Halogens : Chlorine

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Halogens

- The group (VII)A of the periodic table contains elements : fluorine, chlorine, bromine, iodine and astatine.
- They are collectively called 'halogens‘, which means 'sea salt producer' (hale-sea salt, genes- to produce).
- The elements are found in the form of salt.

Chlorine (Cl)

Lab Preparation

Chlorine can be prepared in two way

A) With application of heat
B) Without application of heat

Lab prepation Contd.

A) With application of heat - By application of heat, chlorine can be prepared by two methods.

a) Chlorine is usually prepared by heating conc. hydrochloric acid with MnO_2

$$MnO_2 + \text{conc. } 4HCl \rightarrow MnO_2 + 2H_2O + Cl_2$$

b) Chlorine can also be prepared by heating chlorine salt, conc. sulphuric acid and manganese dioxide as follows.

$$2NaCl + 3H_2SO_4 + MnO_2 \rightarrow MnSO_4 + 2H_2O + 2NaHSO_4 + Cl_2$$

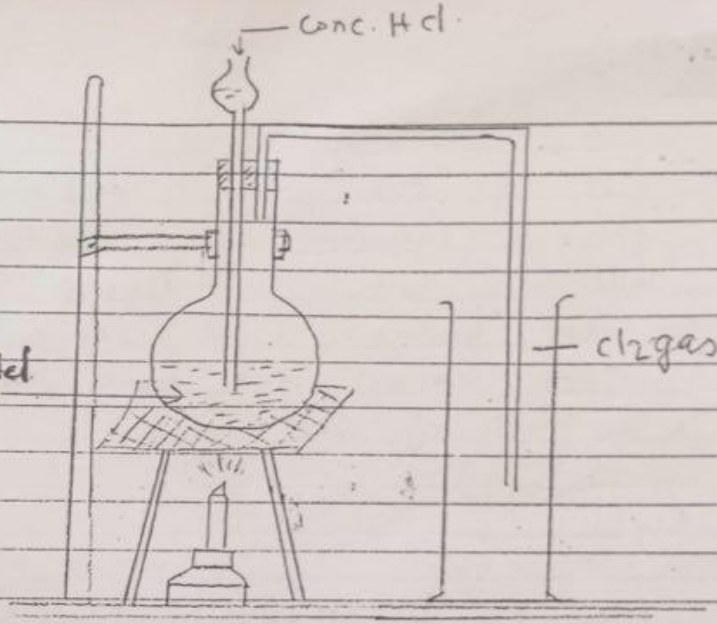


Fig- Lab preparation of chlorine (with appl^{n} of heat

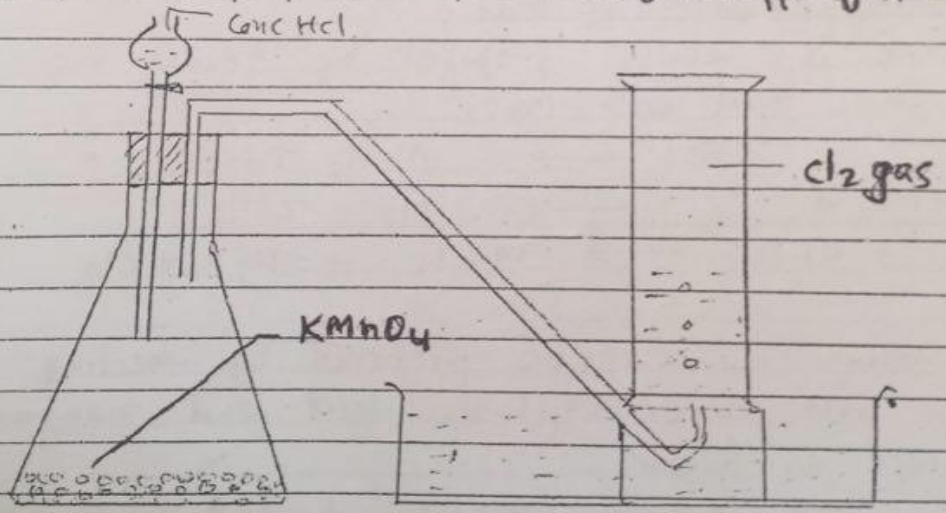


fig- prep^{n} of Cl_2 without application of heat

Lab preparation contd….

B) Without Application of Heat-

a)From $KMnO_4$

Chlorine can be conveniently prepared without application of heat by dropping conc. HCl on powdered $KMnO_4$.

$2KMnO_4 + 16\ HCl \rightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

Lab preparation of Chlorine Contd….

b) From bleaching powder

Chlorine is evolved when bleaching powder is treated with dil. HCl or dil. H_2SO_4.

$$Ca(OCl)Cl + 2HCl \rightarrow CaCl_2 + H_2O + Cl_2$$

Physical Properties of Chlorine

1) Chlorine is a greenish-yellow gas possessing a peculiar irritating smell.
2) It is heavier than air.
3) It is poisonous and attacks the mucous membrane.
4) It is moderately soluble in water, but it is slightly soluble in brine. Hence, collected over brine (10% NaCl).
5) It can be easily liquefied
   Melting point = -101˚C
   Boiling point = -35˚C

Chemical Properties of Chorine

1) Combustibility

Chlorine does not burn, but like oxygen supports the combustion of Hydrogen, Antimony, Phosphorus, Sodium, Copper and many other substances; always with the formation of their chlorides.

2) Action With Hydrogen

Chlorine has got a very great affinity for hydrogen. Chlorine combines with hydrogen, giving hydrides.

$H_2 + Cl_2 \rightarrow 2HCl$ [In presence of sunlight]

(Chlorohydride)

3) Action with Water

At ordinary temperature, chlorine dissolves in water giving Chlorine water which decomposes to give hypochlorus and hydrochloric acid.

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$

(Hypochlorus acid)

4) Action With Alkali

a) With warm and conc. alkali

It gives hypo chlorite (NaClO) which further produce hypochlorate.

$$6NaOH + 3Cl_2 \rightarrow \underset{\text{(Hypochlorate)}}{NaClO_3} + 5NaCl + 3\ H_2O$$

b) With cold and dil. Alkali

$$2NaOH + Cl_2 \rightarrow NaCl + \underset{\text{(Hypochlorite)}}{NaClO} + H_2O$$

5) Action With NH_3

NH_3 undergoes oxidation with Cl_2

a) With excess NH_3, Cl_2 gives NH_4Cl and nitrogen.

$2NH_3 + 3Cl_2 = N_2 + 6HCl$

$6HCl + 6NH_3 = 6NH_4Cl$

$8NH_3 + 3Cl_2 = N_2 + 6HCl + 6NH_4Cl$

b) With chlorine in excess, the product is as follows.

$2NH_3 + 6Cl_2 = NCl_3 + 6HCl$

6) Oxidising Action

Chlorine is a strong oxidising agent in presence of water, it oxidises following compounds

a) Chlorine oxidizes H_2S to Sulphur

$H_2S + Cl_2 \rightarrow HCl + S$

b) Chlorine oxidizes SO_2 to H_2SO_4;

$SO_2 + 2H_2O + Cl_2 \rightarrow 2HCl + H_2SO_4$

c) Chlorine oxidizes sulphites to sulphates;

$Na_2SO_3 + H_2O + Cl_2 \rightarrow Na_2SO_4 + 2HCl$

Oxisising action of Chlorine contd..

d) Chlorine oxidizes thiosulphates to sulphur.

$Na_2S_2O_3 + H_2O + Cl_2 \rightarrow Na_2SO_4 + 2HCl + S$

e) Chlorine also oxidises ferrous salts to ferric salts.

$H_2O + Cl_2 \rightarrow HCl + HClO$

$HClO \rightarrow HCl + O$

$2FeSO_4 + H_2SO_4 + O \rightarrow Fe_2(SO_4)_3 + H_2O$

$2FeSO_4 + H_2SO_4 + Cl_2 \rightarrow Fe_2(SO_4)_3 + 2HCl$

Similarly, acidified ferrous chloride oxidises to ferric chloride

$FeCl_2 + Cl_2 \rightarrow FeCl_3 + HCl$ (In presence of H_2SO_4)

7) Bleaching Action of chlorine(VVI)

The bleaching action of Cl_2 is due to its oxidation reaction.

$Cl_2 + H_2O \rightarrow HCl + HClO$

$HClO \rightarrow HCl + O$

Coloured matter + O → Colourless matter

(Red rose) (Colourless rose)

The bleaching action of chlorine is permanent.

8) Formation of addition compounds

Reaction with unsaturated organic compounds-

Chlorine can be added to ethylene but no catalyst is required.

$CH_2=CH_2 + Cl_2 \rightarrow ClCH_2 - CH_2Cl$

(Ethylene or Ethene)

(Ethylene dichloride)

9)Action with organic compounds

Chlorine reacts with saturated hydrocarbon i-e methane as follows in presence of sunlight.

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$

Methyl chloride

$CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$

Methylene dichloride

$CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl$

Chloroform

$CHCl_3 + Cl_2 \rightarrow CCl_4$ (Carbon tetrachloride)

Chemical properties of chlorine cont..

10) Action with bromides and iodides

Chlorides can liberate Br_2 and I_2 from bromides and iodides respectively.

$2KBr + Cl_2 \rightarrow 2KCl + Br_2$

$2KI + Cl_2 \rightarrow 2KCl + I_2$

11) Action with metals

Reaction of chlorine with metals are the most vigorous.

$2Na + Cl_2 \rightarrow 2NaCl$

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$ (Ferric Chloride)

$Cu + Cl_2 \rightarrow CuCl_2$ (Cupric chloride)

12) Action with non metals

Cl_2 combine with non metals like P, S to varrying degree to give the product as follows:

$P_4 + 10Cl_2 \rightarrow 4PCl_5$

$P_4 + 6Cl_2 \rightarrow 4PCl_3$

13) With metalloids

Cl_2 combines with metalloids like As and Sb as follows:

$2As + 3Cl_2 \rightarrow 2AsCl_3$ (Arsenic Chloride)

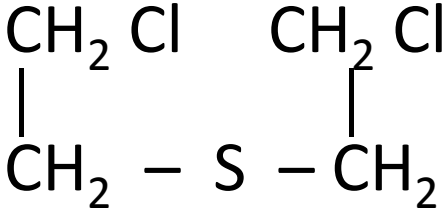
$2Sb + 3Cl_2 \rightarrow 2SbCl_3$ (Antimony chloride)

Uses of Chlorine

i) For bleaching wood pulp for the manufacture of paper and rayen and for bleaching cotton and fine fabrics.

ii) As a disinfectant and germicide for the sterilization of drinking water.

iii) For the preparation of poisonous gases for examples phosgene, mustard gas, tear gas.



(Mustard gas)

iv) In organic chemicals industry for the manufacture of chloroform, carbon tetrachloride, etc.