



ZIMBABWE

**Ministry of Primary and  
Secondary Education**



# Combined Science Module Level II Volume 1



Lifelong and  
Continuing Education  
2020



# Introduction

High demand for education and training in the 21<sup>st</sup> century has triggered change or the desire for every education system to evolve and respond to the ever increasing demand for literacy and numeracy as well as high quality products from the education system the world over. Educational institutions have no option but to transform and evolve and fulfill the increasing demand for quality education. Learners also demand an education system that is sensitive to the changing knowledge-based society. This also includes the need to expand and open up spaces for learning enabling learning to take place anywhere or everywhere.

This module comes as a response to the need for the Zimbabwean education system to reach out to all the learners and improve access to quality education. Upon the realisation that formal education is limited to formal pedagogical approaches and restricts access to education, this module provides learners with alternative approaches to acquiring education especially in the sciences. Coping with daily demands of adult life as well as the need to acquire academic qualifications and increasing one's employability created the need for an open distance learning pathway.

The combined science module will provide you with a learning experience suitable for home learning. The module comes with interactive and exciting approaches to learning where the topics are arranged and designed to provide you with all the tutorials required by the competence based curriculum and sufficient enough depth to guide you for ordinary level combined science public examinations.

Wish you the best in your studies.

# Acknowledgements

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Above all, special thanks goes to UNICEF for providing funding for this Project.

# How to use this module

As you start this journey of acquiring a qualification in Ordinary Level Combined Science through open distance learning, it is critical that you understand the need to manage your study time and balance it with your day-to-day activities. This module will provide you with the basic material to assist you towards your public examinations in Combined Science.

This module has been subdivided into two volumes, that is, Volume 1 Volume 2. You are advised to study Volume 1 first before going to Volume 2.


Wish you the best!

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# BIOLOGY SECTION

# UNIT 1: CELLS AND LEVELS OF ORGANISATION

## CONTENTS

- 1.1 Structure and function of specialised cell
- 1.2 Ecosystems
- 1.3 Types of ecosystems
- 1.4 Energy flow in an ecosystem
- 1.5 The carbon and nitrogen cycle
- 1.6 Biodiversity
- 1.7 Assessment questions

## INTRODUCTION

All living things are made up of small units called cells. Cells are the structural and functional unit of an organism. They are microscopic and consist of a cytoplasm and a nucleus enclosed in a membrane. They differentiate and specialise to perform a specific function. When they are specialised, cells lose their ability to divide. Examples of specialised cells include muscle cells, root hairs and red blood cells.



## OBJECTIVES

After going through this unit, you should be able to:

- Identify specialised cells
- Draw and label specialised cells
- State the specific function or functions of specialised cells
- Use a microscope/bio-viewer to observe cell structures.
- List the components of an ecosystem.
- Explain the concept of natural and artificial ecosystems.
- Construct food chains, food webs and food pyramids.
- Explain how energy is lost in food chains and food webs.
- Describe the carbon and the nitrogen cycles.
- Identifying problems caused by limited biodiversity.



## KEY WORDS

Here is a list of some of the new words you are going to meet in this unit:

**Autotroph**- a producer or a plant

**Biotic**- living things

**Abiotic**- non-living things

**Chlorophyll**- the green colour in plants responsible for photosynthesis

**Haemoglobin**- the red pigment which give the red colour of the blood

**Photosynthesis**- the process whereby green plants manufacture their own food in the presence of water, carbon dioxide, sunlight and chlorophyll

**Ecosystem**-is the interdependence that exists between living organisms and non living things to produce a self sustaining system.

**Biodiversity**- variety of living things in an ecosystem

**Extinction**- total destruction

**Habitat**- a place where organisms live

**Heterotroph**- organisms that cannot make their own food (consumers)

**Population**-a group of organisms of the same species living in the same area

**Producers**- organisms such as plants, which can make their own food



TIME: 8hours

## 1.1 STRUCTURE AND FUNCTION OF SPECIALISED CELLS

Animals and plants have different cells that are specialised to perform different functions.

### SPECIALISED ANIMAL CELLS

#### Red blood cells

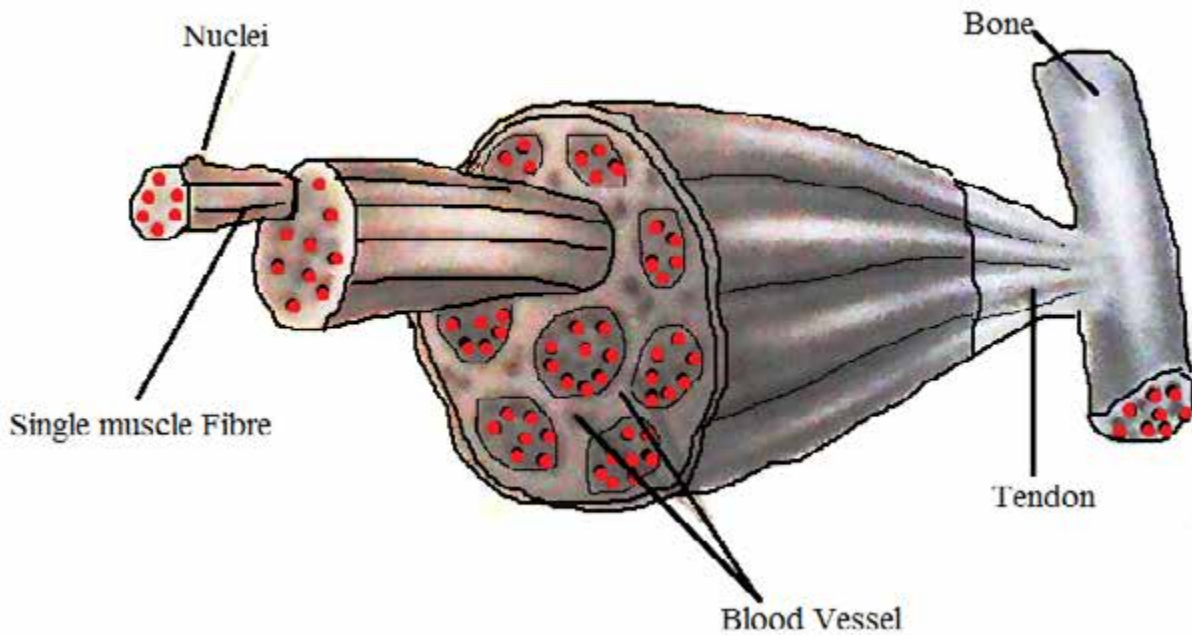
Red blood cells carry oxygen from the lungs to all parts of the body of an animal. They are disk shaped and both sides of the cell's surface curve inwards like the interior of a sphere. This enables the red blood cells to move through tiny blood vessels to deliver oxygen to organs and tissues. They contain antigens which helps the body's immune system to recognise its own red blood cell type. They contain haemoglobin which gives blood its red colour.



**Figure 1.1 showing red blood cells**

#### Muscle cells

Muscle cells are made up of fibres and have the ability to contract or shorten in order to permit movement. Skeletal muscles are attached to the bones with long fibres held together in bundles. They are stimulated by a nerve for them to move. They are also arranged in pairs and when one muscle contract the other muscle relaxes.



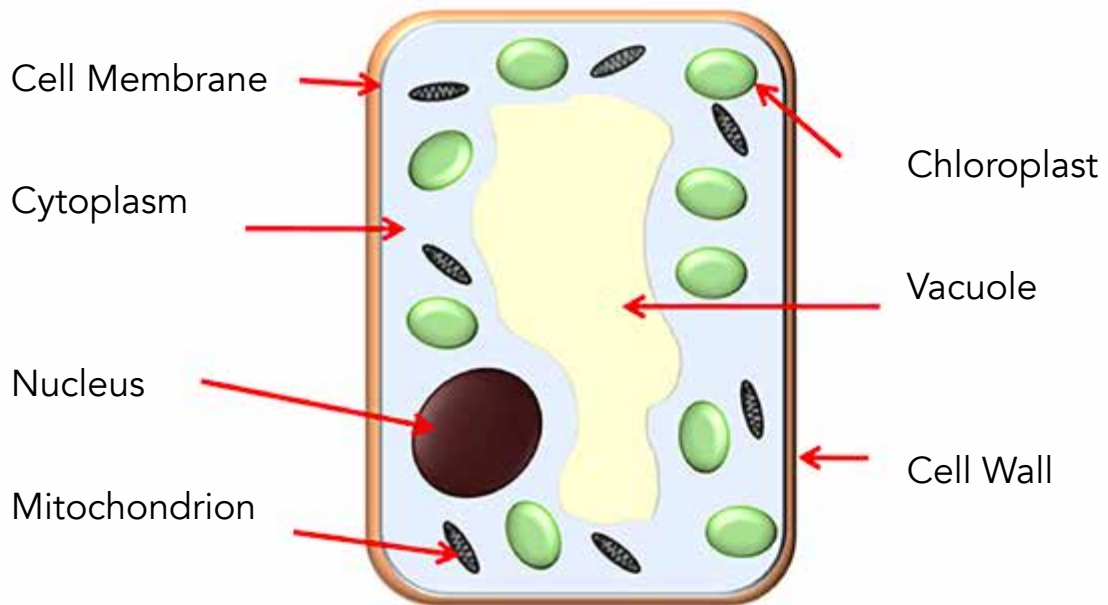
**Fig 1.2 showing the structure of a muscle**

## **SPECIALISED PLANT CELLS**

Like animals, plants have many processes which help them to stay alive and grow. For these processes to take place effectively plants use a variety of specialised cells to perform different functions so that the plant can function as a unit. In this unit we are going to focus on the palisade and the root hair cells.

### **Palisade cell**

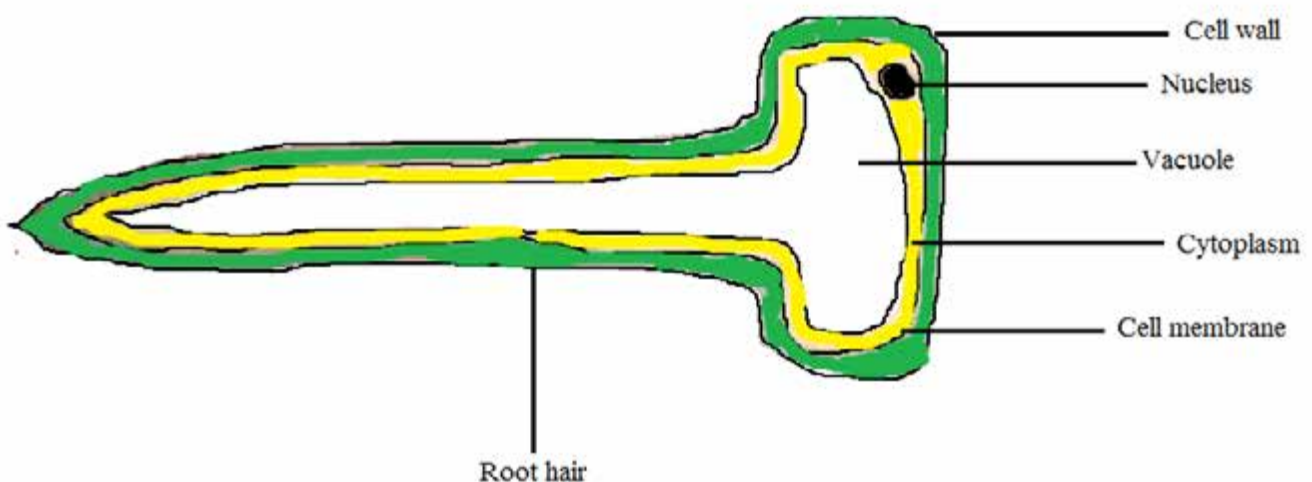
Palisade cells are found under the upper epidermis of all the leaves. They help in the process of photosynthesis. They are long and cylinder shaped. This allows them to be closely packed to each other in order to conserve space. Palisade cells have a large surface area, which helps in absorbing water and carbon dioxide needed for photosynthesis. The cell is packed with chloroplasts which trap sunlight also needed for photosynthesis.



**Figure 1.3 showing the palisade cell**

### Root hair cell

Root hairs are found on the outside layer of the roots. They absorb minerals dissolved in water by increasing the surface area to absorb more water and minerals. They are single celled and delicate structures. They can live for two to three weeks and constantly re-grow. They have long, thin structures that penetrate into the soil. They are made up of very thin cell walls to enable water and nutrients to pass through from the soil into the roots easily. They are found in large numbers in order to increase the surface area for absorption.



**Figure 1.4 showing the root hair cell**





## EXPERIMENT 1

Aim: to observe and draw specialised cells using a microscope or a bio viewer

Materials: a microscope or a bio-viewer, prepared specimens of blood, muscle, palisade and root hair cells.

Method:

1. Place the slide under the microscope or use a bio-viewer to view the prepared slides of specialised cells.
2. Identify the cells and draw diagrams



## ACTIVITY 1

Now that you have learnt more about the structure and functions of specialised cells, complete the table below:

Cell	Function	Specialisation
Red blood cell		
Muscle cell		
Root hair cell		
Palisade cell		

## 1.2 ECOSYSTEMS

An ecosystem is a community of living organisms interacting with non-living components of their environment. The non-living environments include climate, weather, sun, earth, soil and the atmosphere. The earth, all the plants, animals and their surroundings together constitute an ecosystem. An ecosystem also has organisms that mutually benefit from each other. It can be destroyed by a stranger e.g. rise in temperature, rise in sea level, climatic changes, human activities like deforestation, urbanization and natural activities like floods, storms, fires or volcanic eruptions. Examples of ecosystems include a pond, a garden and a forest. These ecosystems vary in size and have different habitats.

## **Components of an Ecosystem**

An ecosystem is made up of physical (non-living) or abiotic components which include light, water, soil, air, temperature, and living things or biotic components made up of producers and consumers. It is said to be healthy when it is able to provide everything needed for the survival of the living organisms in the area. A healthy ecosystem is self-sufficient and all its components are balanced.

### **The physical components of an ecosystem (abiotic)**

These are the non-living or abiotic components of an ecosystem and they include air, water, soil, temperature, rocks, and minerals that make up the soil. The abiotic components live on and interact with biotic components.

### **Soil**

Soil is the top layer of the earth's surface, consisting of rock particles, minerals, decayed organic matter, micro-organisms and water. It is the medium in which plants grow and also anchors or support them. The soils vary in particle size, pH, structure, texture, depth, water holding capacity and the type of nutrients they contain.

### **Water**

Water is needed in an ecosystem to sustain life. The amount and quality required varies from one ecosystem to another. Deserts receive very little water while rainforests have a lot of water. The type of rainfall received determines the type of plants grown in an area and also the types of animals living there. The quality of water can be affected by the amount of mineral salts in the soil, oxygen content, pH and temperature.

### **Humidity**

Humidity is the amount of water vapour in the air. In regions such as deserts the amount of water vapour in the air is low therefore the regions have low humidity. The amount of water vapour in Coastal regions is high therefore the areas have high humidity.

### **Temperature**

Temperature is very important in order to stabilise an ecosystem. Most organisms have an ideal temperature range in which they can live in. Temperature changes greatly affect lives in an ecosystem. Temperatures vary depending on the season (winter or summer) and time of the day (morning, midday, afternoon).

## **Light**

The light in an ecosystem is provided by the sun. The amount of light an area receives depends on aspects such as the season, day-length and topography. For example in mountainous areas the south facing slopes may receive less sunlight than the north facing slopes. This light is also necessary for driving the process of photosynthesis.

## **Land**

Topographic features such as height above sea level, shape and form of the land influence how much sunlight and rainfall an area receives.

## **Biological components of an ecosystem**

The biological components of an ecosystem include humus, producers, and the consumers.

### **Producers**

Plants manufacture their own food and therefore are called producers (autotrophs). They use carbon dioxide from the air, water from the soil and energy from the sun to make glucose and oxygen. The glucose is then used by the plant while the excess is converted to starch and stored in the storage organs.

### **Consumers**

Consumers cannot make their own food but they eat or consume other organisms. There are four types of consumers;

- **Herbivores or plant eaters and these are primary consumers. Examples are rabbits, locusts and mice**
- **Carnivores or meat eaters and these are secondary consumers. They are subdivided into;**
  - **Predators-they catch their own prey e.g. lions and cheetahs**
  - **Scavengers- feed on dead animals e.g. vultures and hyenas**
- **Omnivores eat both plants and meat. They are both primary and secondary consumers e.g. humans, pigs and baboons.**
- **Decomposers are micro-organisms which feed on dead plants and animal matter e.g. bacteria and fungi.**

## 1.3 TYPES OF ECOSYSTEMS

### Natural ecosystems

Natural ecosystems are not influenced by human beings and they occur naturally. They can be very large like deserts, ocean floors and virgin rainforests, or very small like a rock pool or soil around a big tree. Natural ecosystems are self dependent and have a lot of biodiversity. There is very few truly natural ecosystem, most of them are mainly influenced by human activities.

### Artificial ecosystem

These are man-made ecosystems characterised by a low biodiversity. They are supervised and managed by human beings in order to make them sustainable. For example, a garden has to be maintained by weeding, applying fertilisers and using chemicals to kill parasites. Most ecosystems are found between natural and artificial ecosystem due to human activities.



### ACTIVITY 2

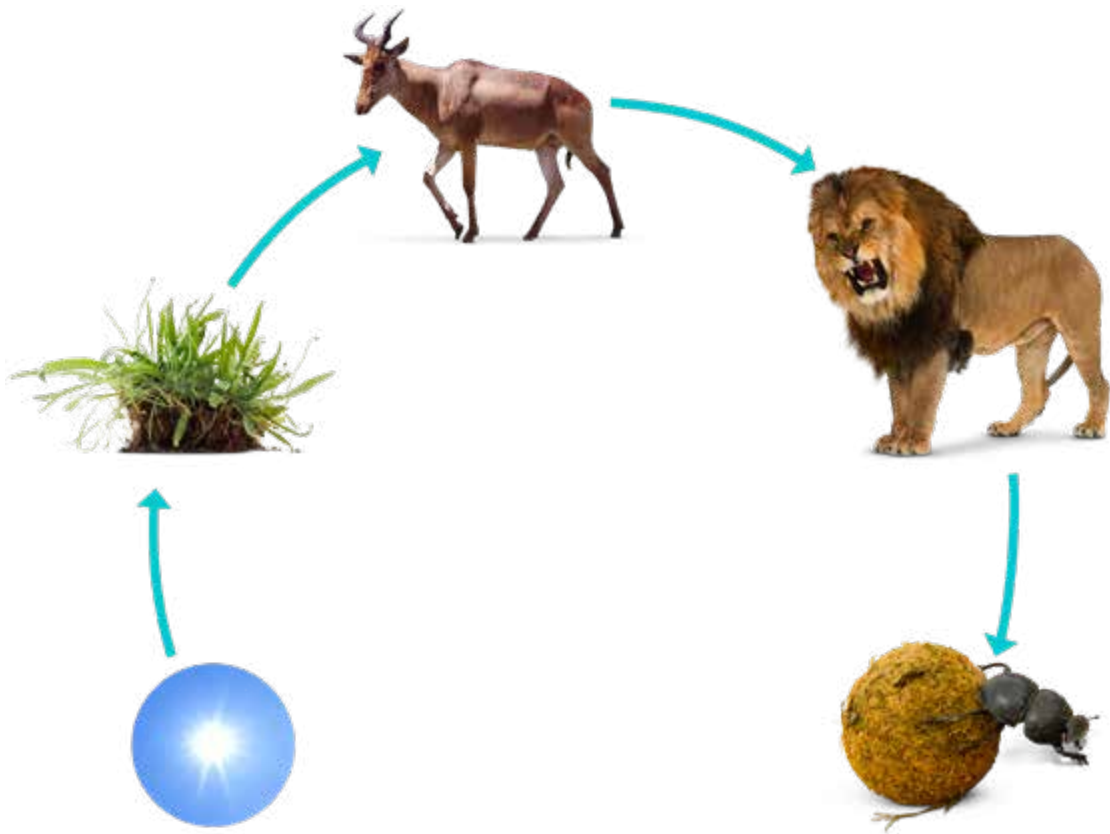
Select an area in your immediate environment and measure 10m X 10m. Identify the biotic and abiotic factors in that area. Remember the biotic factors are the living organisms and abiotic factors are non-living components of an ecosystem.

## 1.4 ENERGY FLOW IN AN ECOSYSTEM

The feeding relationship between consumers and producers in a community is represented in the form of food webs and food chains. These also show the energy flow in an ecosystem

### Food chains

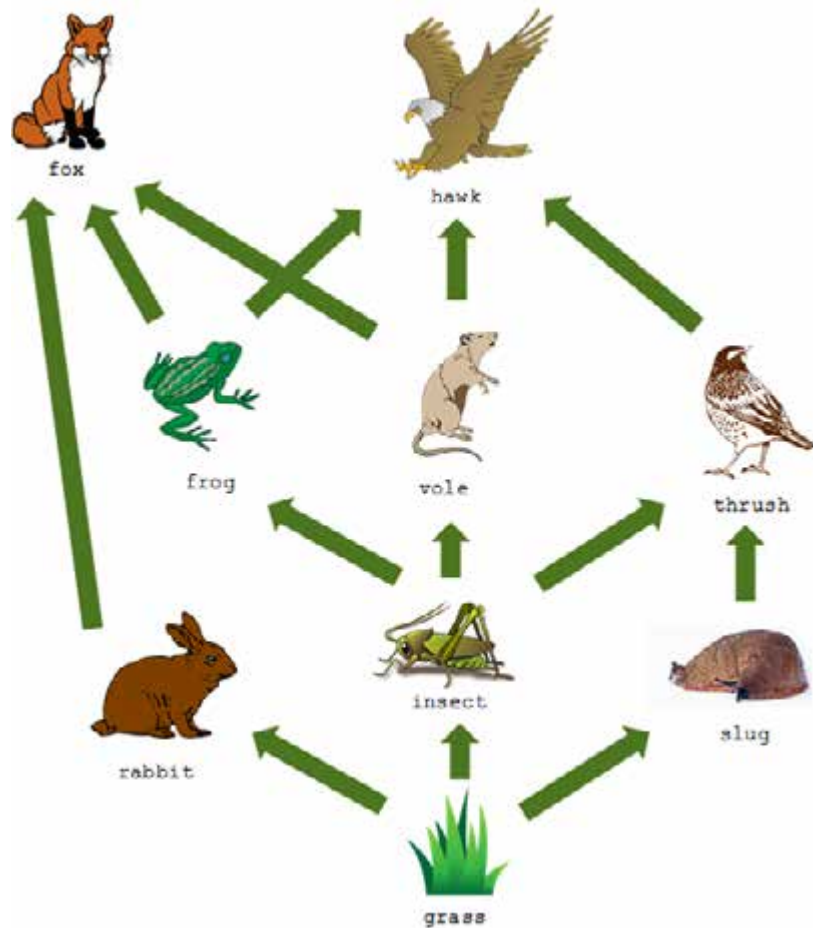
Food chains begin with a producer and these are mostly green plants. The plant is then eaten by the primary consumer which is an omnivore or herbivore. A food chain is then formed which links the movement of energy or food showing organisms feeding on one another. Each individual in a food chain is very important and can affect the whole chain when removed. An organism becomes extinct when it's source of food becomes used up.



**Figure 1.5 food chain**

### **Food webs**

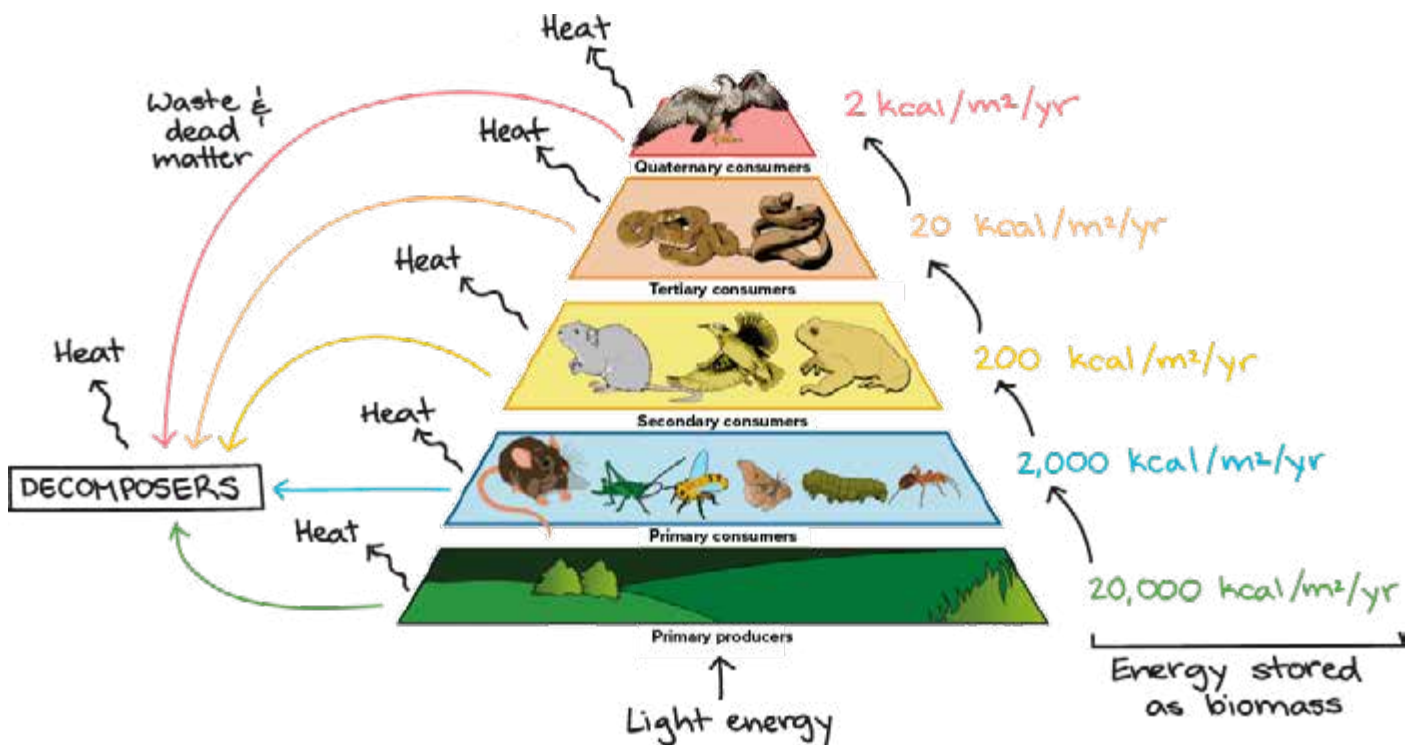
A food web is made up of a network of food chains or feeding relationships by which food and energy is passed from one organism to another in a community. The linkages show the feeding pathways such as where an organism gets its food or energy and the methods of feeding that links the ecosystem. This means a food web is more complicated than a food chain. They consist of many different organisms at the same level that feed on the same type of organism. There are different kinds of feeding relations that can be divided into herbivores, carnivores, scavengers and parasites.



**Figure 1.6 food web**

### Ecological Pyramids

Pyramids have a larger base, with levels that decrease in size as you move on top. Producers form the base of all other life and are found on the bottom of an ecological pyramid. Primary consumers are found on the next level and they feed on producers only. The next level on the pyramid is the secondary consumers which are carnivores and they feed on primary consumers. At the top are the tertiary consumers which feed on both primary and secondary consumers.



**Figure 1.7 Food web**

You can also note that there is a decrease in masses of organisms as you move up the pyramid.

### Energy flow

Energy flows along the food chains from one trophic level to the next in an ecosystem. The sun is the source of energy and during photosynthesis it is converted to chemical energy. A lot of energy is lost from one trophic level to the other due to life processes such as respiration, movement, reproduction and wastes. Organisms that are not eaten by predators at high trophic levels are then eaten by decomposers (organisms that feed on dead animals).

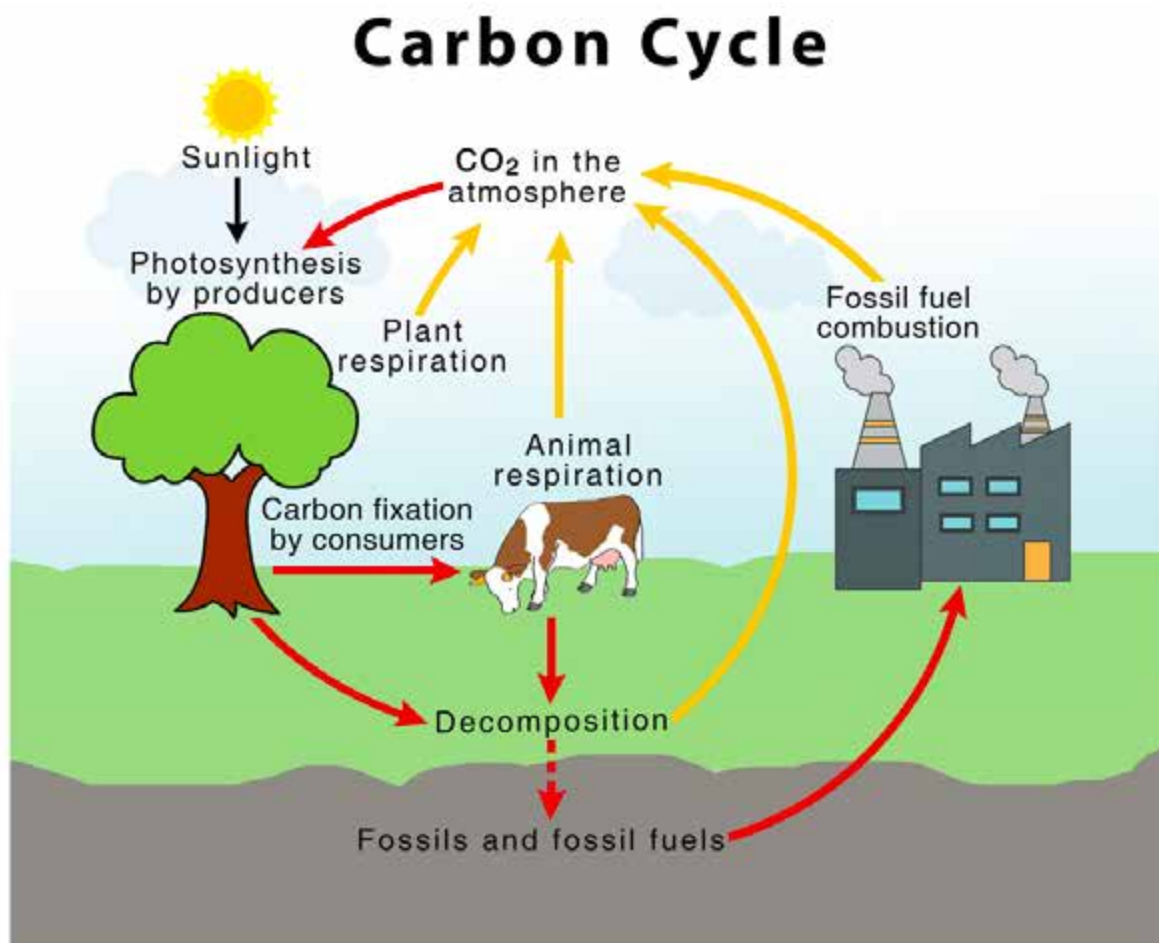
## 1.5 THE CARBON AND THE NITROGEN CYCLE

Chemical substances needed by organisms to survive are obtained from the environment. These substances include oxygen, water, phosphorus, nitrogen and carbon. For them not to be used up, they are cycled through the ecosystem to make them available to be used again.

### The carbon cycle

Carbon is found in all organic compounds and it is obtained from carbon dioxide in the atmosphere or in dissolved water. Plants convert carbon dioxide from the air to organic compounds through the process of photosynthesis. The organic compounds are then passed from the plants to the animals that eat the plants. It is then passed on to other consumers through the food chain.

When respiration takes place, all living organisms including plants and animals give out carbon dioxide. It is also released into the atmospheric air. When they die, decomposers get back carbon from the remains. They decompose carbon and release carbon dioxide in the atmosphere. When burning fossil fuels, carbon dioxide is also released into the atmosphere. Calcium carbonate reacts with acid rain and gives off carbon dioxide into the air.



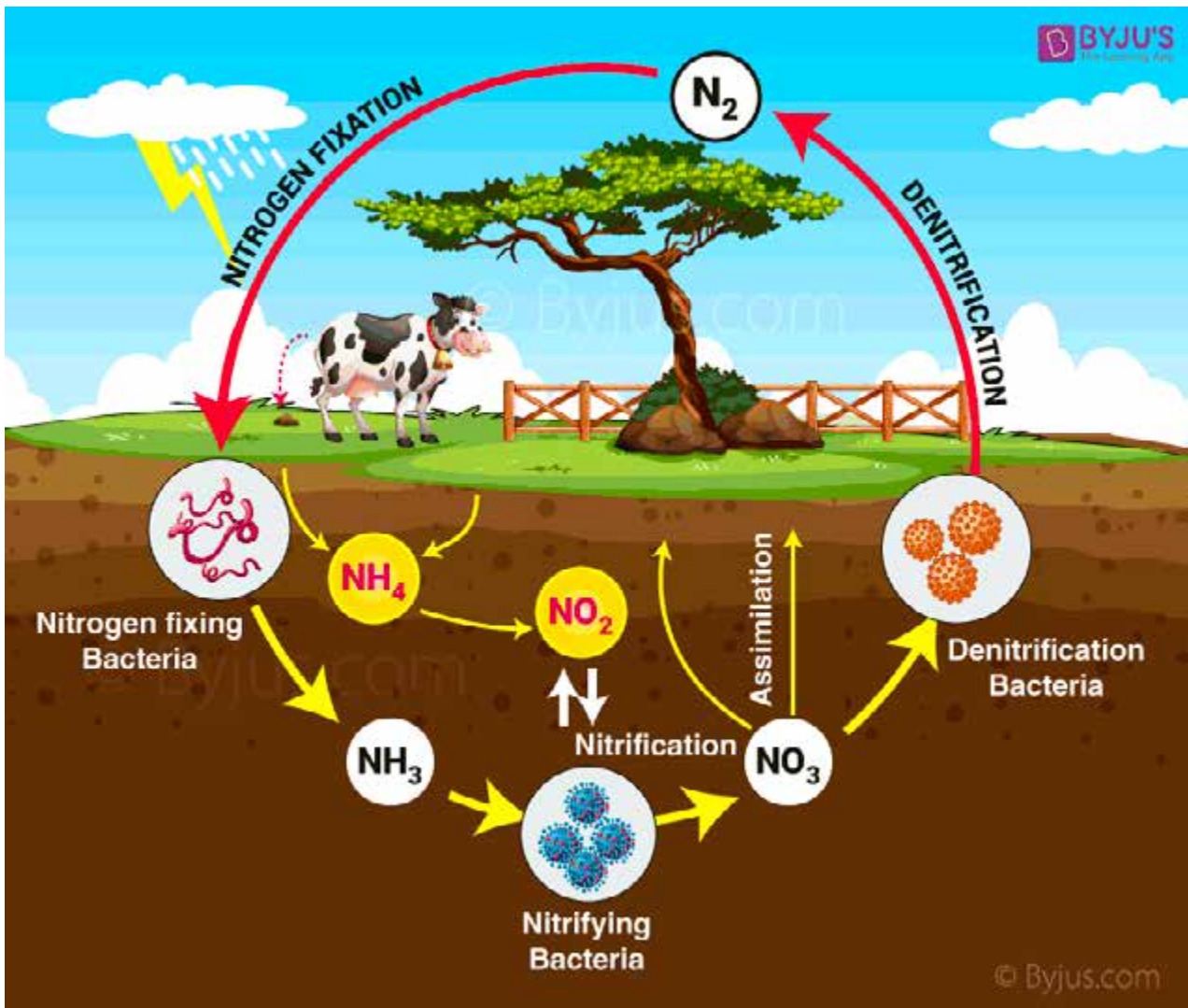
**Figure 1.8 the carbon cycle**

### The Nitrogen cycle

Nitrogen is needed by plants and animals to make amino acids, proteins. The atmospheric air consists of about 78% nitrogen gas. Plants get nitrogen from the soil in the form of nitrates and ammonia. Animals get nitrogen from eating protein foods. The soil can get nitrogen from decomposed dead bodies of plants and animals. Bacteria and fungi help in the decomposition of the bodies. Legumes such as beans and peas contain a nitrogen fixing bacteria which take nitrogen from the soil and convert it into a form used by plants. The bacteria together with nitrifying algae convert nitrogen into nitrates and nitrites.

Car engines combine nitrogen with oxygen to form NO<sub>2</sub> in air will form a weak acid in the event of an electric storm. The acid dissolves in water to form an acid rain. In the soil the acid rain combines with other chemicals to form nitrates. Nitrogen is then released back into the atmosphere by denitrifying bacteria which converts nitrates to nitrogen after metabolism.





**Figure 1.9 the nitrogen cycle**

## 1.6 BIODIVERSITY

Biodiversity or biological diversity refers to a variety of life in an area on earth. It reflects the number of different plants, animals, bacteria and fungi in an area. Biodiversity also includes a variety of organisms found in an ecosystem.

### Limited Biodiversity

#### Problems caused by limited bio-diversity

- Soil infertility
- Pests
- Diseases

## **Advantages of biodiversity**

- wide variety of food source
- self sustenance of an ecosystem
- interdependence of organisms
- less spreading of diseases

## **Disadvantages of limited biodiversity**

- soil infertility
- rampant spreading of pests and diseases

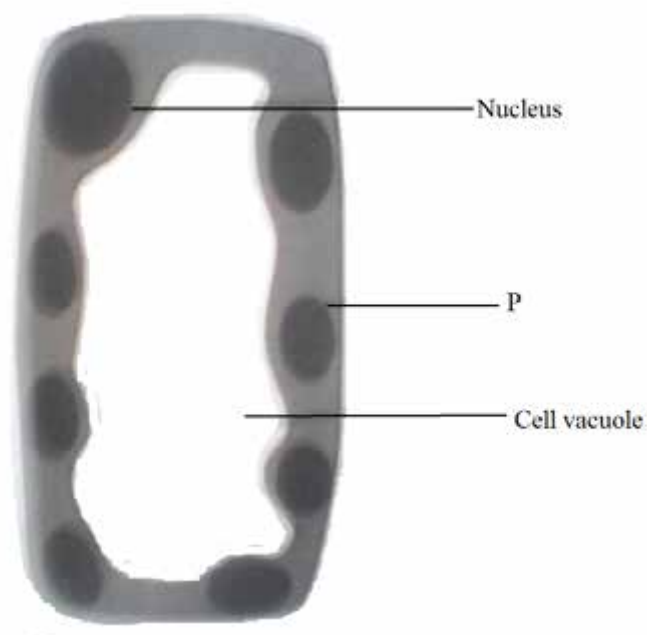
## **SUMMARY**

In this unit we looked at ecosystems and the interaction of living things with their environment. We hope you can now define the term ecosystem, if not revisit the unit again. We can define an ecosystem as a group of organisms interacting with their non-living environment. The ecosystem is made up of the living part and the non-living part. In a natural ecosystem there is no human influence while an artificial ecosystem is a man-made ecosystem. The feeding relationships in an ecosystem between the producer (plants) and consumers (herbivores, carnivores, omnivores, and decomposer) is illustrated using food webs, food chains and ecological pyramids. There is flow of energy in an ecosystem and is lost as we reach the top levels. An ecosystem can recycle important chemicals such as nitrogen and carbon. Human activities lead to the extinction of species and cause a threat to biodiversity.



## 1.7 ASSESSMENT QUESTIONS

1. Haemoglobin is a pigment found in blood cell that carries;
  - A. nitrogen
  - B. oxygen
  - C. carbon dioxide
  - D. water
  
2. Palisade cells have ..... to enable photosynthesis
  - A. cell sap
  - B. cellulose
  - C. chlorophyll
  - D. water
  
3. Consumers are also called.....
  - A. Heterotrophs
  - B. decomposers
  - C. consumers
  - D. carnivores
  
4. Fig.1.1 shows a palisade cell.



a) i) Identify structure P..... [1]

ii) Describe how the palisade cell is adapted for its function.

.....  
.....  
.....  
.....[4]

b) Explain why plants are placed at the base of an ecosystem.

.....  
.....  
.....[2]

c) Name and explain any 2 physical components of an ecosystem.

.....  
.....  
.....  
.....[4]

5a) Identify any 2 human activities which cause a threat to biodiversity

1.....

2..... [2]

b) Define the following terms

i) foodweb[2]

ii) foodchain [2]

c) With the aid of a diagram briefly explain the carbon cycle.....[6]

# UNIT 1 CELLS AND LEVELS OF ORGANISATION

## Assessment Test - Answers

1. B
2. C
3. A

4. Fig. 1.1 shows a palisade cell.

d) i) P Chloroplasts [1]

ii) They are located towards the upper surface of the leaf enabling them to absorb more sunlight needed for photosynthesis.

-The palisade cell has many chloroplasts for photosynthesis

-the cell has a large surface area for the absorption of water and carbon dioxide.

-they have many air spaces allowing the entrance and exit of gases during photosynthesis.

iii) Plants are autotrophs or producers therefore they manufacture their own food through the process of photosynthesis and is eaten by herbivores or omnivores as the primary consumers [2]

e) Soil – is the medium of plant growth. Anchors plant roots and give them water and nutrients for growth.

Water - for life sustainability. Can affect the type of plant and animals in a given area

Humidity – is the amount of water vapour in the air and some areas has a high while others have a low humidity.

Temperature - temperatures vary depending on the season (winter or summer) and time of the day (morning, afternoon and evening)

Other factors are light and land. [4]

5a) 1. Hunting activities

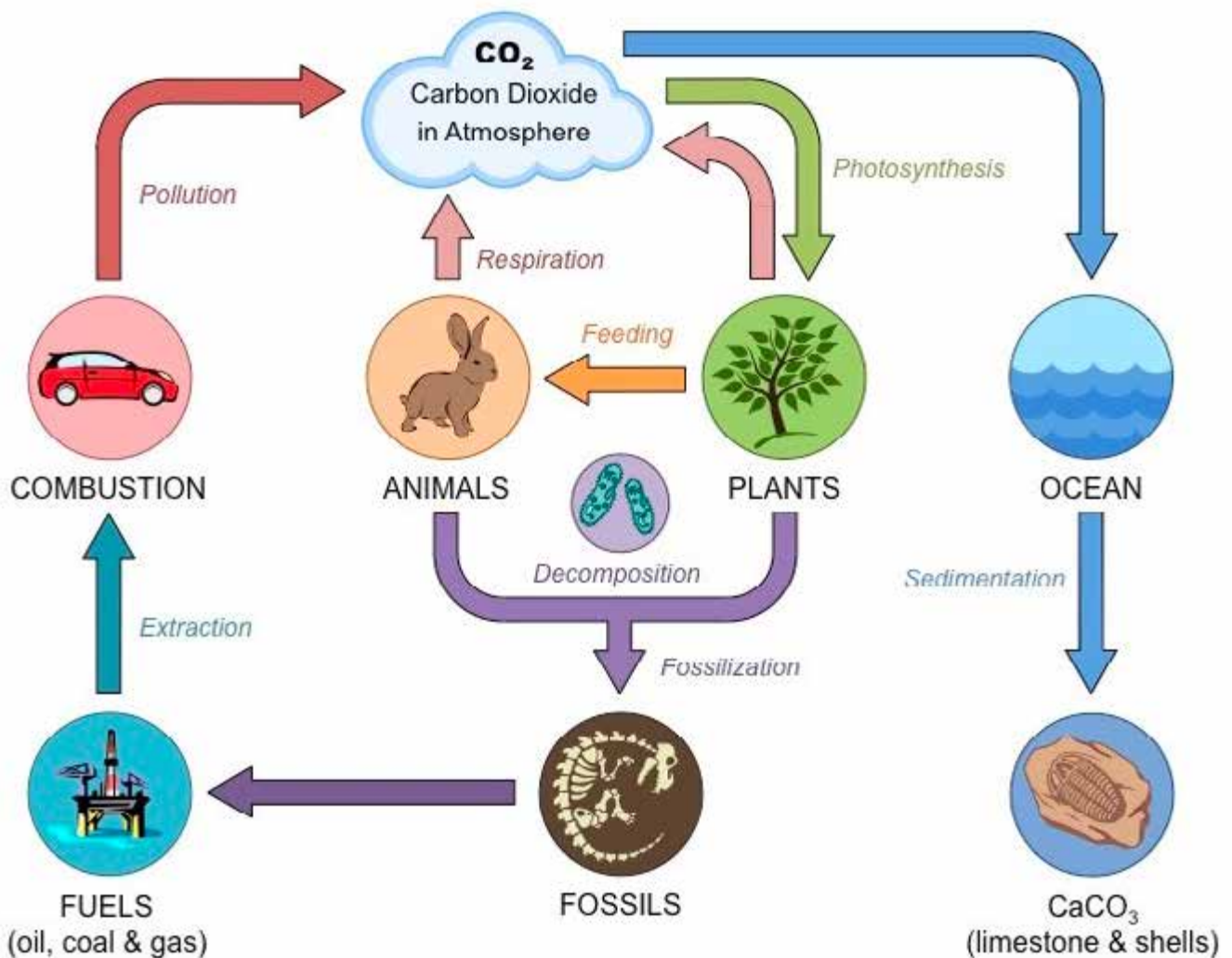
2. Pollution (2)

Other activities are unsustainable farming practices, slashing and burning, over-grazing, over-harvesting introduction of Alien species

b) i) Food web- is a feeding relationship in nature made up of different, interrelated food chains [2]

ii) Food chain- is a feeding relationship where there is movement of energy (food) along the different links of organisms feeding on one another [2]

c) The carbon cycle [6]



Carbon can be obtained from carbon dioxide in the atmosphere or dissolved in water. Plants also convert carbon dioxide in the air to carbon during photosynthesis. Animals produce carbon dioxide as a waste product during respiration which is also released into the atmosphere. Decomposers of dead plants and animals break down the remains and release carbon dioxide in the atmosphere. Carbon dioxide is also released when plants and fossil fuels are burnt. When calcium carbonate reacts with acid rain carbon dioxide is also released into the atmosphere.

# UNIT 2: HUMAN NUTRITION

## CONTENTS

- 2.1 Chemical and mechanical digestion
- 2.2 Human alimentary canal
- 2.3 Balanced diet
- 2.4 Malnutrition and associated diseases
- 2.5 Food tests
- 2.6 Assessment questions

## INTRODUCTION

“A man is what he eats” is one of the famous statements. In this unit you are going to learn about the various food components that human beings eat and their value to the human body. You will also explore how food is digested by the body so that body is able to extract the valuable components from the food. The human digestive system will be explored in greater detail in this unit. Interestingly you will learn about balanced diet also emphasizing on malnutrition and associated diseases. Lastly this unit will equip you with knowledge on food tests. Enjoy the unit, digest and assimilate it.



## OBJECTIVES

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

- Draw and label parts of the alimentary canal and associated organs.
- State functions of parts of the alimentary canal.
- Describe mechanical and chemical digestion.
- Describe the function of components of a balanced diet.
- Explain malnutrition and associated diseases.
- Describe food tests.





## KEY WORDS

**Alimentary canal** - these are organs that make up the human digestive system.

**Diet**- these are various food components eaten by an organism

**Digestion** - The process by which food is broken down into smaller and soluble units

**Enzyme** -biological chemicals produced by the body which help in the process of digestion

**Nutrient** - it is a food component



Time: 8hours



## STUDY TIP

- Make sure you have understood the topic plant nutrition so as to maximise understanding of this unit.

## 2.1 MECHANICAL AND CHEMICAL DIGESTION

The key question that this sub-unit tries to answer is “what happens to food from the point it enters the mouth up to when it is passed out of the body?” In order to fully respond to the question, it is important that we define digestion. What do you think digestion is? I hope you said it is a process whereby the body breaks down food into smaller and soluble molecules which can be absorbed and used by the body. In order for the body to fully digest food, it employs two main forms of digestion which are mechanical and chemical.

### MECHANICAL DIGESTION

The food that is eaten in solid form is usually so large such that it cannot fit into the walls of the small intestines which absorb digested food for use by the body. For this reason such food has to be broken down physically so that it can fit into the walls of the intestines. This is called mechanical digestion. Now what do you think is done by the body in order to mechanically digest food. I hope you mentioned that teeth are very useful in breaking large food molecules into smaller food molecules mechanically. The tongue is also helpful in physical digestion as it helps to direct food to the teeth for effective mechanical digestion. Teeth can be put into the following groups:

- a) **Incisors** - these teeth are found in the front of the mouth and are mainly used for biting food.
- b) **Canines:** these are sharp side teeth whose main function is to tear flesh and food into smaller particles.
- c) **Pre-molars:** found just after the canines, they have a large surface area and they mainly grind food into smaller particles
- d) **Molars:** found at the back of the mouth and they have a very large surface area for maximum grinding of food into smaller particles.

## CHEMICAL DIGESTION

The food that we eat is not taken into the body as it is, sometimes it has to be changed its chemical composition so that it gets into the body in the required form. The process of changing the chemical composition of the food by the body into a chemically new form is called chemical digestion. The body secretes a number of chemicals which help in changing the chemical composition of food. These chemicals are called enzymes.



### ACTIVITY 1

Now can you name some of the chemicals found in the body

.....

.....

.....

.....

.....

Table 2.1 shows some of the enzymes found in the body and their action on various food components:

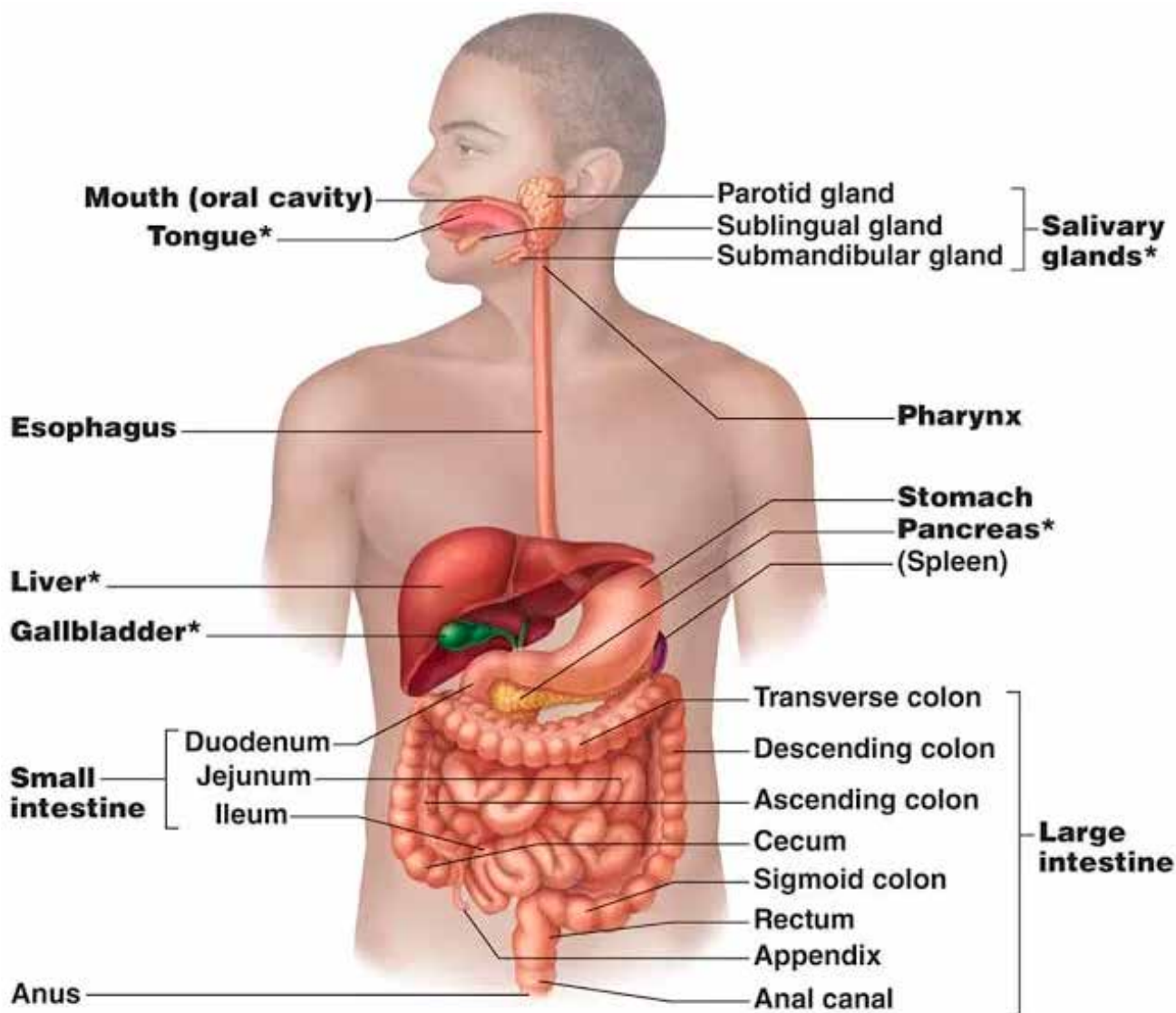
**Table 2.1**

FOOD GROUP	ENZYME	END PRODUCT
Proteins	Protease	Amino acids
Carbohydrates	Amylase	Maltase
Starch	Maltase	Glucose
Lipids	Lipase	Fats acids and glycerol

Enzymes are specific, meaning that each enzyme acts only on one food type and requires conditions such as pH particular to itself only.

## 2.2 HUMAN ALIMENTARY CANAL

Have you ever wondered what happened to food after it has been taken in through the mouth up to when undigested waste ejected out through the anus. Well you need not to wonder anymore. Below is the diagram showing the human alimentary canal.



**Fig 2.1 human alimentary canal**

Food is taken into the alimentary canal through the mouth in a process called ingestion

Digestion in the mouth

- Food is physically broken down by teeth into smaller molecules.
- Food is mixed with saliva. Saliva contains an enzyme amylase which digests starch into maltose.
- Food then moves down the food pipe, gullet or oesophagus. The food moves by a process called peristalsis. Food is then deposited into the stomach.

### **Digestion in the stomach**

In the stomach food is mixed with juices produced from walls, these juices are called gastric juices.

Gastric juices contain

- a) Hydrochloric acid which helps in killing pathogens found in food.
- b) Pepsin digests proteins into peptides
- c) Renin which is especially useful in digestion of milk in infants.

Food then leaves the stomach and moves into the duodenum.

### **Digestion in the duodenum**

When the food leaves the stomach it enters the duodenum. Here food is mixed with bile which is produced by the liver and enters through the bile duct. What do you think is the function of bile? I hope you mentioned that bile is useful for two main reasons.

- To neutralise stomach acids.
- For the emulsification of fats. Emulsification is the breaking of fats into small droplets.

Food is also mixed with enzymes from the pancreas. The juices from the pancreas are called pancreatic juices and they contain many enzymes for the final digestion of carbohydrates, proteins and fats. Food then leaves the duodenum for the small intestines.

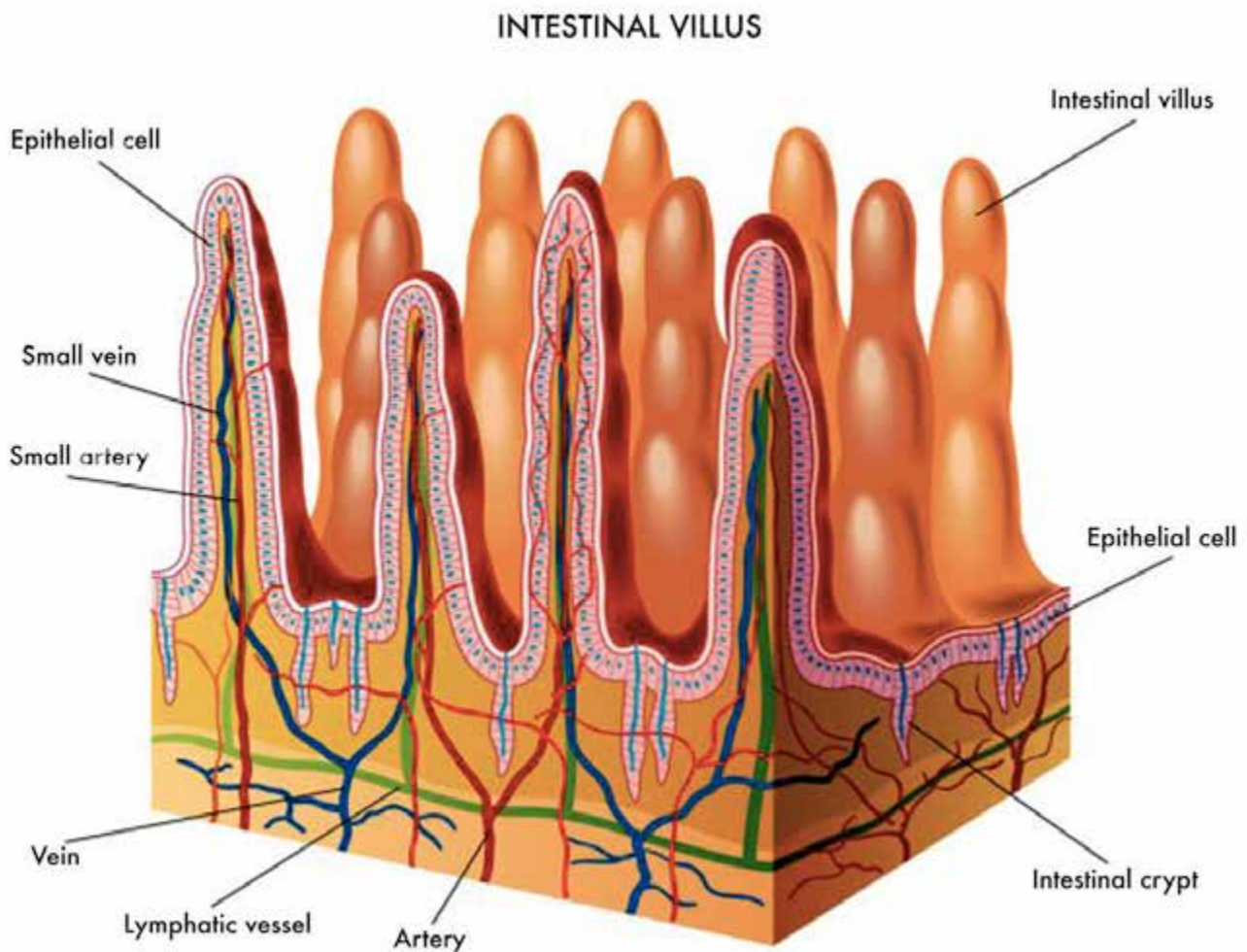
## Digestion in the small intestines (ileum)

In this part of the alimentary canal both physical and chemical digestion are complete and the final products of digestion are now ready to be absorbed into the blood stream.

Below is a list of food components and the final products to their digestion.

- Carbohydrates - glucose
- Proteins - amino acids
- Fats - fatty acids and glycerol

The walls of the small intestines have finger like projections which increase the surface area for absorption of dissolved food. These finger like projections are called villi



**Fig 2.2** *Intestinal villi*

Dissolved food is taken into the blood stream by two main processes.

- a) **Diffusion** - end products of digestion move from the small intestines where they are highly concentrated into the blood stream where there is a low concentration of them.
- b) **Active uptake** - energy is supplied by the body in order to facilitate the movement of certain food molecules across the walls of the small intestines into the body from a region of lower concentration to a region of higher concentration.

The blood vessels which take food from the small intestines join to form one large vessel called the hepatic portal vein which takes all dissolved food from the small intestines to the liver for storage, regulation and distribution.

### Large intestines (colon)

By the time food reaches the large intestines, all the useful food molecules have been absorbed what remains is indigestible solids, fibre and water. Here salts, water and vitamin B are absorbed back into the body. There is no digestion that occurs in the large intestines.

The wastes become semi-solid and are passed out as faeces through the anus.

## 2.3 BALANCED DIET

What do you usually eat in the morning, in the afternoon and in the evening? Do you think what you eat is enough or not for your body? Whatever you eat is your diet but here we want to look mainly at a balanced diet.



Now try to define a balanced diet:

.....

.....

.....

.....

Compare your answer with the correct one below:

## Balanced diet:

It is a diet containing all food nutrients in their correct proportions to give a healthy and active body.

## REMEMBER:

From the definition, it is important for you to identify components of a balanced diet and their uses.

Table 2.2 is a list of these components and their uses:

**Table 2.2**

COMPONENT	FOOD SOURCE	USE
CARBOHYDRATES	Bread Rice sadza	Provide energy to keep the body functioning and energy to do work
PROTEINS	Eggs Fish Beef beans	For growth Repair of worn tissues
Fats	Fatty meat Milk Flying ants	Energy reserves Protection of delicate body organs Insulation( warmth)
Roughage	Mealie- meal(straight run) Fruits Green vegetables	Help to prevent constipation-difficulty in moving food along the alimentary canal

Vitamins	Fruits and vegetables	<p><b>Vit A-</b> improves eyesight and prevents poor night vision</p> <p><b>Vit C-</b> prevents bleeding gums, poor wound healing and symptoms of scurvy</p> <p><b>Vit D-</b> helps in strong bone formation and absorption of calcium</p> <p>Prevents rickets</p>
Water	Fruits Drinking clean water	<p>Medium for chemical reactions in the body</p> <p>Transporting dissolved food substances</p>
Iodine	Iodised salt Sea foods	<p>Growth</p> <p>Prevents goitre</p>
Calcium	Milk liver	Formation of bones
Iron	Red meat spinach	Formation of red blood cells

When one does not take a balanced diet: malnutrition results.

Malnutrition is a condition that results from a lack of one or more nutrients in the diet .it could also result from an excess of one or more nutrients in the diet. (obesity)

Deficiency disease – a disease that results from a lack of one or more nutrient in the diet

Considerations to make when choosing a balanced diet

#### a) **Age**

Different age groups require different quantities of nutrients. The age groups to consider are:

**Infants** - require a lot of vitamins, proteins and carbohydrates

**Middle aged** - these economically active members require a lot of carbohydrates.

**Old age** - require less carbohydrates but a lot of vitamins among other requirements.



## b) Sex

Males and females require different quantities of nutrients for the same age groups. Males generally need more energy giving foods than females for the same age.

## c) Occupation

Different occupations require different amounts of energy levels in a diet. Manual labourers require more energy than sedentary workers such as receptionists.



## ACTIVITY 3

Plan a balanced diet for adolescent, manual worker and sedentary worker

## 2.4 MALNUTRITION AND ASSOCIATED DISEASES

What do you think happens to people who do not eat a balanced diet? I hope you concluded that they may end up being affected by some disease, true. Let us now explore some of the possible diseases that may result due to an unbalanced diet.

**Malnutrition**- this is a diet which either lack certain nutrients (under nourishment) or has too much of other nutrients.

Some common malnutrition diseases

**Obesity** - caused by excessive carbohydrates and fats in diet.

**Marasmus**- caused by a serious lack of carbohydrates in diet.

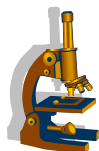
**Kwashiorkor**- caused by lack of enough proteins in diet.

Table below continues with diseases caused by lack of certain nutrients in diet (deficiency diseases).

DEFICIENCY	EFFECTS IN CHILDREN	EFFECTS IN ADULTS
Vitamin A	Possible blindness Respiratory infection	Night blindness Dry skin
Vitamin C	Bleeding gums Poor wound healing	Bleeding gums Poor wound healing
Iron	Anaemia	Anaemia
Calcium	Poor teeth development Poor bone development	Soft and brittle bones
Iodine	Poor mental and physical development	Goitre

## 2.5 FOOD TESTS

In order to know which components are present in the food that you eat, you should be able to carry out food tests. In this unit you are going to cover the following food tests. Test for glucose (reducing sugar). Test for proteins, fats and starch.



### EXPERIMENT 1

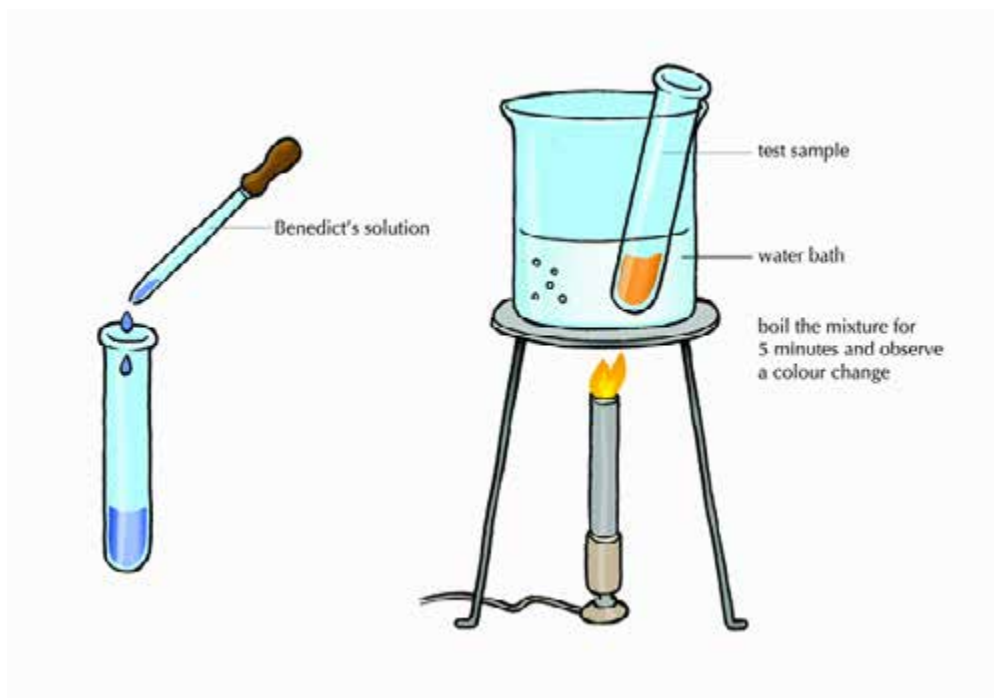
**Aim:** testing for reducing sugar or glucose (Benedict's test)

**Materials:**

- Benedict's solution
- Burner
- 2 test tubes A and B
- Beaker
- Distilled Water
- Glucose

## Method

- Place about 2cm<sup>3</sup> of distilled water into test tube A.
- Place about 2cm<sup>3</sup> of glucose in the other test tube B.
- Add about 2cm<sup>3</sup> of Benedict solution into each of the test tubes.
- Heat test tubes A and B over a water bath as shown in the diagram below.



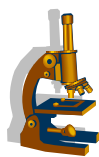
**Fig 2.3 water bath**

- Observe colour changes

## Observations

What colour changes did you observe in each of the test tubes?

- The colour change from blue to orange or red shows presence of reducing sugars.
- If the solution remains blue, it means there are no reducing sugars



## Experiment 2

**Aim** -testing for the presence of glucose using clinistix. Clinistix strip has a pink tip

## Apparatus/ materials

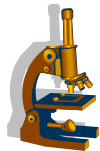
- Test tube
- Clinistix strips
- Food sample – glucose solution

## Method

- Put a few drops of food sample into test tube.
- Dip clinistix strip into food sample.
- Observe the colour changes.

## Observations

- What colour changes did you observe?
- The strip turned purple in colour
- When glucose is present clinistix tip turns purple.



## Experiment 3

**Aim** - Testing for the presence of starch in a food sample

## Apparatus/materials

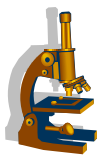
- Food sample (bread crumbs)
- Food sample (sugar solution)
- Iodine solution
- 2 test tube

## Method

- Add a few drops of iodine solution to food samples in each of the test tubes.
- Observe colour changes

## Observations

- What colour changes did you observe?
- If the colour changes to blue black it means starch is present and if it remains brown it means there is no starch in the food item.



## Experiment 4

**Aim** - Testing for the presence of proteins in egg albumin food sample and sugar solution sample.

### **Apparatus/ materials**

- Biuret solution (1cm<sup>3</sup> potassium and hydroxide solution and a few drops of copper sulphate solution)
- Food sample solution
- Egg albumin sample
- Sugar solution
- 2 test tubes

### **Method**

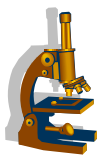
- Dissolve egg albumin sample in water and put the solution in one of the test tubes
- Dissolve sugar in water and put the sugar solution in the other test tube
- Add biuret solution in each tube and shake well.

### **Observations**

- What colour changes did you observe?

### **Hint:**

The purple colour shows presence of proteins and the blue colour shows absence of proteins.



## Experiment 5

**Aim** - testing for proteins in a food sample (albusix test)

### **Apparatus/ materials**

- Food sample in solution form (egg white)
- Food sample in solution form(sugar solution)
- Albusix strip

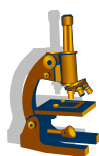
## Method

Dip albugin strip into each of the test tubes.

## Observations

What colour changes did you observe in the two test tubes?

The green colour change on the strip is the positive test for proteins



## Experiment 6

**Aim** - testing for fats in a food sample (cooking Oil) – emulsion test

## Apparatus /materials

- 2 test tubes
- Food sample – few drops of cooking oil and a sample solution of sugar
- Ethanol.
- Water.

## Method

- Put cooking oil into one test tube and sugar into the other test tube
- Add a few drops of ethanol into each of the test tubes and shake the mixtures and allow the solutions to settle.
- Add few drops of water and shake again.
- Observe changes to the mixture.

## Observations

What did you observe in each of the test tubes?

## Hint:

Formation of a cloudy solution shows presence of fats

## SUMMARY

We hope that by now you are well informed and knowledgeable on issues of diet. You can now choose a balanced diet based upon the various considerations you have learnt during the course of this unit. You have also learnt about diseases that affect a person due to malnutrition. It is my profound hope that you have grasped all the concepts taught in this with regards to the human alimentary canal. You have covered in detail the diagram and function of parts of the alimentary canal in relation to digestion. By now you should readily define digestion and also state the forms of digestion. This unit also took you through the concepts of food tests. You should be now able to practically test for the presence of various food components. You should also be able to theoretically outline the test for each food component. It is my hope that you found this unit interesting. Should you have any challenges in understanding any of the concepts taught in this unit please re-visit the unit again paying attention to all details and also seek information from other sources especially the internet.

## 2.6 ASSESSMENT QUESTIONS

Now let us find out how much you have understood this unit.

a

1. Which dietary component is not present in milk?
  - a) Fats
  - b) Fibre
  - c) Proteins
  - d) Carbohydrates
  
2. Which form of carbohydrates cannot be digested by human beings?
  - a) Starch
  - b) Maltose
  - c) sucrose
  - d) cellulose
  
3. What is the end product to the digestion of protein?
  - a) Glucose
  - b) Amino acids
  - c) Fatty acids
  - d) Glycerol

4. The following are the deficiency diseases except:
  - a) Marasmus
  - b) goitre
  - c) obesity
  - d) kwashiorkor
  
5. Lack of iodine in a diet results in:
  - a) Night blindness
  - b) Soft bones
  - c) Bleeding gums
  - d) Reduced mental and physical development
  
6. A positive test for starch would result in the following colour changes
  - a) Blue to brown
  - b) Blue to purple
  - c) Brown to purple
  - d) Brown to blue/black
  
7. Which 2 substances are mixed in a biuret test for proteins?
  - a) Sodium hydroxide and copper sulphate
  - b) Sodium hydroxide and ethanol
  - c) Ethanol and water
  - d) Food samples and albustix
  
8. Give an example of a reducing sugar?
  - a) Starch
  - b) Glucose
  - c) Maltose
  - d) Amino acids



9. The following are functions of the liver in the digestive process except:
- a) Store food
  - b) Produce bile
  - c) Absorb food from the small intestines
  - d) Store mineral salts and irons
10. Chemicals produced by the body in order to help digest food are called :
- a) saliva
  - b) bile
  - c) enzymes
  - d) nutrients
11. How does bile help in the digestive process?
- a) Emulsifies fats
  - b) Converts starch to glucose
  - c) Converts proteins to amino acids
  - d) Helps to produce stomach acids
12. In which part of the alimentary canal is water absorbed back into the body?
- a) Mouth
  - b) Stomach
  - c) Small intestines
  - d) Large intestines
13. Which food component should be given in large quantities to old age?
- a) starch
  - b) glucose
  - c) fats
  - d) vitamins

14. What colour shows a positive test to proteins using albusix?  
a) green  
b) purple  
c) brown  
d) blue
15. A positive test for using iodine shows what colour?  
a) Blue/black  
b) brown  
c) blue  
d) green

## STRUCTURED QUESTIONS

- Describe the benedict test for glucose [2]
- Describe how a diet for a patient in hospital should differ from that of a construction industry labourer [3]
- (a) Define the term 'Malnutrition' [2]  
(b) State 3 examples of deficiency diseases [3]
- State considerations that should be taken when choosing a balanced diet [3]
- Describe how the following organs help in the digestive process  
a) Liver  
b) Pancreas  
c) Colon  
d) Ileum  
e) Gall bladder [10]
- (a) What colour is Benedict's solution [2]  
(b) What is the positive result test for glucose using Benedict solution [2]
- Outline the main use of each type of teeth [3]

## SUGGESTED ANSWERS

1. B
2. D
3. B
4. C
5. D
6. D
7. A
8. B
9. C
10. C
11. A
12. D
13. D
14. A
15. A

## STRUCTURED QUESTIONS

1. Add benedict solution to food sample  
Heat the food sample over a water bath  
Solution turns from blue to brick red in the presence of glucose.
2. A construction industry labourer should be given a lot of carbohydrates and a hospital patient should be given lots of vitamins.
3. a) malnutrition- this is a diet with excess or less components of a balanced diet.  
b) Goitre, Kwashiorkor, Marasmus
4. Age, sex and occupation

5.
  - a) Liver – it produces bile, it stores and distributes food.
  - b) Pancreas- it produces enzymes for the final digestion of carbohydrates, proteins and fats.
  - c) Colon- It absorbs water and salts back into the body.
  - d) Ileum- for the absorption of the end product of digestion into the body.
  - e) Gall Bladder- stores bile
  
6.
  - a) Blue
  - b) Brick red
  
7.
  - a) Incisors for biting food
  - b) Canines for tearing flesh
  - c) Molars and pre-molars for grinding food

# UNIT 3: NUTRITION IN PLANTS

## CONTENTS

- 3.1 Photosynthesis
- 3.2 Factors affecting photosynthesis
- 3.3 Leaf internal structure
- 3.4 Assessment questions

## INTRODUCTION

Every living organism needs food to survive. Some depend on others for food and energy while others can produce their own food. Plants make their own food in a process called photosynthesis. This unit will help you understand the factors affecting the rate of photosynthesis and the leaf internal's structure so that you can appreciate much more other concepts covered in the next units. This unit covers how water, light, carbon dioxide and chlorophyll affect the rate of photosynthesis. You will be expected to examine the internal leaf structure. You need to refer to unit 1 of this course where some of the aspects you will cover in this unit were highlighted.



## OBJECTIVES

After going through this unit you should be able to:

- Describe experiments on factors which affect the rate of photosynthesis.
- Describe the internal structure of the leaf.



## KEY WORDS

You need to understand the following key words which will be used frequently in this unit. Remember if you come across any of the words in the context check again its meaning in the key words section.

**Chlorophyll** - green pigment found mostly in green leaves of plants.

**Chloroplasts** - a part of cell containing chlorophyll for photosynthesis.

**Diffusion** - movement of substance from an area of higher concentration to an area of low concentration.

**Osmosis** - movement of water particles from a region of higher concentration to a region of lower concentration through a semi permeable membrane.

**Photosynthesis** - a process whereby green plants manufacture carbohydrates and oxygen using water and carbon dioxide in the presence of sunlight and chlorophyll.

**Stomata** - pores in the epidermis of the leaf.

**Transpiration** - a process whereby plants lose water through the stomata.

**Vacuole** - space in the cytoplasm of a cell containing air, fluid and food particles.

**Variegated leaf** - refers to a leaf which has patches which are green and parts which are not green.

**Xylem** - these are vessels that carry water.



TIME: 8 HOURS



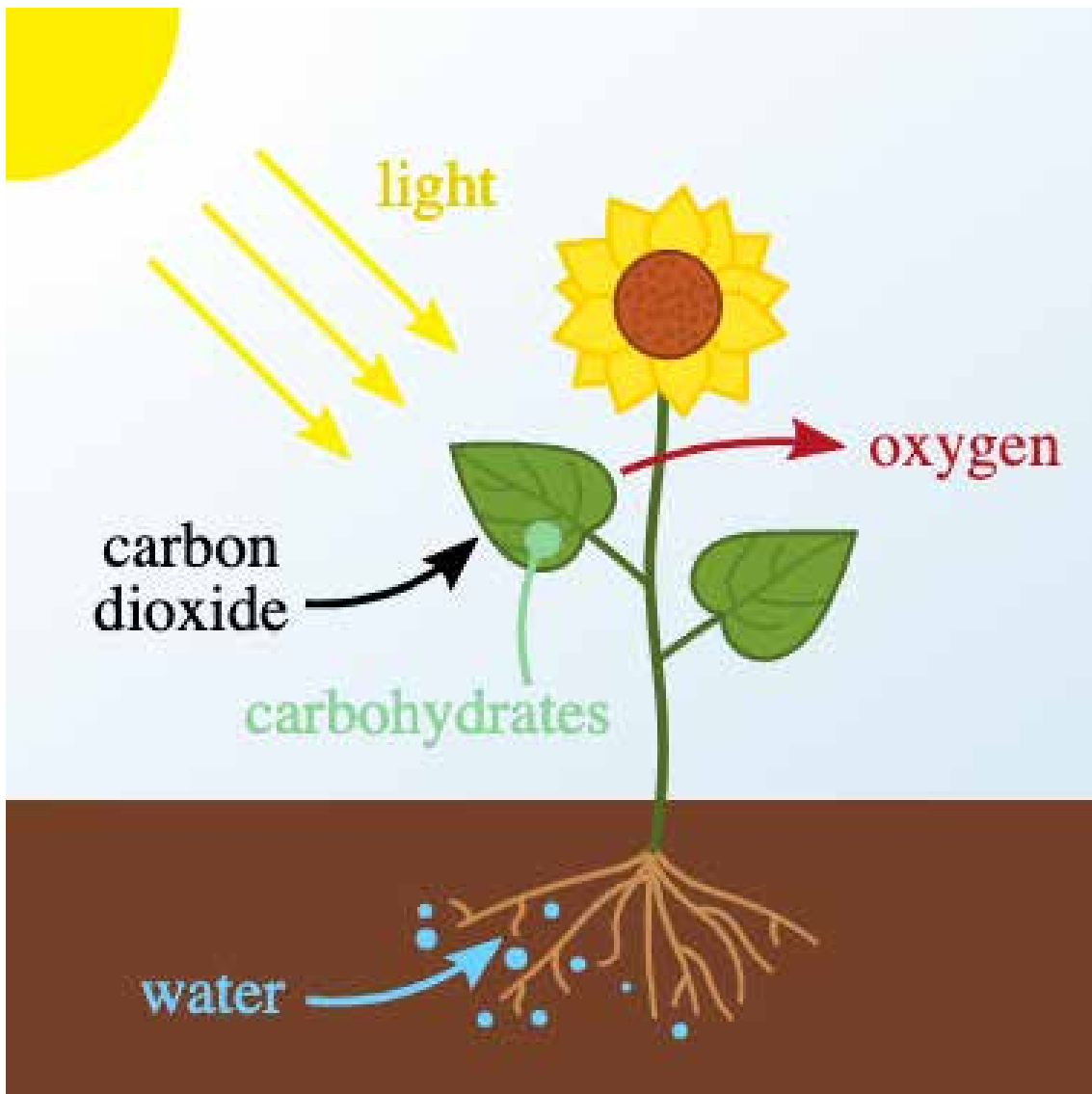
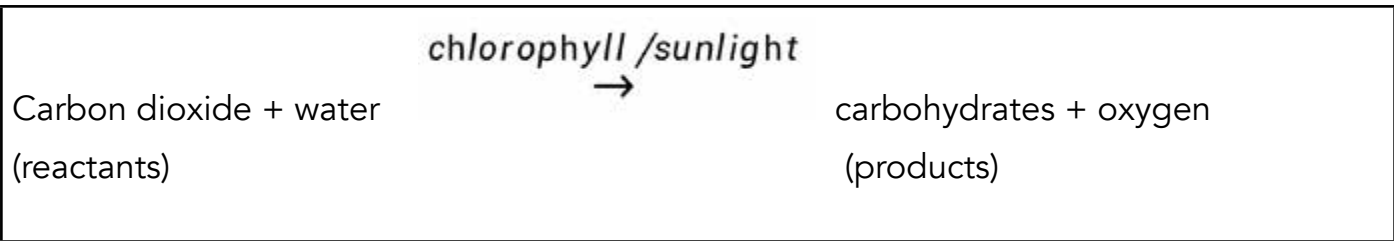
STUDY TIP

Remember if you come across any of the words in the context check again its meaning in the key words section. Photosynthesis is all about plants so in studying this unit ask yourself how plants make their own food. In order to understand this unit you need to have completed level one.

### 3.1. PHOTOSYNTHESIS

What is photosynthesis?

Photosynthesis is the key to survival of all species on earth and is one of the reasons why we see evidence of life in the planet. Did you know this fact? Try to define photosynthesis. Ok we hope you noted that plants make their own food through the process of photosynthesis. Animals feed on plants in order to obtain carbohydrates formed during the process of photosynthesis. Photosynthesis therefore is a process whereby plants make carbohydrates and release oxygen using water and carbon dioxide in the presence of sun light and chlorophyll. In short this process can be summarised by a word equation and the diagram shown below.



**Fig 3.1 process of photosynthesis**

## 3.2 FACTORS AFFECTING PHOTOSYNTHESIS

Raw materials are needed so that plants can make their own food through the process of photosynthesis. The following are the factors and how they are obtained:

- **Water**

Water enters through the root hairs by osmosis into the xylem.

- **Carbon dioxide**

Carbon dioxide enters through the stomata and diffuses into the spaces between the leaf cells.

- **Chlorophyll**

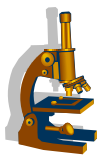
It is found in chloroplasts and is used to trap sunlight

- **Light**

This is the energy from the sun which is trapped by chlorophyll molecules of the chloroplasts. Light provides energy to break down carbon dioxide and water molecules and recombine them into glucose molecules.

You will recall that one of the main products of photosynthesis is starch. In order for you to know whether a named factor is important in the process of photosynthesis you therefore have to test the leaf for starch.





## Experiment 1

### Test for starch

Let us carry out an experiment to test if leaves manufacture starch during the process of photosynthesis.

### Aim

To find out if green leaves produce starch during photosynthesis.

### Apparatus/ materials

Iodine solution, green leaf, beaker, dropper, clear methylated spirit, burner and stand, a beaker, forceps, white tile or white paper

### Method

1. detach a green leaf from a well watered plant
2. boil the leaf in water in a beaker in order to kill the cells of the leaf and stop chemical reactions for five minutes
3. put the leaf in a test tube with methylated spirit and then put the test tube in the beaker with boiling water (water bath) as shown by the diagram below. The leaf is boiled in methylated spirit in order to remove chlorophyll (decolourise)

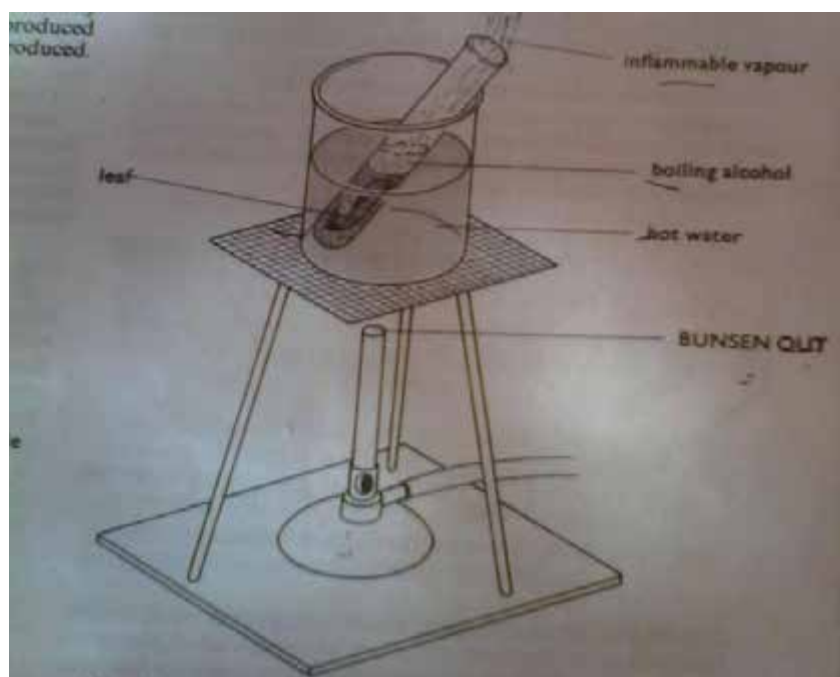


Fig 3.2 Test for starch

## Precaution

4. Switch off the burner because methylated spirit vapour is highly flammable
5. Remove the leaf from boiling methylated spirit after 3 minutes and put it in hot water. The leaf is put in hot water in order to make it soft
6. Remove the leaf from hot water using forceps and place it upside down on a white tile
7. Add a few drops of iodine solution using a dropper and make observations

## Observations

I hope you observed that the leaf felt brittle after removing it from the methylated spirit and when you dipped it for the second time in hot water the leaf became soft. I also hope you observed that the leaf turned blue-black after adding drops of iodine solution. The blue black colour shows presence of starch.

## Conclusion

We can conclude therefore that the leaf is a vital organ that manufactures starch during the process of photosynthesis. Now that you have tested the leaf for starch you need to find out the factors that can affect the production of starch in a leaf. The next sub unit will help you to find out whether the factors given affect the production of starch in leaves. Let us also reflect back on the equation of photosynthesis. Can you still remember the raw materials and products of photosynthesis? If you have forgotten, do not worry yourself go back to the equation of photosynthesis above? Now that you have remembered go ahead and read the next sub unit.

Now that you have carried out the experiment try to answer the following questions below. If you meet any difficulties in finding answers go back to the procedure above.



## Activity 1

1. Was starch present in the leaf? Give reasons for your answer.
2. How does the leaf feel after it is removed from the methylated spirit?
3. How does the leaf feel after dipping it in water for the second time?
4. What do you think is the reason for dipping the leaf in water for the second time?

The activities below will help you to understand that the above raw materials are necessary for photosynthesis to take place.

## Experiment 2

### Aim

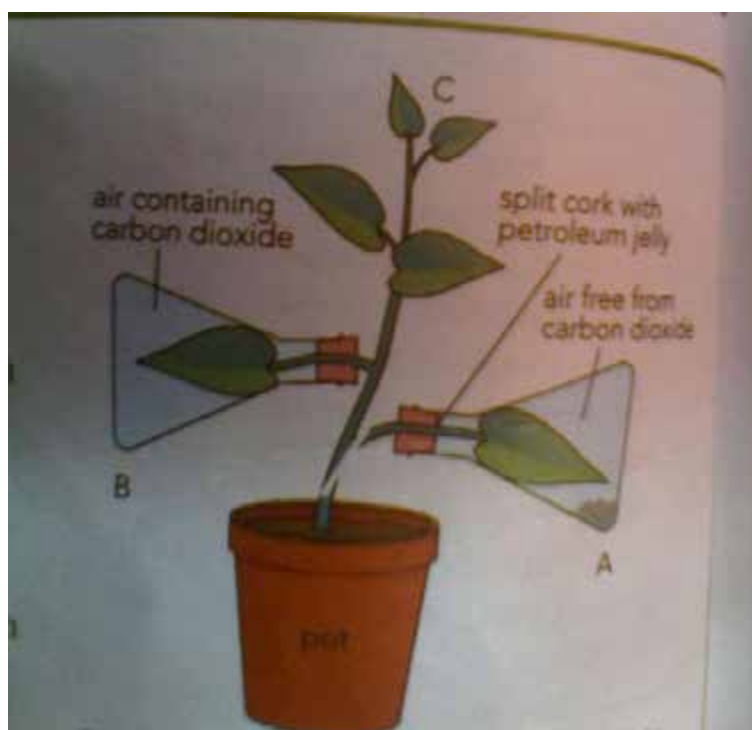
To investigate if carbon dioxide is necessary for photosynthesis to take place

### Apparatus/materials

Materials for starch test, 2 transparent bags, potassium hydroxide, sodium and hydrogen carbonate.

### Method

1. Take two potted plants and de starch them by putting them in a dark cupboard for 24 hours.
2. Put sodium hydrogen carbonate in one of the pots in Petri dish and sodium hydroxide in the other pot. Sodium hydrogen carbonate produces carbon dioxide and sodium hydroxide absorbs carbon dioxide.
3. Cover the potted plants with transparent plastic bags as shown in fig 3.3 below and leave them in sunlight for 3-4 hours. Why do you cover the potted plant with transparent plastics bag?



A - sodium hydroxide, B - sodium hydrogen carbonate

**Fig 3.3 test for carbon dioxide**

4. Detach one leaf from each plant and test for starch.

## Remember:

by the way how do we test for starch? (refer to experiment 1 if you have challenges.)

Now that you have done the above activity use the questions below to help you understand what you observed. If you find the questions difficulty read the observation below it will help you answer the questions.



## Activity 2

1. Which leaf stained brown and why?
2. Which leaf turned blue-black and why?
3. Name the chemical used to test for starch?

## Observation

The leaf with the bag containing sodium hydrogen carbonate turned blue black showing the presence of starch and the leaf from the bag with sodium hydroxide turned brown showing absence of starch. The set up with sodium hydrogen carbonate is known as the control and the one with sodium hydroxide is the experiment.

## Remember:

a control is a set up in which all the conditions necessary for a particular process to take place are present. The experiment is the set up in which one of the conditions for the process to take place is absent.

Reflection - In the above experiment which set up can you say is the control and which one is the experiment?

## Conclusion

Carbon dioxide is therefore necessary for the process of photosynthesis to take place. Now that you know carbon dioxide is necessary for photosynthesis to take place, you also need to investigate whether light is necessary for photosynthesis to take place.



## Experiment 3

### Aim

To investigate if light is necessary for photosynthesis

### Apparatus/materials

Potted plant, aluminium foil or an opaque material, cello tape, materials for starch test

### Method



**Fig 3.4 test for chlorophyll**

1. Put the potted plant in a dark cupboard for 24 hours in order to de-starch the plant.
2. Use aluminium foil paper to cover one leaf of the plant as shown in the diagram above.
3. Expose the potted plant with the leaf partly covered in sunlight for 3-4 hours.
4. Remove the aluminium foil and detach the leaf from the plant.
5. Test the leaf for starch.

### **Observations**

The covered part of the leaf turned brown and the uncovered part turned blue black after adding drops of iodine solution. If your results are similar to the ones above then you can safely deduce that starch is absent in covered part of the leaf and present in the uncovered part.

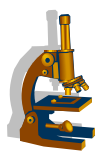
### **Conclusion**

Light is therefore necessary for photosynthesis to take place

### **Remember:**

You must have seen that carbon dioxide and light are necessary for photosynthesis to take place. This is because the leaf which is deprived of light and carbon dioxide stains brown and the one with all necessary conditions tests positive for starch.

The activity below will help you find out if chlorophyll is necessary for photosynthesis to take place. You will use a variegated leaf and if you have forgotten what it is go back to the key word section above.



## **Experiment 4**

### **Aim**

To investigate if chlorophyll is necessary for photosynthesis to take place

### **Apparatus/ materials**

Variegated leaf, apparatus for starch test

The photograph below shows variegated leaves



**Fig 3.5 variegated leaves**

### **Method**

1. Take a potted plant with variegated leaves (leaf with portions with chlorophyll and without) and de starch it by putting the plant in a dark cupboard for 24hours
2. Expose the de-starched plant in sunlight for 3-4hours
3. Test the leaf for starch.

### **Observations**

Parts of the leaf which were green turned blue black and those parts which were not green turned brown when iodine was added to the leaf.

### **Conclusion**

Chlorophyll is important for photosynthesis to take place

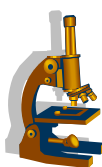
### **Remember:**

A plant is de starched by placing it in a dark cupboard for 24hours. The leaf is exposed to sunlight for some hours so that it receives sunlight. Sodium hydroxide is a chemical used to absorb carbon dioxide. To test for starch you need to refer to **experiment 1.1** of this unit. Now that you have investigated the factors that affect photosynthesis, in the next sub unit you will find out if oxygen is a product of photosynthesis.

## End products of photosynthesis

- Glucose is one of the products of photosynthesis. The glucose is used in the process of respiration in plants. Excess glucose is moved to storage areas such as the stem, roots, and the seeds where the glucose is stored in the form of starch. The sugars are transported to the storage areas in tubes called the phloem vessels. The carbohydrates are converted and stored as starch because starch is insoluble. The starch is converted to sugars whenever the plant requires energy for the process of respiration. Some of the stored starch is used as a source of food by animals as they eat the seeds, stems and the root tubers.

Oxygen is released into the atmosphere and used in respiration and combustion.



## EXPERIMENT 5

In this activity you are required to test whether oxygen is the gas that is released during the process of photosynthesis.

### Aim

To find out if oxygen is the gas that is given off during the process of photosynthesis

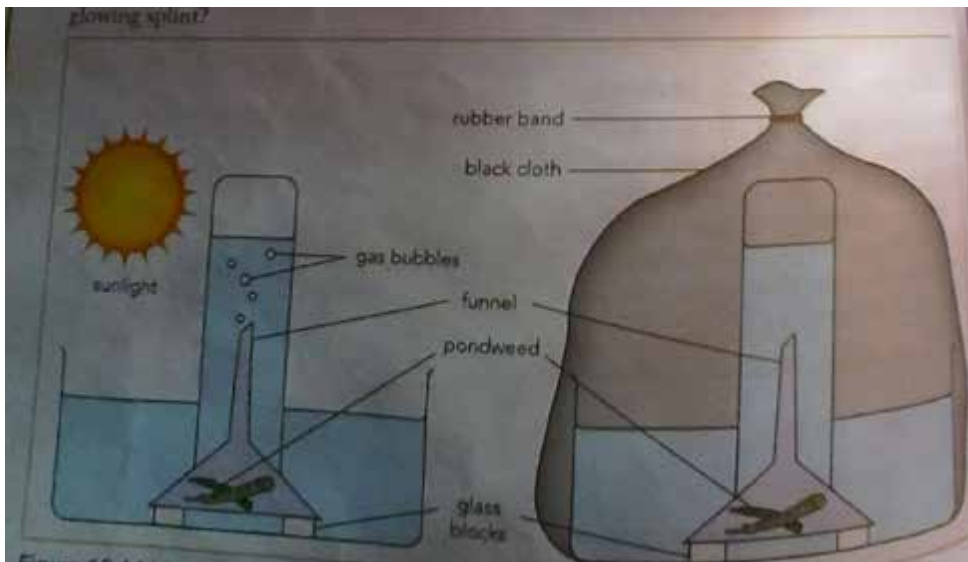
### Apparatus/Materials

Matches, wooden splint, large basin, test tube, glass funnel, elodea or any other water plant, sodium bicarbonate (baking soda) in solution.

### Method

1. Fill the basin with the solution (bicarbonate provides the plant with a source of carbon dioxide)
2. Half fill the beaker with water and place an inverted glass funnel in the beaker covering the pondweed.
3. Place an inverted test tube over the glass funnel as shown by the diagram below.





**Fig 3.6 Test for oxygen**

4. Leave the apparatus in sunlight for 8-10 hours.
5. Carefully remove the test tube with your thumb over the opening and insert a glowing splint into the tube.
6. Observe what happens to the glowing splint.

### Observations

The gas produced will relight a glowing splint or makes it glow brighter

### Conclusion

Oxygen relights a glowing splint, therefore the gas produced during photosynthesis is oxygen

### Example 1

You have noticed that firewood glows brighter or relights in the presence of air and this shows that there is oxygen gas in air.



### ACTIVITY 3

1. What gas was in the test tube?
2. Where was the gas coming from?

## Remember

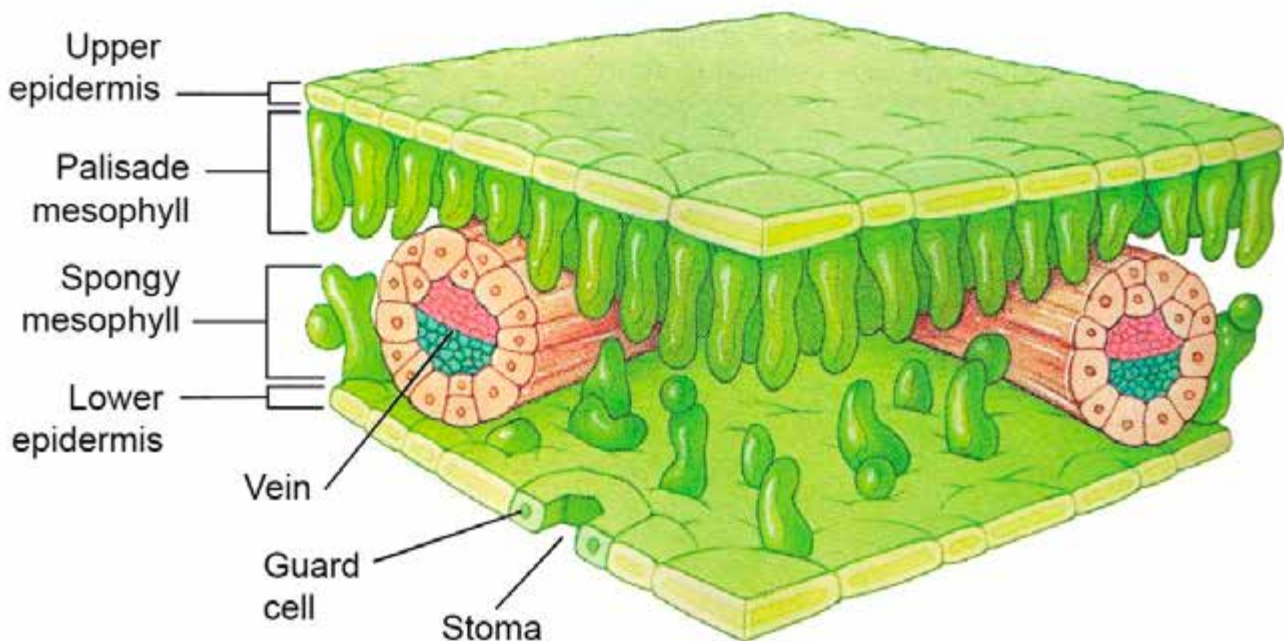
Hope you still remember that during the process of photosynthesis oxygen is released as a product by green leaves of plants.



## EXPERIMENT 6

In the above activities you have been using a leaf to carry out different experiments. Now you need to examine the internal structure of the leaf and what makes it suitable and important for photosynthesis.

### 3.3 THE INTERNAL STRUCTURE OF THE DICOTYLEDONOUS LEAF



**Fig 3.7 The internal structure of the dicotyledonous leaf**

## Remember:

From what you have learnt so far what can you say about the structure of the leaf and its adaptation for photosynthesis?

To answer the above questions, think of the raw materials for photosynthesis and the end products. If you have forgotten go back and read unit 3.1.

## Adaptations of a leaf for photosynthesis

Table 1

Structure of the leaf	Adaptation
Wide, thin and flat	Large surface area to absorb light and carbon dioxide Thinness of the leaf allows gases and sunlight to reach all cells of the leaf
More stomata on the lower surface	Allows exchange of gases, carbon dioxide and oxygen out of the leaf
Spongy loosely packed mesophyll cells with air spaces	Allows gases to diffuse easily between cells
Numerous chloroplasts in the palisade layer	Allows more sunlight energy to be absorbed
Elongated shape	Increases surface area for the absorption of sunlight energy
Network of veins	For adequate supply of water and mineral salts to the cells
Phloem tubes	For the transport of glucose produced during photosynthesis

### Remember:

The leaf is the main organ for photosynthesis. It has xylem vessels that carry water and minerals, phloem for the transportation of glucose. The leaf is also elongated, wide, thin flat and has many chloroplasts so as to absorb as much sunlight as possible. It also has palisade cells where glucose is made and stored as starch. In the next sub unit you are going to look at mineral nutrition.

## SUMMARY

Now that you have read widely about factors affecting the rate of photosynthesis and the leaf's internal structure you can now answer the questions below. If you find any difficulties go back to the unit and read again. It is worthwhile that you read and understand before attempting the questions. Use the spaces provided below to answer the questions. Let's see how much you know. To check your performances refer to end of unit assessment activities in section 3.

## 3.4 SAMPLE ASSESSMENT QUESTIONS

You have to answer all the questions in this section

### Multiple choice questions

#### Tick the appropriate answer

- In the test for starch, what colour does the solution turn if the starch is present?
  - blue black
  - green
  - purple
  - orange(1)
- Which one of the following equations best represents the process of photosynthesis?
  - oxygen + water  $\longrightarrow$  carbohydrates + carbon dioxide
  - water + carbon dioxide  $\longrightarrow$  oxygen + carbohydrates
  - carbon dioxide + water  $\xrightarrow{\text{sunlight / chlorophyll}}$  carbohydrates + oxygen
  - water + carbon dioxide  $\xrightarrow{\text{light / oxygen}}$  carbohydrates + chlorophyll
- Which conditions are necessary for photosynthesis to take place?
  - light, oxygen and water
  - oxygen, temperature and water
  - chlorophyll, carbon dioxide and water
  - carbon dioxide, water, chlorophyll, light

4. How is the leaf adapted for photosynthesis?
- A. it has a network of veins to transport water.
  - B. it turns blue-black when tested for starch.
  - C. it has roots to absorb water.
  - D. it is the main organ for photosynthesis.
5. What do you understand by the term xylem vessels?
- A. xylem vessels are part of phloem vessels.
  - B. xylem vessels carry sugars from the roots of the plant to the leaves.
  - C. xylem vessels transport water and mineral salts from the roots to the leaves.
  - D. xylem vessels store sugars.

### Structured questions

1(a) What is photosynthesis? (1)

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(b) Write down the word equation for photosynthesis. (1)

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(c) In your own words explain why photosynthesis is important? (3)

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(d) What happens to the organic end products of photosynthesis? (2)

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2. (a) There is a danger involved in the process for testing a leaf for starch. State what the danger is and how it may be overcome. (1)

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- (b) Leaves are adapted for the process of photosynthesis. Explain three adaptations which make the process more efficient. (2)

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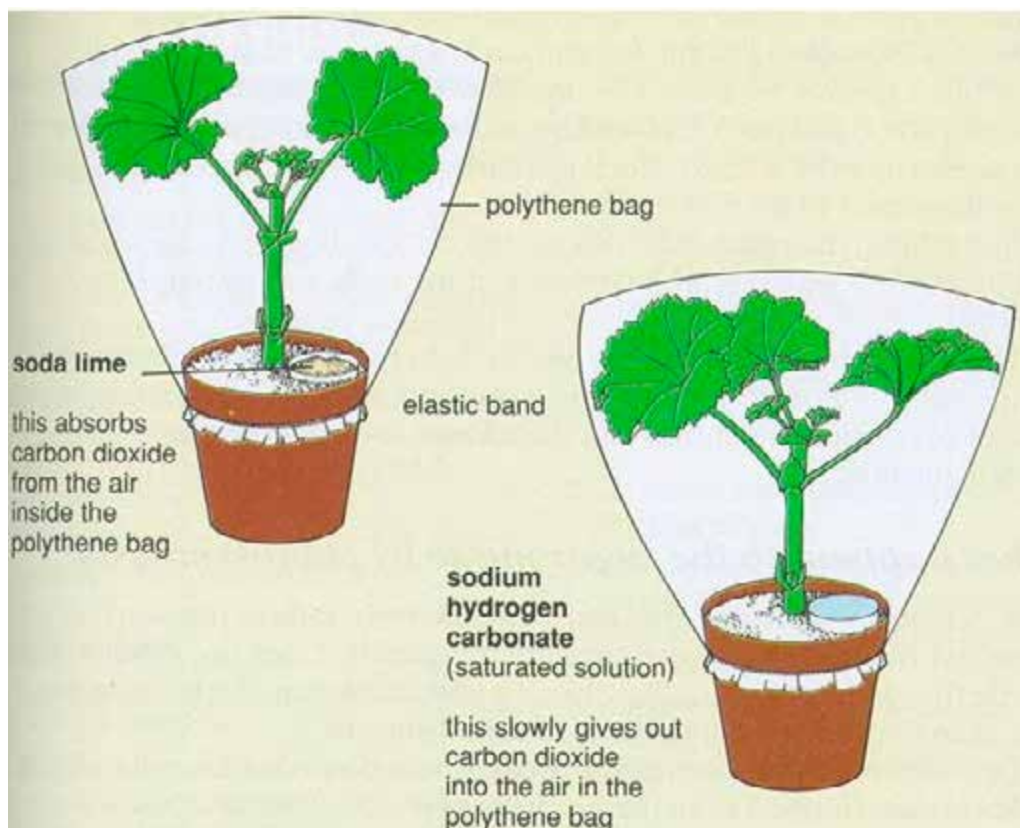
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### Practical question

3. The apparatus shown in fig 1.1 below was set up to find out if carbon dioxide is necessary for photosynthesis.



(a) Is this a controlled investigation? Give a reason for your answer.

-----  
-----  
-----  
-----  
-----  
----- (1)

(b) Name a solution which absorbs carbon dioxide (1)

\_\_\_\_\_

(c) How would you test after a few hours to find out if the plant had been photosynthesising?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2)

ii) Explain any expected results (1)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**TOTAL (20 MARKS)**

# SUGGESTED ANSWERS

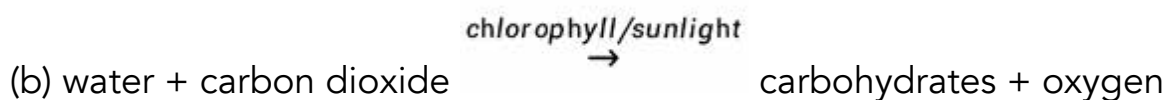
## UNIT 3-NUTRITION IN PLANTS

### MULTIPLE CHOICE

1. A
2. C
3. D
4. A
5. C

### STRUCTURED QUESTIONS

1. (a) photosynthesis is a process whereby green plants manufacture carbohydrates using water and carbon dioxide in the presence of chlorophyll and sunlight



(c) photosynthesis provides the primary source of food for all organisms

- it provides oxygen needed for respiration
- maintains a natural balance of carbon dioxide and oxygen in the atmosphere
- reduces effects of global warming

(d) used to supply energy

- used to make other sugars such as sucrose and fructose
- used to make other organic substances such as cellulose
- oxygen is used in respiration

2. (a) alcohol is highly flammable and you can overcome by switching the burner before using alcohol

(b) stoma - easy gaseous exchange

Veins - to carry water

Broad leaves - for large surface area to trap sun light

Air spaces between mesophyll cells - so that gases can be exchanged freely

Many chloroplasts - to trap sun light



- 3 (a) yes
- There are exposed and enclosed leaves
- (b) – lime water
- (c) (i) – destarch a leaf, boil in alcohol and add iodine solution to test for starch
- (ii) – the leaf which had all conditions present will test blue

# UNIT 4: RESPIRATORY SYSTEM

## CONTENTS

- 4.1 AEROBIC RESPIRATION
- 4.2 ANAEROBIC RESPIRATION
- 4.3 Roles and adaptation of the alveolus
- 4.4 The composition of inhaled and exhaled air
- 4.5 SAMPLE ASSESSMENT QUESTIONS

## INTRODUCTION

Do you know that your body works each and every moment of the day? Taking in oxygen and expelling carbon dioxide is one the work done by your bodies. It involves the contraction and expansion of the chest. For the process to take place it needs energy which we get from the food we eat. The energy is obtained from the food by the process of aerobic or cellular respiration which is initiated by the presence of oxygen. Cellular respiration takes place inside the cell and glucose is used to release energy. It is a life process which takes place in both plants and animals. It occurs in the cells. In this unit we are going to look at the differences between aerobic and anaerobic respiration.



## OBJECTIVES

After going through this unit, you should be able to:

- Define aerobic respiration
- Explain the process of aerobic respiration
- Define anaerobic respiration
- Explain the process of anaerobic respiration
- Carry out the experiments to determine whether germinating seeds produce carbon dioxide and oxygen
- Write down the equations for aerobic and anaerobic respiration
- Explain the role of the alveoli in gaseous exchange
- Describe the structural adaptations of the alveolus



## KEY WORDS

Here is a list of some of the new words you are going to meet in this unit:

**Alveolus** - tiny air sac in the lungs responsible for the exchange of gases to and from the blood

**Breathing** - the process whereby the lungs inhale and exhale air

**Diffusion** - the movement of substances from a region of higher concentration to a region of low concentration

**Inhalation** - the process of taking in air

**Exhalation** - the process of breathing out air

**Fermentation** - a process of undergoing a chemical change caused by the action of an organic substance such as yeast

**Respiration** - is the exchange of gases between a cell and its environment

**Oxyhaemoglobin** - the red substance formed when haemoglobin combine with oxygen



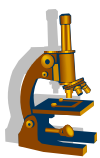
TIME: 8hours



STUDY TIPS

This unit contains simplified equations of respiration; try to write them on your own in order to assess understanding.

## 4.1 AEROBIC RESPIRATION



### Experiment 1

**Aim;** to demonstrate whether germinating seeds produce carbon dioxide

**Materials;** limewater, germinating seeds, soaked, boiled or dry seeds (beans or peas), two jars with seals, two net bags, string, petroleum jelly, 10% formalin or any preservative.

## Method

1. Put equal volumes of limewater into the two jars.
2. Hang a net bag with soaked and germinating seeds in jar A
3. Hang a net bag with dry or boiled seeds in jar B (boiled seeds must be washed with 10% formalin to prevent the growth of fungi)
4. Airtight the two jars with petroleum jelly
5. The jars must be left for 24hours.



## Experiment 2

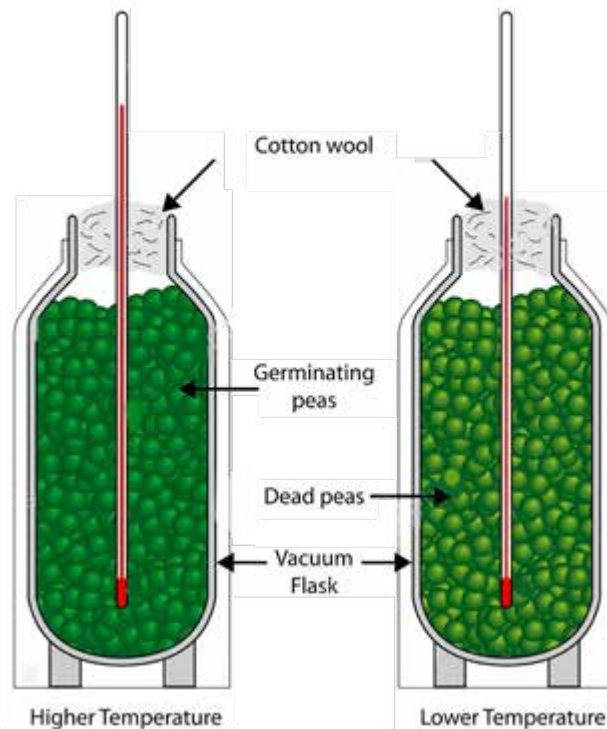
**Aim;** to find out whether germinating seeds produce heat

**Materials;** two vacuum flasks, burner, two thermometers, cotton wool, 10% formalin, 50cm<sup>3</sup> beaker full of seeds

## Method

1. Soak the seeds for 24hours.
2. Take half of the seeds and kill them by putting them in boiling water for five minutes. Wash them with formalin in order to sterilise them
3. Put living seeds in flask A and dead seeds in flask B
4. Put a thermometer in flask A and flask B then wedge them with cotton wool as shown in the diagram below:

## Energy Released During Germination

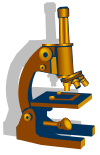


**Fig 4.1 germinating seeds**

5. Turn the flasks upside down carefully and make sure the bulb of the thermometer is surrounded by seeds to ensure accurate readings.
6. Record the temperature of the seeds in each flask at the same time every morning and evening for seven days.
7. Observations
  - What observations did you make?
  - I hope you made the following observations
    1. the temperature of the boiled seeds remains unchanged
    2. the temperature of the unboiled seeds increases gradually and levels off as seeds begin germinating.

### Conclusion

- heat is produced during the respiration process
- seeds respire and release energy during the germination process
- energy is released during the germinating process



## Experiment 3

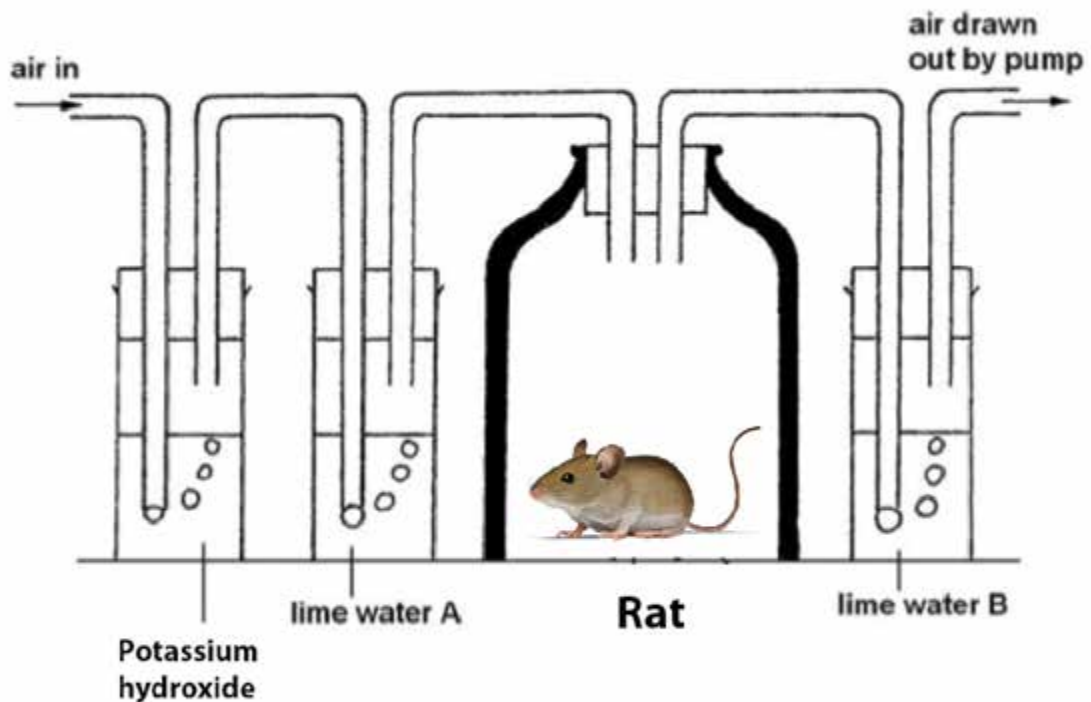
**Aim:** To show that living organisms produce carbon dioxide during respiration

### Apparatus / Materials

Lime water, test tubes, suction pump, jar, small animal (rat)

### Method

- 1 set up the apparatus as shown in the diagram below
- 2 record your observations after about 30 minutes



### Observations

What did you observe?

If you observed that

- 1 Limewater in test tube B turns milky, you are correct.
- 2 Potassium hydroxide is used to absorb carbon dioxide coming from the air.
- 3 Limewater in test tube A is used to test if air coming in does not contain carbon dioxide

## Conclusion

Organisms produce carbon dioxide during respiration

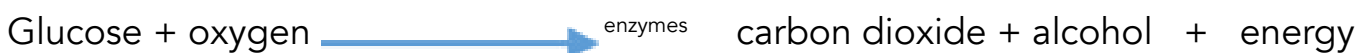
## 4.2 ANAEROBIC RESPIRATION

Anaerobic respiration takes place in the absence of oxygen. Glucose is broken down to release energy giving off alcohol and carbon dioxide or lactic acid. There is less energy produced in anaerobic than in aerobic respiration. The by products are carbon dioxide, alcohol and lactic acids produced during vigorous exercise.

### Alcoholic fermentation

Anaerobic can also take place yeast cells where glucose is broken down to release ethyl alcohol and this is called alcoholic fermentation. It gives off less energy than that of aerobic respiration. It is used by bacteria and yeast to get energy.

Alcoholic fermentation can be represented by the following equation;



### Lactic acid fermentation

This anaerobic respiration takes place in animals during vigorous exercise where you cannot breathe fast enough resulting in less energy to the to your muscle cells to keep them going. Muscle cells produce lactic acid which can be broken down into carbon dioxide and water. This can be done using a lot of energy and is the reason why we breathe very hard after exercise.

Lactic acid fermentation can be represented by the following equation:





## Activity 1

1. Differentiate between aerobic and anaerobic respiration
2. Write the word equation for aerobic respiration
3. Where in the cell can cellular respiration take place?
4. List 2 organisms that can use alcohol fermentation

### 4.3 Roles and adaptation of the alveolus

The alveoli have the following features to enable gaseous exchange to take place effectively;

- It has millions of tiny alveoli to create a large surface area for maximum diffusion and gaseous exchange.
- It has a thin wall to allow gases to diffuse quickly between the blood and the alveoli.
- It has a layer of moisture in gases dissolve to speed up the process.
- It is surrounded by a network of capillaries to accelerate gaseous exchange between the alveolus and the blood

#### **Gaseous exchange**

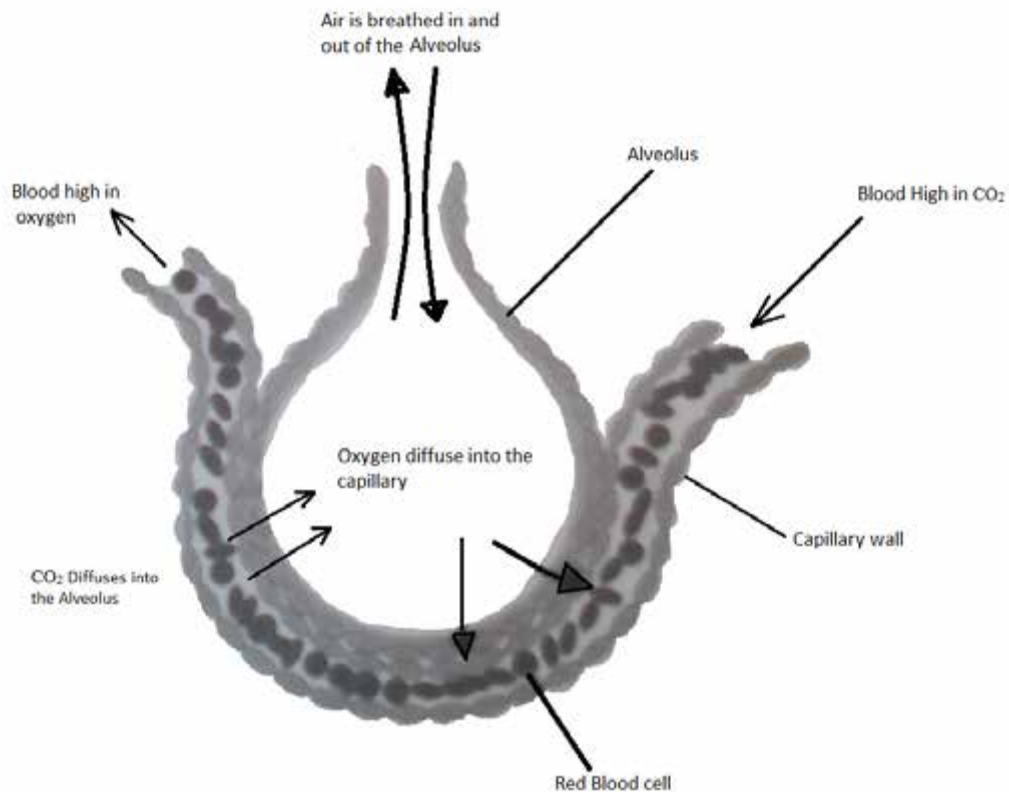
Gaseous exchange takes place in the alveoli of the lungs. When we inhale air, the oxygen in it diffuses into the blood through the lining of the alveoli. When we exhale air, carbon dioxide and water vapour is removed from the body. This process is called gaseous exchange. It is the movement of two different gases in opposite directions across the membrane.

#### **Roles of the alveoli in gaseous exchange**

Alveoli (alveolus single) are clusters of tiny air sacs found inside the lungs. The process of diffusion moves air into and out of the alveoli through the alveolar sacs. Each lung has millions of tiny alveoli providing a large surface area for the diffusion of oxygen and carbon dioxide. A network of capillaries surrounds each alveolus in order to allow a free exchange of gases between the alveolus and the blood. Inhaled air contains a lot of oxygen which will then dissolve in the moist lining of the alveolus. Oxyhaemoglobin is then formed when oxygen diffuses across the walls of the alveolus into the walls of the capillaries and combines with haemoglobin in the red blood cells.

Blood from the body cells is very rich in carbon dioxide therefore the concentration of carbon dioxide in the blood is greater than that in the air of the alveolus forcing it to diffuse out of the blood into the alveolus where it is removed from the body during exhalation.





**Fig 4.2 gaseous exchange in an alveolus**

### Adaptations of the alveoli for gaseous exchange

- they are thin walled for easy diffusion of gases
- they are moist inside to trap gases for longer period inside the air sacs
- they are surrounded by a higher network of blood capillaries to transport gases to and from the air sac

## 4.4 The composition of inhaled and exhaled air

Gas	Atmospheric air (inhaled air)	Exhaled air
Oxygen	21 %	16 %
Carbon dioxide	0.038 %	4 %
Nitrogen	78 %	78 %
Water vapour	Varies	saturated

Now let us find out what is happening during gaseous exchange by comparing the amounts of different gases in the air (inhaled air) with those gases in the air we breathe out (exhaled air). Table 1 showing inhaled and exhaled air.

The above table shows that the composition of inhaled air is different from that of exhaled air. We can see that the lungs absorb oxygen, which can be shown by the differences in concentration of inhaled and exhaled air (from 21% to 16%). The body gives out carbon dioxide and this can be explained by an increase in the amount of exhaled air which raises from 0,038% to 4%. The percentage of nitrogen remained the same in inhaled and exhaled air because it is an inert gas which does not react easily therefore it is not needed in respiration.



## Activity 2

Do the following experiment which will help you to conclude that carbon dioxide is produced during respiration.

### Aim

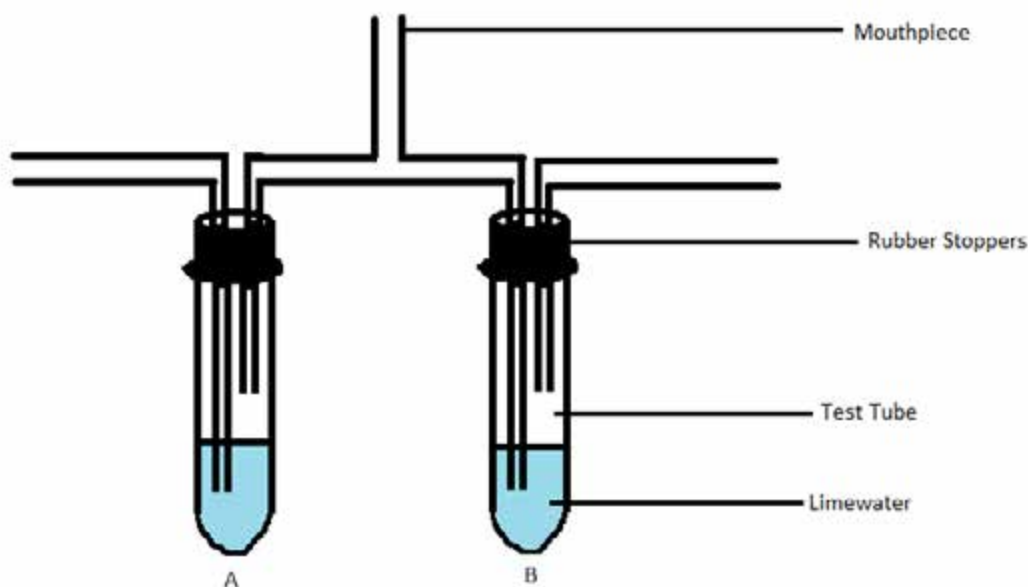
Compare the amount of carbon dioxide in inhaled and exhaled air.

Apparatus/materials

Bicarbonate indicator, lime water, two test tubes, two rubber stoppers with holes, four L-shaped glass tubes with long arms

### Method

1. Set the apparatus as shown below;



**Fig 4.3 comparing inhaled and exhaled air**

2. Breathe in and out of the apparatus gently
3. Atmospheric air is entering tube A and exhaled air is entering tube B

4. Observe what happens in test tube B
5. Try to come with a conclusion for your observation

## Observations

We hope you observed that lime water changed from clear to milky white in test tube B and also in test tube A there was no colour change.

## Conclusion

Inhaled air and exhaled air contain different amounts of carbon dioxide.

## SUMMARY

In this unit we traced the process of cellular respiration from the inhalation of air, what happens to it in the alveoli up to the process of exhalation of air. Are you able to trace the route of air from inhalation to exhalation? Yes, we hope this unit has helped you a lot to understand the process of cellular respiration. The alveolus has structural adaptations to ensure an efficient gaseous exchange. There are millions of tiny alveoli in the lungs in order to maximise the surface area for gaseous exchange. It also has thin, moist walls surrounded by a network of capillaries to accelerate gaseous exchange. The process of gaseous exchange can be noted by comparing the gas composition of inhaled and exhaled air.



## 4.5 SAMPLE ASSESSMENT QUESTIONS

1. Which organ is responsible for gaseous exchange in the body  
a) Trachea    b) lungs    c) bronchus    d) heart
2. The exchange of gases takes place in tiny sacs called....  
a) Villi    b) bronchi    c) alveoli    d) capillaries
3. Bacteria and fungi produce alcohol and carbon dioxide using  
a) Anaerobic respiration    b) lactic acid fermentation    c) aerobic respiration  
d) Breathing

4. Cellular respiration takes place in the

- a) Cells      b) bones      c) nose      d) trachea

5. The following are the by-products for anaerobic respiration

- a) Carbon dioxide + alcohol+ energy      b) lactic acid +energy  
c) Water + carbon dioxide + energy      d) glucose + water + energy

6. Which type of respiration takes place in the absence of oxygen?

- a) Anaerobic      b) alcohol fermentation      c) aerobic      d) glycolysis

7. a) State any two differences between anaerobic and aerobic respiration.

1.....  
.....  
.....

2.....  
.....  
.....[2]

b. i) during cellular respiration glucose and X react to produce carbon dioxide + water +energy

Name the reactant X.

.....[1]

ii) Identify two structural adaptations of the alveolus to its function.

1.....  
.....  
.....

2.....  
.....  
.....[2]

9a) Describe how the process of gaseous exchange takes place in the alveoli.

.....  
.....  
.....  
.....  
.....[4]

10. a) Describe the difference between breathing and respiration

.....  
.....  
.....  
.....  
.....[4]

b) Cellular respiration takes place in the.....  
and ends in the.....of a cell..... [2]

11.a) Briefly describe an experiment to find out whether germinating seeds produce heat.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....[6]

b) Why do we cover the bulbs of the thermometer with seed?

.....  
.....  
.....  
.....[2]

## UNIT 4 RESPIRATORY SYSTEM

### ASSESSMENT QUESTIONS - ANSWERS

- 1 B
- 2 A
- 3 B
- 4 C
- 5 B
- 6 A

7. a) 1. Anaerobic respiration takes place in the absence of oxygen and Aerobic respiration uses oxygen.

2. In Anaerobic respiration there is incomplete breakdown of glucose whereas in Aerobic respiration

glucose is completely broken down.

- Anaerobic respiration release less energy and Aerobic respiration release more energy [2]

b. i) the reactant X is Oxygen [1]

ii) · It has millions of tiny alveoli to create a large surface area for maximum diffusion and gaseous exchange.

· It has a thin wall to allow gases to diffuse quickly between the blood and the alveoli.

· It has a layer of moisture in gases dissolve to speed up the process.

· It is surrounded by a network of capillaries to accelerate gaseous exchange between the alveolus and the blood. [2]

9. a) Each lung has millions of tiny alveoli providing a large surface area for the diffusion of oxygen and carbon dioxide. A network of capillaries surrounds each alveolus in order to allow a free exchange of gases between the alveolus and the blood. Inhaled air contains a lot of oxygen which will then dissolve in the moist lining of the alveolus. Oxyhaemoglobin is then formed when oxygen diffuses across the walls of the alveolus into the walls of the capillaries and combines with haemoglobin in the red blood cells.

10.a) Breathing is the taking in and out of air into the lung and respiration is the exchange of gases between the cell and its environment.

- Breathing takes place in the lungs whereas respiration takes place between the cells. [4]

B cytoplasm

mitochondria [2]

11.a) Soak the seeds in water for one day then divide them into two equal groups. Put one group of the seeds in boiling water for 5 minutes in order to kill them. Put the living seeds in flask A and the dead seeds in flask B then put a thermometer and wedge with cotton wool. Carefully turn the flasks and record the temperature every morning and evening for seven days. [6]

b) To ensure accurate readings. [2]

# UNIT 5: TRANSPORT SYSTEMS IN PLANTS

## CONTENTS

- 5.1 Transpiration and factors that affect the rate of transpiration
- 5.2 Measuring transpiration in plants
- 5.3 Importance of transpiration
- 5.4 Adaptation of leaves
- 5.5 Plasmolysis and turgidity
- 5.6 Sample Assessment questions

## INTRODUCTION

Like you and all other organisms in the world, plants also need water and nutrients from the environment in order to survive. In level one you learnt about osmosis, diffusion and active uptake which describe how water and mineral ions move into plants through the root hair systems. You also learnt about the circulatory system which involves the movement of blood. In this unit therefore, you are going to look at how water is lost in plants and the factors that affect transpiration. You will also be required to measure the rate of transpiration and its importance. Below you will find the key terms that are frequently used in this unit and their meanings.



## OBJECTIVES

- Explain the process of transpiration.
- State the factors affecting the rate of transpiration.
- Measure transpiration in plants.
- Outline the importance of transpiration.
- Describe adaptations of plant leaves to reduce transpiration.
- Explain the terms plasmolysis and turgidity.
- Describe the effects of water loss and water gain in plants.



## KEYWORDS

**Concentration gradient** - the difference of concentration of a substance over a distance.

**Flaccidity** - soft and less rigid

**Humidity** - the amount of water vapour in the atmosphere

**Plasmolysis** - is a process the process when plant cells lose water after being placed in a solution that has a higher concentration of solutes than the cell does.

**Potometer** – an instrument used to measure the rate of transpiration.

**Rate of transpiration** - speed at which plants loses water

**Stomata** – are very small openings or pores found in the epidermal cells of plants through which water and gases pass.

**Transpiration** - it is the process whereby plants lose water to the atmosphere through openings on the leaf called the stomata.

**Turgidity** – swollen cells

**Turgor pressure** - an outward force within the cell that pushes the plasma membrane against a cell wall

**Xylem** - plant tissue that carries water to the leaf



## Time: 8 hours

### Remember:

In level one you learnt that the movement of water and mineral salts inside a plant occurs through two main processes which are (i) diffusion (ii) osmosis. Osmosis and diffusion occur when there is a concentration gradient, so there is a concentration gradient between water in the soil and water in the cells of the root hairs.

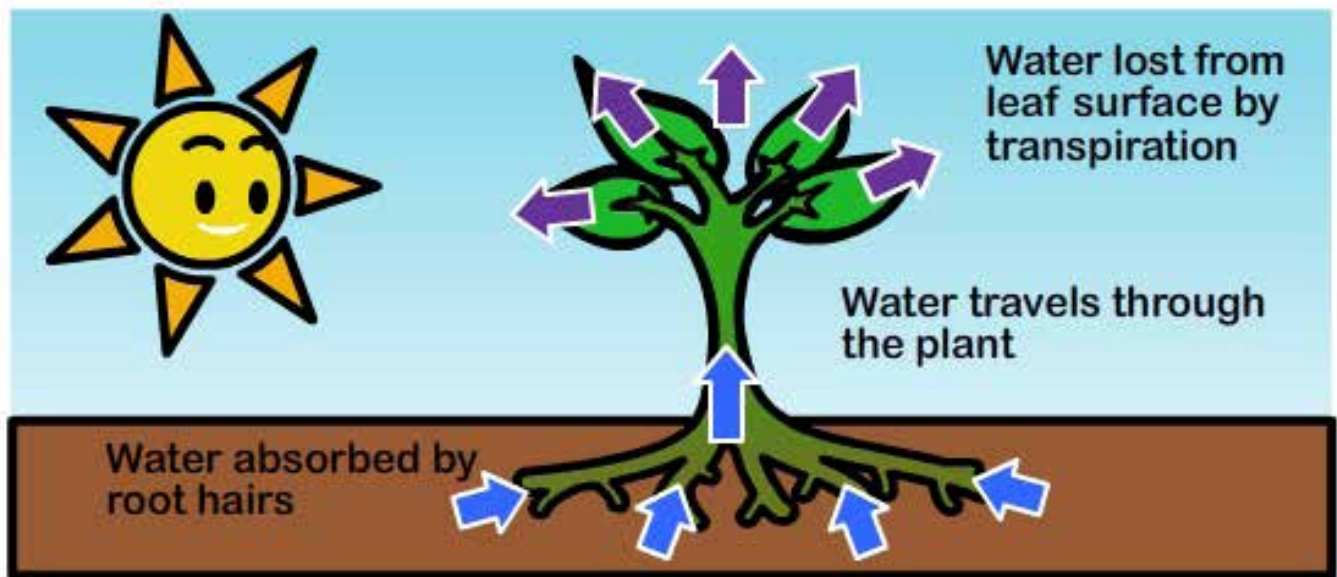
## 5.1 TRANSPIRATION AND FACTORS AFFECTING TRANSPIRATION

### What then is transpiration in plants?

Transpiration in plants is the process whereby plants lose water vapour from the leaves through the stomata to the atmosphere. Xylem vessels carry water from soil and mineral salts to the leaves. In the leaf, the water moves from the cells into the air spaces and due to the heat from the sun the water changes from a liquid to gaseous form. The gas particles (water vapour) then diffuse through the stomata and out



into the open air where it is lowly concentrated. Fig 5.1 below shows the process of transpiration.



**Fig 5.1 Process of transpiration in plants**

Transpiration is influenced by a number of factors. These factors either increase or reduce the rate of transpiration.



## STUDY SKILLS

Before you attempt the activity below, examine a variety of leaves to see any features that help in reducing water loss. Also think about the surface of the leaf.



## ACTIVITY 1

Which factors do you think affect the rate of transpiration? We hope from your examination of the leaf you discovered that the leaf has a large surface area and a network of veins. Let's look at the factors below that affect the rate of transpiration.

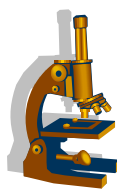
Factors affecting the transpiration rate

- Stomata –the more stomata there are in a leaf the higher the rate of transpiration, less stomata means the rate of transpiration is also likely to be low.
- Surface area –the larger the surface area the higher the rate of transpiration and when the leaves are narrow they have a small surface area and the rate of transpiration will be low

- Temperature –when the temperature is high the rate of transpiration also increases this is because high temperatures increase rate of evaporation. Low temperatures reduce the rate of transpiration since evaporation will be low.
- Humidity –when humidity is high transpiration is low because there will be more water vapour in the atmosphere than in the plant. The concentration gradient is very low when humidity is high. When humidity is low the concentration gradient is steep and transpiration will be high
- Wind/air –when air is moving it carries away water vapour around the leaves leaving room for more water loss from the leaves. So if wind speed increases also transpiration increases
- Light intensity-an increase in light intensity increases the rate of transpiration because light causes the stomata to open. In darkness the stomata close and they are stimulated to open by light.

**Note:** Some trees have leaves with small surface area so they transpire less. You might have seen that there is waxy/cuticle in the leaves, this also reduce water loss. Water cannot escape waxy layer for example in pumpkin leaves. The presence of hairs on the leaf trap water vapour and air thus lessen the loss of more water. Stoma opens during the day and closes at night thus why leaves look firm in the morning. During drought seasons the stomata close most of the time to save water. You might have also noticed that Mopani leaves hang vertically so as to reduce the surface area and reduce water loss. Leaves have few stomata on the upper surface to ensure that the direct rays from the sun are prevented from striking most of the stomata as they are on the lower surface.

You will now carry out an experiment to investigate which surface of the leaf loses more water.



## Experiment 1

### Aim

To determine which surface of a leaf loses more water vapour.

### Apparatus/Materials

Four leaves of similar size, Vaseline, two retort stands, string, balance

## Method

1. Take four leaves of similar size.
2. Label the leaves A-D as shown below.

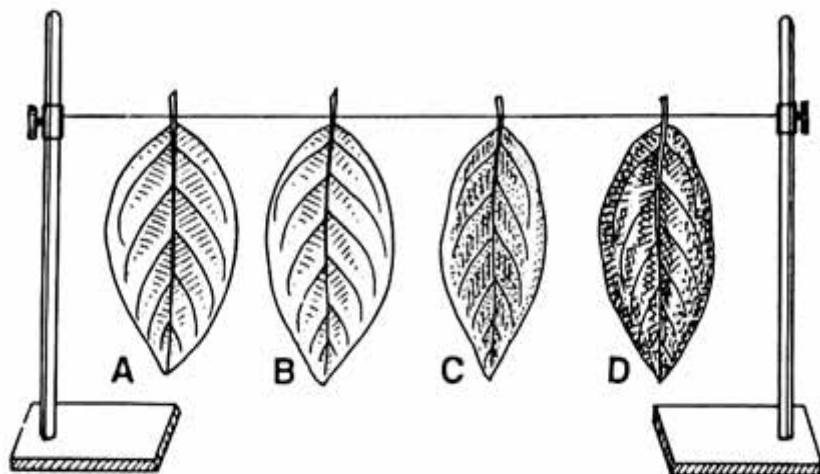


Fig. 2.24. Comparison of transpiration. Demonstration by four leaves.

## Fig 5.2 effects of transpiration

3. Leave leaf A not covered.
4. Smear the underside of leaf B with Vaseline.
5. Cover the lower side of leaf C with Vaseline.
6. Smear leaf D both surfaces with Vaseline.
7. Weigh each of the leaves on the balance and record the results on a table.
8. Place a little Vaseline on the cut end of the stalk and suspend a piece of string between two retort stands and attach each of the four leaves to the string. Leave in sunlight for 2 hours.
9. Observe the appearance of the leaves and reweigh them and record.
10. Calculate the loss in mass of each of the leaves.

**Note:** to calculate the loss in mass use the formula below:

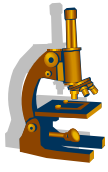
Loss in mass = initial mass of the leaf-final mass of the leaf

## Observations

You might have discovered that leaf D does not lose water at all, leaf A loses water, leaf C loses little water and leaf A dries out fast. More water is lost at A because more stomata are on the lower surface of the leaf.

## Conclusion

The lower surfaces lose more water than the upper surface of the leaf.  
Carry out another experiment to prove that plants lose water.



## Experiment 2

### Aim

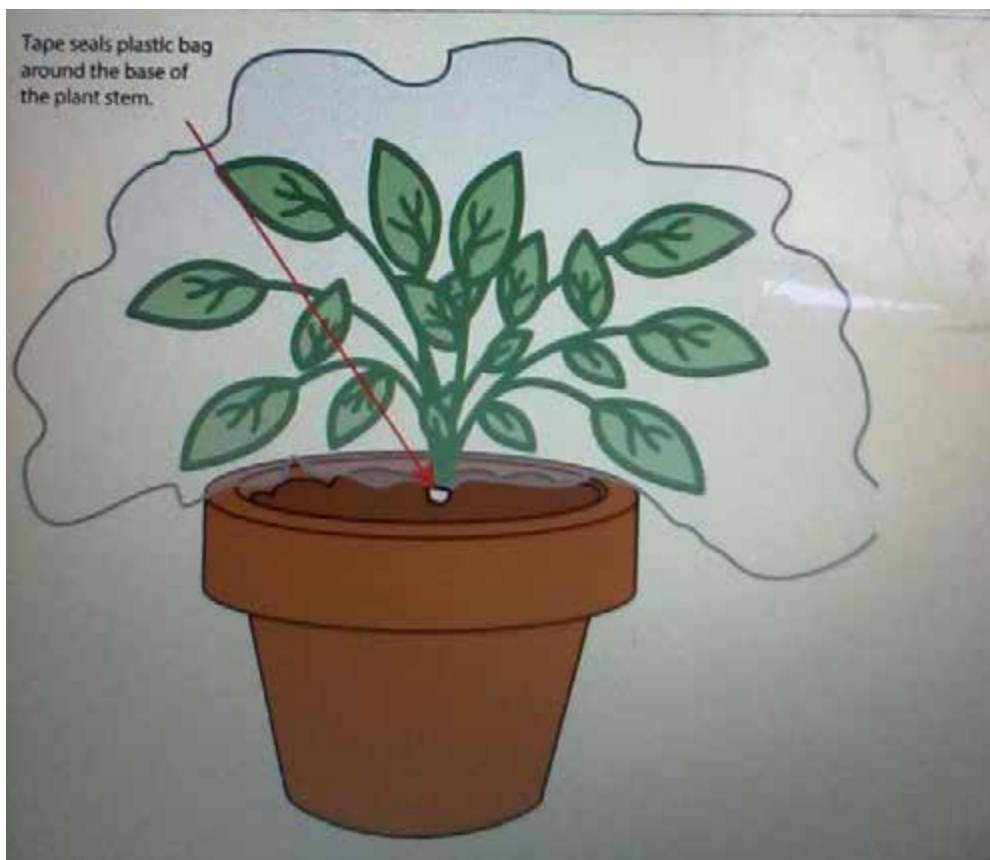
To investigate if plants lose water through leaves

### Apparatus/Materials

One potted plant with leaves, one potted plant without leaves, plastic bag, rubber band and blue anhydrous cobalt chloride paper

### Method

1. Put a transparent bag over both potted plant as shown in the diagram be



*Fig 5.3 to prove that water is lost through leaves*

2. Leave the set up for about 6 hours
3. After 6 hours observe the results
4. If there is a liquid on the plastic paper drop it on blue cobalt chloride paper to check if it is water



**Note:** the blue cobalt paper is used to test for water

### Observations

Hope you observed that there are droplets of water in the transparent plastic bag with leaves and the one without leaves there are no droplets of water.

If you do not see the droplets of water redo the experiment and leave the apparatus for some time until you observe water droplets.

### Results

The blue cobalt paper turns pink which is the positive test for water. Plants therefore, lose water by transpiration through leaves.

### Remember

Now that you have seen the cobalt paper turning pink this shows that water has moved from the plant to the transparent bag. Therefore, you can now conclude that plants lose water by transpiration. You now know that temperatures, surface area, stomata among others are the factors that affect the rate of transpiration. The rate of transpiration is measured using an instrument called a potometer.

## 5.2 Measuring the rate of transpiration in plants

A potometer is an instrument used to measure the rate of water uptake and water loss by the plant. In the next sub unit, you are going to carry out experiments to measure transpiration in plants and using the potometer to demonstrate how water is lost or gained by plants.

### Measuring transpiration in plants.



## Experiment 5.3

### AIM

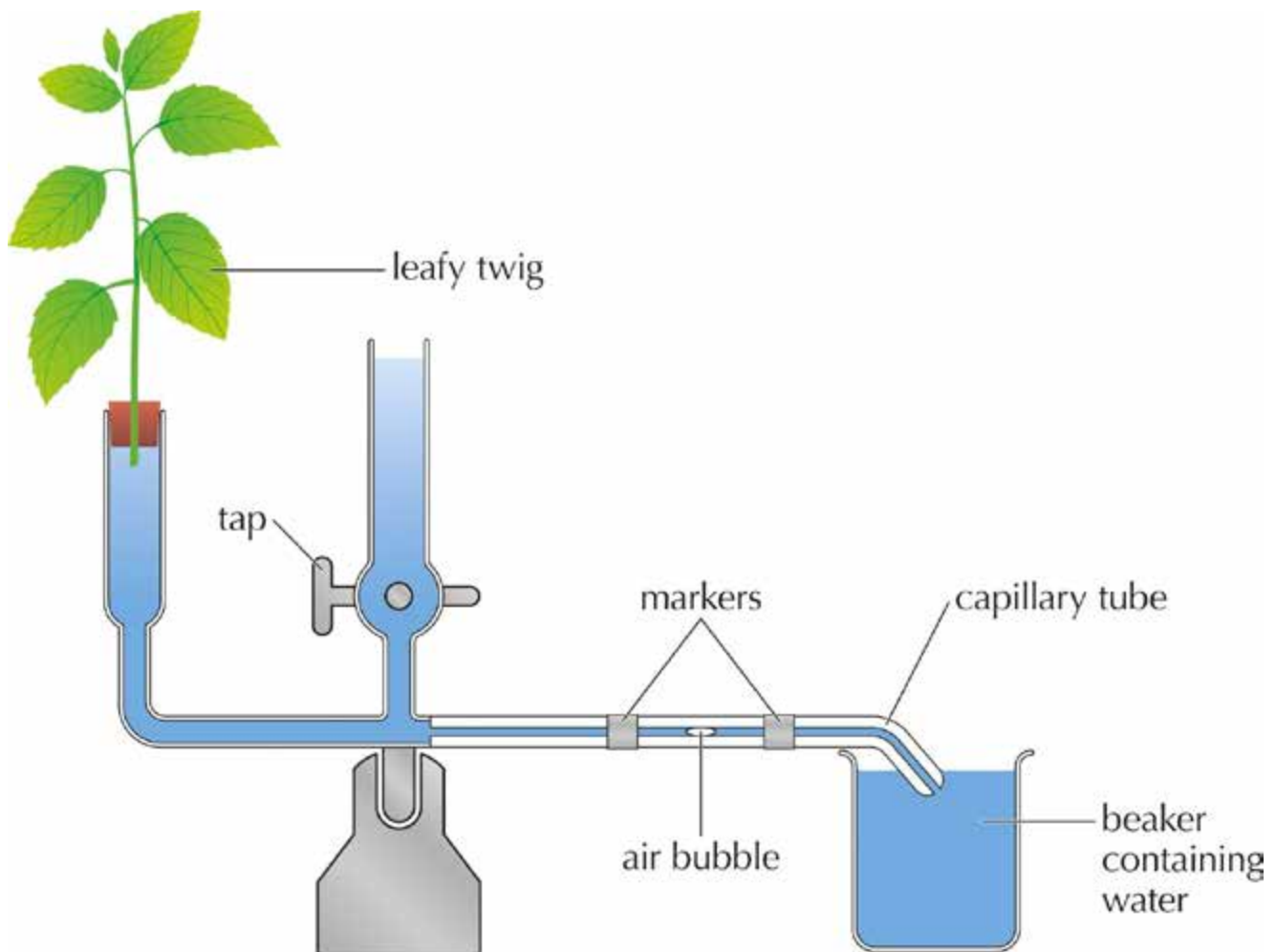
To measure the rate of transpiration in a plant

### Apparatus/Materials

Leafy twig, beaker, water, potometer, rubber band, Vaseline

### Method

Note: the apparatus must be tightly sealed to stop the upward movement of water



**Fig 5.4 The potometer**

1. Fill the beaker with water
2. Cut the leafy twig in water to prevent air from entering
3. Place the leafy twig into the rubber stopper while still holding it under water
4. Place the rubber band as shown in the diagram above
5. Seal all joints and exposed areas with petroleum jelly
6. Keep one bubble in the capillary tube by opening the top of the reservoir
7. Measure the distance the bubble moves along the capillary tube every 5 minutes for 30 minutes
8. Use the below table to record your results

**Table 1**

Time (minutes)	0	5	10	15	20	25	30
Volume of water (ml)							

9. Calculate the rate of transpiration

 **Note:** to calculate the rate of transpiration use the formula below

$$\text{Rate of transpiration} = \frac{\text{volume of water lost}}{\text{Time}}$$

### Observations

You must have seen that water moves into the tube to push other bubbles into the beaker. The distance the bubble travels shows how much water the stem has taken up. The rate of movement of the bubble represents water loss in (ml) by the plant during transpiration.

### Results

The plant uses water from the potometer because the leaves transpire and the water level in the beaker drops as a result.



## Activity 3

1. Define transpiration
2. a) List two factors that affect the rate of transpiration  
b) Using the factors you listed in (2a) explain how they affect transpiration?
3. Why must the stem of the leafy twig be cut under water?
4. Why does the level of the water in the beaker drops?
5. What is the reason for sealing the apparatus?



## Study tips

In order to find the answers to the above questions go back to the last sub units and read again. This will help you to find answers and to remember what you have learnt.



## Activity 4

It is said that transpiration is important in plants, do you think so? Give reasons for your answer.

## 5.3 Importance of transpiration

I hope in the above activity you mentioned that transpiration is important because it helps the plant to take up water and mineral salts. It also helps in cooling the plant. Not all water taken up will be transpired, some will be used in photosynthesis; some is absorbed by cells to increase their turgor.



## Activity 5

Since transpiration occurs mostly in leaves it means that the leaves have special features that make them suitable for their function. Using your knowledge from unit 3, how are leaves adapted for transpiration. If you cannot remember don't worry yourself read the next sub unit below.



## 5.4 Adaptation of plant leaves to reduce transpiration



### Activity 6

Examine a variety of leaves to see if any features help in reducing water loss. Think about the surface of the leaf and other features found in plants that might reduce water loss. The following bullets will help you to understand how leaves are adapted to reduce photosynthesis.

- If the leaf has waxy or cuticle on its surface it closes the stomata hence reducing water loss
- Hairs on the underneath of the leaf trap moisture and reduce the concentration gradient hence reducing the rate of transpiration
- There is less water loss from the leaf if the stomata are on the lower surface as that surface is not exposed to a lot of heat.
- Small leaves to reduce surface area
- Curly leaves to hide the stomata inside the leaf

You might have discovered that not all plants are adapted to reduce water loss especially the flowers and vegetables which you grow in your gardens. Usually you water these plants regularly if you do not the plants tend to lose more water than they absorb from the soil. This means that the leaf cells lose water and they become soft and they hang down. You may have seen such plants in the vegetable garden on hot dry days. This excessive loss of water from the cells is called plasmolysis and when the cells gain water we refer to it as turgid. In the next sub unit, you are going to look at plasmolysis and turgidity.

## 5.5 PLASMOLYSIS AND TURGIDITY

### Plasmolysis

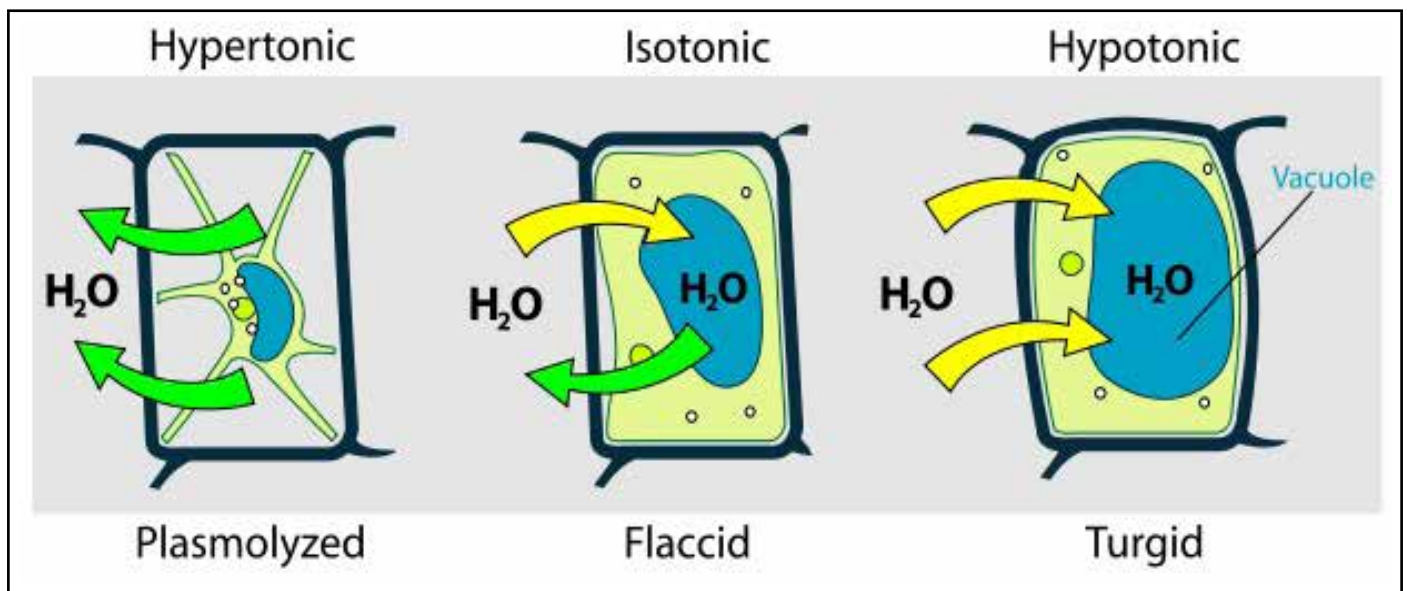
This is the process whereby plant cells lose water. The vacuoles shrink and cytoplasm moves away from the cell wall. The cells become flexible and are said to be flaccid or plasmolysed.

### Turgidity

This means that the cell is completely filled with water and cannot absorb more water. Vacuoles become full and push the cytoplasm against the cell wall. The cells become firm and are said to be turgid.

The diagrams below show a turgid cell, flaccid and plasmolysed cells.

Plasmolysed cell Turgid cell

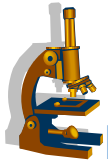


**Fig 5.5 showing cells that have lost or gained water**

You have now seen the plasmolysed and turgid cell. In the next activity you are going to carry out an experiment which shows how plant cells lose and gain water by plasmolysis and turgidity respectively.



## Activity 5.7



## Experiment 1

### Aim

To demonstrate turgidity and plasmolysis.

### Apparatus/Materials

1 large potato, 2 tins containing equal volumes of water, salt/sugar, scale

### METHOD

1. Slice the potato lengthwise 5mm, 3mm and 2mm thick.
2. Weigh the potato pieces and record the results in a table below.

**Table 2**

Thickness of potato (mm)	Initial mass (g)	Final mass in water (g)	Final mass in salt/sugar water (g)
5			
3			
2			

3. Add two table spoons of salt or sugar to one of the dishes and stir until it dissolves.
4. Put half of the potatoes in the dish containing only water.
5. Put the remaining half of remaining potato pieces in the dish of salt/sugar water.
6. Let the potatoes soak overnight.
7. Compare the appearance and size of the potatoes.
8. Weigh the potato pieces again and record the results in the table above.

### Observations

You must have observed that the potato pieces in water remain the same, full and turgid. Potato pieces in salt/sugar solution decrease in mass.

### Conclusion

The cells of the potato in water remain turgid and the potato cells in salt/sugar solution become plasmolysed.

You have now carried out the experiment to show that plasmolysis and turgidity occurs in plant cells if they lose or gain water. Now let's check how much you know.



### Activity 6

1. Compare and discuss the results you recorded in the experiment 1.3 above.
2. Explain what could happen if you added more salt to the water.
3. Define the words osmosis, plasmolysed cell and turgid cell.
4. Draw a diagram of a potato cell after 24 hours in a concentrated solution (salt/sugar water).

## SUMMARY

To sum up in this unit you have learnt that transpiration is the loss of water from the plants. This process has both disadvantages and advantages to the plants. The disadvantage is that a lot of water is lost and cannot be used in photosynthesis. Transpiration process on the other hand aids in the continuous flow of water from the roots up the stems and leaves. It helps the plant to take up dissolved mineral salts and cools the plant when there are higher temperatures. The disadvantage is that if a plant loses more water than it can absorb it becomes soft, flaccid/plasmolysed and eventually dies. You have also learnt that the rate of transpiration is affected by environmental factors such as light, heat, air and wind. Leaves have special features that make them adaptable to transpiration such as hairs, cuticle and the number of stomata and position on a leaf.

Now you are ready to answer the following questions below. If you have any difficulties in answering, go back to unit 5 and read again. To check your performance, refer to end of unit activities in section 5. Use the spaces provided for answering.

## 5.6 SAMPLE- ASSESSMENT QUESTIONS

### Multiple choice questions

**Note:** Circle the letter with the correct answer

1. What is transpiration? (1)
  - A. A process whereby plants manufacture their food using sunlight.
  - B. A process whereby plants lose water from the leaves.
  - C. Movement of water and mineral salts through xylem vessels.
  - D. Movement of sugars through phloem vessels.
  
2. What other factors apart from humidity affect the rate of water loss in plants? (1)
  - A. Number of leaves, hairs on leaf surface, position of stomata.
  - B. Temperature, wind, light
  - C. Water, carbon dioxide, temperature.
  - D. Chlorophyll, sunlight, hairs on leaf surface.

3. What is the correct scientific term used to refer to a plant cell which is full of water?(1)
- A. Plasmolysis
  - B. Turgid
  - C. Xylem
  - D. Osmosis
4. How is the leaf adapted for transpiration? (1)
- A. It has cuticle on its surface.
  - B. It has veins and stomata that transport water.
  - C. It is green in colour.
  - D. It has a thin surface.
5. What happens if you put a piece of potato in sugar solution? (1)
- A. It gains water and becomes turgid.
  - B. It tastes sugary.
  - C. It loses water and become flaccid.
  - D. Nothing changes.

### Structured questions

1a) What do you understand by the following terms?

- (i) Plasmolysed cell (1)
- (ii) Turgidity (1)
- (iii) Plasmolysis (1)

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## SUGGESTED ANSWERS.

### MULTIPLE CHOICE

1. B
2. B
3. B
4. A
5. C

### STRUCTURED QUESTIONS

- 1 (a) (i) plasmolysed cell-it is when the cell lose its turgidity and the membrane shrinks  
(ii) turgidity- swollen cells which are full of water  
(iii) plasmolysis- a process when plant cell lose water after being placed in a solution that has a higher concentration of solutes than the cell does
- (b) - it helps in the uptake of water and mineral salts in the plant  
- it helps in cooling the plant  
- it helps cells to increase their turgor
- 2 (a) - low humidity  
- high light intensity  
- windy and dry air

(b) mopane leaves have thick cuticle on the surfaces so as to close the stomata. This is necessary because it helps cells to retain their turgidity

# UNIT 6: REPRODUCTION IN PLANTS

## CONTENTS

- 6.1 Asexual reproduction in plants
- 6.2 Sexual reproduction in plants
- 6.3 Comparing sexual and asexual reproduction
- 6.4 Germination
- 6.5 Conditions necessary for germination
- 6.6 Sample Assessment questions

## INTRODUCTION

Plants like all other organisms need to produce young ones so that they do not become extinct. In this unit you are going to explore how plants reproduce sexually and asexually. You will also learn about germination. Enjoy the unit.



## OBJECTIVES

After going through this unit, you should be able to:

- Define plant reproduction
- Describe sexual and asexual reproduction in plants
- Outline the advantages and disadvantages of sexual and asexual reproduction
- Compare the differences between sexual and asexual reproduction in plant
- Explain the process of germination





## KEY WORDS

Here is a list of some of the new words you are going to meet in this unit:

**Reproduction-** is a process whereby plants produce young ones of their type

**Sexual reproduction-**a process whereby new plants are produced through the fusion of the male and the female cells

**Asexual reproduction-** a process whereby plants reproduce without the use of seeds

**Rhizome-** a modified stem of a plant which grows horizontally

**Tuber-** an underground stem or root

**Cutting-**a piece of plant used for vegetative or asexual reproduction

**Germination-** is the process by which an embryo starts to grow from a seedling

**Percentage germination-** is the number of germinated seeds divided by the number of seeds planted multiplied by 100.



TIME: 8hours



STUDY SKILLS

Before you proceed with this unit revisit your level one Biology Section on plant reproduction. It will help you to understand the flower as a reproductive organ in plants before moving on to the types of reproduction and what happens after reproduction takes place.

## 6.1 ASEQUAL REPRODUCTION IN PLANTS

### What is reproduction?

Plant reproduction is the growing of new offspring in plants, through sexual or asexual reproduction. Sexual reproduction produces offspring by the fusion of male and female gametes, producing genetically different offspring from the parent or parents. Asexual reproduction produces new individuals without the fusion of gametes, and offspring are genetically identical to the parent plants and each other.

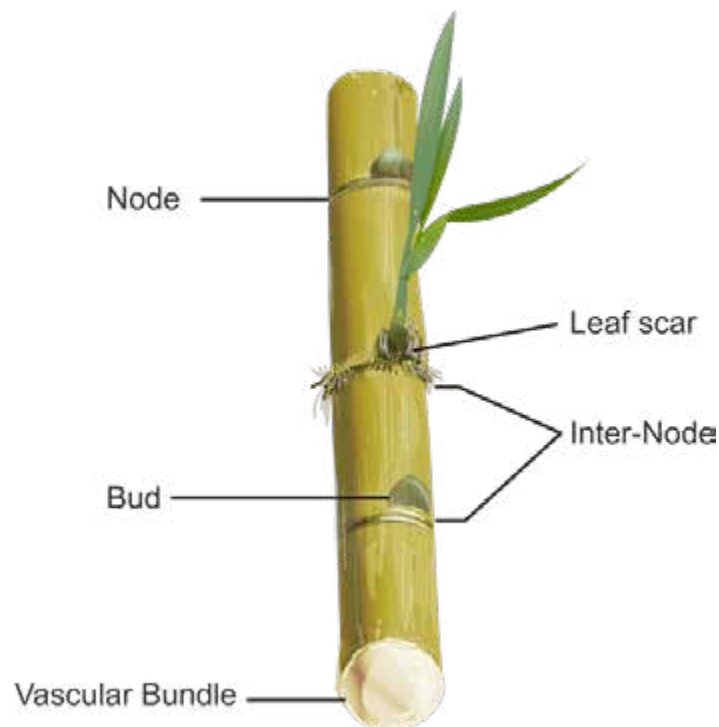
### Methods of asexual reproduction

Asexual reproduction or vegetative reproduction is reproduction without sex.

Offspring or new plants are produced from a part of the parent plant such as roots, stem tubers, root tubers, rhizomes and stolon. These structures act as storage organs. Examples of plants which undergo asexual reproduction include sugar cane, cassava and roses. These new plants are genetically identical to the parent plant. There is no pollination or fertilisation in asexual reproduction and only one parent is involved.

## Cuttings

A cutting is a plant section from the stem, leaf or root that is capable of developing into a new plant. The cutting is placed in a moist soil or in water and if conditions are favourable it will grow as a new plant independent from the parent. A stem cutting produces new roots and a root cutting produces new stem. Leaf cutting produce both stems and roots. Plants that can be grown using cuttings include sweet potatoes, sugar cane, cassava and roses.



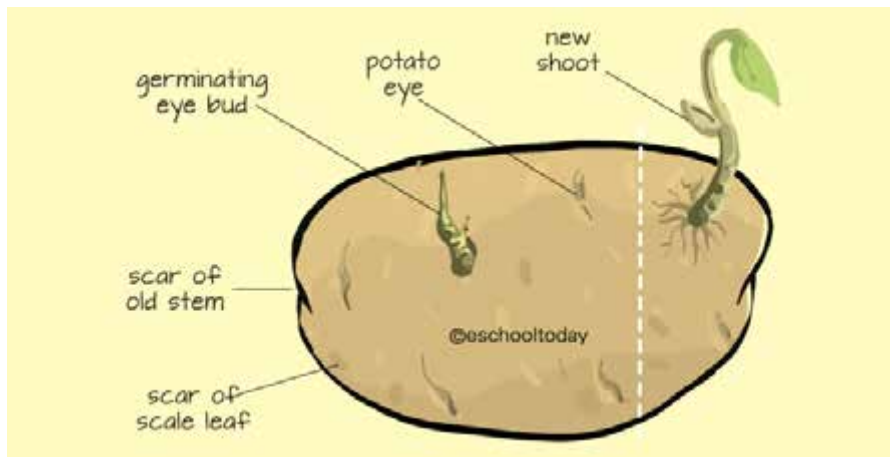
**Fig 6.1 cuttings of sugar cane**

## Tubers

A tuber is a part of a plant that grows underground. They store energy for later use and play an important role in asexual or vegetative reproduction. They occur in the stem or root of a plant.

## Stem tubers

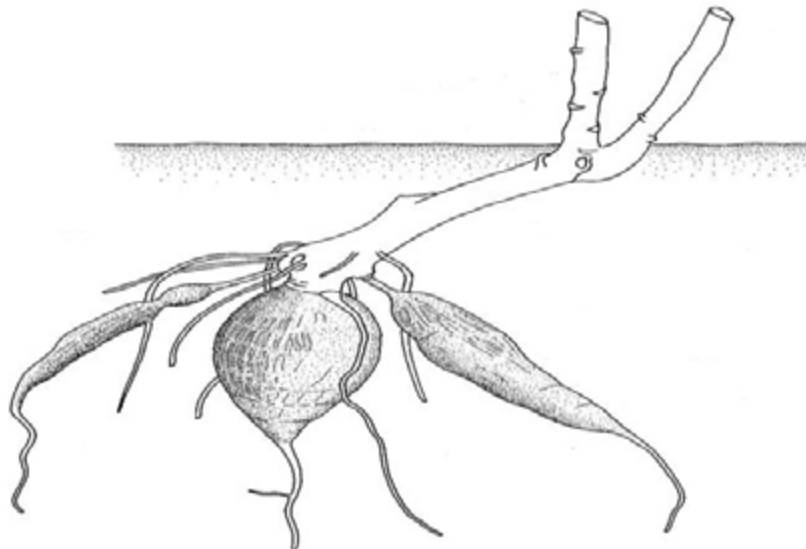
Stem tubers develop at the tip of an underground branch. They do not develop roots. Stem tubers represent a swollen stem. The surface of the tuber develops a number of eyes. Each eye represents a node. Stem tubers can develop chlorophyll. They are found in potatoes and yams.



**Fig 6.2 stem tuber**

### Root tubers

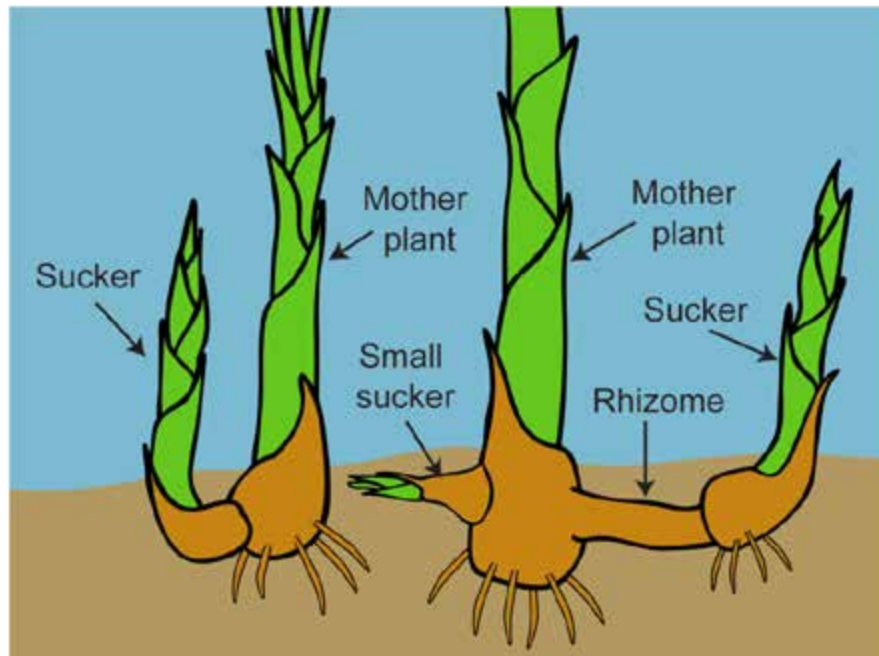
Root tubers represent a swollen root. They arise from any part of the root. Eyes, nodes and internodes are absent. Chlorophyll does not develop



**Fig 6.3 root tuber**

### Rhizomes

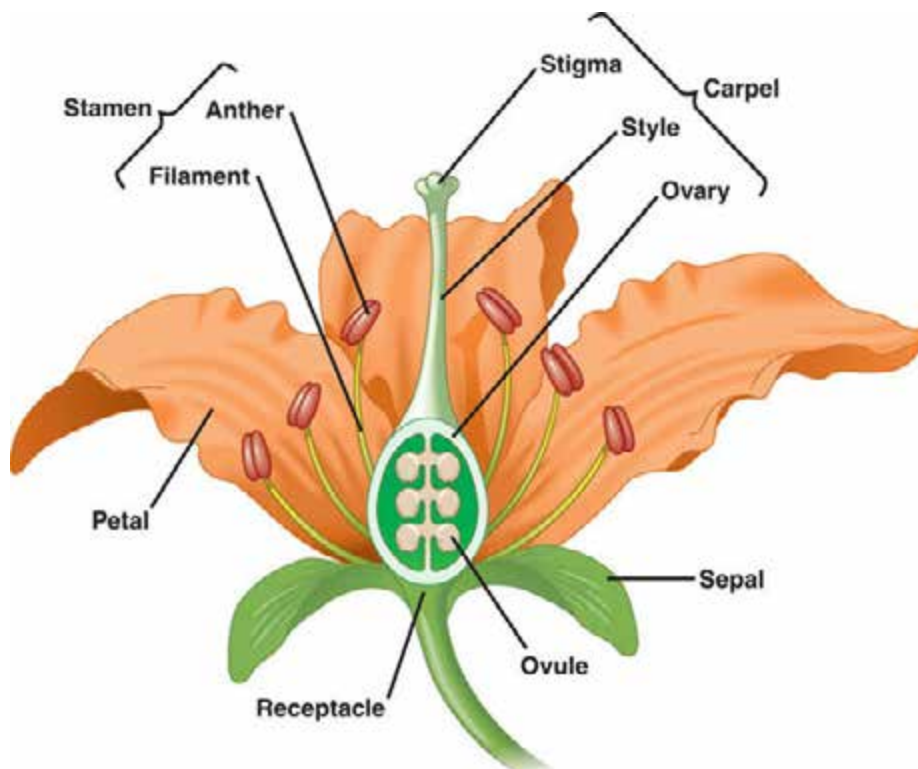
Rhizomes are horizontal underground plant stems that can produce shoot and root systems of a new plant. They store food which enables plants to grow underground. They are used for asexual reproduction. Plants that can be grown using rhizomes are bamboos, water lilies, ginger and ferns.



**Fig 6.4 rhizome**

## 6.2 SEXUAL REPRODUCTION IN PLANTS

Now that you know that plants reproduce by asexual means, we need to discuss about the type of reproduction in plants which is sexual reproduction. In your own words can you describe how plants reproduce sexually? We hope you mentioned that these plants produce flowers for them to reproduce. Sexual reproduction therefore is the fusion of male and female gametes to produce offsprings. The flower is the main reproductive organ of the plant. The diagram below shows a flower.



**Fig 6.5 insect pollinated flower**

## Remember:

There are two types of flowers produced by plants. These are an insect pollinated flower and wind pollinated flower. We will discuss about these two flowers.

The table below shows the parts of an insect pollinated flower and their functions.

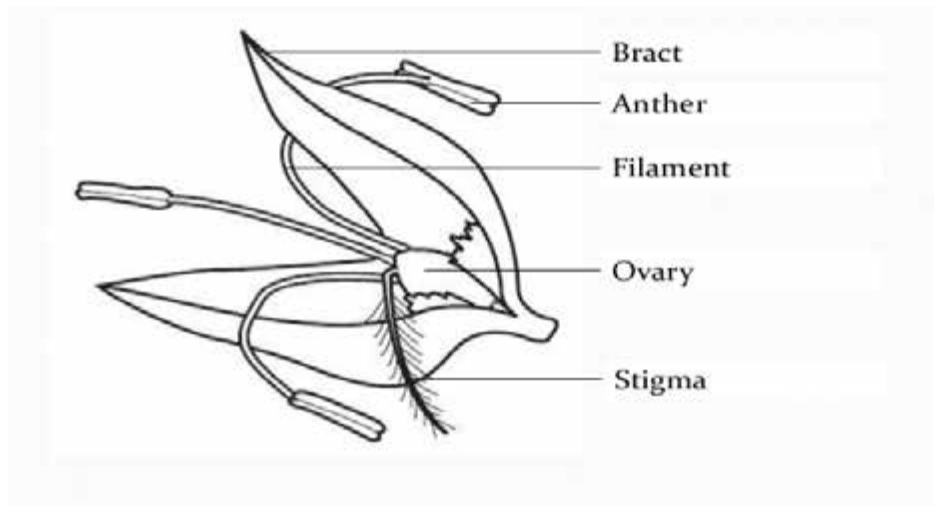
**Table 1**

Part	Function
Petals	-brightly coloured to attract insects -large to protect the insides part of the flower
Filaments	-holds the anther in position
Anther	-to produce male sex cells which are pollen grains
Stigma	-receives pollen grains
Ovary	-produces the female sex cells
Sepals	-holds the flower in position
Style	-holds the stigma in position

## Structure of an insect pollinated flower

- it has bright petals to attract insects
- it has sticky pollen grains and stigma so that pollen grains can be easily deposited in a stigma
- it has nectary to attract insects
- the anther is above the stigma so that pollen grains will easily be deposited on the stigma
- the stigma is inside the flower so that insects brush against it as they enter the flower

## Wind pollinated flower



**Fig 6.7 wind pollinated flower**

### Structure of a wind pollinated flower.

- It has a sticky and exposed stigma so that pollen grains being blown by wind can easily be attached to it.
- The anther is exposed so as to easily scatter pollen grains into the air.
- Produces abundant pollen grains.
- It has dull petals since it does not need to attract insects.
- It has no nectary

### Pollination

It is the transfer of pollen grains from the anther to the stigma, this can happen through the following ways.

### Insect pollination

In this method, insects, mainly bees, transfer pollen grains from the anther to the stigma of the same flower or of different flowers. Pollen grains stick to the feathery legs of the insects as they enter flowers in search of nectar. The pollen grains are later deposited on the stigma as the insects move through the flower.

### Wind pollination

Pollen grains are taken by wind from the anther to the stigma of the same or different flowers. Such type of flower produces light and abundant pollen grains.

## FERTILISATION

When the pollen grains have been deposited on the stigma. What happens? We hope you mentioned the following stages which are illustrated by a diagram below.

### Pollen grain germination

- 1 The head of the pollen grain which contain the nucleus grows down the style to the ovary.
- 2 The nucleus of the pollen grain and the ovule fuse to form a seed.

### Advantages and disadvantages of asexual reproduction

Now that you can define reproduction, let us move on to the types of plant reproduction, how many have you noticed so far? Hope you got them all. Let us start with sexual reproduction, it is the production of offspring by the fusion of a male and a female gamete. It involves fertilisation leading to the formation of a zygote. Sexual reproduction produces offspring genetically different from the parent.

Advantages	Disadvantages
1. Offspring can be produced quickly from one parent when conditions are necessary.	1. offspring has no diversity which means there is no genetic variation therefore new plants can be easily affected by diseases and pests
2. Offspring (clones) are genetically identical to the parent.	2. Offspring may fail to adapt quickly in the changing conditions and unfavourable conditions such as temperature can affect them.
3. It is cheaper as new plants are produced from the existing ones.	3. Asexual reproduction produce offspring that are close together creating competition for space and food.
4. The offspring spread over the area quickly because they are no vulnerable stages involved.	
Asexual reproduction is very helpful in disaster to ensure species survival.	

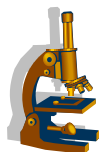
## 6.3 A comparison of sexual and asexual reproduction

Are you able to make a comparison of the differences between sexual and asexual reproduction? The table below listed some of the differences. Check whether you got it right.

Asexual reproduction	Sexual reproduction
Only one parent is needed	Two parents needed
No gametes or sex cells required	Gametes required
Offspring produced are genetically identical to the parent	Offspring are different to the parent

## 6.4 GERMINATION

After a successful reproduction germination takes place. Germination is the development of seeds into a new plant. It starts when a seed absorbs water which causes the seed to swell. It is facilitated by environmental conditions. Dicotyledonous plants are made up of the seed coat, the embryo and the cotyledons. The seed coat is the outer covering layer which is tough. The embryo contains the young root and young shoot which will later develop into a new plant. The cotyledons are the food reserves that provide food for the germinating seed until it is mature enough to make its own food through the process of photosynthesis. Now you are going to observe the process of germination in the following experiment and record the observations.



### EXPERIMENT 1

AIM: To observe the process of germination

#### Apparatus/materials:

10 bean seeds, cotton wool, a saucer, a cool drink bottle, a ruler and fine black permanent marker.

#### METHOD

1. Soak the seeds overnight in little water.
2. Place the seeds in a saucer with a damp cotton wool. The cotton wool must be kept moist throughout the experiment.
3. Observe the germination of the seeds.



## OBSERVATIONS

You must record your observation every day for two weeks. Note the changes of the seed every day and try to draw a picture of it. When the young stems begin to appear start to measure the height of the plant everyday from day 7 to day 10.



## ACTIVITY 2

Fill in the gaps:

--- is the development of seeds into a new plant. It starts when a seed ----- water causing it to----- . Dicotyledonous plants are made up of the seed coat, the----- and the----- . The ----are the food reserves that provides----- for the seed until it is ----- enough to make its own food through the process of----- .

## 6.5 CONDITIONS NECESSARY FOR GERMINATION

What do you think are the conditions necessary germination? Are you able to list them? For a successful germination certain conditions must be provided. The following are the condition necessary for germination:

### Water

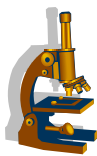
Water or moisture is needed to facilitate the process of germination and to break down the testa. It enters the seed, moisten it and also facilitate chemical reactions to take place inside the seed.

### Oxygen

During the process of germination respiration takes place and it needs air. Oxygen is required in this process for respiration to take place which supplies energy for the germination process. So when the process is taking place in the soil, it must be well aerated to ensure the availability of air for the germinating seed.

### Temperature

Suitable temperatures are required for seed germination in order to enhance chemical reactions inside the seed. Low temperatures reduce or stop the process of germination and very high temperatures may kill the seed



## EXPERIMENT 2

**AIM:** To find out if oxygen is necessary for germination

### **Apparatus/materials**

2 test tubes (or beakers), 10 bean seeds, cotton wool, alkaline pyragollol, rubber stoppers, water

### **METHOD**

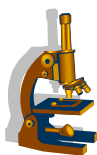
1. Wrap 5 bean seeds in wet cotton wool and put them in a test tube A.
2. Wrap 5 bean seeds in wet cotton wool and put them in test tube B with alkaline pyragollol. Alkaline pyragollol absorbs oxygen. Close the test tube with a rubber stopper.
3. Place the two test tubes in a warm place and leave them for 10 days and observe what happens

### **OBSERVATION**

Hope you have observed that seeds in test tube B did not germinate and those in test tube A germinated. If that was your observation, then you are correct.

### **CONCLUSION**

Oxygen is necessary in the process of germination



## EXPERIMENT 3

### **AIM**

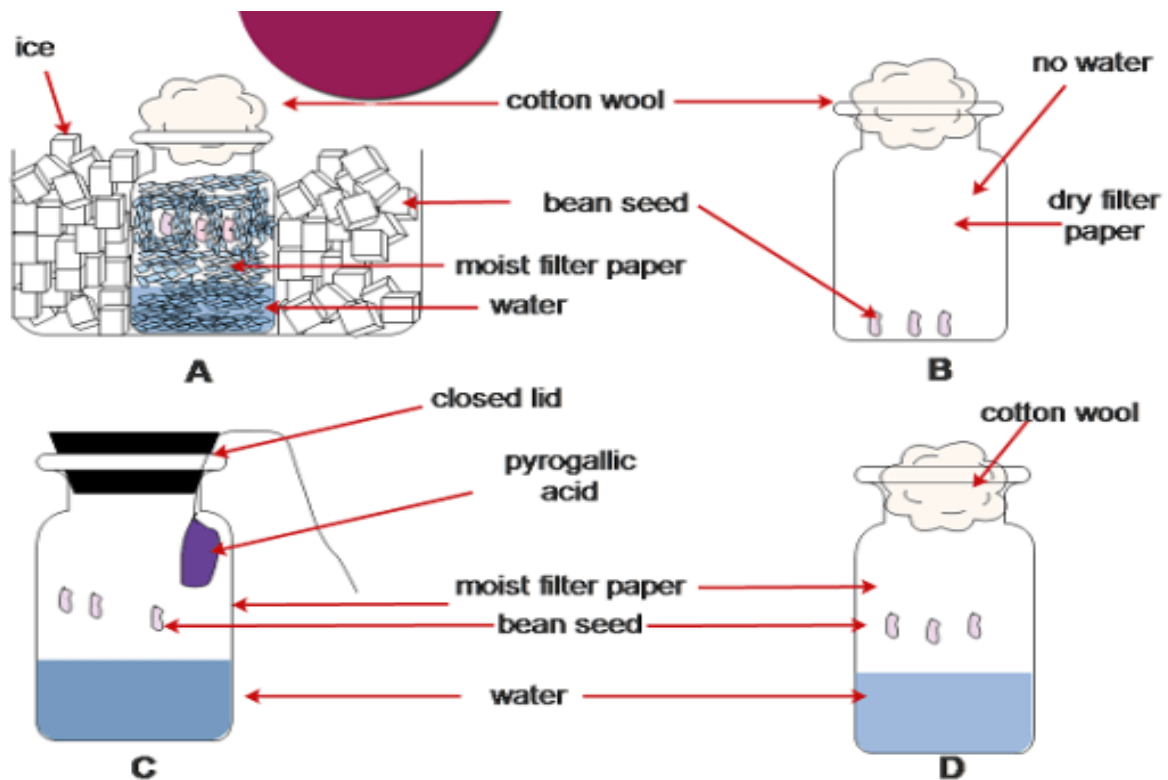
To investigate if moisture is necessary for germination

### **Apparatus/materials**

10 bean seeds, 2 test tubes, water, cotton wool

## METHOD

Wrap 5 seeds in wet cotton wool and put them in tube B and 5 wrap 5 seeds in wet cotton wool place them in tube B.



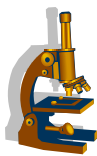
Put the test tubes in a warm place and leave for 10 days and observe what happens.

## OBSERVATION

I hope you have carried out the experiment. What did you observe? If you observed that the seeds in tube germinated, then you are correct.

## CONCLUSION

Therefore, seeds require moisture in the process of germination.



## EXPERIMENT 4

### AIM

To find out if warmth is necessary for the process of germination

### Apparatus/materials

Two test tubes, cotton wool, 10bean seeds, water

### METHOD

Wrap two sets of 5 bean seeds in wet cotton wool

Place the wrapped seeds in each of the test tubes

Put one test tube in a warm and safe place and the other one in a refrigerator and observe what happens after 10 days.

### OBSERVATION

The seeds in the test tube that was placed in refrigerator did not germinate while those put in a warm place germinated.

### CONCLUSION

Warmth is therefore necessary for seed germination.



### Activity 3

1. Is oxygen necessary for germination? Explain
2. Is water necessary for germination? Explain
3. In which test tube did germination occur in experiment 3
4. Identify the conditions necessary for germination.
5. Explain the purpose of the pyrogallic acid.

## Percentage germination

It is very important to know how many of the total seeds planted result in successful germination. These plants will grow into harvestable crops. How do we calculate the percentage germination? We take the number of seeds that germinated, divide it by the total number of seeds that were planted and multiply it by 100.

Percentage germination

$$= \frac{\text{number of germinated seeds}}{\text{total number of seeds planted}} \times 100$$

Percentage germination is very important to farmers as it help them to predict the yields of their crops.

### EXAMPLE

40 seeds were soaked and 10 germinated. Calculate the percentage

Percentage germination

$$= \frac{\text{number of germinated seeds}}{\text{total number of seeds planted}} \times 100$$

$$= \frac{10}{40} \times 100$$

$$= 25\%$$

Can you calculate the percentage germination of the following examples?

- 80 seeds were planted and 20 germinated, calculate the percentage germination.
- Out of the 50 bean seeds planted 25 of them germinated, calculate the percentage germination.

### SUMMARY

We hope by now you now have a clear understanding of reproduction in plants, and conditions necessary for germination to occur. Are you able to differentiate sexual and asexual reproduction? If not read again the content the content covered in this unit. After successful sexual reproduction seeds are produced. Germination is facilitated by certain conditions. These conditions include water, warm or temperature and oxygen. Remember it is also very important to calculate the percentage germination of seeds in order to know the plants which will grow into harvestable crops.

## 6.6 SAMPLE ASSESSMENT QUESTIONS

Answer all questions

1. Which method of propagation is used Irish potatoes?
  - A. Cuttings
  - B. rhizomes
  - C. Seeds
  - D. tuber
  
2. The following are conditions necessary for germination except
  - A. Oxygen
  - B. temperature
  - C. Carbon dioxide
  - D. water
  
3. Which of the following is not a characteristic of an insect pollinated plant?
  - A. Nectar production
  - B. Strong scent
  - C. Bright petals
  - D. Feathery stigma
  
4. After germination the plumule develops into
  - A. Shoot system
  - B. root system
  - C. Leaf system
  - D. Stem system
  
5. A plant with seeds containing a single cotyledon is called a----
  - A. Dicotyledons
  - B. monocotyledons
  - C. Legumes
  - D. broadleaved plants

6. (a) State any two differences between the structure of an insect pollinated flower and a wind pollinated flower.

- 1.-----  
-----
- 2.-----  
-----

(2)

(b) i) Identify and explain two disadvantages of asexual reproduction

- -----

(2)

ii) State any two conditions necessary germination

- -----

(2)

iii) Explain differences sexual and asexual reproduction

- -----

(2)

7 (a) Describe the use of each of the following in germination

Oxygen-----

Water-----

Warm temperature----- (3)

ii) A farmer planted 80 bean seeds. 60 of the seeds germinated. Calculate the percentage germination

- -----

(2)

ii) List 3 vegetative parts that can be used to generate new plants

- -----

(3)

**Answer all questions**

1. D
2. C
3. D
4. A
5. A
6. (a)
  1. insect pollinated flower has big bright petals whereas wind pollinated flower has small and dull petals
  2. insect pollinated flower has a scent to attract insects whereas wind pollinated flower has no scent
  - insect pollinated flower has sticky stigmas whereas wind pollinated flower has large feathery stigma
  - Wind pollinated flower has long and large stigmas whereas in insect pollinated flower the stigmas are orientated
  - Insect pollinated flower has a nectar whereas wind pollinated flower does not have (2)
- (b)
  1. Offspring has no diversity which means there is no genetic variation therefore new plants can be easily affected by diseases and pests
  2. Offspring may fail to adapt quickly in the changing conditions and unfavourable conditions such as temperature can affect them.
  3. Asexual reproduction produce offspring that are close together creating competition for space and food. (2)
  - i) - oxygen, water (moisture) and warm temperature (2)

**Comparison of sexual and asexual reproduction**

1. only one parent is needed	Two parents needed (a male and the female)
2. no gametes or sex cells required	Gametes are required
3. offspring produced are genetically identical to the parent	Offspring are different to the parent

(2)



7. (a) Oxygen- required for respiration to take place which supplies energy for the germination process

Water- is needed to facilitate the process of germination and to break down the testa.

Warm temperature-Suitable temperatures are required for seed germination in order to enhance chemical reactions inside the seed (3)

ii) **Percentage germination**

$$= \frac{\text{number of germinated seeds}}{\text{total number of seeds planted}} \times 100$$

$$= \frac{60}{80} \times 100$$

$$= 75\% (2)$$

ii) Root tubers, stem tubers, cutting, rhizomes, shoots (3)

# UNIT 7: TRANSPORT SYSTEMS IN HUMANS

## CONTENTS

- 7.1 Functions of blood
- 7.2 The double circulatory system
- 7.3 Structure of blood vessels
- 7.4 Sample assessment questions

## INTRODUCTION

From the previous unit on plant transport systems you realised plants carry substances around the plant. We hope you remember the xylem vessels that transport water from the roots to the leaves. Also remember the phloems that carry sugars from the leaves down to the roots. In this unit, the human transport system shall be discussed. Your understanding of the plant transport system will facilitate your understanding of the functions of blood and its components circulating throughout the human body, you shall also be introduced to the structure and of blood vessels.



### OBJECTIVES:

By the end of this unit you should be able to:

- State functions of blood
- Describe the double circulatory system
- Describe the structure of blood vessels
- Outline the differences among blood vessels



### KEY WORDS:

It is important for you to understand the following terms before attempting this unit.

- **Arteries** are elastic vessels strong enough to carry blood from the heart.
- **Capillaries** are the smallest vessels running throughout the body linking the arteries and veins
- **Veins** are large elastic vessels that carry blood from the body back to the heart

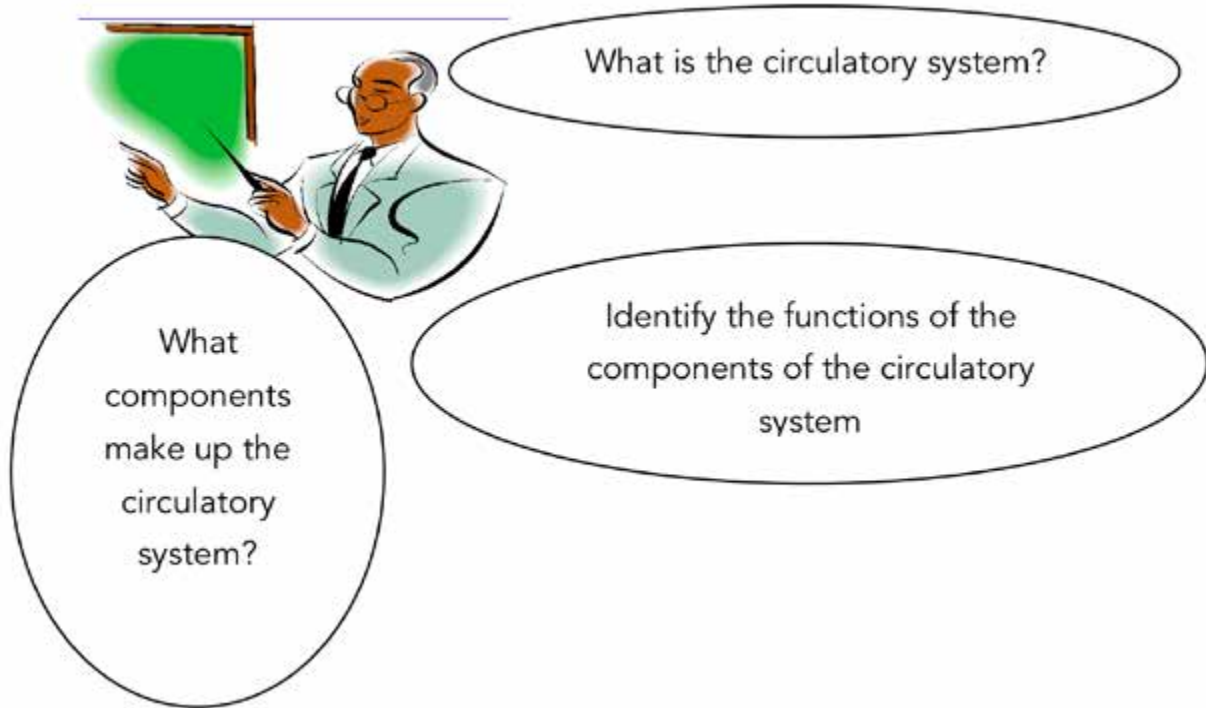


TIME: 8 hours



STUDY SKILLS

Before you start on this unit I encourage you to refresh your knowledge of the circulatory system you covered in module one by attempting the following questions.



### STUDY TIP:

While you are attempting the above activity you are encouraged to revisit the topic in module one.



## ACTIVITY 1

**WRITE YOUR ANSWERS IN THIS BOX**

### 7.1 FUNCTIONS OF BLOOD

#### **What is the function of blood in the human body?**

Generally, blood is a living fluid tissue that travels through all organs of the human body. Blood performs the following functions:

- regulating the body systems (homeostasis)

One function of blood is to keep all things equal in the body. Once there is an imbalance, the body fails to work well. Blood helps to control conditions such as temperature and pH.

- supplying oxygen (O<sub>2</sub>) and nutrients to body tissues

Blood is also useful in the body as it acts as a vehicle that transports substances from one area to another. Blood transports substances such as nutrients, and oxygen to the body cells. Blood also transport carbon dioxide to the lungs where we breathe it out. Substances like Urea are carried to the kidneys. Blood also carries white and red blood cells around the body.

- Defence: Sometimes we feel sick. Blood carries white blood cells that help us fight infections.

Just to refresh on what you have read, attempt the following exercise. You will get guidance from the provided answer guide.



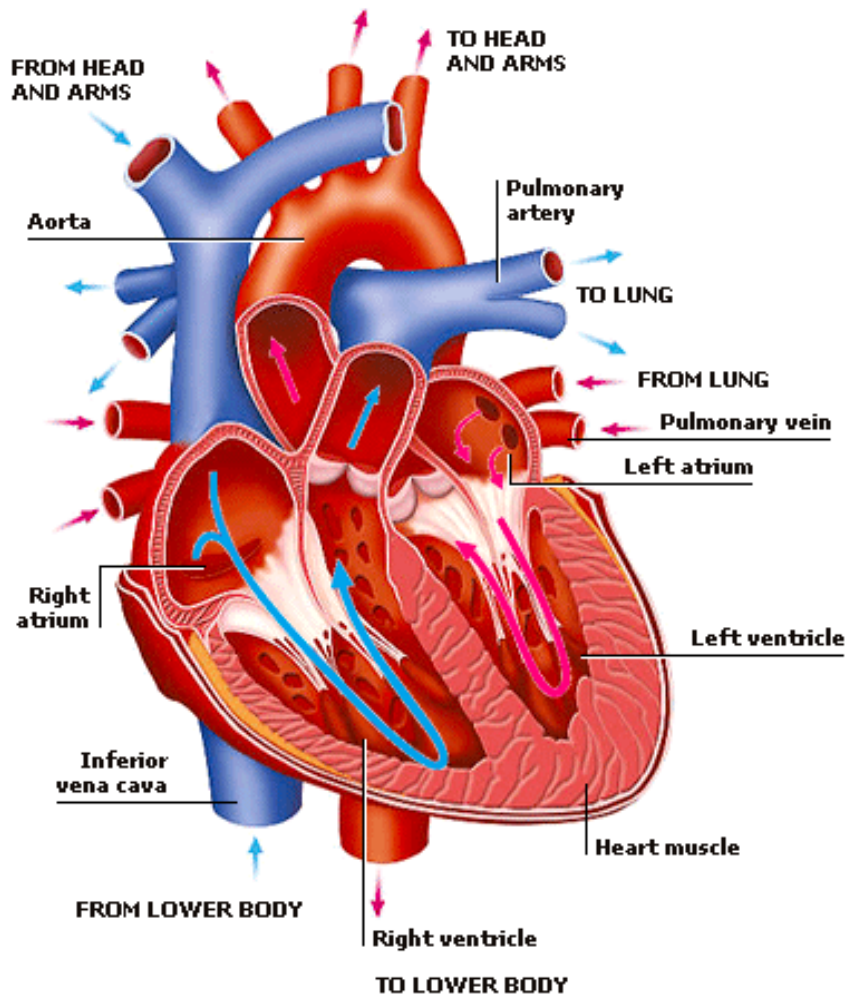
## ACTIVITY 2

1. In your own words define blood
2. State the nutrients transported by the blood to the body tissues
3. Describe how blood functions as defence to the body.

## 7.2 DOUBLE CIRCULATORY SYSTEM

In module one you learnt that the circulatory system is made out of a number of components. Can you remember them? Well if you can't then we encourage you to revise transport systems in animals' module one. We hope now you remember the heart as the muscular organ found to the left of the chest.

The heart is described as the engine that pumps blood in the body. The heart is made up of the left and the right sides. In the two sides are pumps. The right side pump blood to the lungs and back to the heart while the left pumps blood with oxygen to the body and back to the heart. Below is a simple diagram of the heart. Study it carefully and then read the notes below.



**Fig7.1 shows a cross section of a heart**

Now to understand the double circulatory system, you need to remember that deoxygenated blood is pumped out of the heart to the lungs by the right side and the same blood returns to the heart and then pumped out again by the left side to the whole body



**ACTIVITY 3**

Here are some key points to what we have covered so far.

- Blood enters the heart as deoxygenated into the right side.
- Through the right side the deoxygenated blood travels to the lungs for oxygenation
- The air we breathe in oxygenates the blood in the lungs
- In the lungs deoxygenated blood exchanges for oxygen while in the body the oxygenated blood exchanges for carbon dioxide.

If you remember well the key points above go on and try the following activity.

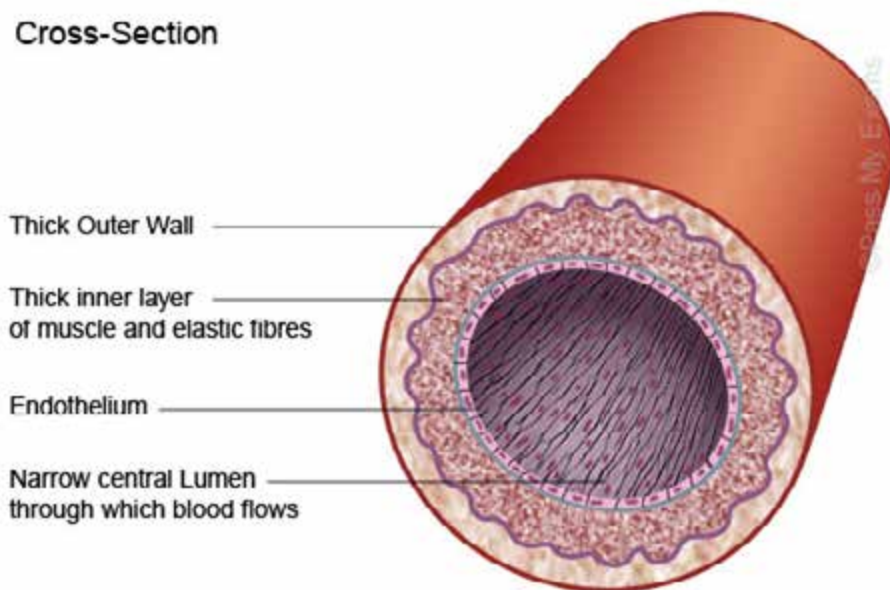


## ACTIVITY 3

- Identify the two sides of the heart and describe their functions in the circulation of blood.
- Identify the vena cava and the aorta giving their functions in the circulatory system.
- In the double circulatory system the heart has two sides. Describe the double circulatory system using the two sides of the heart.

### 7.3 STRUCTURE OF THE BLOOD VESSELS

Now that we have covered the heart describing the double circulatory system we hope you noticed that the heart does not operate in isolation. The heart's function is assisted by the vessels. Can you name the vessels you learnt? Well, we hope you said the pulmonary vein and the pulmonary artery. In this chapter we shall be looking at the structure of the vessels including the capillaries.



**Fig7. 2 The structure of an artery**

From the diagram above did you notice that arteries are made up of three layers? Below is the description of the 3 layers.

#### The Inner layer

This layer is made up of fatty and slippery cells that allow blood to flow smoothly. The inner layer connects with the heart.

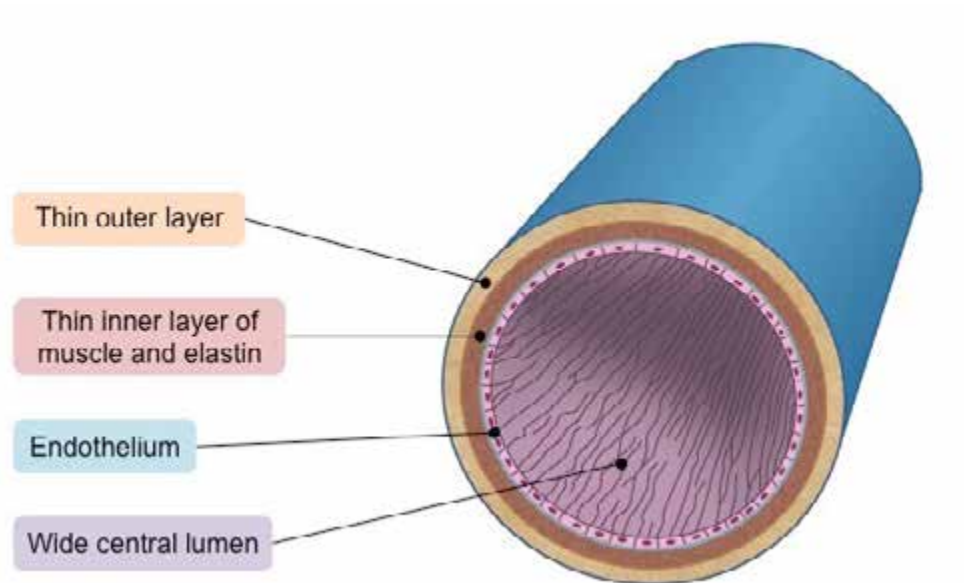
## The Middle Layer

Have you noticed that arteries have a thicker layer in the middle? This muscle layer is elastic allowing the vessel to expand and contract when required to do so.

## The Outer Layer

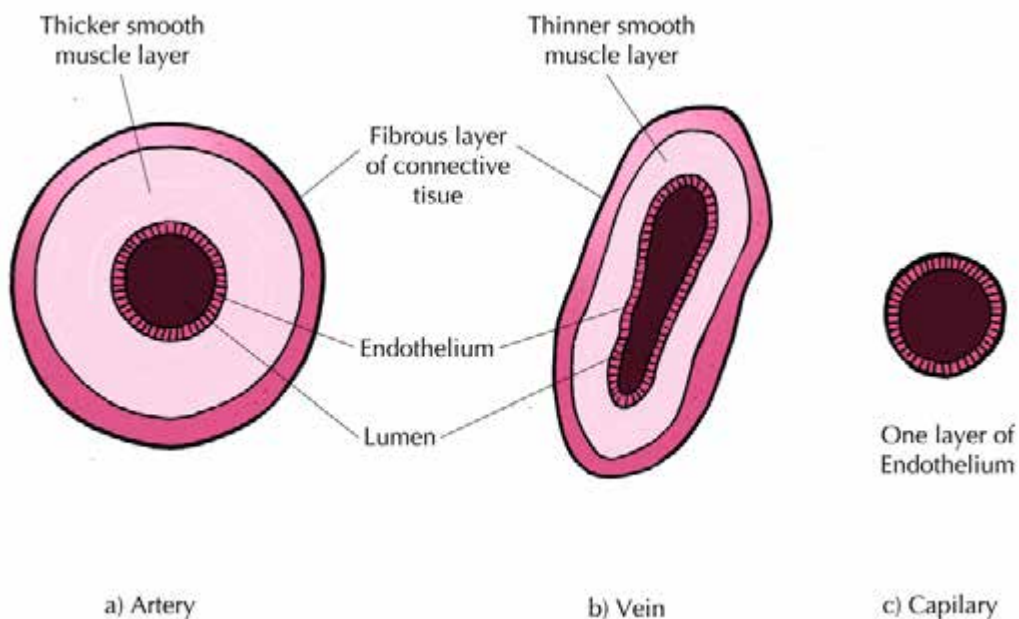
This layer is regarded as rough and elastic allowing the vessel to stretch without breaking from pressure as it transports blood from the heart at a high pressure.

## Vein



**Fig7. 3 cross section of a vein.**

The diagrams below show the comparisons between an artery, vein and capillary.



**Fig 7.4 arteries, veins and capillaries**



Just like arteries, Veins have three layers. You need to notice that veins however have a thicker outer layer. Also notice that the inner layer is thinner as compared to that of the arteries since veins carry blood from the body which has less pressure. Blood pressure is also reduced the veins have a larger lumen as compared to the arteries. Veins have valves that prevent blood from flowing back but forcing it to flow in one direction.

As veins and arteries move away from the body, they branch into smaller branches forming capillaries. These can be described as the smallest blood vessels that reach all body tissues.

The wall of capillaries is made up of only one layer which is one cell thick. The layer allows absorption and loss of substances in and out of the capillary. Oxygen and nutrients diffuse out of the capillaries into tissues while carbon dioxide and waste diffuse out of tissues into the capillaries.

Before proceeding to the next chapter you can attempt the exercise below.



## Activity 4

- 1) Name 3 vessels described in this unit.
- 2) What are the functions of the vessels?
- 3) Draw and label the vessels you learnt in this unit
- 4) Give any two substances that diffuse out of the capillaries to the body tissues.

### Differences among blood vessels

After we have looked at the structure of arteries, veins and capillaries you should be able to outline some differences among the vessels. In table 1 below an outline of the differences has been given.

Table 1: below represents the characteristics of arteries, veins as well as capillaries

	<b>Arteries</b>	<b>Veins</b>	<b>Capillaries</b>
General appearance	Rounded in shape Thick muscle layer small lumens	Often collapsed or flattened Thinner walls larger lumens	Only one layer cells



## ACTIVITY 5

- The arteries have smaller lumen. Can you remember other characteristic of the arteries, and veins
- Draw an artery and name its parts
- Outline the differences between an artery and a vein
- What is the relationship between capillaries and arteries and veins

### Project

Now that we have gone through the unit on transport system in humans and wish to move on to the next unit, let's engage in this interesting project demonstrating our mastery of the unit. I want you to demonstrate your understanding of the components of the circulatory system and their functions.

#### What is needed

- 2 thick pipes of different colours
- Several thinner pipes matching colours above
- 90 cm x 70 cm cardboard box
- Cellotape
- 1 peanut butter empty bottle
- Scissors

### What to do

- Make a human model with the cardboard box
- Use the apparatus you have to demonstrate the transport system in the human body.
- Label your model

### Tip

- Ensure your colour codes on pipes indicate oxygenated and deoxygenated blood to and from the heart.
- Extra point will be awarded for creativity on demonstrating the following
- The capillary bed
- Blood flow.

## SUMMARY

· Blood vessels consist of arteries, veins and capillaries
· Arteries and veins transport blood to and from the heart
· Arteries have smaller lumen and thick outer layer while veins have larger lumen and a thin muscle layer
· Blood circulation is called the double circulatory system because blood has to be pumped to the body through by left side of the heart and back to the heart and pumped again by the right side of the heart to the lungs and back completing two cycles.
· Blood basically transport substances, defend the body and regulates the body's internal environment at a steady state (homeostasis)

## 7.4 SAMPLE ASSESSMENT QUESTIONS

Attempt the following questions to test your understanding of this unit. If you find it difficult take time to revise the unit or consult your facilitator for further skills in reading the unit. Suggested answers to the test are provided in the answer book that comes with this module.

### Tip

The marks indicated after the question suggests to you how much effort is expected for each question.

1. Which of the following is not true?

- a) Blood flows in an anti clockwise direction
- b) Blood carries carbon dioxide only to the body tissue
- c) Blood is important for regulating body temperature
- d) Blood produces white blood cells to fight diseases

2. Which of the following is responsible for carrying oxygen to the body tissue?

- a) Arteries
- b) none
- c) Vein
- d) Plasma

3. Is a common structure with arteries and veins
- Lumen
  - Single wall
  - Vessel shape
  - What they transport to the body tissues
4. Blood circulation system is called a double circulatory system because
- The heart has two sides
  - The heart has two valves that pump blood to the body tissues
  - Blood has to enter the heart twice to complete a cycle
  - Every time the heart has to pump it completes two cycles
5. In the left side of the heart blood contains
- oxygen
  - Water
  - Carbon dioxide
  - Nutrients
6. Draw a well labelled diagram of the cross section of the heart. (3)
- Using arrows show blood flow direction (2)
7. By way of diagrams illustrate the differences between arteries and veins (4)
8. From our discussion on vessels one of the three vessels has the thickest walls. I identify the vessel and explain how the thick wall helps in the function of the vessel. (6)
9. Describe homeostasis as a blood function (5)
10. Why do capillaries have one layer? (5)

[30 Marks]

## SUGGESTED ANSWERS

Multiple choice

1 B

2 A

3 A

4 C

4 A

# UNIT 8: HUMAN REPRODUCTIVE SYSTEM

## CONTENT

- 8.1 Structure of female and male reproductive systems and sex cells.
- 8.2 Fertilisation and the role of the placenta
- 8.3 Menstrual cycle.
- 8.4 Methods of contraception.
- 8.5 Sample assessment questions

## INTRODUCTION

Have you ever asked yourself why there is always a new generation from an existing generation? Have you ever asked yourself why census is always done after every five years? Yes, there is always a new generation. Humans give birth daily in hospitals. Males and females become sexually mature at puberty stage when their bodies undergo changes in appearance and behaviour. At puberty males and females get attracted to each other and when their sex cells fuse reproduction occurs. In this unit you are going to learn about the structure of the male and female reproductive systems, the sex cells that fuse. You will also learn about menstruation because it plays a key part in reproduction. Let us also not forget that if humans increase they will compete for many things such as food and other resources. Therefore, there is need for birth control methods. Below is the list of some key words that you will come across as you go through this unit.



## OBJECTIVES

- Describe the male and female reproductive system and sex cells.
- Describe the role of the placenta.
- Describe the menstrual cycle.
- Describe methods of contraception.



## KEY WORDS

**Cervix-** a muscular tissue which separates the vagina from the uterus.

**Contraception-** a method of birth control.

**Epididymis-** these are coiled tubes in which sperms are stored.

**Ovary-** the female part that contains follicles where eggs are produced.

**Oviduct (fallopian tube)-** the female part where fertilisation takes place.

**Penis-** it is the male sex organ which ejaculates semen into the vagina during sexual intercourse.

**Prostate gland-** a male part that secretes a nutritive fluid to the sperms to form a mixture called semen.

**Scrotum-** it is the sac which contains the testicles.

**Seminal vesicle-** it is another gland that secretes fluid.

**Sexual reproduction-** reproduction involving gamete formation and fertilisation.

**Sperm ducts-** these are tubes that carry sperms from the testes to the urethra.

**Sterilisation-** Is to make an organism unable to reproduce.

**Testes-** it is a male gland which produces sperms.

**Urethra-** it is the tube inside a penis which is the pathway of semen and urine out of the body.

**Uterus-** the part where the foetus develops.

**Vagina-** the female part that receives the male penis during sexual intercourse.

**Zygote-** a fertilised egg.

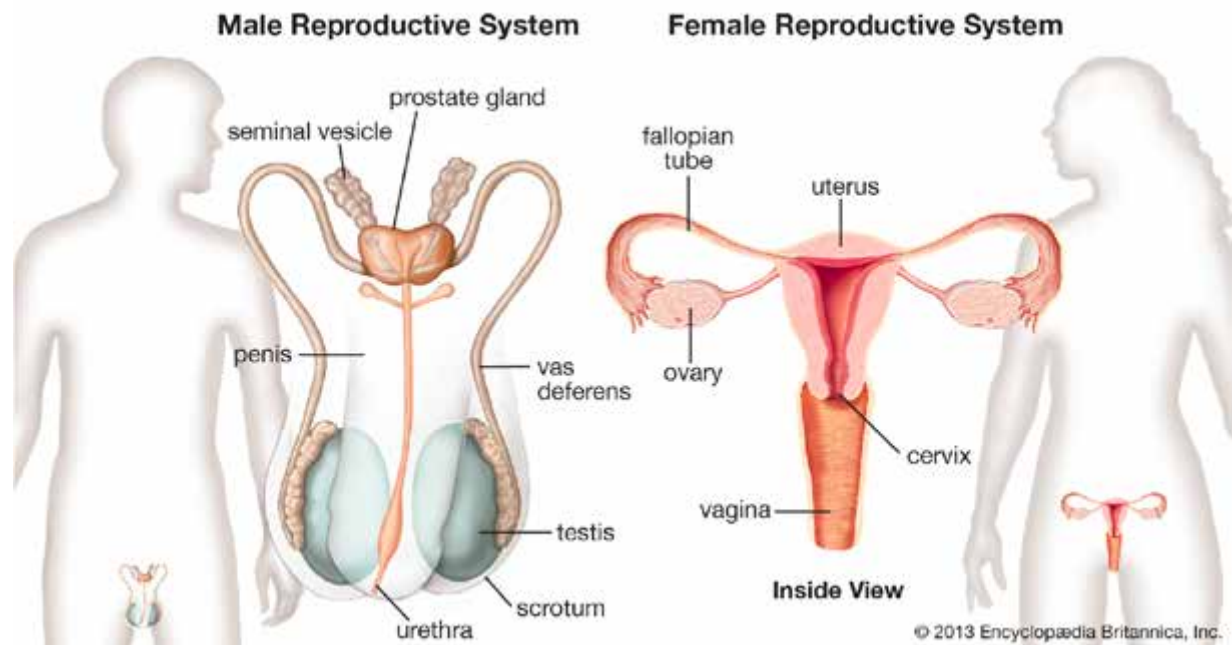
## 8.1 STRUCTURE OF FEMALE AND MALE REPRODUCTIVE SYSTEMS AND SEX CELLS.



### ACTIVITY 1

Draw the male and female reproductive systems.

We hope you did not have any difficulties in drawing the male and female reproductive systems. Compare your drawings with the ones below and perfect where you did not draw well.



**Fig 8.1 Male and female reproductive system**

### Remember

You might have seen from the diagrams above that the male and female reproductive systems are located just below the stomach. There are different parts that make up the systems. The male reproductive organs are specialised to produce sperms and deliver them to the female. The female reproductive organs are designed to receive sperms, produce female sex cells and to hold and protect the growing embryo. Let us now look at the functions of the labelled parts.

The functions of the male and female reproductive systems

Before you learn about the functions of reproductive parts, first of all try to check how much you understand in this unit.



### ACTIVITY 2

1. In your own opinion, what is the main function of the female and male reproductive systems?
2. Draw a flow diagram of the path of a sperm cell from production to ejaculation.
3. Give the functions of the sperm duct, scrotum and epididymis.



The table below shows the functions of the reproductive systems.

**Table 1**

Functions of the male and female reproductive systems

MALE REPRODUCTIVE ORGANS	FEMALE REPRODUCTIVE ORGANS
Testes- they produce millions of sperms - Produce a hormone called testosterone that determines the male's secondary sexual characteristics during puberty	Ovaries- produce hormones that control the menstrual cycle Contains egg cells (ovum)
Epididymis - the part that stores sperms until they mature	Fallopian tube - to carry ovum to the uterus
Scrotum- to protect testes	Uterus- for implantation of the fertilised egg - A place where embryo develops during pregnancy
Penis- the organ that introduces the sperm into the vagina	Cervix- a ring of muscle that leads to a vagina
Foreskin- it covers and protects the head of the penis	Vagina- receives sperms during ejaculation
Sperm duct- a tube that lead sperms into the urethra	
Urethra- a tube leading from the bladder through the penis and carries sperm through the penis to exit the body during ejaculation	

**Remember:**

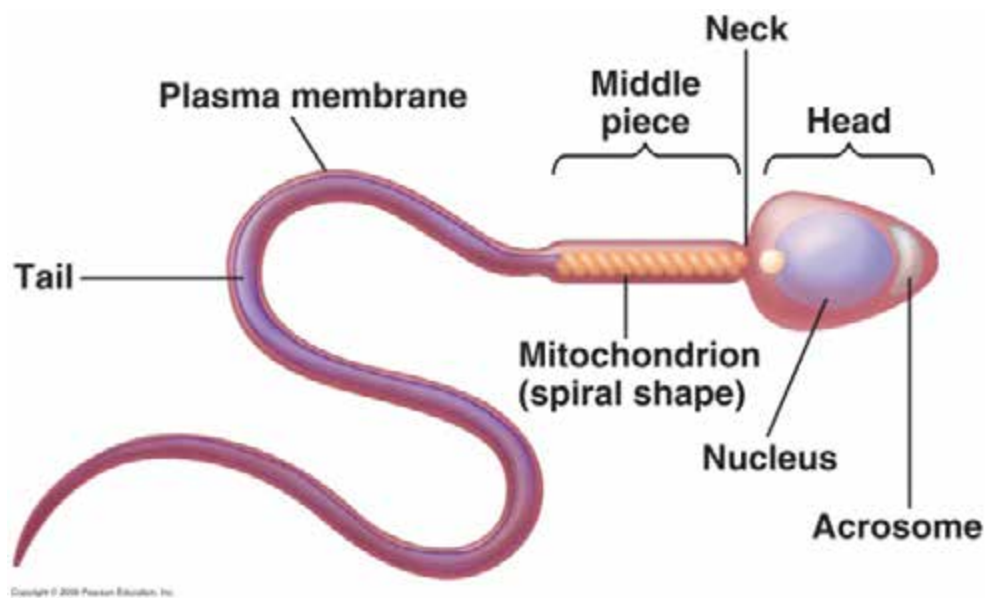
A male human has two testicles which hang outside the body. This allows temperature in the scrotum to be lower than in the body. Why should it be lower? It is lower because the sperms cannot survive in higher temperatures. Remember we also said that the sperms are deposited into the vagina and travel up to the fallopian tube where they meet the ovum and fertilisation takes place. Lets us therefore, look at the structure of the male sex cells (sperm) and female sex cells (ovum).

## The structure and functions of sex cells

The structure of the male and female sex cells is similar. The nuclei of the sperm and ova contain chromosomes that carry the genes of either the mother or the father. Both cells are single cells each containing a cytoplasm surrounded by a cell membrane. Let us now look at these cells one by one taking note of the similarities and differences.

### The structure of a sperm cell

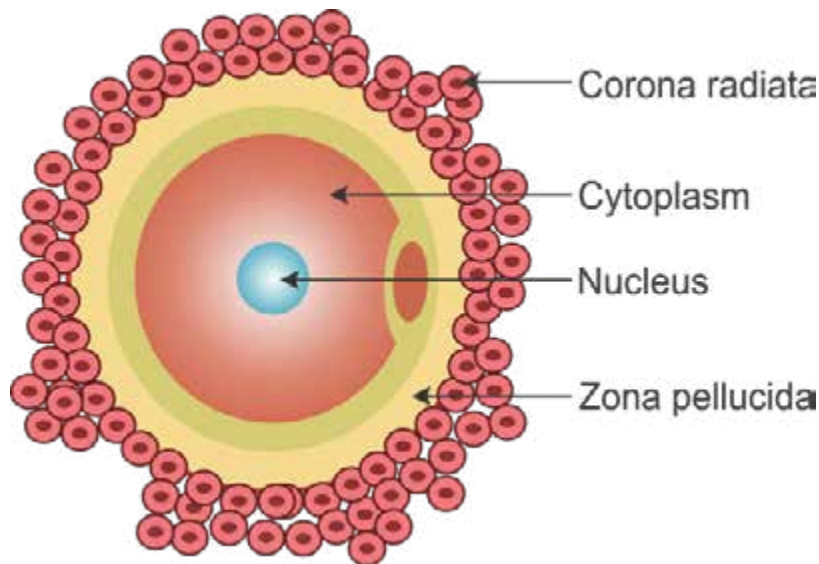
A sperm cell is single celled with oval shaped head. Sperms are 10 000 smaller than ovum and are produced in large quantities to increase the chance of successful fertilisation. They have a tail that enables them to swim to meet the ovum. They also have a large number of mitochondria that release lots of energy to be used in swimming. The sperms are released in every ejaculation. The diagram below shows the structure of the sperm cell.



**Fig 8.2 the sperm cell**

### The structure of an ovum cell

An ovum cell has a spherical shape. It contains a nucleus, cytoplasm and thick membrane. An ovum is larger than a sperm because it needs space to store nutrients on which the embryo feeds on before it reaches the uterus. An ovum does not move by itself but they are swept to the uterus by cilia in the walls of the oviduct. One ovum is released once every month. The diagram below shows the structure of the ovum.



**Fig 8.3 the ovum cell**



### ACTIVITY 3

Close your module. Draw the labelled structures of the sperm and an ovum.

Open your module and compare the structures that you have drawn with the ones that have been drawn for you.

You have now learnt that the sperms travel all the way to the oviduct to meet the ovum. This means that they move from males to females. How then do they do this?

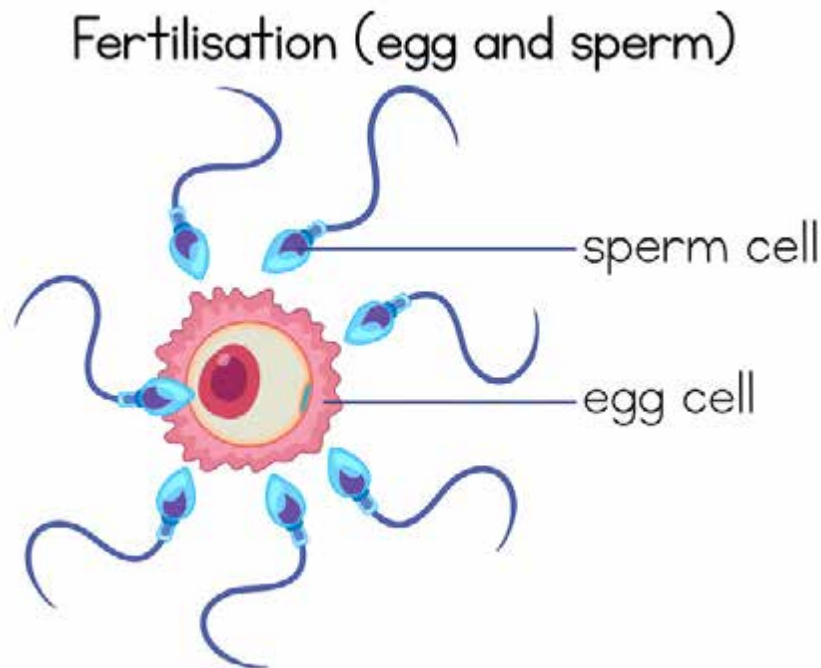
How does the sperm move from the testis to the ovum?

Sperm ducts carry sperms from the testis to the urethra. The urethra further pushes the sperms and they are deposited into the vagina during sexual intercourse. The sperms swim through the cervix into the uterus through wriggling movements of their tail. They pass through the uterus to the oviduct. In the oviduct the sperm enters the cytoplasm of the ovum. The nucleus of the sperm will then fuse with the nucleus of the ovum. When the two nuclei fuse it is called fertilisation.

## 8.2 Fertilisation and the role of the placenta

Fertilisation is the joining of one sperm and an ovum. This process takes place inside the body of the female. When the male and female are sexually attracted the penis becomes erect. During sexual intercourse the man ejaculates semen into the woman's vagina. If the sperm finds the ovum in the fallopian tube it tries to enter the ovum and only one sperm among the many ejaculated becomes successful. The fusion of the male and female sex cell nuclei is called fertilisation.

The diagram below shows the process of fertilisation.



**Fig 8.4 The process of fertilisation**



### Activity 3

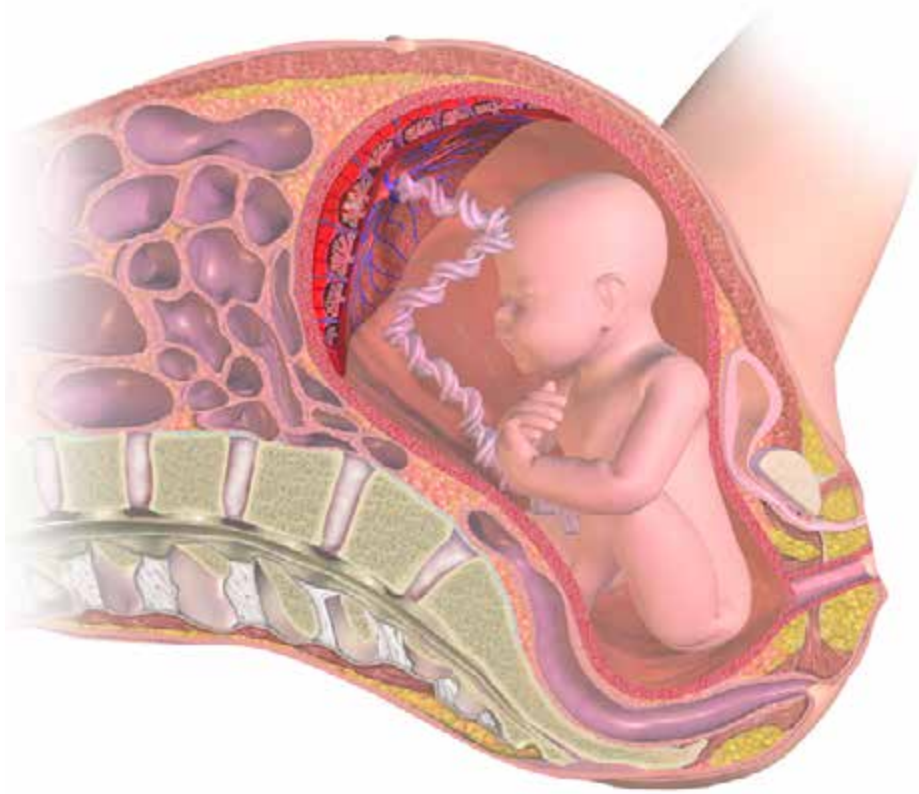
1. State the function of the mitochondria in the sperm cell.
2. What is the function of the nuclei in the sex cells/
3. Define fertilisation.
4. Where does fertilisation take place?
5. Outline the pathway taken by the sperm from the testicles up to the point of fertilisation.

When fertilisation has taken place in the fallopian tube the zygote formed moves to the uterus where it attaches itself. This process is called implantation. The embryo gets its food from the walls of the uterus. The placenta is the exact points on the walls of the uterus where the embryo attaches itself. The placenta now develops around that point. The umbilical cord stretches from the placenta to the foetus.

The role of the placenta

- Supplies oxygen from the mother to the embryo
- It supplies food nutrients from the mother's blood
- It supplies white blood cells
- It removes wastes eg carbon dioxide and urea from the foetus to the mother's blood
- It prevents toxic materials in the mother's blood from reaching the foetus

The diagram below shows the embryo attached to the placenta.



**Fig 8.5** *The embryo linked to the placenta*

**REMEMBER:**

A single ejaculation may contain about five hundred million sperms, only one sperm fertilises the ovum. When one sperm enters the ovum, the ovum forms a barrier such that other sperms will not enter and will die after fertilisation. Before fertilisation the released ovum can survive for about 24 hours and a sperm for 2 to 3 days.

In the next sub unit you will learn about what happens when the ovum does not meet the sperm. What do you think happens? Yes menstruation takes place.



## ACTIVITY 4

The word menstruation is not new to you. You might have heard, learnt or experienced menstruation in your life. Therefore, in your own words describe the menstrual cycle.

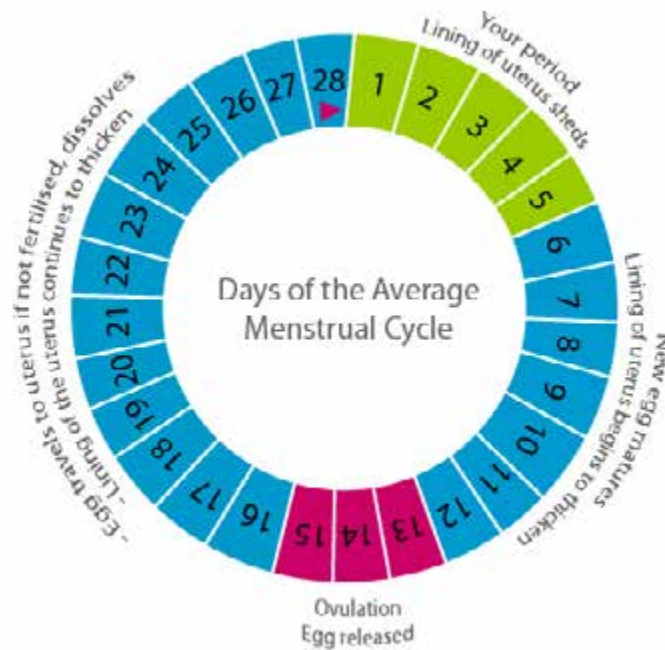
## 8.3 THE MENSTRUAL CYCLE

From a lay man's point of view the menstrual cycle is just the flow of blood that woman experience every month. In actual fact it is not only the flow of blood but it involves some processes such as:

- The uterus preparing to receive a fertilised egg.
- An ovary releasing an ovum.
- The breaking away of the uterus lining if the ovum is not fertilised.

The menstrual cycle is actually the monthly cycle experienced by all woman and girls between the ages of about 11 and 45 years. It is called a "monthly cycle" because in most women it occurs once a month. The normal bleeding from menstruation last about 3 to 7 days. The bleeding indicates that the woman is not pregnant. When the woman is pregnant the bleeding normally stops.

Study the diagram below carefully which summarises the menstrual cycle.



**Fig 8.6 The menstrual cycle**

### Day 1-5

The menstrual cycle begins on the first day when the woman is bleeding through her vagina. The thickened spongy layer of the uterus lining breaks down and passes through the vagina. During menstruation one ovum starts to mature in one of the ovaries.

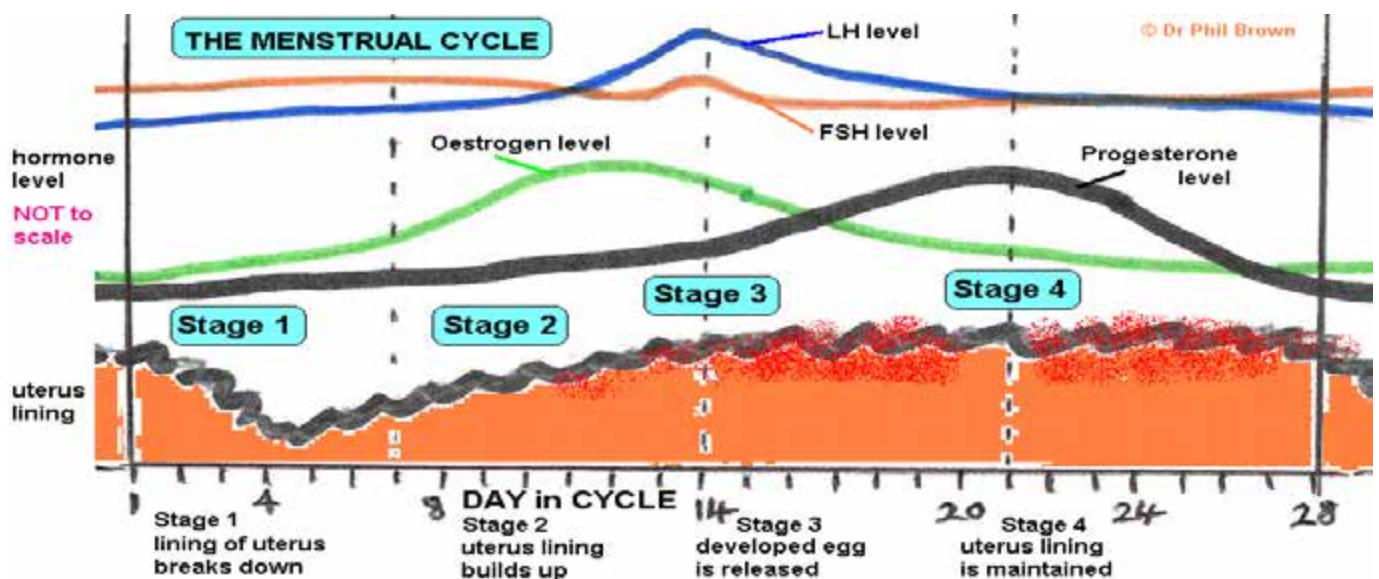
## Day 6-14

The maturing ovum releases the hormone oestrogen that stimulates the endometrium in the uterus to form a new a layer of spongy tissue. On day 14 the mature ovum is released from the ovary into the fallopian tube. The release of an ovum is called ovulation.

## Day 15-28

After ovulation the yellowish body called the corpus luteum develops in the ovary where the ovum has been released. The corpus luteum produces the hormone progesterone that stimulates the tissue of the endometrium to thicken to prepare for the possible implantation of a fertilised ovum. The ovum passes down the fallopian tube to the uterus. If there are sperms in the oviduct (fallopian tube) fertilisation can occur. If the ovum is not fertilised it passes through the uterus to the vagina and out. Now you see what you call blood is actually the uterus lining and broken blood vessels. At this stage the corpus luteum degenerates and stops producing the progesterone. With no progesterone present, the endometrium breaks down again, restarting the menstrual cycle.

**Note:** the menstrual cycle has four phases. The diagram below explains the four phases of the menstrual cycle



**Fig 8.7** The phases of the menstrual cycle

## Ovulation

During this phase an ovary releases an ovum into the fallopian tube and this process is called ovulation and it happens on day fourteen of the menstrual cycle. After an ovum is released it moves down the fallopian tube. At this phase if a woman has unprotected sexual intercourse higher chances are that she might get pregnant. At this phase the lining of the uterus becomes thicker. If an egg is fertilised by a sperm it attaches to the uterus lining and a pregnancy begins. If the ovum is not fertilised, the uterus lining begins to break down and bleeding occurs.

We have discussed a lot about menstruation. Let us check what we can remember from the discussions.

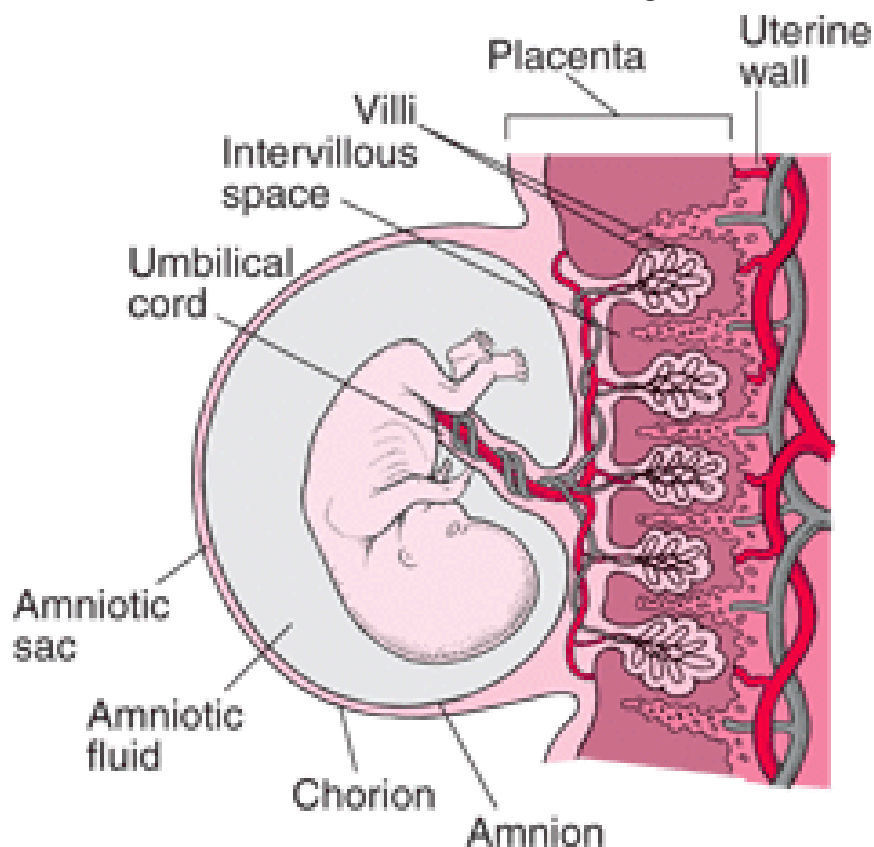


## Activity 6

1. What is menstruation?
2. Describe what takes place on days 1 to 5 and day 14.

### REMEMBER:

The menstrual cycle is the monthly cycle that occurs to every girl or woman from the age of 11 to 45 years. On day 14 of the cycle the egg is released from one of the ovaries and travels to the oviduct (fallopian tube) where it meets the sperm. If the egg and sperm meet fertilisation takes place and a zygote is formed. A zygote is the fertilised egg. The fertilised egg travels to the uterus and attaches itself there and it becomes an embryo. The embryo implants itself to the lining of the uterus and begins to develop on placenta. At about eight weeks after fertilisation the embryo begins to develop features such as heart, head and limbs. At this stage it is called a foetus. The woman is said to be pregnant. The period of pregnancy is called a gestation period and it takes about 40 weeks. The diagram below shows a foetus.



**Fig 8.8 the foetus**



## Reflection

The placenta allows the diffusion of the substances such as oxygen, glucose, amino acids, salts and antibodies from the mother to the foetus. Waste substances like carbon dioxide and urea are excreted with the mother's waste substances. The placenta has a selectively permeable membrane so not all substances are in the mother's blood pass to the foetus. If a pregnant woman smokes or drinks, the alcohol and nicotine will be passed to the foetus through the placenta and may affect the development of the foetus. The umbilical cord attaches the foetus to the placenta and carries the umbilical vein and the umbilical artery. I hope you still remember the veins and arteries from unit 7. Yes the umbilical artery carries the deoxygenated blood and the umbilical vein carries the oxygenated blood. The placenta also contains the amniotic fluid which supports the foetus and protects it from physical damage.



### Activity 5

1. In your own words describe the functions of the following organs:
  - a) Placenta.
  - b) Amniotic fluid.
  - c) Umbilical cord.
2. What are the effects of smoking to pregnant woman?

If you have forgotten the answers to the above questions, do not worry yourself, go back to the last sub units and read again.



### STUDY SKILLS

In order to understand the following sub unit, you need to visit a clinic or hospital.

## 8.4 METHODS OF CONTRACEPTION

Why do people use methods of contraception? People use methods of contraception in order to plan for their families. There are four main methods of contraception that humans use. These methods will be discussed below.



## ACTIVITY 6

Visit the nearest health centre and find out more about the methods of contraception. How and when they are used. Their advantages and disadvantages.

### Natural methods

Natural methods as the word suggests, they are simple and do not use any hormones or devices. There are two types of natural methods the rhythm method and the withdrawal method.

#### How the rhythm method works?

The woman relies on her menstrual cycle. She uses the days in the menstrual cycle. The ovulation days are usually indicated by a rise in temperature. At this time sexual intercourse is avoided as the woman will be highly fertile.

#### How the withdrawal method works?

During sexual intercourse the man withdraws his penis before ejaculation and ejaculates outside the vagina.

#### What are the advantages and disadvantages of this method?

Table 2

Advantages	Disadvantages
No side effects	Not reliable
	High risk of sexual transmitted infections.

### Barrier methods

These include condoms, diaphragm

#### Condoms

There is male and female condom that people use as methods of prevention.

How the male condom works?

The condom is placed over the erect penis before intercourse. During ejaculation, the condom catches up the semen preventing it from entering the vagina.



**Fig 8.9 male condom**

### **How the female condom works?**

The condom is inserted into the vagina and remains there during intercourse to prevent sperm from entering the vagina.

### **How the intra-uterine device (IUD) works?**

The device is made from plastic or copper is placed inside the uterus by a health personnel. It remains there for five years and prevents implantation of the fertilised egg.



**Fig 8.10 the diaphragm or cap**

Advantages and disadvantages of the methods of contraception

These will be put in the table below.

**Table 3**

METHOD	ADVANTAGES	DISADVANTAGES
Male condom	No side effects Up to 98% effective when used correctly Easy to obtain Protects against STI's	Disturbs love making Can break It is used only once
Female condom	Protects against STI's No side effects Upto 98% effective when used correctly	Can be difficult to place into the vagina
Intra-uterine device (IUD)	It is cheap to buy 99 % effective Lasts for many years upto 5 years	Can cause uterine infections Can increase menstrual flow Does not protect against STI's
Diaphragm	90 % effective	Not fully reliable Can be damaged during sexual intercourse
Spermicide	Used only during sexual intercourse	Less effective

### **Hormonal methods of birth control**

These use a variety of hormones to disturb menstruation. There are three main types of hormonal methods and these are the pill, injection and implant.

#### **How the pill works?**

The pill contains oestrogen and progesterone to prevent the production of ovary in the ovaries. It also prevents fertilisation or implantation of fertilised ovum. It is taken daily at the same time.



**Fig 8.11 the pill**

### How the implant works?

A small rod is inserted under the skin on the arm and it contains progesterone.

**Fig 8.12 the implant**



**Fig 8.12 the jadelle**

Advantages and disadvantages of using hormonal methods of birth control

The table below summarises some of the advantages and disadvantages of using hormonal methods.

**Table 3**

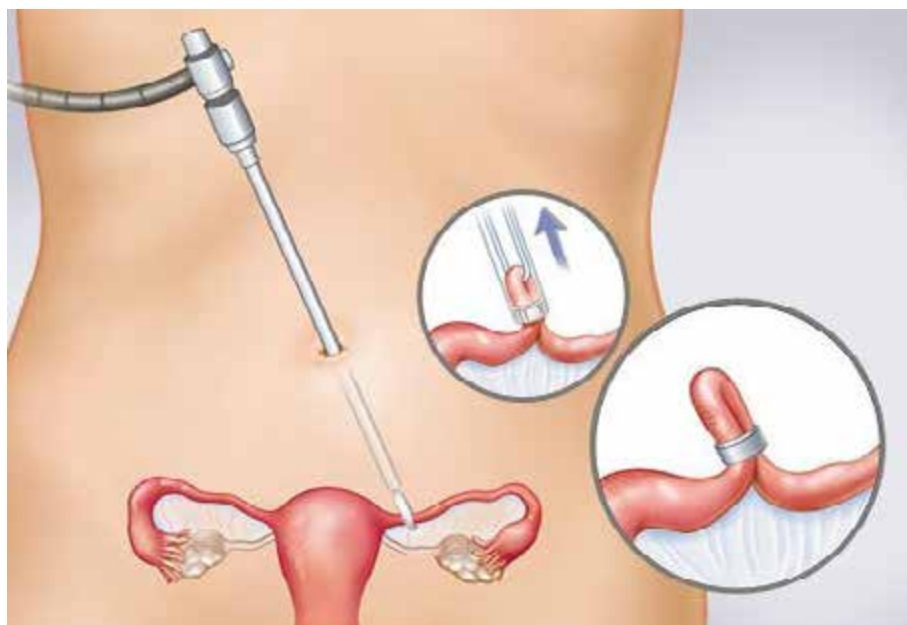
Method	Advantages	Disadvantages
The pill	-easy to take -almost 99% reliable	-does not protect against STIs -increases weight gain -increases high blood pressure -high risk of heart disease -should not be taken with antibiotics
The injection	-very reliable	-might increase weight gain -does not protect against STIs
The implant	-effective three years -very reliable -can be used while breast feeding	-no protection against STIs -may cause head aches -does not protect against STIs

### **The surgical methods of contraception**

Surgical methods of contraception involve sterilisation procedures. There are two types of surgical methods the tubal ligation and vasectomy.

#### **How the tubal ligation works?**

The woman's oviducts are cut and tied so that ova cannot reach the uterus.



**Fig 8.13 tubal ligation**

## How the vasectomy works?

The men's sperm ducts are cut so that sperm cannot leave the body.

## Advantages of surgical methods

They are 100% effective.

## Disadvantages of surgical methods

The disadvantages are that once done its for life. They are irreversible and do not protect against STIs.

Now that you have learnt a lot about the different types of methods of contraception, advantages and disadvantages. Use the questions below to check what you have understood.



## Activity 7

1. List the methods of birth control.
2. Using the methods you listed in (1) above give two examples of each type and advantages and disadvantages of using such a method.

### Remember:

Remember that all birth control methods have advantages and disadvantages. The method of contraception chosen depends on the individual. Some people may experience disadvantages while some advantages on one type of the method used.

## SUMMARY

In this unit you have learnt about the reproductive system, fertilisation and methods of contraception. The reproductive system is the system that ensures the continuation of the species by producing offspring. In humans the male reproductive system are specialised to produce sperms and deliver them to the female while the female produces ova and to protect the growing embryo. You have also learnt that fertilisation can be prevented by four main methods which are natural methods and artificial methods. It should be taken note that every method has its own advantages and disadvantages. Now let us check how much you still remember in this unit. To check your performance refer to end of unit activities in section 8

## 8.5 Sample assessment questions

### MULTIPLE CHOICE QUESTIONS

Tick the most appropriate answer.

1. A zygote is a (1)
  - a) Sperm.
  - b) Fertilised egg.
  - c) Foetus.
  - d) Unborn baby.
  
2. The sac of skin that protects the testes is called (1)
  - a) Ejaculation.
  - b) Epididymus.
  - c) Scrotum.
  - d) Semen.
  
3. Where does fertilisation take place in humans? (1)
  - a) Oviduct.
  - b) Sperm duct.
  - c) Vagina.
  - d) Uterus.
  
4. Which method of contraception is the best to use? (1)
  - a) Abstinence.
  - b) Pill.
  - c) Female condom.
  - d) Sterilisation.
  
5. What is the main disadvantage of using a male condom as a method of contraception? (1)
  - a) It prevents fertilisation.
  - b) The condom may break.
  - c) It prevents STIs.
  - d) It is not reliable.



## STRUCTURED QUESTIONS

Use the spaces provided to answer.

1. What is the main function of the female reproductive system? (2)

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2. Identify the part of the female reproductive system where

a) The foetus develops?

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b) The sperm is deposited by the penis? (2)

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3a) Draw and label the structure of a sperm cell and an ovum. (4)

b) Give two differences and one similarity between the sperm cell and an ovum. (3)

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3. Explain why the oestrogen level drops on day 14? (2)

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4. List two substances that are exchanged through the placenta between a baby and the mother. (2)

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**END [TOTAL 20 MARKS]**

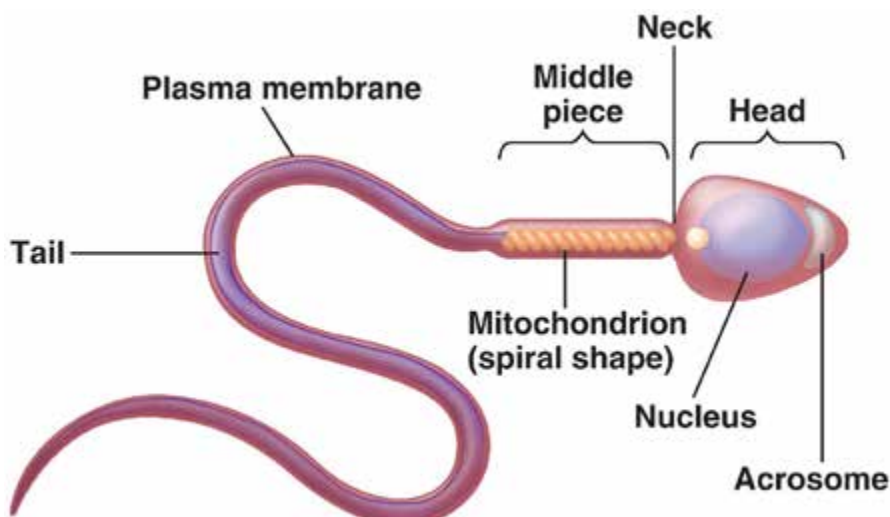
## SUGGESTED ANSWERS

### MULTIPLE CHOICE

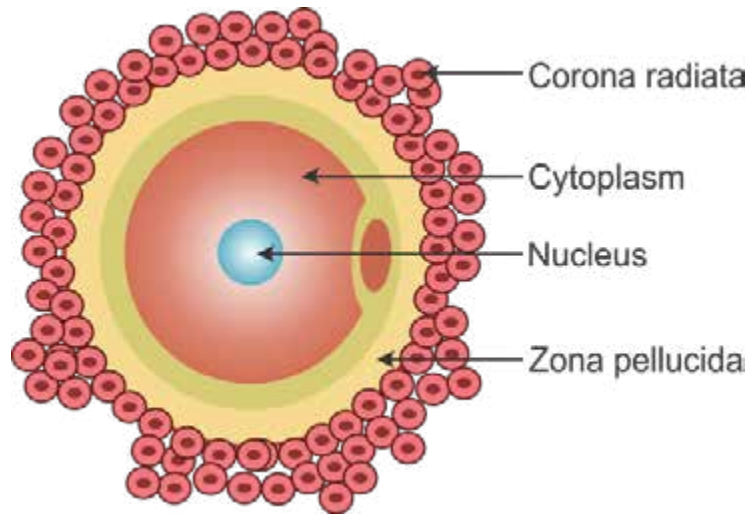
1. B
2. C
3. A
4. A
5. B

### STRUCTURED QUESTIONS

1. - The main function is to play a successful role of fertilisation  
- to keep and protect the embryo and fetus
2. (a) uterus  
(b) vagina
3. (a) sperm cell



## Ovum



(b) - ovum is a small spherical cell with a nucleus, cytoplasm and thick membrane whereas the sperm cell is a single cell with oval shaped head  
- the ovum is larger than sperm  
- both contain a nucleus

1. – the oestrogen level drops because the ovum would have been released
2. – oxygen, glucose, amino acids, antibodies, salts, waste substances.

# UNIT 9: HEALTH AND DISEASES 1

## CONTENTS

- 9.1 Sexually transmitted infections (STIs)
- 9.2 Control methods and treatment of STIs
- 9.3 HIV/AIDS
- 9.4 Substance abuse
- 9.5 Sample assessment questions

## INTRODUCTION

Our bodies need to be free from diseases in order for us to be healthy. While we always wish for our bodies to be healthy pathogens invade our bodies every day putting us at risk of getting sick. This unit discusses diseases that affect our bodies.



## OBJECTIVES

After going through this unit you should be able to:

- List sexually transmitted infections
- Describe the signs, symptoms and effects of: gonorrhoea, syphilis, chancroid, genital herpes
- State the causative agents of gonorrhoea, syphilis, chancroid, genital herpes
- State the control methods and treatment of gonorrhoea, syphilis, chancroid and genital herpes
- Describe the effects of tobacco smoking and alcohol on health
- Explain effects of mandrax and cannabis
- Outline effects of breathing solvents
- Describe the spread and effects of HIV/ AIDS on the body



## Key Words

**Symptoms**-a signal or characteristics of the presence of a disease

**Pathogens**-these are diseases causing organisms



Time: 8 hours



Study skills

Health and Diseases is a topic that is quite applicable in your day to day living. As you read through the topic try to find examples in your area and make the topic as applicable as possible. Local examples will help you remember the main concepts in the topic.

## 9.1 SEXUALLY TRANSMITTED INFECTIONS

STIs is an abbreviation standing for, Sexually Transmitted Infections. As suggested by the name, they are infections that are commonly spread through sexual activities. STIs are spread when two or more partners engage in sexual activity with no protection. They come in various forms as shall be discussed below.

### Gonorrhoea

Gonorrhoea is characterised by a discharge that is why sometimes it is called 'discharge'. The discharge is usually a green, yellow or white fluid. Gonorrhoea is caused by a bacterium called *Neisseria Gonorrhoeae* which is transmitted when one has unprotected sexual intercourse with an infected partner. Gonorrhoea usually affects the urethra, cervix, eyes as well as the anal canal.

### Effects of Gonorrhoea

- Blocked fallopian tubes leading to infertility in females.
- Damaged prostate glands leading to infertility in males.
- Leads to fertilisation that occurs outside the fallopian tube.

## Signs and symptoms of gonorrhoea

- Painfull urination
- Men experience testicular pain and women abdominal pain
- Swelling of the vulva in women
- Increased vaginal discharge and itchy discharge in women
- Fever and frequent urge to urinate
- Irregular menstruation
- Pus or sore throat

## TREATMENT OF GONORRHOEA

Penicillin or tetracycline are antibiotics used to treat gonorrhoea

## Syphilis

This disease is caused by a bacteria called the *treponema pallidum*. It is a sexually transmitted disease but can also be contracted at birth, through cuts and bruises. If you remember well, the functions of the placenta in the female reproductive system. Its role is to protect the foetus from injury and infection from mother to child. However the syphilis bacterium can pass through the placenta to affect the foetus, this is called congenital syphilis. Babies born with congenital syphilis show signs of weakness and are always ill. In most cases such babies survive for a few hours after birth.

## Signs and symptoms

It is a 3 stage condition. That means the condition progresses into three stages after the day of infection ie Primary, secondary and tertiary stages.

### Stage 1 (Primary)

The first sign of infection is a lump on the sexual organs in both men and women ie the penis and the vagina or cervix area. The lump then develops in to an ulcer then disappears. This ulcer is not painful neither does it have an itching effect hence it can appear and disappear without noticing it

## Stage 2 (secondary)



**Fig 9.1 mouth with ulcers**

From the 6<sup>th</sup> to the 8<sup>th</sup> week after infection the infected person develops a fever with rash or wounds in the genital area, mouth, eyes and anus. The infected person may experience enlargement of the lymphatic glands in the neck as well.

## Stage 3 (tertiary)

Syphilis as explained before is a progressive condition hence if it goes untreated can develop into a more serious and complicated condition. Syphilis can take 10 or more years to reach the tertiary stage. During the period the bacteria is known for damaging the various tissues and organs. After damaging the tissues and organs the 3<sup>rd</sup> stage manifests itself as in heart diseases, blindness and ill mental health and eventually leading to death. Note that syphilis can be treated.

## TREATMENT OF SYPHILIS

Syphilis can be treated using antibiotics and penicillin in the early stages of infection. It may however not be easy to treat syphilis in the 3<sup>rd</sup> stage with damaged tissue and organs as they may have been permanently damaged.

## Chancroid

The *haemophilus ducreyi* bacterium causes chancroid. The condition is also known as the Venereal Ulcer. The infected can produce a fluid from the genital area spreading the bacteria to the sexual partner during sexual intercourse. The bacteria can also be spread through touching an open wound.

## Signs and symptoms of chancroid

Barely 2 to 4 days after having unprotected sexual intercourse with an infected person, bump appear on the penis in men or labia in women. In women a burning sensation is experienced during urination and or passing stool. The ulcer may appear and disappear for several months if not treated.

## Treatment of chancroid

An antibiotic such as tetracycline are usually used to treat chancroid.

## GENITAL HERPES

Unlike all the sexual infectious diseases we have discussed before in this unit, genital herpes is an infectious disease caused by a virus. .The virus is contracted through having unprotected sexual intercourse with an infected person. The person suffering from this disease develops sores and these sores produce a fluid which can as well spread the virus and cause infection as it enters through the skin and continue to spread through the nerves of the skin.

## Signs and Symptoms

Genital herpes cannot be cured. Only the signs and symptoms can be prevented. Antiviral medication only reduces pain and outbreak of the sores. The viral effect can also be reduced when infected persons take medication daily also their chances of infecting others are reduced.

## 9.2 Control methods and treatment of STIs

- Abstinence
- Safe sex methods
- Visiting health centres after observing signs and symptoms
- Bring sexual partner for treatment



### Activity 1

Visit the local health centre for more information about STIs.



## 9.3 HIV AND AIDS

HIV is a virus that if not controlled causes AIDS. HIV stands for the **Human Immuno Virus** which is transmitted through a number of ways using body fluids. The virus attacks the immune system weakening it and making it unable to fight any pathogen invasion of the body. The condition cannot be treated but controlled. AIDS stands for **Acquired Immuno Deficiency Syndrome**. This is the condition where the body no longer has any defence mechanisms.

Spread and effects of HIV/ AIDS on the body

As highlighted before, **HIV** is commonly spread through exchange of bodily fluids between an infected person and an uninfected person. Such exchange can be through one or more ways among the following:

- Having unprotected sexual intercourse with an infected person or persons.
- Injecting oneself with a needle that has been used by an infected person. Many drug addicts share needles during self drug injection increasing their rate of spreading HIV.
- An infected mother can infect her unborn child. (Prenatal Transmission) if no measures to protect the baby are taken.
- Through transfusion of contaminated blood.

Acquired Immuno Deficiency Syndrome (AIDS) is a viral condition not a disease. It is referred to as a condition since there is no specific disease called AIDS but a condition in one's immune system that develops defects in protecting the body from infections. This condition gives room for every invasion by pathogens to attack the body freely and the victim falls sick easily. The AIDS condition thus gives room for opportunistic infections. These are diseases that take advantage of a weak immune system. Such infections include but may not be limited to:

- Thrush
- Pneumonia
- Cancer (of the eye)
- TB

Most of the people with this condition become unable to look after themselves and require attention from others every time.

## Signs and symptoms of HIV/AIDS

People suffering from AIDS usually show the following signs

- High body temperature
- Body rashes
- Headaches
- Swollen glands in the neck
- Sore throats
- Tiredness
- Muscle pains
- Joint pains
- Stomach upset

## Methods of controlling the spread of HIV/AIDS

- Abstinence
- Having one faithful and uninfected partner
- Early treatment of STIs
- Prevention of parent to child transmission (PTC)
- Awareness campaigns



### Activity 2

- 1) HIV and AIDS are abbreviations. Write them in full.
- 2) Why do we say HIV/AIDS is not a disease?
- 3) What do you understand by home based care?
- 4) Describe how HIV/AIDS can be spread. In your answer provide how the spread can also be controlled
- 5) What are opportunistic infections? Give examples.

## 9.4 SUBSTANCE ABUSE

### Effect of Tobacco Smoking

Effect	Description
Emphysema	Alveolar walls lose elasticity and break down reducing the surface area for gaseous exchange. This leads to shortness of breath
Low birth weight	Smoking during pregnancy causes low birth weight in children born to smokers
Bronchitis	Inflammation of the lungs that results in production of a large amount of mucus and fluids. This causes the smoker to cough excessively to get rid of the excess mucus. This is known as the smoker's cough

### Effects of alcohol consumption

- Slows down reaction time which may result in accidents when driving or handling machinery
- Liver cirrhosis in which healthy tissue is replaced by non-functioning scar tissue
- Impaired judgement and loss of self control
- Negligence and abusiveness towards family members

### Effects of Cannabis and Mandrax abuse

- Hallucinations - sensory perception of something that does not exist.
- Addiction - physical and psychological dependency on a substance

### Solvents

- Hallucinations
- Intoxication
- Heart and muscle damage
- Addiction



## Activity 3

- 1) What is substance abuse?
- 2) Give two ways substance and drug abuse affects abusers
- 3) Drug abuse can result in loss of control. Explain this view giving examples.
- 4) Drug and substance abuse have further damages that extent to non abusers. Explain how abuse of drugs affect the country`s economy.

### SUMMARY

To end this unit let us look at key points that we have learnt. We have learnt that STIs have a number of effects on the body and some of which are long term but they can be controlled if treatment is done early. You also learnt about HIV/AIDS its causes, symptoms and treatment. The drug abuse is also another area we looked at in detail. We hope by now you are well versed with the contents of this unit. Now you can attempt the self assessment questions below.



### 9.5 SAMPLE ASSESSMENT QUESTIONS

1. What does the abbreviation STI stand for? (2)
2. State the signs and symptoms of gonorrhoea. (4)
3. Group sexually transmitted infections into those caused by bacteria and those caused by the virus. (4)
4. Describe how HIV is transmitted from one person to the other. (5)
5. What are the effects of cigarette smoking? (3)
6. How does the inhaling of glue affect the body? (2)

## Unit 9: health and diseases 1

### Answers

1. STI - sexually transmitted infections
2. - yellowish discharge from the penis  
- yellowish discharge from the vagina  
- pain during urination  
- smelly and itchy discharge

3.

Bacterial infections	Viral infections
Syphilis	Genital herpes
Gonorrhoea	HIV/AIDS
Chancroid	

4. - sexual intercourse with an infected partner  
- sharing sharp objects  
- exchange of body fluids with an infected partner  
- mother to child transmission during birth
5. - bronchitis  
- addictive  
- emphysema  
- lung cancer
6. - brain damage  
- hallucinations  
- muscle weakness

# UNIT 10: HEALTH AND DISEASES 2

## CONTENTS

- 10.1 Causes, signs, symptoms and treatment of Malaria,
- 10.2 Life cycle of malaria parasite and anopheles
- 10.3 Typhoid, Ebola and cholera
- 10.4 Sample assessment questions

## INTRODUCTION

Malaria is one of the top killer diseases in Africa and the world over. It is important for us to learn about the life cycle of malaria. This will help us to prevent this killer disease from causing further deaths. We will also learn about typhoid, Ebola and cholera.



## OBJECTIVES

By the end of this unit you should be able to:

- Describe signs and symptoms of malaria, typhoid, Ebola and cholera
- Outline the life cycle of malaria parasite and anopheles' mosquito
- State the cause of malaria, typhoid, Ebola and cholera
- Explain how the diseases are treated



## Key words

**Life cycle**-stages of development of an organism

**Pathogen**-a disease causing organism

**Vector**- an organism that carries a pathogen



**Time: 8 hours**

# 10.1 CAUSES, SIGNS, SYMPTOMS AND TREATMENT OF MALARIA

## Malaria

Competing with HIV /AIDS and Cancer on the death toll is malaria. Malaria is caused by parasitic protozoa called the plasmodium found in the salivary glands of a female mosquito. The female mosquitoes are called the anopheles mosquito. Through mosquito bites the parasites are passed into the human blood stream. Once in the blood stream, the parasite travels to the liver where they affect the liver cells. The parasite reproduces asexually in the liver cells. Gaining numbers in the liver cells the parasites re-enters the blood stream to affect the red blood cells where they continue to reproduce. Infected red cells burst releasing the pathogen causing fever in humans. When the mosquito bites an infected person, it sucks the pathogen in the process. The diagrams below shows the life cycle of plasmodium and a mosquito.

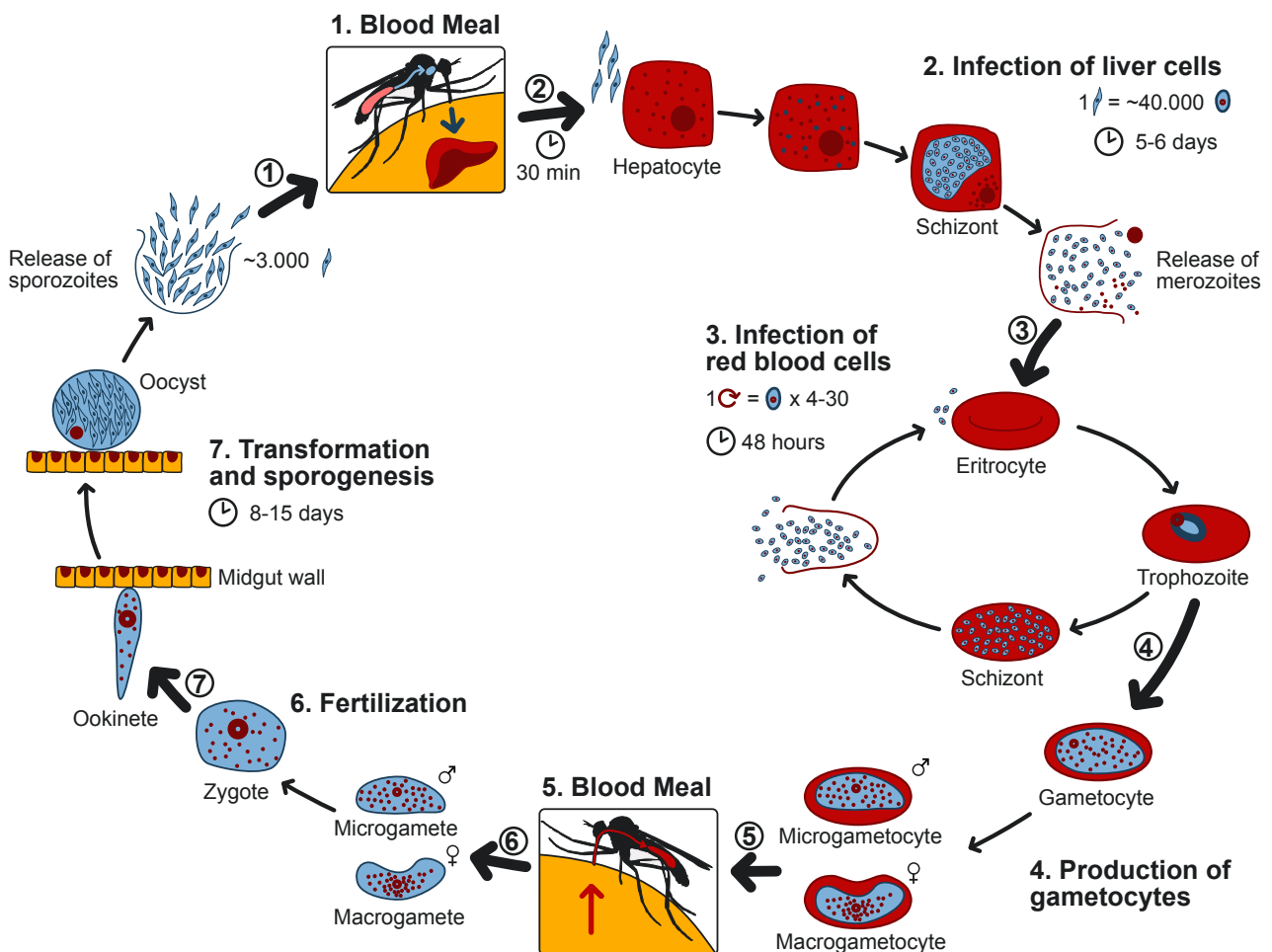
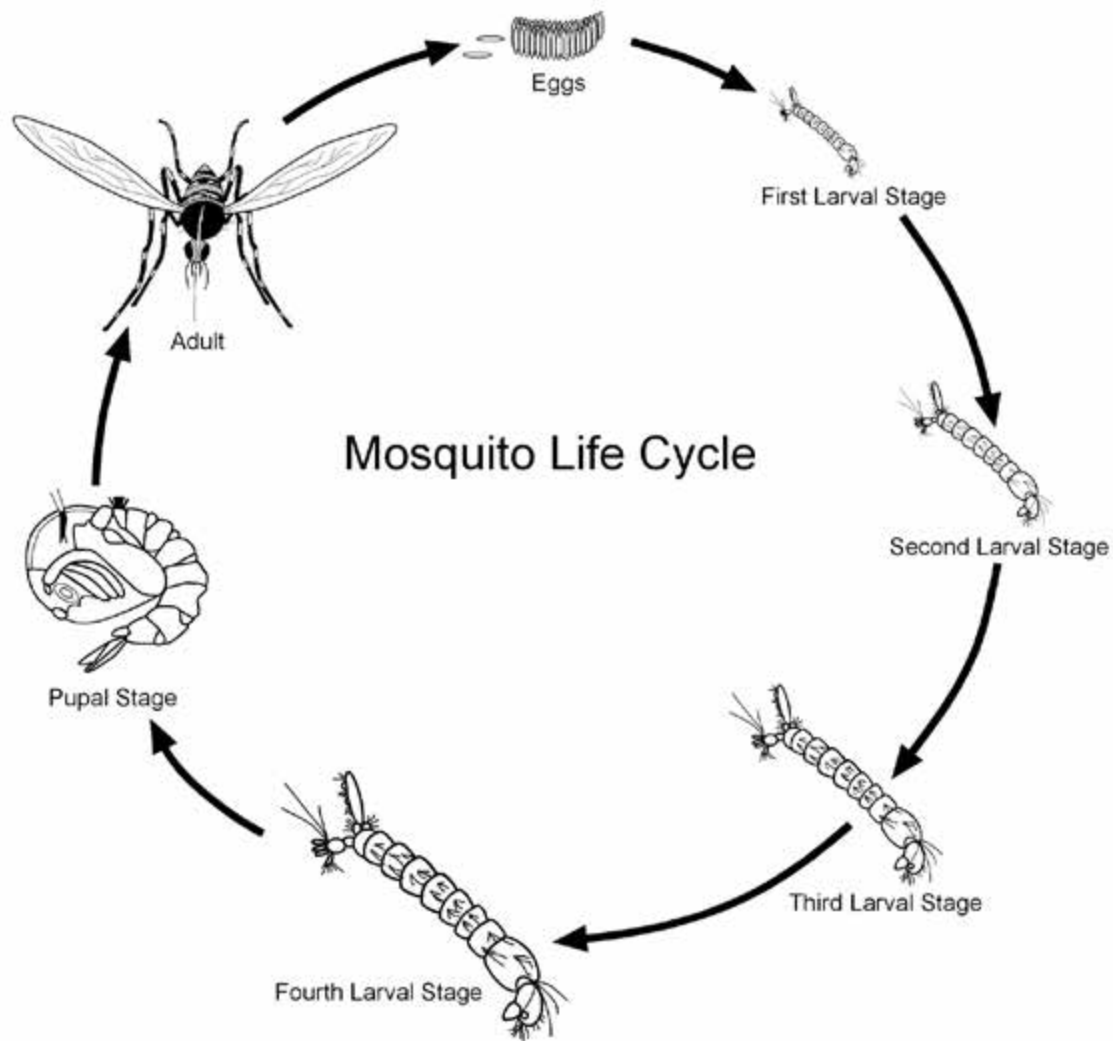


Fig 10.1 plasmodium life cycle

## 10.2 Life of cycle of mosquito



**Fig10.2 life cycle of an anopheles' mosquito**

### Signs and Symptoms of Malaria

Two weeks after the mosquito bite, carriers of the parasite experience the following:

- High fever
- Shivers and sweats
- Headaches
- Vomiting
- Enlarged spleen
- Ankle aches
- Brain attack which may result in death



## Methods of controlling the spread of malaria

a) This is done through controlling the breeding of the vector(mosquito) through the following

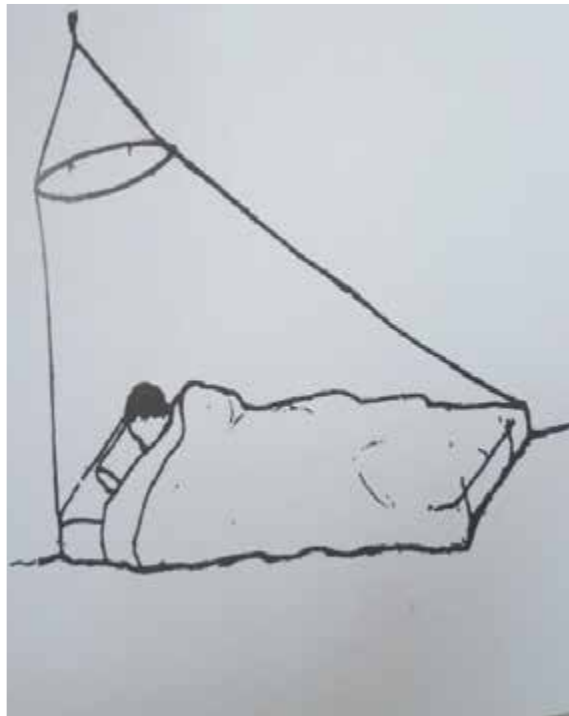
methods:

- grass cutting around homesteads and other places of dwelling
- filling of pot holes and ditches
- removing stagnant water as breeding places
- covering water in ponds with oil to suffocate the developing mosquito
- spraying dwelling places including schools, clinics and toilets in public places
- Use of treated mosquito nets is also an effective method of controlling spread of malaria. Treated mosquito nets are effective for a long time even if they are washed
- Taking preventative drugs when visiting a malaria area. People from uplands and areas not commonly known for malaria are encouraged to take tablets that prevent them from contracting malaria once they visit traditional malaria areas such as the lowveld in Zimbabwe.
- Use of mosquito repellent. Mosquito repellents come as soaps, creams and oils. These repel mosquitoes from reaching the humans
- Use of sprays. Various insecticides are available in shops that can be used to kill or drive away mosquitoes for domestic purposes.
- People are encouraged to avoid dark places as well as taking their birth in daylight to avoid being bitten by mosquitoes
- Putting on of long sleeved clothing. Long sleeves covering all ankles ensure that no mosquito will bite



## Activity 1

Below are ways we can control malaria in our homes. Briefly explain what is happening in each picture.





 **Note:**

Children under the age of 0 to 6 weeks may not be given anti malarial drugs hence the need to take special care to ensure they are not bitten by mosquitoes.



## Activity 2

1. Draw and label the mosquito life cycle
2. Identify and describe any 3 ways you used to control malaria in the environment
3. Besides environmental management explain how else can people prevent bites from malaria mosquitoes
4. What are the signs and symptoms of malaria in humans?

## 10.3 Typhoid, Ebola and Cholera

### **Ebola**

The disease is caused by a virus. The virus is commonly found in the blood, excretions and meat of animals eg chimpanzee, gorillas and fruit bats infected with the virus. Humans contract the virus from these sources as they hunt the animals for food. Transmission of the virus can also be through direct contact with excretions from humans such as semen, saliva, vomit as well as blood and breast milk from infected persons. The virus can also be spread by direct contact with the dead bodies from the disease, contaminated clothes and bedding.

### **Signs and Symptoms**

The virus takes 2 to 21 days to start showing signs and symptoms. The first sign by victims include headaches, high fever, weakness, muscle pain and sore throat. The virus targets all body tissues and organs of the body. Other signs and symptoms could be high temperature, vomiting, diarrhoea and rash within the 10 days of infection. The rash is the result of blood clots disturbing smooth blood flow. With the disease getting worse, the clots continue to grow as well. Infected persons suffer bruises, brain damage and bleeding from eyes, nose, mouth and anus by day 11. Day 12 to 16 internal bleeding is experienced from the lungs, brain, liver, intestines, kidneys, testicles and breast tissues. The infected person eventually dies.

### **Controlling and treating the Ebola**

Balancing patient's fluids and as well as maintaining oxygen levels and blood pressure is critical to the treatment of ebola.

Protection from ebola can be done through:

- Washing hands with soap and water or alcohol –based disinfectant
- Cover your nose and mouth with a cloth or tissue when coughing or sneezing
- Avoid contact with an infected person's blood, bedding, clothing, bodily fluids as well as any medical equipment used on the infected person.



## Activity 3

1. What are the signs and symptoms of Ebola?
2. State any three steps you can take to prevent the spread of Ebola.
3. Explain why ebola can not be treated?

### Typhoid

It is generally water borne disease. This means people usually contract it from drinking contaminated water. However, typhoid may as well be spread through eating contaminated food. Typhoid is caused by bacteria called *salmonella typhosus*. Once this bacterium enters the small intestines and the blood stream, they travel to attack the liver, spleen, gallbladder and the bone marrow where they rapidly multiply.

### Signs and symptoms of typhoid

Upon invasion by the bacteria, one may have a fever, stomach pains, poor appetite, headaches as well as a rash that is noticed on the chest or abdomen (the rash is described as rose spots). Victims may also have diarrhoea among the first signs. Blood and stool tests are used to diagnose typhoid.

### Control and treatment of typhoid

Treatment of typhoid is by administering antibiotics. A patient may recover fully within a week of taking drugs. Typhoid may be controlled by administering a preventative drug before travelling to high risk areas. It is also advisable to provide people with clean and safe water, preventing food contamination as well as practicing high levels of personal hygiene. People with typhoid should avoid preparing food to avoid contamination.

### Cholera

Cholera is mainly water borne disease. Mainly due to poor water and sanitation facilities as well as poor water purification processes water becomes contaminated and people who use the water suffer from cholera. It is caused by bacteria called *Vibrio cholerae*. The disease is also commonly spread through direct ingestion of human and animal faeces. Contamination of food can be by humans, animals and rodents in the household.

## Signs and symptoms of cholera

Cholera victims always suffer from vomiting. People also have watery diarrhoea, (rice water). Patients of cholera also show signs of dehydration and if body fluids are not managed the person may die.

## Control and treatment of Cholera

Since humans are among the main transmitters of cholera, personal and environmental hygiene is top of the priority among other means of controlling the disease. Cholera is prevented by good waste management practices. Making sure food and water is not contaminated as well as keeping rodents away from our food. People are always encouraged to use proper toilets for the disposal of faeces. The Blair toilet is the most appropriate where water is in short supply for water system toilets. People also must always wash their hands using soap or ash. Ensuring that drinking water is always treated or boiled keeps you away from cholera. It is critical to avoid contaminating water sources. In homesteads, our own toilets usually contaminate our own water sources. Children usually contract cholera from playing in contaminated pools of water. It is therefore important to keep such pools clean and safe from contamination.

## SUMMARY

The spread of diseases can be controlled if people have the knowledge about their life cycles and how they infect people. We hope from this unit you have gathered an in depth knowledge of the signs, symptoms and treatment of cholera, malaria, ebola and typhoid. If you have challenges in understanding any of the concepts covered in this unit, revisit the unit and also seek information from other resources. To check your performances attempt the following questions.

## 10.4 SAMPLE ASSESSMENT QUESTIONS

1. Malaria is caused by:

- A. bacteria
- B. protozoa
- C. germs
- D. virus

2. Typhoid is a
- A. disease caused by a virus
  - B. water borne disease
  - C. congenital disease
  - D. tropical disease
3. Victims of ebola usually show signs of
- A. internal and external bleeding
  - B. ill mental health
  - C. diarrhoea
  - D. skeletal muscle damage
4. Cholera can be controlled by
- A. eating healthy food
  - B. spraying indoors
  - C. personal hygiene
  - D. closing dark corridors

### **Structured questions**

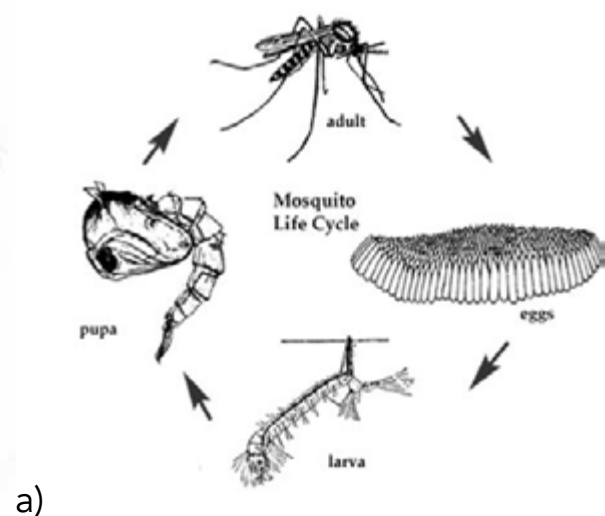
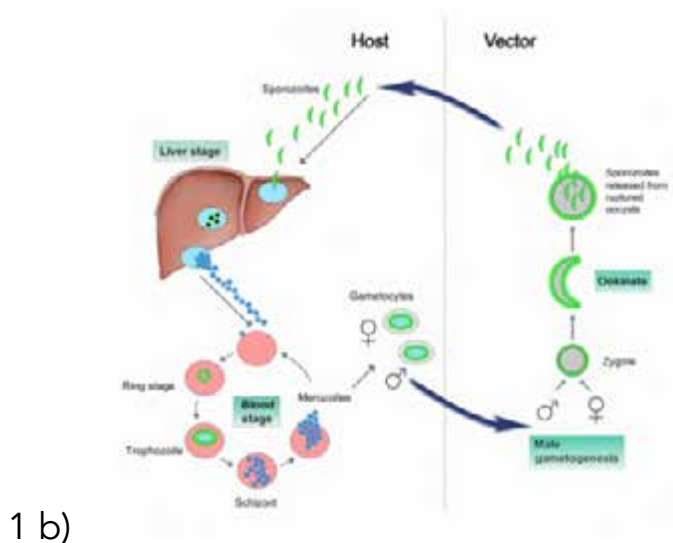
1. Using diagrams describe the life cycle of:
  - a) Anopheles mosquito(5)
  - b) Plasmodium (5)
2. Describe how you can use the environment to control the spread of malaria in your area. (5)
3. How do humans contract ebola virus from wild animals (2)

## Unit 10: health and diseases 2

### Answers

1. B
2. B
3. A
4. C

### STRUCTURED QUESTIONS



- 5
  - cutting tall grass around residential places
  - spraying sources of stagnant water
  - burying empty containers
  - destroying open water sources
3.
  - contact and eating meat of infected wild animals



# UNIT 11: IMMUNITY

## CONTENTS

- 11.1 Natural immunity
- 11.2 Artificial immunity
- 11.3 Immunisation and breast feeding
- 11.4 Sample examination questions

## INTRODUCTION

Immunity is the body's ability to fight against diseases. Immunity can be described in two forms which are natural and artificial immunity.

### 11.1 NATURAL IMMUNITY

Natural immunity is found in three main forms which are the barrier, active natural immunity and the passive natural immunity

The invasion of pathogens is counteracted by the body in two main ways.

#### **The barrier**

The skin makes up the natural barrier that prevents pathogens from getting into the blood. The outer layer of the skin mainly made up of the dead cells provides the natural and the skin produces some chemicals which kill the pathogens. The eyes for example produce an enzyme that kill pathogens which may damage the eyes.

#### **Active natural immunity**

White blood cells engulf pathogens and produce chemicals that kill the pathogens. Some white blood cells also produce chemicals called antibodies which destroy bacteria. Once the animal has recovered from the infection, it is has acquired active natural immunity. The antibodies will not stay for long in the blood after the bacteria is destroyed. Next time the same pathogen invades the body, the body is aware of the bacteria and better placed to fight the infection. This is called active natural immunity.

#### **Passive natural immunity**

This is immunity acquired by babies while in their mother's womb. The baby gets the ready made chemicals from the mother. The antibodies are also acquired through breast milk. The antibodies are however not permanent, they are soon to be destroyed by the body.

## 11.2 Artificial immunity

This immunity is found in two forms and these are passive artificial immunity and active artificial immunity

### Passive artificial immunity

This immunity is induced by ready made antibodies which are injected into the body or taken in as medicines. The antibodies are soon or later destroyed by the body

### Active artificial immunity

This is immunity which is acquired from vaccines. Vaccines contain killed or weakened pathogens. When these are injected into the blood stream, the organism undergoes a mild form of the disease and the white cells manufacture large quantities of antibodies. In this way immunity is artificially acquired and is permanent. When the person is attacked by the real pathogen, the body is found better prepared to fight the disease.

Below is a table showing features of passive and active immunity

**Table 1**

Active immunity	Passive immunity
<ul style="list-style-type: none"><li>Active immunity requires exposure to a pathogen or to the antigen of a pathogen.</li></ul>	<ul style="list-style-type: none"><li>Passive immunity is conferred from outside the body, so it doesn't require exposure to an infectious agent or its antigen.</li></ul>
<ul style="list-style-type: none"><li>Exposure to the antigen leads to the production of antibodies. These antibodies essentially mark a cell for destruction by special blood cells called lymphocytes.</li></ul>	<ul style="list-style-type: none"><li>There is no delay in the action of passive immunity. Its response to an infectious agent is immediate.</li></ul>
<ul style="list-style-type: none"><li>Active immunity is permanent. It lasts for life</li></ul>	<ul style="list-style-type: none"><li>Passive immunity is not as long-lasting as active immunity. It is typically only effective for a few days.</li></ul>
<ul style="list-style-type: none"><li>There is a delay between exposure to the antigen and acquiring immunity. The first exposure leads to what is called a primary response. If a person is exposed to the pathogen again later, the response is much faster and stronger. This is called a secondary response.</li></ul>	<ul style="list-style-type: none"><li>A condition called serum sickness can result from exposure to antisera.</li></ul>

· Active immunity lasts a long time. It can endure for years or an entire life.	· Passive immunity is conferred from outside the body, so it doesn't require exposure to an infectious agent or its antigen.
· There are few side effects of active immunity. It can be implicated in autoimmune diseases and allergies, but generally doesn't cause problems.	· There is no delay in the action of passive immunity. Its response to an infectious agent is immediate.
· Active immunity is effective for life	· Passive immunity is not as long-lasting as active immunity. It is effective for a few days.

**Remember:**

- Passive and active immunity are the main two types of immunity.
- In active immunity , the immune system response to a pathogen making the body produce anti bodies to attack invading bacteria or viruses
- Passive immunity is when anti bodies are introduced from outside the victim`s body for example from breast milk or injections from immunization and the body response immediately to the invading organisms.

### 11.3 IMMUNISATION AND BREAST FEEDING

Breast feeding is encouraged over bottled milk for the following reasons.

- It contains antibodies.
- All nutrients are present giving a balanced diet.
- Hygienic.
- Has correct temperature.
- Creates a bond between mother and child.

#### IMMUNISATION

Immunization is the process whereby a child is made immune or resistant to an infectious disease, typically by the administration of a vaccine. Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease. A vaccine is a weakened pathogen.

Immunisation programme in Zimbabwe

VACCINATION SCHEDULE	
AGE	VACCINATIONS
BIRTH	BCG, Hep B
6 WEEKS	DTP-Hib-Hep B 1, OPV 1, PNEUMOCOCCAL 1, ROTAVIRUS 1
10 WEEKS	DTP-Hib-Hep B 1, 2, OPV 2, PNEUMOCOCCAL 2, ROTAVIRUS 2
14 WEEKS	DTP-Hib-Hep B 1, 2, 3, OPV 3, PNEUMOCOCCAL 3, IPV
9 MONTHS	MEASLES RUBELLA 1, TYPHOID VACCINE
18 MONTHS	DTP, OPV, MEASLES RUBELLA 2
5 YEARS	Td 1
10 YEARS	Td 2
10 YEARS	HPV 1
11 YEARS	HPV 2

VACCINATION RECORD				
VACCINE	DOSE NUMBER			
	1	2	3	4
BCG				
Hep B				
OPV				
IPV				
PENTAVALENT				
PNEUMOCOCCAL				
ROTAVIRUS				
MEASLES RUBELLA				
DTP BOOSTER				
Td				
HPV				

VACCINATION DUE DATES REMINDER	
ANTIGEN	DUE DATE
Penta/OPV/PCV/Rota 1	
Penta/OPV/PCV/Rota 2	
Penta/OPV/PCV 3, IPV	
MR 1, TCV	
MR 2, DTP, OPV BOOSTERS	
Td 1	
Td 2	


  

VITAMIN A SUPPLEMENTATION SCHEDULE					
Age (Months)	6-11	12-23	24-35	36-47	48-59
DOSE	ENTER DATE GIVEN AND BATCH NUMBER				
First Dose					
Second Dose					

For Vit A, Give First dose at 6 months and thereafter a dose every 6 months up to 5 years of age

DEWORMING	
Date	
Batch	

  
**MoHCC 2019**  
 For more information  
 visit your nearest health facility

Vaccine	Disease Prevented	Chiwere Chinodzivirwa	Umkhuhlane Dzikelwayo
BCG	Tuberculosis	Rurindi	Ufuba
Hep B	Hepatitis	Gomarara rechiropa	Imvukuzane yesibindi
Pentavalent	Diphtheria, Pertussis, Tetanus, Meningitis, Influenza, Cancer of the Liver	Rukanda pahuro, Chiomashaya, Chipembwe, Meningitis, Fruenza, Gomarara rechiropa,	Amalonda amakulu, Amaketane, Uqhepha oludondoyo, Meningitis umvimbano olegazi, Imvukuzane yesibindi
OPV, IPV	Poliomyelitis	Mheta makumbo	Imbeleko
PCV13	Pneumonia	Mabayo	Isihlabo
Rotavirus	Rotavirus Diarrhoea	Manyoka	Isihudo
Measles Rubella	Measles and Rubella	Gwirikwiti	Indingindi
Td	Tetanus and Diphtheria	Chiomesa shaya, Rukanda Pahuro	Amaketane lophepha oludonsayo
HPV	Cancer of the cervix	Gomarara yemuro mo wechibereka	Imvukuzane yomomo wesibeletho
Vitamin A	Night blindness	Kusaona zvakanaka Murima	Ukungaboni kahle eminyameni

NAME(S) OF CHILD:
SURNAME OF CHILD:
SEX: <input type="checkbox"/> Girl <input type="checkbox"/> Boy DATE OF BIRTH: [ ][ ]/[ ][ ]/[ ][ ][ ][ ]
PLACE OF BIRTH:
HEALTH CENTRE:
PHYSICAL ADDRESS:
CONTACT NUMBER:
FULL NAME OF MOTHER:
FULL NAME OF FATHER:

NOTES \_\_\_\_\_


**MINISTRY OF HEALTH AND CHILD CARE**  
**CHILD HEALTH CARD**  
**ZIMBABWE**




**GOOD INFANT FEEDING PRACTICE**  
 Give breast milk only for the first 6 months. Introduce solids and liquids from 6 months. Continue breast feeding up to 24 months or beyond unless counseled otherwise by a health worker.

**KUDYA KWAKANAKA KWEMWANA**

Ipai mwana mukaka wezamu chete pamwedzi mitanhatu yekutanga.

Ipai kurwe kudyu kana kurwa kubva pamwedzi mitanhatu.

Rambai muchiyamiswa kusvika pamakore maviri kana kudarika kunze kwekuti makurukura nevutano.

**INDELELA ELUNGILEYO YOKONDLA UMNTWANA**

Nika umtwana uchago lwebele lodwa kunyanga eziyisithupha zokuqala zokuzalwa.

Oaisa ukunika umtwana okunya ukudla lokunathwayo nxa eselenyanga eziyisithupha. Qhubeka umunyisa umtwana aze abe leminyaka embili kusiyaphambili, ngaphandle ukwayiswe ngabezempilakahl.

**SALT AND SUGAR SOLUTION (SSS)**

Give this SOLUTION as often as possible in case of DIARRHOEA and continue feeding and breastfeeding. Consult the community health worker in your area. Take your child to the health facility for further management

**MVURA INE MUNYU NESHUGA**

Ipai mwana MVURA iyi nguva dzose kana ane MANYOKA moramba muchimupa zvokudya nekumnyamiswa. Onai vutano varimuharanda menyu, endesai mwana uyu kuchipatara anoongorora.

**AMANZI ALESAWUDO LETSHUKELA**

Nika umtwana AMANZI aleSAWUDO LETSHUKELA ngasikhathi sonke EHUDO, njalo qhubeka unika umtwana ukudla lokumnyisa. Bona abezempilakahl abasesigabeni sakho ngokuphangisa

Hambisa umtwana esibhedlela ayehlowa.



INFANT FEEDING	
Follow up time	Birth 6W 10W 14W 5M
Breast milk only	
If not exclusive breast feeding indicate what else is given	
Follow up time	6M 7M 8M 9M 10M 11M 12M 13M 14M 15M
Complementary foods	
Breastfeeding Continues	
Food groups given / day	
No. of meals/day	
Follow up time	16M 17M 18M 19M 20M 21M 22M 23M 24M
Complementary foods	
Breastfeeding Continues	
Food groups given / day	
No. of meals/day	
Feeding code	1. Breast milk only 2. Breast milk and Water only 3. Breast milk and other liquids 4. Breast milk and solids 5. Formula only 6. Other milks

CARE	
Is the mother on ART	(Tick appropriate box) YES <input type="checkbox"/> NO <input type="checkbox"/>
ARV prophylaxis given at birth	(Tick appropriate box) YES <input type="checkbox"/> NO <input type="checkbox"/> N/A <input type="checkbox"/>
If yes, specify the ARV prophylaxis:	
Enter initials of the ARV prophylaxis supplied e.g NVP	
HIV Test	Type of test used
Date test done	Test number
Test result (code/1)	Date referred for ART
Date initiated on ART	
Test 1	
Test 2	
Test 3	
Follow up time	6W 10W 14W 5M 6M 7M 8M 9M 10M 11M 12M
ARV supplied	
CTX supplied	
Follow up time	13M 14M 15M 16M 17M 18M 19M 20M 21M 22M 23M 24M
ARV supplied	
CTX supplied	

BARCODE: \_\_\_\_\_

CARE COMMENTS: \_\_\_\_\_

**Fig 11.1 immunisation card**

The card above shows the immunisable diseases and when they should be administered.



**Activity 1**

- 1) Define immunity
- 2) Explain what happens in the immune system if one suffers from cold and manage to recover without medication.
- 3) Give the difference between natural and artificial immunity
- 4) What is passive immunity? Give examples.

## SUMMARY

The body is naturally ready to fight invasions by microorganisms called pathogens. Immunity is the ability of the body to react and fight invasions by pathogens hence protecting our bodies from diseases. The pathogens affect the white blood cells that make up the defence system for the body. Remember we have natural and artificial immunity. How much do you remember about natural immunity? It is important that you remember that if the body's natural immune system is not able to fight or produce antibodies to fight the invading pathogens, one feels sick and requires treatment. In some cases artificial antibodies are introduced in order to help the body fight the pathogen. Remember prevention of tetanus, measles where weakened pathogen has to be introduced in your body during immunisation. Human immunity however can be weakened allowing any invading pathogen to attack the body and making humans sick. The HIV is one pathogen capable of weakening the immunity of our bodies making it vulnerable to attack by opportunistic infections such as STIs, thrush and so on. What does the abbreviation mean? If uncontrolled by use of antiretroviral drugs, the HIV progresses into AIDS. Remember we said this means acquired Immuno deficiency syndrome suggesting that the immune system of your body now lacks and opportunistic infections can easily take advantage of that situation. This means your immune system falls very low and can hardly fight invading pathogens. Once the virus enters the human body the best way is to undergo therapy by means of taking antiretroviral drugs, adhering to a diet as well as refraining from certain lifestyles such as smoking, taking alcohol and other intoxicating drugs.



## 11.4 SAMPLE EXAMINATION QUESTIONS

1. Which of the following is not an advantage of breast feeding?
  - A. contains antibodies
  - B. it is readily available
  - C. it has a correct temperature
  - D. it does not have the ability to resist diseases and infections
2. Choose the term that describes a vaccine.
  - A. active immunity
  - B. passive immunity
  - C. artificial immunity
  - D. natural immunity

1. Define immunity. (2)
2. Describe how natural and artificial immunity work to protect our bodies from falling ill. (4)
3. Explain how infants acquire immunity? (3)

## Unit 11. Health and diseases 3

### Answers

1. D
2. C
1. - the ability of an organism to resist diseases and infections
2. Natural immunity-occurs when the body release antibodies to fight pathogens when it has been invaded.  
Artificial immunity- occurs when a person is injected with dead pathogens that stimulate the production of dead antibodies.
3. - breast feeding  
- immunisation  
- natural immunity

# CHEMISTRY SECTION

# UNIT 12: SEPARATION

## CONTENTS

- 11.1 Separation
- 11.2 Simple distillation
- 11.3 Fractional distillation
- 11.4 Paper chromatography
- 11.5 Sample assessment questions

## INTRODUCTION

Sometimes substances are accidentally mixed and therefore need to be separated. We use many methods of separating mixtures depending on the physical property of the substances mixed. We commonly use some of these methods in our daily lives to separate mixtures of solids, liquids and mixtures of liquids and solids. Some of these methods can be done naturally but others need to be efficiently done using laboratory equipments. In this unit we are going to look at separating solids and liquids that are in a solution using distillation process. We are also going to focus on how to separate mixtures into their own individual components.



## OBJECTIVES

After going through this unit, you should be able to:

- Describe the process of simple distillation
- Explain the process of fractional distillation
- Describe paper chromatography
- State where paper chromatography is applied



 **KEY WORDS**

Here is a list of some of the new words you are going to meet in this unit:

**Adsorb**- to hold a layer of molecules

**Distillate**- a liquid that is collected in the beaker after passing through the condenser

**Condense**-to change from liquid to gas

**Component**-are individual parts or substances in a mixture

**Fraction**- a component or pigment in a mixture separated by fractional distillation

**Fractional distillation**- a method of separating two liquids that do not mix together easily

**Separate**- to detach

**Solvent front**-the highest point that a solvent can reach on the chromatography paper

**Solution** - a mixture of a solid and a liquid substance

**Mixture** - two or more substances put together and can be separated using physical means.

**Miscible** - liquids that mix together easily to form a mixture

**Phase** - stage or one of the procedures in chromatography

**Solution** - a mixture containing a solvent (a liquid) and a solute (a soluble solid)

**Simple distillation** - a method of separating a mixture of a liquids with different boiling points

 **TIME: 8 hours**

### Remember

In the previous level you learnt about various methods of separating mixtures. These methods are used to separate solids from solids, solids from liquids and separating immiscible liquids (liquids that do not mix like oil and water). List some five methods of separation you know. In your list I hope you included hand picking, winnowing, decanting, filtration, evaporation, magnetism and sieving.

## 12.1 Separation

Separation are activities in chemistry used to separate mixtures into their constituent elements or compounds. These techniques help to isolate mixtures depending on the physical and chemical properties of the substances in the mixture. We can therefore choose the most suitable separation technique to isolate substances from mixtures.



### STUDY SKILLS

Before you attempt the activity below, identify some of the methods used for separating mixtures. State the advantages and disadvantages of these methods.



### ACTIVITY 1

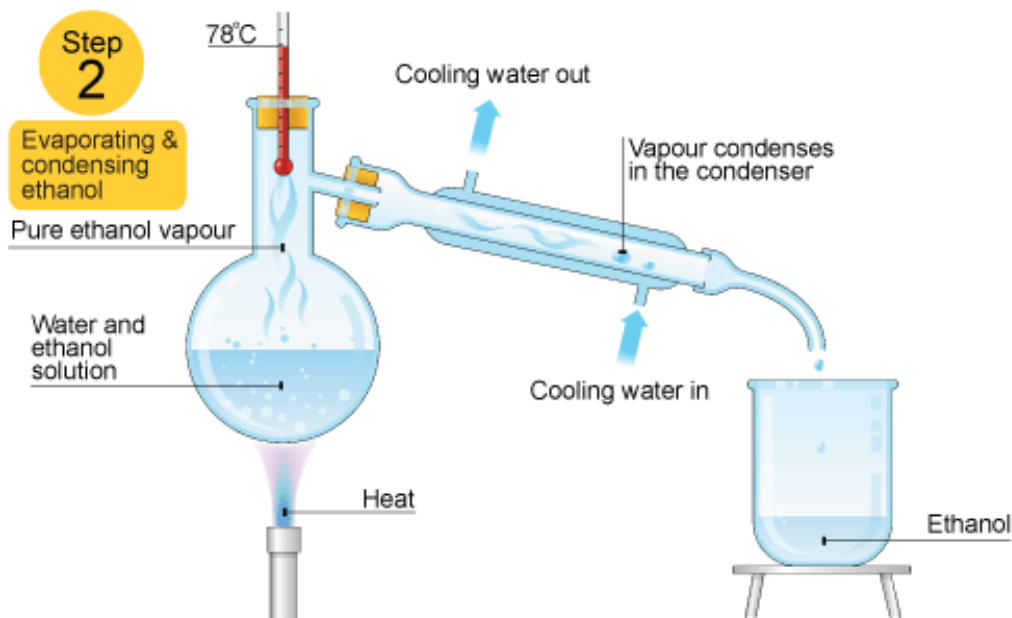
List methods used for separating mixtures. State their advantages and disadvantages.

We hope from the above activity you came up with many methods used in separation. These methods are very important in chemistry as they help to separate substances mixed accidentally and also separate mixtures into their individual components. Let's look at some of the methods of separation below.

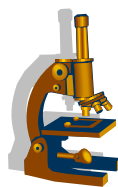
## 12.2 Simple distillation

Simple distillation is a method used to separate a mixture of two liquids with different boiling points. It is therefore used to separate liquids with boiling points that are not very close. Simple distillation can be used to separate a mixture of alcohols and water. Alcohol boils first at  $78^{\circ}\text{C}$  and the water boils at a higher temperature. The differences in their boiling points is then used to separate pure water from a mixture of water and alcohol by the process of distillation

The mixture is heated and at  $78^{\circ}\text{C}$  alcohol boils and evaporates. It goes into the condenser where it condenses. Alcohol is collected and water is left behind. Distillate is the liquid that is collected in the beaker after passing through the condenser.



**Fig 12.1 simple distillation**



## Experiment 1

### Aim

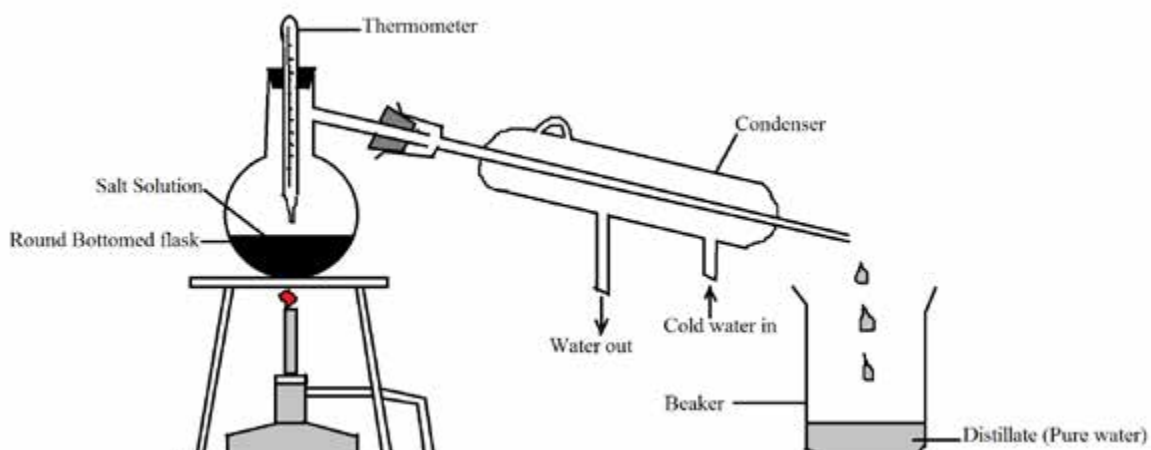
To separate salt from a salt solution using simple distillation

### Apparatus/Materials

Round-bottomed flask, a condenser, a thermometer, a beaker, a clamp stand, rubber tubing, a burner, salt solution.

### Method

1. Set the apparatus as shown below;




2. The water tap must be turned on to allow the steam to be cooled in the condenser.
3. Turn on the burner to allow the liquid to evaporate
4. You must record the temperatures at which the steam is collected
5. You must reduce the heat so that crystals can form in the round –bottomed flask

## Observations

You must note that some of the water remains in the round-bottomed flask and some is collected in the beaker on the other side. The liquid collected in the beaker is pure water.

## Conclusion

Salt and water completely separate

 **Note:** simple distillation is used to separate liquids and solids that are in solution and it allows us to get all the components of the mixture. Therefore we can use this method to separate solutions such as the salt solution, sugar solution and a mixture of water and ink.



## ACTIVITY 2

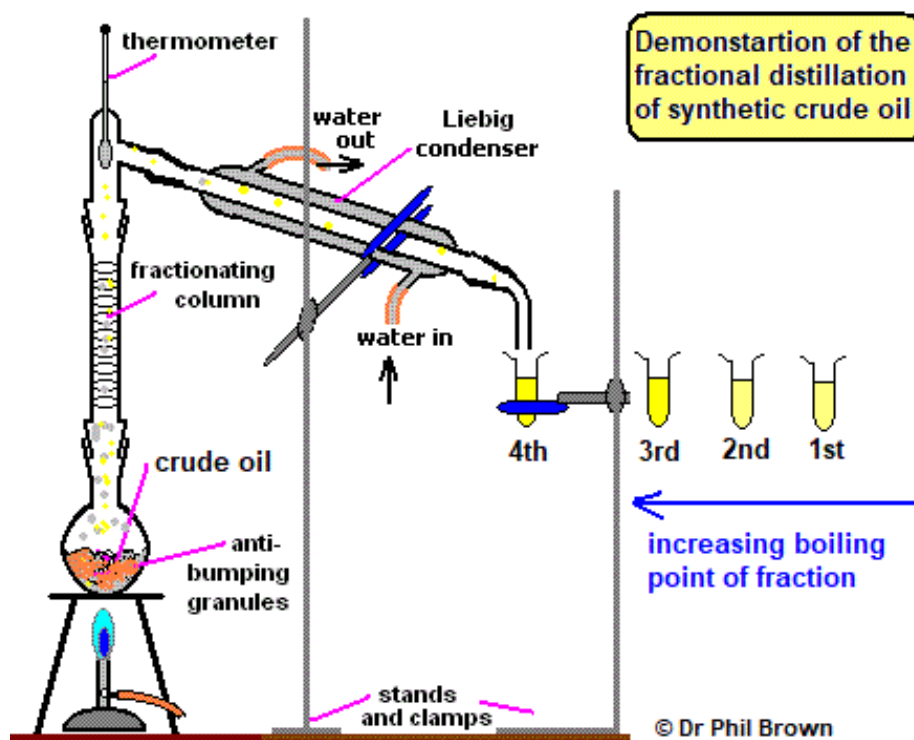
1. Define simple distillation
2. What is the boiling point of water?
3. When do we use simple distillation?
4. What do we call the liquid collected in the beaker after passing through the condenser?
5. Where do we collect pure salt?

## 12.3 Fractional distillation

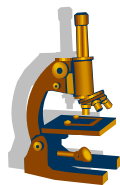
Fractional distillation is used to separate two or more liquids that are miscible (mix together easily). The mixed liquids have narrow but different boiling points.

Fractional distillation uses beads in the fractionating column which gives a large surface area for hot vapour to condense. When heat is added, vapours of both liquids move upwards into the fractionating column. They condense on the glass beads and go back into the flask until the liquids with low boiling point boil. Vapours move through

the condenser and collected in the beaker on the other side. The liquids are called fractions and the fractions with the lower boiling point are collected first. Fractional distillation is effective when two or more liquids with different boiling points are to be separated.



**fig 12.2 fractional distillation**



## Experiment 1

### Aim

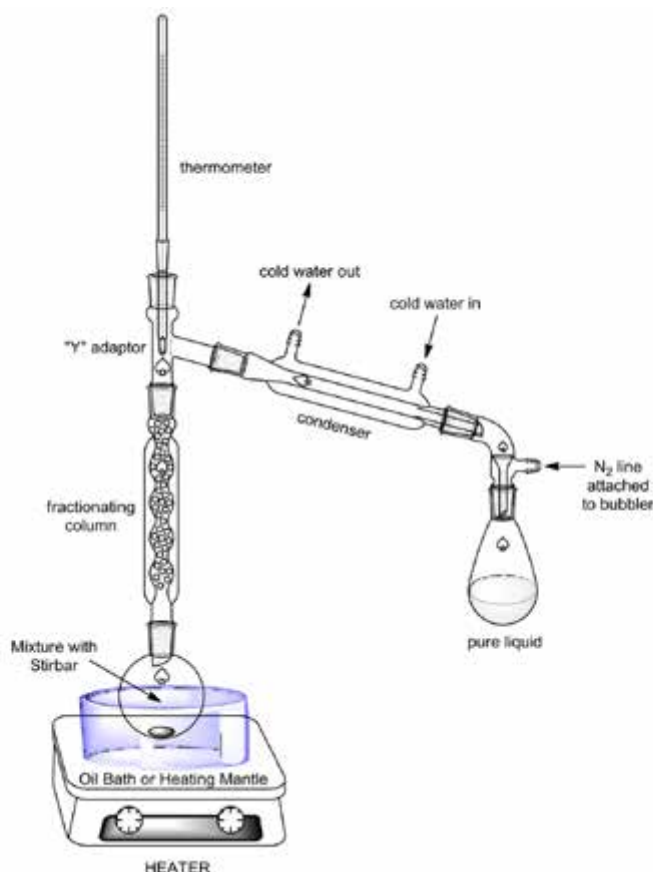
To separate a mixture of ethanol and water using fractional distillation.

### Apparatus/Materials

Round-bottomed flask, a condenser, a fractionating column, a thermometer, a beaker, a clamp stand, a burner, solution of ethanol and water, rubber tubing.

## Method

1. Set apparatus as shown below;



**Fig 12.3 fractional distillation**

2. The water tap must be turned on to allow the fraction to be cooled
3. Light the burner, allow the fraction to evaporate and drip back
4. Record the temperature when the first drop of liquid drips from the condenser.
5. When the reading on the thermometer starts rising again turn off the burner.

## Observations

You must note that some of the liquid remains in the round-bottomed flask and some is collected in the beaker. The two liquids are the pure fractions of the mixtures. Water has a higher than boiling point than ethanol and therefore ethanol is collected first in the beaker or flask on the other side. Water vapour will continue to condense and drip back into the flask.

## Conclusion

A mixture of ethanol and water can be completely separated into two pure fractions.



## Activity 3

- 1 Define fractional distillation
- 2 Which one was the first fraction between water and ethanol?
3. When do we use fractional distillation?
4. Why do we use glass beads in this experiment?
5. Explain why a thermometer is necessary in this experiment.

**Note:** Fractional distillation is used to separate liquids which evaporate easily. The beads in the fractionating column allow vapours to condense by providing a large surface area for the vapours to move through the gaps between the glass beads.



## Activity 4

It is said that separation is important in chemistry, do you agree? Give reasons for your answer. Suggests the differences between fractional and simple distillation.



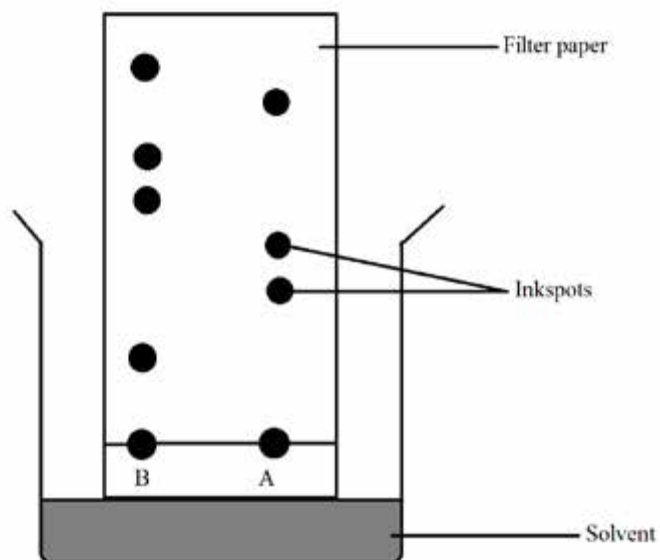
## Study Tip

For you to find the answers to the above questions go back to the last sub units and read again. This will help you to find answers and to remember what you have learnt.

Sometimes there is a need to separate mixtures in their individual components. One of the methods used is paper chromatography. It works well when separating mixtures of coloured substances.

## 12.4 Paper chromatography

Paper chromatography is a method used to separate components in mixture of coloured pigments. A mixture moves through chromatography or filter paper and this determine the rate of movement. The paper allows liquids to pass through it and therefore it is porous. A pure substance has only one defined spot.



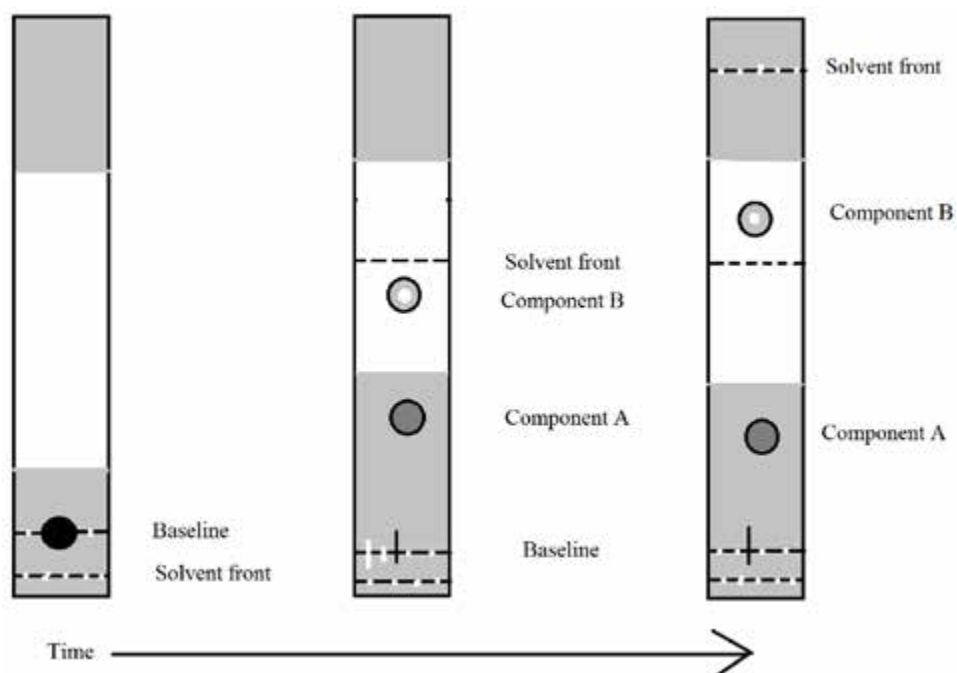
**Fig 12.4 paper chromatography**

A number of spots means the mixtures contains a number of pure components, each representing one of the impurities or components.

### Phases of paper chromatography

Chromatography makes use of two phases which are moving and non-moving phase. The moving phase (mobile phase) is the fraction that must be separated and dissolved in a solvent.

The non-moving phase (stationary phase) is the chromatography paper. We can use chromatography to separate different coloured components that make up black ink using a filter paper and ethanol. The coloured components will settle at the baseline which is the position shown by the filter paper.



**Fig 12.4 chromatography**



This is caused by capillary action which forces molecules to move up between the molecules of liquid and the surface of the solid. The filter paper adsorbs different components as they move upwards through the filter paper. The highest point that the solvent (ethanol in this case) reaches up the filter paper is called the solvent front. Some components hold tightly to the filter paper than others and they move a shorter distance up the paper. Soluble compounds of the ink in ethanol are placed further up the filter paper. This results in different stains of ink on the filter paper and therefore called chromatography.

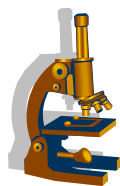
### Where is paper chromatography applied?

- Used in separating coloured substances or pigments into their individual components
- Useful in detecting traces of drugs in people's blood
- Used in analytic purposes for example to analyse materials found at crime scene.
- Industrially it plays an important role in the manufacture of pharmaceutical drugs
- Useful in refining fractions from the fractional distillation of crude oil.



### Study tips

Carry out an experiment in the laboratory on chromatography using black ink and carefully note whether it is composed of different substances. Check the appearance of the chromatography paper after the experiment in order to conclude whether black ink is made up of a single or many coloured substances.



### Experiment 3

#### Aim

To observe the substances or components in black ink.

#### Apparatus/Materials

Chromatography paper or filter paper, black ink, ethanol pencil, dropper, glass jar.

## Method

1. Add 5mm of ethanol into a jar
2. Mark 10mm from the bottom of the chromatography paper using a pencil
3. Drop one drop of ink on the marked line and position the paper up in the jar
4. Leave the paper in the jar for an hour then let it dry.

## Observations

The drops of ink move away from their original position and this shows different components of the black ink were being separated.

## Conclusion

Black ink is made up of different components and it is not a single substance.



## Activity 5

1. Define chromatography
2. What is the appearance of the chromatography paper?
3. From your observation, is black ink a single substance?
4. What do we find on the initial position of the filter paper?
5. How do you identify a pure substance?

## Remember:

Now you have seen that black ink is not a pure substance and is made up of different substances. This can be illustrated by a number of spots on the chromatography or filter paper each representing one of the impurities or components. Therefore, you can now conclude that chromatography separate mixtures into their individual components. You now know that simple and fractional distillation can be used to separate liquids with different boiling points and obtain pure fractions. Also note the final result of all these methods is a complete separation of fractions or substances (components).

## SUMMARY

To conclude this unit, you have learnt that mixtures can be separated into individual components. We also learnt that there are various methods of separation and in this

unit we focused more on three methods. Simple distillation is a method of separation a mixture of two liquids with different boiling points. It is suitable for liquids with boiling points which are not very close. Fractional distillation can separate two or more liquids that are mixed together easily and have boiling points which are close to each other. We also learnt about chromatography which is a method used to separate coloured mixtures to their individual components. It is very useful when separating coloured substances and is mostly used in analytical purposes. Industrially chromatography is used in making pharmaceutical drugs and in the refining of fractions from fractional distillation.

Now you can answer the following questions below in order to assess your understanding. If you face challenges in answering, go back to unit 10 and read again. You must also do all the activities in this section in order to enhance understanding. Use the spaces provided for answering.

## 12.5 SAMPLE ASSESSMENT QUESTIONS

### Multiple choice questions

Note: Surround the letter with the correct answer

- 1 What is distillation? (1)
  - A. process used to isolate mixtures of liquid into their individual components.
  - B. A technique in chemistry used to purify liquids.
  - C. A process used to separate miscible liquids.
  - D. An activity in chemistry used in making hot vapours.
2. The final result of a chromatography procedure is called a; (1)
  - A. Filter paper.
  - B. Solvent front.
  - C. Chromatogram.
  - D. Chromatography paper.
3. In order to purify a sample of drinking water, which method below can we use
  - A. filtration
  - B. simple distillation
  - C. fractional distillation
  - D. evaporation

4. Fractional distillation involves the separation of two liquids that are..... (1)
- A. Miscible.
  - B. Volatile.
  - C. Baseline.
  - D. Solvent.
5. What happens when heat is applied at the bottom of the flask during fractional distillation? (1)
- A. Vapours of both liquids move up through the fractionating column.
  - B. Vapours of both liquids move down through the fractionating column.
  - C. Pure substance remains in the flask.
  - D. Nothing changes.

### Structured questions

1a) What do you understand by the following terms?

(iv) Mixture (2)

(v) Solvent (2)

(vi) Solute (2)

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c) Why is separating mixtures important? (2)

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2a) Explain why do we use round glass beads in the fractionating column when using fractional distillation? (2)

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b) Suggest any two differences between simple and fractional distillation? (2)

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c) What do you call liquids in fractional distillation (1)

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d) What is a distillate (1)

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### Practical question

3) Using a well labelled diagram describe how different components of a mixture move through the chromatography (or filter) paper. (5)

b) How do you identify a pure substance in chromatography (1)

**TOTAL = 25 MARKS**

## UNIT 12 - SEPARATION

### SAMPLE- ASSESSMENT - ANSWERS

- 1 A
- 2 C
- 3 A
- 4 A
- 5 A

### Structured questions

1a) Mixture (2)

- two or more substances combined together

(ii) Solvent (2)

- able to dissolve or form a solution with something

(iii) solute (2)

Dissolved substance

d) Why is separating mixtures important? (2)

- so that mixtures can be separated into individual components

2a) they give a surface area for hot vapour to condense and evaporate (2)

b) simple distillation separates two liquids with different boiling points and fractional distillation separate liquids with very close boiling points

- in fractional distillation the fractionating column has beads to increase the surface area inside the column whereas in simple distillation beads are not there.

Simple distillation deals with liquids that do not evaporate easily and fractional distillation deals with liquids that are volatile.

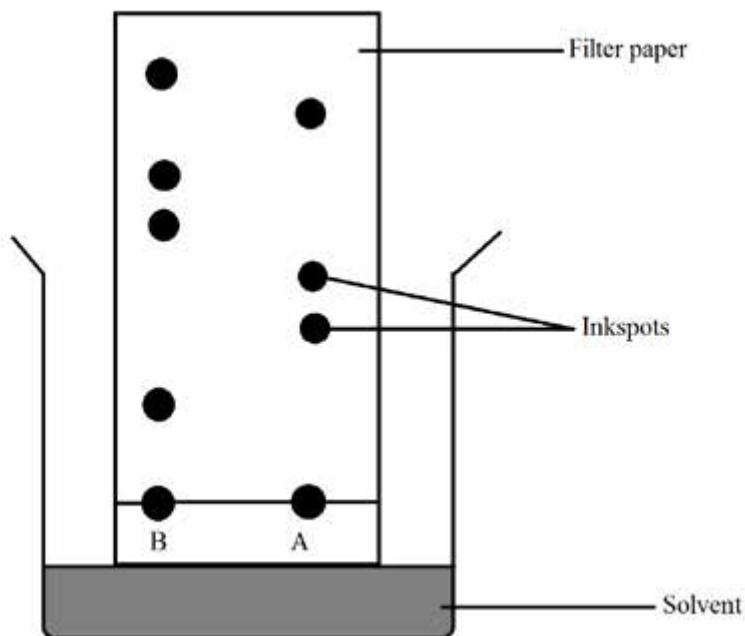
c) fraction (1)

d) a liquid that is collected in the beaker after passing through the condenser (1)

### Practical question

3) Using a well labelled diagram describe how different components of a mixture move through the chromatography (or filter) paper. (5)

A mixture moves through chromatography or filter paper and this determine the rate of the reaction. The paper allows liquids to pass through it and therefore it is porous. A pure substance has only one defined spot.



A number of spots means the mixtures contains a number of pure components, each representing one of the impurities or components

b) How do you identify a pure substance in chromatography (1)

-A number of spots means the mixtures contains a number of pure components, each representing one of the impurities or components.

**TOTAL = 25 MARKS**

# UNIT 13: MATTER

## CONTENTS

- 13.1 Structure of atom and mass number.
- 13.2 The first 20 elements in the periodic table.
- 13.3 Periodic properties and trends.
- 13.4 Ionic and Covalent bonding.
- 13.5 The mole concept.
- 13.6 Concentration.
- 13.7 Reactivity series
- 13.8 Sample assessment questions

## INTRODUCTION

Before you begin this unit let us go back to what you covered in level 1 in your Chemistry section. What did we say matter is? Remember we said that matter is everything around us. Atoms and compounds are all made of very small parts of matter. Those atoms go on to build the things you see and touch every day. Matter therefore, is anything that has mass, volume and occupies space. In this unit you are going to look at the atoms (smallest unit of elements) found in the periodic table, their properties and how they bond to make compounds. You are also expected to describe the relationship between the mole and the molecular mass.



## OBJECTIVES

- Describe in detail first 20 elements in the periodic table
- Describe ionic and covalent bonding
- Define sub atomic particles
- Calculate the mass number and neutron number
- Describe the relationship between the mole and molecular mass and concentration of solution
- Describe the properties of elements on the periodic table and the reactivity series



## Remember:

If you are having trouble understanding matter, look all around you. You can see matter makes up the walls of your house. All objects take up space. Your laptop is taking up space on the desk; you take up space on the bed you sleep on. Let's get closer and closer to the smaller

99 parts of the bed. These small parts of the bed are also made of matter. Below is the list of key words that you will come across as you study this unit.

## Key words

**Anion** --- a negative ion.

**Atom** –it is the smallest unit of an element.

**Cation**-a positive ion

**Covalent bond**- is a chemical bond that involves the sharing of electron pairs between atoms and sometimes called a molecular bond.

**Electron shell**-the space in which electrons orbit the nucleus of an atom.

**Element**- it is a substance that is made entirely from one type of atom and cannot be broken down into any other substance.

**Ionic bond**- it is a type of chemical bonding that involves the electrostatic attraction between oppositely charged ions.

**Isotopes**- atoms of the same element with the same atomic number but different mass number

**Matter** – it is anything that has mass, volume and takes up space.

**Metalloids**- elements that have some metallic and some non metallic properties.

**Mole**- is the amount of substance which contains an Avogadro number of particles, ( $6.02 \times 10^{23}$ )

**Period**-horizontal row on the periodic table.

**Reactive**-the readiness of an atom to lose or gain electrons.

**Reactivity series**- it is the arrangement of elements in the order in which they react

**Valency electrons**-the electrons in the outer most shell of an atom which is involved in bonding.

**Valency**-the number of electrons an atom must lose or gain to obtain a noble gas configuration.



TIME: 8 HOURS

## 13.1 THE STRUCTURE OF ATOM AND MASS NUMBER

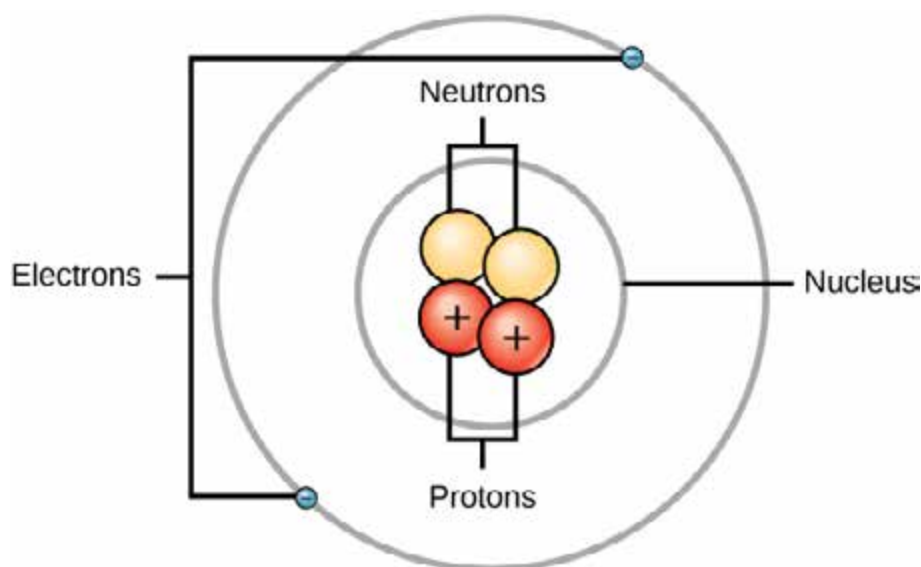
### Matter

Dalton suggested the existence of atoms in all matter.

- An atom is the smallest unit of an element
- Atoms cannot be created or destroyed
- Atoms are the same if they are of the same substance have same properties
- Atoms are too small and cannot be seen by the naked eye
- Atoms consist of sub atomic particles

### The structure of an atom

An atom is the basic unit of matter. It is composed of particles called protons, neutrons and electrons. The diagram below shows the structure of an atom.



**Fig 13.1 the structure of an atom**

In the next sub unit you are going to look at sub atomic particles.

### Sub atomic particles

- These are particles that are found in the atom



## Activity 1

With reference to the diagram above name the three sub atomic particles that form an atom.

After reading this section you will be able to do the following:

- List the three sub atomic particles of an atom
- Discuss the positions of these particles within the atom and what electric charge they carry, if any.

The three sub atomic particles that form an atom are **protons, neutrons and electrons**. The centre of the atom is called a nucleus. Let's therefore learn a bit about these sub atomic particles

### Electrons

These are negatively charged particles that revolve around the nucleus and they have a mass of 0. They are found on shells and are represented with the mark of a (-) sign.

### Protons

These are positively charged particles found in nucleus and they are represented with the mark of a (+) sign. Protons carry a positive charge.

### Neutrons

These are neutral, found in the nucleus of the atom and they have no charge usually represented by a (0) sign. Neutrons have a mass of one. They are said to help hold the protons together since they are positively charged and they can repel each other.

The table below summarises the sub atomic particles, their relative charges, mass and position in the atom.

**Table 1**

Particle	Position	Charge	Mass	Symbol
Proton	nucleus	+1	1	p
Neutron	nucleus	0	1	n
Electron	Atomic shells	-1	1/1840	e

**Note:** in an electrically uncharged atom the number of electrons is equal to the number of protons.

**Remember:**

- Sub atomic particles are particles that are smaller than the atom
- Protons, neutrons and electrons are the three sub atomic particles found in an atom
- Protons have a positive charge. An easy way to remember this is to remember that both **proton** and **positive** start with the letter **P**.
- Neutrons have no electrical charge. An easy way to remember this is to remember that both **N**eutron and **N**o electrical charge start with the letter **N**
- Electrons are negatively charged.

Now that you have learnt about matter and atoms let's see how much you know.



## Activity 2

1. What is (i) matter?  
(ii) An atom?
2. In a table form list three sub atomic particles, their charge, position in the atom and their mass.

If you have problems in answering the above questions go back to the last sub unit and read again you will find the answers. In the next sub unit you are going to learn how to calculate the mass number and neutron number from named atoms in the periodic table.

How to calculate mass number and neutron number

**Tip:** In order for you to calculate the mass number and neutron number you will use elements found in the periodic table below. More details about the periodic table will be dealt with in the next sub-units.

## 13.2 The periodic table

# Periodic Table of the Elements

**Legend:**

- State of matter (color of name):** GAS (red), LIQUID (orange), SOLID (green), UNKNOWN (grey)
- Reactivity:** Alkali metals (yellow), Alkaline earth metals (orange), Halogens (green), Noble gases (grey)
- Other categories:** Lanthanides (blue), Actinides (green), Transition metals (purple), Post-transition metals (pink), Reactive nonmetals (red), Unknown chemical properties (grey)

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
H Hydrogen 1.008	He Helium 4.003	Li Lithium 6.941	Be Beryllium 9.012	B Boron 10.811	C Carbon 12.011	N Nitrogen 14.007	O Oxygen 15.999	F Fluorine 18.998	Ne Neon 20.180	Na Sodium 22.990	Mg Magnesium 24.305	Al Aluminum 26.982	Si Silicon 28.086	P Phosphorus 30.974	S Sulfur 32.065	Cl Chlorine 35.453	Ar Argon 39.948
K Potassium 39.098	Ca Calcium 40.078	Sc Scandium 44.956	Ti Titanium 47.883	V Vanadium 50.942	Cr Chromium 51.996	Mn Manganese 54.938	Fe Iron 55.845	Co Cobalt 58.933	Ni Nickel 58.693	Cu Copper 63.546	Zn Zinc 65.38	Ga Gallium 69.723	Ge Germanium 72.630	As Arsenic 74.922	Se Selenium 78.96	Br Bromine 79.904	Kr Krypton 83.796
Rb Rubidium 85.468	Sr Strontium 87.62	Y Yttrium 88.906	Zr Zirconium 91.224	Nb Niobium 92.906	Mo Molybdenum 95.94	Tc Technetium 98	Ru Ruthenium 101.07	Rh Rhodium 102.905	Pd Palladium 106.42	Ag Silver 107.868	Cd Cadmium 112.411	In Indium 114.818	Sn Tin 118.710	Sb Antimony 121.757	Te Tellurium 127.6	I Iodine 126.905	Xe Xenon 131.29
Cs Cesium 132.905	Ba Barium 137.327	La Lanthanum 138.905	Hf Hafnium 178.49	Ta Tantalum 180.948	W Tungsten 183.84	Re Rhenium 186.207	Os Osmium 190.23	Ir Iridium 192.222	Pt Platinum 195.084	Au Gold 196.967	Hg Mercury 200.59	Tl Thallium 204.383	Pb Lead 207.2	Bi Bismuth 208.980	Po Polonium 209	At Astatine 210	Rn Radon 222
Fr Francium 223	Ra Radium 226	Pr Praseodymium 140.908	Rf Rutherfordium 261	Db Dubnium 262	Sg Seaborgium 266	Bh Bohrium 264	Hs Hassium 265	Mt Meitnerium 268	Ds Darmstadtium 271	Rg Roentgenium 272	Cn Copernicium 285	Nh Nihonium 284	Fl Flerovium 287	Mc Moscovium 288	Lv Livermorium 293	Ts Tennessine 294	Og Oganesson 294
		Ce Cerium 140.12		Pm Promethium 145	Nd Neodymium 144.24	Pu Plutonium 244	Sm Samarium 150.36	Eu Europium 151.964	Gd Gadolinium 157.25	Tb Terbium 158.925	Dy Dysprosium 162.50	Ho Holmium 164.930	Er Erbium 167.259	Tm Thulium 168.930	Yb Ytterbium 173.054	Lu Lutetium 174.967	
		Ac Actinium 227		Np Neptunium 237	U Uranium 238.029	Am Americium 243	Cm Curium 247	Bk Berkelium 247	Cf Californium 251	Bk Berkelium 247	Cf Californium 251	Es Einsteinium 252	Fm Fermium 257	Md Mendelevium 258	No Nobelium 259	Lr Lawrencium 260	

Fig 13.2 periodic table

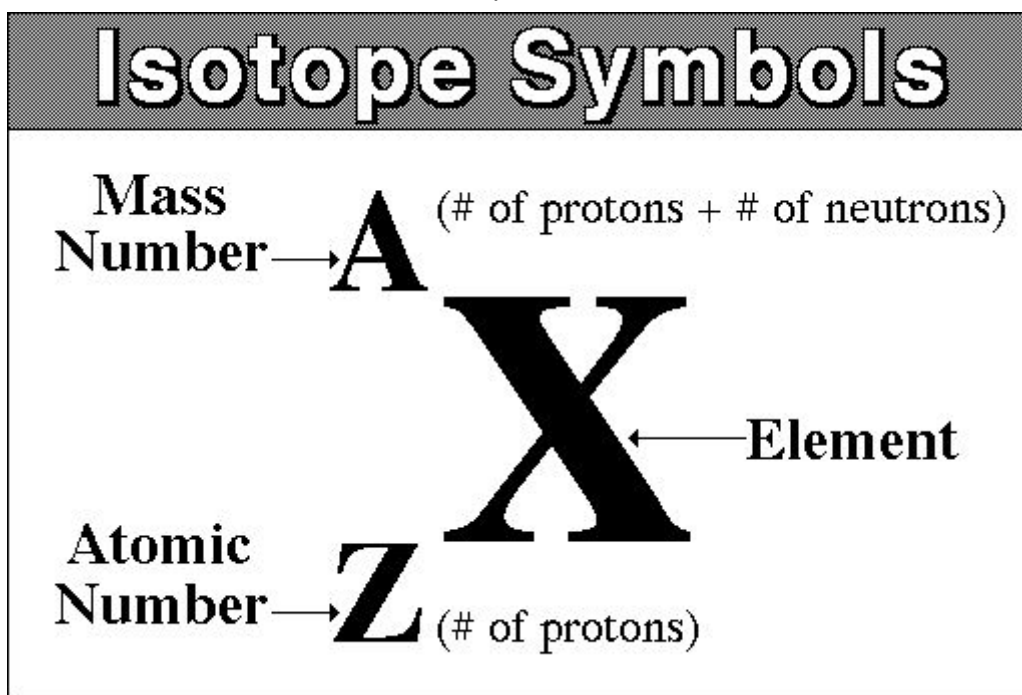
Scientists have developed a modern way of arranging elements by their proton numbers. As you can see in the periodic table above elements are arranged in order of increasing proton numbers starting with Hydrogen as element number 1, followed by Helium as element number 2 and Calcium as element number 20. You are now going to use these elements to identify mass and calculate neutron numbers.

## Study tip

Take your time to look at the periodic table. Check the symbols of the elements used, name of the element, symbol, atomic number and relative atomic mass. I hope you have seen that there is a way these elements are represented in the periodic table. This way is called nuclide notation.

### Nuclide notation

Nuclide notation is the short hand method of showing information about atoms. Numbers are arranged around the outside of the atom's symbol as you will see in the next unit where you will learn about the periodic table.



### Example 1

An element carbon may be represented as shown below



Now you are ready to give the atomic mass and the neutron numbers.

## Atomic number

- an atomic number is the number of protons in the nucleus of an atom
- an atomic number is also called a proton number
- the atom has no charge (electrically neutral) because the number of electrons which is equal to the number of protons

Atomic number = number of protons

## Mass number

- the mass number is the total number of protons and neutrons in the nucleus of the atom
- protons and neutrons are also called nucleons. **Why?** Because they are found in the nucleus of the atom

Mass number = number of protons and neutrons

## Remember:

We said that electron number is equal to the number of protons in an atom. Now look at the example below and then go on to do activity 2.

## Example 1

Potassium has a mass number of 39 and an atomic number of 19. How many neutrons are there in one atom of potassium?

## Answer

Mass number = number of protons + number of neutrons = 39

Proton number = 19

Therefore neutron number = mass number – proton number

= 39-19

=20

## Example 2

Boron has an atomic number of 5 and neutron number of 6. Find the mass number of Boron.

Answer

Mass number = number of protons + number of neutrons

Therefore mass number

$$= 5 + 6$$

$$= 11$$

### Example 3

Carbon has an atomic number of 6 and mass number of 12. Find the electron number of carbon.

### Answer

Electron number is the same as the proton number in an atom

Proton number of carbon = 6

Therefore the electron number = 6



## Activity 4

Now that you have done the examples above you are ready to fill in the table below for each of the following atoms.

Element	Atomic number	Mass number	Neutron number	Electron number
Lithium	3	7		3
Nitrogen	7	14	7	
Oxygen		16	8	8
Neon	10		10	10
Sodium		23	12	11
Sulphur	16	32		16
Chlorine	17	35	18	
Calcium	20		20	20

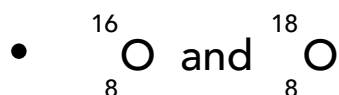
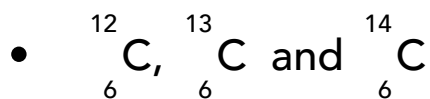
### Remember:

From your study of the elements in the periodic table you might have discovered that there are other elements which are the same but have different atomic mass numbers. These elements are referred to as isotopes.



## Isotopes

These are atoms of the same element with the same atomic/proton number but different atomic mass number. The fact that the mass number is different, proton number remains unchanged it means that the neutron number differs. The following are the examples of isotopes:



This means that carbon has 3 isotopes that is carbon 12, 13, 14, chlorine has 2 isotopes that is chlorine 35 and chlorine 37, oxygen has also two isotopes oxygen 16 and oxygen 18.

### Remember:

Matter is anything that has mass, volume, and occupies space. Atoms exist in all matter. An atom is the smallest unit of element. The structure of an atom consists of neutrons and protons which are found in the nucleus of an atom. Electrons are found in orbits around the shells of an atom. Protons have a positive charge, neutrons have no charge and electrons have a negative charge. In order to calculate neutron number you subtract proton number from the mass number. The periodic table shows elements. Now you will use the periodic table to name and describe the first 20 elements.

# 13.2 Elements in the periodic table

## Periodic Table of the Elements

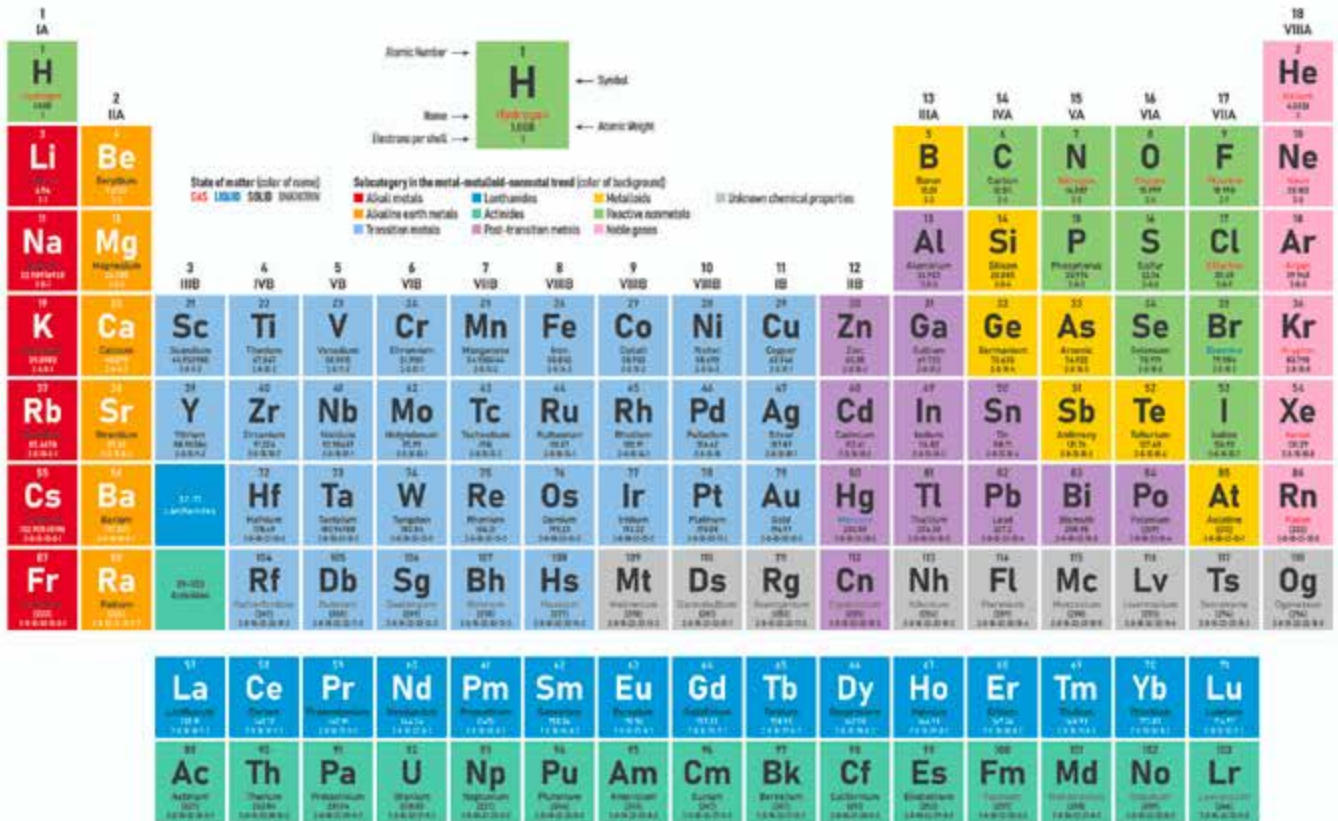


FIG 13.4 Periodic Table



## Activity 5

With reference to the periodic table above, list the first 20 elements.

Name the first 20 elements in the periodic table stating their symbols

**Table 2**

Element	Symbol	Element	Symbol
Hydrogen	H	Sodium	Na
Helium	He	Magnesium	Mg
Lithium	Li	Aluminium	Al
Beryllium	Be	Silicon	Si
Boron	B	Phosphorus	P
Carbon	C	Sulphur	S
Nitrogen	N	Chlorine	Cl
Oxygen	O	Argon	Ar
Fluorine	F	Potassium	K
Neon	Ne	Calcium	Ca

Now that you know the first 20 elements in the periodic table and the number of electrons found in each atom, you are now expected to show how these electrons are arranged in an atom. This arrangement is called an electronic configuration, so electronic configuration is the arrangement of electrons in energy shells around the nucleus. In order to arrange these electrons, there is a rule that has to be followed. Before you arrange the electrons first of all revisit a game that you once did when you were growing up.

### **Name of the game** \_\_\_\_ **Isiphala/Matula/tsoro**

You have to dig 12 holes and count 20 small stones. The first hole will only contain 2 stones only, second hole contain a maximum of 8 stones and third hole contain a maximum of 8 stones. Take note that you are not supposed to fill the next hole before the other is full. Let's now start playing.

I guess you have noticed that you can use all the stones to fill the holes that you have just dug. Take those holes to be shells of the atom and stones to be electrons to be filled in those shells. Now let's go back to electronic configuration.

## How to work out electronic configuration

Remember electronic configuration is the arrangement of electrons in energy shells around the nucleus.

- Atoms are electronically neutral, thus the number of protons is equal to the number of electrons
- Electrons are placed in orbits or shells around the nucleus. This arrangement is called electronic configuration
- Energy shells can hold a certain number of electrons.
- First energy shell can only contain a maximum of 2 electrons. Second shell takes a maximum of 8 electrons and the third shell can hold a maximum of 8 electrons.
- The shells become larger as they move away from the nucleus hence a larger shell holds more electrons.

**Tip:** Before you draw the diagrams, it is wise that you first of all make a table of the first 20 elements.

**Table 3: Electronic configuration of the first 20 elements**

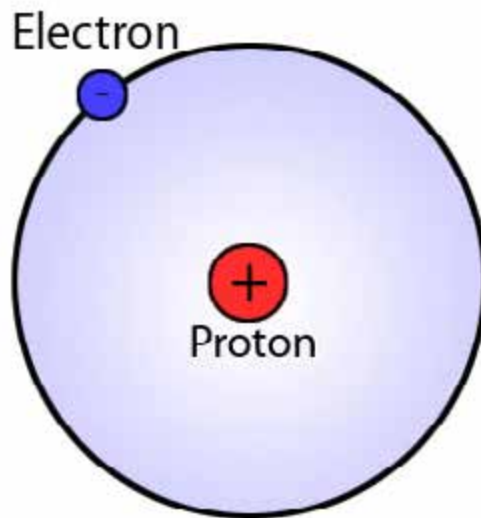
Element	Electronic configuration	Element	Electronic configuration
Hydrogen	1	Sodium	2.8.1
Helium	2	Magnesium	2.8.2
Lithium	2.1	Aluminium	2.8.3
Beryllium	2.2	Silicon	2.8.4
Boron	2.3	Phosphorus	2.8.5
Carbon	2.4	Sulphur	2.8.6
Nitrogen	2.5	Chlorine	2.8.7
Oxygen	2.6	Argon	2.8.8
Fluorine	2.7	Potassium	2.8.8.1
Neon	2.8	Calcium	2.8.8.2

### Electronic configuration diagrams

- To draw electronic configuration diagram first of all look up the atomic number in the periodic table for the chosen element for example carbon atom has 6 protons
- Now arrange the electrons in shells. Fill up the lower energy shell before going to the outer one
- The first 3 examples have been done for you.

### Example 1

### Hydrogen atom

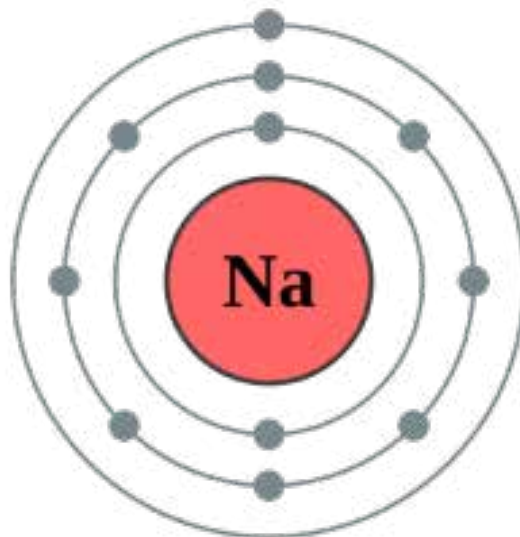


**Fig 13.5 the structure of an atom**

**Note:** the electron configuration of hydrogen is very simple. There is only one electron to place in the first energy shell closest to the nucleus.

### Example 2

### Sodium atom

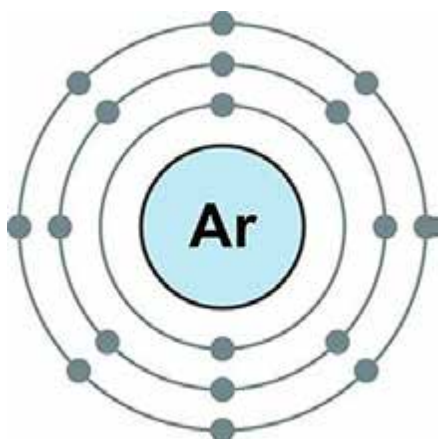


**Fig 13.6 sodium atom**

**Note:** sodium has 11 electrons and its electron configuration is 2. 8.1.

### Example 3

#### Argon atom



**Fig 13.7** the structure of an argon

**Note:** argon has 18 electrons and its configuration is 2,8, 8 so there are 3 shells filled.



### ACTIVITY 6

Now that you have been given three examples of electron configuration diagrams try to draw the remaining 17. If you have difficulties go back to sub unit **11.2.3** and then follow the steps.

In the next sub unit, you are going to look at the significance of the electronic configuration.

### Significance of the electronic configuration

The number of electrons in the outmost shell of an atom determines the chemical properties of an element and also how it reacts with other elements. Elements in the periodic table are grouped into metals and non metals. In the periodic table there are also a group of elements that are called the Noble gases. These include helium, neon, argon, krypton, xenon and radon.



## ACTIVITY 7

Write the electronic configuration of helium, neon, argon, krypton, xenon and radon.

### Remember:

From the above electronic configuration you might have realised that the outermost shells are full. They have 8 electrons except helium which has 2 electrons. These gases are therefore, inert or non reactive. The first three gases helium, neon and argon do not react with anything and they are said to be stable. This lack of reactivity is linked to their electronic structures.

### Metals and non metals in the periodic table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.0026
3 Li 6.94	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.085	15 P 30.974	16 S 32.06	17 Cl 35.45	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.630	33 As 74.922	34 Se 78.971	35 Br 79.904	36 Kr 83.798
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.95	43 Tc 98.906	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	71 Lu 174.97	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po 208.98	85 At 209.99	86 Rn 222.02
87 Fr 223.02	88 Ra 226.03	103 Lr 262.11	104 Rf 261.12	105 Db 270.13	106 Sg 269.13	107 Bh 270.13	108 Hs 269.13	109 Mt 278.16	110 Ds 281.17	111 Rg 281.17	112 Cn 285.18	113 Nh 286.18	114 Fl 289.19	115 Mc 289.20	116 Lv 293.20	117 Ts 293.21	118 Og 294.21
57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 144.91	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05				
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 244.06	95 Am 243.06	96 Cm 247.07	97 Bk 247.07	98 Cf 251.08	99 Es 252.08	100 Fm 257.10	101 Md 258.10	102 No 259.10				

Fig 13.8 The periodic table

Hope you still remember that we said the periodic table contains metals, non metals and metalloids. The metalloids separate the metals and non metals. Remember also that elements in the periodic table are arranged in order of increasing proton number. Elements with similar chemical properties are in the same columns or groups some of the groups have been given names.

- Group 1 - alkali metals
- Group 2 - alkaline earth metals
- Group 17 - the halogens
- Group 18 - noble gases

Note also that horizontal rows are called periods and are numbered from 1-7. Can you see that in the periodic table? Between group 2 and group 3 there is a block of elements called the transition metals containing metals such as copper, iron, nickel, zinc and chromium.

From the above discussions you might have noticed that metals are mostly found on the left and in the middle of the periodic table and the other half contains non metals are found mostly on the right. You have also seen that metals are more than non metals if not go back again and study the periodic table. The blue lines in the diagram above indicate the division between metals and non metals. The red indicate the position of metalloids which are elements that have properties that lie between those of the metals and non metals. Now you are going to look at the periodic properties and trends.

## 13.3 Periodic properties and trends

### Trends in a period

The main trend in the period is the change from metals to non metals. Physical properties include melting, boiling points as well as density. The table below shows the change in physical properties across period three elements.



**Table 4**

	Sodium	Magnesium	Aluminium	silicon	phosphorus	sulphur	chlorine	argon
Electron structure	2,8,1	2,8,2	2,8,3	2,8,4	2,8,5	2,8,6	2,8,7	2,8,8
Melting point (0°C)	98	650	659	1410	448	119	-101	-119
Boiling point (0°C)	897	1117	2447	2677	294	444	-34	-186
Density (g/cm <sup>3</sup> )	0,92	1,74	2,70	2.40	1,82	2,01	0,56	0,40



## Activity 8

From the table above what can you deduce from the elements across period 3?

We hope you have realised that metals have a higher melting point, higher boiling point and the density is also high. Non metals have lower melting and boiling points and their density is very low. Now let's go on to look at the properties.

### Properties of metals

Most elements are metals for example iron, tin and sodium. You can also list some of the metals you know. Use the previous sub units.

Properties of metals (group 1 and group 2)

### Physical properties

- Shiny
- Usually solid at room temperature
- Metallic appearance
- Good conductors of heat and electricity
- Malleable (meaning it can be bent into thin sheets)
- Ductile (it can be pulled into wire)
- Usually dense
- Have very high melting points

### Chemical properties

- Readily lose electrons
- Corrode in air and sea water

## Properties of group 7 elements (halogens)

- Non conductors of heat and electricity
- Usually less dense compared to metals
- Low melting points
- Gains electrons in chemical reactions
- Reactivity decreases down the group
- Colour intensity increases down the group

## Uses of halogens

- Bleach
- Manufacture of plastic
- Refrigerants
- Solvents
- Purification of water using chlorine

## Group 8 elements (noble gases)

- All gases at room temperature
- They are unreactive

## Remember

At this point you have covered metals and non metals in the periodic table. You also covered periodic properties and trends. Let's now check how much you can remember, if you have forgotten go back and read previous units.



## Activity 9

1. Draw a table and identify each element as a metal, non metal and metalloids. Use the list provided below.
  - Copper, oxygen, boron, potassium, silicon, helium, aluminium, hydrogen and calcium.
2. List four physical properties of metals, non metals and metalloids.
3. Name the elements that are found in the following positions
  - a) Group 1, period 3

- b) Group 3, period 2
- c) Group 7, period 2
- d) Group 7, period 3
- e) Group 2, period 4
- f) Group 4, period 2

### Remember:

Elements on the left hand side of the periodic table have 1, 2 or 3 electrons in the outer shells of their atoms. This means that the elements in group 1, 2 and 3 are metals so they lose their outer electrons during chemical reactions. The elements on the right hand side have 4 or more electrons in their outer most shells. These gain electrons in chemical reactions and form negative ions. So when elements on the left and on the right side of the periodic table combine they form what we call ionic bonds. In the next sub unit we will learn about chemical bonding where ionic and covalent bonds are formed.

## 13.4 Ionic and covalent bonding

### Chemical bonding

What is chemical bonding? Chemical bonding is the combination of elements to form compounds. A compound is the chemical composition of two or more elements. Salt is an example of a compound it is composed of one atom of sodium and one of chlorine hence called sodium chloride (NaCl). Water is another example of a chemical compound it is composed of two hydrogen atoms and one oxygen atom (H<sub>2</sub>O). To bond is to join and this makes a compound. When reacting atoms will donate or lose electrons as we said before. They do this so as to form ionic compounds. Sometimes atoms share electrons to form covalent compounds.

### Ionic bonding

An ion is a charged atom meaning it has too few or many electrons to be neutral. As we said before ions of opposite charges attract each other so they do this to form ionic bonds as shown below.



This means that A has lost one of its electrons and it becomes positively charged. B has gained an electron and is now negatively charged. So these two atoms which are oppositely charged will attract each other to form an ionic bond.

When atoms gain electrons and others lose electrons an attraction occurs between them to form compounds and this compound formed in this way is called ionic compound. Since metals lose electrons it means that they form positive ions or

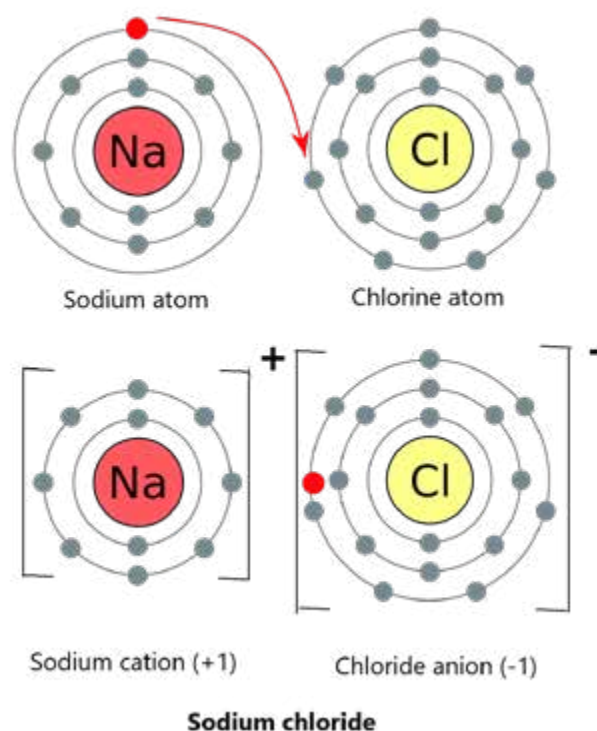
cations while non metals form negative ions or anions when they gain electrons and become negative. The **valence** of an atom is the number of electrons which an atom should gain or lose to attain a full shell or what we call a noble gas configuration.

### Remember:

Let us reflect back to the last sub units, remember we said metals in group 1 have a valence of 1 because they lose one electron to become a cation, group 2 have a valence of two and group 3 and 4 have a valence of 3 and 4 respectively. Group 5 elements will gain 3 electrons to become full and the valence is 3. Group 6 gain 2 electrons and the valence is two and group 7 has a valence of 1. When we show ionic or covalent bonds we use dot and cross diagrams where dots and crosses represent electrons. Now let's work out some few examples to illustrate how ionic bonds are formed.

### Example 1: bonding in sodium and chlorine atoms

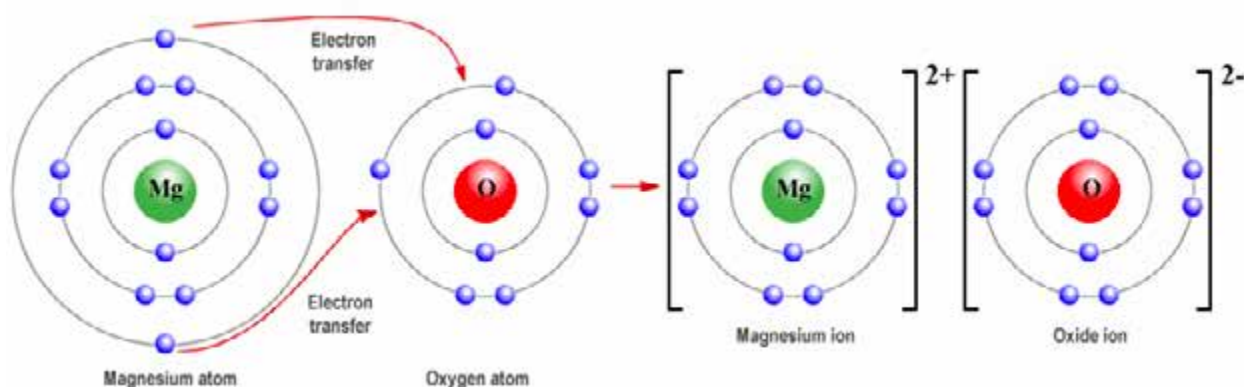
Look at the table of electronic configurations. I hope you have seen that sodium has one electron in its outer most shell and so it becomes stable by losing one electron. When it has lost an electron it becomes a sodium ion ( $\text{Na}^+$ ). A chlorine atom has 17 electrons so it gains one electron and becomes chloride ion ( $\text{Cl}^-$ ). The two now have opposite ions so they attract each other as shown in the diagram below. The formula now is  $\text{Na}^+\text{Cl}^-$  or simply  $\text{NaCl}$  as seen below.



**Fig 13.9 ionic bonding in sodium chloride**

## Example 2: bonding in magnesium oxide

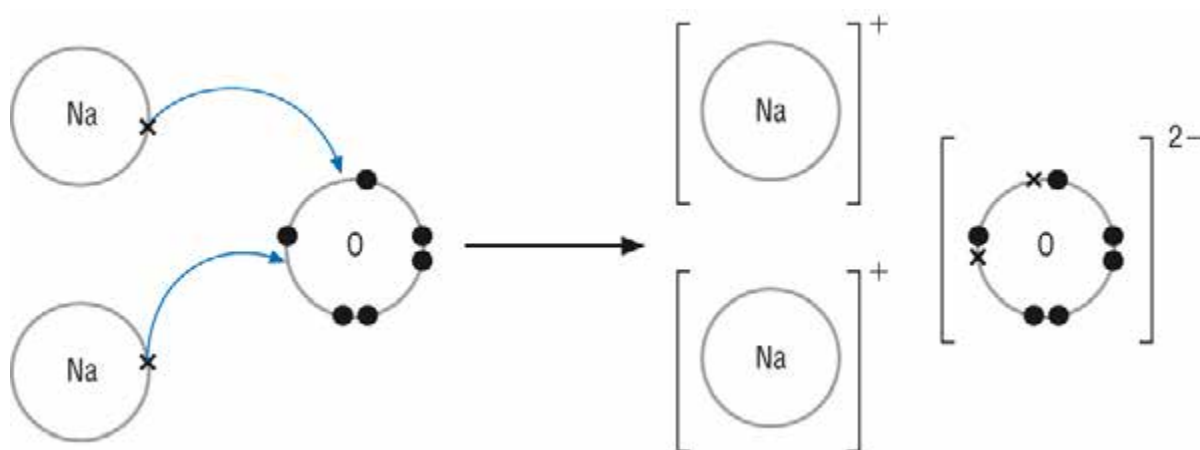
Magnesium has two electrons in its outer shell so it can become stable by losing these two valence electrons. It therefore becomes magnesium ion ( $\text{Mg}^{2+}$ ). An oxygen atom has 16 electrons it needs 2 valence electrons to become oxygen ion ( $\text{O}^{2-}$ ). The combination of the two gives  $\text{Mg}^{2+}\text{O}^{2-}$  or simple  $\text{MgO}$  as shown below.



**Fig 13.10 ionic bonding of magnesium oxide**

## Example 3: bonding in sodium oxide

In the above examples electrons gained or lost are the same. You should be asking yourself what happens when the electrons differ. Bonding in sodium oxide will give you the answer to that question. An atom of sodium metal loses one electron to achieve its stability but an atom of oxygen needs to gain two electrons. So in this case one ion of oxygen needs to bond with two ions of sodium and the ionic compound formed will be  $\text{Na}_2\text{O}$ . This means that you need to have two sodium atoms each giving one electron so that they become two electrons as in the diagram below.



**Fig 13.11 bonding in sodium oxide**

Now that you have done three examples go on and do the activity below.



## ACTIVITY 10

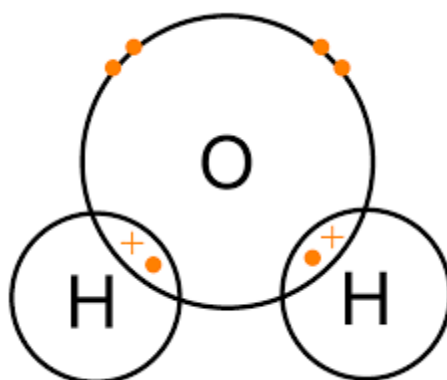
1. Describe how the bonding occurs between aluminium and chlorine.
2. Draw dot and cross diagrams to show the bonding in calcium oxide.

### Covalent bonding

Covalent bonding is when atoms share electrons to attain a noble gas configuration. Let us look at the examples below which show the formation of covalent bonds.

#### Example 1: Formation of a water molecule ( $\text{H}_2\text{O}$ ).

Oxygen has six electrons in its outer most shell so it needs to gain or share so as to achieve stability or noble gas configuration. Hydrogen atoms have each one electron so two hydrogen atoms are needed to share electrons with oxygen atom so that each have a full shell. Therefore, two hydrogen atoms have to bond covalently with one oxygen atom to form water molecule as shown below.



**Fig 13.12 water molecule**

### Example 2: Formation of carbon dioxide molecule (CO<sub>2</sub>)

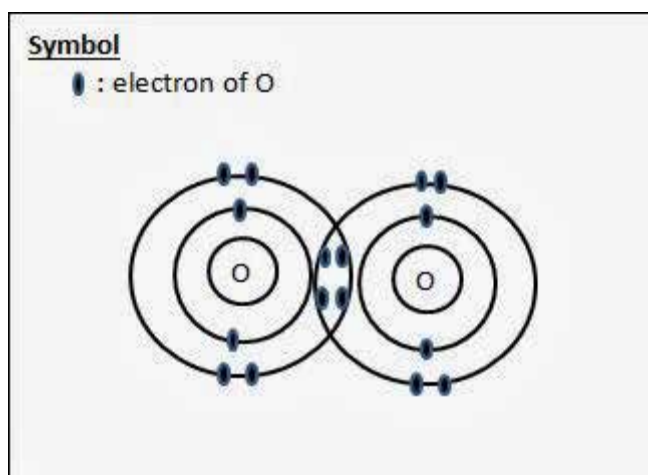
Carbon has four electrons in its outer most shell and oxygen has 2. So carbon needs two oxygen atoms so that they share so as to obtain a noble gas configuration as shown below.



**Fig 13.13 carbon dioxide molecule**

### Example 3: Formation of oxygen molecule

Two oxygen atoms will share two electrons from each atom as shown below.



**Fig 13.14 oxygen molecule**



### Activity 11

- Using dot and cross diagrams show covalent bond between
  - 2 chlorine atoms.
  - 2 hydrogen atoms

### Remember:

Remember we said that the outer most electrons determine how the atom behaves, so it is necessary to look at the properties of ionic and covalent bonds.

### 10.3.3 Properties of ionic compounds

- High melting points because they are solid at room temperature
- Soluble in water
- Conduct electricity when molten

### 10.3.4 Properties of covalent compounds

- Are usually gases and liquids?
- Does not conduct electricity in any state
- Have low melting points
- Insoluble in water
- Soluble in organic solvents

Before we go to the next sub unit check yourself how much you still remember. The next sub unit is about the mole concept.



#### Activity 14

1. What do you understand by the terms  
(a) covalent bonding?  
(b) Ionic bonding?
2. draw dot and cross diagrams to show how ionic bonds are formed between:  
(a) sodium atom and oxygen atom  
(b) Aluminium and oxygen
3. Show how carbon dioxide molecule is covalently bonded.

**TIP:** If you cannot remember how to answer the above questions go back to last units examples have been done for you. It is wise therefore, that you first of all attempt to answer before you check the answers. The next unit will introduce you to mole concept.

### 13.5 Mole concept

Scientists use units to describe very large numbers. Using units is not new for example 1 metre represents 100cm. The unit chemist use to represent molecular mass is the mole. Hope you still remember the position of the mass number in the periodic table. One molecule has a mass in grams that is the same as the relative atomic mass or



relative molecular mass. Carbon dioxide molecule has the relative atomic mass **12 + 16 + 16 = 44**. So, one mole of carbon dioxide has a mass of 44g. A mole is atomic or molecular mass expressed in grams. To calculate the number of moles the formula below is used.

$$\text{Number of moles} = \frac{\text{mass}}{\text{molecular mass}} \quad \text{or } n = \frac{m}{Mr}$$

One mole of magnesium oxide (MgO) = 24 + 16 = 40g

Two moles of hydrochloric acid (HCl) = 2 [1 + 35,5] = 73g

One mole of oxygen = 2 [16] = 32g

### Example 1

1. Express the following in moles: 10g of ammonia (NH<sub>3</sub>).

1 mole (NH<sub>3</sub>) = 14 + 1 [3] = 17g

$$10\text{g of ammonia} = \frac{10}{17} = 0.59 \text{ moles}$$

### Example 2

2. Calculate the mass of:

a) 0,2 moles C<sub>2</sub>H<sub>4</sub>  
 1 mole of (C<sub>2</sub>H<sub>4</sub>) = 2 (12) + 4 (1) = 28g

$$0,2 \text{ moles} = 28\text{g} \times 0,2 = 5,6\text{g}$$

### Molecular mass (Mr)

Remember that molecular mass is given by the sum of atomic masses of the elements.

### Example 3

3a) find the molecular masses of the elements.

$$Mr (\text{NaCl}) = 23 + 35.5 = 58.5\text{g}$$

$$Mr (\text{Na}_2\text{O}) = 2 (23) + 16 = 62\text{g}$$

### Empirical formula

This is the formula that shows the simplest ratio combination of atoms that form up a given substance.


### Example 4

3. 6g of magnesium is heated in oxygen, after cooling and reweighing it is found that there is 10g of magnesium oxide. Find the empirical formula for magnesium oxide.

Ratio	Mg	O
	$\frac{6}{24}$	$\frac{4}{16}$
	0.25	0.25
	$\frac{0.25}{0.25}$	$\frac{0.25}{0.25}$
	1	1

Ratio Mg : O = 1:1

Empirical formula is MgO

 **NOTE:** To find the empirical formula you first of all find the ratio by dividing the given mass by the atomic mass as shown above. In the next example you will learn to find the empirical formula when given percentages.

### Example 5

4. Calculate the empirical formulae of the substances which have the following compositions by mass: 43,4% sodium, 11,3% carbon, 45,3% oxygen

Ratio	Na	C	O
	$\frac{43.4}{23}$	$\frac{11.3}{12}$	$\frac{45.3}{16}$
	1.89	0.942	2.83
	$\frac{1.89}{0.942}$	$\frac{0.942}{0.942}$	$\frac{2.83}{0.942}$
	2.01	1	3

Ratio Na:C:O is 2:1:3

Empirical formula is Na<sub>2</sub>CO<sub>3</sub>

Before we go on to the next unit let us check how much you still remember.



## Activity 11

1. Calculate the mass of 0,25 moles of carbon dioxide.
2. Find the relative molecular mass of:
  - a) Mr ( $\text{Na}_2\text{CO}_3$ )
  - b) Mr (HCl)
  - c) Mr ( $\text{CO}_2$ )
  - d) Mr ( $\text{NH}_3$ )
3. Calculate the empirical formulae of ethane given 80% carbon and 20% hydrogen.

Many chemical reactions take place in aqueous solutions. The solutes are the reactants. If the concentration of the solution is known the number of moles of a solute that are reacting can be calculated. In the next unit therefore, you will learn about concentration.

## 13.6 Concentration

Concentration is the ratio of number of moles of a solute to the volume of a solution. To find concentration you use the formula below.

$$\text{Concentration} = \frac{\text{number of moles}}{\text{volume}}$$

The units are moles per cubic decimetre or grams per cubic decimetre ( $\text{mol}/\text{dm}^3$  or  $\text{g}/\text{dm}^3$ )

Now that you know the formula let us look at the examples below.

### Example 1

1. Find the number of moles of sodium hydroxide in  $25\text{cm}^3$  of solution of concentration  $0.1 \text{ mol}/\text{dm}^3$ .

Number of moles = concentration x volume

$$= 0.1 \times \frac{25}{1000}$$
$$= \underline{0.0025}$$

2. Find volume of solution of concentration  $2\text{mol/dm}^3$  that contains 0,005 moles of hydrochloric acid.

$$\text{Volume} = \frac{\text{number of moles}}{\text{concentration}}$$

$$= \frac{1000 \times 0,005}{2}$$
$$= 25\text{cm}^3$$

## 13.7 The reactivity series

### Remember:

The group 0 elements are all gases called the noble gases. They have full outermost shells and they are stable. Therefore, the noble gases are completely unreactive.

What is meant by a reactive metal?

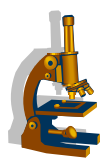
If an element is reactive, it means that it reacts easily with other elements or compounds. As we saw in the last unit elements react with one another to form a full outer shell. Calcium for example, has two electrons in its outer shell and for it to have a full share it has to donate two electrons. We have also seen that transitional metals have valencies that vary so they can share with other elements and compounds in different proportions. The reactivity series therefore is the list of elements mainly metals in order of their reactivity with different substances such as oxygen, water, hydrochloric acid and metal compounds. The more reactive a metal is the more ready it is to form compounds. It is important to remember that metals lose electrons when they combine with non metals to form compounds. We can therefore use experiments to put these metals in order of reactivity. You have to use the following very reactive metals:

- Calcium
- Sodium
- Magnesium
- Aluminium.

You will also investigate how the above metals react with oxygen, water, steam and acids to determine this order of reactivity.

**Note:** if you are finding it difficult to source some of the materials below you can use the internet.

## Reactions with oxygen



### Experiment 1

#### Aim

To investigate the reactions of metals with oxygen.

#### Apparatus/Materials

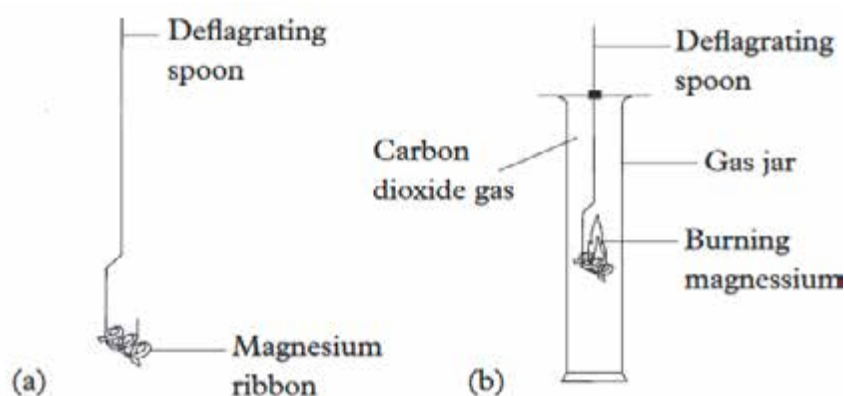
Sodium, calcium, magnesium ribbon, aluminium foil, a retort stand, a Bunsen burner, a deflagration spoon.

Warning: be careful when working with the Bunsen burner; observe the reactions from a distance.

#### Method

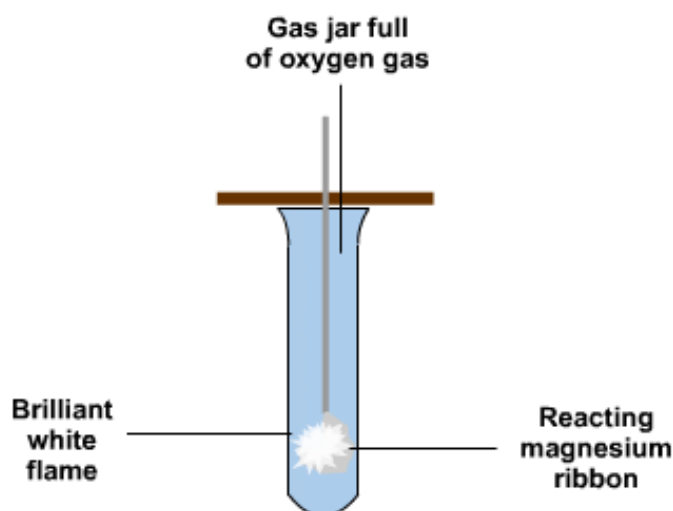
1. Burn a small amount of sodium in air using the apparatus shown below.

**Fig 13.15**





2. Burn a small amount of calcium using the apparatus and record the results.
3. Burn magnesium ribbon and aluminium foil using a Bunsen burner as shown below.



**Fig 13.16**

### Observations

The questions below will help you to understand your observations.

1. What type of product is formed in these reactions?
2. Write word equations for all the reactions.
3. Which one of the metals is most reactive in air and which one is the list reactive?
4. List all four metals in order of reactivity from the most to the least reactive.

## Conclusion

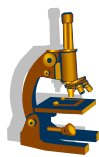
Sodium is the most reactive with oxygen and the least is aluminium. We hope you have seen that a white powder is formed when the above metals are burnt in air except for aluminium which does not burn but is coated with a white powder. This white powder is called an oxide. Sodium reacts faster in air and aluminium burns slowly. The order of reactivity of the four metals is:

Sodium  $\longrightarrow$  calcium  $\longrightarrow$  magnesium  $\longrightarrow$  aluminium

## Word equations

1. Sodium + oxygen  $\longrightarrow$  sodium oxide
2. Calcium + oxygen  $\longrightarrow$  calcium oxide
3. Magnesium + oxygen  $\longrightarrow$  magnesium oxide
4. Aluminium + oxygen  $\longrightarrow$  aluminium oxide

## Reactions with water



### Experiment 2

## Aim

To investigate the reactions of metals with water

## Apparatus/Materials

Beaker, sodium, calcium, aluminium, magnesium, water, forceps.

## Method

1. Half fill the beaker with water.
2. Drop a small piece of sodium into the beaker and observe.
3. Repeat step 1 and 2 using different metals. Observe and record your results in a table.

## Observation

1. What type of product is formed when metals react with water?
2. Write the word equations for the reactions.
3. List the metals in order of reactivity starting with the most reactive to the least reactive.

## Conclusion

Metals react with water by dissolving except for aluminium.

You might have noted that when metals dissolve a gas is also formed. This gas produces a pop sound with a lighted glowing splint. This gas therefore is hydrogen gas. So a hydroxide and hydrogen gas are produced as products when metals react with water. The word equations for the reactions are:

1. Magnesium + water  $\longrightarrow$  magnesium hydroxide + hydrogen
2. Sodium + water  $\longrightarrow$  sodium hydroxide + hydrogen
3. Calcium + water  $\longrightarrow$  calcium hydroxide + hydrogen

**Note;** aluminium does not react with water at all.

The order of reactivity is:

Sodium  $\longrightarrow$  calcium  $\longrightarrow$  magnesium  $\longrightarrow$  aluminium

## Reactions with steam

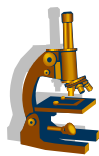
The second group of metals to investigate is:

- Zinc
- Copper
- Lead
- Silver

These elements are less reactive than those in the first group. They do not react with cold water but they do react with steam. You will realise that using steam in a reaction increases the rate of reaction.

**Precaution:** heated substances burn so take necessary precautions.





## Experiment 3

### Aim

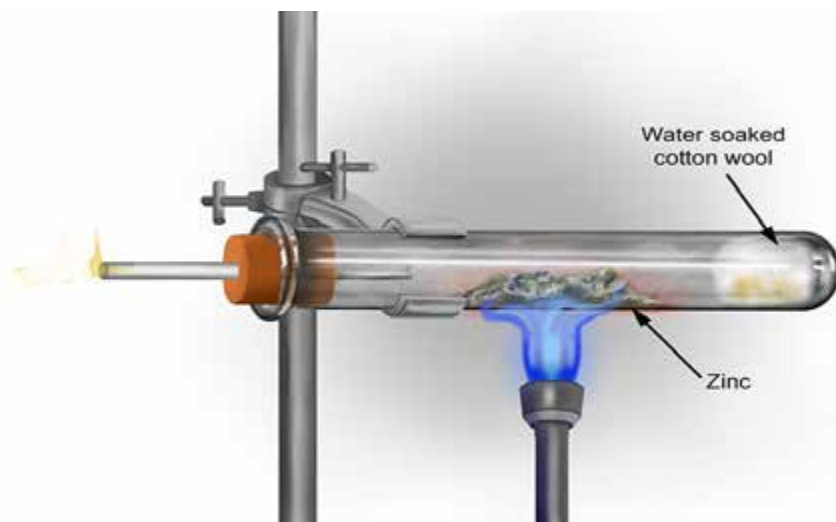
To investigate the reactivity of zinc, copper, silver and lead

### Apparatus/Materials

Zinc, copper, lead, silver mineral wool soaked in water, test tube, beaker with water

### Method

1. Drop a piece of zinc metal in a beaker that contains a little water and repeat with other metals.
2. Record all your results on a table.
3. Pass steam across some zinc as shown in the diagram below. Then repeat the process with the other metals.



**Fig 13.17** the reactivity of metals

### Observations

1. Which metals reacted most easily with steam?
2. Which metals did not react with steam at all?

## Conclusions

Zinc reacts slowly with steam but reacts faster than lead. Copper and silver do not react with steam. Reactions with dilute acids

Metals also react with dilute acids. Copper does not react with either dilute or concentrated hydrochloric acid. The table below summarises the reactions of four different metals.

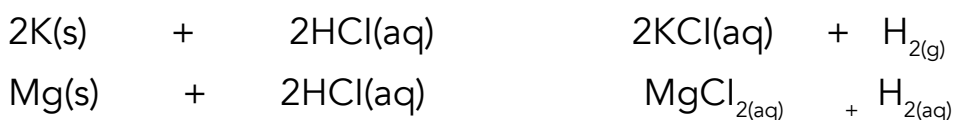
Table 5

Metal	Water	Oxygen	Hydrochloric acid
Zinc	<ul style="list-style-type: none"><li>· Does not react with cold water</li><li>· Dissolves in boiling water</li></ul>	<ul style="list-style-type: none"><li>· Reacts with oxygen</li></ul>	<ul style="list-style-type: none"><li>· Reacts fast with acids</li></ul>
Copper	<ul style="list-style-type: none"><li>· Does not react with cold or hot water</li></ul>	<ul style="list-style-type: none"><li>· reacts slowly by forming a black layer called copper oxide</li></ul>	<ul style="list-style-type: none"><li>· does not react with dilute hydrochloric acid</li></ul>
Iron	<ul style="list-style-type: none"><li>· Reacts slowly with steam</li></ul>	<ul style="list-style-type: none"><li>· Reacts with oxygen</li></ul>	<ul style="list-style-type: none"><li>· React with acids</li></ul>
Silver	<ul style="list-style-type: none"><li>· There is no reaction with steam</li></ul>	<ul style="list-style-type: none"><li>· Does not react with oxygen</li></ul>	<ul style="list-style-type: none"><li>· Does not react with hydrochloric acid</li></ul>

## Metals reacting with acids

When metals react with a dilute acid, hydrogen is released. The dissolves in the acid and a salt is also formed for example: metal + acid  $\longrightarrow$  salt + hydrogen gas.

**Note** that when hydrochloric is used the salt formed is chloride and when sulphuric acid is used the salt formed is sulphate.



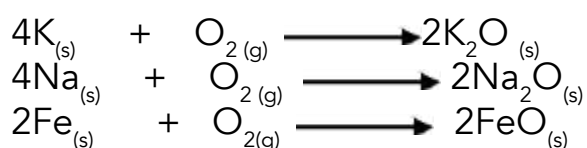


## ACTIVITY 12

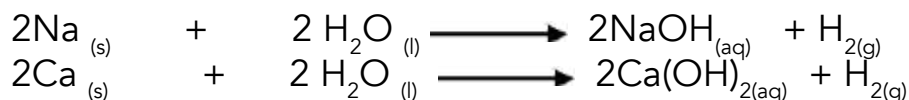
Use other metals such as Na, Ca, Zn and Fe to come up with the above equations.

### Remember:

Some elements react with other elements. When metals react with oxygen they produce a white solid which is an oxide. Now let us look at some chemical equations which show the reactions that take place when metals react in air and the products formed.



When metals react with water the following equations occur. Remember one of the products of the reaction with water is hydrogen gas. Hydrogen produces a pop sound with a lighted splint.



Now that the metals can react differently with different substances a reactivity series can be drawn. The reactivity series is based on the reaction of metals with water or dilute hydrochloric acid. When metals react the atoms lose electrons to become an ion. Below is the diagram summarising the reactivity of metals starting with the most reactive to the least reactive.

Potassium	<b>most reactive</b>
Sodium	
Calcium	
Magnesium	
Aluminium	
Zinc	
Iron	
Lead	
Copper	<b>least reactive</b>

## SUMMARY

To sum up this unit let us remind ourselves of some of the key points that we have learnt. You have learnt that atoms are made up of protons, neutrons and electrons. Protons and electrons are sometimes called the nucleons because they are found in the nucleus of the atom and electrons are found in shells around the nucleus. Protons are positively charged, electrons are negatively charged and neutrons have no charge. The mass number of an element is the sum of protons and neutrons in that element. The number of protons is equal to the number of electrons. Isotopes are atoms of the same type but with different numbers. The reactivity of elements is linked to their electron structures. A compound is the substance that contains two or more different elements that are chemically joined. Noble gases are non reactive because their outer shells are full. Ionic compounds have higher melting and boiling points than covalent compounds. A mole is the amount of substance that contains the same number of particles as there are atoms in 12g of carbon 12. The reactivity series is the list of elements in order of their reactivity with different substances. The most reactive metals are calcium, sodium, magnesium and potassium.

Now having covered all of the above you can now check your performance. To check your performances, refer to end of unit activities in section 11.

## 13.8 SAMPLE ASSESSMENT QUESTIONS

### Multiple choice

Tick the correct answer.

- Where can you find protons in an atom?
  - Shells
  - Orbits
  - Nucleus
  - Neutrons
  
- Sodium has an atomic number of 11. Which answer shows how the electrons are arranged in the energy shells?
  - 2.8.1
  - 2.8.8.1
  - 2.8.2
  - 2.5.4

3. Isotopes are atoms of the same element. In which number do they differ?
- Protons and electrons
  - Neutrons and protons
  - Neutrons only
  - Protons only.
4. Element X has the electron structure 2.8.7. What is the formula of its ion?
- $X^-$
  - $X^{2+}$
  - $X^{2-}$
  - $X^+$
5. What is the main property of covalent compounds?
- They conduct electricity.
  - They are soluble in water.
  - They have low melting points.
  - They have high melting points.

### Structured questions

Use the spaces provided to answer.

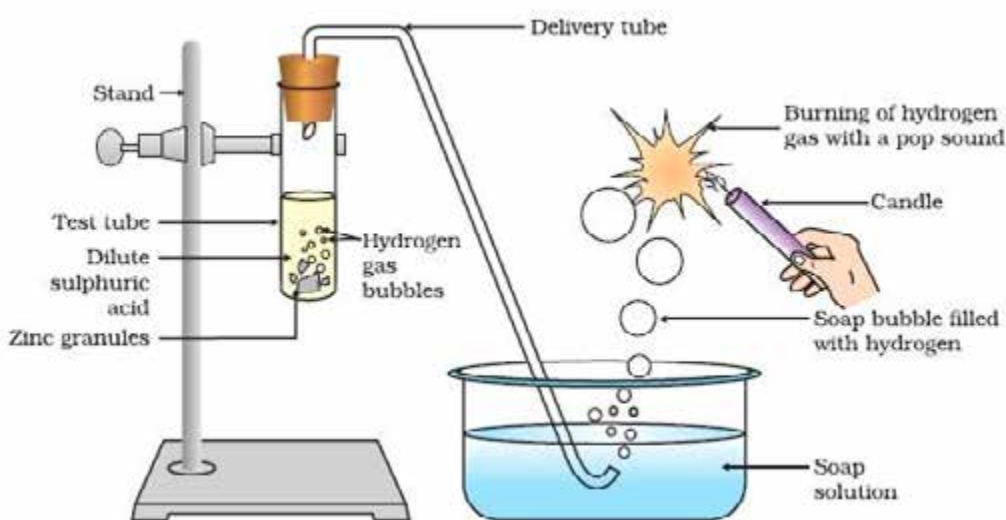
1. Draw dot and cross diagrams to represent the following compounds:
- Calcium chloride ( $\text{CaCl}_2$ ) (2)
  - Ammonia ( $\text{NH}_3$ ) (2)
2. How many moles are there in the following?
- $32_{\text{g}}$  of sulphur. (2)
  - $0.6_{\text{g}}$  of carbon. (2)
3. Calculate the mass of 0.5 moles of sulphur dioxide. (2)

## Practical question

You are provided with magnesium ribbon, calcium pieces, water, two test tubes and a lighted splint.

### Instructions

1. Half fill the test tubes with water.
2. Put a 2cm piece of magnesium ribbon into the water in one test tube marked A.
3. Hold your thumb over the mouth of the test tube. When you feel pressure on the thumb, remove it and put a lighted splint at the top of the test tube as shown below.



4. Repeat step 2 and 3 using calcium pieces.
  - a) What did you observe when the metals were first dropped into the water? (1)

---

---

---

- b) Which metal reacts most vigorously with water? (1)

---

---

- c) Hydrogen is one of the products formed when calcium reacts with water. Write down the equations for the reaction of magnesium and calcium with water. (2)

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d) Place the four metals below in order of their reactivity with water starting with the least reactive to the most reactive. (1)

Calcium, copper, magnesium, aluminium.

END

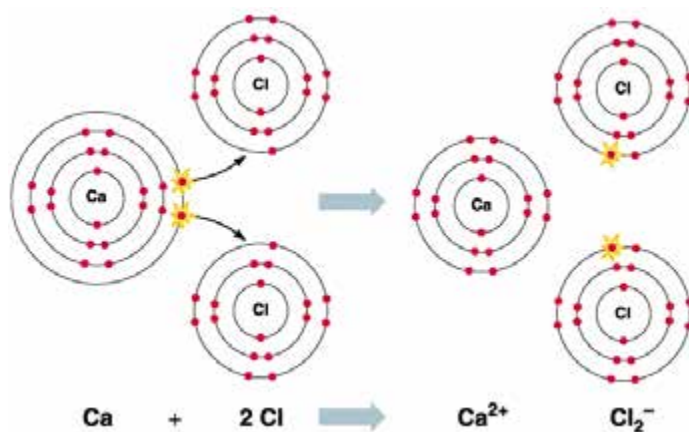
TOTAL [20 MARKS]

## SUGGESTED ANSWERS

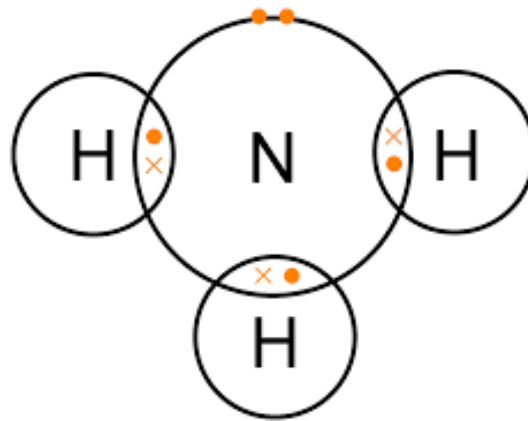
1. C
2. A
3. C
4. A
5. C

## STRUCTURED QUESTIONS

1 (a) calcium chloride ( $\text{CaCl}_2$ )



(b) ammonia (NH<sub>3</sub>)



2 (a) 32g of sulphur

Number of moles =

$$\frac{\text{mass}}{\text{molecular mass}}$$

$$= \frac{32}{32}$$

$$= 1 \text{ mole}$$

(b) 0,6g of carbon

$$n = \frac{m}{M_r}$$

$$= \frac{0,6}{12}$$

$$= 0,05 \text{ moles}$$

3. mass of 0,5moles of sulphur dioxide (SO<sub>2</sub>)

$$1 \text{ mole of (SO}_2\text{)} = 32 + 2 (16) = 64\text{g}$$

$$0.5 \text{ moles} = 64\text{g} \times 0.5$$

$$= 32\text{g}$$



## PRACTICAL QUESTION

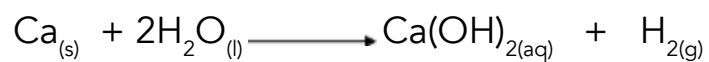
4 (a) bubbles

(b) calcium pieces

(c) magnesium + water  $\longrightarrow$  magnesium hydroxide + hydrogen



Calcium + water  $\longrightarrow$  calcium hydroxide + hydrogen



d) copper, aluminium, magnesium, calcium

# UNIT 14: ACIDS AND BASES

## CONTENTS

13.1 Acids and bases

13.2 pH Scale

13.3 Acid –base reactions, acid –metal reactions, acid -carbonate reactions

13.4 Titrations

13.5 Sample assessment questions

## INTRODUCTION

All substances we find on earth and atmosphere can be classified as acids, bases or neutrals. Some of these substances are natural while some are artificial. In this unit we shall assist you in identifying acids, bases and neutrals using the blue and red litmus paper, or the universal indicator paper or solution.



## OBJECTIVES

After going through this unit you should be able to:

- Identify regions of acidity, neutrality and alkalinity of substances on a pH scale using universal indicator
- Describe reactions with metals, bases and carbonates
- Write word and chemical equations for the reaction
- Identify apparatus used in titration
- Describe acid/ base titration procedure
- Carry out acid base titration



## KEY WORDS

**Acids:** These are substances that can donate (give away) a proton or it is a solution that has more hydrogen ions than the hydroxide ions

**Base:** These are substances that can accept a proton (a proton acceptor) or it is solution that has more hydroxide ions than hydrogen ions

**Indicator** – solution used to show the end point of a titration procedure by enhancing colour.



Time: 8 hours

## 14.1 Acids and Bases

Acids and bases are compounds. When dissolved in an aqueous solution, certain ions are released into the solution. Interestingly every liquid you see will probably have either acidic or basic traits. So what then makes a base or an acid? This unit will introduce us to the concept that when a molecule is put into water, sometimes it breaks and release an  $H^+$  (hydrogen) ion while at times it releases an  $OH^-$  (hydroxide) ion. Let's now look closely at the two conditions.

### Acids

These are substances that can donate proton (s) or have more hydrogen ions than hydroxide ions and their pH values range from 0 up to just below 7. Acids have a sour taste. All citrus fruits and vinegar are acidic. Citrus fruits and vinegar are weak acids. Some acids are classified as strong acids these are used in industries and laboratories. The following are examples of strong acids.

### Examples of strong acids

- Hydrochloric acid( $HCL$ )
- Sulphuric acid ( $H_2SO_4$ )
- Nitric acid( $HNO_3$ )

Other acids are classified as weak acids. These are acids that partially split (break) in solution.

### Examples of weak acids

- Citrus fruit juice such as lemon juice and orange juice
- Methanoic acid ( $CHCOOH$ )
- Ethanoic acid ( $CH_3COOH$ )

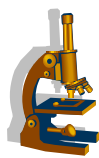
## Properties of acids

You will find that all acids have the following properties.

- Have a sour taste
- Are corrosive (erode or eat away other materials)
- Donate protons
- Turns blue litmus papers red and keeps red litmus paper red

## Bases

Bases or alkalis are substances that accept protons or have more hydroxide ions than hydrogen ions and their pH values are range from just above 7 up to 14. Some bases are strong while others are weak. Strong bases dissociate fully in water while weak bases partially dissolve when dissolved in water.



## Experiment 1

### Aim:

To identify acids and bases using universal indicator paper

### Apparatus/Materials:

Universal indicator paper, Lemon juice, vinegar, ammonia or oven cleaner, Bicarbonate of soda, four test tubes in a test tube rack labelled A, B, C, D

### Method:

1. Pour equal amounts of the following to each of the test tubes. Each solution should be put in its own test tube, do not mix.
  - Lemon juice
  - Vinegar
  - Scrubs ammonia or oven cleaner
  - Bicarbonate of soda
2. Label the test tubes correctly
3. Dip the universal indicator paper into each of the solutions
4. Observe colour changes and record them in the table given below

**Table 1**

Test tube name or number	Colour change of the universal indicator paper	
Lemon juice		
Vinegar		
Scrubs ammonia or oven cleaner		
Bicarbonate of soda		



## Activity 1

1. Which of the following materials are

- a) Acidic
- b) Basic

Lemon juice

Vinegar

Bicarbonate of soda

2. Name two acids and two bases.

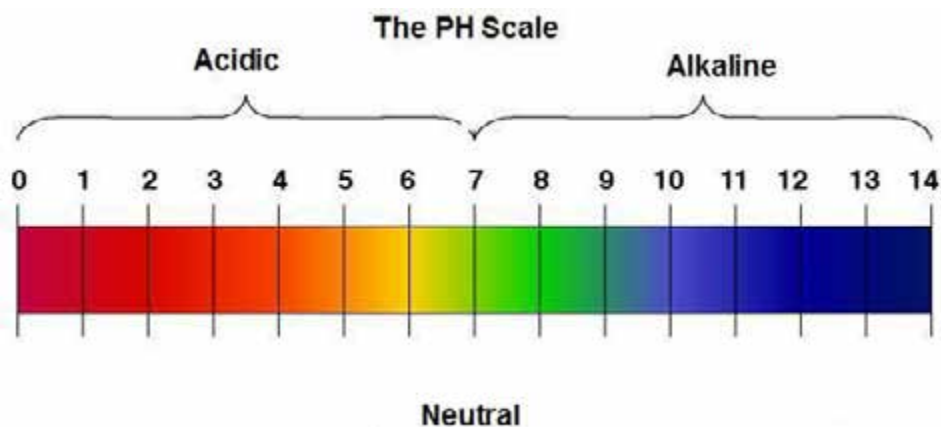
3. An acid turns blue litmus paper ----- and a base turns red litmus paper ----- while the indicator papers -----

## 14.2 pH SCALE

In the previous unit you learnt that solutions can be classified into acids, bases and neutrals. In this unit we look at how we can measure the level of acidity and alkalinity of a solution. Relative acidity and alkalinity of a solution can be measured numerically using a pH scale.

## The pH Scale

The following pH scale shows average values of substances mostly used in households.



**Fig 14.1 the pH scale**

The pH scale starts from 0 to 14. The scale is divided into 3 regions. That is the acid, the neutral and the alkaline regions. The acidic regions start from 0 to just below 7. 7 shows the neutral substances. The alkaline region begins just after 7 up to 14 as indicated above.

Acids have pH values of less than 7 neutral substances have pH value of 7 and bases or alkaline have a pH value of greater than 7.

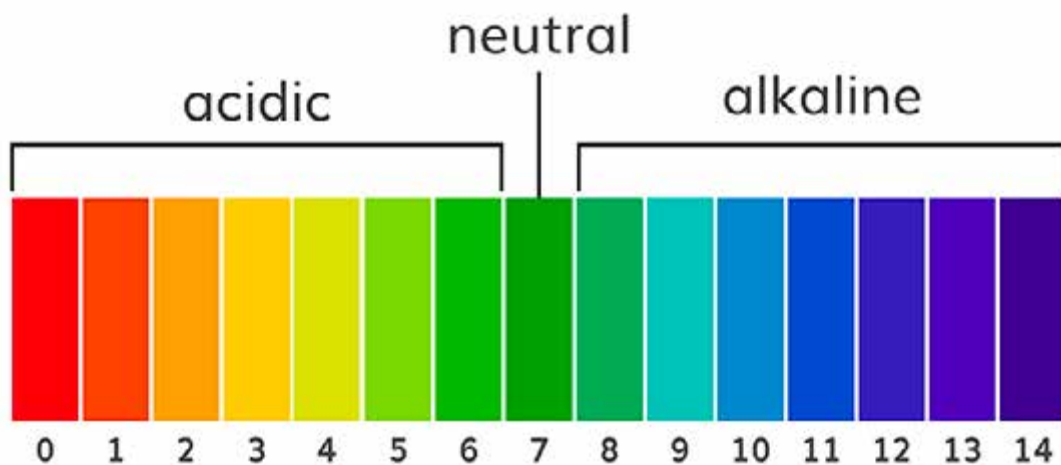
Tip: Solutions/substances with a pH value of 1 are more acidic than those with a pH value of 2 while those with a pH value of 2 are more acidic than those with a pH value of 3 and so on. In the same way solutions or substances with a pH Value of 14 are more alkaline than those with a pH value of 13, 12, 11, 10, 9 and 8.

Acidity is a measure of the  $H^+$  ions in the solutions. If the  $H^+$  ions present in a solution are more, the solution is also more acidic.

The content of alkalinity of a solution is determined by the  $OH^-$  ions. If the  $OH^-$  ions present in a solution are more than the solution is alkaline.

## Universal indicators

Universal indicators are substances that change colour when reacted with acids and bases. They tell us how acidic or alkaline a substance is. Universal indicators are more accurate in giving us information on how acidic or alkaline a solution is. A universal indicator is a mixture of dyes that turn into a wide range of colours depending on the pH of the solution. Each colour represents a particular pH value. The colour formed on the indicator paper or solution is matched with the colour on the universal indicator chart where pH values are also indicated.



**Fig 4.2 illustrates the universal indicator chart**

**Remember:**

What have you learnt so far? Well, I hope you have managed to include in your reflection some of the key points indicated below'

- A substance can be acidic, neutral or alkaline
- The pH ranges from 0 to 14 and this indicates the relative acidity or alkalinity of a substance
- Substances with a pH of 0 up to just below 7 are acidic and those with above 7 to 14 are alkaline
- The smaller the pH value the stronger the acidity and the greater the pH the greater the alkalinity of a substance.
- Substances with a pH value of 7 are neutral.
- Universal indicator can be paper or solution used to determine pH of a substance.

 **Activity 2**

Tsitsi used a universal indicator to determine the pH of 6 solutions. The results obtained are as indicated in table2 below.

**Table 2**

Solution	A	B	C	D	E	F
Ph	3	13	5	9	6	12

- Classify solution A to F as acids or bases
- Which of the solutions is the most :
  - acidic
  - basic /alkaline
- Draw a bar graph of pH against solutions using data in the table above
- Describe fully an activity to determine pH value of a solution.

## 14.3 Acid – base reactions

In the previous interactions you were introduced to these words; acid and base. Try and remember what they mean. Yes we hope you can remember that:

- acids are substances that donate protons
- Bases are substances which accept protons

In this unit you shall be introduced to how acids react with metals, bases and carbonates. After going through this chapter you should be able to describe acid – base, acid –metal and acid carbonate reactions. Also you are expected to be able to write the word equations for the reactions.

### Reactions of acids and bases

General word equation

Acid +base  $\longrightarrow$  salt +water

Hydrochloric acid+ sodium hydroxide  $\longrightarrow$  sodium chloride+ water

### Chemical equations

$\text{HCl(aq)} + \text{NaOH(aq)} \longrightarrow \text{NaCl(s)} + \text{H}_2\text{O(l)}$

HCL ionizes in solution to form  $\text{H}^+$  ions and  $\text{CL}^-$  ion

$\text{HCl(aq)} \longrightarrow \text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq})$

NaOH also ionizes in solution to form  $\text{H}^+$  ions and  $\text{OH}^-$  ions

$\text{NaOH(aq)} \longrightarrow \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$



H<sup>+</sup> ions react with the OH<sup>-</sup> ions to produce H<sub>2</sub>O (water)



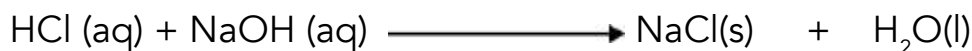
Acid–base reactions are called neutralization reactions since the products are salts and water. The pH value of the product medium is 7. This is the pH value of all neutral substances or solutions.

The form of salt formed is dependent on the type of acid and metal used. Sulphate will be produced if sulphuric acid is used, chlorides will be formed if hydrochloric acid is used and nitrates from nitric acid. The following are the word and chemical equations for the various acids that can be used to form salts.

a) Sulphuric acid + Sodium hydrochloride  $\longrightarrow$  sodium sulphate + water



b) Hydrochloric acid + sodium chloride  $\longrightarrow$  Sodium chloride + water



c) Nitric acid + Sodium hydroxide  $\longrightarrow$  sodium nitrate + Water



Salt can be separated from the water by filtration and dried by a process of evaporation.

## Reactions of acids with metals

General formula

Acid + metal  $\longrightarrow$  metal salt + hydrogen

Hydrochloric acid + Magnesium ribbon  $\longrightarrow$  Magnesium Chloride + hydrogen gas



Sulphuric acid + Zinc  $\longrightarrow$  Zinc sulphate + hydrogen gas

b) When acids react with a metal a metal salt is formed and hydrogen gas evolved (given off). The gas is collected using an upward delivery. You can test for the gas using a burning splint which will burn with a popping sound.

Different metals react differently. Metals above hydrogen in the reactivity series can react with dilute acids. Hydrogen and carbon are not metals but they are included in the reactivity series for reference purposes.

### Remember:

- Acids and bases react in a neutralization reaction. Salt and water are always produced  
Acid and base  $\longrightarrow$  salts + water.
- Soluble bases are called alkalis

Here is an example of an acid and metal reaction

Acids and metal  $\longrightarrow$  metal salt and hydrogen



Hydrochloric acid + magnesium  $\longrightarrow$  magnesium chloride + hydrogen



### Activity 3

1. Complete the following word equation and write balanced chemical equations for each reaction.
  - (a) Potassium hydroxide + nitric acid  $\longrightarrow$
  - (b) Calcium hydroxide + hydrochloric acid  $\longrightarrow$
  - (c) Magnesium + sulphuric acid  $\longrightarrow$
2. Write a general formula for the reaction of a metal with acid.
3. Describe an experiment on the reaction of metal with an acid and explain the gas formed.

Reaction between acids and carbonates

### Tip:

Reactions of acids and metal carbonates produce water, a salt and carbon dioxide.

## Word equation

Acid + carbonate  $\longrightarrow$  salt + water + carbon dioxide





Note that during the reaction a gas is produced. This gas should then be collected and tested using a burning splint, lime water or bicarbonate indicator. In the presence of carbon dioxide the burning splint would be put off, lime water changes colour from clear to milky white while the Bicarbonate indicator changes colour from orange to red.

**Tip:** The indicator under goes several colour changes.

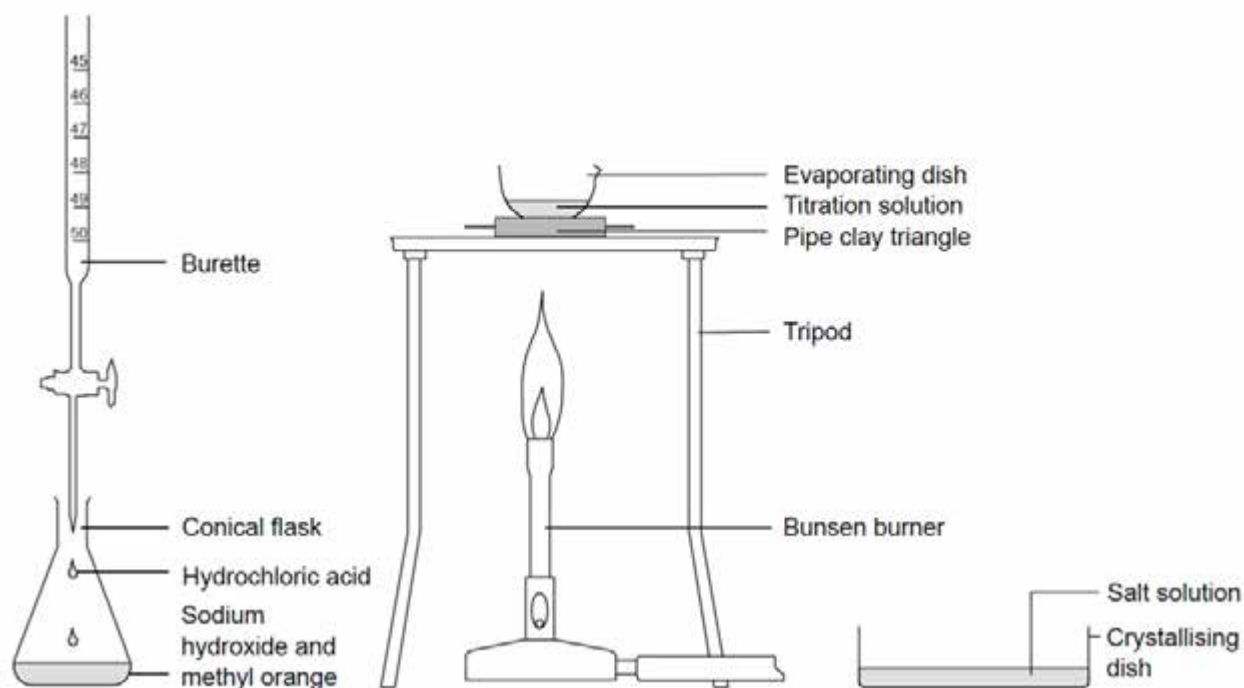
## 14.5 Acid –base Titration

In the previous units we defined acids and bases in terms of their abilities to split in water to release either the hydrogen ion ( $\text{H}^+$ ) or a hydroxyl ion ( $\text{OH}^-$ ). Production of  $\text{H}^+$  makes solutions acidic and the production of  $\text{OH}^-$  ions produces alkaline solutions. You also learnt that acid – base reactions are known as neutralization reaction. In this unit you are going to learn about the laboratory procedure by Chemists to carry out neutralization reactions. By the end of this unit you shall be able to identify the materials and set them up to perform a titration procedure, describe and explain an acid-base neutralization titration procedure as well as doing acid-base titration.

**Table 3: Apparatus used in titration procedure**

Apparatus	Functions
<p>Conical flask</p> 	<p>Safely used to swirl the mixture of the analyte and titrate without spilling any of the mixture</p>
<p>Volumetric pipette</p>	<p>This is used to transfer a single fixed volume of the analyte into the conical flask. The analyte is drawn into the pipette with safety pipette filler.</p>
<p>Dropper</p> 	<p>Transfers small amounts of indicator solution into the conical flask.</p>
<p>Clamp and stand</p>	<p>Held the burette in a vertical position to ensure accurate measurements.</p>
<p>Burette</p>	<p>Used to measure volumes of liquids accurately. It has a tap at the bottom to control the flow of liquid.</p>
<p>Indicator</p>	<p>Shows when the .... The end point has been reacted in an acid-base titration.</p>
<p>End point</p>	<p>A point at which the analyte is equal to the titrant in concentration or volume.</p>

**Fig 14.3 Arrangement of apparatus in a titration procedure**



**Table 4: Indicators used in titration and the colors in acids and alkalis**

Indicator	Colour in acid	Colour in alkalis
Universal	Red	Purple
Methyl orange	Red	Yellow
Phenolphthalein	Colourless	red

### Steps in titration procedure

1. Write down the balanced equation for the reaction being performed.
2. Measure the required volume of analyte using a pipette and run it into the conical flask.
3. Use a dropper to drop a few drops of indicator solution into the flask containing the analyte.
4. Pour the titrant into the burette until it reads zero
5. Place the conical flask below the burette in such a way that the top of the burette is well within the conical flask. Open the tap to allow the titrant to run into the flask.
6. When the indicator start to change colour, close the tap, swirl the mixture and ensure that the titrant come out in a drop by drop fashion until the color changes
7. Record the volume of titrant remaining in the burette.
8. Calculate the volume of the titrant used by subtracting the initial volume from the final volume

## SUMMARY

In this unit we have learnt that a substance can be acidic, neutral or alkaline. Acids are proton donors and that they turn blue litmus paper red when dipped into their solutions. We have also discovered that bases are proton acceptors which turn red litmus paper blue when dipped into their solutions. Strong acids dissociate fully in solutions while weak acids partially do so in solutions. The same has also been discovered about bases where strong bases dissolve fully in solutions while weak bases dissolve partially. You have learnt that the acidic or basic nature of a compound can be measured on a pH scale which ranges from 0 to 14. Do you remember the 3 ranges on the pH scale? We hope you do. We hope you also noticed that the smaller the pH the stronger the acidity and the greater the pH the greater the alkalinity of a substance. Note that the universal indicator solution is used to determine pH of substances.

- Acids and bases react in a neutralisation reaction. Salt and water are always produced
- Acid and base  $\longrightarrow$  salts + water.
- Soluble bases are called alkalis

Remember that form of salt produced when acids and bases react in a neutralisation reaction is dependent on the form of acid used. Also for you to remember is that acids only react with metals above hydrogen on the reactivity series.

## 14.6 SAMPLE ASSESSMENT QUESTIONS

### Multiple choice questions

Choose the correct answer from the following. Each question from this section carries 1 mark

1. \_\_\_\_\_ is an example of a weak acid.
  - a) Lemon juice
  - b) Nitric acid
  - c) Sulphuric acid
  - d) Battery acid
  
2. The pH scale is divided into how many regions?
  - a) 1
  - b) 3
  - c) 5
  - d) None

3. Solutions with a pH value of 1 are \_\_\_\_\_
- Strong acids
  - Alkalis
  - Concentrated acids
  - Weak bases
4. Strong base compounds \_\_\_\_\_
- Split fully when dissolved in water
  - Partially split when dissolved in water
  - Do not split when dissolved in water
  - Can donate away a proton
5. Which of the following is not a product of the reaction between acids and carbonates
- Water
  - Salt
  - Carbon dioxide
  - Sodium hydroxide solution

### Structured Questions.

Under this section you are expected to provide your answers in short notes in order to get maximum point for your answers.

6. Draw a pH scale to illustrate strong and weak bases (3)
7. An acid turns \_\_\_\_\_ litmus paper to \_\_\_\_\_ and a base turns red litmus paper \_\_\_\_\_ (3)
8. Complete this chemical equation as a word equation.  
 $\text{HCl(aq)} + \text{NaOH(aq)} \longrightarrow \text{NaCl(s)} + \text{H}_2\text{O(l)}$  (2)
9. Metals react with acids. Complete the table below.

Metal	Reaction with acid	Presence of gas bubbles	Effect of gas on burning splint	Name of gas formed
Mg				
Cu				

**TOTAL MARKS [20]**

## UNIT 14: ACIDS AND BASES POSSIBLE ANSWERS

### Multiple choice

1 A

2 B

3 A

4 A

5 D



# UNIT 15: INDUSTRIAL PROCESSES 1

## CONTENTS

- 15.1 Fractional distillation of air
- 15.2 Electrolysis of water
- 15.3 Electrolysis of bromine
- 15.4 Coating process
- 15.5 Sample assessment questions

## INTRODUCTION

Gases such as oxygen, hydrogen and nitrogen are needed in large quantities in industries. Oxygen is needed in the steel industry; hydrogen and nitrogen are needed for the production of ammonia in the Haber process. These gases can be separated from the air since it contains large amounts of them. Oxygen and hydrogen can be obtained using the electrolysis method. In this unit we are going to cover more on the importance of electrolysis as well as the production of nitrogen and oxygen.



## OBJECTIVES

After going through this unit, you should be able to:

- explain the production of nitrogen and oxygen
- outline the process of electrolysis of water
- identify the components of a general cell
- list the properties of the electrode and the electrolyte
- describe the anode and the cathode reactions for electrolysis of molten lead bromide
- list the uses of oxygen and hydrogen
- state the reasons for electroplating



## KEY WORDS

Here is a list of some of the new words you are going to meet in this unit:

**Anion** – these are the negative ions in an electrolyte

**Anode**- a positively charged electrode in the process of electrolysis and it attracts anions

**Diatomic elements**- these are elements or atoms which exist in pairs.

**Electrolysis** – is a breaking a chemical substance using electricity.

**Electrolyte** – is a liquid that can conduct electricity

**Electrolyte cell** – a device in which electrolysis is carried out

**Electrode** – these are conducting materials that are dipped in the electrolyte and pass electric current during electrolysis.

**Cathode** – a negatively charged electrode in the process of electrolysis and it attracts cations

**Cations** – these are the positively charged ions in an electrode



**TIME: 8 hours**

### **Remember:**

In the previous level we learnt about the useful gases that are found in the air. Do you still remember that air consists of approximately 78% nitrogen, 21% oxygen and 0.04% carbon dioxide? These gases can now be extracted and used in industries. Remember the process of fractional distillation which is used to get pure fractions from mixtures of substances. Oxygen and nitrogen can also be produced using this process which uses the differences in boiling points. This unit is going to help you more on the production of nitrogen, oxygen and carbon dioxide using fractional distillation.

## **15.1 FRACTIONAL DISTILLATION OF AIR**

Fractional distillation is the process that is used to separate oxygen and nitrogen from the atmospheric air which contains a mixture of gases such as nitrogen, oxygen, argon, carbon dioxide and water vapour. The whole process is summarized in the following steps;

**Step 1:** Air first passes through the filter to remove dust particles and impurities. Carbon dioxide and water vapour are removed. Very low temperatures are used which makes them freeze and solidify. Water vapour freezes at  $0^{\circ}\text{C}$  and it is removed as a solid. The air is then cooled to  $-78^{\circ}\text{C}$  and carbon dioxide turns into a solid and is also removed. This is done to protect the pipes from blocking.

**Step 2:** The remaining gases are then compressed, cooled and allowed to expand. This results in a sharp drop in temperature. This process of compressing, cooling and expanding the gases is repeated several times until the temperature falls to  $-200^{\circ}\text{C}$ . At this temperature both nitrogen and oxygen turn into a liquid.

**Step 3:** Nitrogen has a boiling point of  $-193^{\circ}\text{C}$  and oxygen has a boiling point of  $-183^{\circ}\text{C}$ . The liquid gases of nitrogen and oxygen are then separated using the fractional distillation process. They are channelled into the fractionating column where it is warmed. They are boiled and collected one after the other in different tanks. Nitrogen is the first one to be collected because it has a lower boiling point than oxygen. It is then piped off and collected as a gas. Oxygen has a higher boiling point than nitrogen and it is collected at the bottom in the form of a liquid.

When these gases are obtained, they play an important role in industry. Nitrogen is used in the Haber process for the production of ammonia and nitric acid. Oxygen is used in steelmaking, welding and for medical purposes.

## STUDY TIP

Before you attempt the activity below, carefully read again the stages of fractional distillation of air. Note the steps in their correct order. Also think about the industrial uses of nitrogen and oxygen.



### ACTIVITY 1

Study the process of fractional distillation of air above. Now write down your own summary of the process using a flow chart. The flow chart must show all the steps in correct order and must be all explained.

We hope from the above activity you come up with the correct flow chart with all the stages of fractional distillation of air. This method is very important and it helps to separate gases such as nitrogen and oxygen from a mixture of gases.



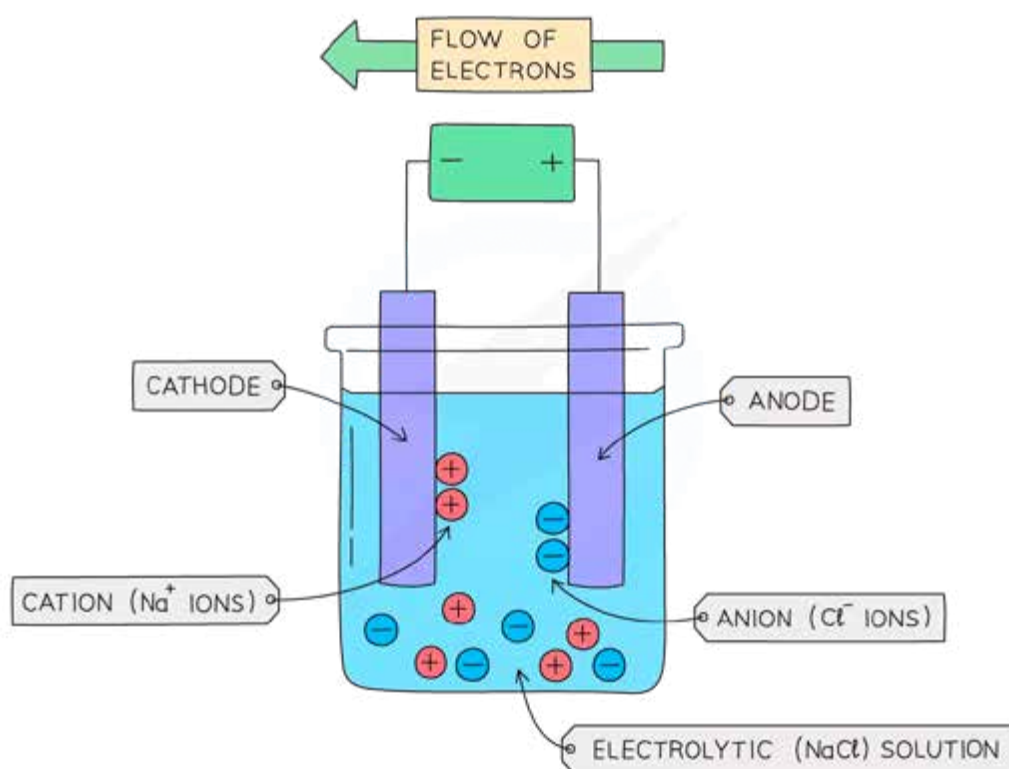
### ACTIVITY 2

1. What is fractional distillation of air?
2. What is the percentage of nitrogen and oxygen in the atmospheric air?
3. Why is it important to filter the gases before the process of fractional distillation?
4. What happens to the air in the fractionating column?
5. Give three industrial uses of oxygen.
6. In the fractionating column where exactly do we collect the nitrogen gas?

Now let us look at another method of isolating gases using electric current.

## 15.2 Electrolysis of water

Electrolysis means to breakdown or to decompose a liquid or molten substance using electricity. The breakdown is caused by passing an electric current through a liquid. The process is called an electrochemical reaction and it changes electrical energy to chemical energy. The process takes place in an electrolytic cell which is made of the internal circuit, two electrodes and an electrolyte. An electrolyte is a liquid which conduct electricity. It will break down ionic compounds during electrolysis. It may be a molten compound or an ionic solution and it must contain ions that are free to move around.



**Fig 15.1 simple electrolysis**

The electrodes make contact with the electrolyte. They are made of either an inert metal that do not change during electrolysis or can be also made of carbon rods. They are usually wider than metal wires in order to provide a large surface area for the reaction to take place. All the chemical changes take place at the two electrodes. Oxidation takes place at the anode or the positive electrode and reduction takes place at the cathode or the negative electrode. The cell or battery supplies electricity needed to perform the process of electrolysis. In Zimbabwe the electrolysis plant for the electrolysis of water is found in Kwekwe at the Sable Chemical Industry. Water which is one of the raw materials is provided by the Sebakwe River and electricity is conducted from a large power station at Munyati.



## ACTIVITY 3

1. What is electrolysis?
2. A liquid which conduct electricity is called----
3. List the three components of an electrolytic cell
4. Oxidation takes place at which electrode during the process of electrolysis?
5. What is the function of an electrolyte?

### Electrolysis of water in the laboratory

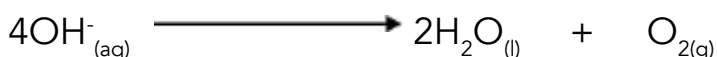
Pure water does not conduct electricity therefore; it is a non-electrolyte. Acids can conduct electricity and can be used as electrolytes. The electrolysis of water is done mainly using dilute sulphuric acid ( $\text{H}_2\text{SO}_4$ ). The following is the equation for the dissociation of water;



Hydrogen ions move towards the cathode and hydroxide ions move towards the anode.

### Reaction at the Anode

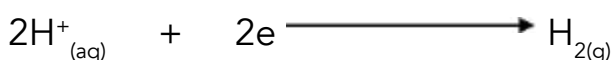
The hydroxide ions move to the anode. The ions lose electrons at the anode and if you still remember, the loss of electrons by a substance is called oxidation. Hydroxide ions are oxidised at the anode to form water and oxygen as shown by the equation below.



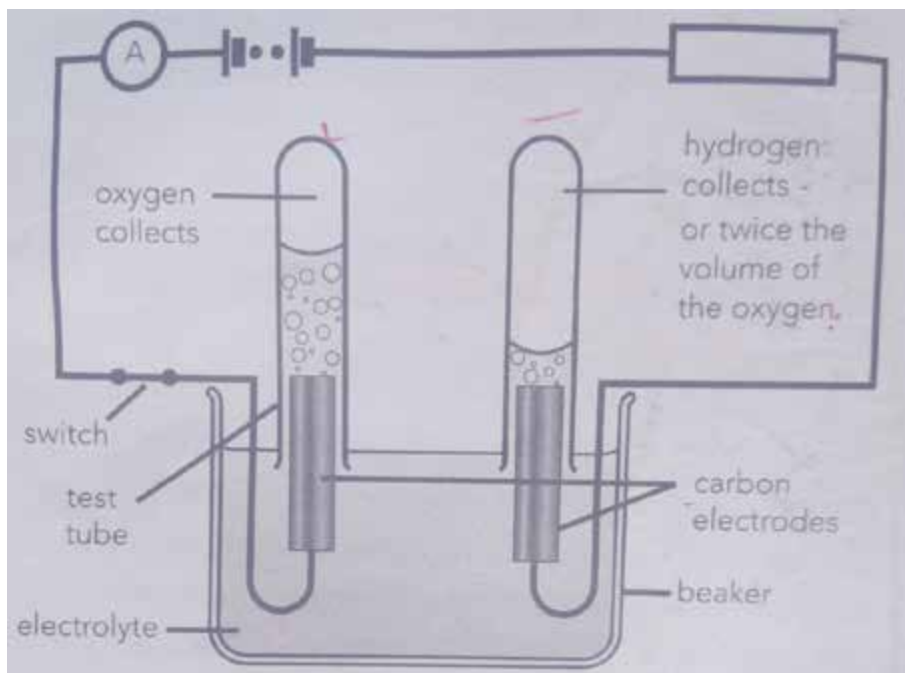
Test tubes are filled with liquid and placed upside down over the electrodes in order to capture the gas released at each electrode. **O**xxygen is collected at the anode and hydrogen at the cathode.

### Reaction at the Cathode

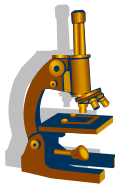
The hydrogen ions move towards the cathode where they are attracted. The hydrogen ions gain electrons at the cathode and they become reduced and they form hydrogen gas. Reduction reaction occurs at the cathode as shown by the equation below



There will be a difference in the volumes of the gas collected which shows that hydrogen is twice as compared to oxygen.



**Fig 15.2 electrolysis of water**



## Experiment 1

### Aim

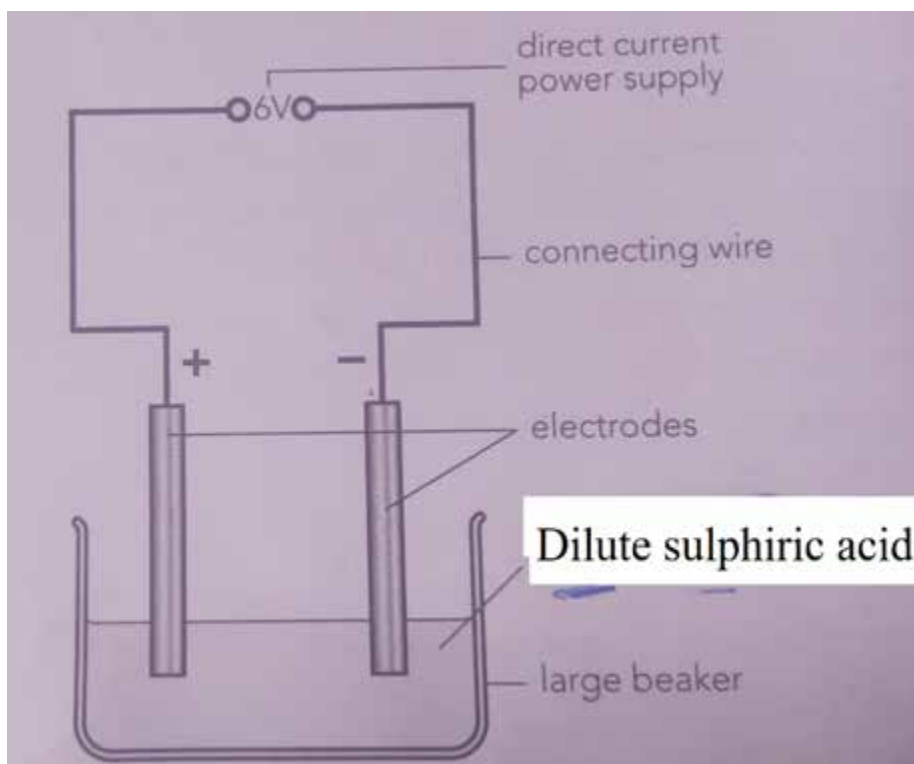
To investigate the electrolysis of water

### Apparatus/Materials

Battery or power supply (12v), a large beaker or a basin, carbon rods, crocodile clips, connecting wires, retort stand, 2 test tubes, tongs, dropper, dilute sulphuric acid, emery nail file.

### Method

1. Clean the electrode with emery nail file
2. Set up apparatus as shown in the diagram below;



Use the retort stand and clamps to secure the electrodes.

3. Note the changes as current flows through the circuit.

### Observations

You must see some bubbles forming at the electrodes. After a while you notice a difference in the volumes of the gas collected in the upside down test tubes.

### Conclusion

The volumes of gases produced after the process of electrolysis are the ratio of 1 volume to oxygen to volumes of hydrogen. The oxygen gas is collected at the anode and the hydrogen gas is collected at the cathode.

### STUDY TIP

You can use a glowing splint to test the gases. If the gas produced is oxygen the glowing splint re-lights and if it is hydrogen it produces a popping sound.

### Uses of oxygen

- Used in steel making
- Used for medical purposes
- Used in welding
- Used in furnaces to keep the flames burning

## Uses of hydrogen

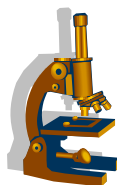
- Used in welding
- Used as a fuel
- Used in the Haber process for the manufacture of ammonia
- Used in the manufacture of margarine



## ACTIVITY 4

1. Define the term electrolysis
2. What are the two atoms that make up the water molecule and their ratios
3. Where do you find the electrolysis plant in Zimbabwe?
4. Hydrogen and oxygen are called diatomic elements, why?
5. Why do we set the test tubes upside down on the electrodes when investigating the electrolysis of water?
6. How do you test that the gas collected in the upside down test tube is oxygen?
7. list two industrial uses of hydrogen

## 15.3 ELECTROLYSIS OF MOLTEN LEAD BROMIDE



### Experiment 2

#### Aim

To investigate the electrolysis of molten lead bromide ( $\text{PbBr}_2$ )

#### Apparatus/Materials

Torch bulb and switch, battery (6V), crocodile clip, carbon rods, tripod, burner, powdered lead bromide, crucible.

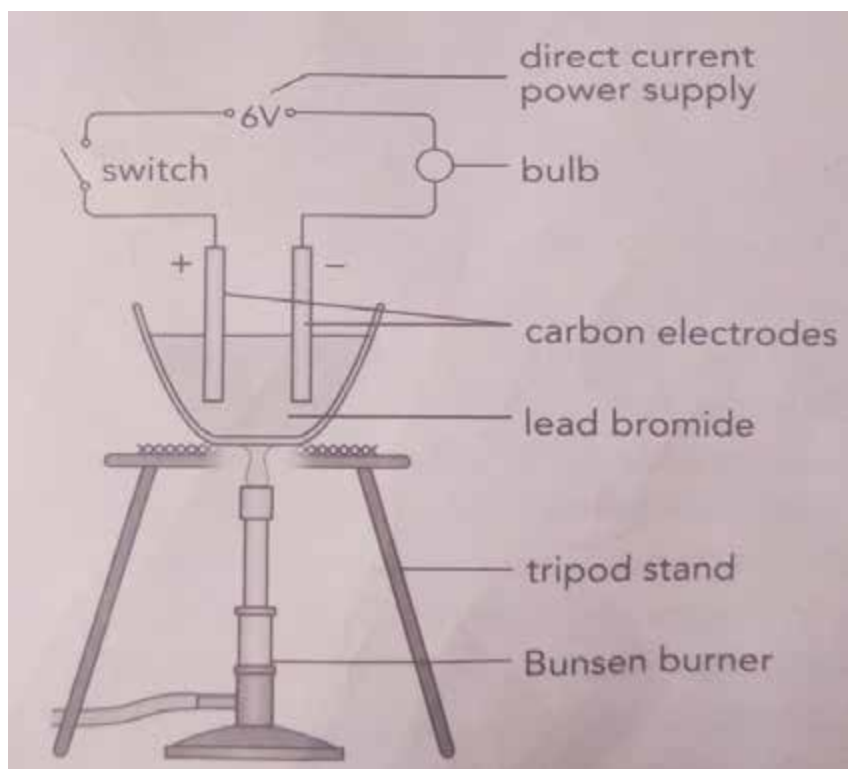
#### Method

1. Take the apparatus in a fume cupboard

**PRECAUTION:** The experiment has to be carried out in an open space because the fumes of bromine are poisonous.



2. Set the apparatus as shown below



3. Put the electrodes in the dry, white lead bromide powder. See what happens to the bulb.
4. Put the powdered lead bromine into a crucible and heat until the powder melts. Put the electrodes in the molten lead bromide and see what happens to the bulb.
5. Observe what happens to the positive and negative electrode.
6. Hold a small piece of paper behind the apparatus and observe what happens
7. Carefully remove the liquid from the crucible and see what left behind

### Observations

You should have seen that lead collects at the cathode and bromine gas released from the anode.

### Conclusion

The lead ions are attracted to the negative electrode. When they come in contact with the electrode they gain electrons (reduced) and become neutral forming lead atoms. At the positive electrode the bromide ions turn into bromine gas. The negative bromide ions give up their electrons (oxidised) and become neutral bromine atoms. The two atoms of bromine then combine to form bromine gas.



## ACTIVITY 6

You have noticed certain characteristics of molten lead bromide during the process of electrolysis. You have seen that when lead bromide is solid nothing happens but when it melts a number of things happens. List some of the things that take place when lead bromide melts during the process of electrolysis.

Here are some of the things that take place when lead bromide melts during the electrolysis of molten lead bromide.

- The bulb lights up showing that electrons are flowing
- Brown bubbles are produced around the anode as bromide gas is released
- At the cathode, lead ions gain electrons to and form lead metal which is found underneath the electrode at the end.

### STUDY TIP

You also have to know that when heat is taken away the lead bromide solidifies and everything stops. The bulb goes off and no more bubbles are produced.

Lead bromide is an ionic compound. When it is solid, its ions are not free to move. As a result solid lead bromide does not conduct electricity. When it melts the ions are free to move around and this movement allow current to flow in the circuit. When the electric current is flowing electrons move away from the left to the right electrode and the excess electrons on the right electrode makes it negatively charged. The electrode on the left is now short of electrons and is positively charged. When lead bromide melts the positive lead ions get attracted to the cathode and picks up two electrons from the cathode making it neutral lead atoms. The lead ions gain electrons and become lead atoms.

#### Reaction at the cathode



Bromide ions are attracted to the positive anode and the extra electron that makes the bromide ion negatively charged moves onto the anode because the electrode is short of electrons. Due to the loss of an extra electron, each bromide ion turn into a bromide atom. They will then join together and form a bromine molecule.

**Note:** during electrolysis, reduction takes place at the cathode and oxidation occurs at the anode. The positive ions or cations are attracted to the negative cathode where they gain electrons. The negative ions (anions) are attracted to the anode where they give up electrons to the electrode.



## ACTIVITY 7

1. What happens when lead bromide is solid during the process of electrolysis?
2. List three things that can be observed when lead bromide melts.
3. Solid lead bromide does not conduct electricity, why?
4. When lead bromide melts, it conducts electricity, why?
5. In any example of electrolysis state where oxidation and reduction occurs

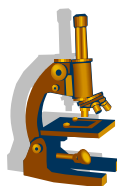
## 15.4 Coating Process

Coating is the process of covering one material with another material. Metals are mainly coated in order to make them look attractive and prevent rust. Painting, galvanising and electroplating are some of the methods used in coating. In this unit, we are going to focus on electroplating as a method of coating metals.

### Electroplating

Electroplating is the process whereby an object made of one type of metal is covered or coated with a thin layer of another type of metal. The metal that is being coated is normally a cheaper metal and the metal that is coating is more expensive. In this process only a small amount of the expensive metal is needed to coat the cheaper metal. Electroplating is done to make objects look more attractive, expensive, shiny and resistant to corrosion. In the process of electroplating the object which is being coated is the cathode and a bar of the coating metal is the anode. Gold, silver and chromium are examples of metals which can be used for electroplating. Electroplating is an example of an electrolysis process and it uses electricity.

For example, if you want to coat an object with chromium, the object suspended in a solution of chromic acid and it becomes the cathode. The anode now is the bar of chromium. The anode becomes thinner because it dissolves during the process and chromium covers the object.



### Experiment 3

#### Aim

To electroplate an iron nail

## Apparatus/Materials

An iron nail, soap, water, paper towel, battery (1,5v), battery holder, 2 crocodile clips, a beaker, concentrated solution, a coil of copper wire.

## Method

1. Clean the iron nail with dilute sulphuric acid and water and dry it with a paper towel.
2. Clip the coil of copper wire in one on one side of a crocodile clip and attach the other side of the crocodile clip to the positive terminal of the battery.
3. Clip the iron nail on the other side of the crocodile clip and attach the other side of the crocodile clip to the negative terminal of the battery.
4. Suspend the coil of copper wire and the iron nail in the copper sulphate solution. The crocodile clip must not get in contact with the liquid.
5. Allow the circuit to run for 20minutes or more until a layer of copper can be observed on the nail.

## Observations

The iron is coated with the copper metal which was in the copper sulphate solution. The copper coloured coating can be clearly observed.

## Conclusion

The iron nail can be coated with copper using the process of electrolysis.



## ACTIVITY 8

1. What is electroplating?
2. List three reasons for electroplating objects.
3. In the experiment of electroplating an iron nail, which material is the anode and which one is the cathode?
4. The results of electroplating can be influenced by a number of factors. State two factors that can influence the results of electroplating.
5. List three metals which can be used to electroplate objects.

## SUMMARY

To conclude this unit, you have learnt that for metals to conduct electricity electrons must be free so that electricity can move from one electron to another. We also learnt that oxygen and hydrogen can be isolated from water through various methods and

in this unit we focused more on the process of electrolysis which uses electricity. Electrolysis is an electrochemical reaction which converts electrical energy to chemical energy. The process takes place in the electrolytic cells made up of two electrodes and an electrolyte. The electrolyte contains ions in solution which conduct electricity. When electricity is passing, oxidation takes place at the anode and reduction takes place at the cathode.

We also learnt about the process of electroplating whereby one metal is coated or covered with another type of metal that is usually more expensive. This expensive metal which is covering is needed in very small amounts in order to cover the cheap metal. Electroplating is done in order to make objects shiny, attractive, expensive and protected from corrosion. We also learnt that this process of electroplating uses electricity and is an example of electrolysis. Coating objects prevents oxygen and moisture from reaching the metal. The electrolyte for electroplating should contain the ions of the metal that is going to cover the cathode. The metal to be plated is placed at the cathode and the bar of the metal coating the object is placed at the anode.

Now you can answer the following questions below in order to assess your understanding. If you faced challenges in answering, go back and read again. You must also do all the activities in this section in order to enhance understanding. Use the spaces provided for answering.

## 15.5 SAMPLE - ASSESSMENT QUESTIONS

### Multiple choice questions

Note: Surround the letter with the correct answer

1. What is electrolysis? (1)
  - A. A process which uses electrodes, electrolyte and a battery.
  - B. A process of breaking down ionic compounds using electricity
  - C. Breaking down using electricity to produce a chemical change
  - D. It is an electrolyte which contains ions free to move around.
2. The following is reason for electroplating objects (1)
  - A. To make them attractive and resistant to corrosion
  - B. To make object exposed to the atmosphere.
  - C. To make objects neutral atoms
  - D. To make objects gain electrons.

3. Why is pure water not an electrolyte? (1)
- A. It allows electrons to move through freely
  - B. It is a diatomic element
  - C. It is a good electrolyte used in electrolysis
  - D. It does not conduct electricity
4. In an electrolytic cell the anode is always..... (1)
- A. Where the gain of electrons takes place
  - B. Where the loss of electrons take place
  - C. The negative electrode
  - D. The positive electrode
5. Which of the following statement is true? (1)
- A. All the electrodes become positively charged when current is passed through.
  - B. Cations are attracted to the cathode and anions are attracted to the anode.
  - C. Water is good electrolyte in the process of electrolysis.
  - D. The cathode metal reacts during the process of electroplating.

### Structured questions

- 1 a) What do you understand by the following terms?
- (i) electrolyte (2)
  - (ii) electroplating (2)
  - (iii) electrolysis (2)
  - (iv) We electroplate items for different reasons. State two reasons for electroplating items. (2)
- 2 a) List two industrial uses of hydrogen (2)
- b) Explain why solid Lead bromide does not conduct electricity (2)
  - c) give one characteristic of an acid (1)
  - d) explain one property of an electrode (1)

## Practical questions

- 3) During electrolysis nothing happens when lead bromide is solid but as soon as it melts a number of changes takes place. Explain what happens when lead bromide melts (5)
- (b) The ions of Bromide are attracted to which terminal? (1)

**TOTAL = 25 MARKS**

## UNIT 15: INDUSTRIAL PROCESSES 1

### SAMPLE- POSSIBLE ANSWERS

Multiple choice answers

- 1.B
- 2.A
- 3.D
- 4.D
- 5.B

### Structured question answers

1 a) What do you understand by the following terms?

(v) electrolyte (2)

– is a liquid that can conduct electricity

(vi) electroplating (2)

Is a process where by an object made of a cheaper metal is covered with a thin layer of an expensive metal

(vii) electrolysis (2)

is breaking a chemical substance using electricity.

(viii) We electroplate items for different reasons. State two reasons for electroplating items. (2)

- to make cheaper objects look nice and attractive (decorative)
- to make objects expensive
- so that objects can resist corrosion

2 a) List two industrial uses of hydrogen (2)

- Used in welding
- Used as a fuel
- Used in the Haber process for the manufacture of ammonia
- Used in the manufacture of margarine

2 b) Explain why solid Lead bromide does not conduct electricity (2)

- Lead bromide is an ionic compound. When it is solid, its ions are not free to move. As a result, solid lead does not conduct electricity.

2 c) give one characteristic of an acid (1)

- Corrosive
- sour taste
- Cause skin irritation
- turns litmus paper red

2 d) explain one property of an electrode (1)

- it is a conducting material and it allow electric current to pass through during electrolysis

### Practical questions

3) During electrolysis nothing happens when lead bromide is solid but as soon as it melts a number of changes takes place. Explain what happens when lead bromide melts (5)

- Particles become free to move therefore electric current start to move
- The bulb lights up showing that electrons are flowing
- Bubbles are produced around the anode as bromide is released
- There is nothing happening at the cathode but metallic lead is found underneath at the end.

(b) The ions of Bromide are attracted to which terminal? (1)

Positive anode

**TOTAL = 25 MARKS**



# UNIT 16 INDUSTRIAL PROCESSES 2

## CONTENTS

16.1 The Haber Process: Manufacture of ammonia

16.2 The Contact Process: Manufacture of sulphuric acid

## INTRODUCTION

Zimbabwe's economy is based on agriculture in addition to minerals that we mine. One needs to visit tobacco auction floors during the tobacco marketing season and see how our farmers are working hard to develop our nation through agriculture. To support this production the chemical industry comes in through provision of agro-chemicals for example fertilizers. In this unit we are going to look at the manufacture of ammonia by the Haber Process, manufacture of sulphuric acid by the Contact Process, manufacture of nitric acid by the Ostwald Process and then how these chemicals play an important role in agriculture and other areas.



## OBJECTIVES

After going through this unit you should be able to:

- List raw materials used to manufacture ammonia, sulphuric acid and nitric acid
- Describe the manufacture of ammonia
- Describe the manufacture of sulphuric acid
- Describe the manufacture of nitric acid
- State uses of ammonia, sulphuric acid and nitric acid



## Key words

**Reversible Reaction:** a reaction that proceeds in both directions

**Catalyst:** a substance that speeds up a reaction without it being changed

**Optimum conditions:** best or suitable conditions for a process.



**TIME: 8 HOURS**

## STUDY TIP

Always refer back to previous units especially on chemical reactions.

### 16.1 THE HABER PROCESS

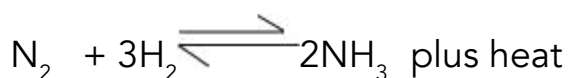
As we said above that agriculture is our backbone in Zimbabwe, the use of fertilizers helps us achieve our agricultural goals. Ammonia is one such chemical that is very important in the manufacture of fertilizers. The reaction of ammonia with nitric acid gives us ammonium nitrate one of the most important fertilizers we need. We have Sables Chemicals In Kwekwe and Windmill as major companies that manufacture fertilizers in Zimbabwe. You are going to look at how this ammonia is produced in Haber process.



**Fig 16.1 One of the companies that manufactures fertilizers .Windmill (pvt) Ltd in Harare**

The raw materials are nitrogen from the air obtained through fractional distillation of air and hydrogen that we get from the electrolysis of water. However hydrogen can also be obtained from natural gas where this gas is in plenty supplies. The two gases react together in a reversible reaction giving ammonia gas.

**Nitrogen + hydrogen**  $\rightleftharpoons$  **ammonia gas**. This reaction produces a lot of heat so it is exothermic.

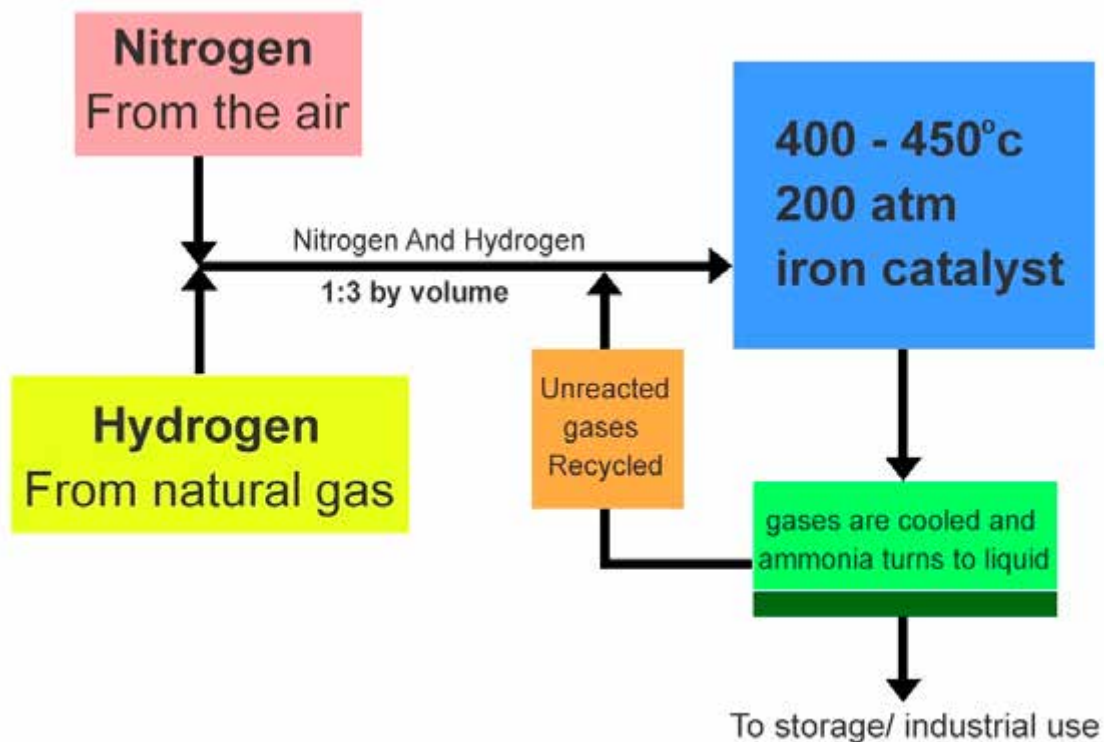


The sign  $\rightleftharpoons$  implies that the reaction is reversible. What does this mean? The Haber process reaction is reversible. This means that the product (ammonia) can break down again into the reactants (nitrogen and hydrogen). This is due to the heat produced by the reaction which is decomposing the products. For a reversible reaction in a closed system, equilibrium is reached where the rate of the forward reaction equals the rate of the reverse reaction. The amount of reactants and products in the equilibrium depends on the conditions. The equilibrium will move to reduce any changes in the reaction

In order to get a maximum yield of ammonia that is to shift the equilibrium to the right, the reaction is carried out under the following conditions.

- temperatures of about 450 °C - 500 °C
- High pressures (200 atm).
- iron catalyst

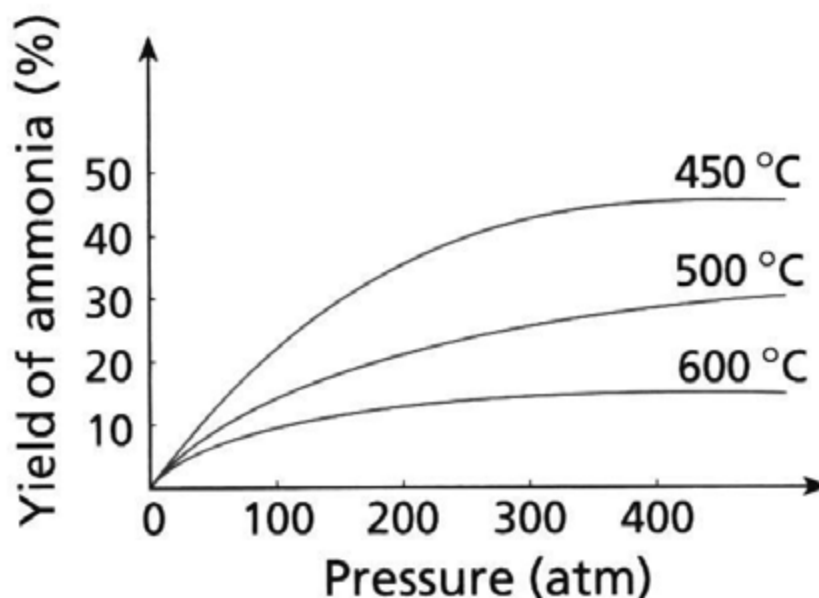
The temperature of 450 °C to 500 °C is chosen as optimum temperature though it is not that high when talking of temperatures in the industry. Remember we said the reaction releases a lot of heat so we do not need very high temperatures. As a result of this seemingly low temperature the reaction slows down and to quicken it up a catalyst is now used. This catalyst is iron which is finely divided. It must be noted that the use of a catalyst is in response to a relatively low temperature. You must recall that the speed of a reaction increases with temperature so a decrease in temperature results in decrease in speed. From the symbol equation above it can be seen that we have 4 volumes of reactants against only 2 volumes of products what this means is that high pressure is needed to reduce 4 volumes of reactant gases into 2 volumes of product gas hence a pressure of 200 atmospheres is employed in the process to achieve a greater yield of ammonia. The flow diagram below summarizes the Haber process.



**Fig 16.2** Flow chart for the Haber Process

Study the graph **Figure 16.3** below to understand the effect of temperature and pressure on ammonia production and answer questions below.

Graph showing effect of pressure and temperature on ammonia production

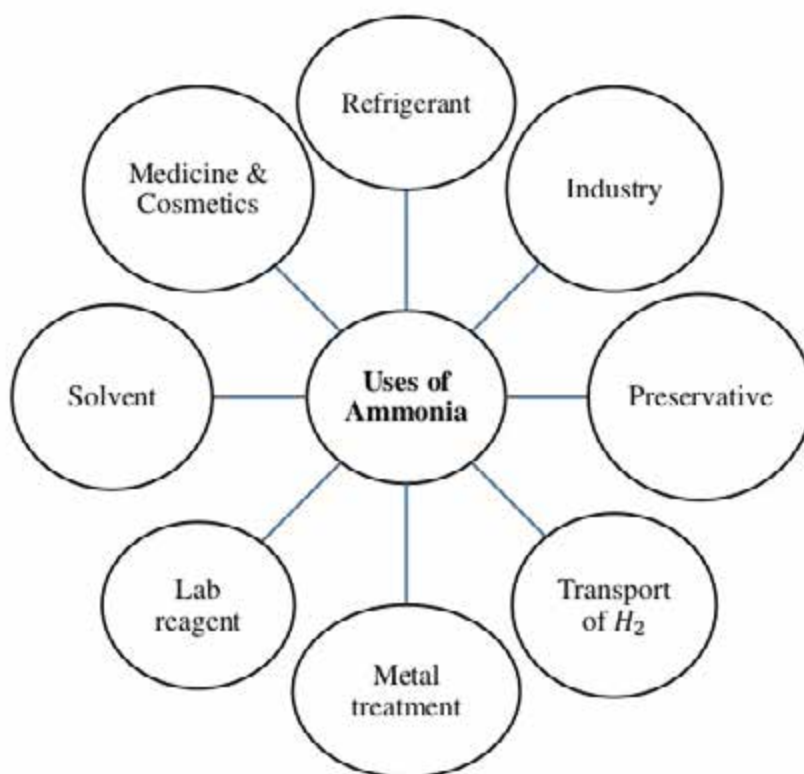


**Figure 16.3** Temperature and Pressure Effects on Ammonia Production

1. At 200 atm pressure what is the best temperature that gives better yield of ammonia?
2. Why is a pressure of 400 atm and a temperature of 550 °C not used?
3. What is the disadvantage of using very high pressure on the reaction vessels used?

## USES OF AMMONIA

Apart from its use in the production of fertilizers ammonia has also other uses as shown below:



**Fig 16.4 Uses of ammonia**

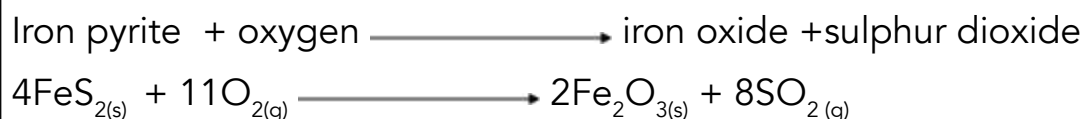
These are some of the use of ammonia and you can see that it is a very important chemical. However, every industrial process will in one way or another affect the environment. Before you move on to the next topic can you think of the impacts of ammonia production on the environment.

## 16.2 THE CONTACT PROCESS

It has been said that then economic development of a country can be measured by the amount of sulphuric acid it produces. Sulphuric acid is one of the most important industrial chemicals because it has many uses. In this part of the unit you are going to study the production of sulphuric acid by the Contact Process. Before you proceed can you write down uses of sulphuric acid? Hope you got the uses right if not do not despair you will get them towards the end of this unit.

To produce something, you need the starting materials which we call the raw materials.

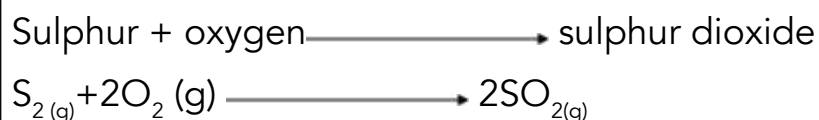
To produce sulphuric acid we need sulphur dioxide and oxygen which we get easily from the air. However not every country has sources of sulphur. Unfortunately, in Zimbabwe we do not produce sulphur but to obtain sulphur dioxide we roast iron pyrite that is iron sulphide to get this gas. We are lucky in Zimbabwe that we have plenty of this iron pyrite so we can easily get sulphur dioxide indirectly like what is shown in the equation below.



## STAGES IN CONTACT PROCESS

### 1. Production of sulphur dioxide

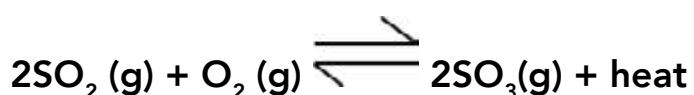
This has been explained above. Sulphur dioxide is obtained from roasting of iron pyrite according to the reaction above. Where sulphur is available the production of sulphur dioxide is as shown below:



### 2. Production of Sulphur trioxide

This is the most difficult stage in the whole process as the reaction is both reversible and exothermic.

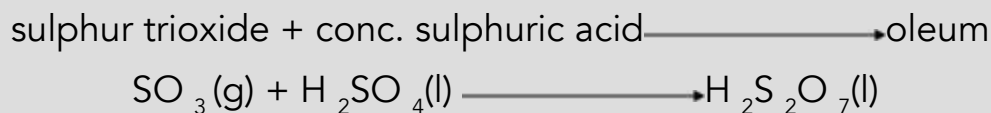
$\text{SO}_2$  gas is transferred to a catalytic converter where it is oxidized to  $\text{SO}_3$ .



The amount of sulphur dioxide can be maximized by carefully controlling conditions. What are these conditions? The conditions for maximum yield include a pressure of 1-2 atmosphere, temperatures of  $450^\circ\text{C}$  -  $500^\circ\text{C}$  and a catalyst of vanadium (v) oxide. The catalyst is needed to increase the reaction rate at moderate temperatures without decreasing the yield. The catalyst is also in pellet form which increases its surface area. The sulphur dioxide gas is also passed over several layers of catalyst beds, cooling the mixture slightly in between each pass. This results in a high conversion of sulphur dioxide into sulphur trioxide.

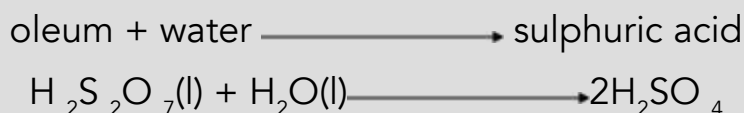
### 3. Absorption of sulphur trioxide

Dissolving sulphur trioxide directly into water gives a misty acid which is very difficult to collect so instead of dissolving directly into water the sulphur trioxide is dissolved in concentrated sulphuric acid to give a fuming substance called oleum. This is done in the Absorption Tower.

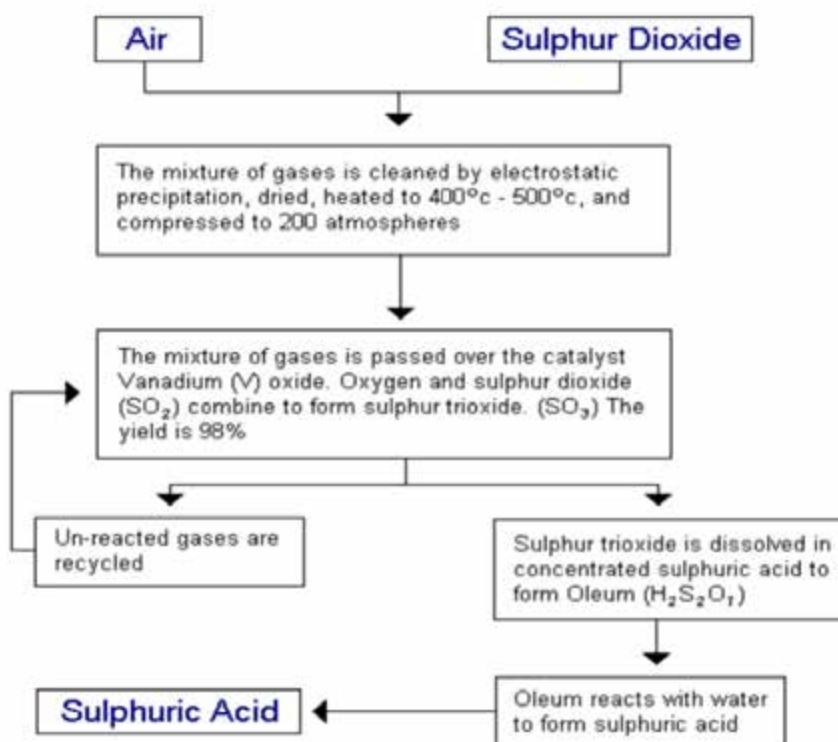


### 4. Dilution of oleum

Oleum unlike sulphuric acid is not a problem to store so when there is a need for sulphuric acid the oleum is now diluted with water to give the acid.



The above stages summarize the Contact Process now let us show this in a flow diagram.



**Fig 16.5 Flow diagrams for the Contact Process**

## USES OF SULPHURIC ACID

If you go back to our introduction of the Contact Process, we said sulphuric acid production is an indicator of a country's economic development because this chemical has a lot of uses which we not all cover in this unit. It is the king of all chemicals. The major use of sulphuric acid is in the production of fertilizers for example ammonium sulphate. Other uses include the making of drugs, synthetic detergents (washing powders), dyes and pigments manufacture, explosives, manufacture of plastics, cleaning materials before electroplating and it is the chemical in car batteries. Can you think of other uses

## IMPACTS OF SULPHURIC ACID PRODUCTION ON THE ENVIRONMENT

Sulphur gas is easily oxidized to sulphur dioxide gas which is a major air pollutant even at low concentrations. Sulphur dioxide dissolves in rain water forming acid rain which affects plants and also stone buildings. The extraction of iron pyrite leaves a lot of pits which can be breeding ground for mosquitoes when filled with water

## SUMMARY

By now you should have how industrial processes are important in our every day lives. The unit has looked at the Haber process for ammonia manufacture and you saw that it is an equally important industrial chemical. However, you learnt that it is not easy to produce ammonia without introducing conditions carefully selected for maximum production. You then looked at the manufacture of sulphuric acid which we said is the king of all chemicals because of having so many uses. Once again the Contact process has special conditions that must be selected to give maximum yield of sulphuric acid.

## 16.3 SAMPLE ASSESSMENT QUESTIONS

### Section A

**Answer all questions.**

1. Which of the following statements is correct about the Haber Process?

- (i) The reaction is exothermic
- (ii) No catalyst is required
- (iii) Finely divided iron is used to slow down the reaction
- (iv) A moderate temperature of  $450^{\circ}\text{C}$  is used.

- A. i and ii
- B. ii and iv
- C. iii only
- D. i and iv



2. In the Haber Process, how is the ammonia produced separated from unreacted nitrogen and hydrogen gas?
- A. cooling and compressing
  - B. compressing and filtration
  - C. compressing and fractional distillation
  - D. Cooling and diffusion
3. Which of the following is not use ammonia?
- A. manufacture of plastics
  - B. manufacture of explosives
  - C. manufacture of metals
  - D. manufacture of dyes
4. Which of the following are raw materials for the production of sulphuric acid?
- A. nitrogen and oxygen
  - B. sulphur dioxide and hydrogen
  - C. sulphur dioxide and oxygen
  - D. sulphur trioxide and vanadium (v) oxide
5. What is the storage state of sulphuric acid?
- A. oleum
  - B. dilute sulphuric acid
  - C. concentrated sulphuric acid
  - D. water
6. Why is sulphur trioxide not dissolved I water to give sulphuric acid?
- A. No acid is formed
  - B. reaction gives a lot of heat that vaporizes the acid produced
  - C. no reaction takes place
  - D. sulphur trioxide does not dissolve.

**SECTION B. Answer all questions in the spaces provided**

9. In the manufacture of ammonia by the Haber Process a moderate temperature is used.

(a) Explain why high temperatures are not used?

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---

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(2)

(b) Write the word equation for the reaction.

---

(2)

(c) The reaction is reversible what do you understand by the term reversible?

\_\_\_\_\_  
\_\_\_\_\_ (1)

(d) Give any 5 uses of ammonia.

(i) \_\_\_\_\_

(ii) \_\_\_\_\_

(iii) \_\_\_\_\_

(iv) \_\_\_\_\_

(v) \_\_\_\_\_ (5)

(e) Describe and explain any environmental impacts of ammonia production

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

9. (a) Describe using a simplified flow chart the Contact Process.

\_\_\_\_\_  
\_\_\_\_\_ (8)

(b) Explain why sulphuric acid is referred as the king of all chemicals.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2)

(c) How is sulphuric acid production important to our economy?

\_\_\_\_\_  
\_\_\_\_\_ (2)

(d) Explain why you should handle sulphuric acid with care.

\_\_\_\_\_  
\_\_\_\_\_ (1)

(e) List any five uses of sulphuric acid

(i). \_\_\_\_\_

(ii). \_\_\_\_\_

(iii) \_\_\_\_\_

(iv) \_\_\_\_\_

(v) \_\_\_\_\_ (5)

(e) Describe the environmental impacts of sulphuric acid production and suggest how these can be minimized.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(4)

## PROJECT

If you can afford visit any of these companies Sables in Kwekwe or Windmill in Harare and find out how much of each product they produce per year. How are they obtaining their raw materials? What are some of the challenges they are facing. At Sables find out how their electrolysis plant is producing hydrogen and oxygen gas and how Windmill is benefiting from these.

## REFERENCES

Smith, R. (2000). *HSC Course: Conquering Chemistry*. Sydney: Mc-Graw Hill Book Company

## POSSIBLE - ANSWERS

Section A MCQ

1. D
2. A
3. C
4. C
5. A
6. B

## Section B

6 (a) reaction releases a lot of heat

High temperatures favour decomposition

(b) nitrogen + hydrogen = ammonia

(c) a reaction that goes both ways

(d) (i) refer to Fig 14.4

(e) waste gases produced are pollutants

7(a) See Fig. 14.5

(b) Has many uses/used in many industries

(c) used in the production of fertilizers and Zimbabwe is an agro-economy

(d) corrosive

(e) See Section 14.4.2 Select any 5

(f) See Section 14.4.3

# UNIT: 17 OXIDATION AND REDUCTION

## CONTENTS

17.1 OXIDATION AND REDUCTION

17.2 PRODUCTION OF IRON IN THE BLAST FURNACE

17.3 ALLOYS OF IRON AND THEIR COMPOSITIONS

17.4 SAMPLE ASSESSMENT QUESTION

## INTRODUCTION

In this unit we are defining oxidation and reduction. Also you are going to describe the process of producing iron in the blast furnace. Alloys of iron produce critical materials used in industry today. The study of their composition as well as the properties is therefore of paramount importance. The unit will also focus on the production of iron and its alloys.



## OBJECTIVES:

After going through this unit you are expected to be able to:

- define oxidation and reduction
- list the raw materials used in the extraction of iron
- Describe the reactions in the blast furnace
- List down alloys of iron and their percentage compositions
- Explain the uses and properties of alloys of iron



## KEY WORDS:

Before attempting this unit, you are encouraged to take your time to understand suggested new terms. We shall use these key terms regularly hence the need for you to pay special attention to their meanings as applied in the unit. Also some concepts are going to be defined to help you understand the unit better.

- **Oxidation** is the gain of oxygen, loss of hydrogen and electrons by a substance
- **Reduction** is the loss of oxygen, gain of hydrogen and electrons by a substance
- **Reducing agent** is a substances that reduces other substances
- **Oxidising agent** is a substance that capable of oxidising other substances
- **Oxidation numbers** are positive or negative numbers that are assigned to some elements through a set of rules.
- **Redox** reactions are reactions in which there is both oxidation and reduction taking place at the same time.



## TIME: 8 HOURS

You are encouraged to take not more than 8 hours in this unit. I encourage you to give time to attempt suggested activities before proceeding to the next sub unit.



## STUDY TIP

Before you start on this unit, I encourage you to refresh your knowledge of the periodic table taking a close look at the elements that will constantly be referred to in this unit.

## 17.1 Oxidation and Reduction

### Oxidation interms of Oxygen

Oxidation is the gain of oxygen in a reaction such as burning reactions and rusting in iron. The following are examples of oxidation in terms of oxygen gain.



Carbon and iron are oxidised to carbon dioxide and iron(III) oxide respectively.

## Reduction in terms of Oxygen

Reduction is the loss of oxygen in a chemical equation. Examples of reduction or loss of oxygen is experienced in the blast furnace during extraction of iron. Study this chemical equation.



In this equation oxygen is removed from iron (iii) oxide to form iron. Iron( iii) oxide is reduced to iron and carbon dioxide

Oxidation and reduction in terms of hydrogen gain /loss .Examples of hydrogen gain is in the Haber process during manufacture of ammonia as illustrated in this equation.



Nitrogen is the species that has been reduced in the above equation by gaining hydrogen



### ACTIVITY 1

Identify substances being oxidised in the following reactions



## Oxidation and Reduction in terms of Electron transfer

Oxidation can also take place through electron transfer. Now oxidation is the loss of electrons and reduction is the gain of electrons.

The diagram below below illustrates reduction and oxidation through loss and gain of electrons respectively.



Reducing agent

Oxidising agent

A is losing an electron

A is oxidised

B gain electron

B is reduced

**Tip:**

A reducing agent makes reduction happen. As well an oxidising agent makes oxidation happen. Two sayings that can be used to remember oxidation and reduction could be OIL and RIG ie

OiL =Oxidation is Loss  
 RiG=Reduction is Gain

of electrons

LEO=Loss of Electrons is oxidation

GER= Gain of Electrons is Reduction

**Reactions of Sodium and chlorine**



One element is being oxidized while the other is being reduced.

Sodium and chlorine start off neutral.

Sodium loses an electron, this is oxidation and the half equation is as follows:



Chlorine gained an electron hence it is reduced. The half reaction is as follows:







## Activity 2

Identify which elements are being oxidised and reduced in the following reactions. Identify the oxidizing and reducing agents in each of the reactions.



### Remember:

As we get to the end of this sub unit, let's reflect on a few key concepts. What did we say about oxidation? Reduction is the reverse of oxidation; do you also remember how it takes place? In your reflection, can you also look at reduction as processes that make reduction happen.



## ACTIVITY: 3

1. Define oxidation and reduction in terms of electron transfer.

2. Considering the following equation



a. Write down oxidation numbers for all elements

b. Is sulphur oxidized or reduced. Explain your answer

c. Is nitrogen oxidized or reduced. Explain your answer

## 17.2 Production of iron in the blast furnace

Earlier on you learnt about oxidation and reduction with reference to gain and loss of hydrogen, oxygen and electrons. Earlier discussions in this unit also introduced you to redox reactions. Now I want us to look at the application of oxidation and reduction in the production of metals from their ores. You will be expected **to** pay special attention to raw materials used in the extraction of iron, reactions in the blast furnace as well as separation of iron and slag.

Let's see if you remember some key concepts on oxidation and reduction



## ACTIVITY 3

Do you remember this ?

1. What is oxidation
2. What is reduction
3. Write these chemical equations as word equations



### Extraction of Iron from iron ore

Many ores contain metal oxides, (metals combined with oxygen). These metals in metal oxides are extracted through reduction reactions. The ore is heated with carbon or carbon monoxide.

There are two more common Iron ores, the haematite ( $\text{Fe}_2\text{O}_3$ ) which contain Iron in only the +3 oxidation state and the magnetite which contains Iron in the two oxidation state ie +2. We are going to look at the haematite in this unit.

**Table 1 below shows raw materials, their contents as well as their functions.**

Raw material	Contents	Function
Iron ore	Iron III oxide	The ore that contains the iron for extraction
Limestone	Calcium carbonate ( $\text{CaCO}_3$ )	Helps to remove impurities from the iron forming slag
Coke(refined coal)	Carbon	Burn in air and produces a lot of heat
Air	Oxygen	Provides oxygen for the coke to burn

### Chemical reactions in the Blast Furnace

The extraction of iron occurs in the blast furnace. Iron ore, limestone and coke (refined coal) are fed into the into the blast furnace from the top. Hot air is pumped into the furnace from the bottom. Oxygen in the hot air is fed into the furnace from the bottom. It reacts with the coke to form carbon dioxide ( $\text{CO}_2$ ). This causes a rise in temperature in the blast furnace

Carbon + Oxygen  $\longrightarrow$  carbon dioxide + Heat



Carbon dioxide then reacts with more coke to produce carbon monoxide.

Carbon dioxide + Coke  $\longrightarrow$  Carbon monoxide



Note that carbon monoxide is the reducing agent that reduces iron(III) oxide to iron and carbon monoxide is oxidized to carbon dioxide. Iron is collected from the base of the furnace as molten iron while carbon dioxide is evolved as a waste.



At high temperature limestone ( $\text{CaCO}_3$ ) decomposes to form Calcium oxide ( $\text{CaO}$ ) and carbon dioxide ( $\text{CO}_2$ )



Calcium oxide reacts with silicon dioxide to form calcium silicate, ( $\text{CaSiO}_3$ ) which is the slag.



Molten Iron from the blast furnace is also called pig iron. The pig iron and the slag ( $\text{CaSiO}_3$ ) are tapped from the base of the furnace. The slag is lighter than molten iron so it floats on top of molten iron in the furnace.

Uses of products from the extraction of iron(III) oxide ( $\text{Fe}_2\text{O}_3$ )

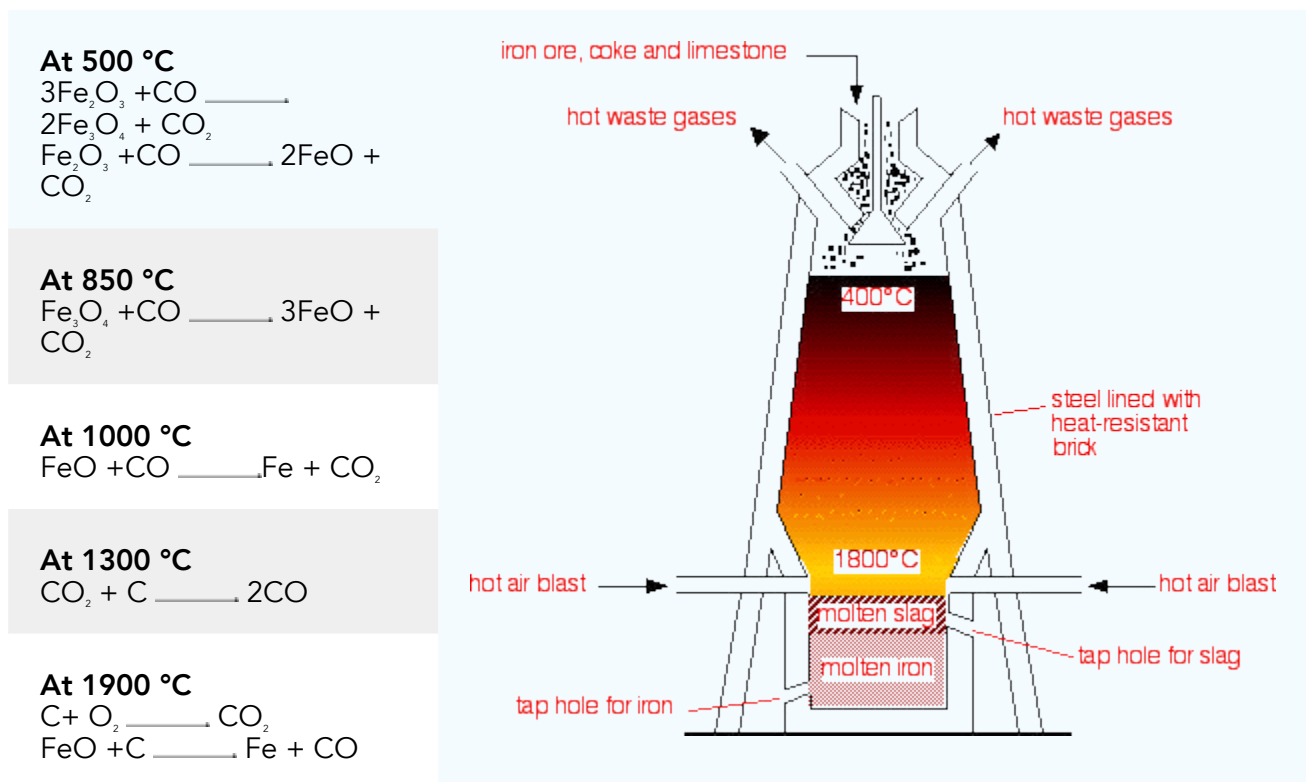
Product	Function
Pig iron	Produces alloys eg casting steel
Slag	Surfacing roads and as fertilizer

Pig iron can be made more pure by blowing hot oxygen through the molten pig iron. This process is called the oxygen lance process. The oxygen combines with sulphur, carbon, phosphorus and manganese producing sulphur dioxide, carbon dioxide, phosphorus dioxide and manganese dioxide.

## The blast furnace

A blast furnace is a large vertical furnace for smelting iron from ore using coke as fuel. It is designed to direct a continuous blast of hot air through fuel in order to obtain a high rate of combustion.

Below is a diagram of a blast furnace.



**Fig 17.1 the blast furnace**

From the diagram above you should have noted specific features of a blast furnace that allow the functionality of the furnace in achieving smelting. Take note of the following features.

- From the top is an opening from which raw material is loaded. What raw materials are loaded into the furnace?
- Close to the inlet are two outlets for the emission of waste gases
- The walls of the blast furnace are made up of steel and heat resistant bricks. Try and investigate why we need the two walls on a blast furnace also consider the next feature of the blast furnace.

There are two outlets just after the two inlets. Did you realise that two products are coming out. Pay special attention to the positions of the two outlets. Try and give reasons for the positioning of the outlets after you have gone through this sub unit.



## Activity 4

From what we have covered so far try the following questions to test yourself.

1. Draw and label the blast furnace
2. Explain the use of limestone in the blast furnace
3. Write down the word equation and chemical equation of the reduction of iron oxide into iron.

## 17.3 ALLOYS OF IRON AND THEIR COMPOSITION

### What is an alloy?

These are substances formed by smelting 2 or more elements. Take note that at least one of the elements be a metal. Notably the components of all alloys cannot be physically separated once they are formed. Alloys hence refer to a combination of a metal with one or more other metals or non metals. This combination often enhances its properties. Let's take this example of steel to help you understand this. Steel is an alloy whose major component is iron. Steel is stronger than iron. Its primary conductivity of an alloy may not differ much from those of its constituent element but its engineering properties like tensile strength and shear strength may be different. You may as well be asking yourself why we have to labour the industry with production of alloys rather than just using the primary constituents. Normally as you may find, highlighted earlier on, the properties of alloys may be different from those of the primary constituent. The chemical and physical properties become superior for an application than that of their pure element. Also take note that in alloys are more resistant to corrosion and rust. Other areas of interest in alloys include electrical and magnetic properties as well as heat resistance but still retaining the metal properties.



### Tip:


An alloy's properties are usually different from its component elements

### Examples of alloys and composition

Have you seen wires like these before? If yes, try and remember where you saw them. Also try and remember where they were used and for what purpose. Let me help you to recall some places where we can find such wires. These could be the electrical cables that transmit power from one area to another. Or have you been to a mine before? Those cables that hold cages transporting mine workers down the tunnels to reach their working areas. You may have seen them in other working areas. Now let's look at some examples of alloys that are commonly used for industrial work and for domestic purposes

The table 2 below shows alloys of Iron and their compositions, properties and uses

Name Of Alloy	Composition	Properties	Uses
Cast Iron	Fe(96-98%) C(2-4%)	Hard and brittle with a low melting point. Easy to melt and mould.	Cookery utensils and decoration
Mild steel	Fe(99,7%) C(0,3%)	Hard but not as brittle as cast iron. Easy to work on.	Car bodies, railway tracks and decoration
Medium steel	Fe (99,5%) C(0,5%)	Tougher than mild steel	Car springs and chairs
Wrought iron	Fe (99%)	Soft,	Ornate
	C(1%)	does not melt and can be worked into shapes using tools.	railings, gates, garden chairs and tables
<p data-bbox="108 1256 343 1294">Stainless steel</p> <p data-bbox="108 1379 491 1417">1-20 of 534,808 results</p>  <p data-bbox="108 1832 327 1870">360 x 360 px</p>	Fe(70%) Cr(20%) Ni(10%)	Very tough and resists corrosion	Car parts, kitchen cutlery, surgical instruments, kitchen sinks

<p>High carbon steel</p> 	<p>Fe(99%) C(1%)</p>	<p>Very brittle</p>	<p>Blades etc</p>
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In addition to the above list get to know more about alloys as you read through the following list of alloys and their descriptions. These are examples of alloys that are commonly found and used for domestic and industrial work.

- **Steel:** the name given to an alloy of iron with carbon, usually with other elements, such as nickel and cobalt. The other elements add a desired quality to the steel, such as hardness or tensile strength.
- **Stainless Steel:** another iron alloy, which typically contains chromium, nickel, and other elements to resist rust or corrosion.
- **18k Gold:** this is 75% gold. The other elements typically include copper, nickel, or zinc. This alloy retains the color and luster of pure gold, yet is harder and stronger, making it better suited for jewelry.
- **Pewter:** an alloy of tin, with other elements such as copper, lead, or antimony. The alloy is malleable, yet stronger than pure tin, plus it resists the phase change of tin that can make it crumble at low temperatures.
- **Brass:** a mixture of copper with zinc and sometimes other elements. Brass is hard and durable, making it suitable for plumbing fixtures and machined parts.
- **Sterling Silver:** is 92.5% silver with copper and other metals. Alloying silver makes it harder and more durable, although the copper tends to lead to greenish-black oxidation (tarnish).
- **Electrum:** Some alloys, like electrum, occur naturally. This alloy of silver and gold was highly prized by ancient man.
- **Meteoritic Iron:** While meteorites may consist of any number of materials, some are natural alloys of iron and nickel, with extraterrestrial origins. These alloys were used by ancient cultures to make weapons and tools.
- **Amalgams:** These are mercury alloys. The mercury makes the alloy much like a paste. Amalgams may be used in dental fillings, with the mercury intact, although another use is to spread the amalgam and then heat it to vaporize the mercury, leaving a coating of another metal.

So far so good, let's look back and see how much you have mastered about oxidation and reduction before we explore it further. Attempt this activity.



## ACTIVITY 5

1. Define oxidation and reduction in terms of electron transfer.
3. In brief explain the extraction of iron in a blast furnace. What are the inputs and outputs from the process?

### Properties of Iron

In previous sub units we have covered oxidation in terms of electron transfer, we want to explore further the concept oxidation in terms of rusting and how it can be prevented. So what is rusting?

### Rusting

When iron comes into contact with oxygen (oxidation), a chemical reaction takes place producing iron oxide ( $\text{Fe}_2\text{O}_3$ ). The common name for iron oxide ( $\text{Fe}_2\text{O}_3$ ) is *rust*.

Here are the word and chemical equations for rusting.



### Conditions for rusting (oxidation of iron)

The following conditions are necessary for oxidation to take place.

Iron (Fe)

Oxygen ( $\text{O}_2$ )

Moisture ( $\text{H}_2\text{O}$ )

### SUMMARY

Now that we have come to the end of our unit, let's look at some very important concepts that we should always remember about oxidation and reduction. Remember we started with oxidation and reduction as the gain and loss of hydrogen and electrons respectively. In the two processes we also learnt that there are reducing and oxidizing agents. Oxidising agents are substances that are capable of oxidizing other substances. Remember oxidation can be explained in terms of:

- a. Electron transfer:- where oxidation is loss of electrons and reduction is the gain of electrons
- b. Oxygen gain: - where there is gain of oxygen in a reaction.



We also looked at alloys of iron in this unit. Alloys if you remember well are a combination of two or more substances in which one has to be a metal. Use of alloys as highlighted in this unit includes their workability as well as their cost. Alloys remember retain properties of their original metals but have improved heat resistance as well as resisting corrosion.

While iron has its advantages in the form of strength, workability and availability worldwide, it has the disadvantage of rusting. We discussed methods of preventing rusting in this unit. Can you remember them? Well I hope you still remember painting, galvanizing and plating. These prevent direct conduct of iron products with oxygen and moisture hence preventing rusting.

Before you proceed to the next unit, try the following questions just to make sure you have understood all we have covered in this unit. Although you have an answer guide we suggest that you consult it after you have gone through every question below.

## 17.4 SAMPLE ASSESSMENT QUESTIONS

Now that we have come to the end of our unit, you need to check on your understanding of this unit by attempting this self assessment test. You are encouraged to try and answer all questions and refer to the answer guide after you have gone through the exercise.

1. Complete the table below showing the raw materials for extraction of iron and their functions in the blast furnace.

Raw material	Function in the blast furnace
a)	Helps remove impurities from the iron, producing slag
Iron ore	b)
Coke	c)
d)	Provides oxygen for burning coke

[4]

2. Define oxidation in terms of electron transfer.[2]

3. Identify the substance being oxidized in the following chemical equation.



4. What is a reducing agent?[1]

- a. An element that makes reduction happen
- b. An electron in the blast furnace
- c. An agent that adds oxygen in the blast furnace
- d. An element that gains an electron

5. In a half reaction [1]

- a. Two elements are reacting with each other
- b. Half an element is reacting in the process
- c. More than one elements are reacting
- d. One element is being oxidized while the other is being reduce

6. The following is true about numbers of neutral elements [1]

- a. They have oxidation numbers of +1
- b. They have an oxidation number of 0
- c. The sum of their oxidation numbers must add up to the ion's charge
- d. They are usually -2

7. What is not true about alloys in these statements? [1]

- A. They are sometimes less expensive
- B. They can be easily moulded into desired shapes and sizes
- C. While alloys include electrical and magnetic properties as well as heat resistance but they can hardly retain their metal properties
- D. Alloy constituents are usually measured by mass.

8. When iron reacts with oxygen and moisture it produces iron oxide. Write the chemical formula for the iron oxide (rust). [3]

9. Rusting can be prevented.

- a. Identify any two methods you can use to prevent rusting[2]
- b. describe the process using the two methods you gave above.[6]

10. List any two elements produced during extraction of iron in the blast furnace.[2]

11. Explain why limestone is added during extraction of iron in the blast furnace.[3]

12. Define an alloy. [2]

**Total [29]**

# ORGANIC CHEMISTRY

# UNIT 18: HYDROCARBONS

## CONTENTS

- 17.1 Naming members of the homologous series up to three carbon atoms and describing their structure.
- 17.2 Uses of methane, ethane, propane, ethene and propene.
- 17.3 Sample assessment questions

## INTRODUCTION

Before you go through this unit let us remember what we learned before. Do you still remember? Yes we learned that there are elements that form covalent bonds by sharing electrons so that they obtain a noble gas configuration structure and compounds. In this unit therefore, we will also learn about other compounds that were formed due to covalently bonding. These compounds are called hydrocarbons. These are compounds of hydrogen and carbon atoms only and they are said to be a family. In your words can you describe what a family is? Yes a family consists of members who share the same blood and often common beliefs so do likewise hydrocarbons share a general formula. Below is the list of key words that you will come across as you go through this unit. Enjoy your study.

## OBJECTIVES

By the end of this unit you should be able to:

- Name the members of the homologous series with three carbon atoms and describe their structure.
- State the uses of methane, propane, ethane and propene.

## KEY WORDS

**Alkane-** a hydrocarbon that only contains a single bond between carbon atoms.

**Alkene-** this is a hydrocarbon that contain at least one double bond between two carbon atoms.

**A homologous series-** it is a series of organic molecules in which each molecule differs from the next by the addition of the same group of atoms each time.

**Hydrocarbon-** organic compounds that contain only hydrogen and carbon atoms.



Time: 8 hours

## REMEMBER:

Organic chemistry is a branch of chemistry connected with compounds of hydrogen and carbons.

## 18.1 What do you understand by the term hydrocarbons?

As the name says these are organic compounds of hydrogen (H) and carbon (C) only for example alkanes and alkenes. They are examples of group 14 hydrides. The carbon atoms join together to form the framework of the compound and the hydrogen atoms attach to them in many different configurations. Hydrocarbons serve as fuels and lubricants as well as raw materials for the production of plastics, solvents and industrial chemicals. There are several families of hydrocarbons all members have formulae which fit a general formula. In the next sub unit you will look deeply into these families.

### Homologous series

A homologous series are families of compounds that differ only in the length of their carbon chain. These share the same chemical properties but differ in their structure due to the number of carbon atoms. These differences can have an effect on the physical properties of the chemicals such as boiling point. In general this means that the compounds are identical with the exception of the number of  $\text{CH}_2$  units in the compound. These organic compounds also have functional groups which define the basic properties of the compound. In short all of the compounds in homologous series have the same functional group with differing numbers of repeating units.

Let us now look in the family of alkanes and alkenes.

### What is an alkane?

Alkanes are hydrocarbons that have only a single C – C or C – H bond. They have a general formula  $\text{C}_n\text{H}_{2n+2}$ . As you go further you will realise that alkanes have a single carbon – carbon bonds and they are saturated. What do we mean by saturated? Alkanes are saturated because they have single bonds between C atoms. Every C atom is bounded by 4 other atoms.



## Activity 1

Draw the electronic configuration structure of carbon.

We hope you still remember that it is 2.4. This means that it has four electrons in its outer most shell and to obtain a noble gas configuration structure it needs extra 4 electrons. So in this case it shares with four hydrogen atoms in order to have a full shell and become stable. Alkanes therefore are difficult to react with other compounds unless they are changed to alkenes. The table below shows the examples of alkanes, number of their carbon atoms and the molecular formula of the alkane.

**Table 1**

Alkane	Number of carbon atoms	Molecular formula of alkane
Methane	1	CH <sub>4</sub>
Ethane	2	C <sub>2</sub> H <sub>6</sub>
Propane	3	C <sub>3</sub> H <sub>8</sub>
Butane	4	C <sub>4</sub> H <sub>10</sub>
Pentane	5	C <sub>5</sub> H <sub>12</sub>
Hexane	6	C <sub>6</sub> H <sub>14</sub>
Heptanes	7	C <sub>7</sub> H <sub>16</sub>
Octane	8	C <sub>8</sub> H <sub>18</sub>



## Activity 2

What can you deduce from the table above?

All alkanes end with a suffix (-ane). As the number of carbon atoms increase by 1 so do the number of hydrogen atoms also increase by 2 taking from the formula above, C<sub>n</sub>H<sub>2n+2</sub>.

### Remember:

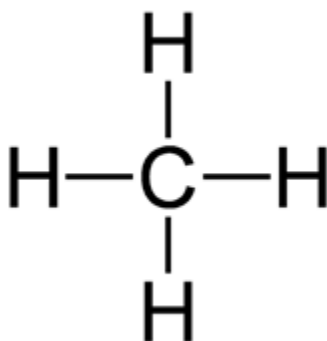
Let us remember that a family of compounds like this is called a homologous series. Each member of the series differs from the one before it by one carbon atom and two hydrogen atoms. The physical state (solid, liquid, gas) of hydrocarbons at room temperature is determined by how many carbon atoms there are in the molecule.

Also remember that all the bonds in alkanes are single bonds and they show how the atoms are arranged in the molecule. The molecular formulae in the table above show how many of each type of atom they are in each molecule of the compound.

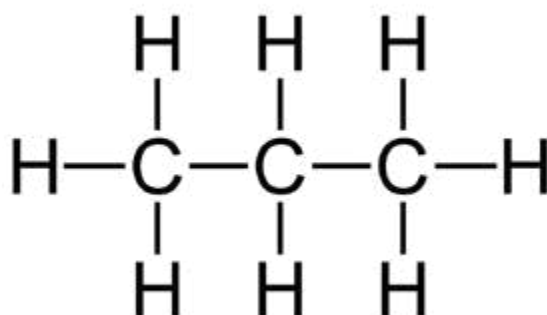
In the next sub unit you are required to draw the structural representation of the alkanes. Some examples have been done for you below.

Displayed structural representation of alkanes

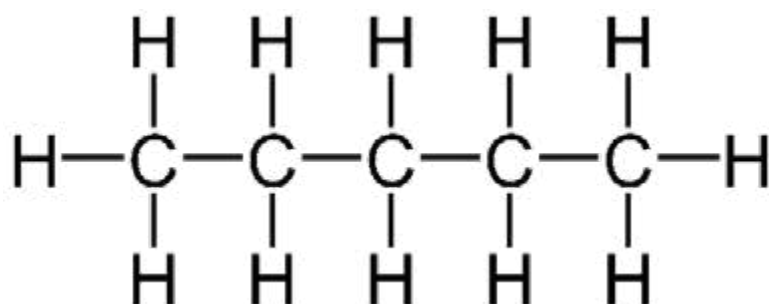
### Example 1: methane



### Example 2: propane



### Example 3: pentane



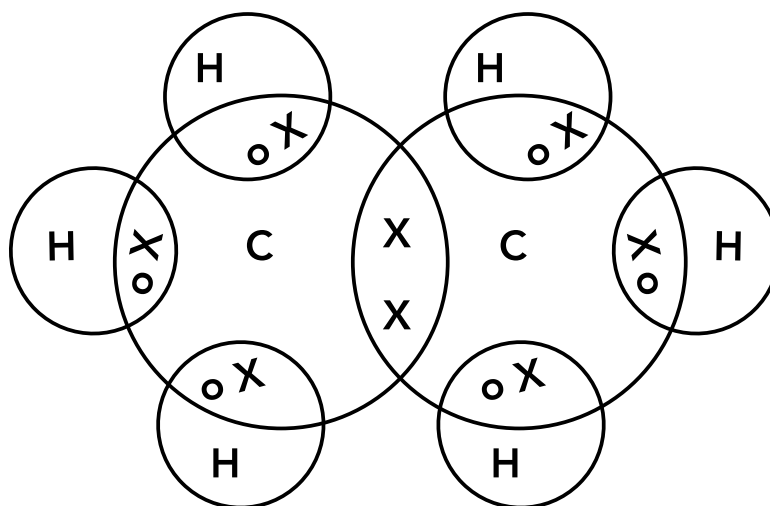
**Note:** you can also represent alkanes using dot and cross diagrams. We hope you still remember how to draw dot and cross diagrams if you have forgotten go back to previous units and read again on how to draw dot and cross diagrams.

Two examples have been done for you below.

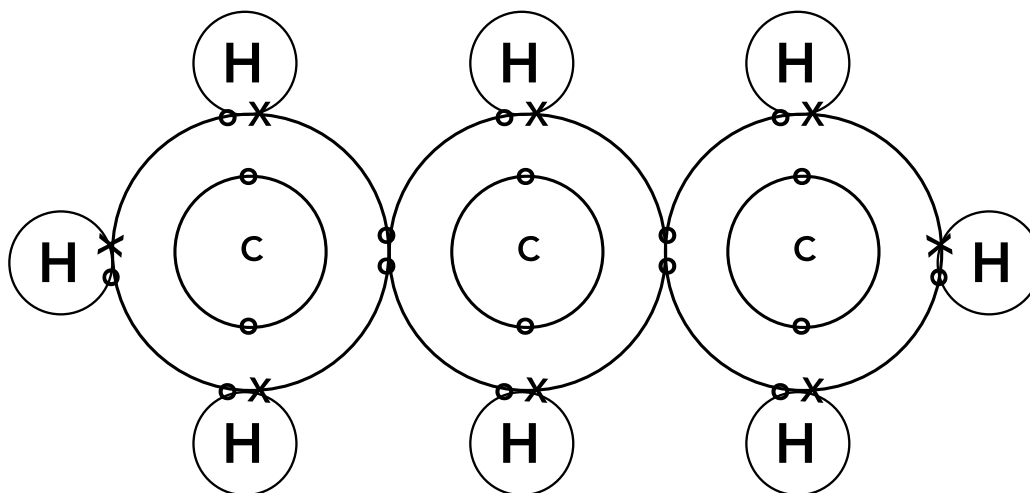
Dot and cross diagrams for alkanes.



### Example 1: ethane



### Example 2: propane



In the last sub units you have covered the definition of hydrocarbons and molecular formula of alkanes. You are also able to represent alkanes diagrammatically. Now check yourself how much you still remember.



### Activity 3

1. In your own words explain what is meant by
  - a) Hydrocarbons.
  - b) Saturated.
2. What is the general structure for alkanes?
3. Draw a table and show the number and molecular formula of the following alkanes:

- i) Ethane
  - ii) Butane
  - iii) Hexane
  - iv) Propane
  - v) Methane
4. Using the above alkanes draw their displayed structural representation and dot and cross diagrams for methane and ethane.

Now that you have covered alkanes you will now look at another member of the homologous series which is alkenes.

## Alkenes

Alkenes like alkanes are organic compounds that consist of carbon and hydrogen atoms with one or more carbon-carbon double bonds (C=C) in their chemical structure. They are also hydrocarbons because they are made of only carbon and hydrogen atoms. They have a general formula  $C_nH_{2n}$ . Unlike alkanes, alkenes are unsaturated.



### Activity 4

Why alkenes are called unsaturated hydrocarbons?

We hope you said they are unsaturated because they have double bonds between the carbons. The carbon atoms that they contain they are bonded to fewer hydrogen atoms than they can possibly hold. Simple they have spare bonds to link up with other atoms and alkenes cannot do this.

**Examples of alkenes are ethene and propene.**

**Remember:** carbon atoms have a valency of four and are able to form covalent bonds with atoms of hydrogen and other carbon atoms. These bonds are also stable and the molecules are unreactive.

The table below show examples of alkenes, number of carbon atoms and molecular formula.

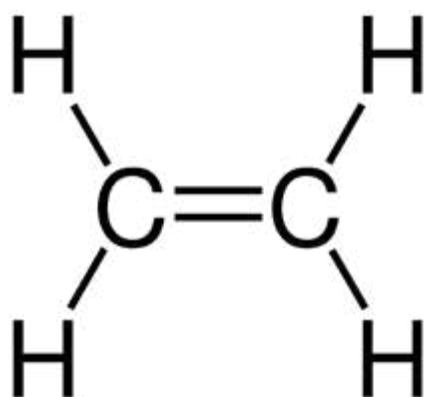
TABLE 2

Alkene	Number of carbon atoms	Molecular formula of alkene
Ethene	2	$C_2H_4$
Propene	3	$C_3H_6$

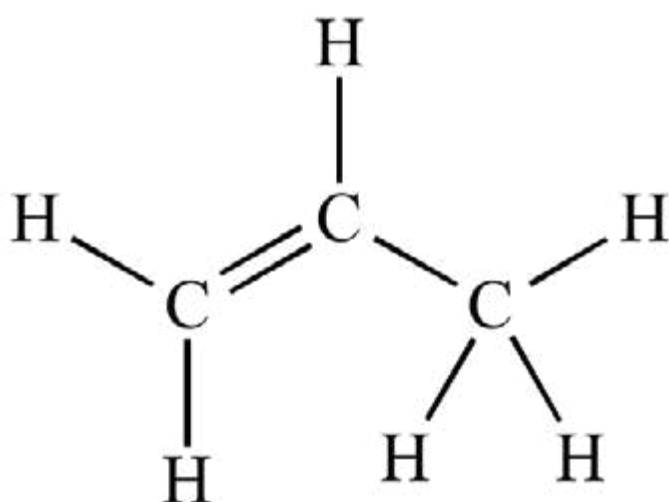
Now that you know the formula of alkenes you can now draw their structures. Remember that alkenes are unsaturated and they have double bonds. Examples have also been done for you.

Displayed structural formula for alkene

### Example 1: Ethene

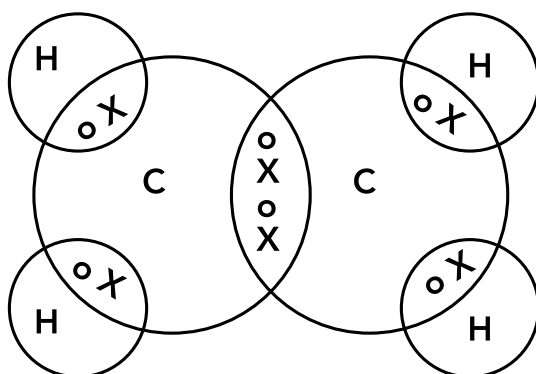


### Example 2: Propene

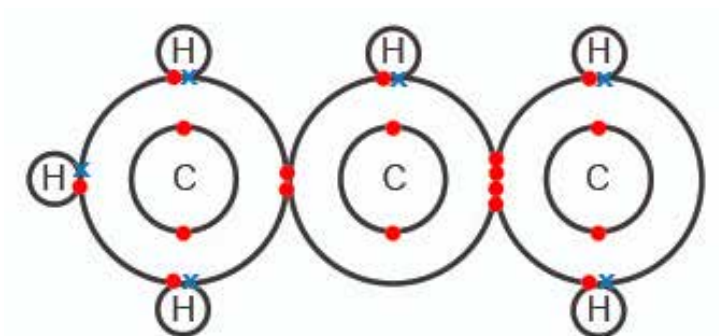


**Note:** you can also represent by using dot and cross diagrams as shown below.  
Dot and cross diagrams for alkenes.

## Ethene



## Propene



### Activity 5

Use the diagrams above for ethene and propene to explain why there is a double bond between the carbon atoms.

There is a double bond because there are few hydrogen atoms.

Let us now check how much you still remember before we go to the next sub unit.



### Activity 6

1. In your own words compare alkanes and alkenes stating their main differences and similarities. Use a table form for your comparisons.
2. Draw dot and cross diagrams for ethane and propene.

**Table 3****Remember**

Alkanes	Alkenes
General formula $C_nH_{2n+2}$	General formula $C_nH_{2n}$
Form single bonds	Form double bonds
Saturated	Unsaturated
They end with suffix -ane	They end with suffix -ene
They have carbon and hydrogen atoms only	They have carbon and hydrogen atoms only

In the next sub unit, you are required to list the uses of some of the hydrocarbons.

## 18.2 What are the uses of hydrocarbons?

The hydrocarbons are the most widely used organic compounds. They are literally the driving force of western civilisation. The greatest amounts of hydrocarbons are used as fuel for combustion particularly in heating and motor fuels. Butane is familiar to everyone in the form of the pocket cigarette lighter.

### Uses of methane

Methane is the odourless, colourless and flammable gas.

- As domestic fuel
- In gas cookers
- In gas fired power stations
- Chemical feed stock
- Manufacture of ammonia and hydrogen
- As liquefied natural gas

### Uses of propane

Propane is a flammable gas that is liquefied through pressurisation. It is the most versatile sources of energy.

- Used in heating
- Gas for cooking
- Heating water
- Transportation

## Uses of ethane

Ethane is an organic chemical compound used in the production of ethylene.

- Used for making plastic
- Detergent
- Ripening agent for fruits
- A refrigerant
- As a substance in producing welding gas

## Uses of propene

Propene is an alkene. Alkenes are well known as starting materials in the synthesis of alcohols, plastics, fuels and detergents. Propene is used for the production of chemicals such as:

- Production of propylene oxide
- Production of acrylic acid

## Remember

I hope you still remember that hydrocarbons are compounds of hydrogen and carbon atoms only. Hydrocarbons include alkanes and alkenes. Alkanes have single bonds while alkenes have double bonds. You are now able to represent alkanes and alkenes diagrammatically.

## SUMMARY

To conclude this unit let us look at some of the key points that we discussed above. You have learnt that organic chemistry involves the study of compounds that are derived from organic matter. A homologous series is a family of organic compounds that follows a particular trend in its physical and chemical properties. Alkanes have names that end in –ane and alkenes end in –ene. Alkanes have single bonds while an alkene molecule has at least one double bond.

Now that you have gone through this unit answer the questions below to check how much you still remember in this unit. To check your performances, refer to end of unit activities in section 15.

## 18. 3 Sample assessment questions

### Multiple choice

Tick the appropriate answer.

- Alkanes are said to be hydrocarbons that are saturated. Saturation means
  - They have a double bond in between C and H.
  - They have a single bond in between C and C
  - They have a triple bond in between C and H.
  - They have a single bond in between hydrogen atoms.
- What is an alkane?
  - A hydrocarbon that contains a double bond.
  - A member of the homologous series with a formula  $C_nH_{2n}$ .
  - A member of the homologous series with a formula  $C_nH_{2n+1}$ .
  - A hydrocarbon that only contains a single bond between carbon atoms.
- Ethane has the formula structure
  - $CH_2CH_2$
  - $CH_2CH_3$
  - $CH_3CH_3$
  - $CH_4$
- Which one of the following organic molecules is not a hydrocarbon?
  - $CH_3CH_3$
  - $CH_3CH_2CH_3$
  - $CH_2ClCH_3$
  - $CH_3CH_3CH_2CH_2CH_3$
- What is the main use of hydrocarbons?
  - As organic compounds.
  - As fuels.
  - As chemicals.
  - As detergents.

## Structured questions

Use the spaces provided to answer.

1a). What is a hydrocarbon. (1)

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b). Name two homologous series that are hydrocarbons? \_\_\_\_\_

(a)

c). Give the molecular and structural formulae of alkanes with the following number of carbons:

(i) 1

(ii) 3

(iii) 4

(iv) 6 (8)

3. Draw the structures of the following alkenes.

a)  $C_2H_4$  (2)

b)  $C_3H_6$

[TOTAL = 20 MARKS]



## UNIT 18 - HYDROCARBONS ANSWERS

### MULTIPLE CHOICE

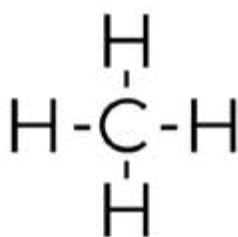
1. B
2. D
3. C
4. C
5. B

### STRUCTURED QUESTIONS

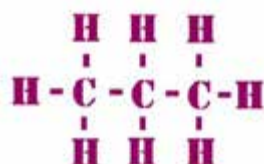
1. (a) are organic compounds of hydrogen and carbon atoms only.

(b) Alkanes, alkenes

(c) (i)  $\text{CH}_4$

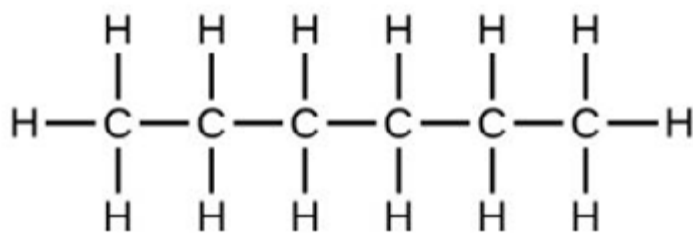


(ii)  $\text{C}_3\text{H}_8$

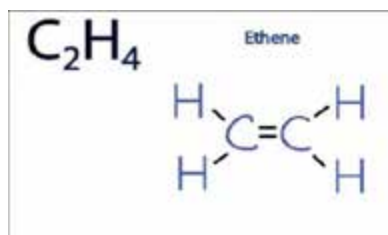


(iii)  $\text{C}_4\text{H}_{10}$

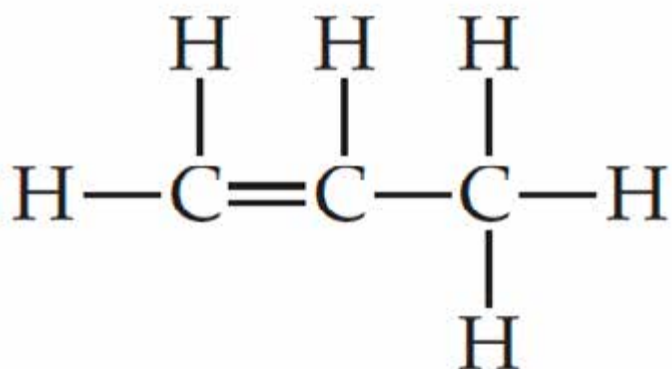
(iv)  $\text{C}_6\text{H}_{14}$



3 (a)  $C_2H_4$



(b)  $C_3H_6$



# UNIT 19 FUELS

## CONTENTS

- 19.1 Production of biogas.
- 19.2 Structure of ethanol.
- 19.3 Global warming.
- 19.4 Sample assessment questions

## INTRODUCTION

What's the big deal about fuels? What are they and why are they so important? You might be asking yourself these questions as you go through this unit. Fuels play an important part in our homes, industries and agriculture. From the last unit 18 you learnt that hydrocarbons are fuels used to make our vehicles move, to light and heat our homes. You also learnt that alkanes are commonly used as fuels; however, they are expensive to produce. In Zimbabwe a national program in support of the construction and use of biogas plants has helped to improve the lives of many Zimbabweans. Energy from biogas is used for cooking. This unit therefore, will introduce you to some more fuels such as biogas and ethanol. You will learn about the production of biogas, structure of ethanol in relation to its use and also about the causes of global warming. Below is the list of key words that you will come across as you study this unit. Enjoy your eight-hour section learning more about fuels.

## OBJECTIVES

By the end of this unit you should be able to:

- Describe the production of fuels.
- Describe the structure of ethanol.
- Define the term global warming and list causes of global warming.

 **KEY WORDS**

**Anaerobic-** a process which does not require oxygen to respire.

**Biogas** – a natural gas that is produced by the fermentation of organic matter.

**Deforestation-** the uncontrolled cutting down of trees.

**Fermentation-** it is the chemical break down of sugar due to yeast or bacteria to produce acids, gases and alcohol.

**Functional group-** it is a particular group of atoms that gives an organic molecule its properties.

**Global warming-** it is the gradual heating of the earth that is caused by increased levels of green house gases in the atmosphere.

**Green house effect-** the trapping of infrared radiation inside the earth's atmosphere due to green house gases.

**Green house gases-** an atmospheric gas that can absorb infrared radiation.

 **TIME; 8 HOURS**

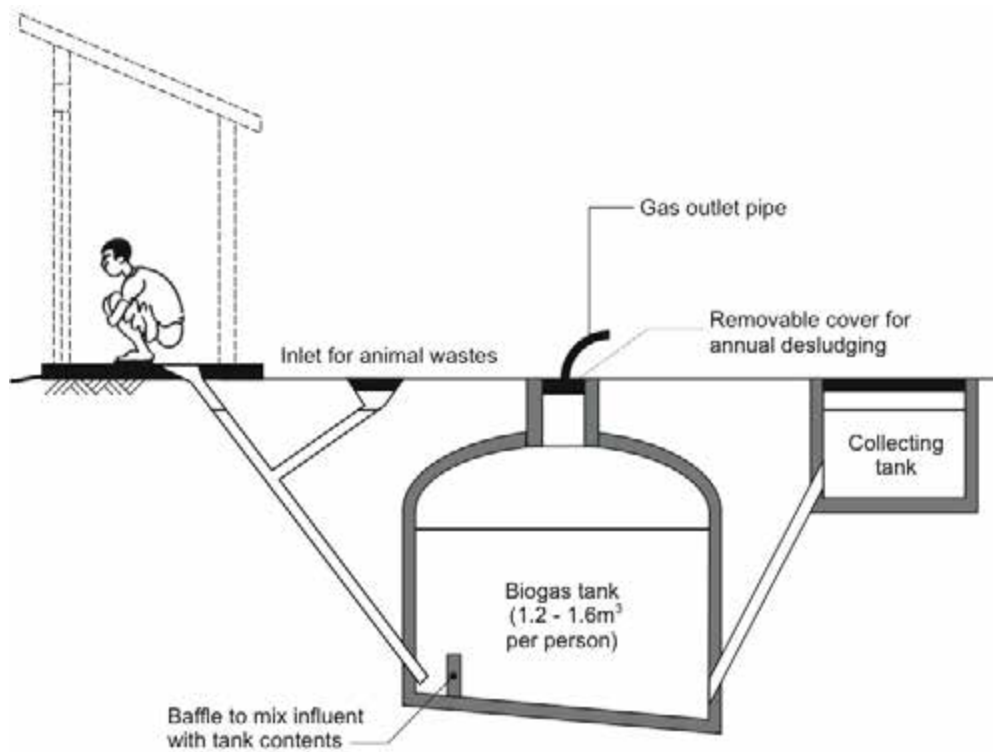
## 19.1 PRODUCTION OF BIOGAS

Biogas is a natural gas that is produced by the fermentation of organic matter. Organic matter used can be cow dung, human waste and plant matter.

### How is biogas produced?

Biogas is produced through the processing of various types of organic waste. Cow dung is collected while fresh and mixed with water to keep it in a semi-solid state which enables chemical reactions to take place. Bacteria found in the waste need warm temperatures so the bio waste is heated to around 37°C. The process takes place through anaerobic digestion in a biogas digester for about three weeks. In the biogas digester microorganisms feed on the organic matter and the biomass enters a gradual process of fermentation. As microorganisms feed on the organic matter such as proteins, carbohydrates and lipids, methane and carbon dioxide gas are produced. The biogas is collected into the spherical gas holder from the top of the biogas digester. The residual solids and liquids created in biogas production goes into a post biogas digester and from there into storage tanks.

Gas produced would be ready for several uses straight from the biogas plant gas holder. The diagram below shows a biogas digester.



**Fig 19.1 Simple biogas digester**



## Activity 2

In your own words outline the production of biogas.

### Remember:

The bacteria that digest cow dung are anaerobic bacteria and a pH of about 7 is kept. The decomposition of organic matter without oxygen is fermentation. Biogas is a mixture of methane, some carbon dioxide, hydrogen and hydrogen sulphide. The products of fermentation are biogas and sludge which is used as farm manure. Human waste, manure, plant matter can be fed into the digester.



## ACTIVITY 3

From the discussion above identify factors affecting the production of biogas.

### Factors affecting biogas production

We hope in activity 3 you mentioned type of waste, temperature, pH and time factor as factors that affect the production of biogas. Let us now look more closely on how these factors affect biogas production.

## Temperature

Some bacteria that are found in the digester prefer temperature conditions which are between 30°C and 38°C and some prefer 50°C-60°C. Those that need higher temperatures aid in the production of more gas and those that require less temperature produce less gas.

## pH

Bacteria enjoy alkaline conditions with pH between 7 and 8. Acidic conditions affect bacteria activity hence less gas is produced while alkaline conditions produce more gas.

## Type of waste

Cattle dung and pig waste produce more gas.

## Amount of oxygen

If oxygen gas is more in the digester anaerobic respiration will not take place hence no gas will be produced.

## What are the uses of biogas?

- Cooking
- Lighting
- Operating a refrigerator



## Activity 4

Conduct a research about household or community based biogas digester in your area. Find out about the materials used and how biogas is produced.

Biogas is a sustainable, renewable fuel that is easily produced from house hold agricultural waste. The primary component of biogas is methane.

Now that you have learned about the production of biogas, factors affecting biogas and the uses of biogas you can now check how much you still remember. If you find any difficulties go back to the last units and read.



## Activity 5

1. What is meant by the term biogas?
2. Explain how the following factors affect the production of biogas in a biogas digester:
  - a) pH
  - b) Type of waste
  - c) Temperature

In the next sub unit you are going to be introduced to the structure of ethanol and its uses. In the last unit 18 you learnt that a family of compounds with the same functional group is called a homologous series. Members of homologous series have same properties because they have similar bonding. In this unit you will learn more about one particular homologous series the alcohols where ethanol is derived from.



## STUDY TIPS

In order to understand this unit, go back to unit 18 and read about alkanes and alkenes.

## 19.2 ETHANOL

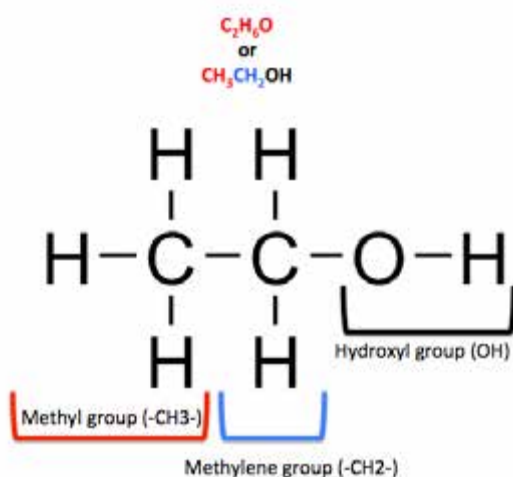
Alcohols are the family of organic compounds that contain the **-OH group**. Alcohols are members of the homologous series with the general formula  $C_nH_{2n+1}OH$ . This formula tells you that alcohols are derived from alkanes by replacing one hydrogen atom with an -OH group. They all have an -OH functional group meaning they all react the same way. All alcohols end with suffix -ol. This tells you that the OH group is attached to a carbon atom at one end of the chain. In alcohols, the OH is not a hydroxide ion but shows a covalent bond between oxygen and hydrogen. The first three members of the series are:

- Methanol,  $CH_3OH$
- Ethanol,  $C_2H_5OH$  or  $CH_3CH_2OH$
- Propanol,  $C_3H_7OH$

### The structure of ethanol

Ethanol is the alcohol that is found in alcoholic drinks and has the molecular formula

$\text{CH}_3\text{CH}_2\text{OH}$ . Below is the structure of ethanol. If you study the structure below you will see that there are 5 hydrogen atoms and 2 carbon atoms and an  $-\text{OH}$  group as shown by the molecular formula.

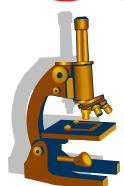


In the next sub unit you will carry out experiments on how to prepare ethanol and how to concentrate the alcohol.

## Production of ethanol by fermentation



### Activity 6



### Experiment 1

#### AIM

To prepare ethanol using fermentation

#### Apparatus/Materials

A flask, a delivery tube, distillation apparatus, a funnel, filter paper, cane sugar, yeast, ammonium phosphate, calcium hydroxide solution (lime water).

#### Method

1. Dissolve 15g of sugar in 100ml of warm water.
2. Add one spoon of yeast and a little ammonium sulphate.
3. Place the stopper tightly on the flask and leave the flask at room temperature for a few days.



4. Observe the flask occasionally and record your observations.
5. After a few days' filter off the residue and then fractional distill the filtrate.

### Observations

You will observe bubbles produced and lime water changing from clear to milky.

### Conclusion

Carbon dioxide gas is produced.

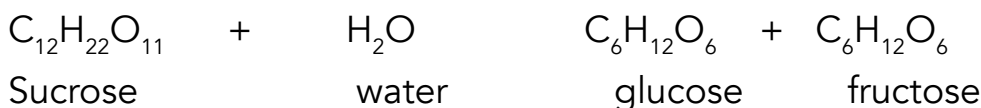
**Remember** when yeast is added on the sugar in the absence of oxygen a solution of ethanol and carbon dioxide is formed. A chemical reaction called fermentation takes place in which the glucose is broken down to ethanol by the action of enzymes in the yeast. Now check how much you can remember.



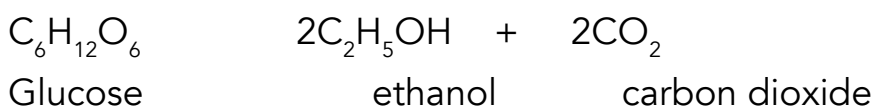
### Activity 6

1. Which gas do you think was released in the reaction? Explain your answer.
2. What is the other product that has formed?
3. Write down the word equation for the fermentation of sugar to form the two products you mentioned.

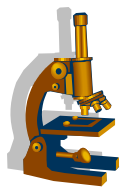
Enzymes in the yeast convert sugar into ethanol and carbon dioxide. The temperature should be kept between 25-50degrees. Above and below these temperatures make enzymes to be in active. The reaction can be summarised by the word and chemical equation below.



**Note:** glucose is then converted into ethanol and carbon dioxide.



**Note:** a fractional distillation is used to concentrate the alcohol.



## Experiment 2

### Aim

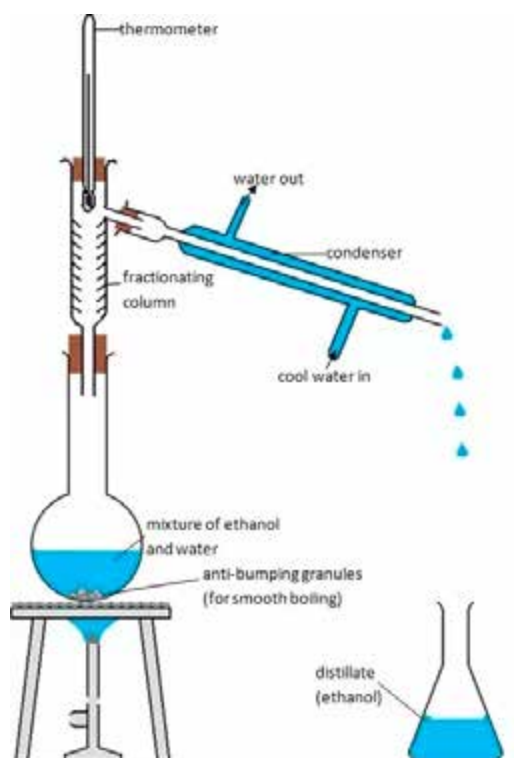
To concentrate the alcohol

### Apparatus/Materials

Thermometer, clamp stand, rubber bungs, round bottomed flask, fractionating column, condenser with rubber tubing, watch glass or tin lid.

### Method

1. Set up the apparatus as shown below.



**Fig 19.2 to concentrate alcohol**

2. Decant any solid residue from the solution.
3. Pour solutions into a large round bottomed flask fitted with a fractionating column.
4. Add a few pieces of broken porcelain into the flask and heat the contents.
5. Try to ignite a few drops of the solution on a watch glass before heating.

6. Heat the solution and collect the fractions coming off at temperatures 78, 82, 86, 90, 94 and 98degrees celcius.
7. Ignite each fraction on a watch glass or tin lid to see if it will burn.

## Observations

As the proportion of alcohol in the distillate increases it will become less difficult to ignite the fraction flame.

## Conclusion

The table below summarises the conclusions that you will draw from the experiment above.

**Table 1**

Boiling point (°C)	Percentage of ethanol (%)
78	86
82	79
86	72
90	62
94	44
98	19

The mixture of water and ethanol is separated by heating the mixture at 78°C. Only alcohol comes out of the mixture.

## Remember:

We hope you did realise that the preparation of ethanol is not new to you, you have been doing this in your home area or you have seen the elders preparing what we call the seven days brew, *ndale, ndhale*. The preparation of ethanol in the lab is not in any way different from what we do in our homes. In the next activity you are required to prepare ethanol using maize meal.

## Activity 7

Using maize meal, prepare ethanol. Take note on how you increase the temperature and how fermentation is done.

In the next sub unit you are required to list the uses of ethanol. Also take note that in Zimbabwe ethanol is produced by the fermentation of sugar at Triangle.

## Uses of ethanol

Ethanol is used:

- As a fuel (petrol) called blend
- To produce cosmetic and drugs
- To produce detergents
- To produce plastics
- To produce waxes and lubricants
- For medical purposes
- In alcoholic beverages

**Note:** did you know that methylated spirits contains 85% ethanol. Colouring has just been added to discourage people from drinking it. You might have also heard that clear beer sold in bottle stores is called spirits. Now you are done with this sub unit check how much you have understood.



## Activity 9

1. Give the general structure of alcohols stating how it differs from the structure of alkanes.
2. Draw the structural formula of alcohol.
3. Describe how sugar is used to produce alcohol.
4. List 4 uses of ethanol.

**Remember:** hope you still remember that the structure of alcohols differs from the alkanes by one carbon atom and an  $-OH$  at the end. Sugar is used in alcohol production by splitting it into two smaller sugars (glucose and fructose). Glucose is then converted into ethanol and carbon dioxide.

The next sub unit is introducing you to global warming.

## 19.3 Global warming

Global warming is the phenomenon in which heat is retained in the earth's atmosphere resulting in the atmosphere getting warmer. It is an increase in temperature of the

earth's atmosphere due to trapping of heat by green house gases. You might be asking yourself what is meant by green house gases. Green house gases are gases such as carbon dioxide which is naturally occurring or by combustion of hydrocarbons. Methane which is emitted during production of fuels or organic matter (think of the biogas digester), smoke from industrial and agricultural activities are all part of green house gases. These gases trap heat and increase the earth's temperature.

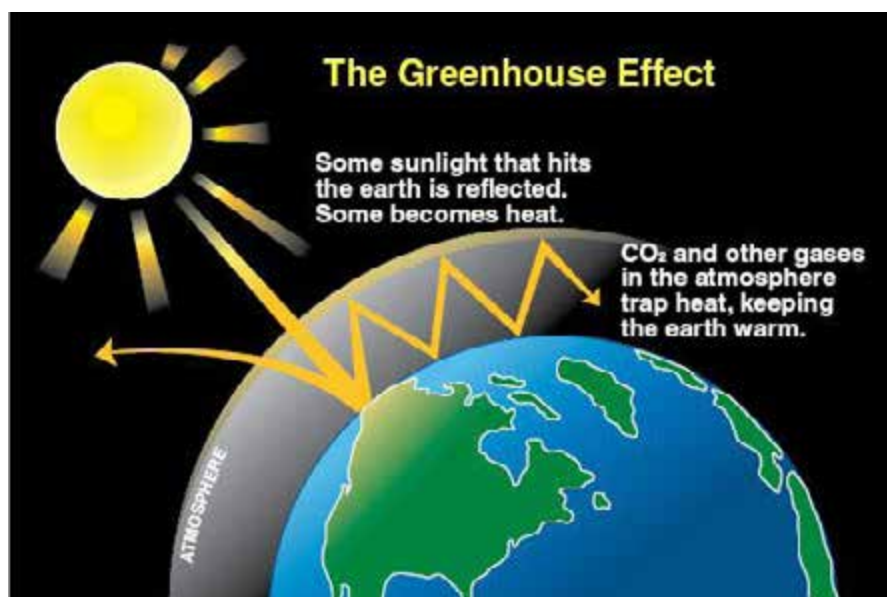
**Note:** have you ever seen a green house and do you know how it works.



## Activity 10

Find out how a green house works?

After doing your activity you will find out that the green house keeps plants warmer than they would be outside. The glass traps the heat and prevents heat from getting out. In a similar way the atmosphere helps to keep the earth warm and this is called green house effect. In the atmosphere the gases layer hold heat energy just as the glass holds heat in the green house. The diagram below shows the green house effect.



**FIG 19.3 the green house effect**

### Causes of global warming

There are many factors that contribute to global warming. These factors can be grouped into two the human activities and green house gases. Below we will discuss these in detail.

## Human activities

- **Industrial processes**

As industries increase in number the levels of air pollution also increases. Think of the Bata industry where shoes are produced. Some factories use fuels in their production systems and many of the ways in which we generate electricity contribute to large volumes of emissions every year.



**Fig 19.4** *pollution from industries*

- **Deforestation**

Deforestation refers to cutting down trees without replacing them. When trees are cut down for agricultural purposes people usually burn the area thereby releasing large volumes of carbon dioxide to the atmosphere. On the other hand the process of photosynthesis will not occur where by plants use carbon dioxide in the atmosphere and replace it with oxygen. This means more increase of carbon dioxide in the atmosphere.

- **Agricultural practices**

Cattle produce methane gas which is one of the green house gases. Use of fertilisers which are nitrogen based result in increase in nitrous oxides when fertilisers dissolve in water.

## Green house gases

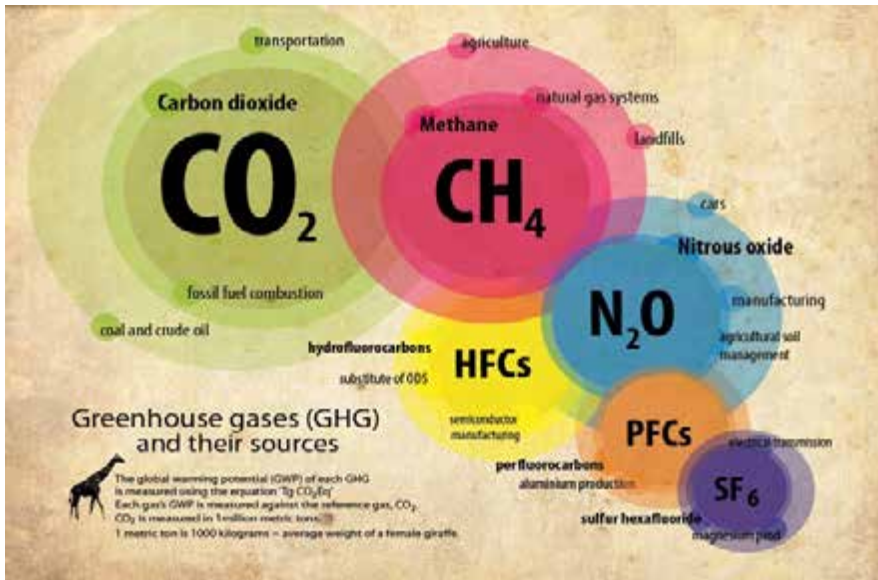


Fig 19.5 the green house gases

- **Carbon dioxide ( $\text{CO}_2$ )**

An increase in the concentration of carbon dioxide in the atmosphere causes the temperature of the earth to rise.

- **Methane ( $\text{CH}_4$ )**

Methane is emitted when fossil fuels are combusted incompletely or when organic matter decomposes. This gas causes high temperatures.

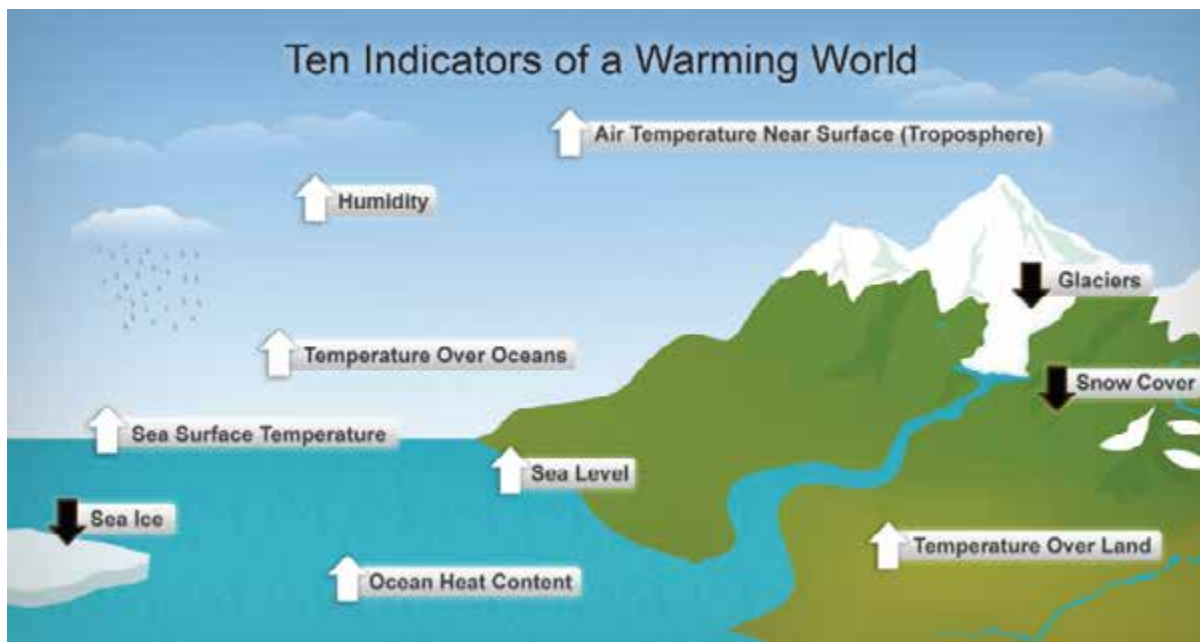
- **Nitrous oxides**

It occurs when forest is cleared by burning or when fertilisers dissolve in water. This gas also causes an increase in the earth's temperatures hence global warming.

Now that you know about global warming and what causes global warming, let us now look at effects of global warming.

## Effects of global warming

- Changing of rainfall patterns
- Increased ocean surface temperature
- Increase air temperature
- Droughts
- Land turned into deserts
- Sea level will rise (this is because water expands when heated and ice melts)
- Floods



**Fig 19.6 effects of global warming**

We believe you now have a clear picture on what global warming is, the causes of global warming and effects. Let's now answer questions below.





## Activity 12

1. What is the meaning of the following words:
  - a) Global warming
  - b) Green house effect
  - c) Green house gases
2. List three causes of global warming.
3. What are the effects of global warming?
4. How can one overcome global warming?

Global warming is the environmental topic that is becoming more and more prominent as the shift in climatic patterns is becoming apparent. Global warming is when heat is retained in the atmosphere. Greenhouse effect is when infrared radiation is trapped inside the earth's atmosphere due to the reflection of green radiant heat from the earth by the greenhouse gas layer. Greenhouse gases include methane, carbon dioxide and any other gases that trap the sun's rays. The two main causes of global warming are human activities and increase in green house gases in the atmosphere. In order to curb the green house effect people should avoid cutting down trees unnecessarily and burning trees and grass.

### SUMMARY

In this unit you have learnt that biogas is another gas which is cheaply produced and can be used in homes for cooking, lighting and heating. There are factors that might affect the biogas production such as the type of waste used, pH, and temperature. You also learned about alcohols that they contain an  $-OH$  group that is covalently bonded onto a carbon atom. The alcohol that is found in alcoholic drinks is ethanol. Sugar cane from Triangle is used to make ethanol through the process called fermentation. Maize meal can also be used instead of sugar in alcoholic fermentation. Ethanol has many uses such as a solvent, fuel, to produce cosmetics and drugs and also in alcoholic beverages. Lastly you learnt that the atmosphere helps to keep the earth warm. It keeps some of the sun's radiation energy that would otherwise escape and this is called the green house effect. Green house gases make the atmosphere warmer resulting in effects such as droughts and floods.

You have now covered three sub units in this unit, the production of biogas, structure of ethanol and global warming. Now check how much you have understood. If you get below 60% go back to the unit and read. Also use internet sources if you have access or other science books. To check your performances, refer to end of unit activities in section 16.

## 19.4 SAMPLE ASSESSMENT QUESTIONS

### Multiple choice

Tick the correct answer.

- What is biogas?
  - It is methane gas.
  - It is a renewable fuel.
  - It is a natural gas that is produced by the fermentation of organic matter.
  - It is a plant where anaerobic respiration takes place.
  
- Which of the following factors play the most important role in the production of biogas?
  - Temperature, yeast, water.
  - Yeast, pH, water.
  - Temperature, pH and type of waste.
  - Type of waste, water and yeast.
  
- Which is the correct general formula for alcohols?
  - $C_nH_{2n+1}OH$
  - $C_nH_{2n+2}$
  - $C_nH_{2n+2}OH$
  - $C_nH_{2n}$
  
- In the fermentation of sugar to produce ethanol, what is responsible for converting the sugar into ethanol and carbon dioxide?
  - Warm water
  - Enzymes
  - Glucose
  - Sucrose

5. How do veld fires contribute to global warming?
- a) By increasing the amount of carbon dioxide in the atmosphere.
  - b) By absorbing carbon dioxide in the atmosphere.
  - c) By using up oxygen in the atmosphere.
  - d) By producing a lot of smoke particles.

### Structured questions

Use the spaces provided to answer.

1. Draw a simple labelled diagram to show the main parts of a biogas digester and the functions of the parts labelled. (3)

2. Write down the structure of ethanol. (1)

Explain the role of green house gases in maintaining an atmospheric temperature that allows for life on earth. (3)

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3. Apart from water vapour and carbon dioxide, name three other green house gases. (3)

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### Practical question

1. You are provided with sugar, water and yeast. Prepare a homemade beer by dissolving sugar in hot water and adding the yeast after the mixture is warm. Leave the solution in warm place for two days, filter and bottle the solution. After two days answer the questions below.

- a) Write an equation for the reaction of yeast on the sugar. (1)

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- b) Why do bottles of homemade beer sometimes explode if kept for some time? (1)

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- c) Why is the mixture cooled before adding the yeast? (1)

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- d) How is the ethanol separated from the mixture? (2)

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**END: TOTAL = 20 MARKS**

## SUGGESTED ANSWERS

1. C
2. C
3. A
4. B
5. A

## STRUCTURED QUESTIONS

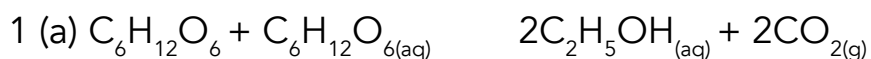
3. \*Labelled diagram of a biodigester\*

4.  $C_2H_5OH$

5. – to hold heat energy  
– to keep earth warm  
- Traps heat energy

4. Methane ( $CH_4$ )  
Nitrous oxide ( $N_2O$ )  
Perfluorocarbons ( $PFC_5$ )  
Sulphur hexafluoride ( $SF_6$ )

## PRACTICAL QUESTION



(b) carbon dioxide gas is produced and it expands hence exploding the bottles

(c) mixture is cooled because higher temperatures destroy the yeast

(d) by fractional distillation





