# NITROGEN AND ITS COMPOUNDS.

*Nitrogen gas occupies 78% by volume in the atmosphere. About four-fifth of atmosphere is free nitrogen.*

*Nitrogen is an essential element necessary for well being of animals and plants, in that it is present in proteins found in living things. Proteins are body building food.*

*The element also exists in minerals such as sodium nitrate*

## (a)INTRODUCTION.

**Question 1.**

(1)The atomic mass and atomic number of nitrogen are 14 and 7 respectively.

(a)State what is meant by,

(I) Atomic mass.

•*Atomic mass is the total number of Protons and neutrons in the nucleus of an atom.*

(ii) Atomic number.

•*Atomic number is the number of Protons in the nucleus of an atom.*

(b)State the number of ,

(I) Protons of nitrogen. 7.

(ii)neutrons of nitrogen 7.

(iii) electrons of nitrogen. 7.

(c)State the,

(I) electronic configuration of nitrogen. 2:5

(ii) formula of the ion formed by nitrogen. ……

(iii)electronic configuration of ion formed by nitrogen . 2:8

(d)State the,

(i) group of the periodic table to which nitrogen belongs , and give a reason for your answer.

- Group V, because it has five electrons in it's outer most energy level.

(ii)period of the periodic table to which nitrogen belongs, and give a reason for your answer.

- Period 2, because it has two energy levels.

(iii) valency of nitrogen , and give a reason for your answer.

- Valency 3, because it gains three electrons to have a complete electronic configuration.

(e) (I) using outermost energy electrons, illustrate with diagrams to show how nitrogen molecule, N2, is formed from it's nitrogen atoms.

***(Skip space of 10 lines for the diagrams, )***

- *In the formation of nitrogen molecule N2, each of the two nitrogen atoms , contributes three electrons out of the five electrons in the outer most energy level, to form* ***3 pairs of shared electrons*** *in nitrogen*

*molecule hence forming* ***triple covalent bonds between nitrogen atoms in nitrogen molecule.***

(ii)Write the structural formula of nitrogen.

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**(b) <u>NITROGEN</u> <u>GAS.</u>**

**The laboratory preparation of nitrogen gas from air.**

**Question 2.(a)**

Explain with the aid of the a well labelled diagram, how a sample of nitrogen gas can be prepared in the laboratory from air.

***(skip space of 16 lines for the diagram, then Continue with Notes)***

•*Air from it's reservoir is passed through sodium hydroxide solution in the bottle, to remove carbon dioxide gas, since gas is acidic, so reacts with sodium hydroxide solution which is a base.*

*Equation of reaction.

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•*The remaining air which consists of oxygen and nitrogen, is then passed over strongly heated copper in the furnace.*

•*Brown copper becomes red-hot when strongly heated and reacts with oxygen forming black copper(II) oxide, hence oxygen is removed from air.*

*Equation of reaction.

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•*Remaining part of air is nitrogen gas, and is collected in the gas jar over water, because nitrogen is slightly soluble in water.*

**N.B,**

(i) The nitrogen gas obtained is not pure , **because it contains traces of unreacted oxygen gas, and about 1% by volume of noble gases mainly argon. Noble gases can't be possibly removed by chemical means.**

(ii) Instead of sodium hydroxide solution, **potassium hydroxide Solution** can be used.

**THE INDUSTRIAL (COMMERCIAL) PREPARATION OF NITROGEN GAS.**

**Question 2(b)**

Describe how nitrogen gas is manufactured on a large scale.

•*Nitrogen is manufactured industrially by* ***fractional distillation of liquid air.***

•*Air is first passed through a purification chamber****, in which solid particles such as dust is removed from air.***

•*Carbon dioxide and water vapour are removed from air* ***because at low temperatures, they would solidify and block the pipes of the apparatus.***

•*Air is passed through sodium hydroxide solution ,* ***to remove carbon dioxide gas.***

*Equation of reaction.

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•*Water vapour is removed by passing air through silicon(IV) oxide.( Silica gel)*

•*Resultant air is compressed at pressures of about 200 atmospheres, and then cooled.*

•*The air is further subjected to repeated cooling , until it liquefies to a liquid mixture of nitrogen and oxygen.*

•*Liquid nitrogen is separated from its liquid mixture with oxygen by* ***fractional distillation.***

•*Liquid nitrogen with a lower boiling point of 77k( - 196 o C) ) distils off first , and collected, leaving behind a liquid very rich in oxygen, which also distills off later at 90k( - 183 o C)*

•*The separated nitrogen is stored in specially designed containers ready for use.*

**THE PHYSICAL PROPERTIES OF NITROGEN GAS .**

**Question 2(d)**

State the physical properties of nitrogen gas.

(I) *Nitrogen gas is colourless and odourless.*
(II) *It is slightly less dense than air.*
(III) *It is slightly soluble in water at ordinary conditions.*
(IV) *It is neutral to litmus paper.( Has no effect on litmus paper)*

**THE CHEMICAL PROPERTIES OF NITROGEN GAS.**

**1)THE UNREACTIVITY OF NITROGEN GAS.**

Nitrogen gas is generally unreactive (inert) under ordinary conditions but can however react with a piece of burning magnesium. It can also react with a burning piece of calcium .

- **Reason why nitrogen gas is generally unreactive.**

*The strong triple covalent bonds between nitrogen atoms in diatomic nitrogen molecule, require a lot of heat energy to be broken to free nitrogen atoms so as it can react.*

- **Reason why nitrogen gas reacts with a burning magnesium ribbon.**

*The heat produced by burning magnesium is strong enough to break the strong triple covalent bonds between nitrogen atoms in nitrogen diatomic molecule into free nitrogen atoms, which readily react with magnesium.*

*Equation of reaction between nitrogen gas and burning magnesium ribbon.

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*Observation made for the reaction above.

*Grey magnesium burns with a bright light flame, forming a white solid of magnesium nitride.*

**N.B,** When water is added to the solid product formed above (magnesium nitride) the observation made is,

•*white magnesium nitride dissolves in water , with effervescence of a colourless gas, with an irritating chocking smell, forming a colourless solution.*

*Equation of reaction between magnesium nitride and water.

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The colourless gas with an irritating chocking smell is *ammonia* and the colourless solution formed is *magnesium hydroxide,* in the reaction above.

**Question 3.**

Although nitrogen gas is generally unreactive, it can however react with burning calcium.

(a)Give a reason

(I) why nitrogen gas is generally unreactive.

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(II) why nitrogen can react with a burning piece of calcium.

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(b)A piece of burning calcium was lowered into a gas jar of nitrogen gas.

(I) State what was observed?

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(ii)Write equation of reaction that took place.

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(c) Water was added to the resultant product in (b)

(I) State what was observed?

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(II) Write equation of reaction that took place.

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**2)THE REACTION OF NITROGEN GAS AND HYDROGEN GAS .**

At low temperatures of about 450- 500 o C, and high pressures of 200 to 500 atmospheres, in presence of finely divided iron catalyst, nitrogen gas reacts with hydrogen gas, ***forming ammonia gas .*** This reaction is used to manufacture of ammonia gas on a commercial scale by ***haber process.***

*Equation of reaction.

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**THE CHEMICAL TEST FOR NITROGEN GAS**

**Question 4**

State how nitrogen gas can be tested in the laboratory.

•*Using chemical tests for other common gases, nitrogen gas is identified by it's negative response to such tests in that , it has no colour or smell, doesn't burn, doesn't support combustion, has no effect on litmus paper and calcium hydroxide solution.*

**N.B,** There is no simple positive test tests for nitrogen gas, since nitrogen gas is generally unreactive. It can only be identified using chemical tests of other common gases, where it shows negative response to such tests.

**THE USES OF NITROGEN GAS.**

**Question 5**

State the uses of nitrogen gas.

**(I)** *Used in the manufacture of ammonia gas in the haber process.*

**(II)** *Used as a refrigerating agent in liquid form.*

**(III)** *Empty petrol and oil tanks are filled with gaseous nitrogen gas to reduce on the risk of explosion, because of it's unreactive nature.*

**AMMONIA GAS.**

**The laboratory preparation of ammonia gas.**

Ammonia gas can be prepared in the laboratory by heating an alkali with any ammonium salt.

**Question 6.**

Explain with the aid of a well labelled diagram, how a dry sample of ammonia gas can be tested in the laboratory from calcium hydroxide and ammonium chloride.

***(leave space of 20 lines for the diagram, then continue with notes)***

•*A mixture of calcium hydroxide and ammonium chloride is first ground, so as to increase the surface area of reaction.*

•*The mixture is then put in a round bottomed flask of a hard glass, and clamped on a retort stand in a slanting position, fitted with delivery tube, connected to a drying chamber.*

•*The mixture is heated , producing ammonia gas.*

*Equation of reaction.

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•*Flask is slanted to prevent water produced by the reaction from running into the hot flask, which would cause the glass to crack and break.*

•*Ammonia gas is passed through calcium oxide, packed in a drying chamber, to dry the gas, since the gas itself is alkaline and so can't react with calcium oxide ,which is a base.*

•*Dry ammonia gas is then collected in the gas jar by upward delivery ( downward displacement of air) because it is less dense than air.*

**NB, The following can be noted.**

1. Ammonia gas is not dried using concentrated Sulphuric acid.
   **Reason.**
   •*Ammonia being an alkaline gas reacts with concentrated Sulphuric acid, forming ammonium sulphate.*
   *Equation of reaction.

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2. Ammonia gas is not dried using anhydrous calcium chloride.
   **Reason.**
   •*Ammonia gas reacts with anhydrous calcium chloride forming a complex compound of tetraamine calcium chloride.*
   *Equation of reaction.

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**3.** Instead of calcium hydroxide solid, potassium hydroxide solution or sodium hydroxide solution ,can be used to prepare ammonia gas in the laboratory, with ammonium chloride. In this case, *the round bottomed flask is placed in the vertical position and heated.*

*Equation of reaction between potassium hydroxide solution and ammonium chloride.

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*Ionic equation of reaction.

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*Equation of reaction between sodium hydroxide solution and ammonium chloride.

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*Ionic equation of reaction.

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4. Instead of using ammonium chloride, ammonium sulphate can also be used with **any alkali** , such as calcium hydroxide to prepare ammonia gas.

*Equation of reaction.

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**Question.**

(a)State the condition of reaction between calcium hydroxide and ammonium chloride to produce ammonia gas.

- *Heat.*

(b)Write the equation of the reaction leading to the formation of ammonia gas from ammonium chloride and calcium hydroxide.

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**<u>THE CHEMICAL TEST FOR AMMONIA GAS.</u>**

**Question.**

(a)Name the reagent that is used to identify ammonia gas in the laboratory.

- *Concentrated hydrochloric acid.*

(b)State what would be observed if ammonia was treated with reagent you have named in (a), and write equation of the reaction that would take place.

**Observation.**

•*Dense white fumes.*

**Equation of reaction.**

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**N.B,** The dense white fumes produced is ***ammonium chloride.***

**Question.**

State how ammonia gas can be tested in the laboratory.

•*A gas jar of ammonia gas is opened close to a beaker containing concentrated hydrochloric acid, dense white fumes are formed.*

**Question.**

State the chemical test for ammonia gas.

•*Ammonia gas forms dense white fumes with hydrogen chloride gas from concentrated hydrochloric acid.*

**<u>THE PHYSICAL PROPERTIES OF AMMONIA GAS.</u>**

**Question.**

State the physical properties of ammonia gas.

*(I) It is a colourless gas with a chocking smell.*

*(II) It is less dense than air. That is why it is collected by downward displacement of air.( Upward delivery)*

(III) *It turns moist( damp) red litmus paper blue, so ammonia gas an alkaline gas .it is the only common alkaline gas.*

(IV) *It is very soluble in water, forming ammonia solution. The high solubility of ammonia gas can be demostrated using* ***fountain experiment.***

**Question.**

Explain with the aid of a well labelled diagram, the ***fountain experiment*** to demonstrate the high solubility of ammonia gas in water in the laboratory.

***(Leave space of 20 lines for the diagram , then continue with notes)***

•*A large round thick walled bottomed flask is filled with ammonia gas*

•*The flask is fitted with the glass tubes* **A** and **B**, *with clips at the end.*

•*The flask is inverted over a trough of water, and clamped on to the retort stand, with glass tubes* **A** and **B** *in water.*

•*Clip of glass tube* **B** *is opened to allow few drops of water into the flask and then closed.*

•*The few drops of water dissolved almost all the ammonia gas in the flask, creating a partial vacuum inside the flask, and reduced pressure of gas inside the flask.*

•*Clip of glass tube* **A** *is then opened and at once water runs up the tube and spreads at the end of the tube forming a fountain.*

•*As soon as the clip of glass* **A** *is opened, the water was forced into the flask because the atmospheric pressure from outside overcame the resistance of the reduced gas pressure inside the flask.*

•*The fountain continues to play until the flask is as full of water as it was formerly full of ammonia gas.*

## THE CHEMICAL PROPERTIES OF AMMONIA GAS.

The chemical properties of ammonia gas are first summarized below.

***(I) Reaction of ammonia gas with hydrogen chloride gas.***
***(II) Combustion of ammonia gas in air***
***(III) Catalytic Oxidation of ammonia gas.***
***(IV) Reaction of ammonia gas with chlorine gas.***
***(V) The reducing property of ammonia gas in which it reacts with***
***-Copper(II) oxide.***
***- lead(II) oxide.***

## 1.THE REACTION OF AMMONIA GAS WITH HYDROGEN CHLORIDE GAS.

When a gas jar of ammonia gas is inverted over a gas jar full of hydrogen chloride gas, the observation made is ****dense white fumes, which settle to a white solid of ammonium chloride.***

*Equation of reaction.

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## 2.THE COMBUSTION OF AMMONIA GAS IN AIR .

Ammonia gas burns in air enrichment with oxygen gas with ***a greenish-yellow flame,*** forming nitrogen gas, and water.

*Equation of reaction.

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**<u>Set</u> -up <u>diagram</u> for the <u>combustion</u> <u>of</u> <u>ammonia</u> <u>gas</u> <u>in</u> <u>air</u>.**

***(skip space of 17 lines for the diagram and then Continue with notes )***

*•A mixture of ammonium sulphate and calcium hydroxide is heated in the hard glass tube , clamped on a retort stand, and fitted with a delivery tube. Ammonia gas is produced as equation below.*

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*•Ammonia gas is passed through calcium oxide in the u-tube, to dry the gas.*

*•Dry ammonia gas from the u-tube is then passed through a delivery glass tube into a combustion vessel, containing glass wool , to which oxygen gas is also directed.*

*•Ammonia gas is then lighted at the end of tube, and **<u>burns in oxygen gas with a greenish-yellow flame,</u>** producing **<u>nitrogen gas</u>** and **<u>water</u>** , as the equation below.*

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•*The role of the glass wool is* ***<u>to spread oxygen gas evenly through out the combustion vessel.</u>***

**<u>3.CATALYTIC OXIDATION OF AMMONIA GAS .</u>**

A hot platinum or hot copper wire, which acts as a ***<u>catalyst</u>*** is suspended in a beaker containing concentrated ammonia solution, and oxygen, from gas cylinder is bubbled into ammonia solution as the diagram below.

( ***Leave space of 16 lines then continue with notes)***

*Observation made in the reaction above.

•*<u>Reddish-brown fumes of nitrogen dioxide formed and the metal catalyst remains red-hot.</u>*

*Equation (s) of reaction (s).

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**N.B,**

•In the reaction above, ammonia gas from concentrated ammonia solution, first reacts with oxygen ,where ammonia gas is oxidized forming *colourless nitrogen monoxide gas and water.*

• Nitrogen monoxide gas formed which is colourless is rapidly oxidized by air forming *nitrogen dioxide gas which is reddish-brown.*

•The metal catalyst remains red-hot ***because the catalytic oxidation of ammonia gas is exothermic.***

An exothermic reaction is the one in which heat energy is released to the surrounding. The heat energy produced makes the metal catalyst to continue glowing red-hot.

•The reaction for the catalytic oxidation of ammonia gas ***is used in the manufacture of nitric acid on a large scale.***

## 4.THE REACTION OF AMMONIA GAS WITH CHLORINE GAS .

When a jet of burning dry ammonia gas ( from preparation) is lowered into a gas jar of chlorine gas, the observation made is ****ammonia burns spontaneously in chlorine forming misty fumes of hydrogen chloride.***

The misty fumes is hydrogen chloride gas. Nitrogen gas is also formed in the reaction.

*Equation of reaction.

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However when **excess** ammonia gas is burnt in chlorine gas, the observation made is ***<u>dense white fumes are formed, which settled to a white solid of ammonium chloride.</u>***

*Equation of reaction.

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**<u>5.THE REDUCING PROPERTY OF AMMONIA GAS.</u>**

**Dry** ammonia gas reduces **heated oxides** of copper and lead to a corresponding **metal ,** and it's self oxidized to **nitrogen gas and water.**

*General equation.

Metal oxide(s) + ammonia (g) ---------- metal(s) + nitrogen (g) + water(l)

*conditions of the reaction.

- *Dry ammonia gas.*
- *Heated metal oxide.*

**•<u>Reaction of ammonia gas with copper (II) oxide</u>.**

When dry ammonia gas is passed over strongly heated copper(II) oxide in a glass tube, the observation made is ***<u>• black solid changed to a brown solid, and a colourless liquid condenses on cooler parts of the tube.</u>***

*Equation of reaction.

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*Explanation of observation for above reaction.

*Dry ammonia gas reduced black copper(II) oxide to copper solid which is brown , and itself oxidized to nitrogen and water which is a colourless liquid.*

***Experimental set-up diagram for the reaction between dry ammonia gas and copper (II) oxide.**

**(*Skip space of 14 lines and then Continue with notes)***

•A stream of **dry** ammonia gas is passed over **Strongly heated** copper (II) oxide which is a black solid, in the hard combustion tube, fitted with the delivery tube , and connected to a u-tube placed in a beaker containing cold water.

•Dry ammonia gas reduced black copper (II) oxide to copper which is a brown solid, and it's self oxidized to nitrogen gas , and water.

*Equation of reaction.

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•The ice-cold water in the beaker **condenses water vapour , produced in the reaction , forming liquid water which collects in the U- tube, as a colourless liquid.**

•Nitrogen gas produced is passed through a delivery tube, fitted on the u-tube, and collected in the gas jar over water, since nitrogen gas is slightly soluble in water.

**N.B**

**1.** The above reaction( reaction of dry ammonia gas with heated copper(II) oxide) is *another method which can be used to prepare a sample of nitrogen gas in the laboratory.*

2.The colourless liquid ( water) which collects in the U-tube can be identified ( tested) in the laboratory, using a reagent ***anhydrous copper (II) sulphate which is white.*** When used to test for water, the observation made is ***white anhydrous copper (II) sulphate changes to blue.***

**Question**

State how ammonia gas reacts with copper (II) oxide. Include equation of reaction.

*•Dry ammonia gas reduces Strongly heated copper (II) oxide to copper and it's self oxidized to nitrogen gas and water.*

*Equation of reaction.

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**Question.**

(a)State the conditions of reaction between ammonia gas and copper (II) oxide.

•*Heated copper (II) oxide.*

•*Dry ammonia gas.*

(b)State what would be observed when ammonia gas reacts with copper (II) oxide.

•*Black solid changed to brown , colourless liquid formed.*

(c) Write equation of the reaction that would take place.

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(d) Explain your observation in( b)

*Dry ammonia gas reduced black copper (II) oxide to copper solid which is brown, and it's self oxidized to nitrogen gas and water , which is a colourless liquid.*

(e)State the property of ammonia gas demonstrated above

*Reducing property.*

•**Reaction of ammonia gas with lead(II) oxide.**

When dry ammonia gas is passed over strongly heated lead(II) oxide in the glass tube, the observation made is, ****reddish brown solid changed***

***to a grey solid, a colourless liquid condenses on cooler parts of the tube .***

*Equation of reaction.

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*Explanation of observation.

*Dry ammonia gas reduces heated lead(II) oxide which is reddish-brown when hot, to grey lead solid, and it's self oxidized to nitrogen gas, and water which is a colourless liquid.*

**Students question**

Dry ammonia gas was passed over strongly heated lead(II) oxide.

(a)State what was observed.

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(b)Write equation of reaction that took place.

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(c) Explain your observation in (a)

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(d)(I)State the property of ammonia gas demonstrated in reaction

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(ii)Name one metal whose oxide can react with ammonia gas in a Similar way as lead(II) oxide in reaction above.

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**Question.**

Explain with the aid of a equation the changes that take place when dry ammonia gas is passed over strongly heated lead (II) oxide.

•*Reddish-brown solid changed to grey solid,and a colourless liquid formed. This is because dry ammonia gas reduced heated lead(II) oxide which is reddish brown to lead solid which is grey, and it's self oxidized to nitrogen gas and water which is a colourless liquid.*

*Equation of reaction.

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**THE INDUSTRIAL ( COMMERCIAL) MANUFACTURE OF AMMONIA GAS.**

Ammonia gas is obtained on an industrial scale by ***haber process*** **,** which is based on the direct combination of nitrogen and hydrogen as the raw materials.

**Question.**

Describe how ammonia gas is manufactured on a large scale by haber process.

•*Dry nitrogen gas obtained from atmospheric air and dry hydrogen gas obtained from either burning natural gas or from water gas, is mixed in the ratio of 1: 3 by volume.*

•*Mixture of two gases is then passed over finely divided iron catalyst with some traces of aluminum oxide, at low temperatures of 450- 500 o C and high pressures of 200 – 500 atmospheres, forming ammonia gas as the equation below.*

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•*iron catalyst is finely divided to increase the surface area over which reaction occurs, and aluminum oxide improves the effectiveness of the catalyst by making it more porous thus providing a higher surface area for the reaction.*

•*Ammonia gas produced is liquefied by refrigeration and stored.*

**Question.**

(a)(I) Name the process by which ammonia gas is manufactured on a large scale.

*Haber process.*

(ii)Name the raw materials used in the manufacture of ammonia gas on large scale.

*Nitrogen gas and hydrogen gas.*

(iii)State the source of each raw material named in (a)(ii)

• *Nitrogen gas is obtained from atmospheric air.*

•*Hydrogen gas is obtained from water, or from burning natural gas.*

(b)(I) Write the equation leading to the formation of ammonia gas on a large scale.

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(ii)State the conditions of reaction leading to the formation of ammonia gas on a large scale.

-Low temperatures of 450-500 o C

-High pressures of 200-500 atmospheres.

-Finely divided iron catalyst mixed with small traces of aluminum oxide.

**THE USES OF AMMONIA GAS.**

**Question.**

State the uses of ammonia gas.

*(I) In the manufacture of nitric acid on a large scale.*

*(II) In the manufacture of ammonium sulphate and ammonium nitrate fertilizers.*

*(III) Ammonia solution is used in laundry work to remove temporary hardness.*

*(IV) Liquid ammonia is used as a refrigerating agent on a large scale such as in ships and warehouses because it evaporates readily , removing heat from the surrounding as it does so.*

## AMMONIA SOLUTION.

**The preparation of ammonia solution.**

Ammonia solution is prepared by dissolving ammonia gas in water.

**Question.**

Draw a well labelled diagram showing how a sample of ammonia gas can be prepared in the laboratory.

***( Skip space of 18 lines for the diagram, then Continue with the notes)***

**N.B ,** The following can be noted on the diagram above

1. Ammonia gas produced in the reaction flask , is passed through a delivery tube, fitted on to the filter funnel , whose rim is immersed into water in the beaker. Ammonia gas ***readily dissolves in water forming colourless ammonia solution.***
2. The filter funnel is used in passing ammonia gas into water, to Prevent the 'sucking back' of water from the beaker into the reaction flask.

## EFFECT OF HEAT ON COMMON SALTS OF AMMONIUM COMPOUNDS.

**(a)Ammonium chloride.**

When ammonium chloride is heated in a tube, the observation made is.

*<u>*White ammonium chloride sublimes , giving off dense white vapour, which settle to a white sublimate on the upper cooler parts of the tube.*</u>

*Equation of reaction.

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**N.B,**

•The cause of sublimation of ammonium chloride is that ammonium chloride dissociates on heating into a vapour, that consists of ammonia gas and hydrogen chloride gas.

**(b)Ammonium nitrate.**

When heated ,white ammonium nitrate melts producing **dinitrogen oxide ( nitrogen(I) oxide** and **water.**

*Equation of reaction.

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Dinitrogen oxide is a colourless gas, denser than air, fairly soluble in water, no effect on litmus paper. <u>Dinitrogen oxide re-lights a glowing splint like oxygen gas.</u>

**(c)Ammonium carbonate.**

When heated, white ammonium carbonate sublimes when heated producing, **ammonia gas, carbon dioxide gas** and **water.**

*****Equation of reaction.

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**(d)Ammonium sulphate.**

When heated ammonium sulphate decomposes when heated forming **ammonia gas** and **Sulphuric acid vapour.**

*Equation of reaction.

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(**e)Ammonium nitrite.**

When heated, white ammonium nitrite decomposes forming **nitrogen gas** and **water .**

*Equation of reaction.

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**<u>TESTING FOR AMMONIUM ION IN AN AMMONIUM SALT.</u>**

**<u>Question.</u>**

Describe briefly how ammonium ion in an ammonium salt in solution can be tested in the laboratory.

*When an ammonium salt in solution in warmed with an alkali , a colourless gas with a pungent chocking smell and turns moist red litmus paper blue is given off. The gas given off is ammonia gas.*

*ionic equation.

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**ACTION OF AQUEOUS AMMONIA ON METALLIC IONS .**

Aqueous ammonia ( ammonium hydroxide solution) react with metallic ions in solution, forming precipitates of metal hydroxide.

Only two metal ions in solution form precipitate , which dissolve in excess dilute ammonia solution, these are; zinc ions and copper(II) ions.

(I) *Zinc ions, form white precipitate soluble forming a colourless solution*
(II) *Copper(II) ions form a pale blue precipitate soluble , forming a deep blue solution.*

The rest of metal ions in solution form precipitate insoluble in excess aqueous ammonia solution. These are

(I) *Magnesium ions, form white precipitate insoluble .*
(II) *Aluminum ions, form white precipitate insoluble.*
(III) *Lead (II) ions, form white precipitate insoluble*
(IV) *Iron(II) ions, form green precipitate insoluble.*
(V) *Iron(III) ions, form brown precipitate insoluble.*

**N.B,**

•The action of aqueous ammonia on metallic ions in solution is further looked at in details, with ionic equations under the topic of ***qualitative analysis on page***…….

## NITRIC ACID.

### The laboratory preparation of nitric acid.

Nitric acid can be prepared in the laboratory from solid potassium nitrate and concentrated Sulphuric acid. Heat is required.

### Question.

Explain with the aid of a well labelled diagram how a sample of nitric acid can be prepared in the laboratory.

( ***Skip space of 20 lines for the diagram, then Continue with notes)***

•*potassium nitrate is put into a glass retort, and concentrated Sulphuric acid added.*

• *Reaction is carried out in all glass retort apparatus, because nitric acid being prepared attacks rubber and cork.*

•*The mixture is heated, since reaction doesn't occur in the cold.*

•*Potassium nitrate gradually dissolves, and effervescence occurs, giving off nitric acid vapour, which is condensed as a yellow liquid in another flask placed in a sink, and cooled by tap water.*

*Equation of reaction.

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•*The reaction is possible, because nitric acid is a more volatile acid, so it is readily displaced from it's salt of potassium nitrate by a less volatile Sulphuric acid.*

•*During heating, reddish-brown fumes of nitrogen dioxide are evolved in the flask, due to thermal decomposition of nitric acid as equation below.*

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•*The reddish brown nitrogen dioxide dissolves in nitric acid produced, making prepared nitric acid to appear yellow.*

**N.B.**

1. Instead of Potassium nitrate , sodium nitrate can be used with concentrated Sulphuric to prepare a sample of nitric acid in the laboratory. Heating is required.

•Equation of reaction.

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•Observation for reaction above.

•*Sodium nitrate gradually dissolves , and effervescence occurs. Reddish-brown fumes are evolved.*

•Explanation of reaction above.

The less volatile acid, concentrated Sulphuric acid displaced a more volatile acid, nitric acid from it's salt of sodium nitrate, then the nitric acid vapour is slightly decomposed by heat , forming reddish-brown fumes of nitrogen dioxide as equation below.

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2. In each reaction, the salt formed is acidic is which potassium hydrogen sulphate and sodium hydrogen sulphate.

The normal salts( potassium sulphate and sodium sulphate are *only formed only at high temperatures, which cannot be reached in the glass apparatus.*

**Sample question.**

Potassium nitrate reacts with Sulphuric acid to produce nitric acid in a laboratory.

(a)State the conditions of reaction.

- *Concentrated Sulphuric acid.*
- *Heat.*

(b)(i)Write equation of reaction leading to the formation of nitric acid from potassium nitrate and Sulphuric acid under the conditions stated in (a)

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(ii)Give a reason why the reaction in(b)(I) leading to the formation of nitric acid is possible.

•*Nitric acid is a more volatile acid, so it readily displaced from it's salt of potassium nitrate by a less volatile Sulphuric acid.*

(c)Explain with the aid of equation why nitric acid prepared in the laboratory is a yellow liquid, yet ordinary nitric acid is colourless.

•*Prepared nitric acid is yellow, because of the presence of dissolved nitrogen dioxide gas in the acid, formed by slight thermal decomposition of nitric acid vapour.*

*Equation of reaction.

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**THE INDUSTRIAL ( MANUFACTURE) OF NITRIC ACID.**

**Question.**

Describe how nitric acid is manufactured on a large scale. Include equations of reaction

The manufacture of nitric acid on a large scale involves 3 stages.

**Stage 1.**

•*Ammonia gas obtained from haber process is mixed with excess air and passed over platinum catalyst at temperatures of about 700 oC, and 9 atmospheres. Ammonia is oxidized to nitrogen monoxide( nitrogen(II) oxide ). The reaction is exothermic.*

*Equation reaction.

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**Stage 2.**

•*Nitrogen monoxide is cooled, and reacts with oxygen from excess air, forming nitrogen dioxide.*

*Equation of reaction.

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**Stage 3.**

•*Nitrogen dioxide together with excess air is absorbed in hot water, forming nitric acid.*

*Equation of reaction.

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**Sample question 1.**

Show with aid of equations only , how nitric acid is manufactured on a large scale.

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**<u>THE CHEMICAL PROPERTIES OF NITRIC ACID.</u>**

Nitric acid chemically reacts in two ways.

(I) As a strong acid.
(II) As a strong Oxidizing agent.

## 1.NITRIC ACID AS A STRONG ACID.

A strong acid is the one which completely ionizes in aqueous solution.

*Equation for the ionization of nitric acid.

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### Chemical reactions of nitric acid as a strong acid.

(**a**)As an acid, dilute nitric acid reacts with metal carbonates, and metal hydrogen carbonates liberating carbon dioxide gas, with formation of a corresponding metal nitrate salt solution, and water.

### General equation of reaction.

M.Carbonate(s) + $HNO_3$(aq)-----M.nitrate(aq)+ $CO_2$(g)+ $H_2O$(l)

and.

M.Hydrogen carbonate(s)+$HNO_3$(aq)----M.nitrate(aq)+ $CO_2$(g) + $H_2O$(l)

*M, in the general equation represents metal.*

- **(i)Reaction of potassium carbonate and dilute nitric acid.**

*****Observation.

*white solid dissolves in acid with effervescence of a colourless gas, colourless solution of potassium nitrate formed.*

*Equation of reaction.

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- **(ii)Reaction of sodium carbonate with dilute nitric acid.**

*****Observation.

*W<u>hite solid dissolves in acid with effervescence of colourless gas, colourless solution of sodium nitrate formed.</u>*

*Equation of reaction.

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**•(III)Reaction of calcium carbonate and dilute nitric acid.**

*Observation.

*<u>White solid dissolves in acid with effervescence of a colourless gas, colourless solution of calcium nitrate formed.</u>*

*Equation of reaction.

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**•(IV)Reaction of magnesium carbonate and dilute nitric acid.**

*****Observation.

*<u>White solid dissolves in acid with effervescence of colourless gas, colourless solution of magnesium nitrate formed.</u>*

*Equation of reaction.

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**•(V) Reaction of zinc carbonate with dilute nitric acid.**

*****Observation.

*White solid dissolves in acid with effervescence of a colourless gas, colourless solution of zinc nitrate formed.*

*Equation of reaction.

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- **(VI) Reaction of lead(II) carbonate with dilute nitric acid.**

*****Observation.

*Yellow lead (II) carbonate dissolves in acid with effervescence of a colourless gas, colourless solution of lead(II) nitrate formed.*

*Equation of reaction.

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- (**VII) Reaction of copper (II) carbonate and dilute nitric acid.**

*Observation.

*Green copper (II) carbonate dissolves in acid with effervescence of a colourless gas, green solution of copper (II) nitrate formed.*

*Equation of reaction.

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- **(VIII) Reaction of sodium hydrogen carbonate and dilute nitric acid.**

*Observation.

*White solid dissolves in acid with effervescence of colourless gas, forming a colourless solution of sodium nitrate.*

*Equation of reaction.

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**(b)**As an acid, dilute nitric acid reacts with metal oxides and alkalis forming a *corresponding metal salt solution and water only.*

**General equation of reaction.**

Metal oxide(s) +Nitric acid(aq)-----Metal nitrate(aq) + water(l)

And.

Alkali(aq)+ Nitric acid(aq)-------Metal nitrate (aq)+ water(l)

•(I) **Reaction of copper (II) oxide and dilute nitric acid.**

*****Observation.

*Black copper (II) oxide dissolved in acid, forming a green solution of copper (II) nitrate.*

*Equation of reaction.

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•(II) **Reaction of zinc oxide and dilute nitric acid.**

*Observation.

*White solid zinc oxide dissolved in acid, forming a colourless solution of zinc nitrate.*

*Equation of reaction.

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……

•(III) **Reaction of lead(II) oxide and dilute nitric acid.**

*Observation.

*Yellow solid lead(II) oxide dissolved in acid, forming a colourless solution of lead(II) nitrate.*

*Equation of reaction.

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- **(IV) Reaction of aluminum oxide with dilute nitric acid**

*observation.

*White solid aluminum oxide dissolves in acid, forming a colourless solution of aluminum nitrate.*

*Equation of reaction.

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- **(V) Reaction of magnesium oxide with dilute nitric acid.**

***Observation.

*White solid magnesium oxide dissolved in acid, forming a colourless solution of magnesium nitrate.*

*Equation of reaction.

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**(c)**As an acid, **very dilute** nitric acid ( about 1%) reacts with magnesium metal **only**, liberating **hydrogen gas**, a corresponding metal nitrate solution is formed.

*Equation of reaction.

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## 2.NITRIC ACID AS AN  A STRONG OXIDIZING AGENT.

An oxidizing agent is an acceptor of electrons. It accepts electrons from the reducing agent with which it is reacting.

### Chemical reactions of nitric acid as a strong oxidizing agent.

- **(I) Reaction of copper and nitric acid.**

**Concentrated** nitric acid oxidizes copper to copper (II) nitrate solution and it's self reduced to nitrogen dioxide gas, and water.

*Equation of reaction.

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*Observation.

*A vigorous reaction occurs, reddish-brown nitrogen dioxide gas evolved, green solution  of coper(II)  nitrate formed.*

However, when concentrated nitric acid is mixed with an equal volume of water(when acid is diluted) , it reacts less vigorously with copper, forming colourless nitrogen monoxide gas, which turns reddish-brown nitrogen dioxide in air.

*Equation(s) of reaction(s)

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**N.B.**

*In the above reaction,* ***dilute*** nitric acid ***oxidizes*** copper to ***copper (II) nitrate,*** and it's *self* ***reduced*** to ***nitrogen monoxide*** *which is a* ***colourless*** *gas and water*. *The colourless gas nitrogen monoxide is* ***oxidized*** *to* ***nitrogen dioxide*** *which is* ***reddish-brown.***

**•(II) Reaction of Sulphur with nitric acid.**

**Hot concentrated** nitric acid **oxidizes sulphur** to **Sulphuric acid**, and it's self **reduced** to **nitrogen dioxide** and **water.**

*Equation of reaction.

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*Observation for above reaction.

*•Yellow Sulphur dissolves in acid, reddish-brown gas evolved, colourless solution formed .*

**•(III) Reaction of carbon with nitric acid.**

**Hot concentrated** nitric acid oxidizes carbon to **carbon dioxide** and itself **reduced** to **nitrogen dioxide** and **water.**

*Equation of reaction.

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*Observation of the reaction.

*Carbon dissolves in acid, producing a reddish-brown gas.*

**Questions**

**1.(a)** State the conditions under which nitric acid reacts with,

(I)Magnesium hydroxide.

*Dilute nitric acid.*

(II)Carbon.

*Hot concentrated nitric acid.*

(b)Write equation for the reaction of nitric acid with,

(I)Magnesium hydroxide.

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……

(II)Carbon.

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.. ……

(c)State the property of nitric acid which is shown by it's reaction with

(I) Magnesium hydroxide.

*As an acid.*

(II)Carbon.

*As an oxidizing agent.*

2.Explain the reaction between nitric acid and Sulphur. Include equation of reaction.

*Hot concentrated* nitric acid *oxidizes* Sulphur to *Sulphuric acid,* and it's self reduced to *reddish-brown nitrogen dioxide,* and *water.*

*Equation of reaction.

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**THE USES OF NITRIC ACID.**

**Question.**

State the uses of nitric acid.

*(I) In the manufacture of ammonium nitrate and calcium nitrate fertilizers.*

*(II) In the manufacture of dyes and explosives.*

**Sample question.**

State briefly how each of the following nitrogen fertilizers is prepared in the laboratory. Include equation of reaction.

(a)Ammonium nitrate.

Ammonium nitrate is prepared by neutralisation of aqueous ammonia solution and dilute nitric acid.

*Equation of reaction.

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(b)Calcium nitrate.

Calcium nitrate is prepared by reacting dilute nitric acid and calcium carbonate.

*Equation of reaction.

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## THE NITRATES.

### (1)THE SOLUBILITY OF NITRATES.

All nitrates are **soluble** in water. Examples of nitrates include

*-Potassium nitrate.*

*-Sodium nitrate.*

*-Calcium nitrate*

*-Magnesium nitrate*

*-Aluminium nitrate.*

*-Zinc nitrate.*

*-Lead(II) nitrate.*

*-Copper (II) nitrate.*

*-Mercury (II) nitrate.*

*-Silver nitrate*

*-Ammonium nitrate.*

### (2)THE EFFECT OF HEAT ON NITRATES.

### (a) Decomposition of potassium nitrate and sodium nitrate.

Potassium nitrate and sodium nitrate ( white solids) when heated *melt to a colourless liquid, and decompose slowly forming colourless gas, and leaving when cool a pale yellow solid.* The pale yellow solid formed is Potassium nitrite and sodium nitrite respectively.

**N.B**

Potassium nitrate and sodium nitrate decompose forming ***metal nitrite*** and ***oxygen gas***.

*Equation for decomposition of potassium nitrate.

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*Equation for the decomposition of sodium nitrate.

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**(b)Decomposition of nitrate of calcium, magnesium, zinc, lead and copper.**

The metal nitrate of calcium, magnesium, zinc, lead and copper decompose forming a ***metal oxide*** **,** ***nitrogen dioxide gas*** and ***oxygen gas***.

*General equation.

**Metal nitrate (s) ---- metal oxide(s) + Nitrogen dioxide (g)+ Oxygen (g)**

(I)**Decomposition of calcium nitrate.**

When calcium nitrate is heated, the observation made is **white solid decomposes , producing reddish-brown nitrogen dioxide gas and white residue of calcium oxide formed .*

*Equation of reaction.

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(II)**Decomposition of magnesium nitrate.**

When magnesium nitrate is heated , the observation made is* *white solid decomposes , producing reddish-brown nitrogen dioxide gas and white residue of magnesium oxide formed.*

*Equation of reaction.

……
……

(III)**Decomposition of zinc nitrate.**

When zinc nitrate is heated, the observation made is **white solid decomposes , producing reddish-brown nitrogen dioxide gas, yellow residue when hot, and white on cooling is formed.*

*Equation of reaction.

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**N.B**, The yellow residue when hot, and white on cooling which is formed in the reaction above is, zinc oxide.

(IV)**Decomposition of lead(II) nitrate.**

When lead(II) nitrate is heated, the observation made is, ***white solid crackles, melts and effervescences, producing reddish-brown fumes of nitrogen dioxide, a reddish-brown residue when hot and yellow on cooling is formed.*

*Equation of reaction.

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**N.B**, Lead(II) nitrate crackles( makes a cracking sound), *because gas*

*forms inside it's crystals and split them when it's expands due to heating.* reddish-brown when hot and yellow on cooling is lead(II) oxide.

(V)**Decomposition of copper (II) nitrate.**

When copper (II) nitrate is heated, the observation made is**green solid decomposes, producing reddish-brown fumes of nitrogen dioxide, black residue of copper (II) oxide formed.*

*Equation of reaction.

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**(c)Decomposition of mercury (II) nitrate and silver nitrate.**

Both mercury (II) nitrate and silver nitrate decompose forming *free metal, nitrogen dioxide gas and oxygen gas.*

*Equation of decomposition of mercury (II) nitrate.

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*Equation of decomposition of silver nitrate.

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**(d)Decomposition of ammonium nitrate.**

When ammonium nitrate is heated, white solid gives off *dinitrogen oxide gas and water.*

*Equation of reaction.

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**Questions.**

1.Write equation of reaction that takes place when each of the following nitrates is strong heated, until there is no further change.

(a)copper(II) nitrate.

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(b)Sodium nitrate.

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(c)Ammonium nitrate.

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(d)Silver nitrate.

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**2.**(a)Lead(II) nitrate was Strongly heated until there was no further Change

(i)State what was observed?

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(ii) Write equation of reaction that took place.

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(b)Dilute nitric acid was added to the residue in (a)

(I)State what was observed?

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(II)Write equation of the reaction that took place.

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**CHEMICAL TEST FOR A NITRATE ION IN SOLUTION.** (***Brown ring test)***

**Question.**

Describe briefly how a nitrate in solution can be tested in the laboratory.

•*To a solution of a nitrate in a test tube, an equal volume of freshly prepared iron(II) sulphate is added. The test tube is held in a slanting position, and concentrated Sulphuric acid is carefully poured inside, down the sides of test tube, a brown ring forms where the two layers meet.*

*Set up experimental diagram for brown ring test.

**(*Skip space of 9 lines for the diagram)***

**THE NITROGEN CYCLE.**

**Research question.**

(a)State what is meant by *nitrogen cycle.*

(b)Form groups , and in your respective groups, discuss and write briefly about the various processes( ways ) how free nitrogen and different forms of nitrogen are removed from and added to the atmosphere. Make a flow chart to show the nitrogen cycle.

(c)state the importance of nitrogen in plants and animals.

**END OF NITROGEN AND IT'S COMPOUNDS NOTES.**

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