogen gas is reacted with chlorine gas.

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

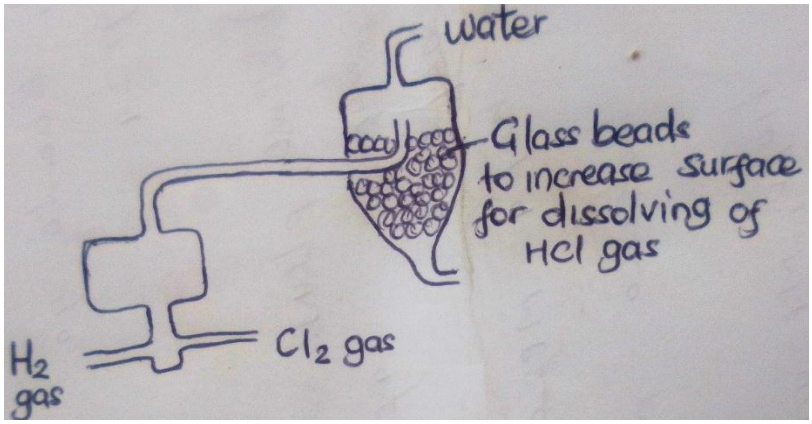
~ The Hydrogen chloride gas formed is dissolved in water to produce HCL acid.

Sources of hydrogen gas.

~ Cracking of alkanes.

Sources of chlorine gas.

~ Electrolysis of brine.



Test for hydrochloric acid.

~ It form white fumes of ammonium chloride (NH_4Cl) when reacted with ammonia.

~ It forms white precipitate when reacted with lead (II) nitrate, Pb $(NO_3)_2$ solution.

$Pb^{2+}_{(aq)} + Cl^- \longrightarrow PbCl_{2(s)}$

Note:

~ Hydrochloric acid is highly soluble in water and if a solution is required it should be dissolved in water using an inverted funnel to prevent sucking back.

Used of hydrochloric acid.

~ Used in manufacture of dyes and drugs.

~ Used in pickling of metals before electroplating. (cleaning metal surfaces)

~ Used in manufacture of PVC pipes.

~ Used in controlling of pH in brine during the manufacture of caustic soda (NaOH)

Note:

- ~ Concentrated hydrochloric acid does not react with copper metal but nitric and sulphuric acid reacts with copper metal, **explain**
  Nitric and sulphuric acid are strong oxidising agents and oxidises copper metal to Cu^{2+} while HCl is a reduced agent and cannot oxidise copper to Cu^{2+}.