8 Study of Compounds — Hydrogen Chloride

SYLLABUS

(i) Hydrogen chloride: preparation of hydrogen chloride from sodium chloride; refer to the density and solubility of hydrogen chloride (fountain experiment); reaction with ammonia; acidic properties of its solution.

Preparation of hydrogen chloride from sodium chloride; (the laboratory method of preparation can be learnt in terms of reactants, product, condition, equation, diagram or setting of the apparatus, procedure, observation, precaution, collection of the gas and identification).

Simple experiment to show the density of the gas (Hydrogen Chloride) – heavier than air.

Solubility of hydrogen chloride (fountain experiment); (setting of the apparatus, procedure, observation, inference) – method of preparation of hydrochloric acid by dissolving the gas in water – the special arrangement and the mechanism by which the back suction is avoided should be learnt.

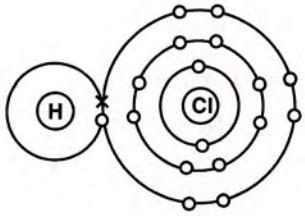
Reaction with ammonia

Acidic properties of its solution – (reaction with metals, their oxides, hydroxides and carbonates to give their chlorides, decomposition of carbonates, hydrogen carbonates, sulphides, sulphites, thiosulphates and nitrates).

HYDROGEN CHLORIDE

Molecular formula : HCl
Molecular mass : 36.5
Bond : Covalent

H:Cl: or H – Cl
Dot diagram or Lewis structure



Orbital diagram

8.1 OCCURRENCE

Glauber prepared the acid in 1648 by heating common salt (NaCl) with concentrated sulphuric acid. Lavoisier named it ***muriatic acid***. Davy in 1810 named it as hydrochloric acid.

1. Hydrogen chloride gas occurs in free state in volcanic emissions.
2. Hydrochloric acid (0·2 – 0·4 percent) is present in gastric juice of mammals and it helps in digestion.

8.2 GENERAL PREPARATION OF HYDROGEN CHLORIDE GAS

1. *By synthesis (Direct combination).*

(i) Moist hydrogen gas combines with chlorine in the presence of diffused sunlight.

Hydrogen + Chlorine → Hydrogen chloride

$$H_2(g) + Cl_2(g) \xrightarrow[\text{Sunlight}]{\text{Diffused}} 2HCl(g)$$

Note : The reaction is *explosive in direct sunlight* but it is *negligible in the dark.*

However, in the presence of a *catalyst such as activated carbon,* the reaction takes place even in the dark. (Activated carbon absorbs hydrogen which increases reactivity).

(ii) Burning jet of hydrogen also burns in chlorine forming hydrogen chloride.

2. *By heating metallic chloride with conc. sulphuric acid*

Metal chloride	+	Sulphuric acid [conc.]		Salt	+	Hydrogen chloride
NaCl	+	H_2SO_4	$\xrightarrow{\leq 200\ ^\circ C}$	$NaHSO_4$	+	HCl [g]
2NaCl	+	H_2SO_4	$\xrightarrow{\text{above } 200\ ^\circ C}$	Na_2SO_4	+	2HCl [g]
$CuCl_2$	+	H_2SO_4	$\xrightarrow{\Delta}$	$CuSO_4$	+	2HCl [g]

8.3 LABORATORY PREPARATION OF HYDROGEN CHLORIDE GAS

In the laboratory, hydrogen chloride gas can be prepared by the action of concentrated sulphuric acid on sodium chloride.

Reactants : Sodium chloride and concentrated sulphuric acid.

Procedure : Set up the apparatus as shown in Fig. 8.1.

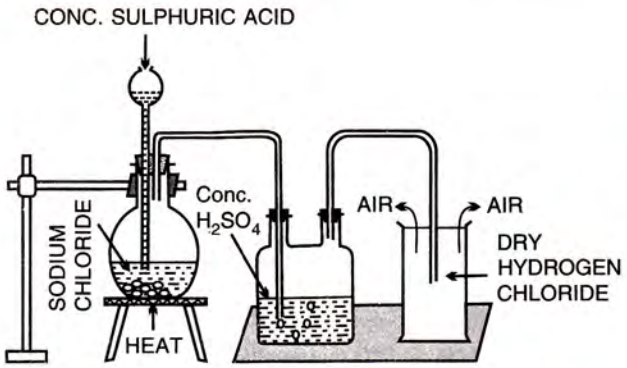


Fig. 8.1 Preparation of hydrogen chloride gas from common salt.

Place some common salt in a flask* and pour concentrated sulphuric acid through the thistle funnel. The reaction proceeds slowly in the cold. On heating the mixture gently there is effervescence and HCl gas is evolved in a controlled manner.

The gas is dried by passing through washer bottle contianing concentrated sulphuric acid.

It is collected by upward displacement of air in a gas jar.

Reaction :

$$NaCl + H_2SO_4 \xrightarrow{<200\,°C} NaHSO_4 + HCl\uparrow$$

Though it is a reversible reaction, yet it goes to completion as hydrogen chloride continuously escapes as a gas.

The reaction can occur upto the stage of formation of sodium sulphate on heating above 200°C.

$$**NaHSO_4 + NaCl \xrightarrow{\text{above } 200\,°C} Na_2SO_4 + HCl\uparrow$$

or

$$2NaCl + \underset{\text{(Conc.)}}{H_2SO_4} \xrightarrow{\text{above } 200\,°C} Na_2SO_4 + 2HCl$$

* Flat bottom flask or round bottom flask can be used. Round bottom flasks are normally used to heat at high temperature.

** This reaction indicates clearly the acid nature of sodium hydrogen sulphate.

Note : (i) Sodium chloride is cheap and therefore it is preferred for preparation of HCl over other metal chlorides.

(ii) **Conc. nitric acid is not used during the preparation of HCl** because it is volatile and may volatilize out alongwith hydrogen chloride.

Purification of HCl gas :

It is dried by passing through conc. sulphuric acid.

The other drying agents like phosphorus pentoxide (P_2O_5) and quick lime (CaO) cannot be used, since they react with hydrogen chloride.

$$2P_2O_5 + 3HCl \rightarrow POCl_3 + 3HPO_3$$

$$CaO + 2HCl \rightarrow CaCl_2 + H_2O$$

Collection :

1. Hydrogen chloride gas is collected by the downward delivery (upward displacement of air) as it is 1·28 times heavier than air.
2. It is not collected over water, since it is highly soluble in water.

Identification

When the jar is completely filled with hydrogen chloride, fumes appear above the jar's mouth.

When hydrogen chloride gas is exposed to air, *it gives white fumes,* due to the formation of hydrochloric acid on reacting with atmospheric water vapour.

In order to know whether the gas jar is full, bring a rod dipped in ammonium hydroxide near its mouth.

$$HCl + NH_4OH \rightarrow NH_4Cl + H_2O$$

Dense white fumes of ammonium chloride will be produced proving thereby that the jar is full of hydrogen chloride gas.

Precautions :

(a) The lower end of the thistle funnel must be dipped in conc. sulphuric acid.

(b) Delivery tube should be dipped in drying agent *i.e.,* conc. H_2SO_4.

(c) Temperature is maintained at nearly 200°C

At higher temperature *i.e.*, above 200°C :

(i) the apparatus which is made of glass may crack.

(ii) fuel is wasted.

(iii) sodium sulphate formed, forms a hard crust which sticks to the glass and is difficult to remove.

8.4 PHYSICAL PROPERTIES OF HYDROGEN CHLORIDE GAS

1. Colour	*colourless* gas
2. Smell	*pungent* choking smell
3. Taste	sour (*acidic*) in taste
4. Physiological nature	It is corrosive in nature. *It irritates nose, throat and lungs.*
5. Density	It is about one and a quarter times heavier than air (V.D. of HCl is 18·25 and that of air 14·4).
6. Boiling point	–83°C
7. Melting point	–113°C
8. Liquefaction and solidification	When subjected to a high pressure (40 atm.) at low temperature (10°C), it is liquefied to a colourless liquid.
9. Solubility	Hydrogen chloride gas is highly soluble in water (1 volume of water dissolves 452 volumes of the gas at room temperature). HCl being polar covalent compound is soluble in organic non-polar solvents also such as acetone and toluene.

Experiment to demonstrate density : *To show that HCl gas is heavier than air.*

It can be proved by pouring the gas in a jar with a burning candle as shown in Fig. 8.2. The candle gets extinguished because HCl gas being heavier occupies the lower portion of the jar and forces the air out of it.

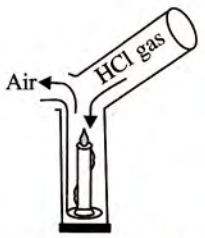


Fig. 8.2 To show that HCl gas is heavier than air

Experiment to demonstrate solubility : *To show that HCl gas is highly soluble.*

The great solubility of the gas can be demonstrated by means of *Fountain Experiment* as illustrated below.

Fountain Experiment : Take a *dry* round bottomed flask filled with dry HCl gas. Arrange the apparatus as shown in Fig. 8.3. On the mouth of the flask, fix a rubber stopper with two holes. Through one hole pass a long jet tube, and through other hole pass a dropper with few drops of water. Put the jet tube in the beaker containing blue litmus solution.

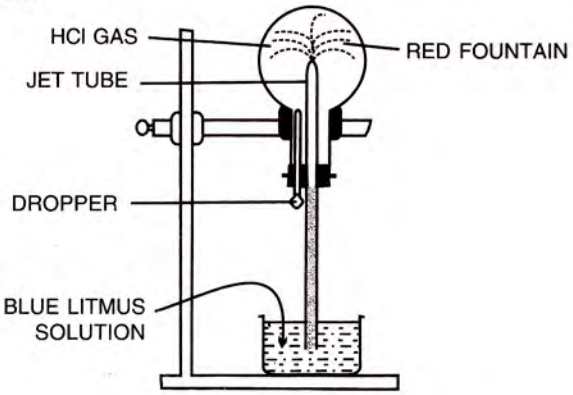


Fig. 8.3 Fountain experiment

Press the dropper. It is seen that the blue litmus solution enters the jet tube with a great force, forming a red fountain.

Reason : As the water goes in the flask from the dropper, HCl gas present in the flask dissolves due to its high solubility, thereby lowering the pressure inside.

The outside pressure being higher, pushes the blue litmus solution inside, through the jet tube.

The blue litmus solution turns red due to the acidic nature of hydrogen chloride gas.

Note : Due to the high solubility, hydrogen chloride gas fumes in moist air forming tiny droplets of hydrochloric acid.

8.5 CHEMICAL PROPERTIES OF HYDROGEN CHLORIDE GAS

1. **Combustibility :** The gas is neither combustible nor a supporter of combustion. *It does not burn, rather it extinguishes a burning splint.*

2. **Thermal dissociation :** On heating above 500°C, it dissociates into hydrogen and chlorine.

$$2HCl \xrightarrow{>500°C} H_2 + Cl_2$$

3. **With metals :** Metals that come before hydrogen in the electrochemical series form their corresponding chlorides when **heated** with HCl and liberate hydrogen.

Metal	+	Hydrogen chloride (g)	→	Metal chloride	+	Hydrogen
2Na	+	2HCl	→	2NaCl	+	H_2
Ca	+	2HCl	→	$CaCl_2$	+	H_2
Mg	+	2HCl	→	$MgCl_2$	+	H_2
Zn	+	2HCl	→	$ZnCl_2$	+	H_2
Fe	+	2HCl	→	$FeCl_2$	+	H_2

4. **Reaction with ammonia :** It combines with ammonia to form dense white fumes of ammonium chloride.

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$$

i.e., two gases combine to form solid

8.6 HYDROCHLORIC ACID

When hydrogen chloride gas is dissolved in water, hydrochloric acid is formed.

The covalent compound ionises in water due to its polar nature.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Important : (i) Dry hydrogen chloride gas and liquefied hydrogen chloride do not turn blue litmus paper red, showing non-acidic character of the dry gas.

(ii) *Liquefied hydrogen chloride does not conduct electricity. It shows covalent nature of hydrogen chloride.*

The gas is also soluble in ***toluene****, (organic solvent) but in that case, it neither turns blue litmus red nor conducts electricity.*

This indicates the absence of H_3O^+ in toluene showing thereby that hydrogen chloride is a covalent compound.

8.6.1 Laboratory method of preparation of hydrochloric acid

The aqueous solution of HCl gas is known as Hydrochloric acid.

It is prepared by dissolving hydrogen chloride gas in water.

The gas is passed into water until no more gas is absorbed. The product is concentrated and contains about 36% of hydrogen chloride by mass.

Procedure :

An inverted funnel, connected to the hydrogen chloride gas supply, is placed in the beaker in such a way that it just touches the water taken in the trough.

Since HCl gas is highly soluble in water, the water rises up in the funnel, back-suction occurs and in turn, the level outside the funnel falls creating an air gap between the rim of the funnel and the surface of water.

The pressure outside and inside then becomes equal and the water which had risen in the funnel falls down again.

This process continues till the water in the trough is saturated with hydrogen chloride gas resulting in the formation of hydrochloric acid.

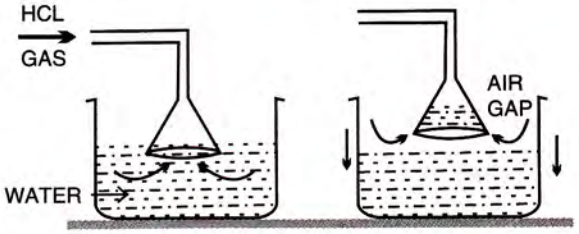


Fig. 8.4 To show funnel arrangement

Mechanism by which back suction is avoided or minimized

The funnel arrangement —

(a) prevents or minimizes back-suction of water.

(b) provides a large surface area for absorption of HCl gas.

Why is funnel arrangement used ?

Hydrogen chloride gas is sufficiently soluble, so, it is absorbed in water more quickly than it is being generated in the flask. In this case, the pressure in the delivery tube and flask is reduced and the atmospheric pressure from outside forces the water back upto the delivery tube. This effect is called '*back suction*'.

If the tube is made of ordinary narrow glass tubing, the water will quickly fill it and pass over into the generating flask. *This would stop the reaction and might result in an explosion due to the heat produced when water comes in contact with hot concentrated sulphuric acid.*

Precaution : To prevent such an accident, an empty flask (anti-suction device) is put between the generative flask and the water trough. In case, the back suction occurs, the water will collect in it and will not reach the generating flask.

A dilute aqueous solution of hydrochloric acid gets gradually concentrated on distillation, till the *concentration* of the acid reaches 22.2% HCl by weight and 77.8% water by weight which boils at 110 °C. No further increase in concentration is possible on boiling, as molecules of HCl (g) get mixed with water vapours.

A constant boiling mixture or azeotrope is a solution which boils without any change in its composition. **HCl acid forms constant boiling mixture at 110°C.**

8.6.2 Properties of hydrochloric acid

Physical properties

1. Colour	Colourless
2. Smell	Pungent choking smell
3. Taste	Sour (acidic)
4. Physiological action	**Concentrated** acid is corrosive and causes blisters on the skin.
5. Solubility	Readily soluble in water in all proportions.
6. Boiling point	110°C (volatile acid)

Chemical properties

1. ***Nature :*** Aqueous solution is strongly acidic, and shows all properties of acids.

Action on indicators

Indicator	Original colour	Changes to
Moist litmus	Blue	Red
Methyl orange	Orange	Pink
Phenolphthalein	Colourless	Colourless

2. **Action on metals :** Hydrochloric acid reacts with metals above hydrogen in the activity series forming metallic chlorides and evolving hydrogen.

Metal	+	Hydrochloric acid	→	Metallic chloride	+	Hydrogen
Ca	+	2HCl	→	$CaCl_2$	+	$H_2\uparrow$
Mg	+	2HCl	→	$MgCl_2$	+	$H_2\uparrow$
Zn	+	2HCl	→	$ZnCl_2$	+	$H_2\uparrow$

3. **Action on oxides and hydroxides :** It reacts with oxides and hydroxides (bases) to form salt and water only.

Metallic oxide/ hydroxide	+	Hydro-chloric acid	→	Metallic chloride	+	Water
MgO	+	2HCl	→	$MgCl_2$	+	H_2O
ZnO	+	2HCl	→	$ZnCl_2$	+	H_2O
FeO	+	2HCl	→	$FeCl_2$	+	H_2O
Fe_2O_3	+	6HCl	→	$2FeCl_3$	+	$3H_2O$
CuO	+	2HCl	→	$CuCl_2$	+	H_2O
NaOH	+	HCl	→	NaCl	+	H_2O
$Ca(OH)_2$	+	2HCl	→	$CaCl_2$	+	$2H_2O$
$Zn(OH)_2$	+	2HCl	→	$ZnCl_2$	+	$2H_2O$
$Cu(OH)_2$	+	2HCl	→	$CuCl_2$	+	$2H_2O$

4. **With salts of weaker acids :** It decomposes salts of weaker acids *e.g.*, carbonates, hydrogen carbonates, sulphites and sulphides.

Carbonates/ hydrogen carbonates	+	Hydrochloric acid	→	Metal chloride	+	Water	+	Carbon dioxide
Na_2CO_3	+	2HCl	→	2NaCl	+	H_2O	+	$CO_2\uparrow$
$CaCO_3$	+	2HCl	→	$CaCl_2$	+	H_2O	+	$CO_2\uparrow$
$NaHCO_3$	+	HCl	→	NaCl	+	H_2O	+	$CO_2\uparrow$
$Ca(HCO_3)_2$	+	2HCl	→	$CaCl_2$	+	$2H_2O$	+	$2CO_2\uparrow$

Sulphites/ hydrogen sulphites	+ Hydrochloric acid (dil) →	Metal chloride	+ Water +	Sulphur dioxide
Na_2SO_3	+ 2HCl →	2NaCl	+ H_2O +	$SO_2\uparrow$
K_2SO_3	+ 2HCl →	2KCl	+ H_2O +	$SO_2\uparrow$
$NaHSO_3$	+ HCl →	NaCl	+ H_2O +	$SO_2\uparrow$

Metallic sulphide	+ Hydrochloric acid (dil) →	Metal chloride	+	Hydrogen sulphide
Na_2S	+ 2HCl →	2NaCl	+	$H_2S\uparrow$
FeS	+ 2HCl →	$FeCl_2$	+	$H_2S\uparrow$

5. Action on thiosulphates : Dilute hydrochloric acid reacts with thiosulphates to produce sulphur dioxide gas and yellow sulphur is precipitated.

$$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2 + S\downarrow$$

Note : *This reaction can be used as a test for distinguishing thiosulphates and sulphites as sulphur is not precipitated when sulphites are treated with dilute HCl.*

6. Reaction with nitrates : Dil. HCl does not normally react with nitrates. However **lead nitrate and mercury (I) nitrate** react with hydrochloric acid to give white precipitate of lead and mercury (I) chloride.

$$Pb(NO_3)_2 + 2HCl \rightarrow PbCl_2\downarrow + 2HNO_3$$
$$Hg_2(NO_3)_2 + 2HCl \rightarrow Hg_2Cl_2\downarrow + 2HNO_3$$

Silver nitrate solution react with hydrochloric acid and it gives a thick curdy white precipitate of silver chloride.

$$AgNO_3 + HCl \rightarrow AgCl\downarrow + HNO_3$$

The white precipitate is *insoluble in nitric acid but soluble in ammonium hydroxide* solution, and forms a complex salt called diammine silver (I) chloride.

$$AgCl + 2NH_4OH \rightarrow [Ag(NH_3)_2]^+ Cl^- + 2H_2O$$

When dilute nitric acid is added to the clear solution of diammine silver (I) chloride, a white precipitate of silver chloride is formed.

$$[Ag(NH_3)_2]^+Cl^-(aq) + \text{Nitric acid} \rightarrow \text{White precipitate of silver chloride}$$

When exposed to light, silver (I) *chloride blackens since it decomposes into chlorine and metallic silver which is liberated as a fine black powder.*

$$2AgCl \rightarrow 2Ag + Cl_2$$

$AgNO_3$ is used as a test for hydrochloric acid and also for chloride ion.

Note : On warming with metallic nitrites, dilute hydrochloric acid gives metallic chlorides and oxides of nitrogen.

$$2KNO_2 + 2HCl \rightarrow 2KCl + H_2O + NO + NO_2$$

7. Oxidation of hydrochloric acid : *Concentrated hydrochloric acid* can readily be oxidised to **chlorine** by strong **oxidising agents such as manganese dioxide, lead dioxide and red lead.** Alternately, we can say that hydrochloric acid readily reduces these compounds.

Oxidising agent	+ Hydro-chloric acid ⟶	Metallic chloride	+ Water +	Chlorine
MnO_2	+ 4HCl (Conc.) $\xrightarrow{\Delta}$	$MnCl_2$	+ $2H_2O$ +	$Cl_2\uparrow$
PbO_2	+ 4HCl (Conc.) $\xrightarrow{\Delta}$	$PbCl_2$	+ $2H_2O$ +	$Cl_2\uparrow$
Pb_3O_4	+ 8HCl (Conc.) $\xrightarrow{\Delta}$	$3PbCl_2$	+ $4H_2O$ +	$Cl_2\uparrow$
$2KMnO_4$	+ 16HCl (Conc.) ⟶	$2MnCl_2 + 2KCl$	+ $8H_2O$ +	$5Cl_2\uparrow$
$CaOCl_2$ (bleaching powder)	+ 2HCl dil. $\xrightarrow{\Delta}$	$CaCl_2$	+ H_2O +	$Cl_2\uparrow$

8. Formation of aqua regia : A mixture having three parts of conc. hydrochloric acid and one part of conc. nitric acid is called *aqua-regia.*

$$\underset{\text{Conc.}}{3HCl} + \underset{\text{Conc.}}{HNO_3} \rightarrow \underset{\text{Nitrosyl chloride}}{NOCl} + \underset{\text{Nascent chlorine}}{2H_2O + 2[Cl]}$$

It gives nascent chlorine. The nascent chlorine reacts with noble metals like gold and platinum, to give their soluble chlorides.

$$\underset{\text{Gold}}{Au} + 3[Cl] \rightarrow \underset{\text{Gold (III) chloride}}{AuCl_3}$$

$$Pt + 4[Cl] \rightarrow \underset{\text{Platinum (IV) chloride}}{PtCl_4}$$

8.7 USES OF HYDROCHLORIC ACID

I. General uses

In the laboratory as a reagent and for preparation of aqua regia.

II. Industrial uses :

(1) In the manufacture of
   (a) chlorine and chlorides, *e.g.*, ammonium chloride used in dry cells.
   (b) dyes, drugs, paints and photographic chemicals (silver chloride).
   (c) glucose from starch.

(2) In industry *to pickle* steel* (clean metal surface by using acid), as HCl dissolves the oxides. Steel before being plated with tin or chromium has to be purified by pickling in HCl and some inhibitors.

(3) For purifying bone black, because HCl dissolves the calcium phosphate present in bones.

(4) To remove rust from iron sheets.

(5) For cleaning metal surfaces before painting, electroplating, galvanising, soldering, etc.

(6) In the extraction of glue from bones.

(7) In tanning and calico printing industry.

* Pickling of metals is a process of removal of oxide coating from the surface of metals before they are painted, electroplated or galvanised.

III. Medicine :

Dilute HCl is prescribed to patients with decreased activity of their gastric juices.

HCl acid helps in the digestion of proteins and also in destroying microorganisms that enter the alimentary canal alongwith the food.

8.8 TESTS FOR HYDROGEN CHLORIDE AND HYDROCHLORIC ACID

(1) HCl gas possesses a characteristic irritating smell.

(2) HCl gas gives thick white fumes of ammonium chloride, when a glass rod dipped in ammonia solution is held near the vapours of the acid.

$$NH_3 + HCl \rightarrow NH_4Cl$$

(3) With silver nitrate solution, both the gas and the acid give a *white precipitate of silver chloride.*

$$AgNO_3 + HCl \rightarrow AgCl\downarrow + HNO_3$$

The precipitate is insoluble in nitric acid but soluble in ammonium hydroxide.

(4) A greenish-yellow gas, *i.e.* chlorine, is liberated when concentrated hydro-chloric acid is heated with oxidising agent like manganese dioxide.

$$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$$

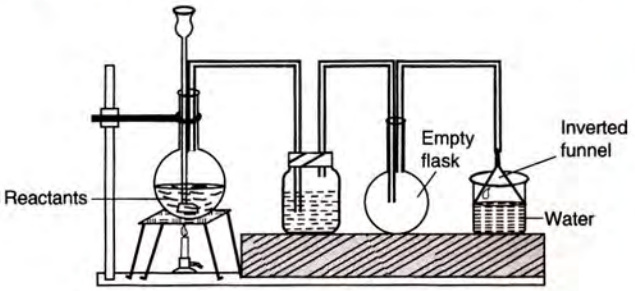
The gas liberated turns moist starch iodide paper blue black.

EXERCISE

1. (a) Draw a labelled diagram for the laboratory preparation of hydrogen chloride gas.
   (b) Give the balanced equation for the reaction.
   (c) Name the drying agent used in drying hydrogen chloride gas.
   (d) Phosphorus pentoxide and calcium oxide are good drying agent but they cannot be used to dry hydrogen chloride gas. Why ?

2. Explain why :
   (a) anhydrous HCl is a poor conductor while aqueous HCl is an excellent conductor.
   (b) when the stopper of a bottle full of hydrogen chloride gas is opened there are fumes in the air.
   (c) a solution of hydrogen chloride in water turns blue litmus red, and conducts electricity, while a solution of the same gas in toluene :
      (i) has no effect on litmus, and
      (ii) does not conduct electricity.
   (d) thick white fumes are formed when a glass rod dipped in NH_4OH is brought near the mouth of a bottle full of HCl gas.
   (e) dry hydrogen chloride gas does not affect a dry strip of blue litmus paper but it turns red in the presence of a drop of water.
   (f) hydrogen chloride gas is not collected over water.

3. The given set up in the figure is for the preparation of an acid.



(a) Name the acid prepared by this method.

(b) Name the reactants used.

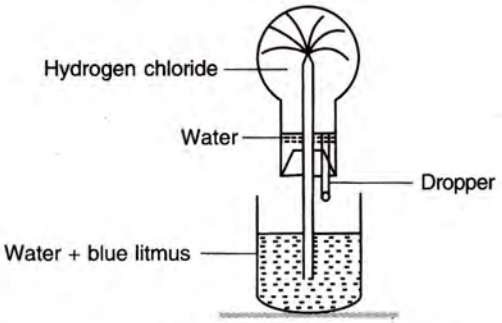
(c) Why empty flask is used.

(d) What is the drying agent used ? Why is this drying agent chosen ?

(e) What is the role of inverted funnel in the arrangement.

4. (a) (i) Name the experiment illustrated below.

(ii) State the colour of the water that has entered the round-bottomed flask.



(b) What property of hydrogen chloride is demonstrated when it is collected by downward delivery (upward displacement) ?

5. (a) Name an element which reacts with hydrogen to form a compound which is strongly acidic in water.

(b) Explain why dilute hydrochloric acid cannot be concentrated by boiling beyond 22.2%.

6. How will you prove that Hydrochloric acid contains (i) hydrogen (ii) chlorine. Write equations for the reactions.

7. Name

(a) black metallic oxide which reacts with hydrochloric acid to give a coloured solution.

(b) two colourless gases, which when mixed produce a white solid.

(c) two gases which chemically combine to form a liquid.

(d) a chloride which is soluble in excess of ammonium hydroxide.

(e) the chemical in which gold can be dissolved.

(f) the experiment which demonstrates that hydrogen chloride is soluble in water.

(g) the gas produced when chlorine water is exposed to sunlight.

8. Solution A reacts with an acid B (which gives greenish yellow gas on reacting with oxidising agents like Pb_3O_4) to give white precipitate C insoluble in nitric acid but soluble in ammonium hydroxide. Name A, B and C.

9. Complete and balance the following reactions, state whether dilute or conc. acid is used.

(a) $NH_4OH + HCl \rightarrow$ (b) $NaHSO_3 + HCl \rightarrow$

(c) $Pb(NO_3)_2 + HCl \rightarrow$ (d) $Pb_3O_4 + HCl \rightarrow$

(e) $Zn + HCl \rightarrow$ (f) $Ca(HCO_3)_2 + HCl \rightarrow$

10. How will the action of dilute hydrochloric acid enable you to distinguish between the following :

(a) Sodium carbonate and sodium sulphite

(b) Sodium thiosulphate and sodium sulphite.

11. Give three distinct tests [apart from using an indicator] you would carry out with solution of HCl to illustrate the typical properties of an acid.

12. MnO_2, PbO_2 and red lead react with conc. HCl acid liberates Cl_2.

What is the common property being shown by these metal oxides ?

13. State which of the two — a solution of HCl in water or in toluene is an electrolyte. Explain.

14. Convert :

(a) Two soluble metallic nitrates to insoluble metallic chlorides using dil. HCl.

(b) Hydrochloric acid to nascent chlorine.

15. A solution of hydrogen chloride in water is prepared. The following substances are added to separate portions of the solution :

S. No.	Substances added	Gas evolved	Odour
1.	Calcium carbonate	.....	.....
2.	Magnesium ribbon	.....	.....
3.	Manganese (IV) oxide with heating	.....	.....
4.	Sodium sulphide	.....	.....

Complete the table by writing the gas evolved in each case and its odour.

16. State the composition of aqua regia. State which component is the oxidising agent in aqua regia.

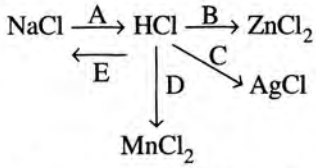
17. Write an equation for the reactions of hydrochloric acid on :

(a) silver nitrate solution, (b) magnesium foil,

(c) caustic soda solution, (d) zinc carbonate,

(e) manganese (IV) oxide, (f) copper oxide.

18. Study the flow chart and give balanced equations with conditions for the conversions A, B, C, D and E.



19. Write balanced equations for the reaction of dilute hydrochloric acid with each of the following :

(a) iron,

(b) sodium hydrogen carbonate,

(c) iron(II) sulphide,

(d) sodium sulphite,

(e) sodium thiosulphate solution.

2010

(a) Aqua regia is a mixture of :

(i) Dilute hydrochloric acid and concentrated nitric acid

(ii) Concentrated hydrochloric acid and dilute nitric acid

(iii) Concentrated hydrochloric acid [1 part] and concentrated nitric acid [3 parts]

(iv) Concentrated hydrochloric acid [3 parts] and concentrated nitric acid [1 part]

(b) How would you distinguish between dilute HCl and dilute HNO_3, by addition of only one solution.

(c) Name two gases which can be used in the study of the fountain experiment. State the common property demonstrated by the fountain experiment.

2011

(a) Choose the correct answer from the choices given :

Hydrogen chloride gas being highly soluble in the water is dried by :

(i) Anhydrous calcium chloride

(ii) Phosphorous pentoxide

(iii) Quick lime

(iv) Conc. Sulphuric acid

(b) Write balanced chemical equation

(i) Sodium thiosulphate is reacted with dilute hydrochloric acid.

(ii) Calcium bicarbonate reacts with dilute hydrochloric acid.

(c) In the laboratory preparation of hydrochloric acid, hydrogen chloride gas is dissolved in water.

(i) Draw a diagram to show the arrangment used for the absorption of HCl gas in water.

(ii) State why such an arrangment is necessary. Give two reasons for the same.

(iii) Write balanced chemical equations for the laboratory preparation of HCl gas when the reaction is :

A. Below 200°C B. Above 200°C

2012

(a) Rewrite the correct statement with the missing word/s :

Aqua regia contains one part by volume of nitric acid and three parts by volume of hydrochloric acid.

(b) Give reason for the following :

Hydrogen chloride gas cannot be dried over quick lime.

(c) Give a balanced equation for the reaction :

Conc. hydrochloric acid and potassium permanganate soluion.

(d) Give balanced equations with conditions, if any, for the following conversion.

(i) Sodium chloride → Hydrogen chloride

(ii) Hydrogen chloride → Iron (II) chloride

(iii) Hydrogen chloride → Ammonium chloride

(iv) Hydrogen chloride → Lead chloride

2013

(a) Identify the gas evolved when :

(i) Potassium sulphite is treated with dilute hydrochloric acid.

(ii) Concentrated hydrochloric acid is made to react with manganese dioxide.

(b) State one appropriate observation for

(i) Copper sulphide is treated with dilute hydrochloric acid.

(ii) A few drops of dil. HCl are added to $AgNO_3$ solution, followed by addition of NH_4OH solution.

2014

(a) Fill in the blank from the choices in the bracket :

Quicklime is not used to dry HCl gas because .....

[CaO is alkaline, CaO is acidic, CaO is neutral].

(b) Write balanced equation for : Action of dilute hydrochloric acid on sodium sulphide.

(c) State your observation : Dilute HCl is added to sodium carbonate crystals.

(d) Study the figure given aside and answer the questions that follow :

(i) Identify the gas Y.

(ii) What property of gas Y does this experiment demonstrate.

(iii) Name another gas which has the same property and can be demonstrated through this experiment.