DEPARTMENT OF EDUCATION

GRADE 11

CHEMISTRY

MODULE 5

METALS AND NON-METALS

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GRADE 11

CHEMISTRY

MODULE 5

METALS AND NON-METALS

IN THIS MODULE YOU WILL LEARN ABOUT:

11.5.1: PROPERTIES OF METALS, METALLOIDS AND NON-METALS

11.5.2: HYDROGEN, NITROGEN AND NITROGEN COMPOUNDS

11.5.3: SULPHUR AND SULPHUR COMPOUNDS

11.5.4: PHOSPHOROUS AND PHOSPHATE FERTILISERS

11.5.5: CHEMISTRY OF HALOGENS

Acknowledgement

We acknowledge the contributions of all secondary teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

Special thanks to the staff of the Science Department of FODE who played active roles in coordinating writing workshops, outsourcing lesson writing and the editing processes involving selected teachers of Central Province and NCD.

We also acknowledge the professional guidance provided by Curriculum and Development Assessment Division throughout the processes of writing and the services given by members of the Science Review and Academic Committees.

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DIANA TEIT AKIS
PRINCIPAL

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Papua New Guinea

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 -2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

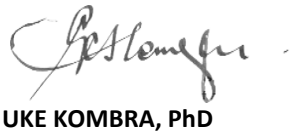
Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system that satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced through this course to provide alternative and comparable pathways for students and adults to complete their education through a one system, two pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all the teachers, curriculum writers and instructional designers who have contributed towards the development of this course.



UKE KOMBRA, PhD
Secretary for Education

MODULE 5: METALS AND NON-METALS

Introduction

In Module 11.2 on chemical and metallic bonding, you have learnt about the Periodic Table. Some important ideas you should have learnt from the Periodic Table are symbols and names of different elements, the kind of information represented by period and group numbers, and how to work out the atomic numbers and masses of the elements. These different elements you have learnt in the Periodic Table fall into two main groups, the metals and non-metals.

In this module, you will learn more about metals and non-metals. The following topics are: Physical and Chemical Properties of Metals and Non-Metals, Metalloids, Corrosion, Metal Alloys and their uses. You will look at some of the common examples of metals and non-metals such as Hydrogen, Nitrogen, Sulphur and Phosphorus.

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Learning Outcomes

After going through this module, you are expected to:

- demonstrate an understanding of the physical and chemical properties of metals and non-metals using the concept of chemical bonding.
- demonstrate an understanding of the uses of metals and metal alloys.
- explain the chemistry of nitrogen and some of its compounds.
- explain the chemistry of sulphur and some of its compounds.
- explain the chemistry of phosphorus and some of its compounds.
- explain the chemical and physical properties of halogens.

Time Frame

Suggested allotment time: **10 weeks**

This module should be completed within 10 weeks.

If you set an average of 3 hours per day, you should complete the module comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular exercise right in the first attempt, you should not get discouraged, but instead, go back and attempt it again. If you still do not get

it right after several attempts then you should seek help from your friend or even your tutor.

DO NOT LEAVE ANY QUESTION UN-ANSWERED.

Terminologies

Before you get into the thick of things, let us make sure you know some of the terminologies that are used throughout this module.

Acidic oxides	When non-metals react with oxygen, they form non-metal oxides. When these oxides are dissolve in water they become acids reacting with oxygen.
Anion	Gain electrons during a reaction and form negative ion.
Alloy	Is a mixture of metals with one or more of other elements.
Basic oxides	When metals react with oxygen, the metal oxides are formed. These oxides dissolve in water forming basic solutions, when reacting with oxygen.
Cation	Lose electrons during a reaction and form positive ions.
Corrosion	refers to a process whereby a metal is broken down (corroded) by reacting with air and water.
F**ertiliser**	Is any substance added to the soil. It helps the crops to grow well.
Nitrogen-fixing bacteria	Some bacteria can also convert nitrogen to nitrates.
Nitrogen Cycle	Nitrogen continually circulates between the air, the soil and living things in a set of processes.
Ostwald process	A lot of the ammonia produced from the Haber process is used to make nitric acid. The basic materials needed to make nitric acid are ammonia, air, and water. This is the process to form nitric acid.

11.5.1 Properties of Metals, Metalloids and Non-Metals

To learn more about a substance, you have to know how it looks like, its size, what is it made of and is it heavy or not and the list goes on. The information that you have about a substance makes up what is called **properties** of the substance.

Knowing the properties of a substance is important because it makes you aware of the substance when dealing with it. All substances do not have the same properties. However, the properties can be put into two groups, **physical** and **chemical** properties.

The appearance, size, hardness, heaviness, melting and boiling points and ability to conduct heat and electric current make up the physical properties of a substance. The chemical property of a substance is how the substance behaves when reacting with other substances.

Physical Properties of Metals

- most metals are solid (except mercury, which is the only metal in liquid state).
- hard (strong) and shiny in appearance.
- malleable (can be hammered or bent into shapes without breaking).
- ductile (can be stretched into wires).
- sonorous (make a ringing noise when they are struck. For example, church's bell).
- have high density means they feel heavy.
- have high melting point and high boiling point means metals need large amount of heat to make them melt or boil.
- can conduct heat and electricity (good conductors of heat and electricity). They allow heat and electric current to travel through them.

Chemical Properties of Metals

- lose electrons during a reaction and form positive ions called **cation**.
- form **basic oxides** when reacting with oxygen. That means, when metals react with oxygen, the metal oxides are formed. These oxides dissolve in water forming basic solutions.

  Example:

  Metal + Oxygen ⟶ Metal oxide

  Magnesium + Oxygen ⟶ Magnesium oxide

  $Mg_{(s)} + O_{2(g)} \longrightarrow MgO_{(s)}$

  Magnesium oxide + water ⟶ Magnesium hydroxide

  $MgO_{(s)} + H_2O_{(l)} \longrightarrow Mg(OH)_{2(aq)}$

- react with acids to form Metal salt and Hydrogen gas.

  Example:

  Metal + Acid ⟶ Metal salt + Hydrogen gas

  Magnesium + Hydrochloric acid ⟶ Magnesium chloride + Hydrogen gas

  $Mg_{(s)} + HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

All metal oxides are bases.

Physical Properties of Non-metals

- liquids and gases in nature
- soft
- non-malleable and non-ductile
- poor conductors of heat and electricity. They do not allow heat or electric current to travel through them.
- non-sonorous. They do not produce sound when you strike them.
- have low melting and low boiling points.

Chemical Properties of Non-metals

- gain electrons during a reaction and form negative ion called **anion**
- not reactive with dilute acids
- reacting with oxygen to form **acidic oxides**. This mean, when non-metals react with oxygen, form non-metal oxides. When these oxides are dissolve in water they become acids.

$$\text{Non-Metal} + \text{Oxygen} \longrightarrow \text{Non-Metal oxide}$$

Example:

$$\text{Sulphur} + \text{Oxygen} \longrightarrow \text{Sulphur dioxide}$$
$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$$

$$\text{Sulphur dioxide} + \text{Water} \longrightarrow \text{Sulphurous acid}$$
$$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)}$$

Exceptions to the properties

The properties we have looked at so far are basically the general properties of metals and non-metals. We can use them to differentiate between these two groups of elements.

The following are the exceptions:

- not all metals are hard solids. Metals in Group I such as sodium and potassium arevery soft and you can cut them with a knife.
- hydrogen is a non-metal, but forms positive ions (H^+) like metals do.
- carbon is a non-metal, that can conduct electric current in the form of graphite.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 1

30 minutes

Answer the following questions:

1. Below is a list of different elements.

sodium, aluminium, sulphur, copper, oxygen, chlorine, hydrogen, magnesium, mercury

a) Group the above elements into two: (i) conduct heat and (ii) do not conduct heat.

Elements that conduct heat	Elements that conduct heat

b) Which of these elements will lose their electrons in a chemical reaction?

_____

c) Which of these elements will gain electrons in a chemical reaction?

_____

d) Name the element from the list that is a metal in liquid form.

_____

2. Define the following:

(i) Ductile

_____

(ii) Sonorous

_____

(iii) Malleable

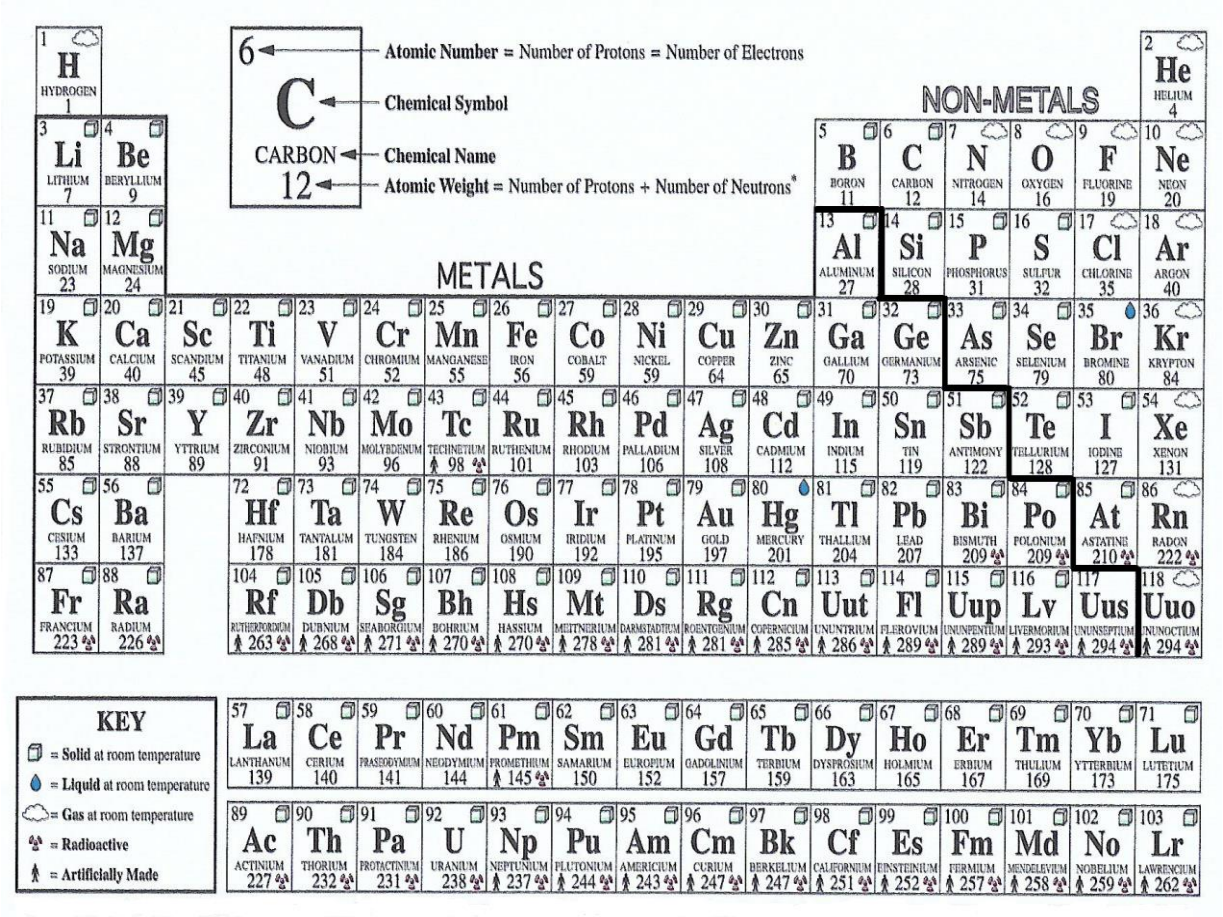
_____

Thank you for completing your learning activity 1. Check your work. Answers are at the end of this module.

The Properties of Metalloids

Metalloids are group of elements in the Periodic Table. They have some properties in common with metals and some in common with non-metals. They are sometimes called **semi-metals**.

Periodic Table of Elements



Which elements are metalloids?

The elements that are generally considered metalloids are: boron (B), silicon (Si), germanium (Ge), Arsenic (As), antimony (Sb), selenium (Se), Tellurium (Te), and polonium (Po).

Properties of Metalloids are:

- brittle like metal.
- forming alloys with metals.
- some conduct electricity under special conditions such as silicon (Si) and Germanium (Ge).
- solid under their normal conditions.
- behaving like non-metals in reactions.

The most abundant metalloid on Earth is **silicon** and the least abundant is **tellurium**.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 2

30 minutes

Answer the following questions:

1. Define metalloid

   _____

2. What is the other name for metalloids?

   _____

3. List down the names and symbols of all metalloids in the periodic table.
   (i) _____
   (ii) _____
   (iii) _____
   (iv) _____
   (v) _____
   (vi) _____
   (vii) _____
   (viii) _____

4. Which metalloids are regarded as semi-conductors? Why are they called semi-conductors?

   _____

Thank you for completing your learning activity 2. Check your work. Answers are at the end of this module.

Corrosion

Have you ever wondered why a piece of metal left out open begin to rust? Not all metals will stay longer. As years go by, the metals will start to peel off and eventually disappear. When this happens, it is said that metals have corroded. **Corrosion** refers to a process whereby a metal is broken down (corroded) by reacting with air and water.

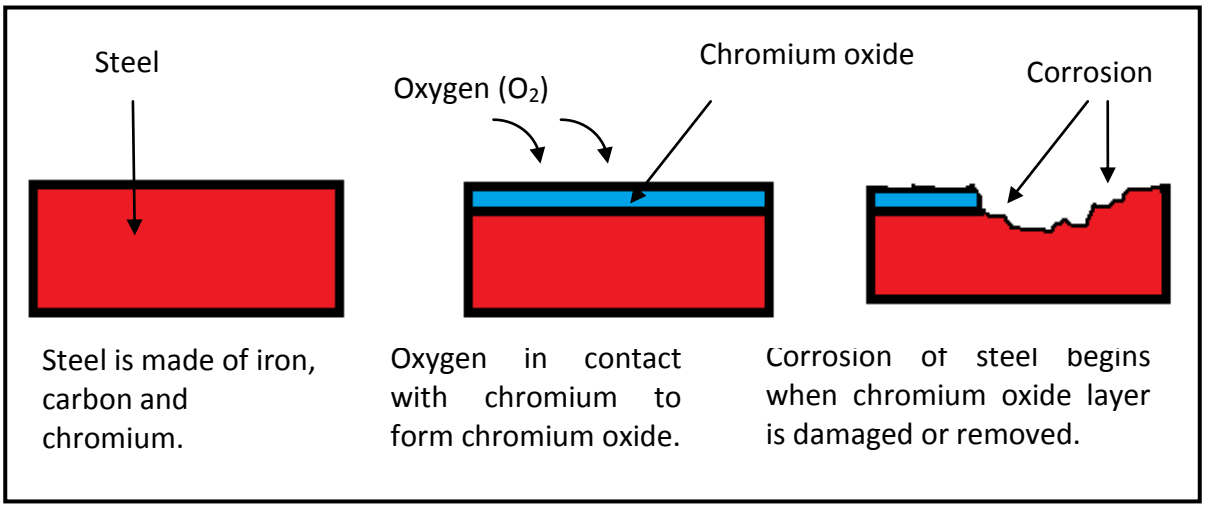
Corrosion of iron and steel

The corrosion of iron and steel is called **rusting**. When an object made of iron or steel is exposed to moist air for some time, a reddish-brown substance slowly forms on the surface of the metal. This substance is called rust and has the chemical name, **hydrated iron (III) oxide.**

Corrosion of Steel

Steel is an alloy of iron, carbon and chromium. It is chromium in the steel that gives it the property to resist corrosion. When steel comes in contact with oxygen, a chromium oxide layer is formed on the surface of the material. This layer protects steel from corroding. However, if this protective layer is damaged, the steel will begin to corrode.

The diagram below shows corrosion of steel.



Corrosion of iron

Following is a simple experiment you can do to investigate rusting of iron.

Title : Rusting of iron

Aim : Is to identify factors that cause iron to rust.

Methods :

1. Stand three identical nails in three test-tubes or bottles (if no test-tubes).
2. Now prepare the test-tubes as shown on the next page, so that:
   - Test-tube 1 contains dry air.
   - Test-tube 2 contains water but no air.
   - Test-tube 3 has both air and water.
3. Leave the test-tubes to one side for 1 week.

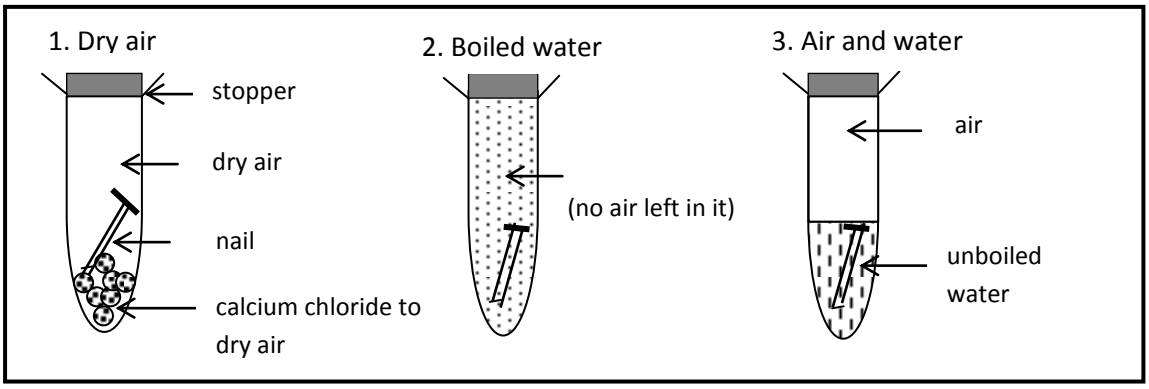


Diagram showing corrosion of iron.

Result : After 1 week, the nails in test-tubes 1 and 2 show no signs of rusting. The nail in test-tube 3 has rust on it. This is because rusting requires oxygen and water.

Conclusion : Rusting of iron happens when iron comes in contact with water and oxygen.

Methods of preventing rusting

Iron is the most widely used metal in the world. Factors affecting corrosion are **O_2 and H_2O**. Rusting destroys things.

The common methods to prevent rusting are:

- painting
- oiling or greasing
- plastic coating
- galvanizing, means coating of iron or steel with zinc metal
- tin-plating. That is iron or steel is coated with tin metal
- sacrificial protection, means coating a more reactive metal to iron or steel so that the re-active metal will corrode instead of iron or steel. That is more reactive metal is sacrificed to protect iron or steel
- using alloys

Painting, oil or greasing and plastic coatings are very common methods of preventing rust in Papua New Guinea.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 3

30 minutes

Answer the following questions:

1. What is corrosion?

   _____

2. Name the two main substances that cause the corrosion of iron.

   (i) _____

   (ii) _____

3. Which two methods of preventing corrosion are commonly practiced here in Papua New Guinea in the rural areas?

   _____

4. Explain the difference between galvanizing and tin-plating.

   _____

5. How is sacrificial protection done to prevent iron from rusting?

   _____

Thank you for completing your learning activity 3. Check your work. Answers are at the end of this module.

Metal Alloys and Their Uses

Pure metals have many useful properties. They are not, however, widely used. Many pure metals are soft. They react with air and water and corrode easily. For this reason, most substances made from metals used nowadays are **alloys**.

What is an alloy?

An **alloy** is a mixture of metals with one or more of other elements. For example, the alloy bronze is a mixture of copper and tin.

Alloys are made by mixing the molten elements (metals or non- metals and carbon) in the right proportion and allowing them to cool down and become solid.

Why are metals often used in the form of alloys?

1. Metals are made harder and stronger by alloying them with other elements. For example, brass is harder and stronger than its components.

2. Alloying is used to improve the appearance of the metal. For example, Pewter is an alloy of tin, antimony, and copper. It is used to make ornaments and souvenir because it looks more beautiful than pure tin.

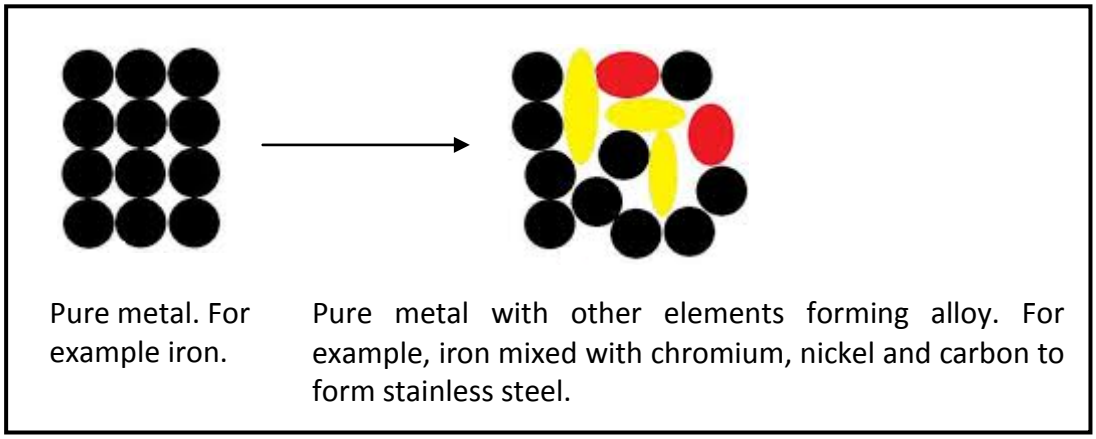
3. Alloying is used to lower the melting points of metals. Solder is an alloy of tin and lead. It has a lower melting point than pure tin or pure lead and is used to join metals.

4. Alloys are more resistant to corrosion than pure metals. For example, pure copper corrodes easily. This is why an alloy of copper is used to make coins instead.

Alloy	Composition	Special properties	Some uses
Bronze	copper (90%) tin (10%)	strong and does not corrode easily	castings and machine parts
Brass	copper (65%) zinc (35%)	does not corrode easily and attractive yellow colour like gold	jewellery, musical instruments and coins
Pewter	tin (95%) antimony (3.5%) copper (50%)	bright and shiny colour like silver	jewellery and decorative ornaments
Solder	tin (50%) lead (50%)	low melting point	joining metal pipes
Stainless steel	iron (73%) chromium (18%) nickel (8%) carbon (1%)	resistant to corrosion	cutlery, utensils, medical instruments and pipe in chemical industries

Examples of alloys, their composition, properties and uses

Note: The percentage composition of metals used to make each alloy may vary.



Pure metal. For example iron.

Pure metal with other elements forming alloy. For example, iron mixed with chromium, nickel and carbon to form stainless steel.

Diagram showing arrangement of particles in an alloy.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 4 **30 minutes**

Answer the following questions:

1. Define alloy

   _____

2. How are alloys formed?

   _____

3. Why alloys are used nowadays than pure metals?

   _____

4. Name the alloy that is used for:

   a. joining metal pipes _____

   b. making musical instruments like flute _____

   c. machine parts _____

5. Why is brass used to make coins instead of pure copper?

   _____

Thank you for completing your learning activity 4. Check your work. Answers are at the end of this module.

11.5.2 Hydrogen, Nitrogen and Nitrogen Compounds

Hydrogen

Hydrogen is a gas. It is the lightest of all the elements. It is so light that there is none in the air because it has escaped from the Earth's atmosphere.
Out in space, it is the most common element in the universe. Inside the sun, hydrogen atoms fuse (collide) to form helium atoms. When this happens, energy is given out. This is the energy that comes from the sun in the form of heat and light that we now enjoy on Earth.

Properties of hydrogen

- It is the lightest of all gases.
- It is colourless and has no smell (odourless).
- It combines with oxygen to form water.
  $2H_{2\,(g)} + O_{2\,(g)} \longrightarrow 2H_2O\,(l)$
- It is a reducing agent. This means, hydrogen lose electrons in a reaction.

Uses of hydrogen

- as a fuel in fuel cells
- to produce margarine by the hydrogenation of vegetable oils
- to produce organic compounds such as methanol (CH_3OH)

Hydrogen is used as fuel in vehicles.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 5 **30 minutes**

Answer the following questions:

1. Which gas does hydrogen combine with to produce water?
   _____

2. List down the common uses of hydrogen gas.
   a. _____
   b. _____
   c. _____

3. Write True or False for the following statements:
   a) Hydrogen has smell _____
   b) Hydrogen is heavier than Oxygen _____
   c) Hydrogen is used as fuel in fuel cells _____

Thank you for completing your learning activity 5. Check your work. Answers are at the end of this module.

Nitrogen

Nitrogen is a gas. It makes up 78% of the air. You breathe it in and breathe it out again unchanged. Nitrogen is important to living things, including humans because it forms protein. Our bodies use protein to build muscles, bones, skin, hairs, blood, and other tissues.

Nitrogen is being used as fertilizers by

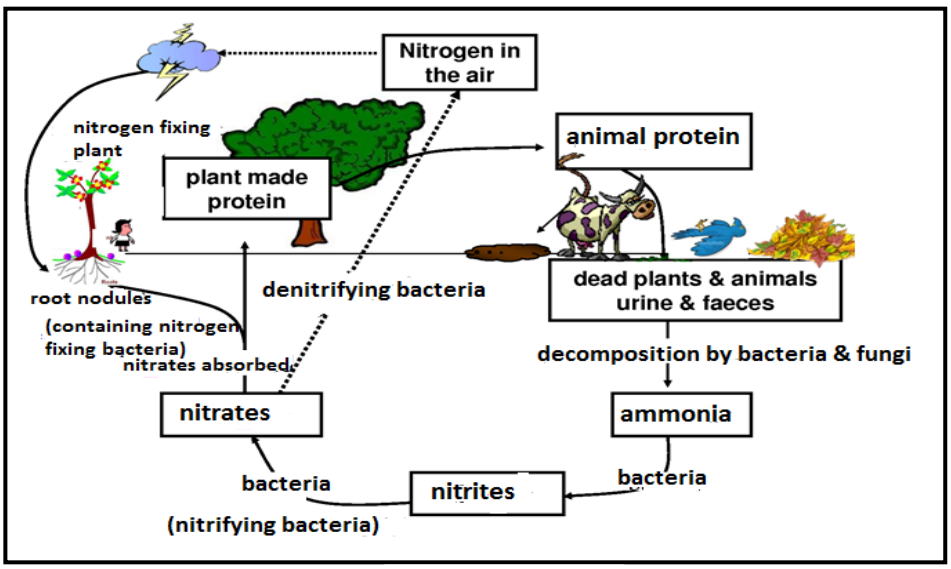
Uses and properties of nitrogen

- It is a gas with no smell
- It is slightly soluble in water
- It is unreactive compared to oxygen
- It reacts with hydrogen to form ammonia

  $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$
- Nitrogen also combines with oxygen at high temperatures to form oxides like nitrogen monoxide (NO) and nitrogen dioxide(NO_2). The main use of nitrogen is in the manufacture of ammonia, nitric acid, and fertilisers.

Nitrogen Cycle

Nitrogen continually circulates between the air, the soil and living things in a set of processes called the **Nitrogen Cycle**.



Nitrogen Cycle

Let us look more closely at the parts of the Nitrogen Cycle.

1. The changing of nitrogen from air to nitrates in the soil. This happens in three different ways:
   a) In the heat of lightning flash, nitrogen and oxygen react to form nitrogen oxides. These dissolve in rain water to form acid rain, which reacts with compounds in soil to make nitrates.
   b) Some bacteria can also convert nitrogen to nitrates. They are called **nitrogen-fixing bacteria**. They live in soil or in swellings called **root nodules** on roots of legume plants like beans and peanuts.
   c) Man turns nitrogen into fertilisers in factories. These are compounds such as ammonium nitrate and ammonium phosphate. Farmers spread them on soil.
2. From **nitrates to protein**, plants take in nitrogen in the form of nitrates through their roots to make protein.
3. From **plants to animals**, animals obtain their protein by eating plants or other animals that feed on plants.
4. Excretion and decay, animals release wastes that contain ammonium compounds. Bacteria also feed on the remains of dead plants and animals, producing ammonium compounds. These are converted to nitrates by **nitrifying bacteria**.
5. From nitrates back to nitrogen, bacteria called denitrifying bacteria complete the cycle. They live in heavy, wet soils. They break down nitrates, releasing nitrogen back into the air.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 6

30 minutes

Answer the following questions:

1. Why do plants need nitrogen?

   _____

2. How do animals get their protein?

   _____

3. Name the compound formed when nitrogen reacts with hydrogen.

   _____

4. What is the function of each of the following bacteria in the Nitrogen Cycle?
   a) Nitrogen-fixing bacteria

      _____

   b) Nitrifying bacteria

      _____

   c) Denitrifying bacteria

      _____

5. Which bacteria live in root nodules of legume plants?

   _____

Thank you for completing your learning activity 6. Check your work. Answers are at the end of this module.

Ammonia

Ammonia is a nitrogen compound. It is a gas with the formula **NH_3**.It is a very important compound because it is used to make fertilisers. It is produced in industries by reacting nitrogen and hydrogen. The reaction is **reversible**.

$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)}$$

Physical properties of ammonia

- It is a colourless gas with a strong, choking smell.
- It is less dense (lighter) than air.
- It is very soluble in water. It easily dissolves in water.

Chemical properties of ammonia

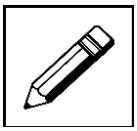
- It reacts with hydrogen chloride gas (HCl) to form a white smoke. The smoke consists of tiny particles of solid ammonium chloride, $NH_{3\,(g)} + HCl_{\,(g)} \longrightarrow NH_4Cl_{\,(s)}$
- Ammonia(NH_3) is a base (turned litmus paper blue) which dissolved in water (H_2O) and form NH_3 solute called NH_4OH
- Since ammonia solution is alkaline, it reacts with acids to form salts. For example with nitric acid it forms ammonium nitrate, $NH_{3(q)} + HNO_{3\,(aq)} \longrightarrow NH_4NO_{3\,(aq)}$

Uses of ammonia

Ammonia is used in the manufacture of:

- fertilisers such as ammonium nitrate and ammonium sulphate
- household cleaning agents
- lyes
- explosives
- nylon
- nitric acid

Now, check what you have just learnt by trying out the learning activity below!



Learning Activity 7

30 minutes

Answer the following questions.

1. Write a balanced chemical equation for the formation of ammonia.
   _____

2. A solution of ammonia is alkaline. Why?
   _____
   _____

3. Name the compound that is use to show that ammonia gas is presence.
   _____

4. Write the formula of the acid that reacts with ammonia (NH_3) to form ammonium nitrate (NH_4NO_3?
   _____

Thank you for completing your learning activity 7. Check your work. Answers are at the end of this module.

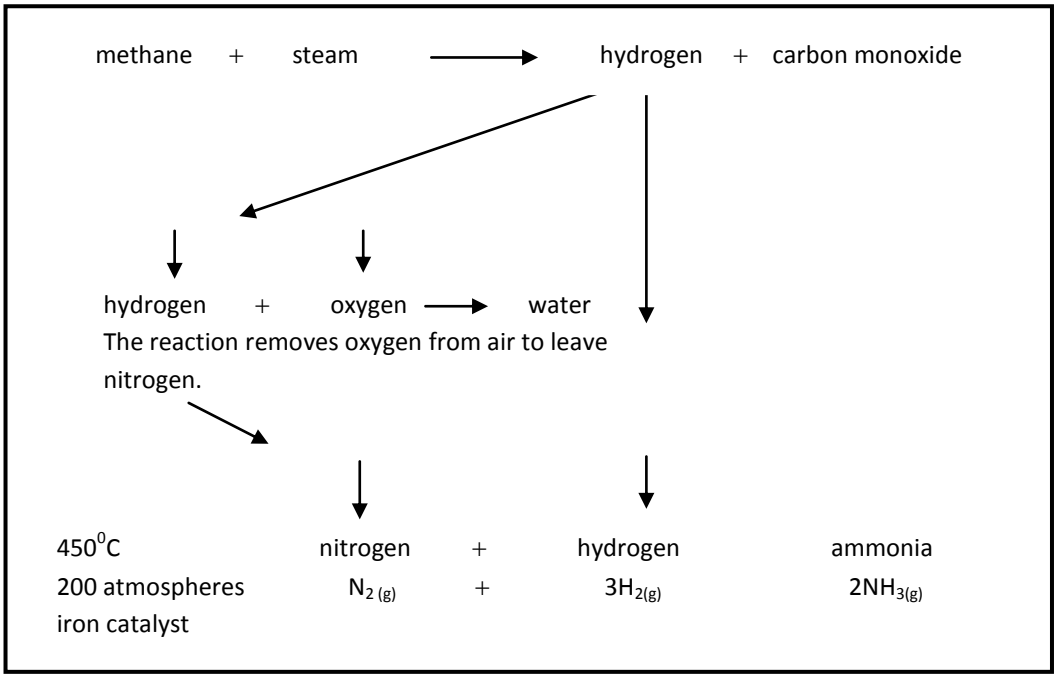
The Haber Process

The raw materials for Haber process are hydrogen and nitrogen. Hydrogen is obtained by reacting natural gas (methane) with steam or through breaking down of crude oil. Nitrogen is obtained by burning hydrogen in air. Air is mixture 80% nitrogen, nearly all the rest is oxygen. When hydrogen is burned in air, the oxygen combines with the hydrogen, leaving nitrogen behind.

Nitrogen and hydrogen will react together under these conditions:

- a high temperature(450 ^{0}C)
- a high pressure(200 atmospheres)
- an iron catalyst

The flow chart shows the main stages in the Haber process. Reaction is reversible and some nitrogen and hydrogen remain mixed with the ammonia. The reaction mixture is cooled so that the ammonia turns in liquid and can be removed.



Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 8

30 minutes

Answer the following questions:

1. Name the process for making ammonia

   _____

2. How is nitrogen obtained to make ammonia?

   _____

3. How is hydrogen obtained to make ammonia?

   _____

4. Which conditions are needed by nitrogen and hydrogen in-order to react and form ammonia?

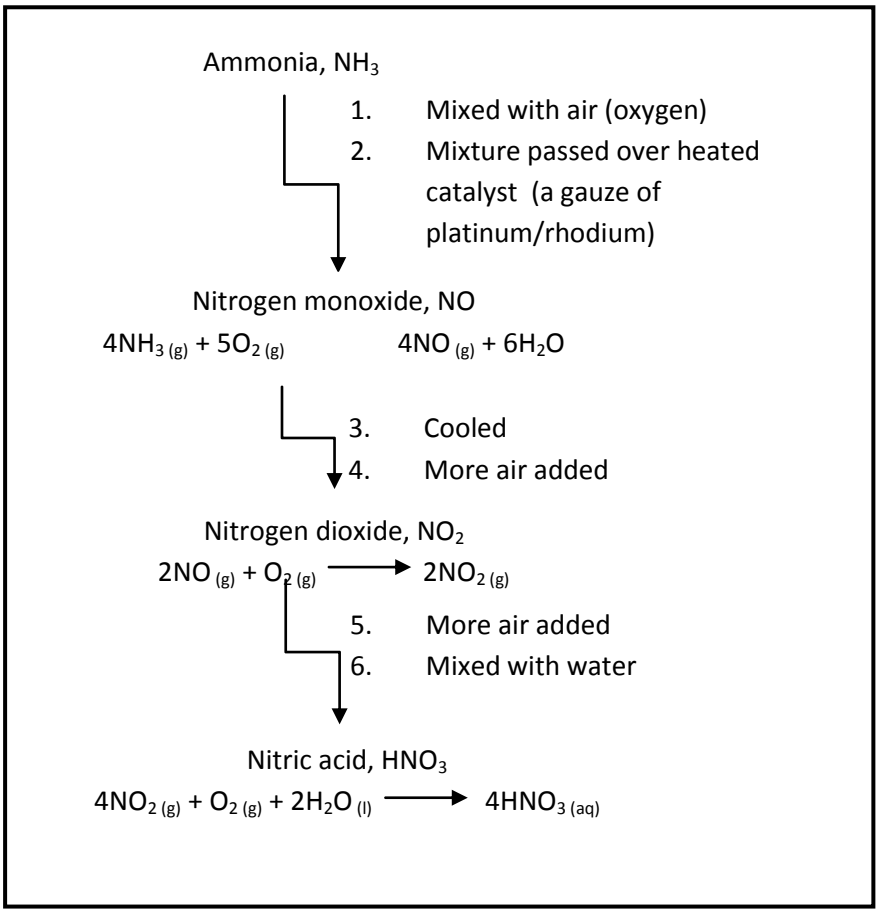
   _____

Thank you for completing your learning activity 8. Check your work. Answers are at the end of this module.

Nitric Acid

A lot of the ammonia produced from the Haber process is used to make nitric acid. The basic materials needed to make nitric acid are ammonia, air, and water. The process to form nitric acid is called **Ostwald process**.

The flow chart below shows the stages in the Ostwald process.



Ostwald process

Physical properties of nitric acid, HNO_3

- colourless liquid
- boiling point 86^0C (if pure)
- good conductor of electricity in solution form
- fully splits into ions in water to give hydrogen ions (H^+) and nitrate ion(NO_3^-)

Chemical properties of nitric acid, HNO_3

- strong acid
- reacts with metals to produce colourless nitrogen monoxide when dilute acid is used and orange-brown nitrogen dioxide when concentrated acid is used.
  $3Mg_{(s)} + 8HNO_{3(aq)} \longrightarrow 3Mg(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$
- reacts with carbonates to produce salt, water, and carbon dioxide.
  $CaCO_{3(s)} + 2HNO_{3(aq)} \longrightarrow Ca(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(q)}$
- reacts with a metal hydroxide or metal oxide to produce salt and water.
  Metal hydroxide + nitric acid $\longrightarrow$ salt + water
  $NaOH_{(aq)}$ + $HNO_{3(aq)}$ $\longrightarrow$ $NaNO_{3(aq)}$ + $H_2O_{(l)}$

Metal oxide + nitric acid ⟶ salt + water

$CuO_{(s)} + 2HNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2H_2O_{(l)}$

- reacts with ammonia to form ammonium nitrate solution

$NH_{3(aq)} + HNO_{3(aq)} \longrightarrow NH_4NO_{3(aq)}$

Uses of nitric acid, HNO_3

- to make fertilisers
- make explosives
- making nylon and terylene
- making drugs(medicine)

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 9

30 minutes

Answer the following questions:

1. What is the formula for nitric acid?

   _____

2. Name the process for making nitric acid.

   _____

3. What are the main materials for making nitric acid?

   _____

4. Name the products formed when carbonate reacts with nitric acid.

   _____

5. Name the products formed when
   (i) carbonate reacts with nitric acid.

   _____

   (ii) nitric acid reacts with a metal.

   _____

Thank you for completing your learning activity 9. Check your work. Answers are at the end of this module.

Artificial Fertilisers

Every crop a farmer grows takes nutrients from the soil. Some get replaced naturally. In the end the soil gets used up. New crops will not grow well. So farmer has to add artificial fertilisers.

A **fertiliser** is any substance added to the soil to help the crops to grow well.

There are two types of fertilisers

1. Artificial fertilisers (inorganic) are man- made such as ammonium nitrate, ammonium phosphate, and potassium.
2. Animal manure and compose is a natural (organic) fertilisers.

Types of artificial fertilisers

1. Straight N fertilisers
   This fertilisers only contains nitrogen. For example, ammonium nitrates (NH_4NO_3).

2. NPK compound fertilisers
   This fertilisers is a mixture of ammonium nitrate(NH_4NO_3),ammonium phosphate ($(NH_4)_3PO_4$), and potassium chloride (KCl). That is the fertilisers made up of nitrogen(N), phosphorus (P) and potassium(K) mixed together.

Problems with fertilisers

Fertilisers help farmers to grow a bigger crop in the same soil year after year. That sounds good, but there are problems.

1. Fertilisers can get washed out into rivers or lakes from farmland or gardens. In the river and lake, fertilisers help tiny water plants called **algae** to grow. These can cover the water like a carpet. When algae die, bacteria feed on them at the same time using up the oxygen dissolved in the water. So fish and other river life die from oxygen starvation. The river or lake becomes smelly and lifeless. This is called **eutrophication**.

2. Excess nitrate in the river may get into drinking water. It can cause a disorder in infants called **blue-baby syndrome**. What happens is these bacteria in the feeding bottle or the baby's body convert the nitrate into nitrite. This gets taken up instead of oxygen by haemoglobin in blood. The baby turns blue and can die.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 10

30 minutes

Answer the following questions:

1. Define:
   a. Fertilisers
   _____

   b. Straight N fertilisers
   _____

   c. NPK compound fertilisers
   _____

2. Name the two major problems caused by usage of fertilisers.
   a. _____
   b. _____

Thank you for completing your learning acivity 10. Check your work. Answers are at the end of this module.

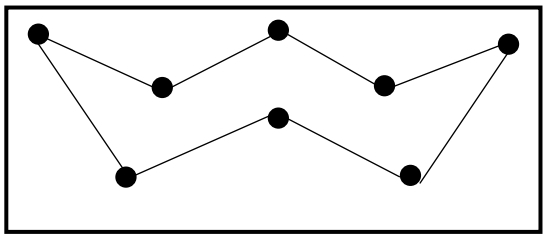
11.5.3 Sulphur and Sulphur Compounds

Sulphur

Sulphur is a common non- metal element in the Earth's crust. It is found

- as element in a large underground deposits. It is found around the rims of volcanoes.
- as combined with metals in many metal ores like in iron pyrites (FeS_2).
- in natural gas as hydrogen gas sulphide (H_2S) and in crude oil as organic sulphur compounds.

Properties of sulphur



Sulphur molecule

- yellow solid
- made up of crown-shaped molecules each with eight atoms
- has a low melting point (115^0C)
- does not conduct electricity
- insoluble in water (It does not dissolve in water.)
- reacts with metals to form sulphides, $Fe_{(s)} + S_{(s)} \longrightarrow FeS_{(s)}$
- burns in air(oxygen) to form sulphur dioxide, $S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$

Extraction of sulphur

i. From oil and gas

Sulphur compounds found in petroleum and natural gas are separated from petroleum and natural gas. These sulphur compounds are then reacted with oxygen with the help of a catalyst to produce pure sulphur.

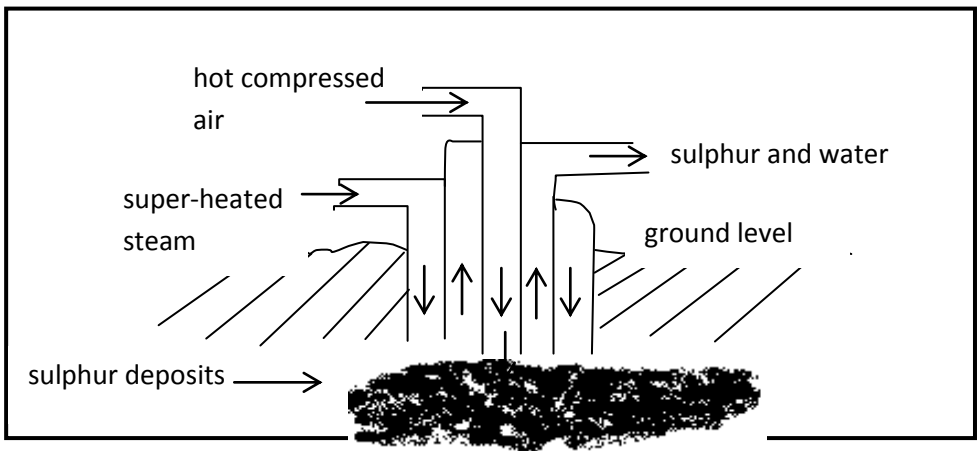
For example, natural gas is mainly methane (CH_4).It can have as much as 30% hydrogen sulphide. This is separated from methane. Then it is reacted with oxygen with the help of catalyst to give sulphur.

Hydrogen sulphide + Oxygen $\longrightarrow$ Sulphur + Water

$2H_2S_{(g)} + O_{2(g)} \longrightarrow 2S_{(s)} + H_2O_{(l)}$

ii. Frasch Process

This method of extraction of sulphur is from underground deposits. Super-heated steam and hot compressed air are piped underground to melt sulphur and carry it up to the surface. At the surface, sulphur cools down and becomes solid.



Frasch process

Uses of sulphur

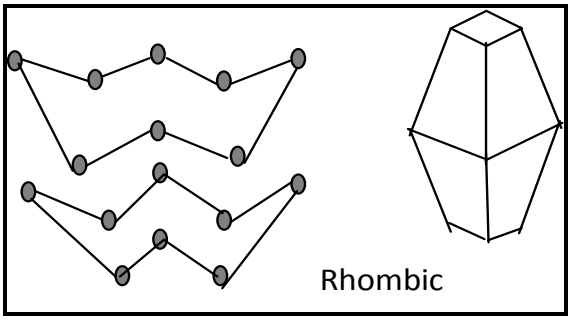
- To make sulphuric acid.
- It is added to rubber to toughen it.This is called **vulcanizing** the rubber.
- Making drugs, pesticides, dyes, matches, and paper.
- Making cosmetics, shampoos, and body lotions.
- It is added to cement to make sulphur concrete. This is not attacked by acid. It use for walls and floors in factories that use acid.

Allotropes of Sulphur

Sulphur has two different forms called **allotropes** (same element with different structures) and they are either **monoclinic sulphur** or **rhombic sulphur**.

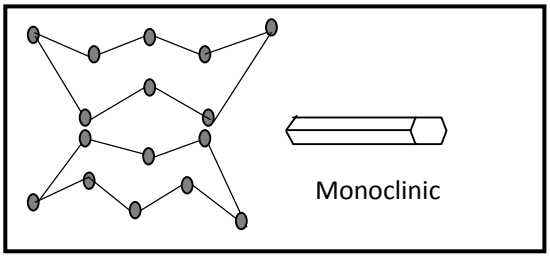
a) Rhombic sulphur

- stable below 96^0C
- has low melting point(110^0C)
- pale yellow crystals
- denser



b) Monoclinic sulphur

- stable above 96^0 C
- has high melting point (119^0C)
- pale yellow long- thin crystal
- less dense



Sulphur dioxide

Sulphur dioxide is formed when sulphur burns in air. Its formula is SO_2.

Properties of sulphur dioxide

- colourless gas with a strong choking smell
- heavier than air
- soluble in water. The solution is acidic because the gas reacts with water to form **sulphurous acid** (H_2SO_3). $H_2O_{(l)} + SO_{2\,(g)} \longrightarrow H_2SO_{3(a}$
  This breaks down easily again to sulphur dioxide and water.
- acts as bleach when it is damp or in solution. It removes the colour from coloured compounds by **reducing** them.

Uses of sulphur dioxide

- use to make sulphuric acid
- use to bleach wool, silk and wood pulp for making papers
- use as sterilizing agent in making soft drinks and jam, and in drying fruits. It stops the growth of bacteria and moulds.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 11

30 minutes

Answer the following questions:

1. Name three sources of sulphur in the Earth's crust.
   a. _____
   b. _____
   c. _____

2. Name the two allotropes of sulphur.
   a. _____

   b. _____

3. Write a balanced chemical equation that shows how sulphur dioxide is form.
   _____

4. Explain how Frasch process is done to extract sulphur deposited underground.
   _____
   _____

5. Why is sulphur dioxide used as a sterilizing agent in making soft drinks, jams and drying fruits?
   _____
   _____
   _____

Thank you for completing your learning activity 11. Check your work. Answers are at the end of this module.

11.5.4 Phosphorus and Phosphate Fertilisers

Phosphorus

Phosphorus is a non-metal and solid element that comes in different forms.

Properties of phosphorus

- The two main combining power of phosphorus are 3 and 5.
- White phosphorus automatically combines with the oxygen in the air forming white fumes of phosphorus (V) oxide. For this reason, white phosphorus is stored under water.

$$P_{4\,(s)} + 5O_{2(g)} \longrightarrow P_4O_{10(s)}$$

- When white phosphorus is heated in a stream of dry chlorine, phosphorus(III) chloride is formed:

$$P_{4\,(s)} + 6Cl_{2(g)} \longrightarrow 4PCl_{3(l)}$$

Allotropes of Phosphorus

Phosphorus also has two allotropes: **white** and **red phosphorus**.

(i) White phosphorus

- yellow solid consisting of P_4 molecules. One molecule of white phosphorus is made up of 4 atoms of phosphorus
- low melting point (44^0C) and low boiling point (280^0C)
- very poisonous
- insoluble in water. It cannot dissolve in water
- burns in air
- chemically reactive

(ii) Red phosphorus

- red solid
- has a high melting point (590^0C)
- only poisonous when not pure
- insoluble in water
- stable in air. It does not react with air
- less chemically reactive

Uses of Phosphorus

- it is used to make fertilisers
- red phosphorus is used for making matches

Production of Phosphate Fertilisers

This flow diagram shows how phosphate fertilisers are made.

1. Crushing of Rock phosphate, $Ca_3(PO_4)_2$

↓

2. Fine (very small) particles of rock phosphate

↓

3. Reaction with sulphuric acid, H_2SO_4

$$Ca_3(PO_4)_{2\,(s)} + H_2SO_{4\,(aq)} \longrightarrow 2CaSO_{4\,(s)} + Ca(H_2PO_4)_{2\,(s)}$$

↓

4. Phosphate fertilizer, $Ca(H_2PO_4)_2$

Most of the phosphate is used as fertilisers. Phosphate fertilisers contain the element phosphorus that helps roots and leaves to grow and crops to ripen.

There is also a problem with phosphate fertilisers. When these fertilisers get washed away from farmlands into rivers and lakes, they cause algae in rivers and lakes to grow quickly and cover the area. The algae near the surface prevents the sunlight from reaching algae and plants lower down, thus preventing them from carry out photosynthesis and releasing oxygen in the water. When algae die, bacteria feed on them, at the same time using up the oxygen dissolved in the water. So fish and other river life die from lack of oxygen, and the river or lake becomes smelly and lifeless. This is called **eutrophication**.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 12

30 minutes

Answer the following questions:

1. Name the mineral that you can find phosphorous.

   _____

2. What are the two allotropes of phosphorus?

   a. _____

   b. _____

3. Which of the allotropes of phosphorus is most reactive?

_____

4. Why do plants need phosphorus?

_____

5. Name the problem faced due to phosphate fertilisers getting washed into rivers and lakes.

_____

_____

Thank you for completing your learning activity 12. Check your work. Answers are at the end of this module.

11.5.5 Chemistry of Halogens

Halogen is a Greek word meaning **"salt –former"**. The elements in Group VII of the Periodic Table are called halogens. The elements in the group are fluorine (F), chlorine (Cl), bromine (Br), iodine (I) , and astatine (At).

Fluorine (F_2), chlorine (Cl_2), bromine (Br_2), and iodine (I_2) exist as diatomic molecules (molecules made of two atoms):F_2, Cl_2, Br_2 , I_2.

The chemical reactivity of all halogens decreases as you go down Group VII. The halogen at the top of the other is more reactive than the ones below it.

In this topic, we look at only three of these halogens. They are fluorine, chlorine, and bromine.

Fluorine

Properties of fluorine

- a pale yellow gas
- poisonous
- exists as diatomic molecule (containing two atoms).For example, F_2
- most reactive of all halogens

Uses of fluorine

- it is added to toothpaste (Example colgate) to reduce tooth decay.
- it forms a compound called **fluorocarbons**, which are used to cover the inside of frying pan or pots to stop food sticking.
- it is added to drinking water to help children from tooth decay when drinking the water.

Chlorine

Properties of chlorine

- a green gas
- poisonous
- exists as diatomic molecules, Cl_2
- it is a reactive halogen but less reactive than fluorine
- heavier than air and slightly dissolves in water
- it turns moist litmus paper colourless. It has bleaching ability
- it combines directly with metals to form metal salt.

Uses of chlorine

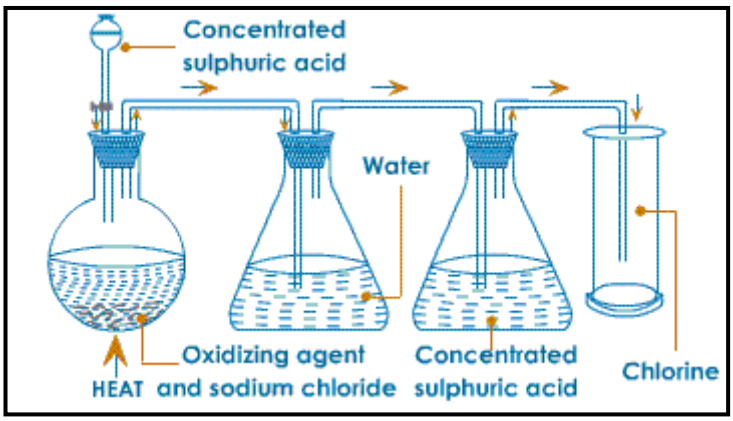
- strong bleaching agent
- put into swimming pools to keep them clean and to kill bacteria
- added to drinking water to kill bacteria so that water is safe for drinking
- make insecticides
- make hydrochloric acid

Production of chlorine

1. Laboratory Preparation of Chlorine

   Chlorine can be prepared by removing the hydrogen from hydrochloric acid using an oxidizing agent. Any oxidising agent such as manganese dioxide, lead dioxide, trilead tetroxide, potassium permanganate or potassium dichromate can be used.

   Firstly, the oxidising agents are taken in the round bottomed flask. Concentrated hydrochloric acid is then added through a thistle funnel. This mixture is then heated. The oxygen of the oxidizing agents combines with the hydrogen of the hydrochloric acid leaving behind chlorine i.e. hydrogen is removed from hydrochloric acid. The metallic ions of the oxidising agents combine with part of chlorine to form the respective chlorides.



Preparation of chlorine from sodium chloride

2. Electrolysis of molten sodium chloride

These are the following steps:

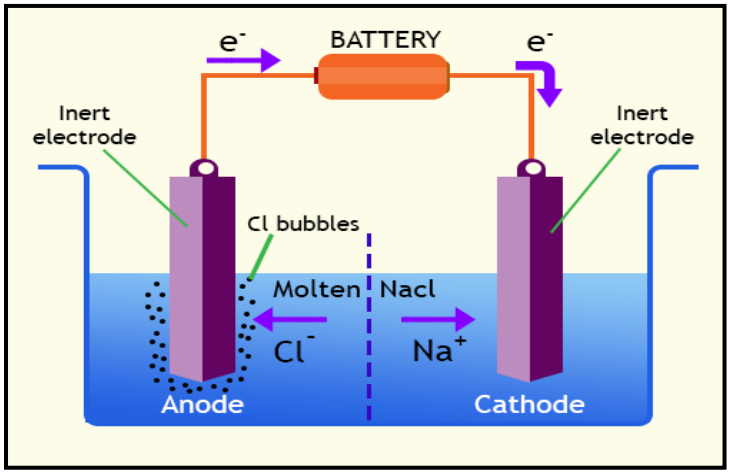
(i) The rock salt contains impure sodium chloride. It is heated to make a molten sodium chloride. Present in the solution is ion (Na^+) and chloride ion (Cl^-).

(ii) Electric current is passed through the solution. It splits sodium ion and chloride ion.

(iii) Chloride ion which is negative is attracted to the positive terminal of the circuit and becomes chlorine gas.

Chlorides are compounds formed when chlorine combines with another element. The chlorides of non-metal are covalent compounds usually in liquids or gases. For example, hydrogen chloride is a gas. Chlorides of metals are ionic compounds and usually solid and can dissolve in water.

For example, sodium chloride is a solid and can dissolve in water.



Electrolysis of molten sodium chloride

Reaction at negative terminal (cathode) shows chlorine gas is produced. This is shown by the equation.

$$2Cl^-_{(l)} \longrightarrow Cl_{2\,(g)} + 2e^-$$

Reaction at positive terminal (anode) gives sodium. The equation is shown below.

$$2Na^+_{(l)} \longrightarrow Na_{(l)} + 2e^-$$

Bromine

Properties of bromine

- It is a red liquid at room temperature which readily evaporates to a poisonous red-brown / gas.
- Exists as diatomic molecules, Br_2.
- It dissolves water forming a yellow/orange solution called bromine water.
- It combines with metals to form bromides.

Uses of bromine

- It used to make certain medicines, pesticides and dyes.
- It used to make silver bromide for photographic films.
- It is used to make ethylene bromide (CH_2BrCH_2Br) which is added to petrol to stop lead accumulating in engines.
- As flame retardants. This means some compounds formed by bromine have
- The ability to reduce the chances of catching fire. This compound is commonly used in electronic products.
- It is used to form a strong acid called hydro bromic acid. This acid is formed when hydrogen bromide is dissolve in water.

The reactivity of halogens decreases down the group. Therefore, during reaction halogens at the top will displace the ones at the bottom from their compounds.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 13

30 minutes

Answer the following questions:

1. What does the word halogen mean?

   _____

2. Which of the halogens in Group VII is the most reactive?

   _____

3. Why do they add chlorine in drinking water?

   _____

4. Write a word equation for the reaction between potassium iodide and bromine .

   _____

5. Which of the halogen acts as a bleaching agent?

_____

6. Which of the halogens is added to toothpaste? Why?

_____

7. Name the compound of a halogen used for making photograph film.

_____

8. How is hydrobromic acid formed?

_____

Thank you for completing your learning activity 13. Check your work. Answers are at the end of this module.

REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE.

SUMMARY

You will now revise this module before doing Assessment 6. Here are the main points to help you revise. Refer to the module topic if you need more information.

- Elements in Group VII are called Halogens. Halogens means “salt marker”.
- Reactivity of halogens decreases down the group.
- Fluorine, chlorine, bromine, and iodine exist as diatomic molecules.
- Fluorine and chlorine are both gases while bromine is a liquid.
- Fluorine the most reactive halogen. Fluoride ions are added to toothpaste and a fluorine compound is the surface on non-stick pans.
- Chlorine is mostly used as the bleaching agent.
- Certain bromine compounds are used for making photographic films, and added to petrol to stop lead piling up in the engines of vehicles.

The physical properties of metals are as follows:
- usually are solids and have high densities, high melting, and boiling points
- are ductile, malleable, sonorous, and lustrous
- good conductors of heat and electricity

The physical properties of non-metals are as follows:
- most are liquids and gases
- usually soft and non-shiny and non-sonorous
- non-malleable and non-ductile
- poor conductors of heat and electricity
- have low melting point and low boiling point

The chemical properties of metals are as follows:
- lose electrons and become positive ions
- react with oxygen to form basic oxides
- react with acids to form metal salt and hydrogen gas

The chemical properties of non-metals are as follows:
- receive electrons and become negative ions
- react with oxygen to form acidic oxides
- do not react with dilute acids

Corrosion is a process where air (oxygen) and water react with a metal resulting in a metal to break down.

Some common methods of stopping corrosion of metals are:

- painting
- oiling or greasing
- galvanizing
- tin-plating and sacrificial protection

A Metalloid element contains some properties of both metal and non-metal.An alloy is a mixture of a metal with one or more of other elements.

The main reasons for making alloys:

- to improve the strength and hardness of metals
- to improve the appearance of metals
- to improve the resistance of metals against corrosion
- to lower the melting points of metals

- Hydrogen is the lightest of all gases. It combines with oxygen to form water.
- Nitrogen is an important element that is needed to make protein by plants.
- Protein is used for growth and repair of damaged body tissues.
- Animals obtain their protein by feeding on plants or eating other animals that ate plants.
- Nitrogen is continuously replaced back into the air by the Nitrogen Cycle.
- Haber process is the process for making ammonia. Ammonia is a compound formed by nitrogen reacting with hydrogen.
- Release of white smoke when hydrogen chloride gas reacts with a substance shows the presence of ammonia gas.
- Ammonia is used to make fertilisers and nitric acid.
- The basic materials for forming nitric acid are ammonia, air, and water. Ostwald process is the process for making nitric acid.
- There are two types of artificial fertilisers. They are straight N fertilisers and NPK compound fertilisers.
- The common problems caused by usage of fertilisers are eutrophication and blue-baby syndrome.

A molecule of sulphur is made up of 8 atoms of sulphur.

Sulphur can be found in:

(i) underground deposits and rims of volcanoes
(ii) metal ores
(iii) natural gas or crude oil

Sulphur can be extracted from

(i) oil and gas
(ii) Frasch process

Two allotropes of sulphur are rhombic sulphur and monoclinic sulphur. Sulphur dioxide is formed when sulphur burns in air (oxygen). Sulphurous acid is formed when sulphur dioxide is dissolved in water.

$$H_2O_{(l)} + SO_{2\,(g} \longrightarrow H_2SO_{3\,(g)}$$

- Phosphorus is found in a mineral called rock phosphate.
- The two allotropes of phosphorus are red phosphorus and white phosphorus.
- Phosphorus is needed by plants for the growth of their roots and leaves and to ripen their fruits.
- Eutrophication is one of the environmental problems faced when phosphate Fertilisers are washed into rivers or lakes.

NOW YOU MUST COMPLETE ASSESSMENT 5 AND RETURN IT TO THE PROVINCIAL CENTRE CO-ORDINATOR.

ANSWERS TO LEARNING ACTIVITIES 1-13

Learning Activity 1

1. (a)

Elements that conduct heat	Elements that conduct heat
(i) sodium	(i) oxygen
(ii) aluminium	(ii) sulphur
(iii) magnesium	(iii) chlorine
(iv) copper	(iv) hydrogen
(v) mercury	

(b) Sodium, aluminium, magnesium, copper and mercury
(c) Oxygen, sulphur, chlorine and hydrogen
(d) Mercury
2. Ductile can be stretched and made into wires.
Conductor means a substance (metal) that allows heat or electricity to pass through them. Sonorous means can make a ringing noise when hit. Malleable means can be hammered and bent into shapes without breaking.

Learning Activity 2

1. Metalloidoth properties of metals and non-metals.
2. Semi-metals
3. i. Boron (B)
ii. Silicon (Si)
iii. Germanium (Ge)
iv. Arsenic (As)
4. Silicon and germanium, because they are able to conduct electricity under special condition.

Learning Activity 3

1. Corrosion is a process where air and water react with a melt resulting in the metal to break down.
2. Air (oxygen) and water
3. Painting and oiling or greasing
4. Galvanizing is coating of iron with zinc metal while tin-plating is the coating iron with tin metal.

5. Sacrificial protection means coating more reactive metal to iron which results in the reactive metal to corrode instead of iron thus preventing iron from corrosion.

Learning Activity 4

1. Alloy is a mixture of a metal with a few other elements.
2. Alloy is formed by melting the elements and mixing them and then allowing them to solidify.
3. Because alloys are stronger and resist corrosion than pure metals.
4. (a) Solder
   (b) Brass
   (c) Bronze
5. Because brass does not corrode easily while pure copper metal does.

Learning Activity 5

1. Oxygen
2. (a) fuels for fuel cells
   (b) make margarine by hydrogenation of vegetable oil
   (c) produce organic compound
3. (a) False
   (b) False
   (c) True

Learning Activity 6

1. To make protein for growth and repair of body tissues.
2. By eating plants or feeding on animals that ate plants.
3. Ammonia
4. a) Nitrogen fixing bacteria convert nitrogen from the air into nitrates
   b) Nitrifying bacteria convert ammonium compounds into nitrates
   c) Denitrifying bacteria break down nitrates and release nitrogen back into the air
5. Nitrogen- fixing bacteria

Learning Activity 7

1. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$
2. Because ammonia solution contains hydroxide ions that turn red litmus paper blue.
3. Hydrogen chloride
4. HNO_3

Learning Activity 8

1. Haber process
2. Nitrogen is obtained from the air.
3. Hydrogen is obtain by reacting natural gas (methane) with steam or breaking down crude oil.
4. 450^0C, 200 atmospheres and iron catalyst

Learning Learning Activity 9

1. HNO_3
2. Ostwald process
3. Ammonia, air and water
4. Carbon dioxide, salt, and water
5. Salt and hydrogen gas

Learning Activity 10

1. (a) Fertilisers is any substance added to soil that helps the crop to grow well.
   (b) Straight N fertilisers contains only nitrogen.
   (c) NPK compound fertilisers has mixture of nitrogen, phosphorus and potassium.
2. (a) Eutrophication
   (b) Blue-baby syndrome

Learning Activity 11

1. (i) Underground deposits
   (ii) Metal ores
   (iii) Natural gas or crude oil
2. Monoclinic sulphur and rhombic sulphur
3. $S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$
4. Super-heated steam and hot compressed air are piped underground to melt sulphur and carry up to the surface. At the surface, sulphur cools down and become solid.
5. Sulphur dioxide stops the growth of bacteria and moulds.

Learning Activity 12

1. Rock phosphate $Ca_3(PO_4)_2$
2. White phosphorus and red phosphorus
3. White phosphorus

4. To help with the roots and leaves to grow and ripen the crops.
5. Eutrophication

Learning Activity 13

1. Halogen means salt marker
2. Fluorine
3. Because to kill bacteria so that water is safe to drink
4. Potassium iodide + bromine $\longrightarrow$ potassium bromide + iodine
5. Chlorine
6. Fluorine because it stops the tooth from decaying
7. Silver bromide
8. Hydrogen bromide dissolving in water

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FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONE (COORDINATOR)	CUG PHONE (SENIOR CLERK)
1	ALOTAU	P. O. Box 822, Alotau	6411343/6419195	72228130	72229051
2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
11	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	72229056
12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
13	MADANG	P. O. Box 2071, Madang	4222418	72228126	72229063
14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General / Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	General / Advance Mathematics	General / Advance Mathematics	General / Advance Mathematics
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry and Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.