Chapter 9A. Ammonia

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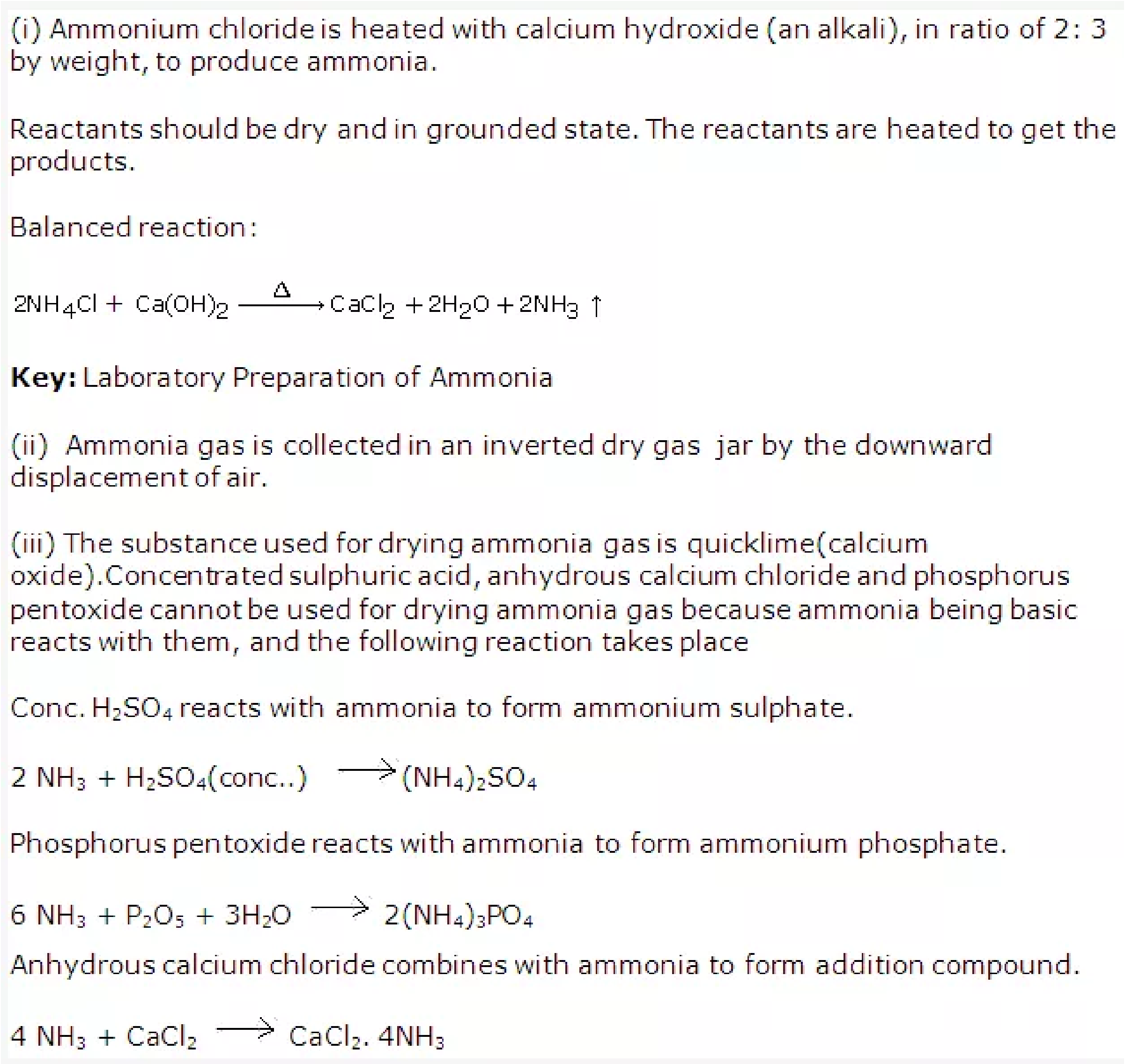
Solution 1:
Ammonia is found both in free state and in combined state. In free state, it is formed in traces amount by decaying urine and other organic matter.
In combined state, ammonia is found as ammonium salts mainly as ammonium chloride and ammonium sulphate.

Solution 2:

1. (i) **Liquid ammonia** – Compressed ammonia gas at 6 atmospheric pressure. Chemical formula -NH3
2. (ii) **Liquor ammonia** – It is saturated solution of ammonia in water. It is very dilute solution of ammonium hydroxide (NH_4OH).
3. A saturated solution of ammonia in water is called liquor ammonia Fortis.

Solution 3:



(i) Ammonium chloride is heated with calcium hydroxide (an alkali), in ratio of 2: 3 by weight, to produce ammonia.

Reactants should be dry and in grounded state. The reactants are heated to get the products.

Balanced reaction:

$$2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3 \uparrow$$

Key: Laboratory Preparation of Ammonia

(ii) Ammonia gas is collected in an inverted dry gas jar by the downward displacement of air.

(iii) The substance used for drying ammonia gas is quicklime(calcium oxide).Concentrated sulphuric acid, anhydrous calcium chloride and phosphorus pentoxide cannot be used for drying ammonia gas because ammonia being basic reacts with them, and the following reaction takes place

Conc. H_2SO_4 reacts with ammonia to form ammonium sulphate.

$$2\ NH_3 + H_2SO_4(conc..) \longrightarrow (NH_4)_2SO_4$$

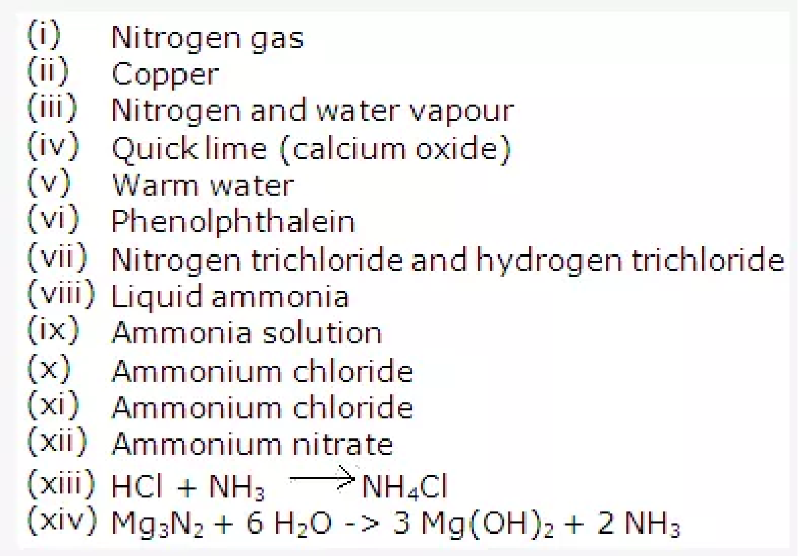
Phosphorus pentoxide reacts with ammonia to form ammonium phosphate.

$$6\ NH_3 + P_2O_5 + 3H_2O \longrightarrow 2(NH_4)_3PO_4$$

Anhydrous calcium chloride combines with ammonia to form addition compound.

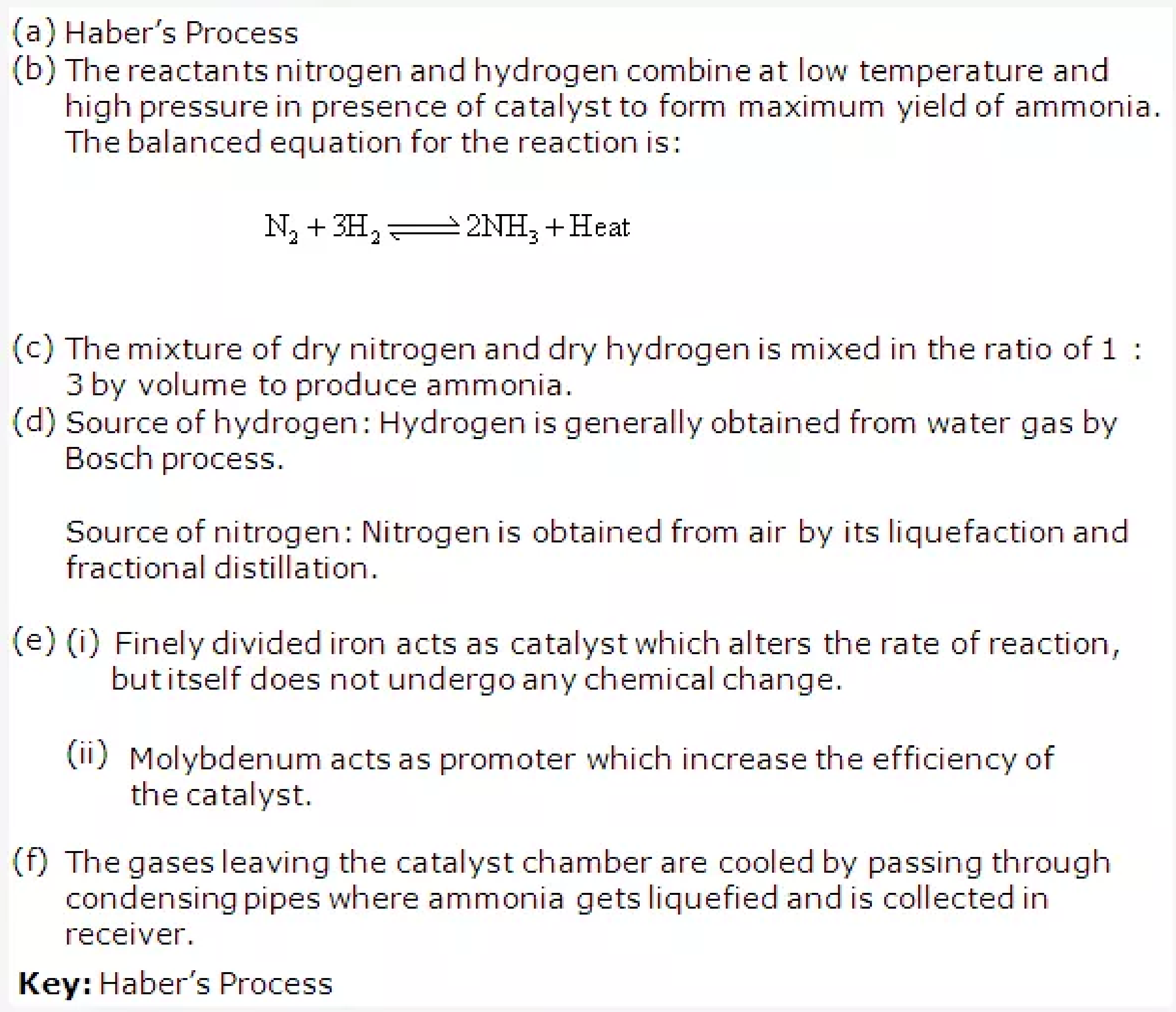
$$4\ NH_3 + CaCl_2 \longrightarrow CaCl_2.\ 4NH_3$$

Solution 4:



(i) Nitrogen gas
(ii) Copper
(iii) Nitrogen and water vapour
(iv) Quick lime (calcium oxide)
(v) Warm water
(vi) Phenolphthalein
(vii) Nitrogen trichloride and hydrogen trichloride
(viii) Liquid ammonia
(ix) Ammonia solution
(x) Ammonium chloride
(xi) Ammonium chloride
(xii) Ammonium nitrate
(xiii) $HCl + NH_3 \longrightarrow NH_4Cl$
(xiv) $Mg_3N_2 + 6\ H_2O \rightarrow 3\ Mg(OH)_2 + 2\ NH_3$

Solution 5:



(a) Haber's Process

(b) The reactants nitrogen and hydrogen combine at low temperature and high pressure in presence of catalyst to form maximum yield of ammonia. The balanced equation for the reaction is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$$

(c) The mixture of dry nitrogen and dry hydrogen is mixed in the ratio of 1 : 3 by volume to produce ammonia.

(d) Source of hydrogen: Hydrogen is generally obtained from water gas by Bosch process.

Source of nitrogen: Nitrogen is obtained from air by its liquefaction and fractional distillation.

(e) (i) Finely divided iron acts as catalyst which alters the rate of reaction, but itself does not undergo any chemical change.

(ii) Molybdenum acts as promoter which increase the efficiency of the catalyst.

(f) The gases leaving the catalyst chamber are cooled by passing through condensing pipes where ammonia gets liquefied and is collected in receiver.

Key: Haber's Process

Solution 6:

Ammonia is highly soluble in water. This can be demonstrated by Fountain experiment.

- We take a round bottom flask filled with ammonia gas.
- The flask is closed with a two holed rubber stopper, one for the jet tube and the other for a dropper filled with water.
- The flask is fixed to the stand in an inverted position.
- The free end of the jet tube is dipped into a beaker containing red litmus solution.
- When the bulb of dropper is pressed, it is observed that red litmus solution rises up and strikes the wall of the flask and spreads in form of fountain, which is blue in colour.

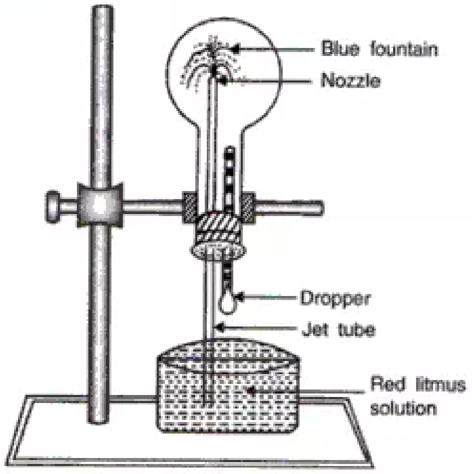


Fig. : Fountain experiment

Solution 7:

(i) Action of heat on ammonium chloride is reversible. When heated, it decomposes to form ammonia and hydrogen chloride. When the products are cooled, they recombine to form ammonium chloride.

$$NH_4Cl \overset{\Delta}{\rightleftharpoons} NH_3 + HCl$$

This is thermal dissociation reaction.

(ii) Ammonium nitrate on heating completely disappears, escaping in the form of water vapour and nitrous oxide.

$$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$$

This is thermal dissociation reaction.

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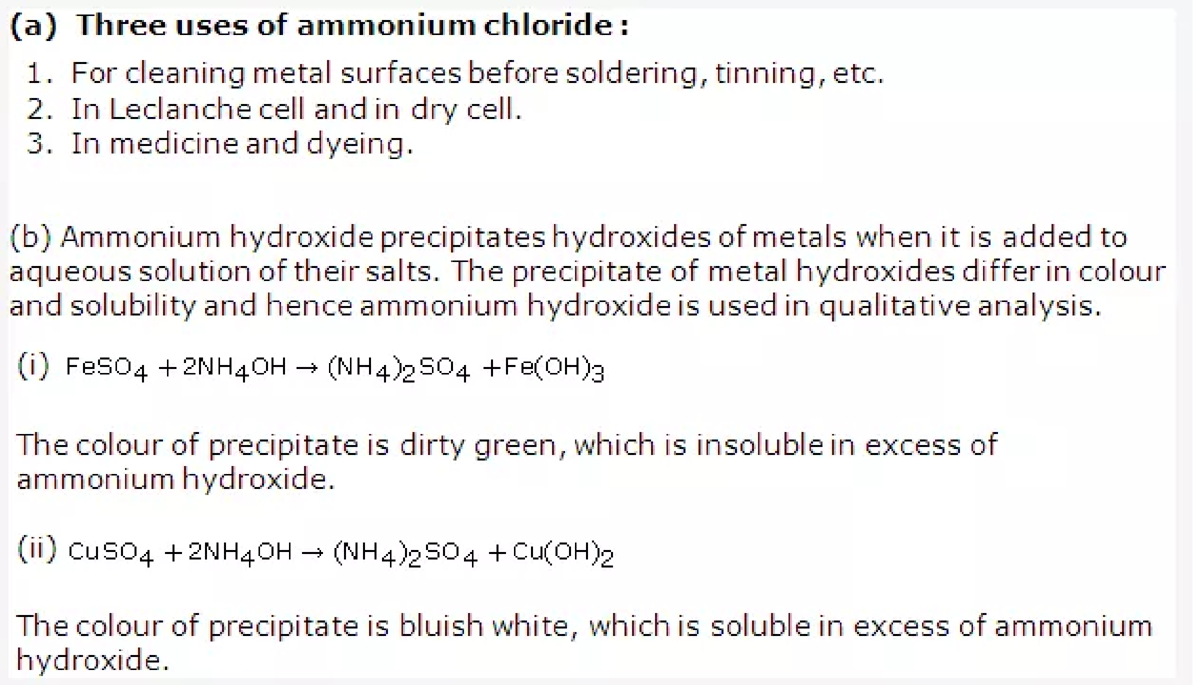
Solution 8:

1. **Liquid ammonia is used as refrigerant as:**
    - It is highly volatile
    - It has high specific latent heat of vaporization. 1 mole (17g) of liquid ammonia vaporises by absorbing 5.7 kcals of heat from the surroundings, which is there by cooled.
    - It easily liquefies under pressure at room temperature.
2. Ammonia emulsifies fats and grease. Thus it is used to clean oils, fats and body grease etc. from clothes.

3. Liquid hydrogen is dangerous to transport as it is highly combustible. Thus, hydrogen is converted to liquid ammonia and transported in cylinders. Later it is catalytically converted to hydrogen.
   Key: Uses of ammonia

Solution 9:



(a) Three uses of ammonium chloride :

1. For cleaning metal surfaces before soldering, tinning, etc.
2. In Leclanche cell and in dry cell.
3. In medicine and dyeing.

(b) Ammonium hydroxide precipitates hydroxides of metals when it is added to aqueous solution of their salts. The precipitate of metal hydroxides differ in colour and solubility and hence ammonium hydroxide is used in qualitative analysis.

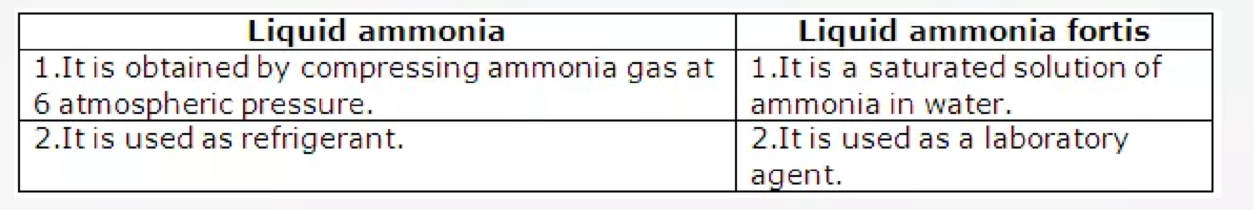
(i) $FeSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Fe(OH)_3$

The colour of precipitate is dirty green, which is insoluble in excess of ammonium hydroxide.

(ii) $CuSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Cu(OH)_2$

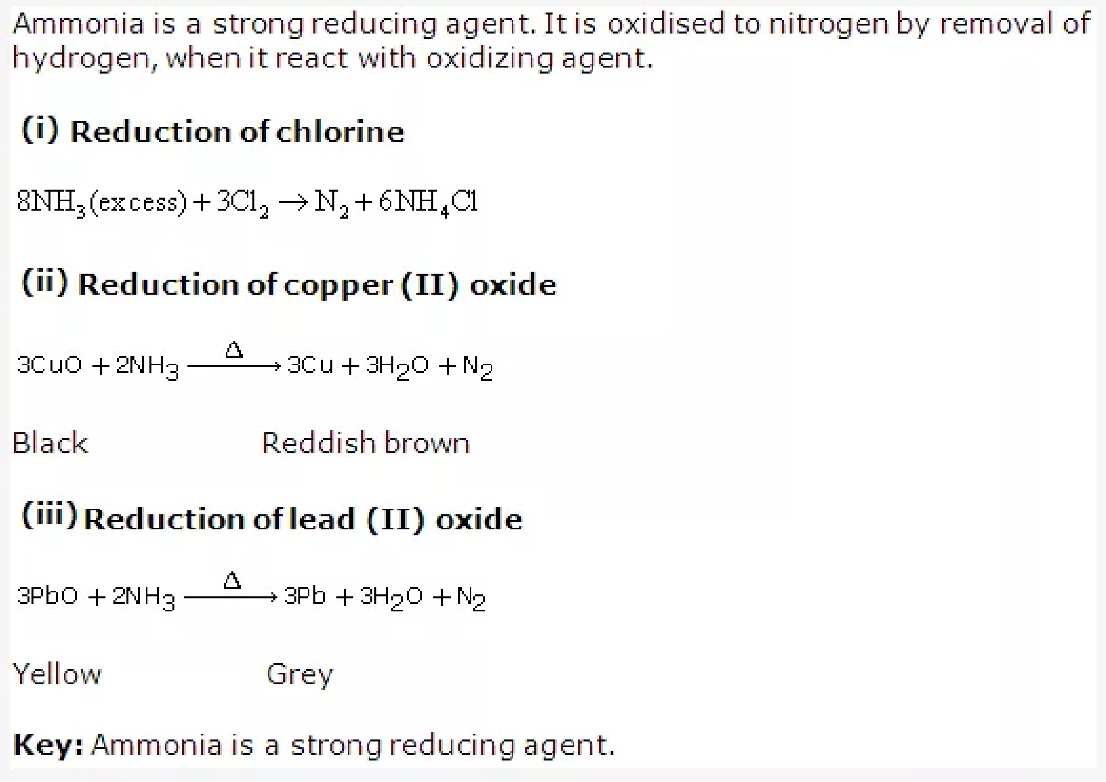
The colour of precipitate is bluish white, which is soluble in excess of ammonium hydroxide.

Solution 10:



Liquid ammonia	Liquid ammonia fortis
1.It is obtained by compressing ammonia gas at 6 atmospheric pressure.	1.It is a saturated solution of ammonia in water.
2.It is used as refrigerant.	2.It is used as a laboratory agent.

Solution 11:



Ammonia is a strong reducing agent. It is oxidised to nitrogen by removal of hydrogen, when it react with oxidizing agent.

(i) Reduction of chlorine

$8NH_3(excess) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$

(ii) Reduction of copper (II) oxide

$3CuO + 2NH_3 \xrightarrow{\Delta} 3Cu + 3H_2O + N_2$

Black Reddish brown

(iii) Reduction of lead (II) oxide

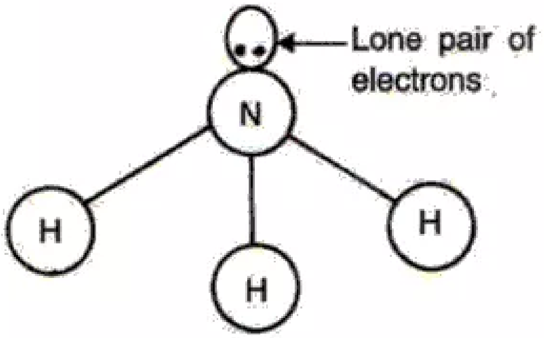
$3PbO + 2NH_3 \xrightarrow{\Delta} 3Pb + 3H_2O + N_2$

Yellow Grey

Key: Ammonia is a strong reducing agent.

Solution 12:

Structure of ammonia



Structure of ammonia

The presence of lone pair of electrons on the nitrogen atom makes ammonia basic in nature in its aqueous solution. Aqueous solution of ammonia dissociates partially to produce hydroxyl ion.

$$NH_3 + H_2O \rightleftharpoons NH_4OH$$
$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

Key: Aqueous solution of ammonia is alkaline in nature.

Solution 13:

An aqueous solution of ammonia is prepared by dissolving ammonia in water. Ammonia is highly soluble in water.

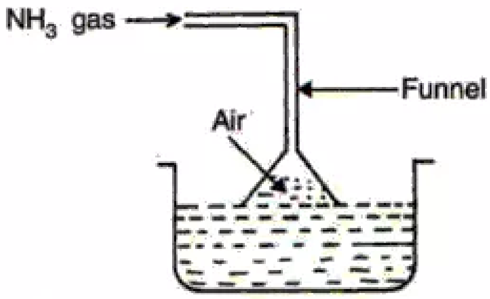


Fig. Funnel arrangement in preparation of aqueous ammonia solution

The funnel arrangement is used to prepare aqueous solution of ammonia. In this method, ammonia gas is introduced through a funnel tube where the rate of dissolution of ammonia is faster than it is produced. This creates a partial vacuum, in delivery tube, resulting in low pressure. Thus, water is forced in to equalise the pressure. To overcome this problem of back suction, the funnel is attached to outer end of the delivery tube and mouth of funnel just dips into the water in the trough.

Two advantages of this method:

(i) Prevents back suction of water into the flask.

(ii) Provides a larger surface area for the absorption of the gas.

Key: Ammonia is highly soluble in water.

Solution 14:

(a) Two fertilizers manufactured from ammonia: Urea, ammonium sulphate, ammonium nitrate.

(b) Fertilizer from ammonia: Urea

$$2NH_3 + CO_2 \xrightarrow{150^\circ C, 150atm} NH_2CONH_2 + H_2O$$

Key: Ammonia is used in manufacture of fertilizer.

Solution 15:

(i) Once the reaction starts, further heating is not required because the reaction is exothermic. The heat evolved is sufficient to maintain the optimum temperature.

(ii) Ammonium nitrate is explosive in nature and it decomposes to give nitrous oxide and water. Thus, it is not used in the laboratory preparation of ammonia.

(iii) Calcium hydroxide is preferred as it is cheap and not deliquescent like NaOH or KOH.

(iv) Liquid ammonia is a polar covalent compound and neutral to litmus. Liquor ammonia is solution of ammonia in water, which is weakly basic in nature. It turns red litmus blue.

(v) Presence of moisture may result in formation of ammonium hydroxide. Thus dry N_2 and H_2 must be used in the Haber's process.

(vi) A promoter is a substance that is added to increase the efficiency of a catalyst.

(vii) Aqueous solution of ammonia that is ammonium hydroxide dissociates partially to hydroxyl ions. Thus, it conducts electricity.

$$NH_3 + H_2O \rightleftharpoons NH_4OH$$
$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

(viii) Ammonia is highly soluble gas in water and so cannot be collected over water.

(ix) Ammonia is formed by decaying urine and other organic matter. Thus it is present in sewage water.

(x) Ammonium hydroxide precipitates hydroxides of metals, which differ in colour and solubility in excess of ammonium hydroxide. Thus it is used in identification of metal ions.

Solution 16:

(i) $8NH_3(\text{excsess}) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$

(ii) $3CuO + 2NH_3 \xrightarrow{\Delta} 3Cu + 3H_2O + N_2$

(iii) $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O + \text{Heat}$

(iv) $NH_3 + 3Cl_2(\text{excsess}) \rightarrow NCl_3 + 3HCl$

(v) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

(vi) $NH_3 + H_2O \rightleftharpoons NH_4OH$

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$

(vii) $2NH_4Cl + CaCO_3 \rightarrow (NH_4)_2CO_3 + CaCl_2$

(viii) $3CuO + 2NH_3 \xrightarrow{\Delta} 3Cu + 3H_2O + N_2$

Solution 17:

(i) When excess ammonia is mixed with chlorine, ammonium chloride and nitrogen is formed.

$$8NH_3(excsess) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

(ii) When excess ammonia is mixed with chlorine, ammonium chloride and nitrogen is formed.

$$8NH_3(excsess) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

(iii) The filter paper turns into deep pink suggesting that ammonia solution is alkaline or basic in nature.

(iv) On passing ammonia over heated lead oxide yellow coloured lead monoxide is reduced to grey coloured lead metal.

$$3PbO + 2NH_3 \xrightarrow{\Delta} 3Pb + 3H_2O + N_2$$

Yellow Grey

(v) On adding ammonium solution to ferric chloride solution we get ammonium chloride and reddish brown precipitate of ferric hydroxide which is insoluble in excess of ammonium solution.

$$FeCl_3 + 3NH_4OH \rightarrow 3NH_4Cl + Fe(OH)_3$$

(vi) Initially when ammonium solution is added to aqueous solution of copper sulphate a bluish precipitate of copper hydroxide is obtained which dissolves in excess of ammonium hydroxide.

$$CuSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Cu(OH)_2$$

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$$

(vii) Ammonia affects the lachrymal glands and brings tears to the eyes.

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Solution 18:

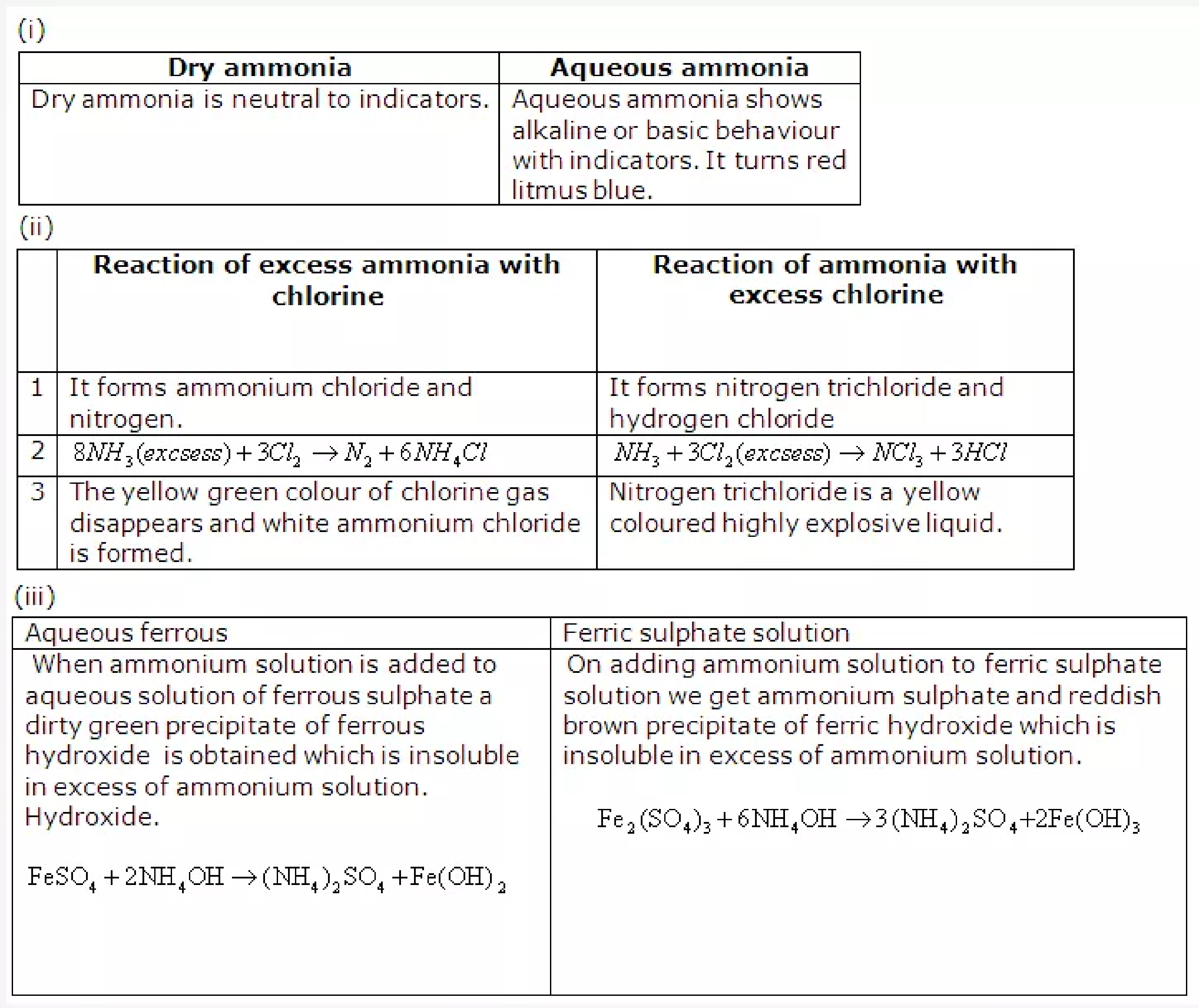
(a) $NH_3 + H_2O \rightleftharpoons NH_4OH$

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$

(b) $8NH_3(excsess) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$

(c) $3CuO + 2NH_3 \xrightarrow{\Delta} 3Cu + 3H_2O + N_2$

Solution 19:



(i)

Dry ammonia	Aqueous ammonia
Dry ammonia is neutral to indicators.	Aqueous ammonia shows alkaline or basic behaviour with indicators. It turns red litmus blue.

(ii)

	Reaction of excess ammonia with chlorine	Reaction of ammonia with excess chlorine
1	It forms ammonium chloride and nitrogen.	It forms nitrogen trichloride and hydrogen chloride
2	$8NH_3(excsess)+3Cl_2 \rightarrow N_2+6NH_4Cl$	$NH_3+3Cl_2(excsess) \rightarrow NCl_3+3HCl$
3	The yellow green colour of chlorine gas disappears and white ammonium chloride is formed.	Nitrogen trichloride is a yellow coloured highly explosive liquid.

(iii)

Aqueous ferrous	Ferric sulphate solution
When ammonium solution is added to aqueous solution of ferrous sulphate a dirty green precipitate of ferrous hydroxide is obtained which is insoluble in excess of ammonium solution. Hydroxide. $FeSO_4+2NH_4OH \rightarrow (NH_4)_2SO_4+Fe(OH)_2$	On adding ammonium solution to ferric sulphate solution we get ammonium sulphate and reddish brown precipitate of ferric hydroxide which is insoluble in excess of ammonium solution. $Fe_2(SO_4)_3+6NH_4OH \rightarrow 3(NH_4)_2SO_4+2Fe(OH)_3$

Solution 20:

1. (i) Use of Ammonium Chloride
   -Used in Leclanche cell and dry cell
   (ii) Use of Ammonium Sulphate
   -Used as a fertilizer
   (iii)use of Ammonium nitrate
   -Used in fireworks
   (iv) Use of Ammonium Carbonate
   -Used in baking powder
2. **Test of ammonia and ammonium ions:**
   - Ammonia gas has a characteristic pungent smell
   - A glass rod dipped in concentrated hydrochloric acid and is introduced into the gas produces thick white fumes of ammonium chloride.

Solution 21:

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

(A) (B)

$NH_4NO_3 \xrightarrow{250^\circ C} N_2O + 2H_2O$

(C) (D)

Solution 22:

(i) Ammonia gas on reacting with aqueous solution of zinc chloride produces white gelatine like precipitate of zinc hydroxide.

$ZnCl_2 + 2NH_4OH \rightarrow NH_4Cl + Zn(OH)_2$

(ii) Ammonia gas on reacting with aqueous solution of ferrous sulphate produces dirty green precipitate of ferrous hydroxide.

$FeSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Fe(OH)_2$

(iii) Ammonia gas on reacting with aqueous solution of ferric chloride produces reddish brown precipitate of ferric hydroxide.

$FeCl_3 + 3NH_4OH \rightarrow 3NH_4Cl + Fe(OH)_3$

(iv) Ammonia gas on reacting with aqueous solution of lead nitrate produces white precipitate of lead hydroxide.

$Pb(NO_3)_2 + 2NH_4OH \rightarrow 2NH_4NO_3 + Pb(OH)_2$

(v) Ammonia gas on reacting with aqueous solution of copper sulphate produces bluish white precipitate of cupric hydroxide.

$CuSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Cu(OH)_2$

(vi) Ammonia gas on reacting with aqueous solution of Chromium chloride produces green precipitate of chromium tri hydroxide.

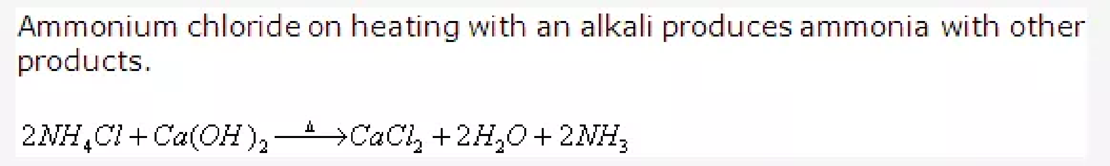
$CrCl_3 + 3NH_4OH \rightarrow 3NH_4Cl + Cr(OH)_3$

Solution 1992-1:
Silver chloride

Solution 1992-2:
Ammonia is highly soluble gas in water and so cannot be collected over water.

Solution 1992-3:
Ammonia is the odd one out.
Ammonia forms weakly basic solution when dissolved in water.
The others give acidic solution when dissolved in water.

Solution 1992-4:



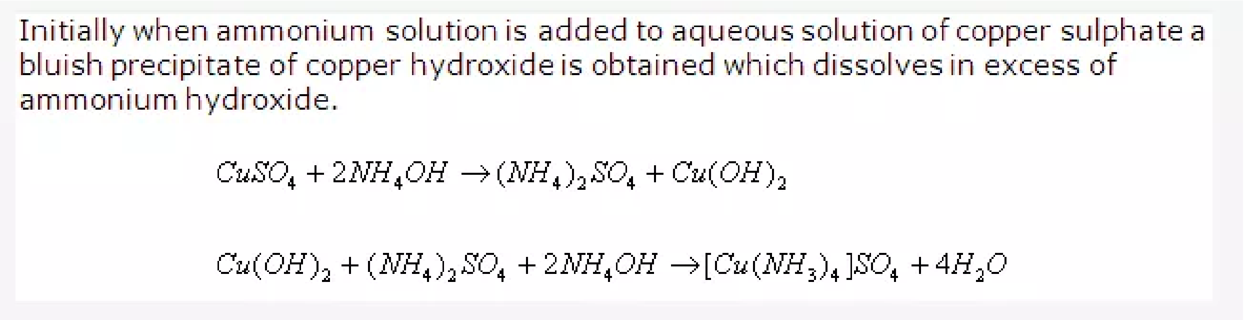
Ammonium chloride on heating with an alkali produces ammonia with other products.

$$2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3$$

Solution 1992-5:

1. Ammonia is used in the manufacture of fertilisers such as ammonium sulphate, ammonium nitrate, etc.
2. It is used in the industrial preparation of nitric acid by Ostwald's process.

Solution 1993-1:

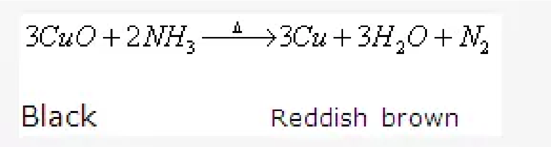


Initially when ammonium solution is added to aqueous solution of copper sulphate a bluish precipitate of copper hydroxide is obtained which dissolves in excess of ammonium hydroxide.

$$CuSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Cu(OH)_2$$

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$$

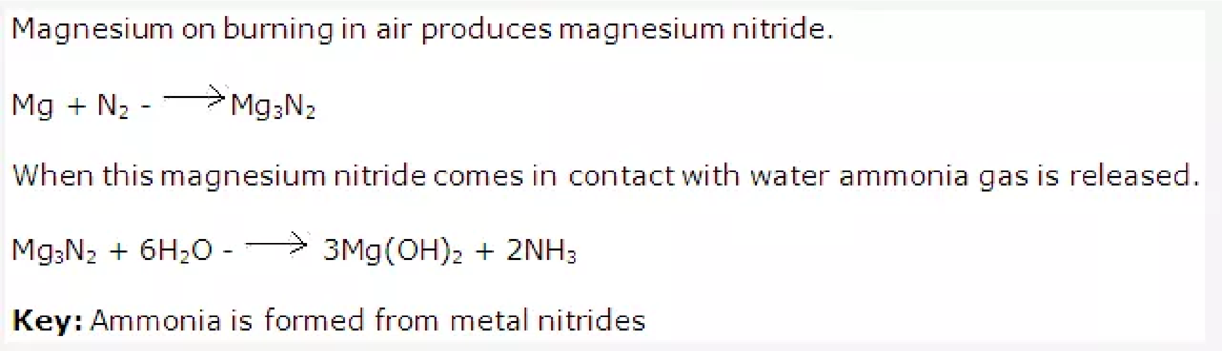
Solution 1993-2:



$$3CuO + 2NH_3 \xrightarrow{\Delta} 3Cu + 3H_2O + N_2$$

Black Reddish brown

Solution 1994-1:



Magnesium on burning in air produces magnesium nitride.

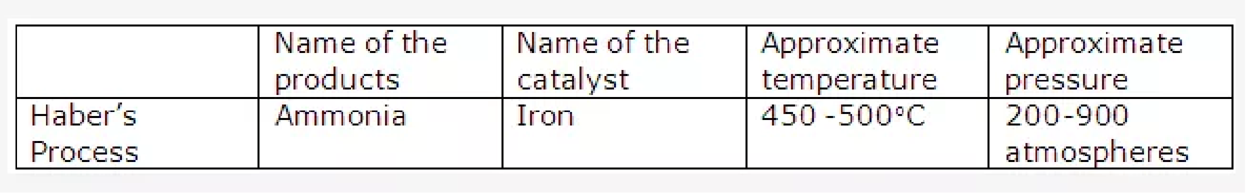
$Mg + N_2 - \longrightarrow Mg_3N_2$

When this magnesium nitride comes in contact with water ammonia gas is released.

$Mg_3N_2 + 6H_2O - \longrightarrow 3Mg(OH)_2 + 2NH_3$

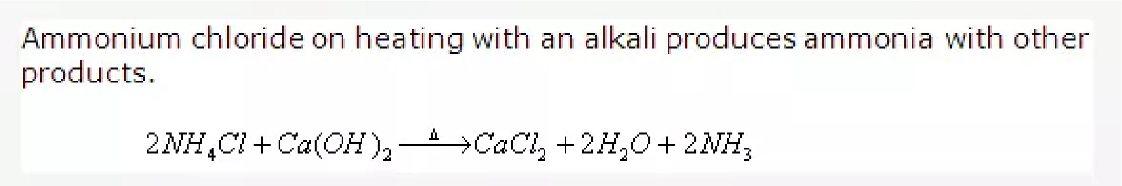
Key: Ammonia is formed from metal nitrides

Solution 1994-2:



	Name of the products	Name of the catalyst	Approximate temperature	Approximate pressure
Haber's Process	Ammonia	Iron	450 -500°C	200-900 atmospheres

Solution 1994-3:



Ammonium chloride on heating with an alkali produces ammonia with other products.

$$2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3$$

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Solution 1995-1:

The cation is Cu^{2+} ion. Solution B is copper sulphate. It is bright blue in colour.

Solution 1995-2:

Three ways to identify ammonia gas:

1. It is a pungent smell gas.
2. It gives white precipitate when bubbles through a solution of lead nitrate.
3. It gives a brown colour or precipitate when treated with Nessler's reagent.

Solution1995-3:

(i) $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$

(ii) $2NH_3 + 3CuO \rightarrow 3Cu + 3H_2O + N_2$

(iii) $8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$

(iv) $4NH_3 + 5O_2 \rightarrow 6H_2O + 4NO + \text{Heat}$

Solution 1995-4:

This reaction shows that ammonia is a reducing agent.

Solution 1995-5:

This process is called as Ostwald's Process .The catalyst used is platinum.

Solution 1995-6:

During laboratory preparation of ammonia, it is passed through a drying tower containing quicklime (calcium oxide).
Ammonia is collected in an inverted dry gas jar by the downward displacement of air.

Solution 1995-7:

Ammonia gas

Solution 1996-1:

Ammonia forms ammonium hydroxide and turns red litmus blue as it is alkaline in nature.

Solution 1996-2:

$$NH_4Cl + NaOH \xrightarrow{\Delta} NaCl + H_2O + NH_3$$

Solution 1996-3:

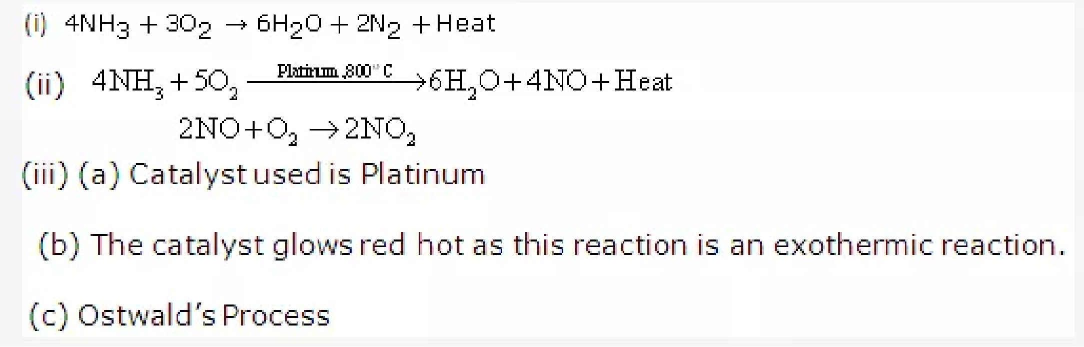
Haber's process is used in industrial preparation of ammonia.
Gaseous inputs in Haber's process are dry nitrogen and dry hydrogen gas. They are mixed in the ratio of 1:3 by volume.

The following conditions favour maximum yield of ammonia:

1. Low temperature
2. High pressure
3. Use of catalyst

The gases after reaction pass through condensing pipes of cooling chamber where ammonia gets liquefied and is collected in receiver.
Ammonia can also be collected by downward displacement of air.

Solution 1997-1:



(i) $4NH_3 + 3O_2 \rightarrow 6H_2O + 2N_2 + \text{Heat}$

(ii) $4NH_3 + 5O_2 \xrightarrow{\text{Platinum, } 800^\circ C} 6H_2O + 4NO + \text{Heat}$

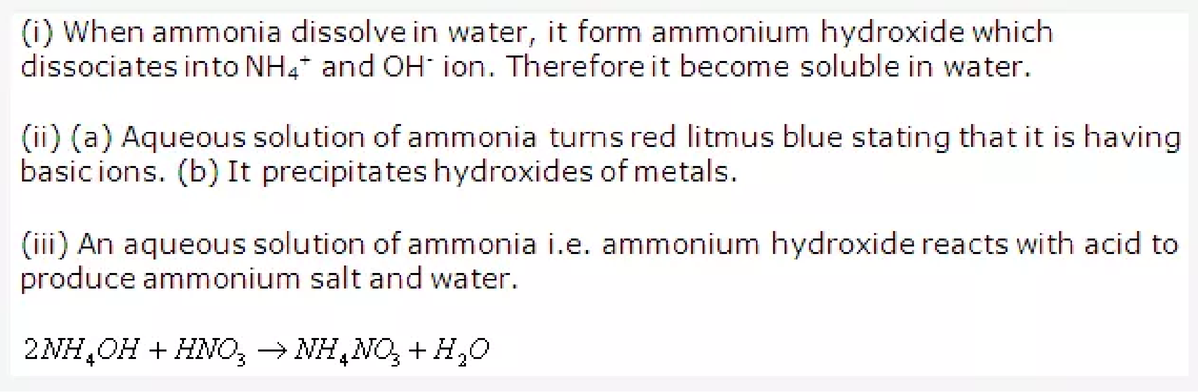
$2NO + O_2 \rightarrow 2NO_2$

(iii) (a) Catalyst used is Platinum

(b) The catalyst glows red hot as this reaction is an exothermic reaction.

(c) Ostwald's Process

Solution 1997-2:



(i) When ammonia dissolve in water, it form ammonium hydroxide which dissociates into NH_4^+ and OH^- ion. Therefore it become soluble in water.

(ii) (a) Aqueous solution of ammonia turns red litmus blue stating that it is having basic ions. (b) It precipitates hydroxides of metals.

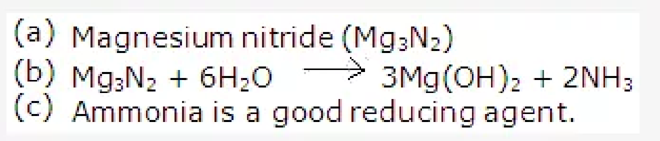
(iii) An aqueous solution of ammonia i.e. ammonium hydroxide reacts with acid to produce ammonium salt and water.

$2NH_4OH + HNO_3 \rightarrow NH_4NO_3 + H_2O$

Solution 1998-2:

Ammonium salts are used as fertilizers in fields.

Solution 1998-3:



(a) Magnesium nitride (Mg_3N_2)

(b) $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$

(c) Ammonia is a good reducing agent.

Solution 1998-1:

Dry ammonia are neutral to litmus. An aqueous solution of ammonia turns red litmus blue stating that it is basic in nature.

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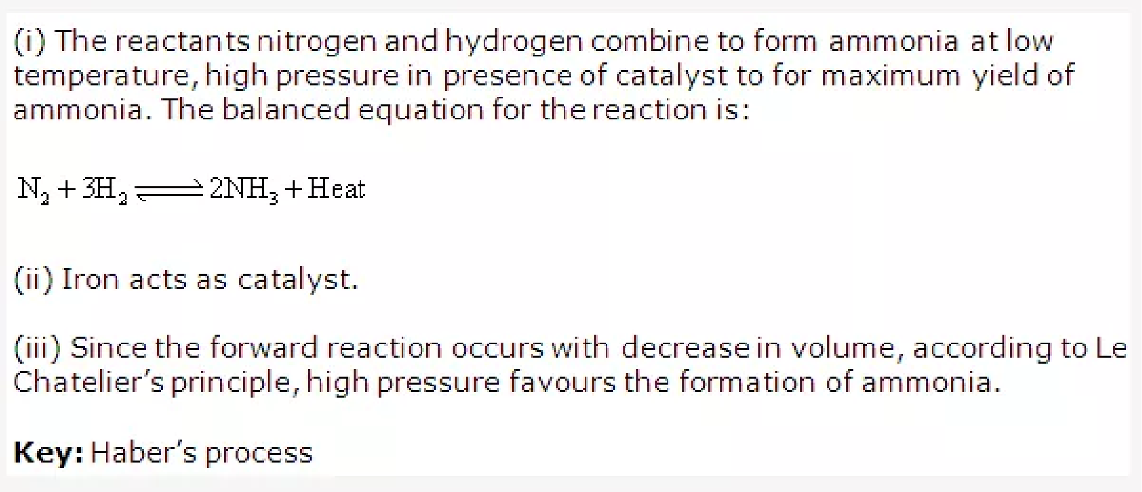
Solution 1998-4:



(i) The reactants nitrogen and hydrogen combine to form ammonia at low temperature, high pressure in presence of catalyst to for maximum yield of ammonia. The balanced equation for the reaction is:

$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{Heat}$

(ii) Iron acts as catalyst.

(iii) Since the forward reaction occurs with decrease in volume, according to Le Chatelier's principle, high pressure favours the formation of ammonia.

Key: Haber's process

Solution 1998-5:

Ammonia (vapour density(V.D)= 8.5) is less dense than air (vapour density (V.D.)= 14.4) and so is lighter than air.

Fountain experiment proves that ammonia is highly soluble in water.

The balanced equation for the reaction between ammonia and sulphuric acid is

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

Solution 1991-1:

1. Ammonia
2. Nitrogen

Solution 2001-1:

Ammonia

Solution 2001-2:

(i) $2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3 \uparrow$

(ii) $NH_3 + HCl \xrightarrow{\Delta} NH_4Cl$

Solution2001-3:

$$2NH_3 + 3CuO \rightarrow 3Cu + 3H_2O + N_2$$

Solution 2001-4:

Aqueous solution is acidic in nature due to presence of hydrogen ion.
Aqueous solution of ammonia is weakly basic in nature due to presence of hydroxyl ion.

Solution 2002-2:

Thermal dissociation.

Solution 2002-1:

Action of heat on ammonium chloride is reversible. When heated, it decomposes to form ammonia and hydrogen chloride. When the products are cooled, they recombine to form ammonium chloride.

$$NH_4Cl \overset{\Delta}{\rightleftharpoons} NH_3 + HCl$$

Ammonium nitrate on heating completely disappears, escaping in the form of water vapour and nitrous oxide.

$$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$$

Solution 2003-1:

$$Mg_3N_2 + 6\ H_2O \longrightarrow 3\ Mg(OH)_2 + 2\ NH_3$$

Solution 2003-2:

Ammonia is collected by downward displacement of air.

Solution 2003-3:

Ammonia is highly soluble in water and so it is not collected over water.

Solution 2003-4:

Quick lime (calcium oxide) is used as a drying agent for ammonia.

Solution 2004-1:

$$8NH_3(excsess) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Solution 2004-4:

(i) The reactants nitrogen and hydrogen combine to form ammonia at low temperature, high pressure in presence of catalyst to for maximum yield of ammonia. The balanced equation for the reaction is:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 + Heat$$

(ii) The gases which leave the catalyst chamber contain ammonia and unreacted nitrogen and hydrogen gas. The gases leaving the catalyst chamber are cooled by passing through condensing pipes where ammonia gets liquefied and is collected in receiver.

Solution 2005-1:

(i) This shows that ammonia molecule accept H^+ ion from water to form ammonium ion.

$$NH_3 + H_2O \rightleftharpoons NH_4OH$$

$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

(ii) When ammonia dissolves in water, the hydroxyl ion is also formed.

(iii) The precipitation of metal hydroxides from their aqueous solution confirms the presence of OH^- ion in the solution.

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Solution 2005-2:

(i) Ammonium chloride on heating with an slaked lime produces ammonia with other products.

$$2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3$$

(ii) $AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3$

Solution 2006-1:

Ammonia gas on reacting with aqueous solution of lead nitrate produces white precipitate of lead hydroxide, which is insoluble in excess of ammonium hydroxide.

$$Pb(NO_3)_2 + 2NH_4OH \rightarrow 2NH_4NO_3 + Pb(OH)_2$$

Solution 2006-2:

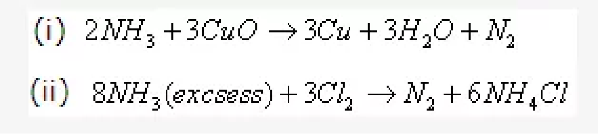
Ammonia gas on reacting with aqueous solution of lead nitrate produces white precipitate of lead hydroxide, which is insoluble in excess of ammonium hydroxide.

$$Pb(NO_3)_2 + 2NH_4OH \rightarrow 2NH_4NO_3 + Pb(OH)_2$$

Solution 2007-1:

By the pungent smell of ammonia gas.

Solution 2007-2:



(i) $2NH_3 + 3CuO \rightarrow 3Cu + 3H_2O + N_2$

(ii) $8NH_3(excsess) + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$

Solution 2008-1:

(c) Magnesium nitride

Chapter 9B. Nitric acid

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Solution 1:

Nitric acid is formed in atmosphere during lightning discharge. Nitrogen in atmosphere combine with oxygen to form nitric acid.

Solution 2:

(i) Gas produced in air during lightning is Nitric Oxide.
(ii) Hydrogen gas is obtained by treating manganese with 1% nitric acid.
(iii) Salt referred to as Chile saltpeter is $NaNO_3$.
(iv) Salt used in laboratory to prepare nitric acid is $KNO_3/NaNO_3$.
(v) Products obtained by catalytic oxidation of ammonia are NO, water& heat.
(vi) Products obtained by heating concentrated nitric acid are NO_2, water & O_2.
(vii) Copper nitrate is blue coloured, cobalt nitrate is coloured.

Solution 3:

(a) Aqua fortis: It is the other name for nitric acid , it is also known as 'strong water'. It was called so because earlier this was the only liquid which could dissolve many metals including silver.

(b) Aqua Regia: It is a mixture of concentrated nitric acid and concentrated hydrochloric acid in proportionof 1:3(by volume).

(c) Fuming nitric acid: It contains NO_2 dissolved in concentrated HNO_3.It is obtained by distilling concentrated HNO_3 with little starch.

(d) Decrepitation: It is the breaking of a substance usually accompanied by the emission of a crackling sound. An example for a substance which decrepitates on heating is lead nitrate $(Pb(NO_3)_2$

Solution 4:

(a) In laboratory, nitric acid is prepared by heating a mixture of concentrated sulphuric acid and potassium or sodium nitrate with conc. H_2SO_4 at 200°C.

$KNO_3 + H_2SO_4 \rightarrow KHSO_4 + HNO_3$

(b) Concentrated sulphuric acid is non-volatile and produce volatile nitric acid.

(c) The temperature is maintained at 200°C in the above reaction to awoid following problems:

- Nitric acid would decompose at high temperature.
- Potassium or sodium sulphate is formed which will stick to the walls of glass and cannot be removed be easily.
- The glass apparatus may break at high temperature.

(d) No, concentrated HCl cannot be used in the place of concentrated H_2SO_4 because HCl is more volatile than HNO_3 and hence nitric acid vapours will carry HCl vapours.

Solution 5:

(a). **Ostwald process** is used for used for the manufacture of nitric acid.

(b). Reactants required for Ostwald process are ammonia and oxygen of air.

(c). In ostwald process ammonia gas and air are taken in 1:10 ratio.

(d). Pt gauge is used as a catalyst in ostwald process.

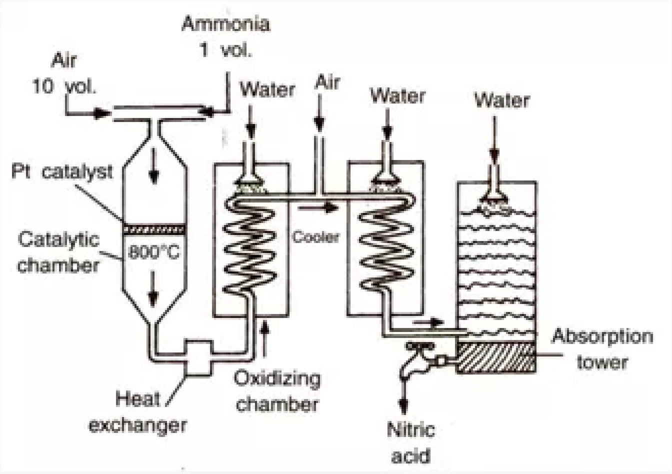
(e). Oxygen is the oxidizing agent which converts ammonia to nitric acid.

(f). $4NH_3 + 5O_2 \xrightarrow[800°C]{Platinum\ gauge} 4NO + 6H_2O + Heat$

$2NO + O_2 \xrightarrow{50°C} 2NO_2$

$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$

Solution 6:



Ostwald process-

The nitric acid is manufactured by Ostwald process. In ostwald process ammonia gas and air are taken in 1:10 ratio. Pt gauge is used as a catalyst in ostwald process. Following steps are involved in Ostwald's process for the manufacture of nitric acid.

1. Oxidation of ammonia in catalytic chamber.

$$4NH_3 + 5O_2 \xrightarrow[800^\circ C]{\text{Platinum gauge}} 4NO + 6H_2O + \text{Heat}$$

2. Oxidation of nitric acid in oxidation chamber.

$$2NO + O_2 \xrightarrow{50^\circ C} 2NO_2$$

3. Absorption of nitrogen dioxide in water.

$$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

Solution 7:

(a) Nitric acid cannot be concentrated beyond 68% by the distillation of a dilute solution of HNO_3 because it forms an azeotropic mixture i.e. at 121°C it boils without any change in its concentration of the mixture with water.

(b) 98 % nitric acid is obtained by distilling 68% nitric acid with conc. H_2SO_4 under reduced pressure. The function of H_2SO_4 is to absorb water.

Solution 8:

Three equations to prove acidic nature of nitric acid are-

(a) Reaction with basic oxide-

$CaO + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$

(b) Reaction with carbonates and hydrogen carbonates-

$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O(l) + CO_2$

$NaHCO_3 + HNO_3 \rightarrow NaNO_3 + H_2O + CO_2$

(c) Reaction with metallic sulphites-

$Na_2SO_3 + 2HNO_3 \rightarrow 2NaNO_3 + SO_2 + H_2O$

Solution 9:

Uses of nitric acid are-

(i) Nitric acid is used in the purification of silver, gold, platinum etc. because impurities of other metals are dissolved in it.

(ii) Nitric acid is used as an oxidiser in rocket fuel because it can supply large amount of oxygen.

(iii) Nitric acid is used in the manufacture of dyes, perfumes, drugs etc. from coal tar products since nitrobenzene is one of the raw materials of it which is manufactured from nitric acid.

Solution 10:

(a) Brown ring test-

Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated H_2SO_4 is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers.

$6FeSO_4 + 3H_2SO_4 + 2HNO_3 \rightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$

$FeSO_4 + NO + 5H_2O \rightarrow [Fe(NO)(H_2O)_5]SO_4$

Hydrated nitrosoferrous

Sulphate(brown ring)

(b) Freshly prepared ferrous sulphate solution is used in the ring test otherwise Ferrous sulphate undergoes aerial oxidation and converts to ferric sulphate

(c) If the test tube is disturbed brown ring will disappear because the complex formed will get dissolved in the layers of the liquid.

Solution 11:

(a) In laboratory preparation of nitric acid all the apparatus including cork should be made up of glass because nitric acid vapours are highly corrosive in nature and corrodes cork, rubber etc.

(b) Commercial nitric acid is yellow in colour because of presence of nitrogen dioxide but when it is diluted with water, it turns colourless because nitrogen dioxide get dissolved in water.

(c) Aluminum does not react with nitric acid of any concentration because of the formation of extremely thin, unreactive, protective layer of insoluble metallic oxide on the surface of aluminium which stops further reaction.

(d) Concentrated nitric acid renders iron passive because of the formation of extremely thin, unreactive, protective layer of insoluble metallic oxide on the surface which stops further reaction.

(e) Nitric acid is used in the purification of gold because impurities of other metals are dissolved in it.

(f)

$$3HCl + HNO_3 \longrightarrow 2H_2O + NOCl + 2[Cl]$$

Gold in Aqua regia:

$$Au + 4[Cl] \longrightarrow AuCl_3$$

Platinum in Aqua regia:

$$Pt + 4[Cl] \longrightarrow PtCl_4$$

(g) Nitric acid usually do not yield hydrogen gas with metals, instead it reacts with metals and form respective nitrates , nitric oxide and water.

(h) Lightning is a blessing as it is the natural source of synthesis of nitric acid.

(i) Concentrated nitric acid is brown in colour due to the presence of nitrogen dioxide formed by heating the acid.

(j) Concentrated nitric acid is a stronger oxidizing agent due to nascent oxygen which it gives on decomposition.

$$2HNO_3 \rightarrow H_2O + 2NO_2 + [O]$$

(Conc.) nascent oxygen

$$2HNO_3 \rightarrow H_2O + 2NO + 3[O]$$

(Dilute) nascent oxygen

Solution 12:

Two tests for nitric acid are-

(i) Brown ring test-

Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated H_2SO_4 is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers.

$$6\ FeSO_4 + 3H_2SO_4 + 2HNO_3 \rightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

$$FeSO_4 + NO + 5H_2O \rightarrow \underset{\text{Hydrated nitrosoferrous Sulphate(brown ring)}}{[Fe(NO)(H_2O)_5]SO_4}$$

(ii) Nitric acid on heating gives brown fumes of nitrogen dioxide.

$$4HNO_3 \xrightarrow{\Delta} 2H_2O + \underset{\text{Brown fumes}}{4NO_2} + O_2$$

Solution 13:

(a) Action of concentrated nitric acid on copper-

$$Cu + \underset{\text{(Conc.)}}{4HNO_3} \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

(b) $2\ AgNO_3 \xrightarrow{\Delta} 2\ Ag + O_2 + 2\ NO_2$

Solution 14:

(a) When sodium hydrogen carbonate is added to nitric acid, formation of sodium nitrate, water and carbon dioxide will occur.

$$NaHCO_3 + HNO_3 \rightarrow NaNO_3 + H_2O + CO_2$$

(b) When cupric oxide reacts with nitric acid formation of copper nitrate and water will occur.

$$CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$$

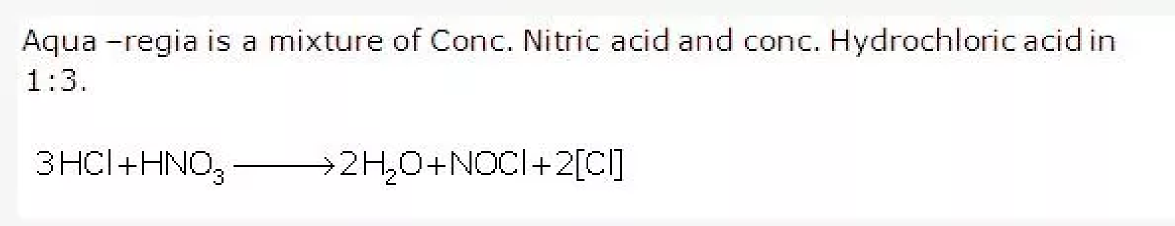
(c) When zinc reacts with dilute nitric acid formation of zinc nitrate, water and nitric oxide will occur.

$$3Zn + 8HNO_3 \rightarrow 3Zn(NO_3)_2 + 4H_2O + 2NO$$

(d) When concentrated nitric acid is heated formation of nitrogen dioxide will occur-

$$4HNO_3 \xrightarrow{\Delta} 2H_2O + 4NO_2 + O_2$$

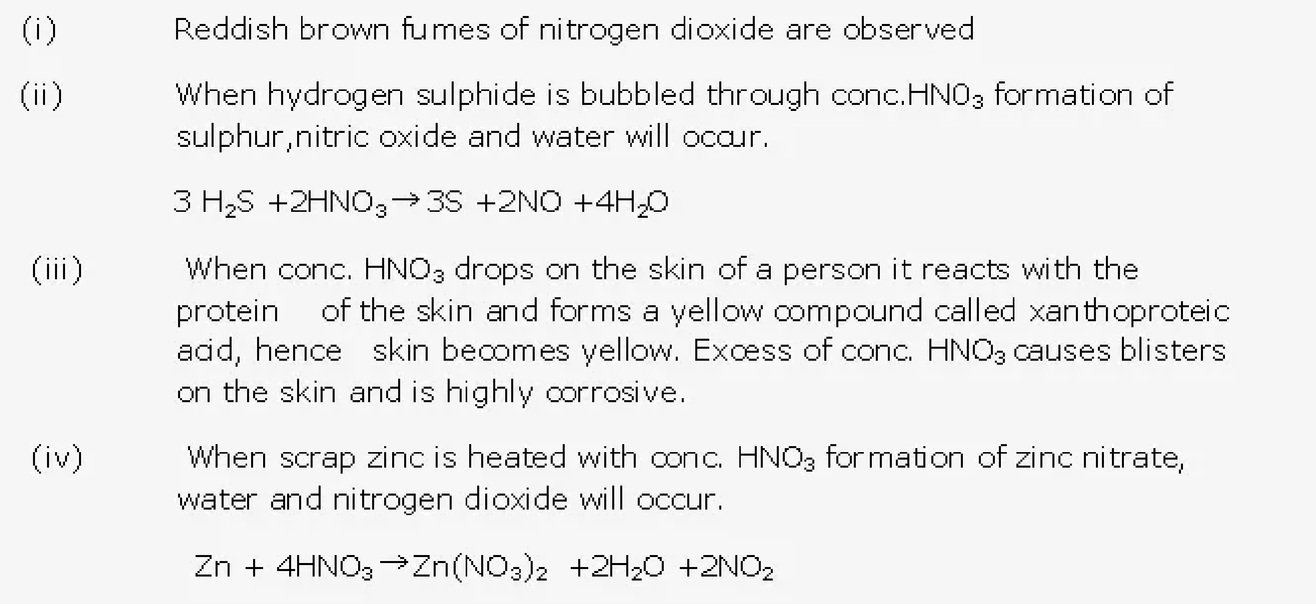
Solution 15:



Aqua –regia is a mixture of Conc. Nitric acid and conc. Hydrochloric acid in 1:3.

$$3HCl+HNO_3 \longrightarrow 2H_2O+NOCl+2[Cl]$$

Solution 16:



(i) Reddish brown fumes of nitrogen dioxide are observed

(ii) When hydrogen sulphide is bubbled through conc.HNO_3 formation of sulphur,nitric oxide and water will occur.

$$3H_2S + 2HNO_3 \rightarrow 3S + 2NO + 4H_2O$$

(iii) When conc. HNO_3 drops on the skin of a person it reacts with the protein of the skin and forms a yellow compound called xanthoproteic acid, hence skin becomes yellow. Excess of conc. HNO_3 causes blisters on the skin and is highly corrosive.

(iv) When scrap zinc is heated with conc. HNO_3 formation of zinc nitrate, water and nitrogen dioxide will occur.

$$Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$$

Solution 17:

(a) When sulphur is added to hot and conc. HNO_3 formation of oxide or oxy-acid will occur.

$S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2$

(b) Nitric acid act as oxidizing agent and oxidizes iodide to iodine.

$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$

$KI \rightarrow I^- + K^+$

$2I^- \xrightarrow{-2e^-} I_2$

$2HNO_3 + H_2O + 2KI \rightarrow NO_3^- + I_2 + 2KNO_3 + H_3O^+$

(c) Nitric acid ionizes in water to form free hydronium ions and nitrate ions.

$HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$

(d) When nitric acid is added to washing soda carbon dioxide will form which when passed through a freshly prepared lime water, turns lime water milky.

$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O(l) + CO_2$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

(e) When limestone reacts with nitric acid-

$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O(l) + CO_2$

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Solution 18:

(i) $C + 4HNO_3 \longrightarrow 2H_2O + 4NO_2 + CO_2$

(ii) $3SO_2 + 2HNO_3 + 2H_2O \longrightarrow 3H_2SO_4 + 2NO$

(iii) $3Fe + 8HNO_3\,(conc.) \longrightarrow 3Fe(NO)_3 + 4H_2O + 2NO$

(iv) $FeSO_4 + NO + 5H_2O \longrightarrow [Fe(NO)(H_2O)_5]SO_4$

(v) $Pt + HNO_3 + HCl \longrightarrow PtCl_4$

(vi) $2HNO_3 + 6FeSO_4 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$

Solution 19:

Dilute nitric acid	Dilute hydrochloric acid
1. On reacting copper metal with nitric acid brown fumes of nitrogen dioxide. $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$	1. On treating copper metal with HCl We don't observe any reaction.
2. Brown ring test: Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated H_2SO_4 is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers. $6\ FeSO_4 + 3H_2SO_4 + 2HNO_3 \rightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$ $FeSO_4 + NO + 5H_2O \rightarrow [Fe(NO)(H_2O)_5]SO_4$ Hydrated nitrosoferrous Sulphate(brown ring)	2. No brown ring test is observed in the case of hydrochloric acid.

Solution 1991-1:

Gold will dissolve only in aqua regia i.e., a mixture of conc. hydrochloric acid and conc. nitric acid in 1:3 but copper will dissolve in nitric acid.

To separate gold from a mixture of gold and platinum add some nitric acid to the mixture, gold will remain undissolved hence can be filtered.

Solution 1991-2:

$$KNO_3 + H_2SO_4 \xrightarrow{200^0 C} KHSO_4 + HNO_3$$

Solution 1991-3:

Balanced equation: $Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Word equation: copper + nitric acid $\xrightarrow{\Delta}$ copper nitrate + nitrogen dioxide + water

Solution 1992-1:

In the laboratory preparation of nitric acid, the mixture of concentrated sulphuric acid and sodium nitrate should not be heated very strongly, above 200°C because a higher temperature can cause following problems:

1. Nitric acid would decompose to form nitrogen dioxide.
2. Sodium sulphate is formed which may stick to the glass and cannot be removed easily
3. The glass apparatus may break.

Solution 1992-2:

$$Cu + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

Solution 1992-3:

Commercial nitric acid is yellow in colour because of presence of nitrogen dioxide but when it is diluted with water, it turns colourless because nitrogen dioxide gets dissolved in water.

Brown ring test can be used to test nitric acid:

Brown ring test: Nitric acid in a test tube is taken and then and then freshly prepared ferrous sulphate solution is added. Concentrated H_2SO_4 is then added carefully down the sides of the test tube, dark brown ring is formed at the junction of two layers.

$$6\,FeSO_4 + 3H_2SO_4 + 2HNO_3 \rightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

$$FeSO_4 + NO + 5H_2O \rightarrow [Fe(NO)(H_2O)_5]SO_4$$

Hydrated nitrosoferrous
Sulphate(brown ring)

Solution 1992-4:

Oxidation of ammonia in catalytic chamber.

$$4NH_3 + 5O_2 \xrightarrow[800°C]{\text{Platinum gauge}} 4NO + 6H_2O + \text{Heat}$$

Solution 1994-1:

Copper is heated with nitric acid, they react together to produce nitrogen dioxide.

$$Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

Solution1994-2:

$$Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

Solution 1994-3:

The nitric acid is manufactured by Ostwald process. In ostwald process ammonia gas and air are taken in 1:10 ratio. Temperature is maintained at 800°C I the catalytic chamber, as the reaction is exothermic so the heat evolved maintains the temperature in the catalytic chamber.

Solution 1994-4:

$$KNO_3 + H_2SO_4 \xrightarrow{200^0 C} KHSO_4 + HNO_3$$

Solution 1995-1:

During a thunderstorm, the rainwater contains nitric acid. The nitric acid is formed as a result of three chemical reactions which is described as follows:

1. During lightning discharge , nitrogen in atmosphere combines with oxygen to form nitric oxide.

$$N_2 + O_2 \xrightarrow{\text{lightning}} 2NO$$

2. Nitric oxide is further oxidized to nitrogen dioxide.

$$2NO + O_2 \longrightarrow 2NO_2$$

3. Nitrogen dioxide dissolves in moisture or rain water to from nitric acid.

$$4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$$

Solution 1997-1:

Lead nitrate is a soluble salt . On heating lead nitrate the following reaction occurs:

$$2Pb(NO_3)_2\,(s) \xrightarrow{\Delta} 2PbO\,(s) + 4NO_2\,(g) + O_2\,(g)$$

Preparation of nitric acid from potassium nitrate:

$$KNO_3 + H_2SO_4 \xrightarrow{200^\circ C} KHSO_4 + HNO_3$$

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Solution 1998-1:

$$N_2 + O_2 \xrightarrow{\text{lightning}} 2NO$$

Solution 1999-1:

When concentrated nitric acid is added to copper brown fumes of nitrogen dioxide are observed.

Solution 2000-1:

When concentrated nitric acid is added to copper brown fumes of nitrogen dioxide are observed.

Solution 2001-1:

1. Nitrogen dioxide
2. Ammonia gas

Solution 2001-2:

(i) concentrated

(ii) $S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2$

Solution 2001-3:

(i) $Na_2CO + 2HNO_3 \longrightarrow 2NaNO_3 + H_2O + CO_2$

(ii) $Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Solution 2002-1:

For laboratory preparation of nitric acid potassium nitrate or sodium nitrate and conc. Sulphuric acid is required.

Solution 2002-2:

Yellowish brown colour of nitric acid is due to the presence of nitrogen dioxide formed due to thermal decomposition of nitric acid.

Solution 2002-3:

(i) $Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$

(ii) $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$

Solution 2002-4:

Platinum glaze is used as catalyst in the manufacture for nitric acid

Solution 2003-1:

The apparatus used is made up of glass as nitric acid is highly corrosive in nature.

Solution 2003-2:

$$KNO_3 + H_2SO_4 \xrightarrow{200^0 C} KHSO_4 + HNO_3$$

Solution 2005-1:

$S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2$

Solution 2005-2:

(i) Dilute nitric acid is generally considered to be a typical acid except for its reaction with metals, nitric acid did not evolve hydrogen gas on reacting with any metal, other than manganese and magnesium.

(ii) $Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$

(iii) In a glass apparatus nitric acid gets decomposed by sunlight .Yellowish brown colour of nitric acid is due to the presence of nitrogen dioxide formed due to thermal decomposition of nitric acid.

Solution 2006-1:

(i) Nitric acid is highly corrosive in nature and corrodes cork, rubber, etc.

(ii) Nitric acid ionizes in water to form free hydronium ions and nitrate ions. This shows that nitric acid is aidic in nature.

Solution 2007-1:

(i) A =sulphuric acid, B=potassium nitrate , C= nitric acid

(ii) $4HNO_3 \longrightarrow 4NO_2 + 2H_2O + O_2$

(iii) $Cu + 4HNO_3 \xrightarrow{\Delta} Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Solution 2007-2:

If nitric acid is kept in a bottle for long time then it will become brown in colour.

Solution 2008-1:

$AlN + 3H_2O \rightarrow Al(OH)_3 + NH_3$

Solution 2008-2:

Name of process	Inputs	Catalyst	Equation for catalysed reaction	Output
Haber Process	Hydrogen +	Iron	$N_2(g) + 3H_2(g) \xrightleftharpoons{Fe, Al_2O_3} 2NH_3(g)$	Ammonia
Ostwald process	Ammonia + Air	Platinum	$4NH_3 + 5O_2 \xrightarrow[800^0C]{\text{Platinum gauge}} 4NO + 6H_2O + Heat$	Nitric acid

<

Solution 2009-1:

oxygen gas is evolved on heating sodium nitrate.