PROTOTYPE

NCDC
NATIONAL CURRICULUM
DEVELOPMENT CENTRE

CHEMISTRY TEXTBOOK

SENIOR ONE

LOWER SECONDARY
CURRICULUM

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Contents

Preface

This Teacher's Guide has been designed to enable the teacher to interpret the revised curriculum and use the accompanying learner textbook effectively. The Teacher's Guide provides guidance on what is required before, during and after the teaching and learning experiences.

To ease the work of the teacher, all the activities and instructions in the Learner's Book have been incorporated in this Guide but with additional information and possible responses to the activities. The guide has been designed bearing in mind the major aim of the revised curriculum which is to build in the learners the key competences that are required in the 21st century while promoting values and attitudes and effective learning and acquisition of skills, to prepare the learner for higher education and eventually the world of work.

This learner textbook has been written in line with the Revised Lower Secondary School Curriculum. The book has incorporated knowledge, skills partly required to produce a learner who has the competences that are required in the 21st century; promoting values and attitudes; effective learning and acquisition of skills in order to reduce unemployment among school graduates.

Hon. Janet K. Museveni
First Lady and Minister for Education and Sports

Acknowledgements

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Our gratitude goes to the various institutions which provided staff who worked as a panel, the Subject Specialist who initiated the work and the Production Unit at NCDC which ensured that the work produced meets the required standards. Our thanks go to ***Enabel*** which provided technical support in textbook development.

The Centre is indebted to the learners and teachers who worked with the NCDC Specialist and consultants from Cambridge Education and Curriculum Foundation.

Last but not least, NCDC would like to acknowledge all those behind the scenes who formed part of the team that worked hard to finalise the work on this Teacher's Guide.

NCDC takes responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for effectively addressing the inadequacies. Such comments and suggestions may be communicated to NCDC through P. O. Box 7002 Kampala or email: admin@ncdc.go.ug.

Grace K. Baguma
Director National Curriculum Development Centre

CHAPTER 1

Chemistry and Society

Key Words	By the end of this chapter, you will learn to:
▪ Chemistry ▪ Careers ▪ Science ▪ Technology ▪ Society	*explain the discrete nature of Chemistry.* *explain why we study Chemistry and its relationship with other subjects.* *explain the importance of Chemistry in everyday life and identify the careers linked to the study of Chemistry.* *outline the contribution of Chemistry to the economy of Ugandan.*

COMPETENCY: By the end of this topic, you will be able to assess the application of Chemistry in our everyday life, and its contribution to our economy.

Introduction

Chemistry is a laboratory science. Its subject materials and theories are based on experimental observation. However, its scope reaches out beyond the laboratory into every aspect of our lives – to our understanding of the nature of our planet, the environment we live in, the resources available to us and the factors that affect our health.

Therefore, in this topic, you will be able to find out about the application of chemistry in our everyday life and its contribution to our economy.

1.1: What is the Nature of Chemistry?

You have previously learnt that science is a study of living and nonliving things. All living and nonliving things occupy space and are known as matter. We now look at science as made of separate branches namely: chemistry, biology and physics. Each of the branches of science deals with matter in a different way. Physics deals with the relationship between energy and matter, biology deals with living things. In the following activity, you will find out what chemistry deals with.

Activity 1.1: Find substances in our everyday life that relate to Chemistry.

1. In groups of 5-6, discuss what common things in everyday life you think are made up of chemicals.
2. In your groups, produce a mind-map to show your conclusions.
3. Present your responses in a plenary.

From your discussions, you will find out that chemistry is all around us. Common chemicals in pharmaceuticals and cosmetics, plastics, food and beverages, soaps and detergents, water treatment, and indigenous chemistry in your local environments are related to chemistry.

Activity 1.2: Find products in our everyday life that are made with the knowledge of Chemistry.

Critically observe the pictures below and answer the following questions.

Fig 1

The above picture shows some common products used in our everyday life. The products are obtained using the knowledge of Chemistry.

1. Give the uses of the products in the picture above.
2. Name other products produced using the knowledge of Chemistry.
3. What careers require the study and knowledge of Chemistry?

The Meaning of Chemistry

Chemistry deals with the study of materials. In the following activity we shall explore the meaning of chemistry further.

ACTIVITY 1.2: Find out what changes take place to substances in everyday

1. Burn a piece of paper using a candle or a lighted match. What changes take place to the paper during the burning?
2. Now consider the following processes which take place in everyday life:
    i) The rusting of a kitchen knife
    ii) The boiling of water
    iii) The rotting of fruits

    Describe the changes that take place in each of the processes (i – iii) above.

    What are the necessary conditions for each of the above changes to take place?
3. Name any other processes in which materials change from one form to another?

The changes you have observed and many others show what the study of chemistry is about.

Hence chemistry is the study of matter and the changes that occur to substances under different conditions.

1.2 Why we Study Chemistry and How it overlaps with other Subjects

	ACTIVITY 1.3: Discuss the reasons why we study or we should study

In this activity, you will discuss in groups the reasons why we study Chemistry and how it overlaps with other subjects.

1 In groups of 5-7, brainstorm on the reasons why we should study Chemistry.

2 In your same groups, discuss the relationship between Chemistry and other subjects such as biology, physics, agriculture, geography and mathematics.

3 Prepare your reports and present your responses in a plenary.

1.3 The Importance of Chemistry its Relationship to Relevant Careers

Everything is made of chemicals. Many of the changes you observe in the world around you are caused by chemical reactions. Chemistry is very important because it helps you to know the composition, structure and changes of matter. All matter is made up of chemistry. In your everyday life, you use various forms of chemicals. You even use some of them as food.

What are some examples of Chemistry in Daily Life?

You encounter chemistry every day, yet you might have trouble recognising it, especially if you are asked as part of an assignment!

What are some examples of chemistry in daily life? In the following activity, you will find out things that concern chemistry in everyday life.

Activity 1.3: Find the examples of Chemistry in everyday life.

In groups, using the explanation of what chemistry is, brainstorm on the different examples of Chemistry in our daily life.

Hint: Consider areas such as human and animal medicine, pharmacy, chemical engineering, teaching, etc. and produce a table to present your ideas.

Example	Nature of Action
1. Digestion	Digestion relies on chemical reactions between food and acids and enzymes to break down molecules into nutrients the body can absorb and use.
2.	
3.	
4.	
5.	

Examples of Chemistry in the Real World

There are many examples of Chemistry in daily life, showing how prevalent and important it is.

i) Digestion relies on chemical reactions between food and acids and enzymes to break down molecules into nutrients the body can absorb and use.

ii) Soaps and detergents act as emulsifiers to surround dirt and grime so it can be washed away from clothing, dishes, and our bodies.

iii) Drugs work because of chemistry. The chemical compounds may fit into the binding site for natural chemicals in our body (e.g., block pain receptors) or may attack chemicals found in pathogens, but not human cells (e.g., antibiotics).

iv) Cooking is a chemical change that alters food to make it more palatable, kill dangerous micro organisms, and make it more digestible. The heat for cooking may denature proteins; promote chemical reactions between ingredients, sugars, etc.

1.4: Contribution of Chemistry to the Economy of Ugandan

Activity 1.4:

Research on the contribution of Chemistry to the economy of Uganda

1. In groups of 5-7, research on how Chemistry contributes to the economy of Uganda.
2. Base your research in the fields of medicines, industries, transport and agriculture.

3. Write a short report identifying the areas in chemistry which contribute to the economy of Uganda.

Industry is very limited in Uganda. The most important sectors are the processing of **agricultural** products (such as coffee curing), the manufacture of light consumer goods and textiles, and the production of beverages, electricity, and cement.

Chemistry plays a vital role in feeding the world population. There are a number of chemicals which help in increasing food production to keep pace with the growing population of the world. These chemicals have both negative and positive impacts.

Activity of Integration

As a young Chemistry student, organise a half-day workshop for people in your community to sensitise them on the application of Chemistry in their everyday life, and the economic contribution of Chemistry to the country.

Fig. 2

Fig. 3

Task:

1. Develop short messages which you will deliver to the people in this community about application of Chemistry in everyday life.
2. Develop some messages to illustrate the contribution of Chemistry to the economy of the society.
3. How would you ensure the members of the community appreciate the use of Chemistry in everyday life?

Hint: Use the resources in Fig. 2 and 3 to develop your message.

Summary

You should know that:

- Chemistry is a laboratory science. Its subject materials and theories are based on experimental observation.
- common chemicals in pharmaceutics and cosmetics, plastics, food and beverages, soaps and detergents, water treatment, and indigenous Chemistry in your local environments are related to Chemistry.
- Chemistry is the study of the matter and the changes that occur to substances under different conditions.
    - the importance of chemistry in everyday life and the careers linked to the study of chemistry.
- Chemistry plays a vital role in feeding the growing world population and contributes greatly to the Ugandan economy.

End of Chapter Questions

1. Why is Chemistry laboratory science?
2. Physics deals with the relationship between energy and matter, biology deals with living things. What does Chemistry deal with?
3. The following are changes that take place in everyday life:
    i) The rusting of a kitchen knife
    ii) The boiling of water
    Describe the changes that take place in each of the processes i) and ii) above.
4. Why is Chemistry important in our everyday life?
5. Identify the areas in Chemistry which contribute to the economy of Uganda.

CHAPTER 2

Experimental Chemistry

Matter

Key Words	By the end of this chapter, you will learn to:
Laboratory Apparatus Experiment Purity Scientific method	▪ *explain the importance of the laboratory rules and regulations.* ▪ *demonstrate appropriate choice and use of equipment/apparatus for different experiments.* ▪ *explain the scientific procedure/method of carrying out investigations and its importance.* ▪ *describe how a mixture can be purified, given the composition of its components.* ▪ *apply the knowledge of melting point and boiling point in identifying purity of a substance compressing.*

Introducing Chemistry

In the preceding chapter, you learnt about what Chemistry is, its importance to you as an individual and to the world. The study of Chemistry involves the process of finding facts or investigating evidence of facts about the knowledge of Chemistry. This is done through systematic steps of collecting information or facts in order to find out the truth about a given or required knowledge in chemistry. The steps used to collect information or facts are known as the scientific method.

The scientific method requires the use of appropriate tools to gather or collect particular information. These tools are collectively known as apparatus. There are several different forms of apparatus depending on the kind of information required and the degree of accuracy.

In this section, you will explore the importance of the scientific method and use of some of the apparatus. You will also learn how to apply the scientific method and make suitable choices of apparatus for different experiments.

For the sake of simplicity at this level, the examples of experiments have mainly been limited to methods, separation of mixtures and testing purity. You will, however, study the topic on mixtures and pure substances in greater detail later in chapter 6.

2.1: Laboratory Rules & Regulations and Scientific Methods

In this activity, you will learn about the scientific methods used in the study of chemistry and the rules and regulations that help to guide activities in the laboratory.

Activity 2.1: Prepare a Fruit Juice

In groups of five, prepare a glass of juice using a fruit named by your teacher.

1. State the aim of the activity.
2. List the materials required for the activity.
3. Identify the steps followed in making the juice.
4. Describe the process involved in making of the juice.
5. What safety measures were required to prepare safe juice?

> ***Project Work***
>
> *Identify a suitable activity of interest where the scientific process will be applied or used*

What you have just carried out is called the scientific method. It involves:

1. Observing a particular behaviour.
2. Making immediate conclusions about the behavior.
3. Identifying a problem to be acted upon.
4. Making a hypothesis.
5. Determining and controlling variables.
6. Planning method of the investigations.
7. Analysing and interpreting data.
8. Making conclusions.
9. Writing a report.

2.2: Laboratory and Laboratory Rules/Regulations

Referring to activity above, which place would be the most suitable for preparing the fruit juice and why?

You will discover that different experiments require different special places for carrying them out. These places are called ***laboratories***. In many instances, a special room is required although some experiments may be done outside the room.

What special safety measures were required in the preparation of juice?

	Activity 2.2: Read the passage above about rules in the laboratory.

Read the passage below:

Mukisa, *an S1 student was required to prepare a salt solution in the laboratory. He wrapped his sweater around his waist, picked on his books and ran to the laboratory. On entering, he knocked a table with glassware spilling a colorless liquid. His books fell down into the pool of the colourless liquid while the glass fell on the floor and broke. Mukisa tried to collect the broken pieces of glass. The pieces cut his fingers while the books were burnt by the liquid. In pain he rushed to wash his fingers using water and in the process the sweater around his waist pulled down a beaker of hot water from another table that poured on his leg. Mukisa was rushed to the clinic and never carried out his experiment.*

1. From the above passage, what errors were committed by Mukisa?
2. How could Mukisa have avoided the accident?

3. Using the above story, what rules should be enforced to ensure safety in the laboratory?

Further reading about safety in laboratory

2.3: Laboratory Apparatus

Every work place has its own tools or equipment for example equipment used in the kitchen is called kitchenware. In the same way, hoes, pangas, rakes, slashers are known as garden tools. Equipment used in the laboratory for different experiments are called **apparatus.** In the following activity, you will choose and try to use some of the laboratory apparatus**.**

Activity 2.3: Identify and use of common laboratory apparatus.

Some apparatus used in the Chemistry laboratory are shown below.
With the help of your teacher,

1. Observe those that are present in your laboratory.

2. Suggest the name and of use of each apparatus.

Fig. 2.1

	Activity 2.4: Compare the accuracy of different volume measuring apparatus.

What you need

1. Graduated beaker (250cm^3)
2. Measuring cylinder (100cm^3)
3. Burette
4. Water
5. Retort stand

What to do

1. Clamp the empty burette into a retort stand
2. Measure 50cm^3 of water using a measuring cylinder provided

Transfer the water into an empty burette and note the volume.

3. Repeat the same procedure using a beaker and record the new volume reading on the burette.

Results and Discussion

1. Which of the volumes measured using the two instruments is closest to the volume on the burette scale?
2. Which of the two apparatus is more accurate?

2.4: Scientific Procedure and Experiment

Chemistry is a practical subject. To get knowledge, chemists carryout experiments during which they make careful observations and measurements. In order to do this, they use a variety of measuring instruments and containers which are collectively called **apparatus.**

The success of an experiment is often dependent on the accuracy with which the measurements are taken. The measuring devices which are used in everyday life, like the locally made weighing balance in some butcheries and measuring jug, are not sufficiently accurate for the needs of a chemist.	

Volume

The volume of a substance is the amount of space that it occupies. The units of volume are the cubic meter or decimetre (dm-^{3}), for large volumes and the cubic centimetre (cm^{3}) for smaller volumes. For very large volumes, the cubic metre (m^{3}) may also be used.

1 m^{3} = 1000 dm^{3} 1 dm^{3} = 1000 cm^{3}

The use of units in litre (L) and millilitre (ml) for volumes are sometimes not commonly used in many measurements of simple laboratory experiments. Instead, their equivalent in cubic decimetre (dm^{-3}) and cubic centimetre (cm^{-3}) respectively are more frequently used in laboratory practice.

All these units are useful and can appear in any scientific texts. They are also commonly used in everyday life.

You therefore must endeavour to understand their inter conversion or relationship.

1L = 1dm^{-3}, 1ml = 1cm $^{-3}$,
1 dm^{-3} = 1000 cm^{-3}

1 L = 1 dm^{3} 1 ml = 1 cm^{3}

measuring cylinder beaker

syringe conical flask

Fig. 2.2 Apparatus that shows approximate volume

The apparatus used in Ugandan laboratories often show volume in l or ml. These values must be converted into dm^{3} and cm^{3} as appropriate for use in calculations. Chemical apparatus for measuring volume can conveniently be divided into two groups.

The apparatus which shows approximate volume (Fig. 2.2) and apparatus which show accurate volumes (Fig 2.3).

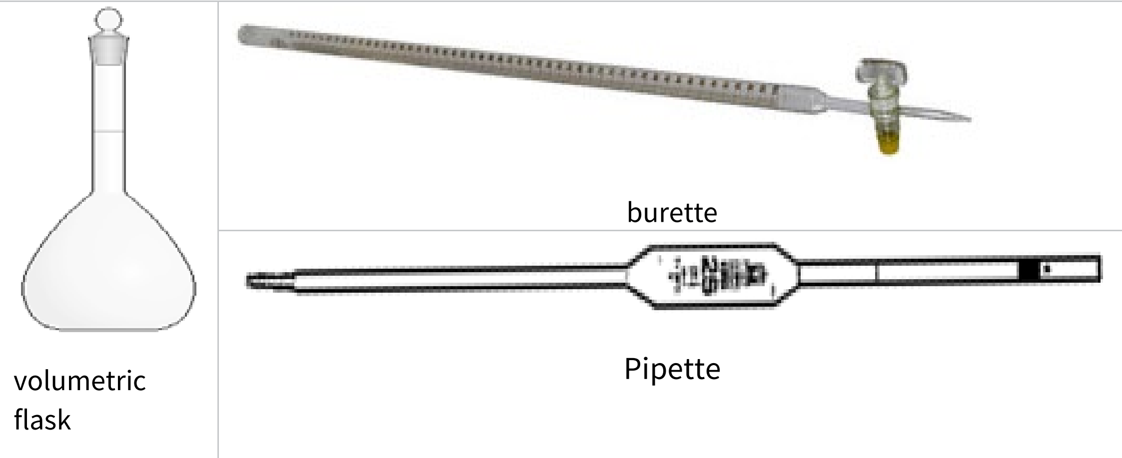


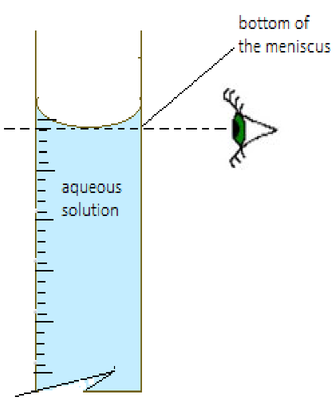
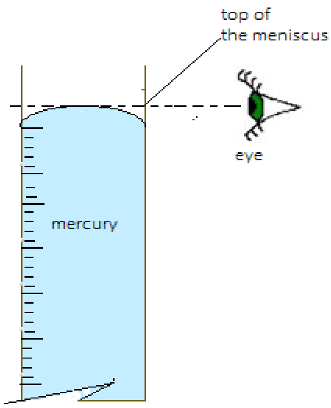
Fig. 2.3 apparatus that shows accurate volume

Apparatus like the beaker provide only a rough guide to the volume of the liquid it contains, but the accuracy is not sufficient to be used in calculations. Apparatus like the burette can be read to a high degree of accuracy. Table 1.1 shows the degree of accuracy to which some of this apparatus can be read. Readings from such apparatus can be used in calculations.

Apparatus	Degree of accuracy
burette	to the nearest 0.05 cm^3
pipette	marked value $\pm$ 0.05 cm^3
volumetric flask	marked value $\pm$0.01 cm^3

Table 1.1. Accuracy of some apparatus used to measure volume

Care must be taken when measuring the level of a liquid in a tube.

		When the liquid is an aqueous solution, the volume is read from the bottom of the meniscus. If the liquid is mercury, the volume is read from the top of the meniscus. For coloured liquids which are opaque i.e. the bottom of the meniscus cannot be seen, the upper level is read

The volume of the gas produced during a chemical reaction can be conveniently and accurately measured using a gas syringe.

An alternative but less accurate method is to collect the gas in an inverted burette filled with water (Fig. 1.). This method is limited to gases which are effectively insoluble in water. For those gases which are soluble in water, mercury can be used in place of water.

The volume of the gas produced during a chemical reaction can be conveniently and accurately measured using a gas syringe.

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Activity of Integration

As a student who now understands what Chemistry is and how it is studied,

1. Prepare a brief message to deliver to new students on:
   i) the importance of the laboratory in the study of chemistry.
   ii) why you should not enter the laboratory and carry your own experiments without instruction from a teacher or laboratory worker.
   iii) why it is important to consider safety precautions while in the laboratory. Discuss how you can ensure safety in the laboratory.
   iv) the essential steps that you would follow to carry out an experiment in a chemistry laboratory.
2. Make a list of four different apparatus that can be used to measure volume of a liquid in the laboratory and discuss the conditions under which each of them would be most appropriate to choose for measurement of volume.

Assessment Exercise

Using a 100 ml measuring cylinder, 100 ml beaker and a 50 ml burette, design a scientific method to carry out an experiment to find out which one of the three apparatus is;

a) most accurate in measuring volume.

b) least accurate in measuring volume.

Summary

You should know that:

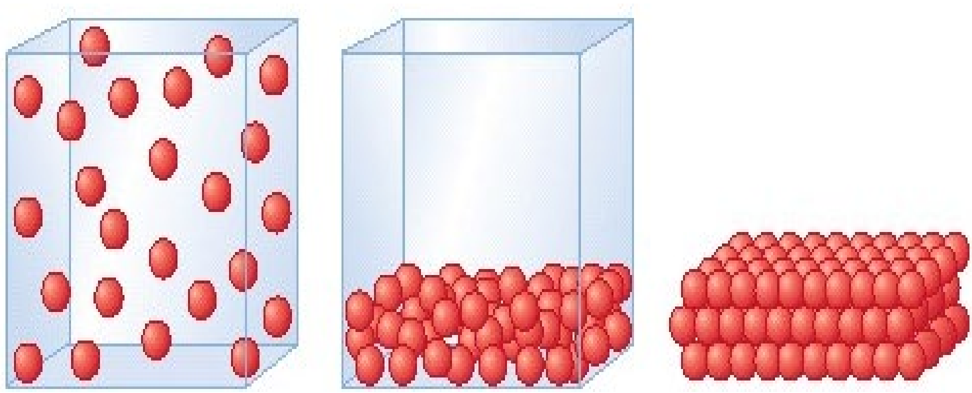
- finding facts or investigating evidence of facts about the knowledge of chemistry is done through systematic steps.
- through the different steps, data/information is collected in order to find out the truth about a given or required knowledge in chemistry and the systematic steps used in collecting information or facts is known as the scientific method.
- the special places for conducting experiments is called a laboratory.
- the laboratory regulations for your safety and the safety of others in the class.
- equipment used in the laboratory for different experiments are called **apparatus.**
- scientific procedures require one to make careful observations and measurements.

End of Chapter Questions

1. Why is Chemistry a laboratory science?
2. Physics deals with the relationship between energy and matter, biology deals with living things. What does chemistry deal with?

CHAPTER 3

States and Changes of States of Matter



Key words	By the end of this chapter, you will learn to:
◆ **Matter** ◆ **States of matter** ◆ **Particle theory** ◆ **Diffusion** ◆ **Kinetic theory**	▪ explain what matter is. ▪ recognise that different states of matter have different properties. ▪ use the kinetic theory of matter to explain particle arrangement, inter particle forces, movement of particles and the properties of solids, liquids and gases. ▪ explain the changes in states of matter when heat is gained or lost. ▪ appreciate the cooling effect of evaporation and how it contributes to maintaining constant body temperature.

Introduction

Our natural surrounding is made up of very many different objects that occur in different forms. You can detect or feel the presence of these objects or anything around you, when you see, hear, smell, touch or taste them. For example, when you are at the lake or river shores or the beach, you see many grains of sand, plants, water and anything else.

Fig 3.1: Heaps of sand at the lake shores

What do you think is the scientific term/name given to the grains of sand and anything else around you?

In this chapter, you will find out about the scientific terms used to describe the general composition of objects or materials around you, the forms in which they occur and the properties of each of these forms.

3.1: What is Matter?

Everything you see, hear, smell, touch, and taste is matter. Matter is anything that has mass and takes up space. Matter exists in many shapes, colours, textures, and forms. Water, rocks, living things, and stars are all made of matter.

By studying matter, we learn to understand how and why some things work. After that, we can manage and control those things to make new things that improve our lives. The study of matter is important because it guides us in classifying substances.

To understand matter, you need to take a closer look at it. As you observe or examine matter more closely, more of its parts are revealed. Now that the term 'matter' has been introduced, we can use it to say there are three states of matter; solids, liquids and gases.

Assignment 3.1

Look at the picture. Make a table with three columns labeled 'solid', 'liquid' and 'gas'. Write all the solid things you can see in the picture in the column labeled 'solids'. Do the same with the other two columns named `liquids' and `gasses'. Get physical substances you have listed as solids or liquids from your class or outside class and observe them critically.

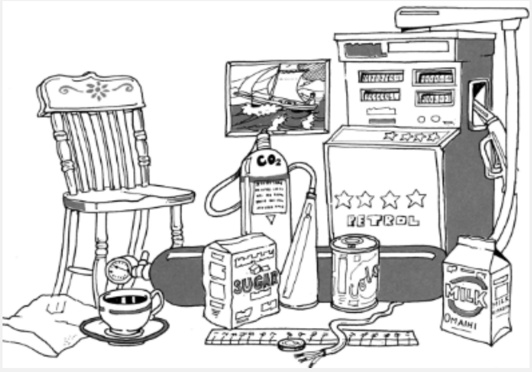


Fig. 3.2: Group of assorted items

3.2: What are the Properties of Different States of Matter?

To understand the properties of matter, you need to look at the composition or particle nature of matter. Describing the composition of matter is not easy since the actual composition can only be inferred rather than observed. Suppose you take a piece of charcoal and break it up into tiny pieces and then break these tiny pieces into dust. It is still charcoal. Then take the dust and further divide it until it is no longer visible. These invisible particles are still charcoal.

As early as 400 B.C., the Greek philosopher Democritus thought that matter could be broken down until it can no longer be subdivided. He called these invisible particles **atoms** (from the Greek word meaning not divisible).

By observing how particles behave in water and smoke, scientists developed a model (**the particle theory of matter**) to identify the composition of matter.

The Particle Theory of Matter

1. All matter is made up of extremely tiny particles. There are spaces between the particles.
2. Each pure substance has its own kind of particles, different from the particles of other pure substances.
3. Particles attract each other.
4. Particles are always moving.
5. Particles at a higher temperature move faster on average than particles at a lower temperature.

There are things we experience in our daily life situations which can also explain that solids, liquids and gases are made of small particles which we cannot see with our naked eyes. For example, when your clothes are drying or when sugar mixes (dissolves) in water, we cannot see what is happening. Scientists use the idea of **particles** to explain what is happening. The particles are so small that we cannot see them.

What do you think happens to the water particles when clothes dry and to the sugar particles when they dissolve in the water?

The water particles on your clothes escape into the air.

Thr particles that the sugar crystals are made of move away from the sugar crystals into the water.

Fig. 3.3: A vehicle raising a lot of dust on marram road

If rock breaks, it can form a fine powder which we call dust. When you travel on a dusty road, you may have noticed that very fine dust stays in the air for a long time and can also easily get inside the vehicle. You can even see very fine dust with your naked eye. But each grain of dust is made up of even smaller particles which you cannot see. It takes millions of small particles to make the grain of dust which you can see.

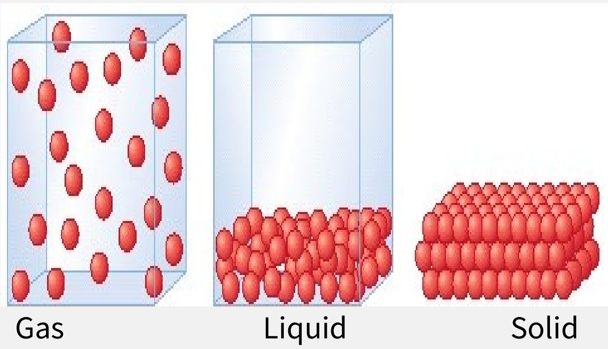
Think about Air

We cannot see air particles because they are very much smaller than grains of dust.
We know that they exist because we breathe in air particles. We also feel the wind when many air particles are moving and hitting us.

Investigating Properties of Solids, Liquids and Gas

The properties of substances depend on how the particles in these substances are arranged, and how they are held together. To investigate the properties of solids, liquids and gases including shape, pouring and compressing, it is important to study the arrangement, the forces between the particles and movement of the particles.

Forces between Particles



It is easier to run fast on land than it is to swim fast. Why is this? Particles are held together by forces. The forces holding water particles together are much greater than the forces which hold air particles together.

Therefore, when you swim you have to use more force to break the water particles apart. The diagram on the left shows how particles are held together in solids, liquids and gases.

Particles in Solids

The particles in solids are very close to one another and are in fixed positions. The forces of attraction between particles are strong. The particles can vibrate but cannot move past each other. They are close together, touching each other.

Particles in Liquids

The particles in liquids vibrate but can also move past each other. They are close together, touching each other, as in a solid. However, the forces of attraction between the particles are not as strong as in solids. The weak attraction between them cannot support particles in one position so liquids take up the shape of the container

Particles in Gases

The particles in gases are very far from each other. They move quickly in all directions so they spread out. If squeezed in a closed container, they move closer together.

The next activity compares a liquid with a gas. It provides *evidence* for the idea that particles are close together in a liquid and far apart in a gas.

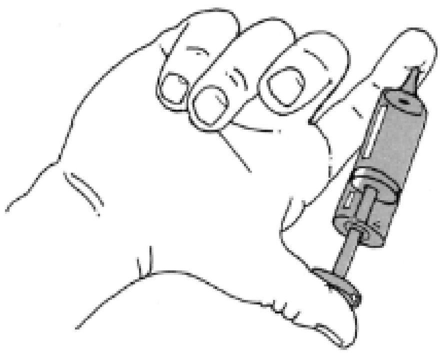
Activity 3.1: Find out if gas or liquid can be compressed.

Which is easiest to compress: a gas or a liquid?

What you need

- a syringe
- water

What to do



1. Draw some air into a syringe.
2. Close the opening with your finger so the air cannot get out.
3. Press down on the plunger (piston) as shown in the picture. Observe what happens.
4. Do the same with a syringe containing water. Observe what happens.

You will have found that it was easy to compress (squeeze) the syringe full of air, but impossible to compress the water.

This tells us that the water particles are already close together and cannot be pushed closer together. In the gas, the particles are far apart and can easily be pushed closer together.

What Evidence is there for Particles?

We cannot see particles; they are too small. But scientists believe they exist. This is a **scientific theory**. Scientists think up theories to explain their observations.

Then they look for **evidence** that their theory is correct. Evidence is something that you can see or hear or touch that can be explained by the theory.

The next activity provides some *evidence* for particles. You will make an observation that can be explained by the theory of particles.

Activity 3.2: Investigate Evidence of Particles using Balloon Filled with Air.

How can we explain what happens to a balloon full of air?

What you need

- a balloon
- string

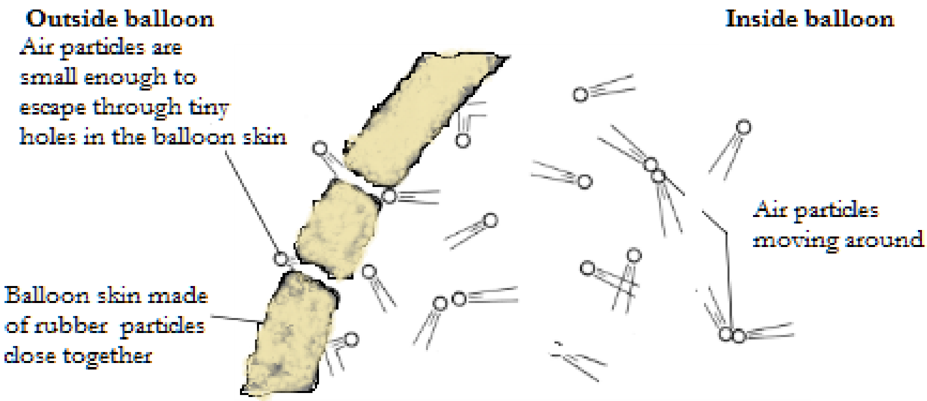
What to do

1. Blow up a balloon.
2. Tie the string tightly around the neck of the balloon many times.
3. Look at the balloon every day to see if it has changed size.

Results

- Did you see that the balloon gets smaller and smaller? This is because the air is escaping.
- How is it escaping? Can you think of an explanation for why the balloon goes down?
- Here is an explanation that uses the theory of particles. The balloon going down is *evidence* for the theory of particles.

- Look at the picture. It shows the rubber skin of the balloon. The skin is made of rubber particles packed closely together. But there are places where the air particles can get out through holes between the rubber particles. The air particles inside the balloon are constantly moving around and hitting the skin of the balloon. A few manage to get out of the balloon.



- Solids and liquids are also made of particles. When we mix a cool drink powder (a solid) in water (a liquid), we notice that the powder seems to disappear into the water. The water takes the colour of the powder and tastes different.

Activity 3.3: Investigate Evidence of Particles using Liquid

How do we know that solids and liquids are also made of particles and are in a state of motion?

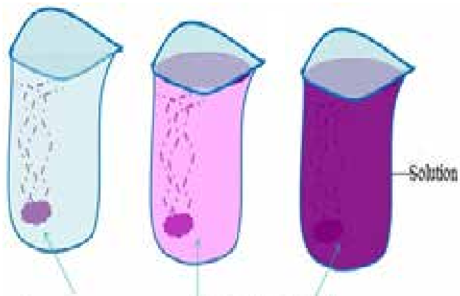
What you need

- A crystal of potassium permanganate
- a drop of ink
- water
- two small containers (tops from jam jars are suitable)

What to do

1. Fill the containers with water.
2. Carefully place a crystal of potassium permanganate in the water on one side of one container.
3. At the same time, a friend must carefully place a drop of ink in the water on one side of the other container.
4. Do not move the containers. Look at what happens to them during the rest of the lesson. Leave them overnight and look again. What is the difference between them?

What happened to the crystal of potassium permanganate? Did you see that the crystal of potassium permanganate changed the colour of the water? This can be explained by the idea of particles. Each particle that leaves the crystal moves in between the particles of water and spread.



Potassium permanganate ($KMnO_4$) dissolving in water

You cannot see each particle of water because the particles are very, very small. When particles of a substance spread from one region of higher concentration to another of lower concentration, the process is called **diffusion**. After some time, all the particles from the potassium permanganate crystal have spread evenly throughout the water to form a **solution**. This is why the crystal cannot be seen any more. It has **dissolved**.

Think of coloured liquid like ink. What would happen to the colour of water if a drop of the ink is put into the glass of water?

The particles in the ink (which is a liquid) will also diffuse (spread) throughout the water until the colour becomes the same throughout the solution.

Diffusion in Gases

If someone is cooking in the kitchen, it doesn't take long for the smell to travel around the house to other rooms. This is because of diffusion. Gas particles from car exhaust fumes, perfumes or flowers diffuse through the atmosphere. Our nose detects the small particles. This is how we smell things around us.

You don't have to mix the gases by waving your arms around - it mixes on its own.

You can easily show this with a gas that has a smell such as butane in a burner. One person should turn on the burner for a few seconds in the front of the classroom.
Are you able to smell anything?

Activity 3.4: Investigate Particles in Gases

How do we know that gases are also made of particles?

What you need

- Gas of bromine vapour
- Two empty gas jars
- Cover plate

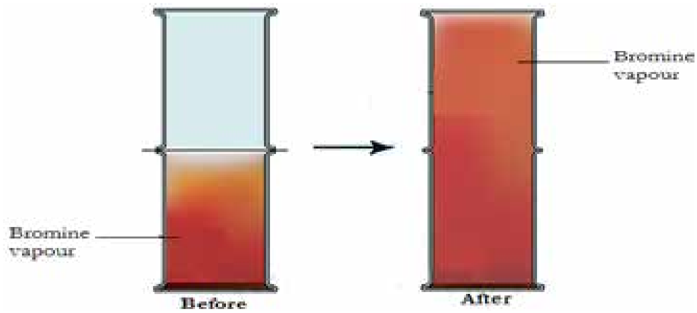
What to do

1. Fill one of the gas jars with bromine gas and cover it with cover plate carefully.
2. Invert the gas jar and place it on top of a jar full of bromine with its cover.

3. Carefully remove the cover plate and let the two open ends of the jars be in contact.
4. Do not move the jars. Look at what happens to the bromine gas.
5. What is the difference between two jars?

Results and Discussion (start here)

The difference between the two jars can be explained by the idea of particles. Each particle that leaves bromine vapour moves in between the particles of air in the jar on top. The bromine gas spreads (diffuses) rapidly into the air to produce a uniform pale brown colour in both jars. You cannot see each particle because the particles are very, very small. But you see the brown colour spreading throughout the two jars.



Diffusion in gases is quick because the particles in a gas move quickly. Gas particles are further apart than liquid particles and so other gases can diffuse between them easily. It happens even faster in hot gases.

Exercise/Assessment

Using suitable examples explain what the following terms mean;

Kinetic theory of matter

Brownian motion

Diffusion

a) Describe two ways in which properties of;

a liquid is similar to that of a solid

a gas is similar to that of a liquid

b) Give reasons for each of the similarities you have stated in (a) above

c) Why is gas compressible while a liquid is incompressible, yet particles of the two states undergo Brownian motion in a similar pattern?

3.3: The Kinetic Theory of Matter

Activities 2.3 (particles in liquids) and 2.4 (particle in gases) can be used to explain kinetic theory of matter.

These activities demonstrated that particles in liquid and gases are constantly moving freely and randomly in all directions, and keep colliding with each other. The particles in liquids and gases move freely because forces of attraction between particles in liquids are weak, while forces between particles in gases are negligible

The particles in solid also do move but the movement of the particles in solid differs from that in liquids and gases in that they do not move freely, they vibrate about a certain average/mean position.

Therefore, the kinetic theory matter states; all matter is made up of small particles that are in continuous state of motion.

3.4: Changes of State by Heat gain or Heat loss

Many of the uses of the different states of matter rely on their changing from one state matter to another. For example, purifying water relies on a change of state from liquid to gas and back again, as does the formation of rain. The burning of candle relies on the wax changing from a solid to a liquid and then to a gas.
Understanding that when things change from one state to another requires energy (heat) gain or loss is very important. Substances can move from one state to another when specific **physical conditions** change. For example, when the temperature of a substance goes up, the particles in the substance becomes more excited and active. If enough energy is placed in a substance, a change of state may occur as the matter moves to a more active state.

In this section, the particle model will help you to explain how substances change from one state to another. An example of this is the changing of ice water to water (liquid) to water vapour (gas) during boiling of water.

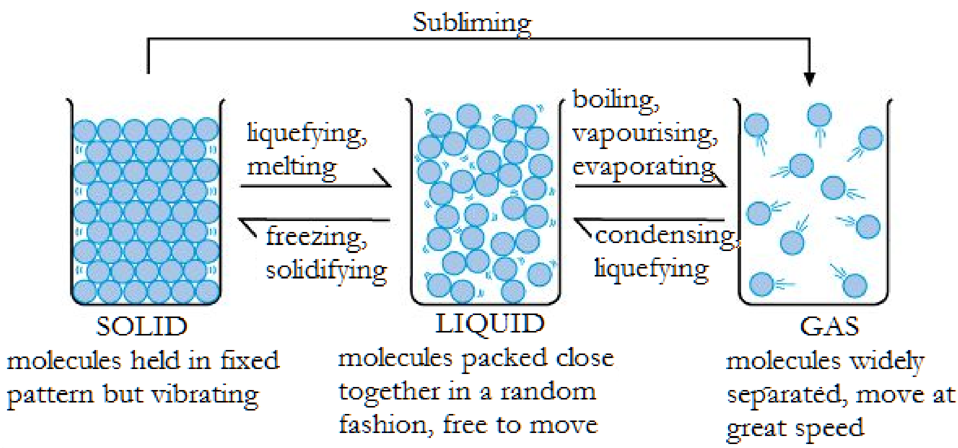
Can you give example of substances which are always in a solid form but you change them into a liquid form before use? How do you do it?

What happens when you put drinking water in fridge? Why do you put other drinks in fridge?

What happens to particles of any warm liquid when put in fringe?

Look at the diagram below and explain what happens to arrangement of particles, and forces holding the particles together when energy heat increases at every state.

Do the same to explain when heat energy decreases at every state.



This can be explained by the idea of the movement of particles due to increase or decrease of heat energy.

When matter is heated, the particles absorb heat energy; move faster, thus an increase in the kinetic energy.

When matter is cooled, the particles will release heat energy, move slower, thus a decrease in kinetic energy.

Activity 3.5: Observe the Changes of State when Water is Heated.

What you need

- Source of heat
- Ice Cubes (100mL)
- Celsius Thermometer
- Stirring Rod
- 250mLBeaker
- Stop Watch or Wall Clock

Safety Precautions:
To avoid burnings, do not touch the source of heat or beaker at any moment when you are performing this experiment.

What to do

1. Put150ml of water and 100ml of ice into a beaker and place the beaker on the hot plate.
2. Put the thermometer into the ice/water mixture. Do not stir with the thermometer or allow it to rest on the bottom of the beaker.
3. Record the temperature of the ice/water mixture.
4. Put the ice water on a source of heat and record the temperature every minute in the table below including the physical state of the water.
5. Continue doing this until water begins to boil.
6. NOTE: Before making each temperature measurement, stir the ice/water mixture with the stirring rod.
7. Use your data to plot a graph of temperature (^{O}C) vs. time (sec).

Data Table:

Time (min)	Temperature (°C)	Physical state
0		
1		
2		
3		
.		

Energy Changes during Heating and Cooling

When you heated a beaker of ice, you noticed that the temperature stayed at 0^0C until all the ice had melted. Only after this does the temperature rise. So, what happens to the heat energy that you put into the ice if it does not make the ice warmer? The answer is that energy is needed to pull apart the particles in the ice so that they are no longer in regular rows but are moving around. This energy has a name; it is called the latent heat of melting of ice.

Try the opposite experiment. Put a beaker of water containing a thermometer in an icebox and look at the temperature as it cools. It will go down to zero and then it will stop going down any further as the water freezes. The temperature of the ice will not start falling again until all the water has frozen. This is because when the water particles stop moving around as ice is formed; their kinetic energy is given out as heat energy. This stops water from cooling further. In this case the latent heat is given out.

3.5: Cooling Effect of Evaporation

Activity 3.5: Investigate the Effect of Evaporation.

What you need

- Ether or acetone
- A spatula

What to do

1 With the help of spatula, get some ether or acetone onto the spatula
2 Carefully put a drop of ether or acetone on the back of your hand
3 Keep drop on back of your hand until it completely evaporates off
4 Pay attention to sensation or effect produced/felt on your skin as the drop evaporates

1. **Results and Discussion**What did you feel on your skin as the drop was evaporating?
2. What conclusion can you draw about the effect of evaporation on the back of your hand?
3. Explain how this effect is an important aspect in the life of living organisms.
4.

Integration of Situations

At this stage you are aware that matter is made up of small particles (atoms, molecules, ions). With the help of beads and wires to represent particles and bonds or any small fruits and tooth picks develop models to show arrangement of particles in;

(i) Solids
(ii) Liquids
(iii) Gases

a) Use the models you have developed and the nature of movement of particles in each of the states to demonstrate why;
   (i) Solid state has a definite shape and volume
   (ii) Liquid state fixed volume but not fixed shape
   (iii) Gas state has no fixed volume of shape

b) Prepare a presentation to explain why diffusion takes place in liquids and gases but not solids.

Summary

You should know that:

- anything around you or within you is called matter.
- matter is scientifically defined as anything that has mass and can occupy space.
- matter can occur in three common states of solid, liquid and gas but may also occur in another fourth state known as plasma.
- a given matter can change from state to another either by absorption of heat energy or release of heat energy. For example, change from solid to liquid (melting) takes place by absorption of heat energy while the reverse (freezing) takes place by releasing heat energy, or evaporation takes place by absorption of heat energy while condensation takes place by release of heat energy.
- matter is made up of small particles that are constantly moving and arranged differently in each of the three states:
  - in solids the particles are closely packed in a regular shape because they have strong forces of attraction between them. The movement of the particle in solid state involves vibration about a mean or average position. Therefore, resulting

physical property of matter in solid includes; cannot flow, has a definite shape and volume, cannot be compressed.

- in liquid state the particles are further apart than in solids and randomly arranged because they have weak forces of attraction between them. The particles move freely and randomly in any direction but within the bulk of the liquid. Therefore liquids; can flow, they have definite volume but no definite shape and they take the shape of the container in which they are put, they are incompressible.
- in gas state the particles are far apart from each other, they have negligible or no forces of attraction between them and randomly arranged. The particles move freely and randomly in any direction colliding with each other and the wall of the container in which they are put. Therefore gas; can flow and spread to fill any available free space, they have no definite volume and definite shape, they are compressible.
- the random movement of particles in liquids and solids is called Brownian motion.
- the spreading/movement of substance from the region of plenty (where they are in high concentration) to a region where they are fewer (are in low concentration) is called diffusion.

End – of – Chapter Questions

1 The particles in liquids and gases show random motion. What does that mean, and why does it occur?

2 Why does the purple colour spread when a crystal of potassium manganate (VII) is placed in water?

3 Bromine vapour is heavier than air. Even so, it spreads upwards in the experiment above. Why?

4 **a)** What is diffusion?

b) Use the idea of diffusion to explain how the smell of perfume travels.

5 Write down two properties of a solid, two of a liquid, and two of a gas.

6 Which word means the opposite of:

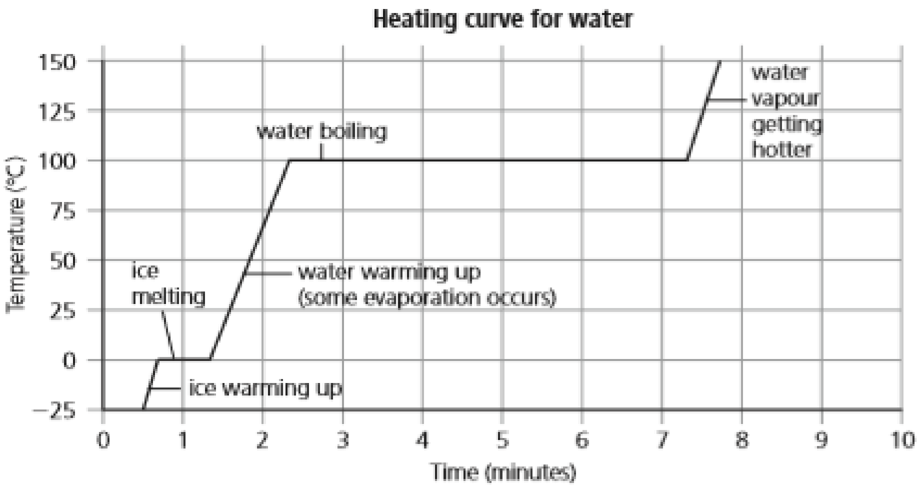
a) boiling?

b) melting?

7 Which has a lower freezing point, oxygen or ethanol?

8 Which has a higher boiling point, oxygen or ethanol?

9 Look at the heating curve below.



a) About how long did it take for the ice to melt, once melting started?

b) How long did boiling take to complete, once it started?

c) Try to think of a reason for the difference in a and b.

10 Use the idea of particles to explain why:

a) solids have a definite shape

b) liquids fill the bottom of a container

c) you cannot store gases in open containers

d) you cannot squeeze a sealed plastic syringe that is completely full of water

e) a balloon expands as you blow into it.

CHAPTER 4

Using Materials

Key Words	By the end of this chapter, you will learn:
▪ Materials ▪ Natural ▪ Artificial ▪ Synthetic ▪ Physical properties ▪ Recycle ▪ Molecular structure ▪ Polymers ▪ Pollution	▪ *to classify materials used in everyday life into natural and synthetic groups, and how this affects their use.* ▪ *about how the physical properties of polymers determine their uses in everyday life such as in building, fabrics, fabricating utensils used in homes, etc.* ▪ *about the molecular structures of materials and relate this to their use.* ▪ *about how common materials can pollute environment and which materials can be recycled.* ▪ *about how heating changes the structure and properties of some materials.*

Introduction

From the earliest times, humans have depended on different materials for getting and cooking food, for clothing and shelter and a lot of other uses. The ways we use these different materials depend on the different properties of the materials. In this chapter you will learn more about some of the common substances you can find around your home and school. You will study the physical and chemical properties of these substances. You will learn how these properties make them suitable for what we use them for.

Classifying Materials

Activity 3.1: Classify materials used in everyday life.

Look at the materials in the picture and try to classify them according to their properties. Remember that when you classify materials you put them in groups. Each group has a common property. Here are some headings under which some of the materials could be grouped:

- hard, soft, flexible (easily bent), shatter easily
- solids, liquids, gases
- metals, non-metals
- elements, compounds
- glass, wood, metals, plastics, etc.

Compare your classifications with that of your classmate next to you. There are many ways of classifying materials. It is possible that your friend has a very different classification from yours.

In the picture, most materials are solids. One way of classifying the solid materials is to put them into these groups in a table like this one. Try and complete the table.

Glass	Wood	Plastic	Ceramics (pottery)	Fibres	Metal
	Table	Plate		Towel	

The use we make of materials depends very much on their properties. But why do materials have particular properties that make them useful? How are materials made? These are some of the questions you will try and find answers to in this chapter.
To start, try this simple activity.

Activity 3.1: Find out what happens to materials when you hammer or heat them.

What you need

- Pieces of wood
- Concrete
- Glass
- Paper
- Plastic
- Brick
- Cloth
- Pottery
- Rubber
- metal, etc.;
- hammer (or a stone)
- Bunsen burner

What to do

1. Take each material and hammer or hit it. (Take care: If the material breaks easily, you should wrap it in a piece of cloth before you hit it so that you do not get any pieces in your eyes.)
2. Heat a small piece of each material with the burner.
3. Describe the results in a table.

This activity is best done outside

What happened to the materials when you hammered them? Did you notice that different materials behaved in different ways? Glass shatters while wood probably squashed into a number of long fibres. It is difficult to shatter the brick but you might have been able to chip off the ends and sides. The metal pieces are flattened.

What happens when the materials are heated? Some of them burn. Some may break. Others may be resistant to heat.

All these differences are due to the differences in the structure of the different materials. In previous section you studied some of the different ways in which atoms are joined together into molecules and how molecules are arranged in solids. Let us now think more about the structures of some of these materials.

To help you, here is a table which contains a summary of the different kinds of bonds that atoms form when they join together.

Bond	**Properties of materials with these bonds**
Ionic	Crystalline solids that are easily broken
Covalent	Gases, liquids or solids with a low melting point
Covalent giant structure	Very hard solids with high melting points (such as sand)
Metallic	Ductile, malleable solids that are good conductors of heat and electricity

The Structure of Materials that Shatter Easily

Concrete

Concrete is one of the most useful materials that we make. Concrete is made out of sand, gravel and cement. If you look at a piece of concrete carefully with a magnifying glass or a microscope, you can see that it is made up of lots of long thin crystals which overlap each other. These crystals come from the cement, which is a mixture of two substances (calcium silicate and aluminium silicate). The two substances are made by heating together limestone with clay at a temperature of about 1 400 °C in a gas-fired furnace.

The crystals in cement start forming when water is added to it. They are strongest if the concrete is allowed to dry out slowly so that the crystals grow longer and stronger. This is why it is a good idea to wet concrete with water for several days after it has been made. It is these crystals locking together that make concrete so strong and hard. But because concrete is made out of crystals, it is quite easily broken with a hammer because crystalline substances are easily broken.
Limestone and clay are very common all over the world, so cement and concrete are used everywhere.

Source: Author – Tororo cement works. It uses limestone from the quarry behind.

Glass

Glasses are usually hard, brittle, transparent materials. Unlike cement, they are non-crystalline solids and the molecules in them are not arranged in any particular pattern. You will remember that a liquid has a structure in which the molecules are close together but not arranged in any particular pattern. This means that glass has a structure like a liquid but the molecules are too large to move around. So, glasses are really liquids that behave like solids!

The common kind of glass is made by heating limestone (calcium carbonate) with sodium carbonate and sand (silicon dioxide) in a furnace. The three compounds melt together and run out of the bottom of the furnace as a clear liquid. The liquid can be allowed to cool as a flat sheet of glass or it can be moulded into any shape before it cools and turns solid.

Other substances, particularly metal oxides, can be added to make different kinds of glass. Some of these glasses are coloured.

Although the glass you tested broke easily, certain types of glass like this bulletproof glass being tested are very strong. Some presidents ride in cars with windows made of bulletproof glass.

Ceramics

The piece of pottery you tested in Activity 3.1 was a ceramic. Ceramics are some of the earliest classes of materials made by humans. They are mainly objects shaped out of clay and then hardened by heat.

Ceramic objects are made from clay, which is common all over the world. Clay contains a mixture of compounds (mainly aluminium oxide and silicon dioxide). It has several important properties, which have caused it to be used for making pottery objects.

- It can easily be moulded when wet. This is because the molecules in the clay attract water molecules by electrostatic attraction. These water molecules allow the clay molecules to slip easily around each other.
- When clay dries it goes hard.
- If the clay is then heated in a fire or oven it goes permanently hard.
- When clay is fired the molecules in the clay react with each other and a hard-giant structure is produced. The structure is similar to the structure of silicon dioxide (sand).

These are handmade pots made in Arua. They are made out of soft clay and then fired.

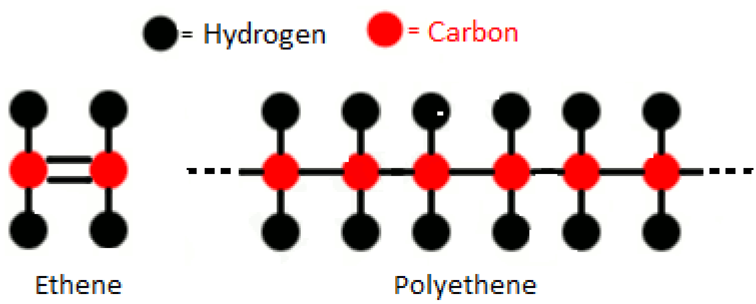
The Structure of Materials that do not Break Easily

Plastics

Plastics are synthetic materials. Synthetic materials are made by humans – they are not found in nature. Although the first plastic was made over 100 years ago, most of the plastics we use in our daily lives have been developed in the last 50 years. They have become very important to us, mainly because they are cheap to make and can easily be moulded into different shapes.

The properties of plastics vary from transparent to opaque, hard to soft, weak to very strong, heat resistant to easily melted. They do not conduct electricity and so many are used as electrical insulators. These properties are very different from the properties of concrete and ceramics and so it is not surprising that the molecular structure of plastics is also very different from the structure of ceramics.

Some atoms, particularly carbon atoms, can join together in long chains. These long chain molecules are called **polymers**. 'Poly' means 'many' and polymers are compounds that are made of many small molecules joined together to form one long one. This is shown in the diagram, which shows polythene.



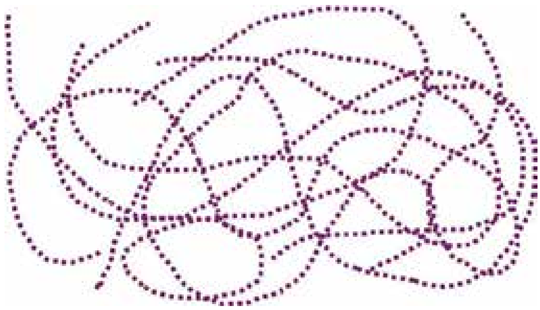
This very common plastic, polythene, is made from small molecules of a gas called ethene.

The main element in most plastics is carbon. Atoms of carbon join together to form long chains and these are joined to atoms of other elements, particularly hydrogen. There can be thousands of atoms in each molecule that are held together strongly by covalent bonds.

Polythene is a cheap flexible plastic and so it is useful for shopping bags and many other items. But it is not very strong.

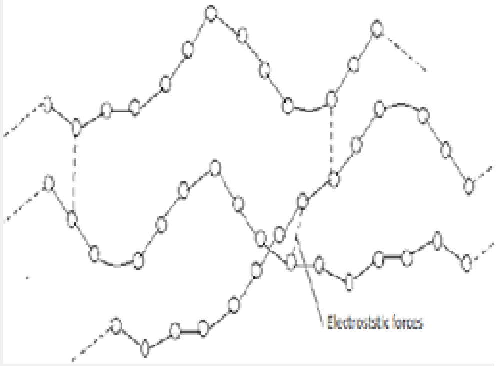
Other polymers such as nylon are much stronger but they are more expensive. Others such as the 'polycarbonate' that your plastic ruler is probably made of are stiffer but are quite easily broken.

The differences in these physical properties of plastics can be explained by the structure of the molecules that these polymers are made from. The diagrams on the next pages show how the polymer chains are held together in different plastics.

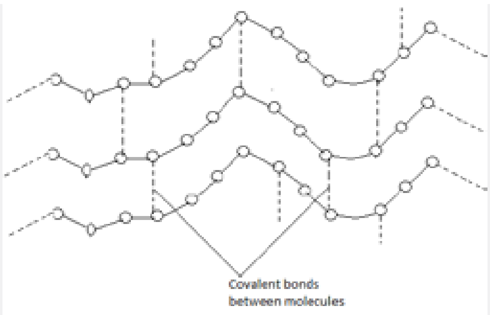


In polythene, the polymer chains are not held to each other very strongly. This means that polythene is not very strong. The molecules line up in different directions in the plastic.

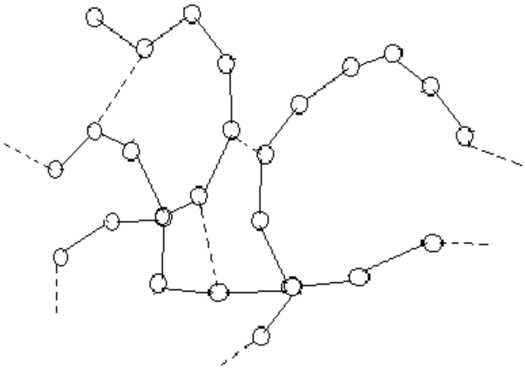
Most plastics are made from crude oil, coal or natural gas. We have seen that polymers are made from small molecules joined together in a chain. The small molecules, which are usually gases, are first made from the oil. This process takes place at very high pressures and is helped by a substance called a catalyst. (A catalyst is a substance that helps a chemical reaction to take place more easily and faster, but is not itself used up during the reaction.) In many plastics there are forces between the polymer chains that hold them together. These forces are usually electrostatic and are caused by nitrogen or oxygen atoms in the polymer molecule. In some plastics there are covalent bonds that form strong links between the polymer chains. The examples below show how important these forces between the polymer chains are.



Nylon is used to make clothes, fishing line and ropes. It is very strong and flexible. The polymer molecules contain some nitrogen and oxygen atoms, which attract each other by electrostatic forces that hold the chains together. These forces make the molecules of the polymer line up in the same direction. It is the arrangement of molecules in the same direction that makes nylon so strong. Because the forces between the molecules are electrostatic and not chemical bonds, the molecules can slide next to each other. This means that nylon can be stretched quite a lot without breaking.



Melamine is the plastic surface of many desks and tables. In this plastic there are strong covalent bonds between the polymers. This makes the polymer rigid; it is hard, it cannot be stretched and it will not melt. When it is heated it burns without melting.



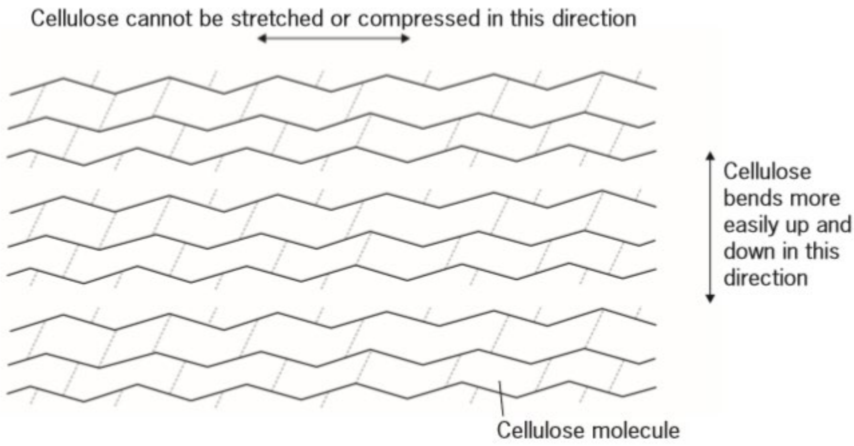
Plastics like polyurethane have their polymer molecules very loosely joined together in a random way. This allows the plastics to be squashed or stretched without permanently changing their shape. They are like rubber. They are not at all strong. They can be made into a foam like the mattress in the picture by adding chemicals to them which react to form a gas like carbon dioxide as the plastics set.

Natural Polymers

The plastics you have been studying so far are all synthetic. There are also many polymers that occur naturally. They are made by living things as they grow. One natural polymer is being made by you at the moment! Your hair and fingernails are made out of it. It is called keratin. You will learn more about this polymer when you study wool later in this chapter.

One very well-known natural polymer is cellulose. This is the polymer that wood is made of. It has a complicated structure made out of atoms of carbon, hydrogen and oxygen. There are covalent bonds and strong electrostatic forces holding the polymer chains together. These chains all line up next to each other to form the 'grain' of the wood. Because of the bonds and forces holding the molecules together, wood has great strength.

It is possible to bend it in the direction of the polymer chains but it is almost impossible to stretch it or to break it by pulling it. This is why it is such a useful material.



The Structure of Cellulose

If wood is crushed, it forms long thin pieces of cellulose called cellulose fibres. These fibres can be made into paper. Do the next activity to find out more about the cellulose fibres in newspaper.

Activity 3.5: Find the direction in which the fibres are located in a newspaper?

What you need

- A sheet of newspaper,
- a microscope or good magnifying glass

What to do

1. Tear the newspaper down the page.
2. Now try tearing the newspaper across the page.
3. Write down the differences you noticed and what conclusions you made about the direction of the fibres in the paper.
4. If you have a microscope, use it to look at the paper. Can you see the fibres? Are they lying in the direction you concluded in step 3?
5. Roll up a page of newspaper and try pulling one end while your friend pulls the other. Can you break it?

Newspaper under a Microscope

The way the paper is made causes the fibres to line up roughly in the same direction. Each fibre contains millions of cellulose molecules lined up in the direction of the fibre. It is difficult to tear the paper across the fibres but much easier to tear it between the fibres. The fibres are very strong if they are pulled; it is very difficult to break them. As you will learn in the next section, there are many other natural polymers that we use to make fibres.

Fibres

Fibres, like plastics, are made from polymers. They are used to make thread that can be made into cloth. They can be classified into two main groups: natural fibres and synthetic fibres. Natural fibres can be classified further into three groups, those from animals and those from plants and also those made out of minerals such as asbestos that are dug out of the ground in quarries. The mineral fibres are long thin crystals that can be spun into a thread.

Some examples are shown in the table on the next page.

Natural Fibres			**Synthetic Fibres**
From plants	**From animals**	**From minerals**	Nylon Polyster Terylene
Cotton Sisal Jute Linen Hemp	Silk Wool Mohair	Asbestos	

An important use for fibres is making cloth that is then made into clothing. Some clothes are warm, others are cool. Some clothes stretch easily, others do not. Some clothes dry quickly after you wash them; others take a long time to dry. Some clothes last a long time, others wear out quickly. Some feel comfortable to wear, others do not. Many of these differences are caused by differences in the polymer molecules that the fibre is made out of.

Materials Used for Building Houses

In Uganda there are many different kinds of houses. What the houses are made of in any area depends on a number of things such as:

- the availability of building materials
- the cost of building materials
- the space available for building
- the weather conditions in the area
- the size of the house.

In this section we are going to look at the different materials used for building some of the different kinds of houses in Uganda. You will investigate the advantages as well as disadvantages of the different materials and find out why certain materials are used for particular purposes.

Exercise

Describe the shape and colour of a typical house in your area.
List the materials that the different parts of the house are made of.
List the advantages and disadvantages of the materials used.

Materials Used for Building Walls

There are many different materials used for building house walls. Most houses have walls made of bricks but the bricks may be made of concrete or mud or fired clay. How strong are these bricks? To answer this question, try the next activity.

Activity 3.5: Find how strong bricks are?

What you need

- Mud and/or clay (used for brick-making)
- Cement
- Sand
- Water
- container for mixing cement or mud
- boxes for moulding the bricks (for example, long-life milk or juice cartons with a flat side cut out)
- bucket
- piece of wood

What you do

Making the bricks

Make several different bricks out of different materials. Here are some ideas for some of the bricks.

1 Try these mixtures for your bricks:
- two parts of cement added to two parts of sand
- one part of cement added to three parts of sand
- three parts of cement added to one part of sand
- mud suitable for brick-making.

2 Add water to each mixture until it is a firm paste.

3 Mould each mixture into a box and label it carefully.

4 Leave the bricks to dry for a week (not in the sun).

Testing your bricks – compression

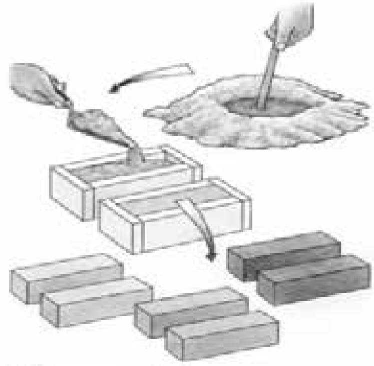
5 Test the compression strength of your bricks with a bucket on top of the brick as shown. Fill the bucket with water. What happens to the brick? Test all the bricks using the same piece of wood (why?).

6 Write the results in a table. If your brick breaks in this test you will have to make another one for the next test!

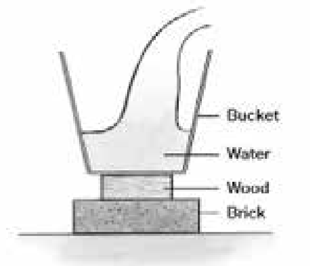
Testing your bricks – bending

7 Test the strength of each brick by hanging a bucket underneath it as shown. Make sure that the testing experiment is exactly the same for each brick.

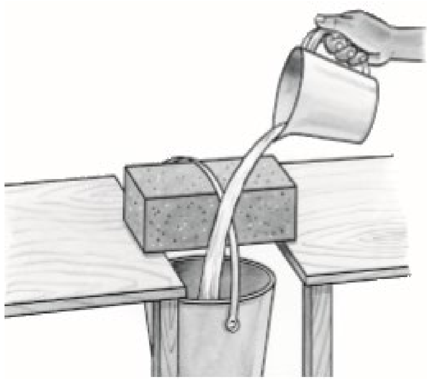
8 Write down in the table how much water you put into the bucket before the brick broke. (Your brick may not break at all. Congratulations! You have made a good strong one.)



Making your own bricks



Testing the compression strength of your bricks



Testing the tensile strength of your bricks

You have tested the bricks in two ways. The first way tests the compressive strength of bricks. You have applied a force to compress it. The second one tests the tensile strength of the brick. You have applied a force to pull or to bend the brick.

A material that is difficult to break by pulling is said to have good tensile strength. A material that is difficult to break by crushing is said to have good compressive strength.

What conclusions can you make about the strength of your bricks? When bricks are used they are compressed by the bricks above them. The material the bricks are made of must have a good compressive strength but it does not need to have a high tensile strength. The materials should also be cheap. Cement is quite expensive but sand and mud are cheap. Bricks must also be able to stand up to the rain and the heat of the Sun.

Which of your bricks do you think is best value for money for building a house?

Summary

You should know:

- that we can classify solid materials into glass, wood, metal, plastics, ceramics and fibres. The use we make of these materials depends on their properties.
- that cement is made by heating together limestone (calcium carbonate) with clay (mainly aluminium silicate) at a temperature of about 1 400 °C. Concrete is made out of sand, gravel and cement. When the concrete sets, long crystals form which lock together. These make concrete hard, but it can easily be broken with a hammer. Building materials such as concrete and bricks must have a good compressive strength, but do not need to have a high tensile strength.
- Glass has the structure of a liquid but behaves like a solid because the molecules are too large to move around. We make glass by heating limestone (calcium carbonate) with sodium carbonate and sand (silicon dioxide) in a furnace.
- Ceramics are made from clay that has been dried and then heated (fired). Firing the clay produces a hard, three dimensional structure.
- Plastics are formed from long chains of carbon atoms together with atoms of other elements. They are manufactured from crude oil, coal or natural gas. The properties of a plastic depend on the structure of the polymer molecules and particularly the kind of forces holding molecules together. Cellulose is a natural polymer from which wood is made.
- Both natural and synthetic fibres are made from polymers. Mineral fibres are made from minerals that form long thin crystals. The properties of fibres depend on the structure of the polymer from which they are made. For example, the polymer molecules in wool are like small springs. This means that wool stretches easily, whereas nylon polymer molecules are long and straight and so they cannot stretch easily. Some fibre polymers, such as the polymer in wool, can attract water molecules, whereas the nylon polymer does not attract water molecules strongly.

End – of – Chapter Questions

1 Plastics, metals and ceramics are very important and useful materials. Select one of them and describe what life might be like if the material you have selected was no longer available.

2 Describe how you could improve your home to make it cooler in summer and warmer in winter. Give reasons for your suggestions.

3 Each of the following objects is made of a fibre. In each case describe the most useful properties you would want the fibre to have. Of the fibres you have studied, which would be the most suitable for each of these uses?

   a) A set of seat covers for a car
   b) A sweater for winter
   c) A baby's nappy

CHAPTER 5

Temporary and Permanent Changes to Materials

Key Words	By the end of this chapter, you will learn to:
◆ Physical change ◆ Chemical change	▪ explain the permanent changes undergone by many substances when they are heated or burnt. ▪ distinguish between temporary (reversible) and permanent (irreversible) changes to matter under different conditions.

Introduction

You must have come across many changes taking place around you. Some of these changes can be reversed while others cannot be reversed. In this section you will find out how to identify or categorise the different kinds of changes and what happens to chemical substances when they change during reactions.

5.1: Temporary (Physical) and Permanent (chemical) Changes

Activity 5.1a: Demonstrate temporary (physical) change.

In this activity you will investigate what happens to a piece of fat placed on a hot saucer.

What you need

- A piece of fat
- Ice cold water
- Ice bath
- A hot saucer/frying pan
- Metallic cup
- Source of heat

Fig. 5.1. Cube of Fat on Saucer

What you do

1. Place a piece of fat on a saucer/frying pan placed on a heating source
2. Observe for five minutes

3 Pour the molten fat into a metallic cup and place the cup in an ice bath

4 Observe for ten minutes

Results:

1) Name the condition to which fat is subjected
2) How does this condition affect the fat?

3) How is this change used in everyday life for the benefit of man?

Activity 5.1b: Demonstrate permanent (chemical) change.

In this activity you will investigate what happens to a piece of wood when burnt in air.

What you need

- Wood splints
- Source of heat

What you do

1 Ignite a piece of dry wooden splint in a flame and allow it burn in air.
2 Collect the product of burning wood on a white tile

Results

1) How does the product of burning differ from the original material?
2) Suggest a process if any, by which the product of burning can be reversed to wooden splint

3) Explain what has happened to matter in the original wooden splint

4) How can this change be utilised by man for his benefit?

Changing Substances

What do we mean by a change? When something changes it goes from one kind of substance to a different one. When we boil a kettle, we change water to water vapour. When we burn paper, it changes from paper to a black substance that we call carbon.

In the next activity you will investigate how you can change substances by heating them.

Activity 5.2a: What kinds of changes can be caused by heating substances?

What you need

- Burner,
- tin lid,
- test tube,
- a pair of tongs
- bits of wood,
- a stone,
- a piece of glass,
- salt,
- sugar,
- candle wax,
- bread,
- steel (nail),
- lead,
- copper,
- zinc,
- bits of plastics,
- copper sulphate,
- copper carbonate,
- sulphur and other substances your teacher may give you

What to do

1. Choose the most sensible way of heating a substance, either in a test tube or in a tin lid, and heat it.
2. Carefully observe any changes that happen.
3. Stop heating and note any changes that happen as the substance cools down.
4. Record the changes in a table.

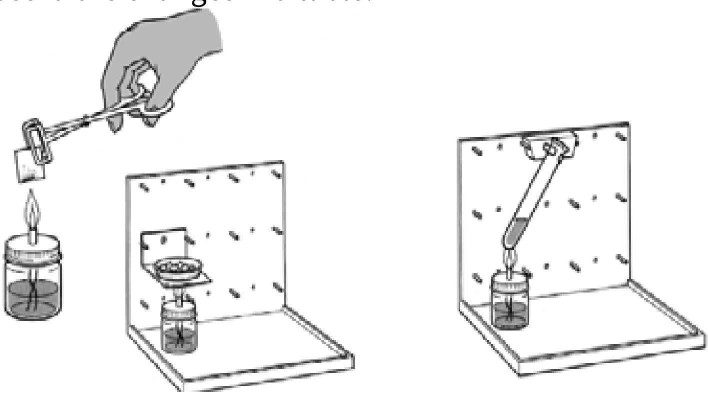


Fig. 5.2 (Give it a name)

Can you think of ways to *classify* the changes that happen when you heat substances? You could have one group of substances that did not change at all and another group of substances that caught fire. What other groups could you have? One way of classifying changes is to put them in two groups:

- Group 1 – substances which changed and then changed back to the original substance when they cooled down
- Group 2 – substances which changed to something completely different.

We call the first group **temporary changes** and the second group **permanent changes**.

Make a list of the substances you heated that were changed temporarily and another list of the substances that changed permanently.

Activity 5.2b: Identify Temporary changes in everyday life.

Can you name a few examples where temporary changes take place in everyday life? You should be able to name examples which are often used in the house, especially in the kitchen.

We use a sieve to separate foods from the boiling water when food is prepared. In the building industry large sieves are used to separate different sized stones from each other for use in different kinds of concrete.

Temporary changes happen when tea leaves are separated from the tea we drink.

Fig. 5.3. Using a Sieve to Separate Stones

When water evaporates from drying clothes and puddles, this is a temporary change because it will go into the air and eventually change back to water in clouds or in rain. When we wash clothes or water plants the changes are physical changes because the water does not change into something else.

But what about eating food or sweating?

Are these physical or chemical changes?

Can they be changed back?

Activity 5.2c: Identify Permanent changes in everyday life.

You will remember that when a change is permanent, new substances are formed that cannot be changed back into the original ones.

This means that substances change **chemically** during permanent changes. These changes are called **chemical reactions**. New substances are formed during chemical reactions.

Activity 5.3: What happens when magnesium burns?

What you need

- A piece of magnesium ribbon
- a burner
- a pair of tongs

You Must Wear Safety Spectacles!

What to do

1. Clean a 3 cm length of magnesium ribbon. Look carefully at the ribbon.
2. Use the tongs to hold the end of the strip in the flame.
3. Burn the magnesium in the air after igniting it in the flame.

Warning: Don't look directly into the bright light of the burning magnesium!

4. Look carefully at the substance formed when the magnesium burns. Write down your observations about how the magnesium has changed.

The bright metal changed into a white powder. Can you change it back into the metal? This change is permanent. It is a chemical change. The magnesium has changed into a new substance which is called magnesium oxide.

There are many examples of chemical reactions in everyday life.
A rusting truck is one such example.

Figure 5.6

Cooking food is also a chemical change. Eating food is a chemical change (you cannot change your waste products back into food, can you?).

Fig. 5.4

A slow chemical change. This iron is slowly changing into iron oxide. The common name for iron oxide is **rust**.

In Life Science you will learn more about two important chemical reactions, **respiration** and **photosynthesis**. These are both reactions that take place in nature.

The chemical change that takes place when we burn a match, a candle or a fire is a chemical reaction. It gives out energy in the form of heat and light. Chemical reactions very often give out energy.

Fig. 5.5. Wood Burning

Name a few more examples of chemical reactions which take place in nature or which are used in industry and everyday life.

5.2: Differences between Temporary (Physical) and Permanent (Chemical) Changes

You have already found that substances can undergo different kinds of changes. The changes may be **temporary** or they may be **permanent**.

Temporary changes (such as ice melting) are usually **physical changes** in which no new substance is made. Physical changes are simple changes which can be reversed. Examples of physical changes are the changes of state, size, shape and temperature. Changes such as melting, boiling, dissolving, freezing and condensing are all physical changes. They can all easily be reversed.

Permanent changes (such as wood burning) are usually **chemical changes** in which new substances are made. Chemical changes are not easily reversed and are often called **chemical reactions**.

Chemical Changes

Strike a match or light a paraffin lamp and observe carefully what happens.

Can you get the wood back from the ash of the match? Can you get paraffin back from the smoke of the paraffin lamp?

You cannot get wood back from the ashes or paraffin from the smoke. New substances have been formed. It is not possible to reverse these changes. The changes are **permanent**.

Did you notice that energy was released? Heat and light energy were given off. This kind of change is known as a **chemical change**. Chemical changes are permanent and they involve a change in energy.

Classifying Changes as Physical or Chemical

Activity 5.4: Classify changes as physical or chemical.

Below is part of a conversation among students who were carrying out a practical activity. Read and follow the written conversation among the students. Use questions and responses made by the students in written text below to identify changes that took place during the practical activity.

Aita: (recording the group's notes about a practical): What happened?
Akuma: It went fizzy (foamy).
Aita: Did you see any new substances?
Akuma: No!

Wadri: What shall I write down was formed?

Musema: A blue colour.

Task 1

i) Identify the type of change the learners were following in this group practical. Give a reason for your answer.

ii) Identify the changes which are temporary in the text.

What one criterion is used to identify chemical change from the conversation?

Task 2

Make a table showing the differences between physical and chemical changes deriving from the different activities you have done.

Physical Changes	Chemical Changes

Integration of Situations

The images below show some of the changes which the different materials undergo when subjected to various conditions. What is happening in all these photographs?

 Meat Roasting	 Copper Ore turning Colour	 Mould Growing on Tomato
 Rainfall	 A Lorry moving with Fumes along Masaka Road	 Maize Germinating

a. Classify the images into temporary and permanent changes taking place
b. For each image explain why you have classified it into temporary or permanent change
c. Carry out an investigation to demonstrate the temporary and permanent changes taking place during the growth of a tree

Summary

You should know:

That pure substance has fixed melting and boiling points.

Mixtures do not have single fixed melting and boiling points. They melt or boil over a range of temperatures.

A physical change does not produce any new substance. A chemical change results in the formation of new substances. During chemical changes energy is often given off or taken in. Physical changes are usually easy to reverse but chemical changes are difficult to reverse.

Chemical reactions can be written in the form of an equation:

$$\text{reactants} \rightarrow \text{products}$$

A chemical reaction which takes in energy is called an endothermic reaction; a chemical reaction that gives off energy is called an exothermic reaction.

Synthesis, decomposition, combustion and neutralisation are all kinds of chemical reactions.

A synthesis reaction is one in which simple molecules join together to form a more complex one.

End – of – Chapter Questions

1 **Substances can undergo two kinds of change, physical and chemical. List four observations that will tell you that a substance has changed chemically.**

2 **Draw a table with two columns labelled physical change and chemical change. Write down each of the following changes in the correct column: water boiling; a car rusting; petrol burning; sugar dissolving in tea; food being digested; bleach cleaning a dirty cloth; beer fermenting; ice cream melting; wind blowing; milk turning sour; seawater evaporating.**

3 **a) Name the two products formed when a candle burns. Explain how you would fi nd out that these two products have been formed.**

b) Explain why these same two products are formed when petrol, paraffin and butane gas are burned.

4 **Copy and complete: Matter is something that takes up _____________and has______________**

5 **Identify two substances that sublime.**

6 **Identify and list the physical and chemical changes that take place during the burning of a candle.**

CHAPTER 6

Mixtures, Elements and Compounds

Key Words	By the end of this chapter, you will learn to:
◆ **Pure substance** ◆ **Element** ◆ **Compound** ◆ **Mixture**	▪ *demonstrate criteria for determining whether a substance is pure or not.* ▪ *distinguish between elements, mixtures and compounds.* ▪ *devise means of separating components of different mixture.* ▪ *distinguish between miscible and immiscible liquids.*

Introduction

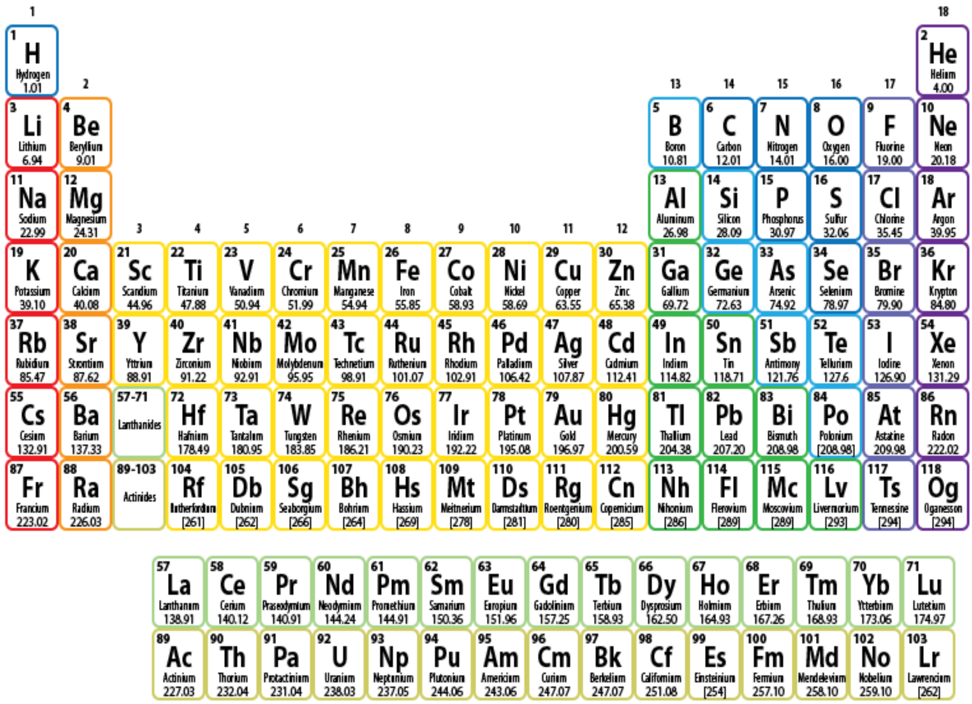
All the different forms matter or substances are chemical in nature. Chemicals can broadly be classified into elements, compounds and mixtures. In this chapter you learn about each of these classes of matter and their properties.

Determining purity of substances

A pure substance is one that contains only one type of atoms or molecules. The physical properties of a pure substance include a well-defined melting point or boiling point

In this section you will learn about the chemical elements and how they are the building blocks from which all other substances are made. Over 150 years ago, a Russian chemist called Mendeleev thought of a way of classifying the elements. He called it the **Periodic Table of the Elements**.

The Periodic Table below shows all the elements.



Questions

What is an element?

Do you know the names of any of the common elements?

Which of these elements do you know?

Iron or carbon or sulphur or oxygen?

6.1: Criteria for Determining Purity

	Activity 6.1: Investigate the melting point of pure and impure water.

In this activity you will find out the difference in melting point of pure and impure water

What you need

- 100g of crushed ice made from distilled water
- 100g of crushed ice made from tap water
- Thermometer
- Stop clock
- Plastic cup

What to do

Task I

1 Put 100g of the crushed ice made from the distilled water in the plastic cup
2 Insert the thermometer into the ice in the plastic cup and immediately start the stop clock
3 Watch the ice as it melts while occasionally stirring with the thermometer until the ice completely melts. Stop the clock as soon as the ice completely melts and note the time taken for the ice to melt.

Task II

4 Repeat procedure 1 to 3 above using the ice from tap water

5 Record your findings in the table below:

Results

	Melting point (^{0}C)	Time taken to melt (min)
Ice from distilled water		
Ice from tap water		

Discussion

Compare the values of melting points you have obtained with the true values given in the text books. From your comparisons;

a) Which of the two samples of water is pure and impure? Give reasons for your answer
b) What conclusion can you make about the freezing point of a pure substance? Can this conclusion be enough to confirm the purity?
c) What is the effect of impurity on the melting point of a substance

Activity 6.2: Investigate how to test for purity using boiling point of a liquid.

How can we know that a given colourless liquid is water and it is pure?

What you need

- Three unknown liquids A, B and C (any of liquids may be pure water, pure ethanol or mixture of the two)
- Six text tubes, rack petri dish
- Anhydrous copper(II) sulphate
- Boiling water over flame
- Thermometer

  Anhydrous cobalt(II) chloride paper.

CAUTION
Use eye protection
Ethanol is flammable. Keep a safe distance when heating.

What to do

1. Label your test tubes, two of them A, another two B and the last two C as shown below.
2. Put 3 cm^3 of liquid A in each of boiling tubes labelled A, do the same for liquid B in test tubes labelled B, and same for liquid C in test tubes labelled C (Fig 1.8).
3. Use one test tube labelled A, dip the end of anhydrous cobalt (II) chloride paper into the liquid. Note any change in table below.
4. Put a spatula end full of anhydrous copper (II) sulphate in a Petri dish, add 3 drops of liquid A and record your observation.
5. Repeat instructions 3-4 for one of the test tubes of liquid B and one for liquid C.
6. Put a thermometer in the remaining test tube of A. put the test tube in boiling water as shown in figure 1.9 and note and record the constant temperature at which the liquid boils.
7. Repeat instruction 6 for remaining test tube for B; again, note and record the boiling point for liquid B.
8. Repeat same instructions 6 for remaining test tube for C, again note and record the boiling point for liquid C.

Results

LIQUID	**A**	**B**	**C**
Boiling point			
Observation on testing with cobalt(II) chloride paper			
Observation on testing with anhydrous copper (II) sulphate			

Discussion

1. Given that boiling point of water is 100^{0}C and for ethanol is 21^{0}C (at sea level), judging from your results above, which liquid was:
   a) Pure water
   b) Pure ethanol
   c) Mixture of ethanol and water?
2. Basing on your findings, give reason for your answer in each case, can anhydrous copper(II) sulphate and cobalt(II) chloride be used to test for purity? Explain using evidence from your experiment.

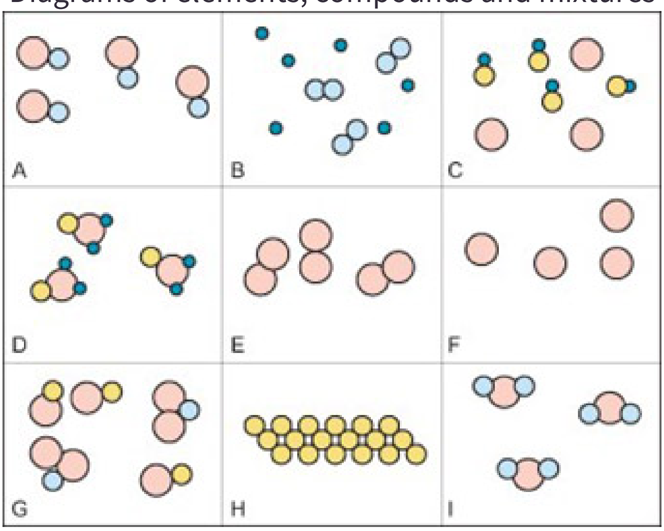
6.2: Elements, Compounds and Mixtures

Activity 6.2: Think-pair-share

In this activity you will find out substances which are elements, compounds and mixtures.

What you need

- Diagrams of elements, compounds and mixtures



What to do

1. Obtain a copy of the diagrams for elements, compounds and mixtures
2. Work in pairs to identify which diagrams represent the elements, the compounds and the mixtures. You should to be able to explain your choices.
3. Compare your answers with that of another group. If you disagree, you have to discuss the example with each other and agree on the right answer.
4. Then write the correct answers as you have agreed.

Elements and Compounds

Substances are classified in two groups: mixtures and pure substances. We can classify pure substances into two more groups. We call these two groups **elements** and **compounds**.

The group called compounds contains substances like water, sugar and salt. The group called elements contains substances like the metals; copper, iron and aluminium, and the gases nitrogen, oxygen and hydrogen.

What is the difference between compounds and elements? Read on.

Compounds

Most of the pure substances that we use every day are compounds. Examples are water, salt, sugar, white flour, polythene, nylon, polyester, aspirin, paracetamol, etc.

Compounds are pure substances but they can be broken down chemically into simpler substances. There is a simple way you can do this with water using electricity. This process is called **electrolysis**.

Activity 6.2: Split water into simpler substances

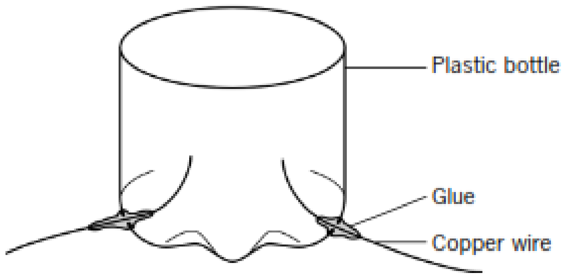
Is it possible to split water into simpler substances?

What you need

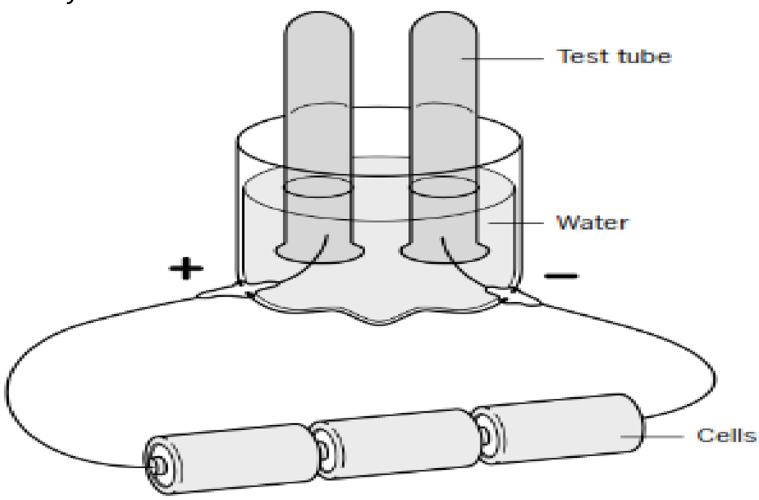
- Cells and cell holder,
- thick household copper wires,
- plastic bottle,
- small test tubes,
- water,
- dilute sulphuric acid

What to do

1 Make an electrolysis cell from the bottom of a plastic bottle and two thick copper wires as shown below.



2 Put water in it and put two test tubes full of water upside down over the wires. Add a little dilute sulphuric acid to the water to make it conduct electricity better. Connect it to the three electrical cells.



3 Watch what happens. Do you see any gases?

The equipment in this activity is called an **electrolysis cell**. It is made out of two pieces of thick household copper electrical wiring. These are called the **electrodes**. When the electrodes are connected to electricity you can see bubbles of gas on them and some gas will be collected in the test tubes.

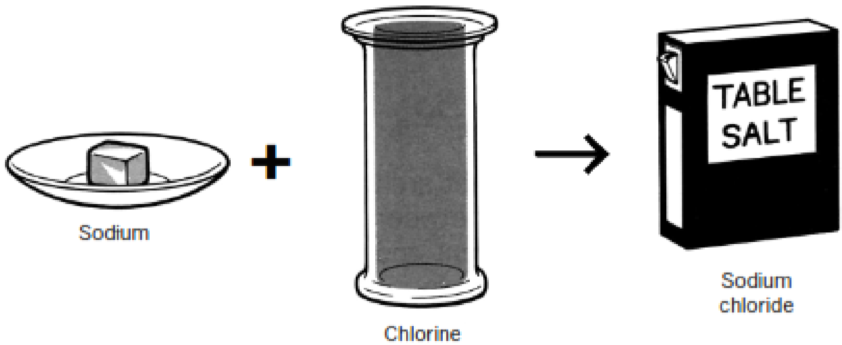
You will see more gas collected in the tube above the **negative electrode** than above the **positive electrode**. The positive electrode is the one connected to the positive pole of the cell.
In this activity water is broken down into two simpler substances. The substances are the gases hydrogen and oxygen.

Hydrogen is the gas that is produced at the negative electrode. The volume of hydrogen that is made is bigger than the volume of oxygen.

The two gases made in this activity are both elements, and water is a compound. It is a compound of hydrogen and oxygen.

We can write an **equation** to show this reaction:

$$\boxed{\text{water} \rightarrow \text{hydrogen} + \text{oxygen}}$$



The element sodium is a metal that is so soft it can be cut with a knife. It is very reactive and is therefore kept under paraffin.

The element chlorine is a green poisonous gas. But when these two elements join together the compound sodium chloride is formed.
Sodium chloride is the chemical name for table salt. So, the compound, table salt, that we must eat if we are to stay alive, is made from two harmful or poisonous elements.
Very often, when two elements join to make a compound, the compound is very different from both of the elements.

Elements

An element is a substance that *cannot* be broken up into simpler substances. It cannot be broken up by a physical process because it is a pure substance. It cannot be broken up by a chemical reaction either. Elements are the simplest substances.
A few examples of elements are copper, gold, silver, iron, aluminium, oxygen, hydrogen, nitrogen, carbon and sulphur.

All compounds are made from elements. All substances are made from elements. There are 92 elements. When you burn magnesium in oxygen, a compound called **magnesium oxide** is formed from two elements, magnesium and oxygen.
We can write an equation to show this:

$$\boxed{\text{magnesium} + \text{oxygen} \rightarrow \text{magnesium oxide}}$$

Magnesium is a metal; oxygen is a gas. Magnesium oxide is not like either of these; it is a white powder. The element oxygen is a gas and it is one of the gases in the air.

The next activity shows how two more elements, sulphur and iron, can react together to form a compound.

Activity 6.3: Form compounds of Sulphur and iron.

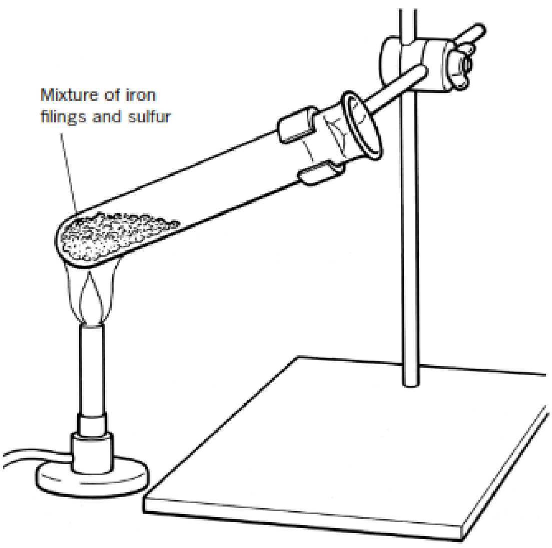
Can the elements sulphur and iron form a compound?

What you need

- 7 g iron filings,
- 4 g powdered roll sulphur,
- magnet,
- test tube,
- burner

What to do

1. Mix the iron filings and sulphur thoroughly.
2. Test the mixture with a magnet. Hold the magnet above the mixture. What do you observe? Which element is attracted by the magnet?
3. Put the mixture in a test tube and clamp it. Heat only a small part of the mixture. Stop the heating as soon as the mixture starts to glow. What happens to the mixture?



4. Take the new solid out of the test tube. Look closely at it. What does it look like? Does the magnet have any effect on it?

5 Do you agree that a completely new substance was formed by the reaction? What are the main differences between the new substance and the mixture of iron filings and sulphur?

The compound formed by the reaction between iron and sulphur is called iron sulphide. The properties of iron sulphide are very different from those of the mixture or of iron or sulphur.

Make a list of the properties in a table like the one below.

Substance	***Appearance***	***Effect of magnet***
Iron filings		
Sulphur		
Product (iron sulphide)		

In the mixture of iron and sulphur, the iron particles and sulphur particles could easily be separated when you used a magnet. In the compound, however, the iron atoms and the sulphur atoms are joined together by the chemical reaction to form the compound iron sulphide. They could not be easily separated.

This reaction can be written down like this:

Iron + sulphur → iron sulphide

In the mixture, atoms of iron and atoms of sulphur were not joined together. When the reaction started, they joined together chemically to form molecules of the compound iron sulphide.

Assignment

Find out which elements combine to form the following compounds: water, carbon dioxide, candle wax, sugar, salt, polythene, starch (white flour), lime, sand.

Classifying elements

How can we classify the 92 elements? There are many ways. One simple way is to classify them into two groups, metals and non-metals. The table below shows some well-known elements in these two classes.

Metals	Non-metals
aluminium	oxygen
iron	nitrogen
magnesium	carbon
copper	iodine
gold	chlorine

Non-metals

At the beginning of the chapter you looked at differences between metals and non-metals. You have seen that most non-metals have the following properties:

- they are poor conductors of electricity
- they are poor conductors of heat
- they are not malleable
- they cannot be pulled out into wires (are not ductile)
- they are not shiny
- they have low densities
- they do not make ringing sounds when dropped on a hard surface.

	Activity 6.3: Find out if non-metal elements burn in air?

What you need

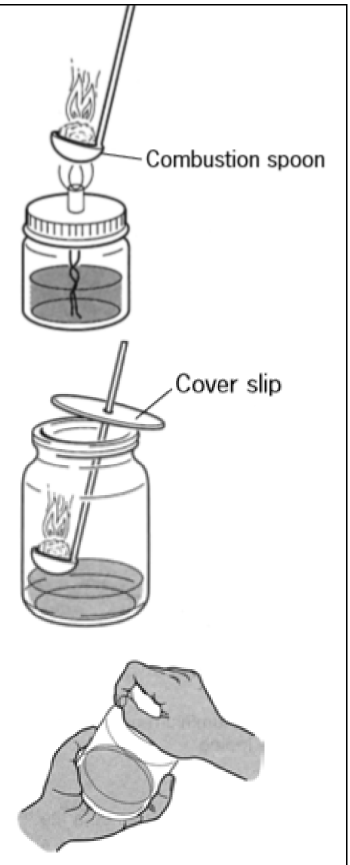
- Small samples of carbon
- phosphorus and sulphur
- combustion spoon
- burner
- us paper
- jars with covers
- water
- blue litm

What to do

1. Put a small sample of each non-metal in a combustion spoon.
2. Carefully heat it.
3. What do you observe? Look carefully at the colour of the flame and whether any smoke is formed.
4. Lower the burning element into a jar with a bit of water in the bottom.
5. Allow the burning element to burn out just above the water.

Take out the combustion spoon and shake the jar to dissolve any gases in the water.

The gases formed when sulphur and phosphorus burn are unpleasant. This part of the activity is best done by the teacher.



7 Test the water with blue litmus paper. Write your results in a table.

Non-metal	Brief description of the reaction	Product	Test with blue litmus	Word equation
Sulphur	melts and burns with yellow flame	sulphur dioxide	red	Sulphur + oxygen sulphur dioxide
Carbon	bluish flame	Carbon dioxide	red	Carbon + oxyegen carbon dioxide
Phosphorous		Phosphorous pentoxide	white	Suphur + oxygen sulphur pentoxide

Integration of Situation

Phosphorus burns with a yellow flame and makes a thick white smoke. Sulphur burns with a pale blue flame and a gas is formed. Carbon glows until there is almost nothing left behind. Again, a gas is produced.

When the products are dissolved in water and tested with blue litmus paper, the litmus paper turns red. This means that the oxides are acidic. This is an important difference between metals and non-metals. Metal oxides are basic but non-metal oxides are acidic.

These are the equations for the reactions:

- carbon + oxygen → carbon dioxide
- sulphur + oxygen → sulphur dioxide
- phosphorus + oxygen → phosphorus pentoxide

You have shown that metals react with one non-metal, oxygen. Do you think that metals will react with other non-metals such as chlorine or iodine?

Summary

You should know that:

- elements can be classified into metals and non-metals.
- metals differ physically from non-metals. Most metals are shiny, strong, dense, malleable and ductile, and also conduct electricity and heat. These properties of metals have made them very useful to us.
- most metals react with oxygen to form metal oxides. This process is called corrosion. The corrosion of iron and steel (an alloy of iron) is called rusting. Water and oxygen cause iron and steel to rust. Iron and steel can be prevented from rusting by coating them with a number of substances. Tin, zinc, chromium, paint, grease and plastic are all used to coat iron to stop it from rusting.
- metals are mixed with other metals (and sometimes with non-metals) to make substances called alloys. Alloys have properties that the original metals do not have. These properties are often very useful to us.
- many metals react with water or acids. When this happens, hydrogen gas is formed. Some metals are more reactive than others. When metals react with water, they form the metal oxide as well as hydrogen.
- non-metal elements also react with oxygen to form oxides. Non-metal elements will react with the more reactive metals.

End – of – Chapter Questions

1 a) List four physical properties of metals.

b) List some metals and non-metals mined in Namibia.

c) Give examples of metals that occur in the ground as free elements and give a reason why they are not combined with other elements.

d) State which is the most common metal in the Earth's crust.

CHAPTER 7

Air

Key Words	**By the end of this chapter, you learn to:**
◆ Air ◆ Rusting ◆ Burning ◆ Oxides ◆ Pollution	▪ *illustrate that air is a mixture of gases that can be separated.* ▪ *explain the effect of air pollution on atmosphere.* ▪ *demonstrate and explain that processes such as burning and rusting use oxygen from air to form oxides.*

Introduction

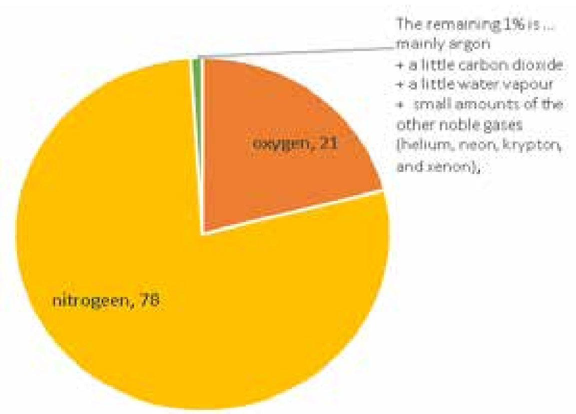
Air is space above the earth's surface. It is also referred to as the atmosphere. It is a layer that is composed of a mixture of gases. It is about 700 km thick. We live in the lowest layer, the troposphere. The gas is at its most dense here, thanks to gravity. As you go up, it quickly thins out. In fact, 90% of the mass of the atmosphere is in the lowest 16 km. Here in the troposphere, we usually call the atmosphere air.

Clean air has specific composition of gases that can be expressed in percentages. This composition of clean air has its natural importance that supports different forms of life and processes that take place in air. This composition has its natural means of maintaining the balance.

Unfortunately, it may no longer be possible to refer to as being clean because some other foreign gases have been deposited into air, hence the term pollution of air. The foreign particles are referred to as pollutants

7.1 Air as a Mixture of Gases

This pie chart shows the gases that make up clean air:



The composition of the air changes very slightly from day to day, and place to place. For example:

- there is more water vapour in the air around you on a damp day;
- pollutants such as carbon monoxide and sulphur dioxide are likely to be given out from busy cities and industrial areas. But since air is continually on the move, the pollutants get spread around too.

Oxygen: the gas we need most

Most of the gases in air are essential to us. For example, we depend on plants for food, and they depend on carbon dioxide. And without nitrogen to dilute the oxygen, fuels would burn too fast for us. But the gas we depend on most is **oxygen**. Without it, we would quickly die. We need it for the process called **respiration**, which goes on in all our cells:

glucose + oxygen $\rightarrow$ carbon dioxide + water+ energy

The energy from respiration keeps us warm, and allows us to move, and enables hundreds of different reactions to go on in our bodies. (And note that respiration, in some form, takes place in the cells of all living things, not only humans.)

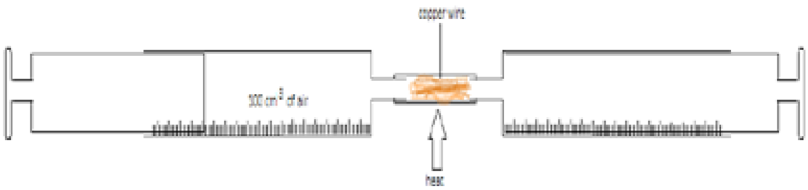
Activity 7.1: Find the percentage of oxygen in the air.

What you need

- Two glass syringes
- Combustion tube
- Copper wire
- Source of heat

What to do

1. Connect combustion tube packed with copper wire to two gas syringes A and B. At the start, syringe A contains 100 cm^3 of air. B is empty.



2. Heat the tube containing copper using a Bunsen burner. Then push in A's plunger, as shown above. This forces the air into B. When A is empty, push in B's plunger, forcing the air back to A. Repeat several times. As the air is pushed to and fro, the oxygen in it reacts with the hot copper, turning it black.
3. Stop heating the tube after about 3 minutes, and allow the apparatus to cool. Then push all the gas into one syringe and measure its volume. (It is now less than 100 cm^3.)
4. Repeat steps 1 and 2 until the volume of the gas remains steady. This means all the oxygen has been used up. Note the final volume.

Results

1. What was the volume of air that remained?
2. What was the volume of air used up?
3. Why did the volume of air decrease?
4. Calculate the fraction and percentage of the air used '
5. What conclusion can you make from your calculation

Questions

What percentage of air is made up of;

a nitrogen? **b** oxygen? **c** nitrogen + oxygen?

About how much more nitrogen is there than oxygen in air, by volume?

What is the combined percentage of all the other gases in air?

Mount Everest is over 8.8 km high. Climbers carry oxygen when attempting to reach its summit. Explain why.

Which do you think is the most reactive gas in air? Why?

a) Write down the name and formula of the black substance that forms in the experiment above.

b) Suggest a way to turn it back into copper

7.2 Separating Components of Air

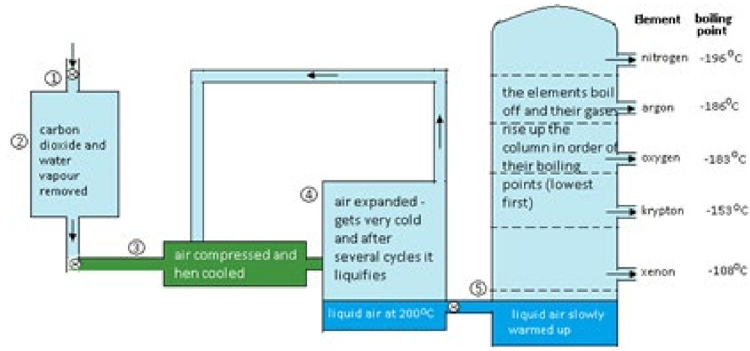
Separating Gases from the Air

As you saw, air is a mixture of gases. Most of them are useful to us. But first, we must separate them from each other. How can we separate gases? There is a very clever way. First the air is cooled until it turns into a liquid. Then the liquid mixture is separated using a method you met in Chapter 2: fractional distillation.

carbon dioxide	-32	
argon	-108	
krypton	-153	
oxygen	-183	
argon	-186	
nitrogen	-196	
Neon	-246	
helium	-269	

The Fractional Distillation of Liquid Air

This method works because the gases in air have different boiling points. (Look at the table.) So, when liquid air is warmed up, the gases boil at different temperatures, and can be collected one by one.



The Steps

The diagram shows the steps.

1 Air is pumped into the plant, and filtered to remove dust particles.

2 Next, water vapour, carbon dioxide, and pollutants are removed (since these would freeze later and block the pipes). Like this:

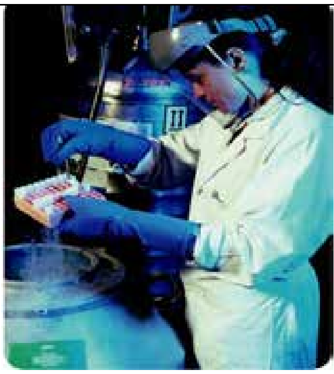
- First the air is cooled until the water vapour condenses to water.
- Then it is passed over beds of adsorbent beads to trap the carbon dioxide, and any pollutants in it.

3 Now the air is forced into a small space, or compressed. That makes it hot. It is cooled down again by recycling cold air, as the diagram shows.

4 The cold, compressed air is passed through a jet, into a larger space. It expands rapidly, and this makes it very cold.

Steps 3 and 4 are repeated several times. The air gets colder each time. By 2200 °C, it is liquid, except for neon and helium. These gases are removed. They can be separated from each other by adsorption on charcoal.

5 The liquid air is pumped into the fractionating column. There, it is slowly warmed up. The gases boil off one by one, and are collected in tanks or cylinders. Nitrogen boils off first. Why?

 Liquid nitrogen is used in medical research, to keep tissue samples frozen	 A patient on oxyge**n**, to help breathing

Easy: slicing through steel with an oxy-acetylene flame.

Some Uses of Oxygen

- Planes carry oxygen supplies. So do divers and astronauts.
- In hospitals, patients with breathing problems are given oxygen through an oxygen mask, or in an oxygen tent. This is a plastic tent that fits over the bed. Oxygen-rich air is pumped into it.
- In steel works, oxygen is used in converting the impure iron from the blast furnace into steels.
- A mixture of oxygen and the gas acetylene (C_2H_2) is used as the fuel in oxy-acetylene torches for cutting and welding metal.

- When this gas mixture burns, the flame can reach 6000 °C. Steel melts at around 3150 °C, so the flame cuts through it by melting it.

Some Uses of Nitrogen

- Liquid nitrogen is very cold. (It boils at 2196 °C.) So, it is used to quick-freeze food in food factories, and to freeze liquid in cracked pipes before repairing them. It is also used in hospitals to store tissue samples.
- Nitrogen is unreactive. So, it is flushed through food packaging to remove oxygen and keep the food fresh. (Oxygen helps decay.)

Some Uses of the Noble Gases

The noble gases are unreactive or inert. This leads to many uses.

- Argon provides the inert atmosphere in ordinary tungsten light bulbs. (In air, the tungsten filament would quickly burn away.)
- Neon is used in advertising signs because it glows red when a current is passed through it.
- Helium is used to fill balloons, since it is very light, and safe.

Questions

In the separation of air into its gases:

- why is the air compressed and then expanded?
- why is argon obtained before oxygen?
- what do you think is the biggest expense? Explain.

Give two uses of oxygen gas.

A mixture of oxygen and acetylene burns with a much hotter flame than a mixture of air and acetylene. Why?

Nitrogen is used to keep food frozen during transportation. Which properties make it suitable for this?

Give three uses for noble gases.

Pollution Can Affect the Atmosphere

The air: a dump for waste gases

Everyone likes clean fresh air. But every year we pump billions of tonnes of harmful gases into the air. Most come from burning fossil fuels.

The fossil fuels

These are coal, petroleum (or crude oil) and natural gas. Natural gas is mainly methane, CH_4. Coal and petroleum are mixtures of many compounds. Most are hydrocarbons – they contain only carbon and hydrogen. But some contain other elements, such as sulphur.
Fossil fuels provide us with energy for heating, and transport, and generating electricity. But there is a drawback: burning them produces harmful compounds. Look at the table below.

The main Air Pollutants

This table shows the main pollutants found in air, and the harm they do:

Pollutant	How is it formed?	What harm does it do?
Carbon monoxide, CO colourless gas, insoluble, no smell	Forms when the carbon compounds in fossil fuels burn in too little air. For example, inside car engines and furnaces.	Poisonous even in low concentrations. It reacts with the haemoglobin in blood, and prevents it from carrying oxygen around the body – so you die from oxygen starvation.
Sulphur dioxide, SO_2 an acidic gas with a sharp smell	Forms when sulphur compounds in the fossil fuels burn. Power stations are the main source of this pollutant.	Irritates the eyes and throat, and causes respiratory (breathing) problems. Dissolves in rain to form acid rain. Acid rain attacks stonework in buildings, especially limestone and marble – they are calcium

Pollutant	How is it formed?	What harm does it do?
		carbonate. It lowers the pH in rivers and lakes, killing fish and other river life. It also kills trees and insects.
Nitrogen oxides, NO and NO_2 acidic gases	Form when the nitrogen and oxygen in air react together, inside hot car engines and hot furnaces.	Cause respiratory problems, and dissolve in rain to give acid rain.
Lead compounds	A compound called tetra-ethyl lead used to be added to petrol, to help it burn smoothly in car engines. It is still added in some countries. On burning, it produces particles of other lead compounds.	Lead damages children's brains. It also damages the kidneys and nervous system in adults.

Reducing Air Pollution

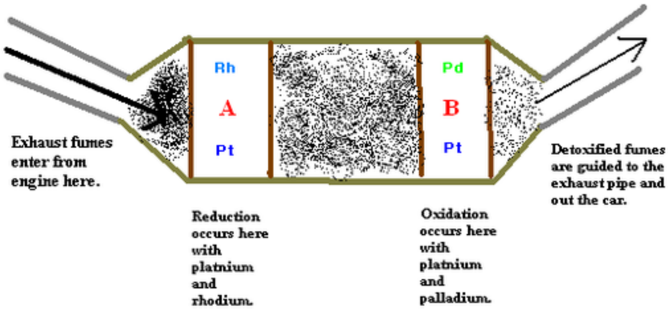
These are some steps being taken to cut down air pollution.

- In modern power stations, the waste gas is treated with slaked lime (calcium hydroxide). This removes sulphur dioxide by reacting with it to give calcium sulphate. The process is called flue gas desulphurisation.
- Most countries have now banned lead in petrol. So, lead pollution is much less of a problem. But it can still arise from plants where lead is extracted, and from battery factories.
- The exhausts of new cars are fitted with catalytic converters, in which harmful gases are converted to harmless ones. See below.

Catalytic Converters for Car Exhausts

When petrol burns in a car engine, harmful gases are produced, including: oxides of nitrogen, carbon monoxide, CO un-burnt hydrocarbons from the petrol; these can cause cancer. To tackle the problem, modern car exhausts contain a catalytic converter.

In this, the harmful gases are adsorbed onto the surface of catalysts, where they react to form harmless gases. The catalysts speed up the reaction. The converter usually has two compartments, marked A and B below:



Catalytic Converter Compartments, marked A and B

Integration of Situation

Resources

Car Fumes

Chimneys are always High

Task

1 What advice would you give to children who run after vehicles that produce fumes? Explain.
2 Why should the chimneys of power stations and factories always be very high?
3 How would you advise a community to reduce the burning of wood, charcoal and oil?
4 What else is being burnt that could cause pollution?
5 How can we keep the dust down?

Summary

You should know that:

- the air is made up of a mixture of gases. It is approximately four-fifths nitrogen, one-fifth oxygen, with small amounts of other gases which include carbon dioxide, argon and water vapour.
- carbon dioxide is made by green plants, humans and animals when they respire. It is also made when fuels that contain carbon, such as wood, coal, oil and gas, burn. It is removed from the atmosphere by photosynthesis.
- we can make carbon dioxide by pouring acid onto some marble chips. Carbon dioxide is a colourless, odourless gas that is heavier than air. It turns limewater milky.
- carbon dioxide dissolves in water. This is important because it allows plants that are under the water to photosynthesise. A solution of carbon dioxide water is slightly acidic.
- carbon dioxide is the gas in fizzy drinks. It is also the gas that makes bread and cakes 'rise'. We make carbon dioxide in cooking by using yeast and by using baking powder.
- carbon dioxide is used in certain fire extinguishers. Solid carbon dioxide is used to keep things like medical supplies cool in cool boxes. It is a white solid and has a temperature of –78 °C.
- oxygen is a colourless, odourless gas that is used up when substances burn. The substances combine with oxygen, giving

out heat energy. The same reaction happens in the cells of living things when they respire. Oxygen will relight a glowing splint.

- oxygen is soluble in water. When water plants and animals respire, they use this dissolved oxygen. Oxygen is produced in the water by water plants when they photosynthesise.
- we use oxygen for welding steel and also to help sick people in hospital breathe better.

End – of – Chapter Questions

1 Which of the following gases makes up around one-fifth of the air?

A) argon C) nitrogen
B) carbon dioxide D) oxygen

2 Which of the following describes photosynthesis?

A) oxygen reacts with starch to produce carbon dioxide and water
B) carbon dioxide and water react to produce starch and oxygen
C) yeast uses sugar to make carbon dioxide and alcohol
D) carbon dioxide turns limewater milky

3 Which of the following reactions uses up carbon dioxide from the air?

A) burning wood C) respiration
B) fermenting yeast D) photosynthesis

4 How much oxygen will there be in a litre of air?

A) 100 cm^3 C) 500 cm^3
B) 800 cm^3 D) 200 cm^3

5 You are given two tubes of a colourless gas. Explain how you could find out if the gas is oxygen or carbon dioxide.

6 Many fuels contain carbon.

a) Name one of the gases that would be produced when fuel burns.
b) Design an experiment to find out whether the methylated spirits in your burner contains carbon.

7 Some wet rotting leaves were placed in a jam jar. A small open tube of limewater was also put in the jar and the lid was screwed onto the jar. After a day or two the limewater looked milky.

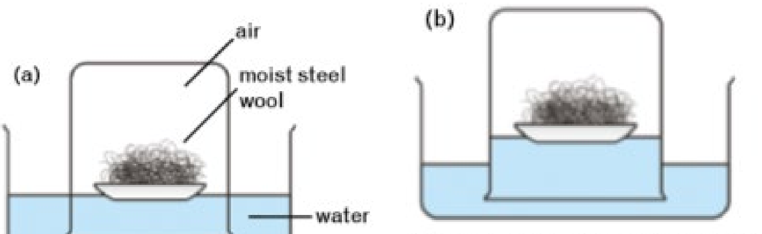
a) Explain why the limewater turned milky.
b) Explain what the experiment tells you about what happens when leaves rot.

8 When you unscrew the top of a bottle of fizzy drink, you see bubbles coming up. Explain how you would try to find out if the bubbles were carbon dioxide. Draw a picture showing what you would do.

9 Observe - explain

Write a sentence explaining each of these observations. If you do not know the answer, use your scientific knowledge to suggest one.

a) Rainwater is always slightly acidic.
b) If you cover a fire with sand, it stops burning.
c) Water plant leaves are often covered with bubbles when the sun shines on them. If the bubbles are collected, they will relight a glowing splint.
d) The equipment in sketch (a) was set up. A week later the water levels were as shown in sketch (b).



The same equipment after a week

e) Fires burn more strongly when a wind is blowing.

CHAPTER 8

Water

This is part of river Nile in Uganda

Key Words	**By the end of this chapter, you will learn to:**
◆ Natural resource ◆ Water cycle ◆ Sewage ◆ Recycle	▪ *eutline the occurrence of water as a natural resource, demonstrate physical and chemical properties of water and explain the importance of water in everyday life.* ▪ *eemonstrate how water is recycled by the natural process.* ▪ *explain and demonstrate the process of water and sewage treatment.*

Introduction

Water is a common liquid. Most of it found in seas and oceans where it contains dissolve salts making it unsuitable for many uses. It is usually known as salty water (non-fresh water) Less than 3% occurs as fresh water found in lakes, rivers, wells, springs. Some form of water occurs as water vapour in the atmosphere.

Presence of water and its supply is very vital to all forms of life.

Water is a colourless, odourless, tasteless liquid. It is an oxide of hydrogen. Each molecule of water is made of two atoms of hydrogen and one of oxygen. We write its formula, H_2O. Water is such a common substance that we do not think much about it. And yet it is a very unusual and surprising substance in many ways. Here are two reasons why it is surprising:

- The first surprising thing about water is that it is a liquid. Other similar substances like ammonia (NH_3), hydrogen sulfide (H_2S) and hydrogen chloride (HCl) are gases.
- The second unusual thing about water is that when it cools below 4 °C it does not contract like other substances, it expands. This means that ice, or solid water, is less dense than liquid water and floats on it.

Do you think it would be possible for life to exist on Earth if water was a gas at the normal temperatures found on Earth?

Do you think it would be possible for life to exist in water if ice formed at the bottom of water?

If water were not such a surprising substance we would not be here!

Properties of Water

All substances have physical properties and chemical properties. Physical properties are the properties that we can measure, such as the temperature at which a substance melts or boils, its density or whether it is a solid, liquid or gas. The chemical properties of a substance are the kinds of chemical reactions it takes part in.

Physical Properties of Water: Freezing and Boiling Points

You may remember from your work in primary Integrated Science that the boiling point of water is 100°C and the freezing point of water is 0°C. You will have learnt that this is a test for water.

If you have a colourless liquid that looks like water you can find its boiling and freezing points; if they are 100°C and 0°C then the liquid must be water because no other liquid has these two properties.

All this, however, is not quite true. Firstly, unless you live near the coast, if you boil water you will find that it boils at less than 100°C. The boiling point of water differs from place to place in Uganda.

At Kampala, which is close to Lake Victoria at a lower altitude, the boiling point is 100°C. For every 500 metres above sea level, the boiling point drops about 1°C. What is the boiling point of water where you live? Can you calculate roughly how high above sea level you are?

Water boils at a lower temperature if the atmospheric pressure is low. You learnt in primary that atmospheric pressure is lower at higher altitudes. This is why the boiling point of water is lower in the Arua (96°C) than in Kampala (98°C). Any impurities in the water will raise the boiling point and lower its freezing point. In some countries rain freezes on the roads during winter nights. This makes the roads slippery and dangerous.

To make the roads less slippery, salt is spread on these roads. The salt lowers the freezing point of the water and prevents the formation of ice when the temperature drops below 0 °C at night. You can show this by adding some salt to crushed ice and taking the temperature of the mixture. The temperature will drop below 0 °C and you will notice that some of the ice melts.

Physical Properties of Water: Density

You will remember from Grade 8 that one cubic centimetre of water has a mass of 1 g and that 1 cubic decimetre has a mass of 1 kg. This is the density of water – water has a density of 1 g/cm^3 or 1 kg/dm^3. But this also is not quite always true. Try the following activity.

8.1 To find out what happens to fresh egg when you put it in water?

What you need

- Egg,
- water,
- jam jars,
- salt,
- spoon

What to do

1. Fill the jar about two-thirds with pure water. Put in the egg. Note what happens.
2. Add salt to the water and stir. Now what happens to the egg?
3. Can you explain what you observe?

Predict, observe, and explain

1. Pour some salt water in a jar and then very carefully pour pure water on top of the salt water. It will stay on top because it is less dense.
2. Predict what will happen when you put in the egg. Test your prediction.

3 Explain what you observe.

In this activity the egg does not change but the water does. A fresh egg sinks in pure water but floats in salt water. This is because the egg has a density of just over 1.1 g/cm^3 (you could measure it) and so it sinks in pure water because it is denser than pure water.

When you put an egg in salt water it floats. This tells you that the density of the salt water is more than the egg and so it is also more than pure water. So, the density of water increases when substances dissolve in it. This is important in the oceans; very salty water is dense and sinks. This sinking process causes many of the world's ocean currents and these affect our weather.

Chemical Properties of Water

You know from primary that water is a good **solvent**. Many things dissolve in water to form solutions and sometimes these solutions have important chemical properties. They may be acidic or alkaline, for example. The next activity shows a simple chemical test for water.

Activity 8.2: Find out if a colourless liquid contains water.

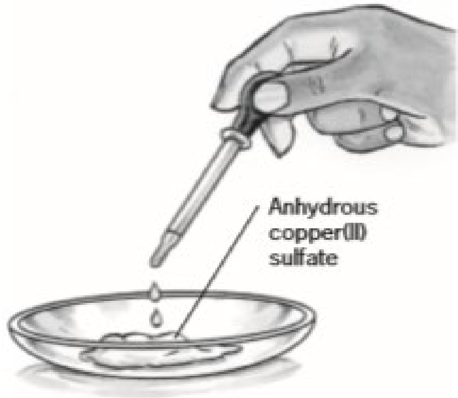
There are many liquids that are not water. If we have a colourless liquid how can we find out if it contains water?

What you need

- Anhydrous copper(II) sulphate,
- tap water,
- methylated spirits,
- paraffin,
- distilled water,
- salt solution,
- sugar solution,
- vinegar,
- watch glass,
- teaspoon

What to do

1. Place a few crystals of anhydrous copper sulfate on the watch glass.
2. Add drops of tap water to the anhydrous copper sulfate. In a table like the one below, record your observations.
3. Wash off the copper sulfate and dry the watch glass.
4. Repeat steps 1 to 3 with the other liquids and record your observations.



Liquid	Observations
Tap water	
sugar solution	
Paraffin	
…	

Did you notice that most of the liquids turned the copper sulphate blue? Water will make anhydrous copper sulphate turn from **white** to **blue**.

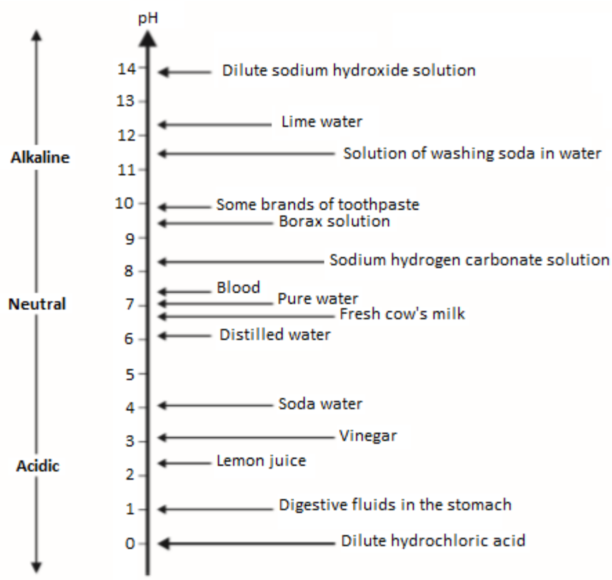
Which of the liquids tested contained water?

You may be surprised to find that a liquid like methylated sprits may contain water. It is often very difficult to get all the water out of many liquids, even out of a liquid such as petrol.

Water and pH

Do you remember any work you did on acids and alkalis? Acids and alkalis are solutions of some compounds in water. Lemon juice is an example of an acid solution. Washing soda solution is alkaline.

Acids have a sharp taste while alkalis have a nasty bitter taste. Acids and alkalis react with each other – they neutralise each other.



Do you remember this pH scale?
Pure water has a pH of 7 but water is such a good solvent that it is not often pure. Rainwater has a pH of about 5 to 6 because it has carbon dioxide dissolved in it, which makes it slightly acidic. Strong acids are found at the bottom of the scale and strong alkalis at the top. Weak acids are found in the middle of the scale below 7 and weak alkalis in the middle above 7.

You can tell whether a solution is acidic or alkaline with litmus. Litmus is an **indicator** – it turns red when it is in acid solutions and blue in alkalis.

You can find the pH of a solution using universal indicator paper, which changes a different colour depending on the pH of the solution it is dipped in.

8.1 Understanding the Occurrence of Water

We all need water.

At home we need it for drinking, cooking, washing things (including ourselves) and flushing toilet waste away.
On farms it is needed as a drink for animals, and to water crops.
In industry, they use it as a solvent, and to wash things, and to keep hot reaction tanks cool. (Cold-water pipes are coiled around the tanks.)
In power stations it is heated to make steam. The steam then drives the turbines that generate electricity.

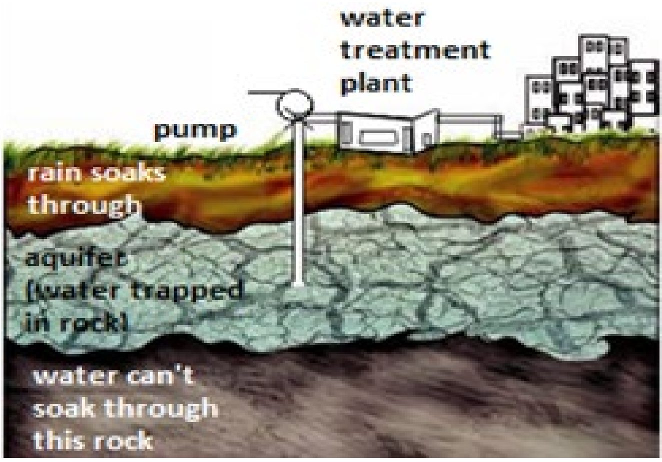
Everyone needs water

So where does the water come from?

Much of the water we use is taken from rivers. But some is pumped up from below ground, where water that has drained down through the soil lies trapped in rocks.

This underground water is called **groundwater**. A large area of rock may hold a lot of groundwater, like a sponge. This rock is called an **aquifer**.

Is it clean?

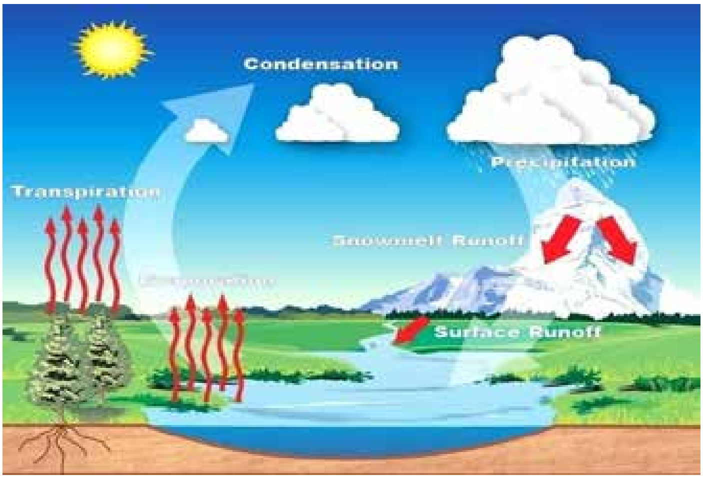


River water is not clean – even if it looks it! It will contain particles of mud, and animal waste, and bits of dead vegetation. But worst of all are the microbes: bacteria and d other tiny organisms that can make us ill.

Over 1 billion people around the world have no access to clean water. They depend on dirty rivers for their drinking water. And over 2 million people, mainly children, die each year from diarrhoea and diseases such as cholera and typhoid, caused by drinking infected water.

8.2 Water Cycle

The water cycle is vital to supporting all life on earth. Without it, nothing would grow or survive. This set of activities introduces the stages of the water cycle to pupils so they can see all the different processes at work. The activities can be used to enable pupils to gain a broader picture of why water is essential to life.



	Activity 8.3. Build a model water cycle.

What you need

- A clear plastic jar (they should label their jars so that they can observe and record what is happening)
- Cling film or sheets of clear plastic
- Rubber band
- Soil
- Seed
- Measuring cup
- Water

What to do

1. Ensure that the plastic jar is clean and dry.
2. Add a layer of soil to the bottom of the jar. The layer should be about 2 cm deep.
3. Sprinkle about half a teaspoon of chicken feed over the soil.
4. Cover the seeds with another layer of soil that is also about 2 cm deep.

5 Measure 60 ml of water using the measuring cup. Slowly pour this over the soil. Make sure the water is poured evenly over the soil's surface.
6 Cover the top of the jar with cling film or plastic and secure it with a rubber band.
7 Place the jars on a window sill or other place where they can remain in direct sunlight. Over the next few days, the pupils should examine their jars and record what they can see.

Results

1 How did the appearance of the jar and plastic cover change?
2 Did droplets appear on the inside or outside of the jar?
3 Where do you think the droplets came from?
4 What happened to the seed?
5 What role did sunlight play in the change from liquid water to water vapour?

8.3 Water and Sewage Treatment

Water Pollution

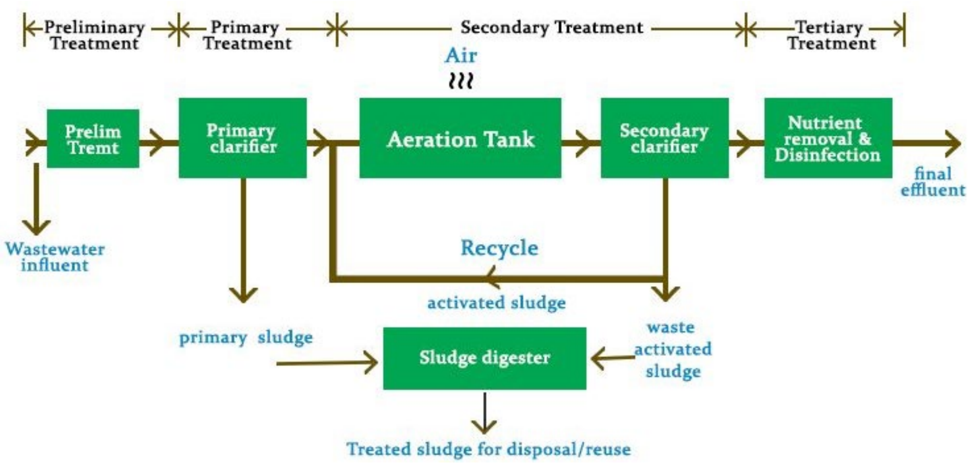
What should we do with water after we have used it?

Think how often we use water for cleaning things. We use water for cleaning because it dissolves substances so easily. We make the water dirty when we use it for cleaning because many things dissolve in it. Every day we throw away a lot of water that has things dissolved in it.

What happens to this impure water? If we let it get into our rivers and wells, it will pollute the water and we will not have clean water to drink and use. Many of the plants and animals that need clean water will also suffer or die. When this happens we call it water pollution.

We have sewage works which clean polluted water. We need the sewage works because we need the water which is such a good and useful solvent.

Waste from sinks and toilets are called sewage. It is mainly water, but it contains many solids that are dissolved in it. The sewage also contains substances that are not soluble, such as faeces and toilet paper. It also contains harmful bacteria which can cause serious diseases. It is very important that we treat our sewage to make sure it does not pollute our rivers and our wells. In many towns the sewage from toilets goes to the sewage works. In the sewage works the sewage is filtered and the water is cleaned. It is dangerous to drink unpurified river water and groundwater, even if it looks clean. The bacteria that make us sick are too small to see. The picture showing some bacteria was taken using a microscope. The bacteria are less than one hundredth of a millimetre long. The diagram below shows how water is purified before we use it, and also how it is treated after we use it.



Liquid Waste (Sewage/Wastewater) Treatment

Wastewater (liquid waste) from flushing the toilet, bathing, washing sinks and general cleaning goes down the drain and into a pipe, which joins a larger sewer pipe under the road. The larger pipe also joins a major pipe that leads to the treatment centre.

Stage One: Screening

Screening is the first stage of the wastewater treatment process. Screening removes large objects like, diapers, nappies, sanitary items, cotton buds, face wipes and even broken bottles, bottle tops, plastics and rags that may block or damage equipment.

Special equipment is also used to remove grit that gets washed into the sewer.

Stage Two: Primary Treatment

This involves the separation of organic solid matter (or human waste) from the wastewater. This is done by putting the wastewater into large settlement tanks for the solids to sink to the bottom of the tank. The settled solids are called ‘sludge’.

At the bottom of these circular tanks, large scrappers continuously scrape the floor of the tank and push the sludge towards the centre where it is pumped away for further treatment. The rest of the water is then moved to the Secondary treatment.

Stage Three: Secondary Treatment

The water, at this stage, is put into large rectangular tanks. These are called aeration lanes. Air is pumped into the water to encourage bacteria to break down the tiny bits of sludge that escaped the sludge scrapping process.

Stage Four: Final Treatment

Next, the ‘almost’ treated wastewater is passed through a settlement tank. Here, more sludge is formed at the bottom of the tank from the settling of the bacterial action. Again, the sludge is scraped and collected for treatment. The water at this stage is almost free from harmful substances and chemicals.

The water is allowed to flow over a wall where it is filtered through a bed of sand to remove any additional particles.

Summary

- Water is a colourless, odourless and tasteless liquid and is the compound formed between hydrogen and oxygen. Unlike other similar compounds of hydrogen, it is a liquid at the normal temperatures found on Earth. Ice, which is solid water, is unusual because it is less dense than liquid water and floats on top of it. Both these unusual properties are essential to life on Earth.
- Pure water has a boiling point of 100 °C and a freezing point of 0 °C at sea level. It has a density of 1 g/cm^3. The chemical test for water is that it turns white anhydrous copper sulphate blue.
- Hard water is water that does not lather easily with soap. Hardness is caused by substances that are dissolved in the water. These substances are usually salts of the elements; calcium or magnesium, which have dissolved in the water in the rivers or under the ground. Sometimes the hard water can be softened by boiling the water. This kind of hardness is usually caused by the presence of calcium hydrogen carbonate (also called calcium bicarbonate) in the water.
- We need water for drinking, cooking, washing, agriculture and industry. Because some countries are dry, they must recycle their water and reuse it. There are many underground water sources, but it often takes hundreds of years for rain to replace them when we use them, so we must try and use water from dams or reservoirs wherever possible.
- Water is a very good solvent. Dissolved substances often alter the pH of water making it alkaline or acidic.

CHAPTER 9

Rocks and Minerals

Key Words	By the end of this chapter, you will learn to:
◆ **Rock** ◆ **Mineral** ◆ **Igneous rock** ◆ **Magma** ◆ **Earth Solution** ◆ **Precipitates** ◆ **Ion** ◆ **Sedimentary rock** ◆ **Metamorphic rock** ◆ **Cycle** ◆ **ore** ◆ **Prospecting** ◆ **Remote sensing** ◆ **Geochemical**	▪ describe, with examples, the characteristics of igneous, sedimentary and metamorphic rocks ▪ explain the formation of igneous, sedimentary and metamorphic rocks ▪ explain the rock cycle ▪ describe surface and subsurface mining ▪ describe the reasons for extracting rocks and minerals ▪ describe the impact of rock and mineral extraction on the environment and human populations ▪ discuss methods of landscape restoration after rock and mineral extraction ▪ explain the terms sustainable resource and sustainable development ▪ discuss how rocks and minerals can be used sustainably.

Introduction

The study of rocks, minerals and earth's surface is called geology. A person who studies these things is therefore called a geologist. To understand everything about rocks and minerals, let us first define the terms "rocks and "minerals"

	Activity 9.1: Identify rocks and minerals.

In this activity, you will describe the given samples and try to identify whether they are rocks or minerals.

What you need

Samples of rocks and minerals

What to do

1 Obtain the samples of the rocks or minerals from the teacher to study.

2 Label the samples as A, B, C and D

A

B

C

D

Fig. 9.1 (A) Granite (B) Limestone (C) Mica (D) Feldspar

Results

Specimen	Description	Is it a rock or a mineral	Name of rock or mineral
A			
B			
C			
D			

Activity 9.2: Study minerals.

In this activity, you'll study and describe a sample of a mineral.

What you need

- Sample of quartz
- hand lens

What to do

1 In Activity 1, you have already identified a mineral. In this activity you will study another mineral called, quartz.

2 Obtain the mineral from your teacher or use the photo below instead to study.

3 Observe the mineral and answer the question in the table below.

Fig. 9.2 Quartz

Questions	**Observations**
1. What is the chemical composition of quartz?	
2. Is the quartz the same mineral throughout?	
3. Describe some features of quartz (e.g. shape, colour and hardness) that you can identify	

Minerals

Minerals are building blocks of all rocks. They are natural substances in which the particles are arranged in patterns. Minerals often occur in beautiful shapes called **crystals**. Metals, gems and industrial materials of many kinds are made of minerals. Examples of minerals are quartz, mica and feldspar as seen in Fig. 9.1, and Fig.9.2.

Only eight elements- oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium make up 99% of all minerals. For example, quartz is made up of silicon and oxygen- these are the two most common elements that make up the Earth.

Some minerals are made up of only one metal element, such as gold, silver or platinum, and are called **native metals.**

Characteristics of Minerals

Minerals have different properties and characteristics as described below.

Hardness is an important property of minerals. A mineral is harder than the other if it can scratch it, without getting scratched itself. The scale for hardness of minerals was invented by an Australian called Frederic Mohs in 1812. The scale ranges from 1 – 10 points. Ten (10) on the point scale is the hardest, and one (1) on the scale is the softest.

If a mineral is higher on the Mohs than another, it can scratch the one that is lower. Consider the Mohs scale below (left) and some common objects rate on the scale (right).

Mohs scale of hardness	
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Hardness of common objects	
Finger nail	2.5
Copper coin	3.5
Iron nail	4.5
Glass	5.5
Steel knife	6.5
Emery board	9.5

Activity 9.3: Identify minerals using "hardness scale".

In this activity, you will put four samples of rock in order of their hardness.

What you need

- Mineral samples (magnetite, quartz, calcite and azunite)
- iron nail
- glass
- steel knife

What to do

1. This is a scratching activity. It should be done in groups. The table of common objects above shows that a steel knife has a hardness of 6.5. Scratch the mineral samples using the knife. Be careful when handling the knife.
2. Does the knife scratch all the samples?
3. Use the iron nail, glass and your fingernail to scratch all four samples. Use the results to put the samples in order of hardness.
4. Record the hardness in order in the table. Write your description of each in the correct space in the table.

Results

Sample	Mineral samples	Description of the mineral	Hardness scale
A	Magnetite		
B	Quartz		
C	Calcite		
D	Azunite		

Although a mineral may have a specific **colour**, this is not a reliable enough property to identify it. A better method is to crash it into a powder.

The colour of a powdered mineral is called its **streak.** This can be seen by rubbing a mineral on a white tile. Some minerals do not produce a streak, while other powdered minerals have different coloured streak than the mineral itself.

Many groups of people worldwide use powdered minerals as decorations for painting materials.

Fig. 9.3: 'Imbalu' Boy being Circumcised

In Uganda, the Bagisu use some kind of clay mixed with white sorghum flour for decoration when performing the 'imbalu' dance in preparation for circumcision. The powder of the clay and sorghum flour are mixed with water and applied to the bodies and faces of the boys as in Fig. 9.3.

The table below shows colours found in some common rocks:

Name of coloured rock	Colour of streak	Where coloured rock is collected
Haematite	Red	Found in pebbles (murram)
Kaolin	White	In creek or river beds
Charcoal	Black	Produced in fires

Different colours in minerals are caused by the different chemicals in them. The red colour of haematite is caused by lots of iron (also known as rust). These coloured rocks can mix to form other colours. Charcoal is commonly mixed with kaolin to make grey. The powders are also mixed with egg, juice or blood to make a paste that can be painted onto rocks or body.

Fig. 9.4: Body Painting using Powder from Sandstone/iron oxide in Uganda

Crystals

Many minerals have a specific crystal structure. The word 'crystal' comes from Greek word *kryos,* meaning 'icy cold'. In ancient times it was believed that quartz crystals were composed of water that had frozen so solid that it could never melt.

Because each mineral has a different crystal structure and colour, they reflect light differently. **Lustre** is a term that refers to the way a mineral reflects light.

Some crystals have an internal structure that causes them to break apart more easily in particular directions. These are called **cleavage planes.**

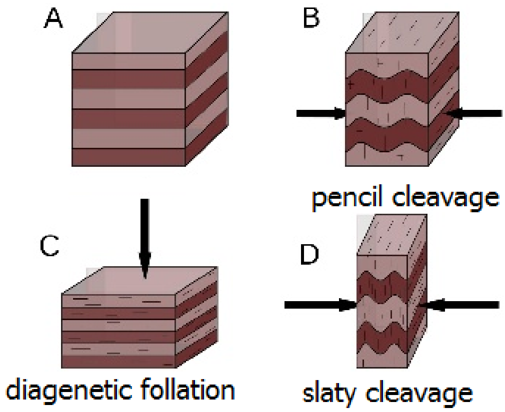


Fig. 9.5: Cleavage Planes

Rocks

	**Activity 9.4: Study granite rock.**

In this activity, you'll study the properties and formation of granite.

What you need

- Granite rock
- hand lens

What to do

1 In Activity 9.1 you have already identified a rock.

2 You obtain a sample of granite for this activity from your teacher

3 Observe the granite and answer the following questions in the table below.

Questions	**Observations**
1. Which minerals make granite?	
2. How does granite form?	

3. Describe some physical properties of granite (e.g. shape, colour and hardness) that you are able to identify	

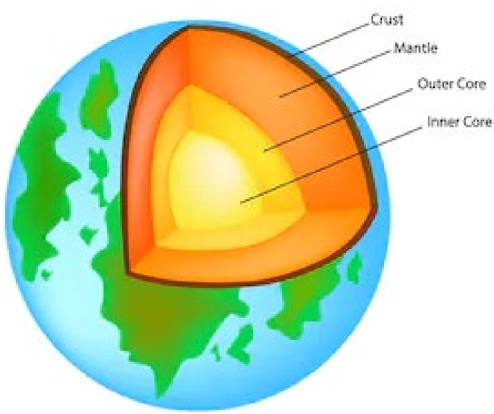
Ores

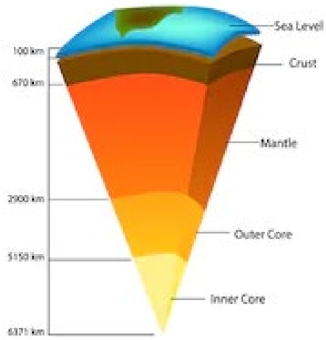
Ores are rocks or minerals containing elements that can be extracted. For example, iron is extracted from an ore called **haematite**, and aluminium from the ore **bauxite**. This is a Table of some economically important minerals in Uganda:

Mineral	Source	Use
Gold		
Limestone		
Iron ore		
Copper		

Formation of Rocks

Types of Rocks





Igneous Rocks

Igneous rocks are formed when molten rock from the crust and upper mantle cools. The molten rock is called magma when it is still below the surface and lava when it reaches the surface. Magma is found in the outer mantle; it is hot, liquid rock that is under pressure from the rocks above it. When it cools it turns to solid rock. When liquid magma rises to the surface from volcanoes the cooling occurs quickly and forms lava. Igneous rocks are made of material that was once molten; they usually contain crystals that are formed as the molten material cools.

The crystals found in rocks are formed when solutions of minerals cannot absorb any more dissolved minerals. Some of each mineral type precipitates out of solution to form the centre of a crystal. This then provides a surface for more mineral ions to precipitate onto. The crystal becomes larger until the solution disappears.

If the rock cools quickly, only very small crystals can form before the rock becomes solid. Rapid cooling occurs when magma is released from volcanoes onto the surface of the Earth's crust.

If magma rises from the mantle into the crust without reaching the Earth's surface, then the magma cools more slowly, allowing the formation of larger crystals. Many of these crystals contain valuable minerals that are used for a wide range of industrial processes. Heat and pressure are the usual reason for minerals becoming dissolved; a reduction of heat and pressure usually leads to the formation of crystals.

Examples of igneous rocks are granite and basalt (Figures 9.2 and 9.3).

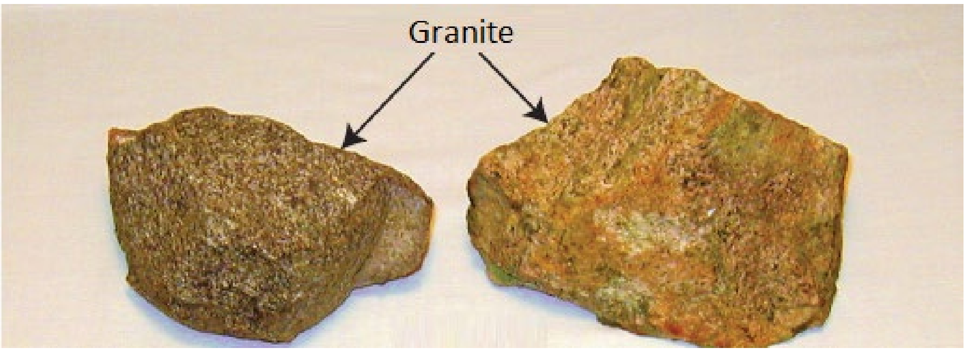


Fig. 9.5 Pieces of Granite

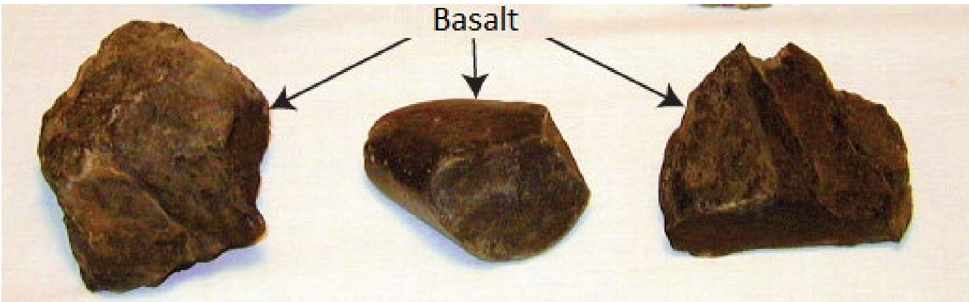


Fig. 9.6 Pieces of Basalt

Sedimentary Rocks

Sedimentary rocks are formed by the weathering of existing rocks at the Earth's surface, the accumulation and fossilisation of living material, or the precipitation of dissolved materials out of solution in water. Weathering processes release small mineral particles that accumulate to form sediment. Over time, layers of sediment build up to form sedimentary rock. The sediments include different-sized mineral particles.

The smallest particles are clays, followed by silts and then sands. These particles are important in the formation of soils. Larger particles of gravels and small boulders can also be found in sediments.

The particles are transported by streams and rivers and then deposited as sediment. Each layer of sediment becomes more compact and harder because of the pressure created by the newer deposits above them. Examples of sedimentary rock are limestone, sandstone and shale.

Fig. 9.7. A Piece of Limestone

Fig. 9.8 Sandstone

Fig. 9.9 A Piece of Shale

Metamorphic Rocks

Metamorphic rocks are created from existing rocks when the heat (above 150 °C) or pressure (above 1.5 × 108 Pa or 1480 atm), or both heat and pressure, causes changes in the rock crystals without melting the existing rock.

The existing rock therefore changes in structure, becoming a metamorphic rock. The changes in structure can be chemical or physical or both.

Sedimentary and igneous rocks can become metamorphic rocks, and a metamorphic rock can become another metamorphic rock. Metamorphic rocks are usually harder than sedimentary rocks.

Examples of metamorphic rocks are marble and slate

(Figures 9.7 and 9.8).

When the Earth's crust first formed, all the rocks were igneous. These rocks were slowly eroded, releasing small particles that formed sediment, and these sediments built up over time to form sedimentary rocks. The rocks that make up the Earth's crust are always moving, which creates the heat and pressure needed to form metamorphic rock.

All rock types are constantly eroded and formed in the rock cycle (Figure 8.9). Table 1.1 compares the characteristics of the different rock types.

Igneous	Sedimentary	Metamorphic
Made from liquid magma	Made from other rock fragments	Made from existing rock
Magma cools to form solid rock	Rock fragments become buried and increased pressure forms a rock	The original rock is changed in form by heat and pressure
Mineral crystals sometimes present; the size of the crystals depends on the speed of cooling	Crystals absent	Mineral crystals present
No fossils present	Fossils may be present	No fossils present

Table showing characteristics of the different rock types.

Fig. 9.10. A piece of marble.

Fig. 9.11. A piece of slate

The Rock Cycle

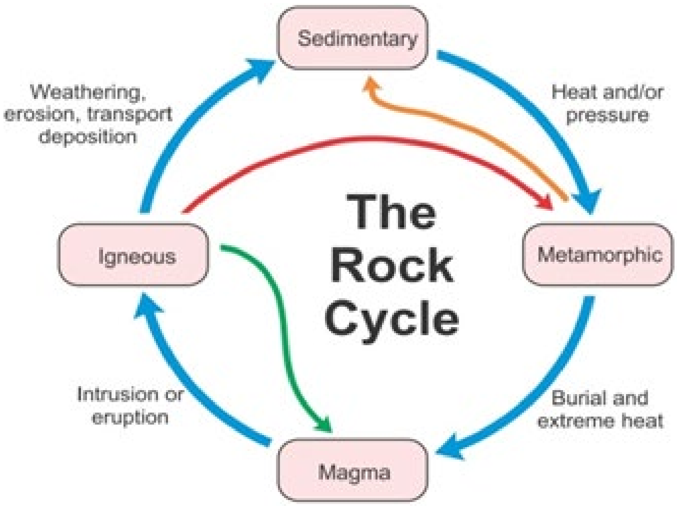


Fig. 9.12

The figure above shows the rock cycle relationship between three rock types, sedimentary, metamorphic and igneous. The diagram also shows the interactions between these types, their origins and the processes by which they are interconnected.

	Activity 8.1: Rocks and the Cycle.

What you need

- For the first part you will need to be able to access the Interactive Rock Cycle website (www.cambridge.org/ links/scspenv4000).
- For the second part, which can be done on a different day, your teacher will provide you with a selection of rocks.

What to do

1. For the first part of the practical, go to the web page and look at the interactive diagram.
2. For the second part of the practical, choose one of the rocks.
3. Observe and describe your chosen rock, thinking about things like shape, colour, weight, softness or hardness.
4. Return your rock to the table, and put a letter by it. Each rock should end up with a different letter by it.
5. Working on your own, select another rock but this time do not pick it up.
6. Spend about five minutes writing a description of your rock, without anyone else knowing which one it is.
7. Swap your description with someone else and take it in turns to work out which rock has been described.

Extraction of Rocks and Minerals from the Earth

Minerals provide us with a wide range of materials that we use in everyday life. Coal and oil provide energy and many chemicals used in industry. Metallic **ores** provide us with the metals and alloys needed to make products such as computers, mobile phones, cars, wires and nails. The demand for minerals continues to increase, both from developed and developing countries.

Fig. 9.13 Mubende Gold Mining

Summary

You should know that:

- A rock is:
  - A solid
  - Naturally occurring
  - Is made up of minerals or mineral like matter.
- **s**ome rocks are composed of just one mineral. Pyrite and quartz are two common rocks that fit this category. Most rocks are a solid mixture of several minerals like granite.
- rocks are classified by how they are formed. There are three basic groups, igneous, sedimentary, and metamorphic.
- in each group of rocks, distinctions are made for texture or grain size and chemical or mineral content.
- minerals are building blocks of all rocks.
- Mohs scale of hardness is used to identify common minerals

End – of – Chapter Questions

1. What is meant by the term rock?
2. What is meant by the term mineral?
3. What is meant by a rock cycle?

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