# Chapter 8. Study of Compounds-I: Hydrogen Chloride

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**Solution 1:**

(i) Acid present in the stomach of mammals is hydrochloric acid.

(ii) Concentrated sulphuric acid is used to dry hydrogen chloride gas.

(iii) Salt obtained by heating sodium chloride with concentrated sulphuric acid below 200 degree Celsius is sodium hydrogen sulphate

$$NaCl + H_2SO_4 \xrightarrow{<200^\circ C} NaHSO_4 + HCl$$

Sodium chloride chloride — Sulphuric Acid(conc.) — Sodium hydrogen sulphate — Hydrogen gas

(iv) When ammoniagas is bubbled through hydrogen chloride white precipitate of ammonium chloride is obtained.

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

White precipitate)

(v) Two solutions that yields white precipitates, when treated with hydrogen chloride or hydrochloric acid are-

(a)Silver nitrate

(b)Lead nitrate

(vi) Gas obtained by treating metals with hydrochloric acid is hydrogen gas.

(vii) Gas obtained by treating ferrous sulphide with hydrochloric acid is hydrogen sulphide ($H_2S$).

(viii) Five oxidizing agents that liberated chlorine from concentrated hydrochloric acid are-

(a)$MnO_2$

(b)$PbO_2$

(c)$KMnO_4$

(d)$K_2Cr_2O_7$

(e)$CaOCl_2$

(ix) Hydrochloric acid is used to extract glue from bones.

(x) Silver chloride is soluble in excess of ammonium hydroxide.

(xi) Chlorine is a greenish yellow gas.

(xii) Gold can be dissolved in aqua regia which is mixture of three parts of concentrated hydrochloric acid and one part of concentrated nitric acid.

(xiii) $K_2Cr_2O_7$ reacts with hydrochloric acid to give a coloured solution.

(xiv) HCl and $NH_3$ are two colourless gases which when mixed produce a white solid.

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**Solution 2:**

Calcium oxide and phosphorous pentoxide are very good drying agents but they are not used to dry HCl gas because they react with hydrogen chloride.

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

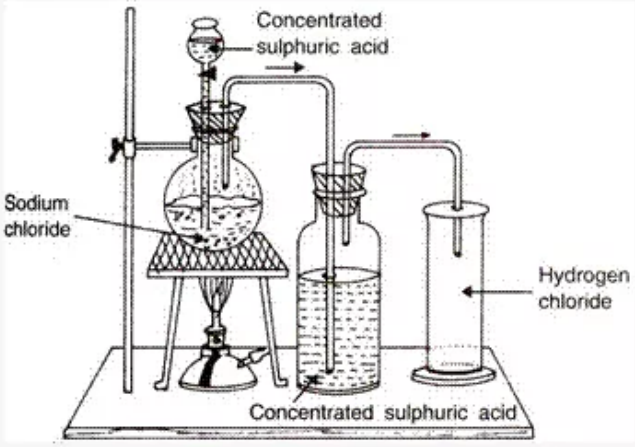
$2P_2O_5 + 3HCl \rightarrow POCl_3 + 3HPO_3$

**Solution 3:**

(i) Hydrogen chloride gas is prepared by the reaction of sodium chloride and sulphuric acid at the temperature below 200°C. Sodium chloride is preferred for laboratory preparation of HCl gas since it is cheapest and most easily available chloride. Lower temperature is preffered because at higher temperature sodium sulphate forms a hard crust and sticks to the bottom of the flask and is difficult to remove.

$$NaCl + H_2SO_4 \xrightarrow{<200^\circ C} NaHSO_4 + HCl$$

Sodium chloride — Sulphuric acid (conc.) — Hydrogen chloride gas




(ii) A glass rod dipped in ammonia solution is brought near the mouth of the gas jar.Dense white fumes of ammonium chloride will be produced. It proves the presence of HCl gas in the gas jar.

(iii) Concentrated $H_2SO_4$ is used to dry HCl gas.

(iv) The gas is collected by upward displacement of air because-

(i) It is heavier than air.

(ii) It is highly soluble in water.

(v) Important precautions are-

(i)The lower end of thistle funnel must be dipped below the concentrated $H_2SO_4$.

(ii)Temperature should be maintained nearly 200°C because at higher temperature –

(a)The apparatus may break

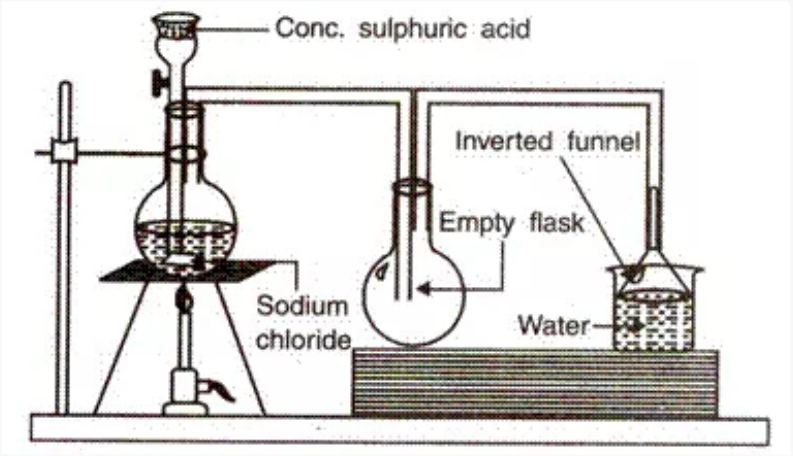
(b)Fuel is wasted.

(c) Sodium sulphate formed in the reaction forms a crust on the surface which is difficult to remove.

## Solution 4:

Hydrochloric acid cannot be prepared by mixing hydrochloride gas directly in water as it leads to back suctions.

A complete set up of apparatus for the preparation of hydrochloric acid in laboratory is shown in the given figure.




Hydrogen chloride gas prepared by the reaction of sodium chloride and sulphuric acid, is passed to inverted funnel arrangement through empty flask. An inverted funnel connected to the HCl gas supply is placed in a beaker in such a way that the rim of the funnel just touches the surface of water in the beaker. HCl gas coming through delivery tube fills the mouth of the funnel and then dissolves in water. By this way we get hydrochloric acid in the beaker.

**OR**

Hydrogen chloride gas is dissolved in water by inverted funnel arrangement. HCl gas cannot be dissolved in water directly as it lead to back suction.

The purpose of funnel while preparing hydrochloric acid from HCl gas is :

1. To prevent back suction of water.
2. It provides a larger surface for dissolution of hydrogen chloride gas.

**Solution 5:**

(i) Lower temperature is preferred because at higher temperature sodium sulphate forms a hard crust and sticks to the bottom of the flask and is difficult to remove.

(ii) Hydrogen chloride is not collected over water because it is highly soluble in water

(iii) Hydrochloric acid cannot be concentrated over 22.2 % by boiling because this mixture(77.8 % water +22.2 % HCl) boils at a constant temperature of 110°C without any change in concentration. Such a mixture is called as azeotrope

(iv) HCl gas does not conduct electricity ,but hydrochloric acid conducts electricity because in hydrochloric acid(aq), hydrogen ions are present to facilitate the movement of electrons whereas no such medium is present in gas

(v) Dilute hydrochloric acid cannot be concentrated beyond 22.2%(by weight) by distillation.This is due to the fact that this mixture(77.8% water+22.2% HCl) boils at a constant temperature of 110°C without any change in concentration. So if its concentration is high it will fall back at a lower concentration

(vi) When the stopper of a bottle full of HCl gas is opened there are fumes in the air due to high solubility of HCl gas in water. It fumes in moist air forming a cloud of tiny droplets of hydrochoric acid.

(vii) A solution of HCl gas in water turns blue litmus red and conducts electricity, while HCl gas dissolves in toluene and it has no effect because hydrochloric acid is a polar covalent compound .In polar solvent like water it ionizes to give hydrogen ions and also facilitates the movement of electrons to conduct electricity while it does not ionize in organic solvents like toluene.

(viii) Dissolved chlorine reacts slowly with water to give hydrochloric acid and hypochlorous acid:

$$Cl_2 + H_2O \longrightarrow HCl + HClO$$

(ix) Formation of Hydrochloric acid in the reaction is responsible for the acidic nature.

**Solution 6:**

(i) If calcium oxide is used to dry HCl, then it will react with HCl gas and result in the formation of calcium chloride and water.

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

(ii) When concentrated hydrochloric acid is kept open,it fumes in moist air forming a cloud of tiny droplets of hydrochloric acid.

(iii) Hydrochloric acid is formed when Hydrogen chloride gas prepared in laboratory, is passed through water, using a delivery tube.

**Solution 7:**

In the following reaction, hydrochloric acid acts as an acid.

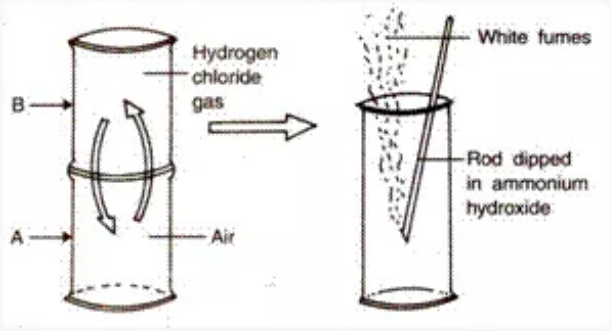
$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

$$CuO + 2HCl \rightarrow CuCl_2 + H_2O$$

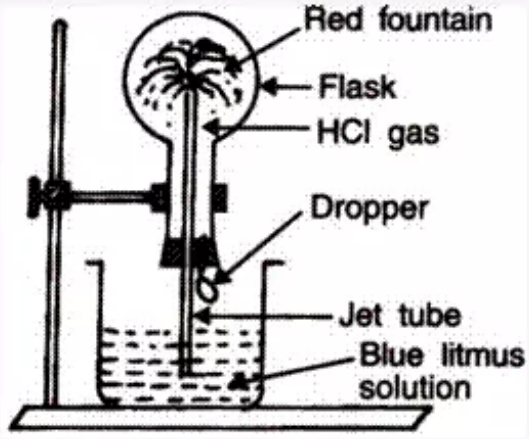
$$FeS + 2HCl \rightarrow FeCl_2 + H_2S$$

**Solution 8:**

(i) Two gas jars A and B are taken.A is filled with air and B with dry HCl gas.B is inverted over A ,kept for few minutes and then jar is removed. Now a rod dipped in ammonium hydroxide is introduced into the jar A, white fumes are seen. This shows that HCl displaces the air since it is heavier than air.




(ii) The high solubility of HCl gas can be demonstrated by "Fountain experiment". In it, a well dried round bottom flask is filled with dry HCl gas and fitted with a two holed rubber stopper. A jet tube is inserted into the flask through one of the holes. A dropper filled with water is fitted into the other hole. Closing the outer end of the jet tube, the flask is inverted and the tube is dipped into a blue litmus solution taken in a beaker, then dropper is pressed. It is seen that the blue litmus solution enters the jet tube with a great force, forming a red fountain.




It happens because water introduced from dropper completely absorbs HCl gas, thereby creating a very low pressure within the flask. To make up for this loss in pressure, blue litmus solution rises in the jet tube and colour of litmus changes to red.

(iii) When HCl gas is heated above 500°C,it dissociates into hydrogen and chlorine.

$$2HCl \underset{}{\overset{>500^\circ C}{\rightleftharpoons}} H_2 + Cl_2$$

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**Solution 9:**

a)

(i)Hydrogen

(ii)Carbon dioxide

(iii)Sulphur dioxide

(iv)Hydrogen sulphide

(v) Carbon dioxide

(vi) sulphur dioxide

(b)

(i) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

(ii) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

(iii) $Na_2SO_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O$

(iv) $PbS + 2HCl \rightarrow PbCl_2 + H_2S$

(v) $Mg(HCO_3)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O + 2CO_2$

(vi) $K_2SO_3 + 2HCl \rightarrow 2KCl + SO_2 + H_2O$

**Solution 10:**

(i)Aqua regia is a mixture is 3 parts of concentrated HCl and 1 part of concentrated $HNO_3$.

(ii)It is used to dissolve noble metals like gold and platinum.

(iii)HCl dissolves noble metals like gold and platinum.HCl with $HNO_3$ reacts to produce nascent chlorine which reacts with gold, platinum etc. to form their respective chlorides.

**Solution 11:**

Two tests for hydrochloric acid are-

(i)When silver nitrate solution is added to hydrochloric acid,it gives white precipitate of silver chloride.

(ii)When lead nitrate solution is added to it, it gives white precipitate of lead chloride.

**Solution 12:**

Uses of hydrochloric acid are-

(i)It is used in the production of dyes, drugs, paints, photographic chemicals etc.

(ii) It is used in the extraction of bone charcoal,by dissolving away calcium phosphate.

(iii)It is used in the extraction of glue from bones.

(iv) It is used in the production of glucose from starch.

**Solution 13:**

(i) $2HCl \underset{}{\overset{>500^{o}C}{\rightleftharpoons}} H_2 + Cl_2$

(ii) $MnO_2 + 4\ HCl \rightarrow MnCl_2\,(aq) + 2H_2O + Cl_2\uparrow$

Manganese dioxide — Manganse chloride

(iii) $NaCl + H_2SO_4 \xrightarrow{<200^{o}C} NaHSO_4 + HCl$

Sodium chloride — Sodium hydrogen sulphate

**Solution 14:**

(i) On reaction with metals, hydrochloric acid forms respective chlorides and liberates hydrogen.

$Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$

(ii) On reaction with oxidizing agents,hydrochloric acid forms respective salts water and pungent smelling,greenish yellow chlorine gas.

$MnO_2 + 4HCl \rightarrow MnCl_2\,(aq) + 2H_2O + Cl_2\uparrow$

Manganese dioxide — Manganese chloride

**Solution 15:**

(i) 3:1 conc. HCl and conc. $HNO_3$
(ii) Azeotropes
(iii) Oxidising
(iv) diffused sunlight
(v) silver chloride
(vi) hot water

**Solution 1991-1:**

Silver nitrate crystals are dissolved in distilled water to prepare its solution and not in tap water .This is due to the reason that tap water contains chloride ions which gives white precipitate with $AgNO_3$ solution.

Dilute hydrochloric acid decomposes metallic carbonates, hydrogen carbonates tc give the corresponding metal chloride and carbon dioxide. The gas $CO_2$ liberated with brisk effervescence while sulphuric acid does not give $CO_2$.

**Solution 1992-1:**

(a) HCl and $NH_3$ combine chemically to form a solid.

(b) Silver chloride is soluble in excess of $NH_4OH$.

(c) On reaction with metals, hydrochloric acid forms respective chlorides and liberates hydrogen.

$Zn + 2HCl \rightarrow ZnCl_2 + H_2 \uparrow$

On reaction with oxidizing agents,hydrochloric acid forms respective salts water and pungent smelling, greenish yellow chlorine gas.

$$\underset{\text{Manganese dioxide}}{MnO_2} + 4HCl \rightarrow \underset{\text{Manganese chloride}}{MnCl_2(aq)} + 2H_2O + Cl_2\uparrow$$

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

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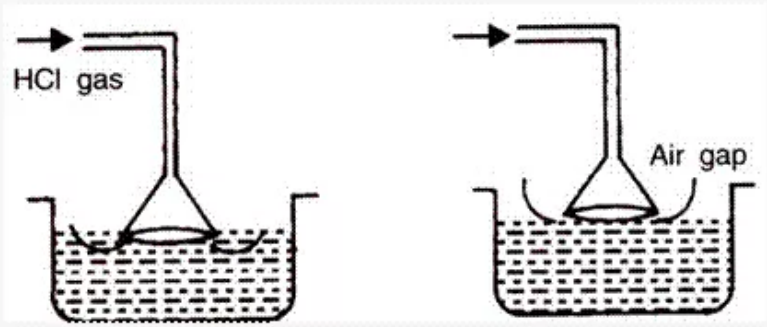
**Solution 1992-2:**




An inverted funnel connected to the HCl gas supply is placed in a beaker in such a way that the rim of the funnel just touches the surface of water in the beaker.HCl gas coming through the delivery tube fills the mouth of the funnel and then dissolves in water.Hence,a low pressure is created and back suction occurs.As a result of it,water level rises in funnel and level of water in the beaker is lowered.Thus,the rim of the funnel loses contact with water and the outside air rushes in through the gap to equalize the pressure on either side of the funnel.The solution falls back into the beaker due to force of gravity.The water level then falls and the funnel drops back to its original position.

**Solution 1992-3:**

Dilute hydrochloric acid cannot be concentrated beyond 22.2%(by weight) by distillation.This is due to the fact that this mixture(77.8% water+22.2% HCl) is an azeotropic mixture, it boils at a constant temperature of 110°C without any change in concentration.

**Solution 1994-1:**

When dilute hydrochloric acid is added to a mixture of iron and sulphur, then hydrogen gas will evolve. While, when dilute hydrochloric acid is added in turn to the compound formed between iron and sulphur the gas formed will be $H_2S$.

**Solution 1995-1:**

Chlorine gas is evolved when an oxide and concentrated hydrochloric acid are heated.

**Solution 1996-1:**

Lead chloride cannot be prepared by adding dilute HCl to lead sulphate solution because lead sulphate is insoluble salt. Infact it can be prepared by adding dilute HCl to lead nitrate solution since lead nitrate is soluble compound.

**Solution 1997-1:**

Hydrogen chloride to anhydrous $FeCl_3$ by adding hydrochloric acid to $Fe_2O_3$

$$Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$$

**Solution 1998-1:**

When silver nitrate solution is added to dilute HCl, white precipitate of AgCl is formed and nitric acid is formed.

$$AgNO_3 + HCl \longrightarrow AgCl\ (s) + HNO_3$$

**Solution 2000-1:**

(a) Sulphuric acid must be added to sodium chloride to prepare hydrogen chloride.

(b) $NaCl$ (Sodium chloride) + $H_2SO_4$ (Sulphuric acid(conc.)) $\xrightarrow{<200^\circ C}$ $NaHSO_4$ (Sodium hydrogen sulphate) + $HCl$ (Hydrogen chloride gas)

(c) When hydrogen chloride mixes with ammonia white fumes of ammonium chloride will be observed.

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

**Solution 2000-2:**

(a).Fountain experiment demonstrates that hydrogen chloride is very soluble in water.

(b).Tests for hydrogen chloride are-

(i)When silver nitrate solution is added to hydrochloric acid, it gives white precipitate of silver chloride.

(ii)When lead nitrate solution is added to it, it gives white precipitate of lead chloride.

(iii)Concentrated hydrochloric acid when added to oxidizing agents like manganese dioxide, lead dioxide etc., it liberates chlorine gas which is a greenish yellow, pungent smelling gas.

**Solution 2000-3:**

(a) $CaOCl_2 + 2HCl \rightarrow CaCl_2 + H_2O + Cl_2$

(b) $Pb(NO_3)_2 + 2HCl \rightarrow \underset{\text{White}}{PbCl_2\downarrow} + 2HNO_3$

(c) $\underset{\text{Manganese dioxide}}{MnO_2} + 4HCl \rightarrow \underset{\text{Manganese chloride}}{MnCl_2(aq)} + 2H_2O + Cl_2\uparrow$

(d) $\underset{\text{Lead dioxide}}{PbO_2} + 4HCl \rightarrow \underset{\text{Lead chloride}}{PbCl_2(aq)} + 2H_2O + Cl_2\uparrow$

**Solution 2000-4:**

When concentrated HCl is added to lead (IV) oxide and warmed, formation of metal chloride, water and greenish yellow chlorine gas will occur.

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**Solution 2001-1:**

Reaction between sodium sulphite and dilute hydrochloric acid is-

$Na_2SO_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2\uparrow$

**Solution 2001-2:**

(a). $\underset{\text{Sodium chloride}}{NaCl} + \underset{\text{Sulphuric acid (conc.)}}{H_2SO_4} \xrightarrow{<200^\circ C} \underset{\text{Sodium hydrogen sulphate}}{NaHSO_4} + \underset{\text{Hydrogen chloride gas}}{HCl}$

Sulphuric acid should be concentrated.

(b). When hydrogen chloride mixes with ammonia white fumes of ammonium chloride will be observed.

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

**Solution 2001-3:**

Lead dioxide can be used to oxidize hydrogen chloride to chlorine

**Solution 2002-1:**

When dilute hydrochloric acid is added to lead nitrate solution, white precipitate of lead chloride forms.

$Pb(NO_3)_2 + 2HCl \rightarrow \underset{\text{White}}{PbCl_2\downarrow} + 2HNO_3$

**Solution 2002-2:**

(a). All are oxidizing agent which is used to convert HCl into chlorine gas.

(b). $Pb_3O_4 + 8HCl \rightarrow 3PbCl_2(aq) + 4H_2O + Cl_2\uparrow$

Trilead tetroxide (Purple) — Lead chloride

**Solution 2004-1:**

$Pb_3O_4 + 8HCl \rightarrow 3PbCl_2(aq) + 4H_2O + Cl_2\uparrow$

Trilead tetroxide (Red) — Lead chloride

**Solution 2004-2:**

| S.N. | Substance added | Gas evolved | Odour |
|---|---|---|---|
| 1. | Calcium carbonate | $CO_2$ | Odourless |
| 2. | Magnesium ribbon | $H_2$ | Odourless |
| 3. | Manganese(IV)oxide with heating | $Cl_2$ | Pungent |
| 4. | Sodium sulphide | $H_2S$ | Rotten egg |

**Solution 2004-3:**

Silver nitrate crystals are dissolved in distilled water to prepare its solution and not in tap water .This is due to the reason that tap water contains chloride ions which gives white precipitate with $AgNO_3$ solution.

**Solution 2005-1:**

$CuO + 2HCl \rightarrow CuCl_2 + H_2O$

$MnO_2 + 4HCl \rightarrow MnCl_2(aq) + 2H_2O + Cl_2\uparrow$

Manganese dioxide — Manganese chloride

**Solution 2005-2:**

(a) Fountain experiment.
(b) This experiment demonstrates that hydrogen chloride is very soluble in water.
(c) Red

**Solution 2006-1:**

(a) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

(b) When silver nitrate solution is added to hydrochloric acid,it gives white precipitate of silver chloride

**Solution 2007-1:**

(a) Hydrogen chloride is more dense.
(b) The gas is collected by upward displacement of water.

## Solution 2008-1:

(a) Sulphuric acid is although weaker then hydrochloric acid hydrochloric acid is more volatile than sulphuric acid this property makes it useful in the preparation of hydrochloric acid.
(b) It is heavier then air so it is collected by downward delivery.
(c) It is soluble in water so it is not collected over water.

## Solution 2009-1:

(a) $Pb_3O_4$ + $8HCl \rightarrow 3PbCl_2(aq) + 4H_2O + Cl_2\uparrow$

Trilead tetroxide (Red) — Lead chloride

(b) $Mg + 2HCl \longrightarrow MgCl_2 + H_2$

## Solution 2009-2:

Hydrochloric acid is not prepared directly dissolving hydrochloride gas in water because it may lead to back suction.When the delivery tube carryin HCl gas is directly immersed in water, the reverse rise of water in delivery tube is known as back suction.

To prepare hydrochloric acid from hydrogen gas, it is essential to avoid back suction and it is done by using 'inverted funnel arrangement'.