THE REPUBLIC OF UGANDA

Ministry of Education and Sports

SELF-STUDY LEARNING

SENIOR 4

CHEMISTRY

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NATIONAL CURRICULUM DEVELOPMENT CENTRE

UGANDA NATIONAL EXAMINATIONS BOARD

S.4 CHEMISTRY

TOPIC: CHLORINE AND ITS COMPOUNDS

Learning Outcomes

By the end of this lesson, you should be able to:

1. describe and explain the laboratory preparation of chlorine
2. outline the properties of chlorine.
3. outline the uses of chlorine.

Introduction

From earlier learning, you now know that chlorine is a chemical element with the symbol Cl and atomic number 17. The electronic configuration of chlorine is 2:8:7. Chlorine naturally occurs in combined states mostly as chloride. The commonest chlorine containing compound is sodium chloride or common salt. The food additive improves taste of food and required by the body. The human body require chloride ions to manufacture hydrochloric acid, a stomach acid required for food digestion. The name chlorine is derived from chloros, meaning green, referring to the colour of the gas.

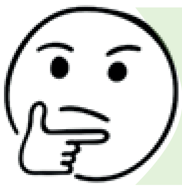
Read more: https://www.lenntech.com/periodic/elements/cl.htm#ixzz6SFdOStQiChlorine gas bleaches moist materials and a poisonous gas.

In this topic, you will learn how chlorine behaves with other substances and how useful products of chlorine are.

From the electron configuration of chlorine, can you predict the position of chlorine in the periodic table?

- To which group and period does it belong?
- Is chlorine a metal or non-metal?

Chlorine can occur freely as chlorine gas;



Time to think

- How can chlorine be prepared in the laboratory?
- What are physical properties of chlorine gas?

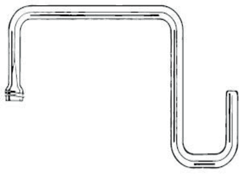
Lesson 1: Preparation of Chlorine in The Laboratory

How can a sample of chlorine be prepared in the laboratory?

Like other gases, chlorine can as well be prepared in the laboratory. You will easily understand this preparation as you draw the set-up of apparatus used.

Investigation: To draw the laboratory preparation of chlorine gas

What you will need: reference to laboratory equipment drawings

Pencil, paper and ruler	Retort stand	Heat source	Gas jar	Round bottomed flask
Reagents; Ammonium chloride, sodium nitrite, water				
Thistle funnel	Bee-hive	Conical flask	Delivery tube	Rubber cork
				

Expectation: Assemble and make a well-drawn and labelled apparatus setup to preparation of chlorine in the laboratory

Activity:	
▪ Draw a retort stand, on its base place a tripod stand with wire gauze, beneath which stands a Bunsen burner.	
▪ Clamp a round bottomed flask over the burner (it contains potassium permanganate on a retort stand, stopper its top with a thistle (concentrated hydrochloric acid) and a delivery tube plunged through cork.	
▪ Connect the delivery tube through a reagent bottle with water. Then another delivery tube links the reagent bottle with a conical flask containing concentrated sulphuric acid. Finally, a delivery tube connects the flask to a gas jar placed on the table covered with a card board.	
▪ Label your apparatus and indicate using an arrow how the prepared gas flows though the set-up	

- Follow the link: https://www.google.com/search?client=firefox-b-d&q=preparation+of+chlorine+in+the+laboratory#kpvalbx=_qaoOX7OdMN2KjLsPj6yiiAs36 to watch a video on how chlorine can be prepared in the laboratory.

- Write an equation of reaction that leads to the preparation of chlorine gas using the reagents in video or drawing
- Why is chlorine collected by downward delivery method?

Conclusion

- To prepare pure chlorine in the laboratory, concentrated hydrochloric acid is reacted with potassium permanganate. The products formed include potassium chloride, manganese chloride, water and chlorine gas.

Equation of reaction

$$2KMnO_4(s) + 16HCl(aq) \longrightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$$

Physical properties of chlorine

Chlorine is a greenish-yellow, diatomic, dense gas with a sharp smell (the smell of bleach).

Do it yourself:

Obtain pure lemon juice from fresh lemon, put it in a clear plastic bottle till ¼ full.
Add liquid bleach like 'Jik' till ½ full. Quickly tightly cover the bottle.
Let it stand for some time. Check for the gas give out, which colour is the gas?
(Note: don't open the bottle even after observing. The gas trapped inside it is very poisonous).

Uses of chlorine

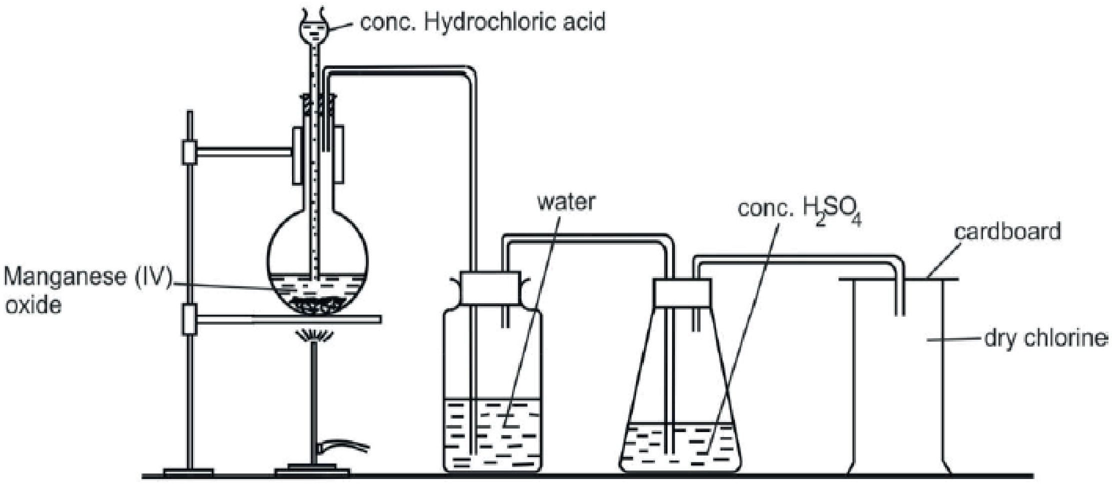
- **Collect the following items**

Pvc bag	**Jik bleach**	**Water disinfectant tablet**	**Paint**
			

- Make research about the products above, suggest the possible uses of chlorine gas.

Summary:

- Chlorine is a non-metal in group VII and period 3 of the periodic table. It is a greenish yellow reactive gas. It is a very poisonous gas.
- It is prepared in the laboratory by a reaction concentrated hydrochloric acid and potassium permanganate.
- Laboratory preparation of chlorine gas



- Chlorine kills bacteria – it is a disinfectant. It is used to treat drinking water and swimming pool water. It is also used to make hundreds of consumer products from paper to paints, and from textiles to insecticides. About 20% of chlorine produced is used to make PVC.

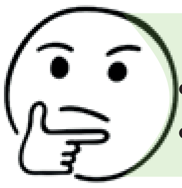
Lesson 2: Reactions of Chlorine

a) with metals

By the end of this lesson, you should be able to:

1. outline the reaction of chlorine with metals and water.
2. write equations for reaction of chlorine with metals and water.

Chlorine gas is a reactive gas, it combines with metallic elements and compounds to form a wide range of useful compounds.



Time to think

- Identify commonly used materials that contain chlorine.
- How are materials made from chlorine?

Let us investigate:

Materials needed:

1. Common table salt
2. bleach solution
3. pen and paper

Procedure:

1. You are now aware that the chemical name of common salt is sodium chloride. How is it formed from its constituent atoms?
2. Write an equation for the formation of table salt.
3. Read the table of contents on bleach solution or powder. What is the chemical name of bleach solution like 'Jik'?

Findings:

- Sodium chloride is derived from chlorine gas and sodium metal.
- Metals react with chlorine to form chlorides, for example sodium chloride.
- How is bleach solution prepared from chlorine and water?
- Bleach solution of hypochlorous acid (HOCl) is the active ingredient in the solution. How is HOCl formed from constituent elements or compounds?

Conclusion:

- Chlorine reacts with metals to form metal chlorides like sodium chloride and iron III chloride.
- Bleach solution is a solution from a reaction of chlorine and water. Its chemical name is hypochlorous acid.

Lesson Summary

- Reaction with water.
  Chlorine is moderately soluble in water; Chlorine is hydrolysed in water to some extent.
  $$Cl_2\,(g) + H_2O\,(l) \longrightarrow HCl\,(aq) + HOCl\,(aq)\ [\text{chloric (I) acid}]$$
  When chlorine water is exposed to sunlight, chloric acid (I) decomposes to liberate oxygen
  $$2HOCl\,(aq) \longrightarrow 2HCl\,(aq) + O_2(g)$$

Further reading

a) Chlorine as breaching agent

Chlorine bleaches a few drops of litmus solution dropped in a jar of chlorine. The bleaching property is due to presence of hypochlorous acid (HOCl) from the reaction of chlorine with water.

$$Cl_2(g) + H_2O(l) \longrightarrow HOCl\,(aq) + HCl(aq)$$

Hypochlorous acid is very reactive compound and readily give up its oxygen to the dye, to form a colourless compound

Coloured dye + HOCl $\longrightarrow$ HCl + colourless dye-O.

b) Reactions with turpentine

When a filter paper dipped in turpentine is dropped into a jar of chlorine; Chlorine and turpentine react violently with a red flash giving of a black cloud of solid particles of carbon and hydrogen chloride.

$$C_{10}H_{16}\,(l) + 8Cl_2(g) \longrightarrow 10C(s) + 16HCl\,(g)$$

c) **Reaction with hydrogen**

Chlorine reacts with hydrogen to form hydrogen chloride gas Chlorine, bromine and iodine combine with many non-metals for example.

$H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$

Follow-up exercise 1

Explain how the reactions of chlorine can be used to manufacture chemical products?

TOPIC: NITROGEN AND ITS COMPOUNDS

Learning Outcomes

By the end of this lesson, you should be able to:

- draw a setup to prepare nitrogen in the laboratory.
- write an equation of reaction for preparation of nitrogen.

Introduction

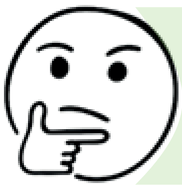
From earlier learning, you now know that nitrogen a chemical element with the symbol N and atomic number 7. The electronic configuration if nitrogen is 2:5. Nitrogen naturally occurs in both free and combined states. It can be available in soil as nitrates formed by bacterial actions or in fertilisers. Nitrogen is a building block for proteins in both plants and animals.

In this topic, you will learn how nitrogen behaves with other substances and how useful products of nitrogen are.

From the electron configuration of nitrogen, can you predict the position of nitrogen in the periodic table?

- To which group and period does it belong?
- Is nitrogen a metal or non-metal?

Nitrogen occurs naturally in the atmosphere as nitrogen gas;



Time to think
- What do you think is the fraction of nitrogen gas in atmospheric air?
- Why is the fraction of atmospheric nitrogen so big as compared to other atmospheric gases?

Lesson 1: Preparation of Nitrogen Gas

Learning Outcome

By the end of this lesson, you should be able to:

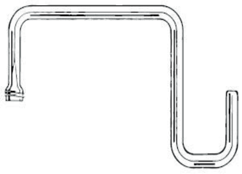
1. describe and explain the laboratory preparation of nitrogen gas.
2. outline the properties of nitrogen.
3. outline the uses of nitrogen gas.

How can a sample of nitrogen be prepared in the laboratory?

Like other gases, nitrogen can as well be prepared in the laboratory. You will easily understand this preparation as you draw the set-up of apparatus used.

Investigation: To draw the laboratory preparation of nitrogen gas

What you will need: reference to laboratory equipment drawings.

Pencil, paper and ruler	Retort stand	Heat source	Gas jar	Round bottomed flask
Reagents; Ammonium chloride, sodium nitrite, water				
	Bee-hive	Trough	Delivery tube	Rubber cork
				

Expectation: Assemble and make a well-drawn and labelled apparatus setup to preparation of nitrogen in the laboratory

Activity:	
▪ Draw a retort stand, on its base place a tripod stand with wire gauze, beneath which stands a Bunsen burner.	
▪ Clamp a round bottomed flask (it contains a mixture of sodium chloride and ammonium chloride) on a retort stand, stopper its top with a thistle (contains water) and a delivery tube plunged through cork.	
▪ Connect the delivery tube through a beehive on which a gas jar is inverted and submerged in water in a trough.	
▪ Label your apparatus and indicate using an arrow how the prepared gas flows though the set-up	

- Follow the link: https://www.youtube.com/watch?v=6mos8zB36TY to watch a video on how to nitrogen can be prepared in the laboratory.

- Write an equation of reaction that leads to the preparation of nitrogen gas using the reagents in video or drawing
- Why is nitrogen collected over water?

Conclusion:

- To prepare pure nitrogen in the laboratory, a mixture of ammonium chloride (NH_4Cl) and sodium nitrite ($NaNO_2$) is heated. The first product that is formed; ammonium nitrite (NH_4NO_2) is unstable it breaks up into nitrogen and water.

Equation of reaction

$$NaNO_2(s) + NH_4Cl(s) \xrightarrow{water} NaCl\,(aq) + NH_4\,(NO_2)\,(aq)$$

Ammonium nitrite

$$NH_4(NO_2)(aq) \longrightarrow N_2(g) + 2H_2O(l)$$

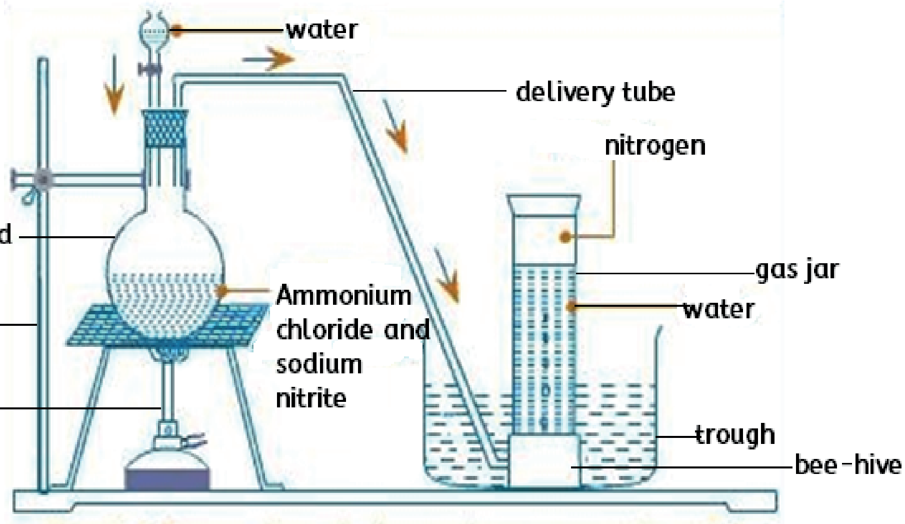
Summary

- Nitrogen is a non-metal in group V and period 2 of the periodic table. It makes a big fraction of about 78.1% of the atmospheric air. It is less reactive because of the triple bond between the nitrogen atoms which is very strong. This makes nitrogen less utilised from atmospheric air hence this big fraction.
- It is prepared in the laboratory by a reaction of ammonium nitrite, water and sodium chloride.

Chemistry Achievers

Daniel Rutherford, a Scottish physician in 1772 was the first to discover and isolate Nitrogen.

- Laboratory preparation of nitrogen gas

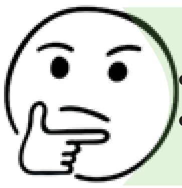


Lesson 2: Reactions of Nitrogen

b) with metals

By the end of this lesson, you should be able to outline the physical properties of nitrogen

Nitrogen gas makes a big percentage of atmospheric air.
How does nitrogen appear physically?



Time to think

- The atmosphere contains nitrogen; why can't you see it in air?
- Which observations can prove that nitrogen gas has reacted with other substances?

Let us investigate:

What you will need:

4. Colourless plastic bag/polythene and a string.

Procedure:

1. Open the polythene bag, then swing it to trap air.
2. Close tightly the polythene bag opening with a string.

Observation

The polythene bag now contains air which is a mixture richer in nitrogen.

- Look through the polythene bag, which colour is the gas inside?
- Slowly release and sniff the trapped gas. How does the gas smell?
- Continue releasing the gas across the tongue. What is the taste of this gas?

Conclusion:

- Since nitrogen in air makes over 78% composition, the air trapped in the polythene is richly nitrogen.
- Nitrogen is a colourless, odourless and tasteless gas.

Follow-up exercise 1

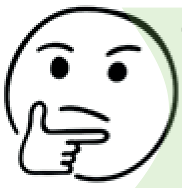
What makes the presence of nitrogen in air quite hard to notice?

Lesson 3: Chemical Reactions of Nitrogen

By the end if this lesson, you should be able to:

- outline the reactions of nitrogen gas.
- write the equations of reaction.

The big fraction of nitrogen by composition in air points at a fact that nitrogen is not very reactive. Due to this less reactivity, a few processes can utilise atmospheric nitrogen.



Time to think

- Why is nitrogen gas less reactive?
- With which substances does nitrogen react?
- What are products of nitrogen reactions?

Activity 1: study the material and investigate

Materials needed:

5. Support picture
6. Pen and paper

Procedure:

Study the picture below:

Observations:

a) Carefully study the picture, write down what you see happening in the picture.

b) Thunder provides heat and light required for nitrogen in the atmosphere to combine with oxygen. What product results from this reaction? Can you write the equation of reaction?

c) The product in b) above combines with rain water forming an acid. Which acid is formed? Can you write the equation of reaction?

d) When nitric acid formed in c) above reaches soil, it is very useful to plants. Which component in acid is useful to plants? How is the component useful to plants?

Conclusion:

Nitrogen reacts with oxygen naturally during rainfall with lightening. Each bolt of lightning carries electrical energy that is powerful enough to break the strong bonds of the nitrogen molecule in the atmosphere. Once split, the nitrogen atoms quickly bond to oxygen in the atmosphere, forming nitrogen dioxide. Along with raindrops, nitric acid is formed which is a source of nitrates in soil.

Activity 2: Visit and investigate

Materials needed:

7. Pen and paper
8. Access to a site with decomposing matter or a place where people frequently urinate like urinal

Procedure:

1. Visit a place where people frequently urinate or animal urine is kept or damping site with decomposing matter. Plan your visit during mid-morning or afternoon.
2. You can alternatively sniff at animal urine.

Observations

- Be sensitive, how does this place or urine smell?
- The chemical composition of the gas you have detected is mainly ammonia (NH_3). Write an equation of reaction that leads to formation of ammonia gas.

Conclusion:

Nitrogen reacts with hydrogen to form ammonia gas. This is a direct combination reaction.

Lesson summary:

Nitrogen is less reactive; however, it can react with oxygen to form nitrogen dioxide and with hydrogen to form ammonia.

Follow-up exercise 1

a) State two physical properties of nitrogen gas
b) With equations, state how nitrogen reacts with
   i) Oxygen
   ii) Hydrogen

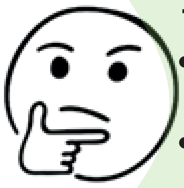
Lesson 4: Separation of Nitrogen from Air

Learning Outcomes

By the end of this lesson, you should be able to:

- outline steps to separate nitrogen in air.
- state the uses of nitrogen.

Can nitrogen be separated from air?



Time to think

- Air is a mixture of gases. How then can nitrogen be separated from the air mixture?
- On what basis can the method of separating nitrogen from air mixture be based?

Let us reflect upon earlier learning;

- Mixtures are not chemically combined. A physical means or method has to be applied.
- Which method would be appropriate for air mixture?
- Methods like filtration, distillation, use of a magnet may not be useful.
- Gases form air, each has a boiling point different from another. How can we use this fact to explore the separation of nitrogen from air?

Let us investigate:

What you will need:

- gases boiling point fact chart
- drawing
- resource document

Procedure:

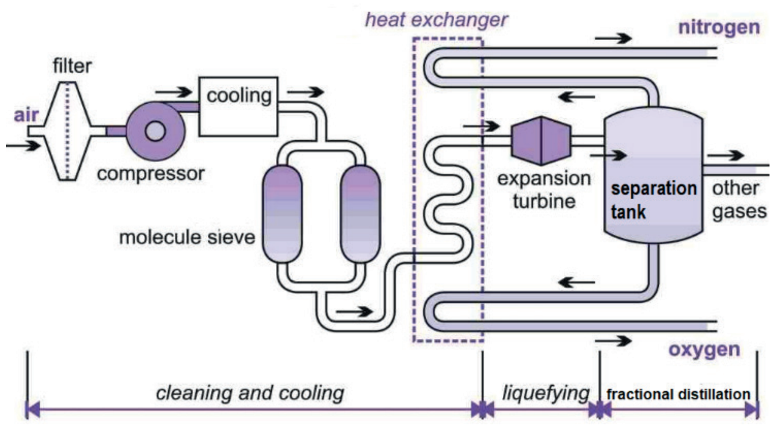
1. Study the fact sheet carefully, taking note of the difference in boiling points of gases in air.
2. How can gases be boiled? Study the resource document as you discover the right method.

Boiling point fact chart

Gas	Boiling point
Nitrogen	-196°C
Argon	-186°C
Oxygen	-183^{0C}
Carbon dioxide	-78°C

Resource document

During air separation, the inlet air must be **filtered**. Filtration ensures that suspended solid in air are removed. Such solids/particles include dust. The clean air is then compressed and chilled to about -185°C, this process allows air to change its state of matter to liquid a process call **liquefication.** The liquefied stream must then be fractional distilled in large fractional distillation towers to separate air into its component phases based on differences in their boiling points.



Nitrogen makes up roughly 78% of the air we breathe. Because nitrogen is inert to most materials, it is widely used to eliminate the risk of fire and explosion, in numerous industrial inerting systems and in pneumatic conveying operations. Nitrogen is also being increasingly used to improve oil and gas recovery. A nitrogen atmosphere is also used in packaging technology to protect food and other perishable products from atmospheric contamination. Liquid nitrogen is used for food freezing, process cooling, and other materials.

Observations:

- What is the difference in boiling points of gases as compared to nitrogen gas?
- Why is the air mixture filtered, compressed and cooled during the process of separating nitrogen gas?
- What is the scientific logic behind separation of nitrogen from air?

Conclusion:

- So, how do you separate nitrogen from air? By a process called fractional distillation of liquid air to produce nitrogen. In simple terms, a four-step process is used: filter the air, compress and cool it, fractional distil the liquefied air, isolate the nitrogen and then collect it.

Follow-up exercise 1

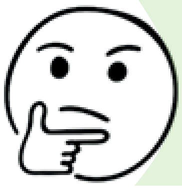
- Briefly describe how to separate nitrogen from air, include a scheme (not a diagram).
- State two uses of nitrogen gas

Lesson 5: Ammonia

Learning Outcome

By the end of this lesson, you should be able to explain and draw the preparation of ammonia in the laboratory.

Ammonia, is composed of nitrogen and hydrogen atoms and has a chemical formula NH_3. The colourless gas has a distinct odour. It is produced naturally in the human body and in nature—in water, soil and air, even in tiny bacteria molecules.



Time to think

- How can we prepare ammonia gas in the laboratory?
- Which apparatus and reagents are required for this preparation?
- Which method of gas collection is best for this gas?

Let us investigate:

Laboratory preparation of a dry sample of ammonia gas.

Materials needed:

- Heat source,
- calcium hydroxide
- ammonium chloride
- round bottomed flask
- delivery tube
- cardboard
- gas jar
- drying tower bottle and a retort stand
- Pen and paper

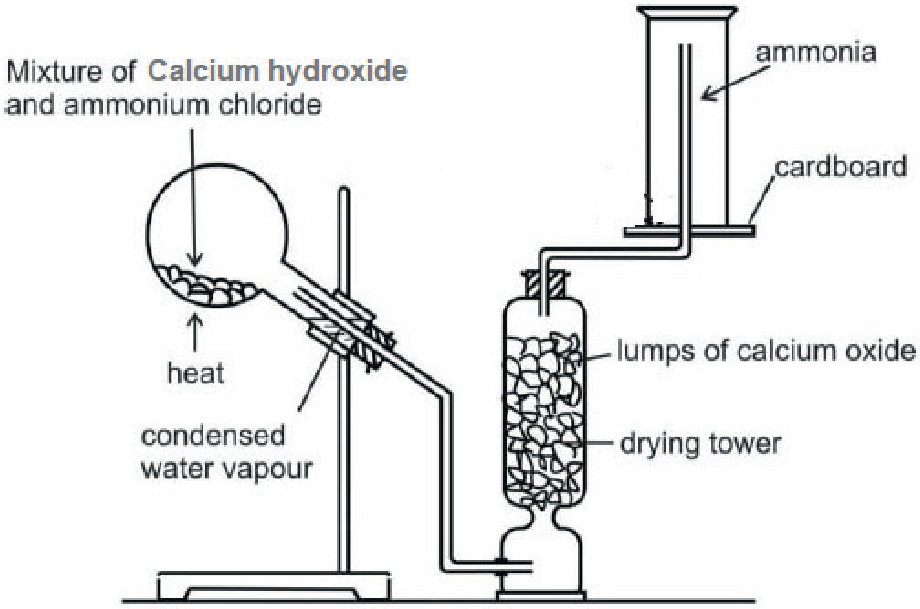
Procedure

1. Draw a clumped and slightly tilted round bottomed flask containing calcium hydroxide and ammonium chloride mixture onto a retort stand
2. Draw a heat source beneath the flask.
3. Draw a connection of a delivery tube from the flask to a drying tower filled with calcium oxide.
4. Connect the upper end of the drying tower to a delivery tube linking it to an inverted gas jar covered with a card board above the tower with a delivery tube.
5. Label all the apparatus drawn.

Observations:

- Why is the gas passed through calcium oxide?
- Which method of gas collection is used and why?
- Write the chemical equation of reaction.

Conclusion:



Summary:

Ammonia gas is usually prepared in the laboratory by gently heating ammonium chloride (NH_4Cl) and calcium hydroxide/slaked lime [$Ca(OH)_2$]. NH_3 is prepared in the laboratory by heating an ammonium salt with NaOH. Calcium hydroxide is used to dry the gas. Ammonia is collected by upward delivery method.

Equation of reaction:

$$2NH_4Cl(s) + Ca(OH)_2(aq) \longrightarrow CaCl_2(aq) + 2NH_3(g) + 2H_2O(l)$$

Follow-up exercise 1

- Briefly describe how to ammonia in the laboratory, diagram not required.
- Write the equation of reaction

Lesson 6: Industrial manufacture of ammonia gas

Learning Outcome

By the end of this lesson, you should be able to:

- describe how ammonia is manufactured industrially by haber process
- list the uses of ammonia

The Haber process, also called the Haber–Bosch process, is an artificial nitrogen fixation process and is the main industrial procedure for the production of ammonia today. The process combines nitrogen from the air with hydrogen derived mainly from natural gas (methane) into ammonia. The reaction is reversible and exothermic. The catalyst used is iron.

Time to think

- How can large quantities of ammonia be prepared?
- Of what use is ammonia gas?

Let us investigate:

What you will need:

- Resource document
- Drawing

Procedure:

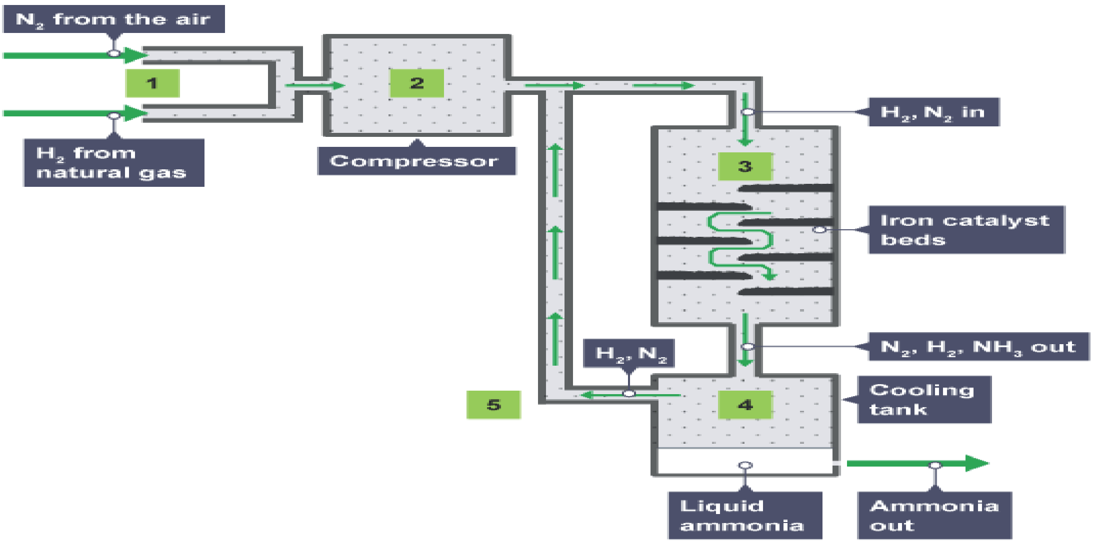
Study the resource material/document carefully.

Resource document

The Haber process

Ammonia is an important industrial product used to make fertilisers, explosives and dyes. It is manufactured using the Haber process. This involves a reversible reaction between nitrogen and hydrogen: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The main stages in the Haber process



In the Haber process:

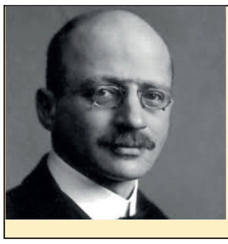
a) nitrogen (extracted from the air) and hydrogen (obtained from natural gas) are pumped through pipes

b) the pressure of the mixture of gases is increased to 200 atmospheres

c) the pressurised gases are heated to 450°C and passed through a tank containing an iron catalyst

d) the reaction mixture is cooled so that ammonia liquefies and can be removed

e) unreacted nitrogen and hydrogen are recycled



The Haber process was developed by a German chemist **Fritz Haber**

Summary:

- In the Haber process: nitrogen (extracted from the air) and hydrogen (obtained from natural gas) are pumped through pipes. The pressure of the mixture of gases is increased to 200 atmospheres. The pressurised gases are heated to 450°C and passed through a tank containing an iron catalyst.
- The Haber process is still important today because it produces ammonia, which is needed for fertilizer and for many other purposes.

Follow-up exercise

- Develop a scheme diagram for the Haber process
- State the condition for the Haber process.

TOPIC: SULPHUR AND ITS COMPOUNDS

Introduction:

Sulphur is a chemical element with the symbol S and atomic number 16. It is abundant, multivalent, and non-metallic. Elemental sulphur is a bright yellow, crystalline solid at room temperature. In nature it occurs as the pure element or as sulphide and sulphate minerals. In this topic, you will learn how sulphur reacts with other substances and how useful products of sulphur are.

From the electron configuration of sulphur, can you predict the position of sulphur in the periodic table?

- To which group and period does sulphur belong?
- Is sulphur a metal or non-metal? Explain your answer.

Lesson 1: Extraction and Allotropes of Sulphur

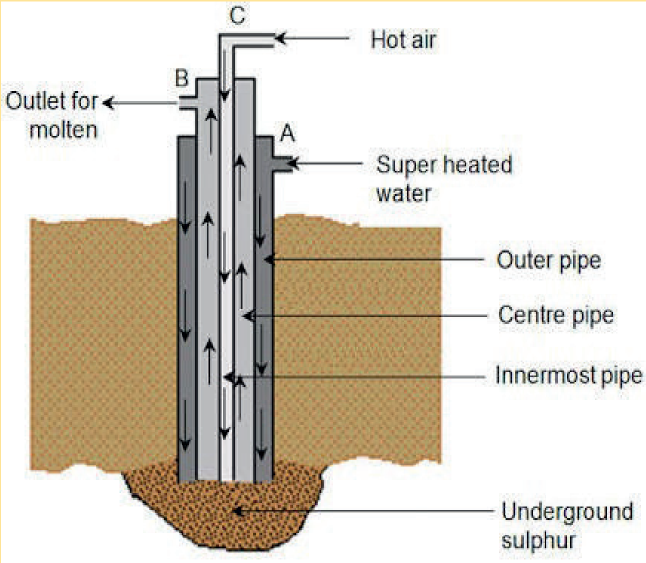
By the end of this lesson, you should be able to:

1. draw a setup to extract sulphur.
2. outline preparation of allotropes of sulphur.
3. give differences between the allotropes of sulphur.

Where does sulphur come from?

Sulphur is obtained from underground deposits by the Frasch process. Follow the link and watch this video https://www.youtube.com/watch?v=yVuyXxsmdUI or read the resource document below;

Extraction of sulphur by Frasch process



Elemental sulphur comes from deposits in the ground. Sulphur has two physical properties that are used in the extraction process. ***Those are low melting point and low density.*** *The extraction process is called The Frasch process. There are basically seven steps to how it works. The steps aren't very complicated.*

Starting out, a well is drilled into the soil for mineral deposit. After the well is drilled, superheated water is pumped into the deposit. This superheated water is usually heated to around 170 ℃, which is about 340 ℉. That water is pumped down into the deposit. The hot water melts the sulphur in the deposit. Because sulphur has a ***low melting point,*** *this allows for the water to easily melt sulphur. Although sulphur is now melted, it is still down in the deposit. In addition to superheated water being pumped into the well, compressed air is pumped down into the well. It is because of that compressed air; the molten sulphur comes to the surface.*

The second physical property of low density allows compressed air to be able to push sulphur to the surface. When the molten sulphur is at the surface, it cools and solidifies then driven away for further processes. This is the ***Frasch process****.*

Time to think

- What are the main steps in the extraction of sulphur?
- Why is hot air important in the process?

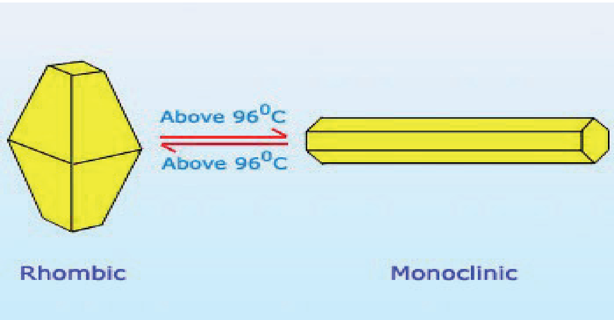
Allotropes of sulphur:

Allotropy or allotropism is the property of some chemical elements to exist in two or more different forms, in the same physical state, known as allotropes of the elements.

A lot of ointments contain sulphur. However, are you aware "which" sulphur it is talking about? Did you know that there is more than one type of sulphur, even if you don't see it on the periodic table? They are the allotropic forms of sulphur. So, what are these allotropic forms exactly? Sulphur has two main forms; crystalline sulphur and amorphous sulphur.

Crystalline forms include; rhombic and monoclinic sulphur. Let us read about their types, properties and uses.

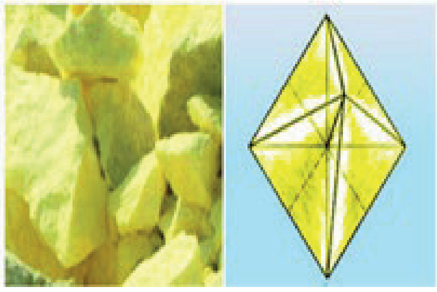
Appearance of the allotropes



- Carefully study the two crystalline forms of sulphur,
- In a table, write three difference between the two forms of sulphur.

How are the two allotropes obtained from sulphur?

Read the resource materials below;



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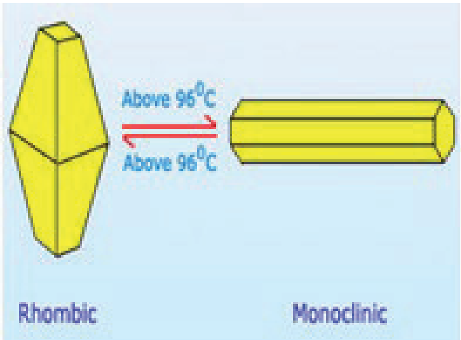


Rhombic sulphur is a crystalline allotropic form of sulphur. This is the most stable variety of sulphur. All other varieties of sulphur eventually revert to rhombic form on standing.

Preparation

Rhombic sulphur is prepared by dissolving powdered sulphur in carbon disulphide at room temperature. The mixture is then filtered. The filtrate is then kept in a small beaker covered with a filter paper. The carbon disulphide will slowly evaporate away leaving behind large octahedral crystals of rhombic sulphur (or α-sulphur).

Properties

- It exists as rhombic crystals
- Its density is 2.06g/mL
- It melts at 112.8°C
- When slowly heated to 96°C, it changes into monoclinic or β-sulphur. However, when cooled below 96°C, it returns to rhombic form.
- It is insoluble in water and soluble in carbon disulphide.

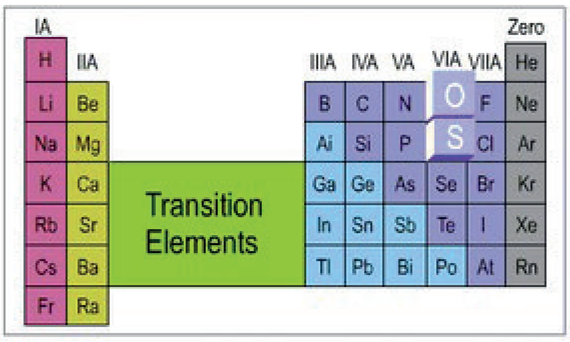
Monoclinic sulphur is a crystalline allotrope of sulphur obtained when rhombic sulphur is heated to 94.5°C. this form is stable only above 96°C. when left at room temperature, it reverts back to rhombic form. It has S_8 ring molecules in crystalline structure.

Preparation

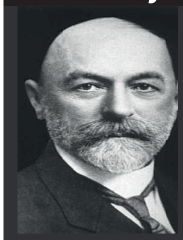
Sulphur is heated in an evaporating (porcelain) dish till it melts. The molten sulphur is then allowed to cool slowly. During the cooling process, a solid crust will be formed over the surface. As this crust is being formed, two holes are made in the crust. The molten sulphur is then poured out of these holes. The crust is then removed. On the lower side of the crust, long needle-shaped crystals of monoclinic sulphur are formed.

Summary:

- Sulphur is a chemical element having atomic number 16. It is easily accessible at room temperature. It is basically a splendid yellow crystalline solid. Sulphur is a non-metal, the position of Sulphur in the periodic table is as follows:



Chemistry Achievers



American chemist Herman Frasch, invented and named after the Frasch process used to extract sulphur.

- Sulphur exists in a number of structures in the same physical state. However, the most important crystalline structures are rhombic or octahedral (α – sulphur), and monoclinic sulphur (β – sulphur). Rhombic sulphur is stable at a temperature below 96°C while monoclinic sulphur occurs at a temperature over 96°C.

Follow-up exercise:

1. *Describe how sulphur can be extracted from sulphur deposits beneath the ground.*
2. *Compare the crystalline forms of sulphur.*

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