CHAPTER 1

Chemistry and Society

Key Words	**By the end of this chapter, you should be able to:**
◆ chemistry ◆ careers ◆ science ◆ technology ◆ society	▪ *know appropriate activities to explain the discrete nature of chemistry (k, u)* ▪ *understand why chemistry is studied and how it overlaps with other subjects such as biology, physics, mathematics, and geology (k, u)* ▪ *understand the importance of chemistry and relate knowledge of chemistry to relevant careers (u)* ▪ *know the contribution of chemistry to the Ugandan economy (k)*

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 chapter, 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 non-living things. All living and non-living 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: Finding substances in our everyday life that relate to Chemistry.

1 In groups, 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 local chemistry in your local environments are related to chemistry.

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

Critically observe the pictures below and answer the following questions.

Fig 1.1: Showing some common products used in everyday life

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 1.3: Finding out what changes take place to substances in everyday

1. Burn a piece of paper using a candle or a lighted match stick. 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
   iv) Describe the changes that take place in each of the processes (i – iii) above.
   v) 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 1.4: Discussing the reasons why we study or we should study chemistry

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

1 In groups, 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 1.5: Finding 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.

Table 1.1. Examples of chemistry in everyday life

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: Carrying research on the contribution of Chemistry to the economy of Uganda

1. In groups, 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. Your sensitisation message should clearly bring out the application of Chemistry in everyday life, contribution of Chemistry to the economy of the society and ensure that members of the community appreciate the use of Chemistry in everyday life.

You can use the resources in Fig. 2 and 3 to develop your message.

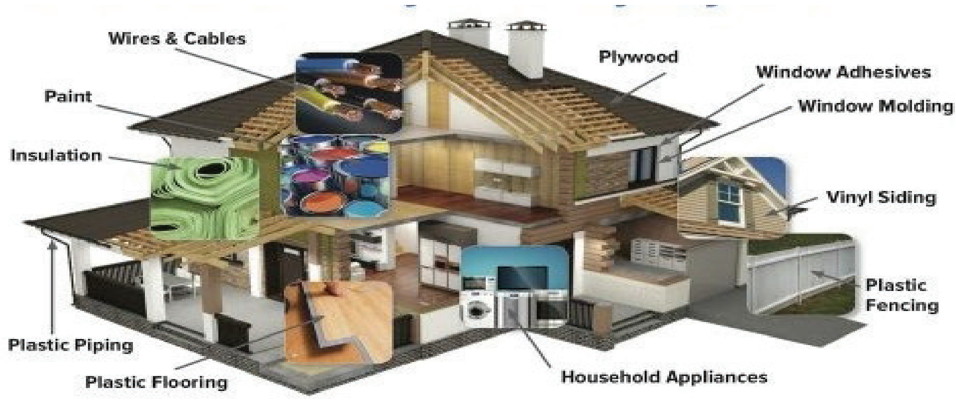

Fig. 1.2: Materials used on a house

Fig. 1.3: Common things we eat and drink

Summary

In this chapter you have learnt 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 chemistry in your local environments are related to chemistry.
- Chemistry is the study of 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

Key Words	By the end of this chapter, you should be able to:
◆ laboratory ◆ apparatus ◆ experiment ◆ purity ◆ scientific method	▪ *know laboratory rules and regulations and understand the importance of risk assessment in order to work safely, and action required in the event of an accident (k)* ▪ *know and use laboratory equipment (such as burettes, pipettes, measuring cylinders, thermometers, the Bunsen burner, and balance) appropriately for measuring time, temperature, mass and volume (s, k)* ▪ *understand the scientific method to carry out investigations and the importance of risk assessment to keep self and others safe (u)* ▪ *know how to purify a mixture, given information about the substances involved (s, k)* ▪ *know how to identify substances and their purity by using their melting and boiling points (k, s)*

Competency: Understand that chemistry is a process of evidence-based enquiry involving the collection of evidence about the natural world, the identification of trends and patterns in the evidence and the development of theories that help us explain the evidence.

Introduction

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: Preparing a Fruit Juice

In groups, 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?

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

1. Observing a particular behaviour.
2. Making immediate conclusions about the behaviour.
3. Identifying a problem to be acted upon.
4. Making a hypothesis.
5. Determining and controlling variables.
6. Planning methods of investigation.
7. Analysing and interpreting data.

Project Work

Identify a suitable activity of interest where the scientific process will be applied or used

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: Reading a passage about rules in the laboratory

What to do

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 colourless 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: Identifying 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.

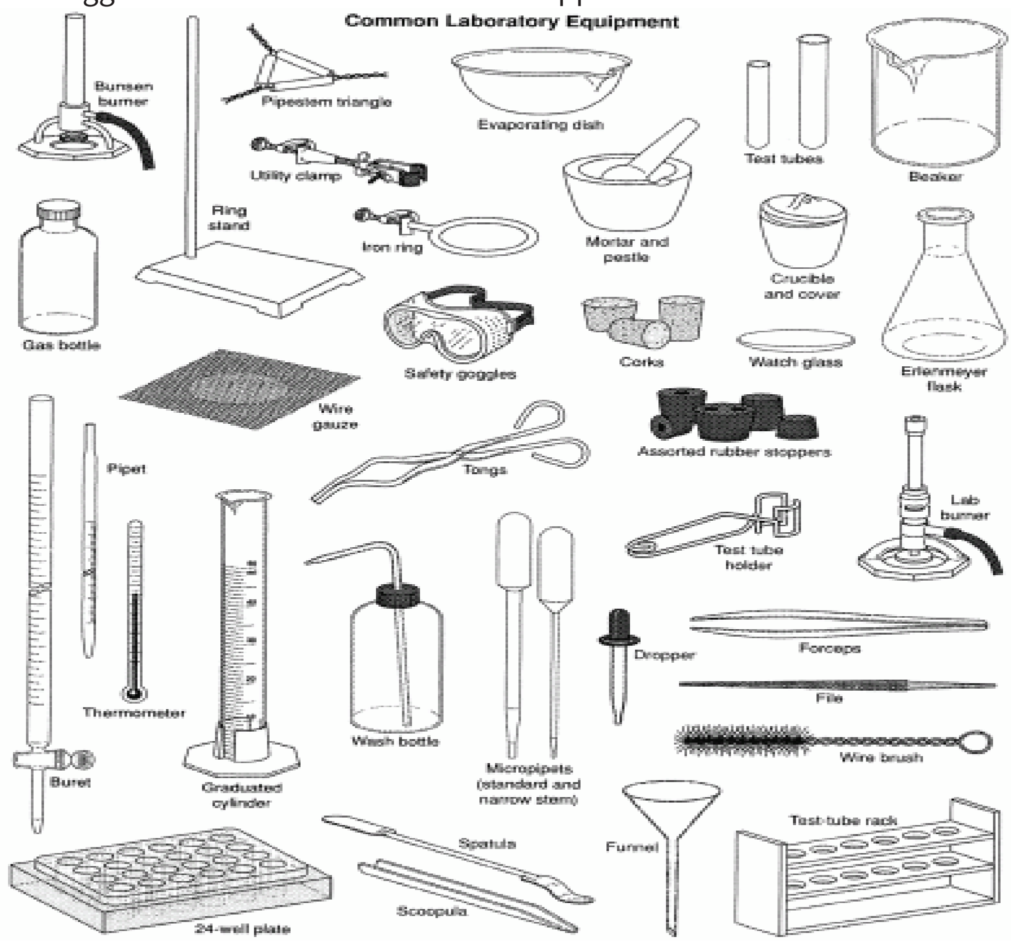

Fig. 2.1: Common laboratory apparatus

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

What you need

- Graduated beaker ($250cm^3$)
- Measuring cylinder ($100cm^3$)
- Burette
- Water
- 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
3. Transfer the water into an empty burette and note the volume.
4. 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.

Fig. 2.2: Weighing balance

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. 2.3: 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. 2.3) and apparatus which show accurate volumes (Fig 2.4).

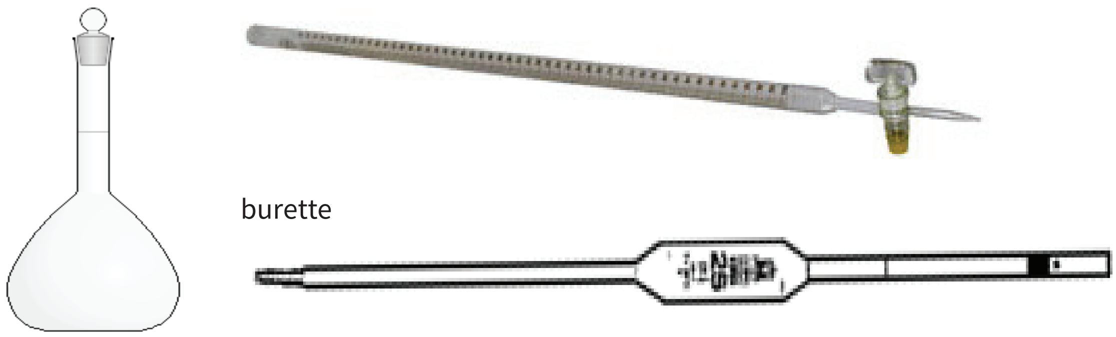

Fig. 2.4: Apparatus for measuring accurate volumes

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 2.1 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 2.1. Accuracy of some apparatus used to measure volume

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

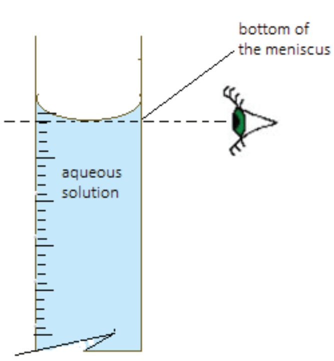

Fig. 2.5a: Meniscus of aqueous solution

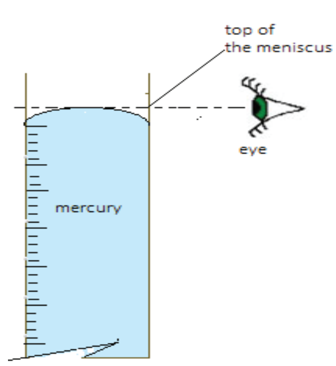

Fig. 2.5b: Meniscus of mercury

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. 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.

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Exercise 1.1

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.

Activity of Integration

Fig. 2.6: Support resources

As a student who now understands what Chemistry is and how it is studied. Prepare a brief message to deliver to new students on: the importance of the laboratory in the study of chemistry, detailing why they should not enter the laboratory and carry their own experiments without instruction from a teacher or laboratory worker.

Summary

In this chapter, you have learnt 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 What apparatus do we need to carry out the following steps in an experiment?
   a) Measure 200 ml of water and boil the water.
   b) Take out 10 drops of liquid A from bottle Q and 10 drops of liquid B from bottle P. Then mix A and B.
   c) Measure 5 g of salt and 100 ml of water. Dissolve the salt in water by mixing and stirring them.

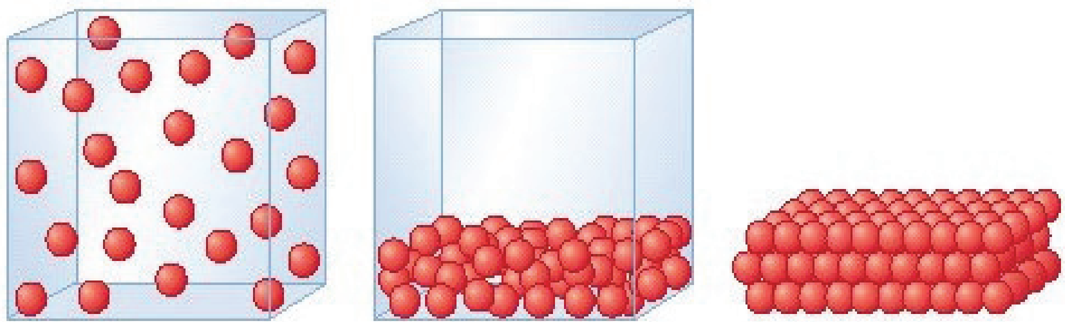
2 What apparatus do we need in order to carry out the following steps in an experiment?
   a) (i) Measure 7ml of water and boil the water.
   (ii) Measure the temperature of the boiling water.
   b) (i) Measure 20g of salt and 100ml of water.
   (ii) Add the salt to the water in a beaker and stir it. Measure the time taken for all the salt to dissolve in water.

3 The melting point of a substance Z melts over a range of temperatures from 117°C to 121°C. What can be said about the melting point of a pure sample of substance Z?
   A. The melting point would be between 117°C and 121°C.
   B. It would melt at temperatures lower than 117°C.
   C. It would melt at temperatures higher than 121°C.
   D. Its melting point cannot be determined.

4 Two hikers, A and B are boiling water simultaneously. Hiker A is at the base of the mountain while Hiker B is at the top of the mountain. Hiker B's water starts boiling much earlier than Hiker A's. Why is this the case?

CHAPTER 3

States and Changes of States of Matter



Key words	By the end of this chapter, you should be able to:
◆ matter ◆ states of matter ◆ particle theory ◆ diffusion ◆ kinetic theory	▪ *understand that matter is anything which occupies space and has mass and can exist in a solid, liquid, gas and plasma form (u)* ▪ *understand that solids, liquids and gases have different properties including shape, pouring and compressing (u, s)* ▪ *know the kinetic theory of matter and use it to explain particle arrangement, inter-particle forces, movement of particles and the properties of solids, liquids and gases (k, u)* ▪ *understand that a change from one state to another involves either heat gain or heat loss (u, s)* ▪ *appreciate the cooling effect of evaporation and how this contributes to maintaining constant body temperature (k, u, s)*

Competency: The learner uses knowledge of the arrangement and motion of particles to explain the properties of solids, liquids and gases.

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 use knowledge of the arrangement and motion of particles to explain the properties of solids, liquids and gases in everyday life.

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 "gases". Get physical substances you have listed as solids or liquids from your class or outside class and observe them critically.

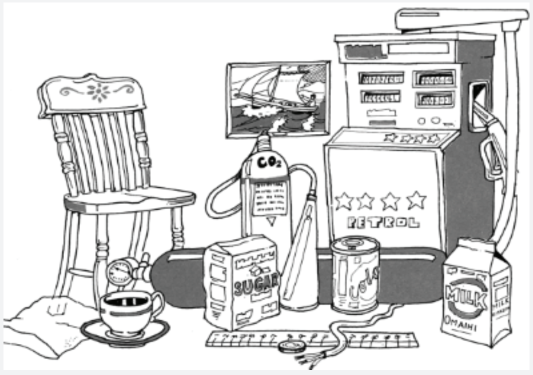


Fig. 3.2: Group of assorted items

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?

When wet clothes dry, the water from the clothes gets evaporated and the water vapour formed from it goes into the atmosphere. When wet clothes are kept in the sunlight, Due to the sun's hot rays, the molecules of water which present in the clothes gain energy and evaporate.

Sugar gets disappeared once added to water. The molecules have broken down into atoms and dispersed in the water. The sugar molecules cannot go away but they can disperse in the water. They will still be sugar molecules just not attached to any other molecules of sugar. The water and the sugar particles will be mix together and form a new substance.

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.

3.3. 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

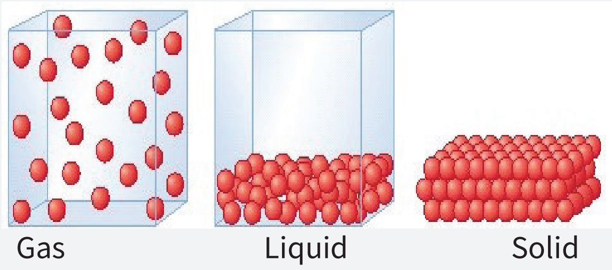


Fig. 3.4: Arrangement of particles in gas, liquid and solid

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. Fig. 3.4 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: Finding 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.

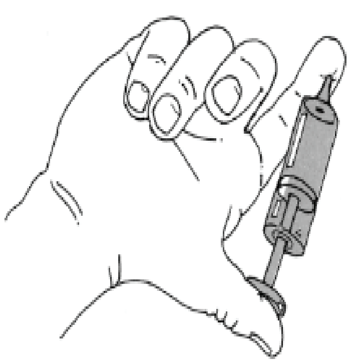


Fig. 3.5: Compressing as or quid

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: Investigating 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.

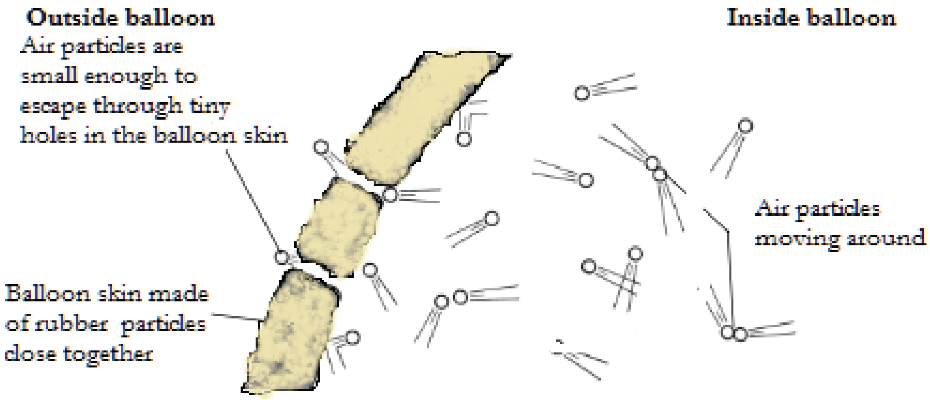


Fig. 3.6: Balloon filled with air

- 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: Investigating 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.

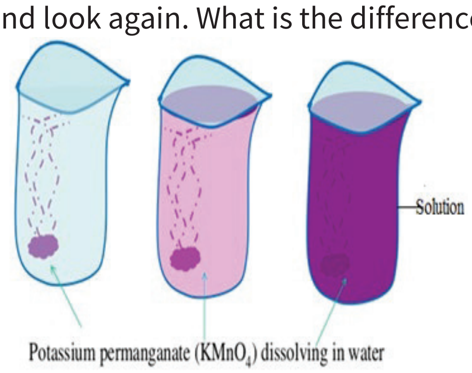


Fig. 3.7: Showing difussion in liquids

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: Investigating 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

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.

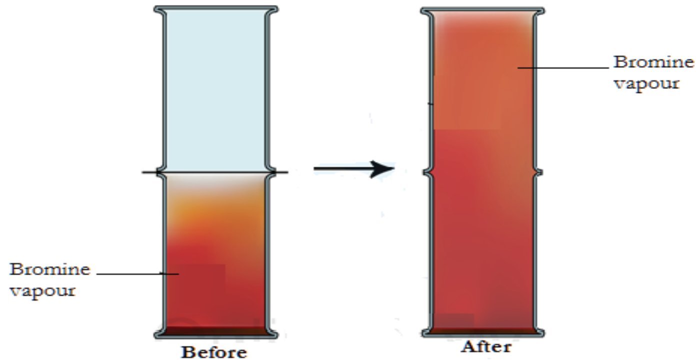


Fig. 3.8: showing diffusion in gases

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?

3.4: 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.

3.5: 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.

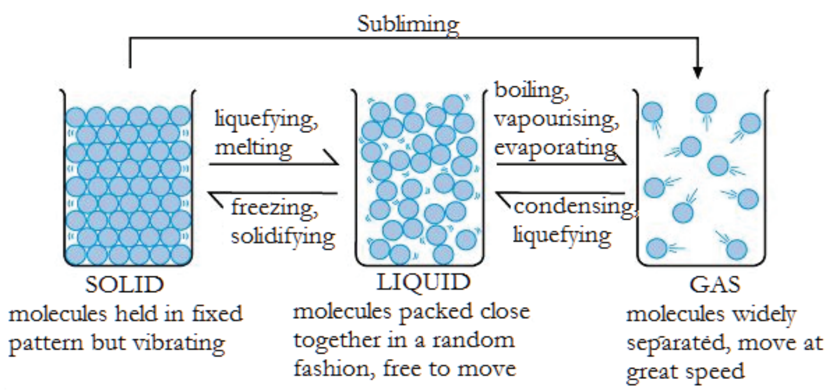


Fig. 3.9: Showing changes of states

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: Investigating the changes taking place when water is heated.

What you need

- source of heat
- ice cubes (100ml)
- Celsius thermometer
- stirring rod
- 250ml beaker
- 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		

3.5. Energy Changes during Heating and Cooling

When you heated a beaker of ice, you noticed that the temperature stayed at 0^{0}C 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 this 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.

Activity 3.6: Investigating the changes of state that occur when ice is heated

What you need

- source of heat
- ice cubes (100 ml)
- thermometer
- stirring rod
- beaker (250ml)
- stop watch or wall clock

What to do

1. Put 150 cm^3 of water and 100 cm^3 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. Before making each temperature measurement, stir the ice/water mixture with the stirring rod.
7. Use your data to plot a graph of temperature (°C) against time (seconds).

Table 4: Results of temperatures of ice on cooling

Time (min)	Temperature (°C)	Physical state
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		

14		
15		
16		
17		
18		
19		
20		

3.6: Cooling Effect of Evaporation

Activity 3.5: Investigating 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

Results and Discussion

What did you feel on your skin as the drop was evaporating?

1. What conclusion can you draw about the effect of evaporation on the back of your hand?
2. Explain how this effect is an important aspect in the life of living organisms.

Activity of Integration

Look at the poster in Fig. 3.10. The Ice Cream Company FILOFILO Ltd has employed you as the marketing officer. Write a short feature article for a newspaper advertising ice cream for the company. In your advertisement, explain the ingredients of the ice cream, the state and why the state in which it is sold is important.

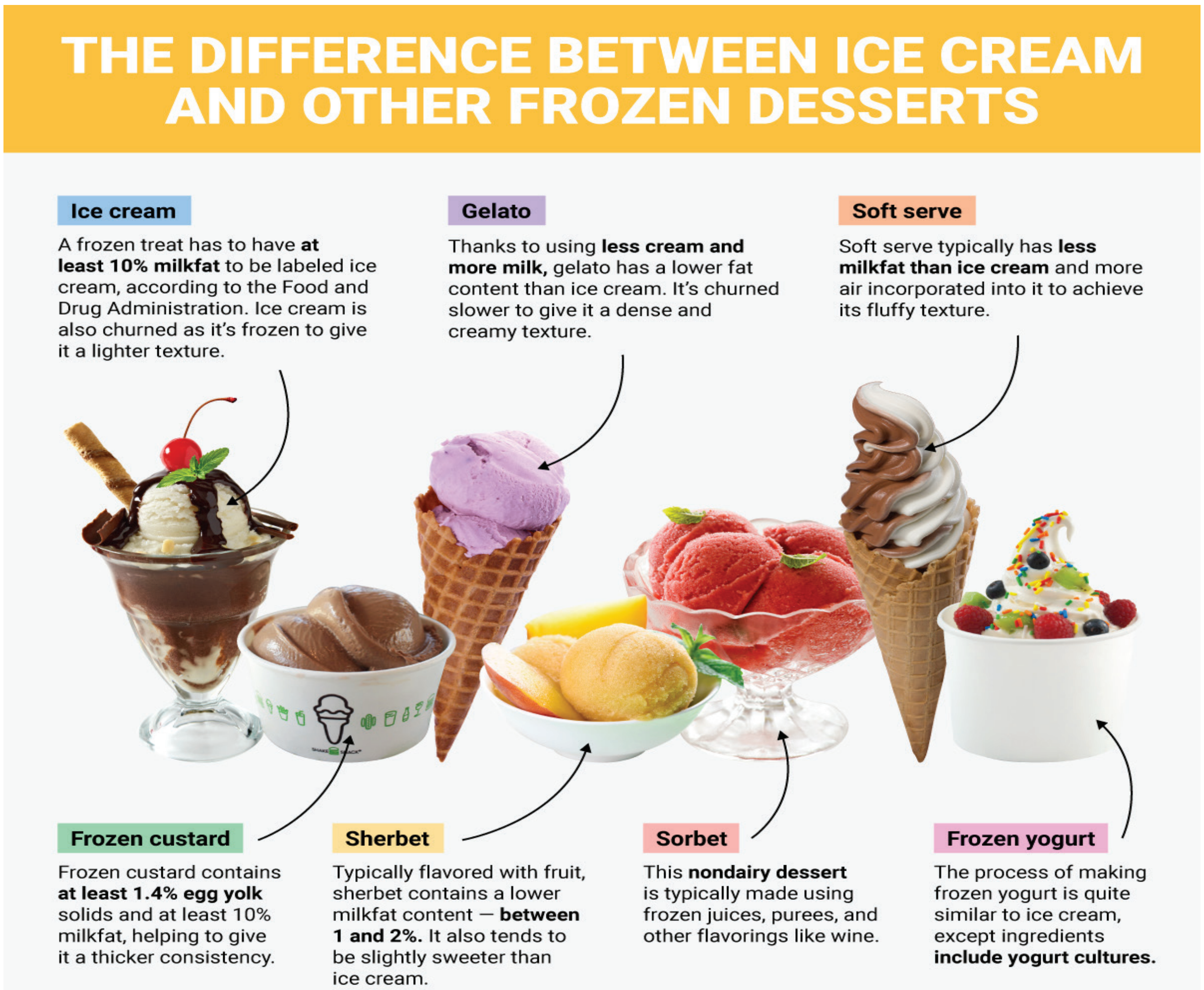


Fig. 3.10: Types of frozen ice cream

Summary

In this chapter, you have learnt 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:

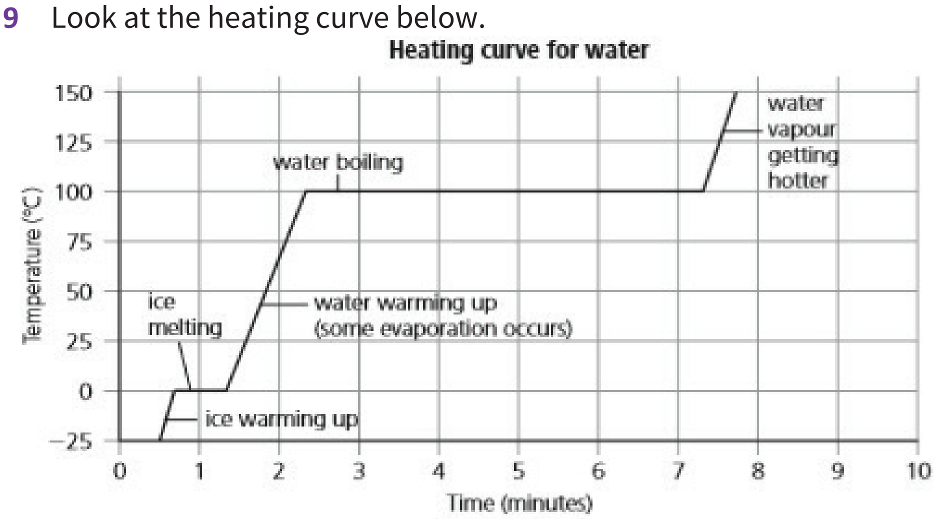
a) boiling?

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 should be able to:
◆ materials ◆ natural ◆ artificial ◆ synthetic ◆ physical properties ◆ recycle ◆ molecular structure ◆ polymers ◆ pollution	▪ *know that materials used in everyday life can be classified into natural and synthetic group, and how this affects their use in everyday life (s, k)* ▪ *understand how the physical properties of polymers determine uses in everyday life such as in building, as fabrics, fabricating utensils used in homes, etc. (k, u)* ▪ *know about the molecular structures of materials and relate this to their use (k, u)* ▪ *know that polymers are useful long chain molecules made by both natural and synthetic processes (k, u)* ▪ *understand how the physical properties of polymers determine uses in everyday life such as in building, as fabrics, fabricating utensils used in homes, etc. (k, u)* ▪ *know how common materials can pollute environment and which materials can be recycled (k)*

Competency: The Learner should be able to explore how materials are used and relate these uses to their molecular structures.

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.

4.1. Classifying Materials

Activity 4.1: Classifying 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.

Fig. 4.1: Common materials in the house

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 4.1.

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 4.2: Finding 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.

Table 4.2. Summary of properties of chemical bonds

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

4.2. 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.

Fig. 4.2: 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.

Fig. 4.3: Showing shattered glass

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).

Fig. 4.4: Homemade clay pots from Arua

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

4.3. 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.

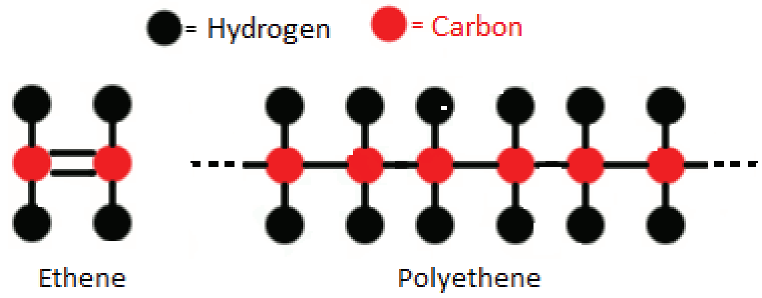


Fig. 4.5: Formation of polyethene

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. Figures 4.6, 4.7. 4.8, 4.9 and 4.10 show how the polymer chains are held together in different plastics.

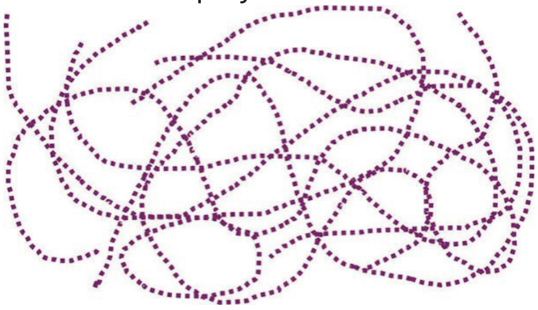


Fig. 4.6: Polymer chain of polyethene

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.

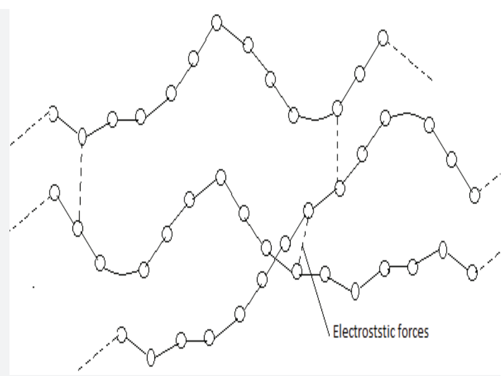


Fig. 4.7: Polymer chain of nylon

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.

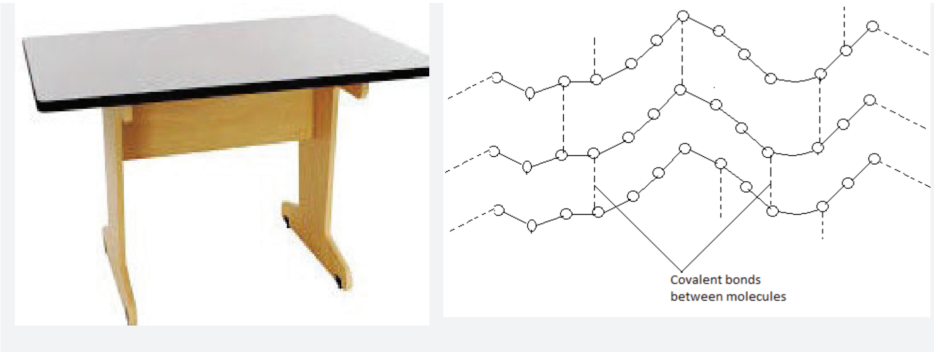


Fig. 4.8: Polymer chain in melamine

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.

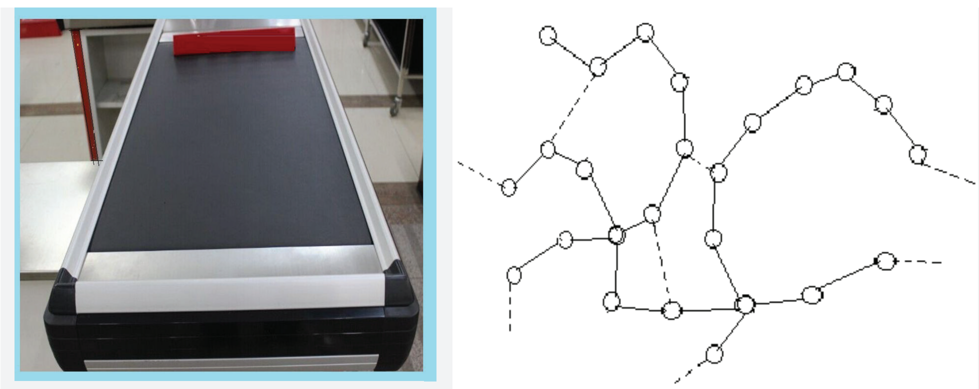


Fig. 4.9: Polymer chain in polyurethane

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.

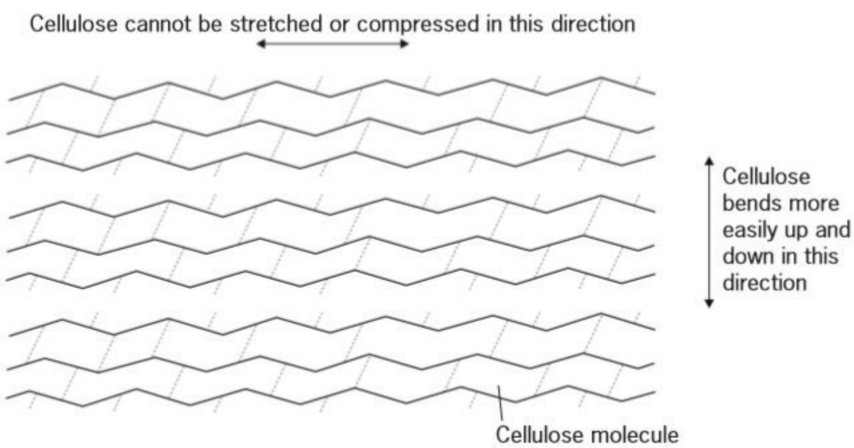


Fig. 4.10: The Structure of Cellulose

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 4.3: Finding 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?

Fig. 4.11: 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 table 4.3.

Table 4.3. Natural and synthetic fibres

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 4.1

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 4.4: Finding 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 to 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!

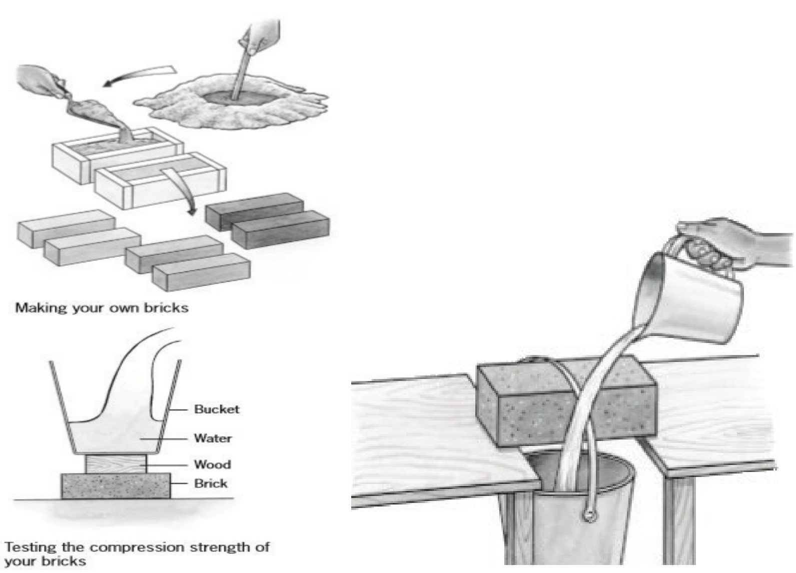


Fig. 4.12: Testing the tensile strength of your bricks

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.)

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?

4.3 Physical properties of polymers and their uses

A polymer is a large molecule or a macromolecule which essentially is a combination of many subunits. The term polymer in Greek means "many parts". Polymers can be found all around us.

Polymers may be naturally found in plants and animals (**natural polymers**) or may be man-made (**synthetic polymers**). Different polymers have a number of unique physical and chemical properties due to which they find usage in everyday life.

Different materials have different properties. Polymers are strong and tough, and often flexible.

Polymers are made by chemical reactions that join lots of small molecules together to make long molecules. For example, a molecule of poly(ethene) is made by joining thousands of ethene molecules together. Long molecules like these give polymers their properties.

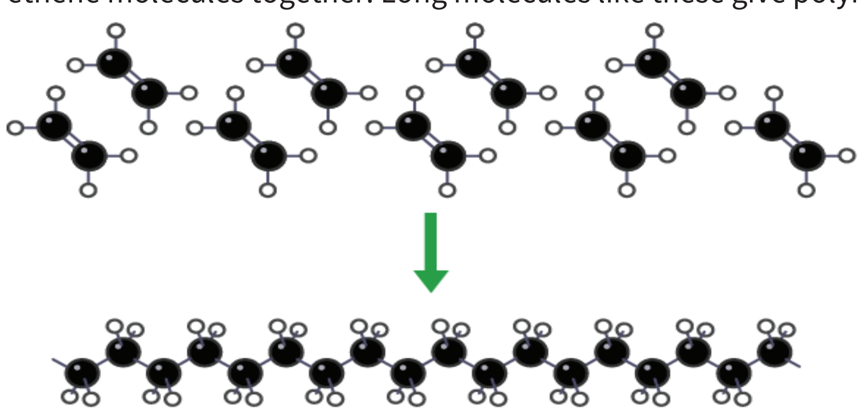


Fig. 4.13: Ethene molecules join together to make long molecules of poly(ethane)

Polymer properties

Polymers often have these properties in common. They are:

- chemically unreactive
- solids at room temperature
- plastic – they can be moulded into shape
- electrical insulators
- strong and hard-wearing

The table shows some polymers, their typical uses and the properties that make them suitable for these uses:

Table 4.4. Polymers and their uses

Polymer name	Typical use	Properties
Poly(ethene) or polythene	Plastic bags	Strong and hard-wearing
PVC	Water pipes	Strong, hard-wearing, chemically unreactive
PVC	Outer layer of electric wires	Electrical insulator, hard-wearing
Nylon	Clothing	Can be made into fibres, strong and flexible
Lycra	Sports clothing	Can be made into fibres, very elastic and tough

Fig. 4.14: Electrical socket

Some polymers are hard and rigid, like the polymer used to make this electrical socket in Fig. 4.11.

In the next activity you will work in groups to investigate properties of different materials.

Activity 4.4. Investigating the physical properties of materials and their uses

What you need

- wood
- paper
- cotton
- silk
- nylon
- polyethene
- polyester
- rubber
- starch
- wool
- polytetrafluoroethene
- glass

What to do

1 Classify the materials according to their physical properties (such as strength, flexibility, tensile and compressive strength, elasticity, absorbency.
2 Tabulate your findings in a table.
3 In your groups, discuss the uses of the materials and relate them to the specific physical properties.

Table 4.5. Physical property of polymers and their uses

Material	Physical property	Use of material
wood		
paper		
cotton		
silk		
nylon		
polyethene		
etc.		

Observation and conclusion

You may have observed that uses of the different materials are directly related to their physical properties. You might have also observed that the natural polymers such as wood, cotton, paper, and wool have good absorbency, and they are mainly used for clothing and textiles. Artificial polymers have high tensile strength, elasticity and flexibility; and they mainly used in making household equipment and hardware.

Assignment 4.4

1. In groups, carry out a research using internet or library on how do polymers have different physical properties? Give examples.
2. Write a report to be presented to the whole class.

Did you know?

In polymers, monomers are bonded, by different molecular interactions. Nature of these interactions, yield polymers of varying elasticity, tensile strength, toughness, thermal stability, etc. Monomers forming a linear chain with weak bonding. Polymers with strong forces of interaction between the monomer in both linear and between the chains have higher tensile strength and are used as fibres.

4.4: Environmental pollution by materials and recycling

Every year Ugandans generate millions of tons of waste… call it garbage, refuse, or trash… it's the waste we produce in our homes and communities. Each of us can make a difference by reducing, reusing, and recycling materials at home and throughout our communities—and encouraging our neighbours to do the same.

Assignment 4.5

In groups carry out research and write a report on ways to:

1. dispose of materials using appropriate methods to guard against polluting the environment
2. identify materials in your community or home that can be recycled

Activity 4.5. To classify materials into recyclable and non-recyclable

In this activity, you will work in groups to classify materials used in everyday life as those that can be recycled (recyclable) and those that cannot be recycled (non-recyclable).

What you need

- wood
- paper
- natural and synthetic fibres
- plastics
- cotton
- sisal
- silk
- nylon
- polythene
- polyester
- protein
- rubber
- starch
- wool
- polystyrene
- glass
- polytetrafluoroethene

What to do

1. sort the materials you are given into those that can be recycled and those that cannot.
2. Record your results into a table and compare your results with those of other groups.

Table 4.6. Recyclable and non-recyclable materials

Material	Natural or synthetic	Recyclable	Non-recyclable
wood			
paper			
plastics			
cotton			
sisal			

3. From your results what kind of materials (Natural or synthetic) are recyclable and which ones are not recyclable.

Results and conclusion

Some items that are mainly composed of paper also have a small amount of wax, plastic or foil added to them, rending them not recyclable. Frozen food boxes, juice boxes, dairy milk cartons and soymilk cartons are specific types of these items.

Recyclable resources are those substances which one can reuse in any form again and again after use. ... Non-recyclable substances include all those which cannot be put to use in any form again, for example polythene bags.

Plastic shopping bags can be returned to many stores for recycling. PP (polypropylene) has a high melting point, and so is often chosen for containers that must accept hot liquid. It is gradually becoming more accepted by recyclers. How to recycle it: Number 5 plastics can be recycled through some curb side programs.

Non-recyclable items

- Garbage
- Food waste
- Food-tainted items (such as: used paper plates or boxes, paper towels, or paper napkins)
- Ceramics and kitchenware
- Windows and mirrors
- Plastic wrap
- Packing peanuts and bubble wrap
- Wax boxes
- Photographs
- Medical waste
- Polystyrene or styrofoam
- Hazardous chemicals and chemical containers
- Plastic toys or sporting goods equipment
- Foam egg cartons
- Wood
- Light bulbs

Fig. 4.15. Recyclable

Polymer problems

Polymers are usually chemically unreactive. This is a useful property because it means that plastic bottles will not react with their contents. Unfortunately, it makes polymers difficult to dispose of. They do not rot away very quickly and they can cause litter problems.

4.5 Effect of heat on structure and properties of materials

Have you ever wondered whether it is possible or not to put glass or plastic waste to proper use? What happens when these waste materials are subjected to heat? Did you ever realise that some of the materials when heated can be reshaped or changed into new form?

In the next activity, we shall investigate the effect of heat on some materials and explain why they may be reshaped or not.

Fig. 4.16. Waste materials

Fig. 4.17: Broken glasses

Activity 4.6. Investigating the effect of heat on materials used in everyday life

What you need

- polyethene
- polyester
- paper
- glass
- melamine plate
- rubber
- plastic plate
- steel or iron
- source of heat
- pair of tongs

What to do

1 Heat a small piece of each of the materials while holding using a pair of tongs.

2 Observe what happens each time you heat a piece of the material and record your results in a table.

Table 4.7. Results of heating substances

Material	Observations	
	On heating	After heating
polyethene		
rubber		
glass		

3 Which materials can be reshaped into new ones or soften on heating?

4 Compare your results with those of the other groups.

Observation and conclusion

The effect that heat has on polymers depends in part on what type of polymer it is. A thermoplastic polymer will be a crystalline solid below a certain temperature, then undergo a glass transition when it softens, then melts, and finally burns. A thermoset, or cross-linked, polymer will remain solid until it begins to char and burn.

When heat is added to a substance, the molecules and atoms vibrate faster. As atoms vibrate faster, the space between atoms increases. The motion and spacing of the particles determine the state of matter of the substance. The end result of increased molecular motion is that the object expands and takes up more space.

Activity of integration of situations

You have been given a contract to sensitise people in your home town on how to select building materials for constructing a community school. They are expected to gather materials for the walls and the roof. Since there are many people, in the community, they will need to deal with the waste materials.

Task: Plan your sensitisation message for the community.

Summary

In this chapter, you have learnt that:

- We can classify solid materials into class, wood, plastics, ceramics and fibres. The use we make of these materials depends on their properties.
- Cement is made by heating limestone (calcium carbonate) with clay (mainly aluminium silicate) at 1400°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.
- 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 calcium carbonate and sand (silicone 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 joining together with atoms of other elements. They are manufactured from crude oil, coal or natural gas. The properties of plastics depend on the structure of the polymer molecules and particularly the kind of forces holding the 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 crystals. The properties of the 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 should be able to:
◆ physical change ◆ chemical change ◆ reversible ◆ irreversible ◆ permanent ◆ temporary	▪ understand that many substances undergo permanent changes when they are heated or burnt, forming new materials while other substances change temporarily (u, s) ▪ recognise temporary (reversible) and permanent (irreversible) changes to matter under different conditions (u)

Competency: The learner should be able to recognise occurrence of temporary and permanent changes, and their importance in everyday life.

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, and their importance in everyday life.

5.1: Temporary and Permanent Changes

Activity 5.1a: Investigating 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: Investigating permanent (chemical) changes.

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: Investigating the changes which take place on heating substances

What you need

- Bunsen 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.

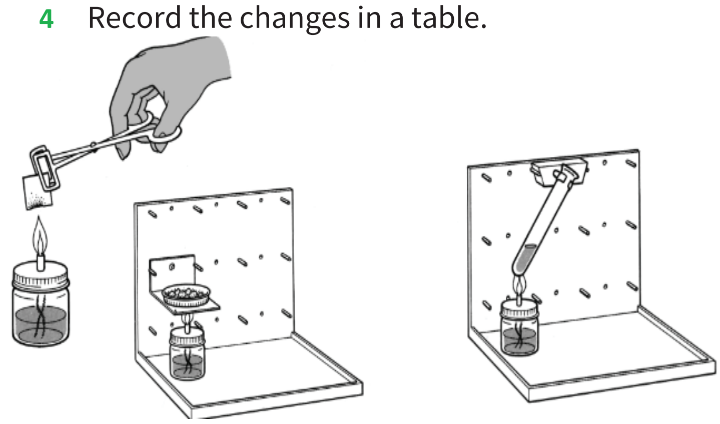


Fig. 5.2: Heating substances

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: Finding out what happens when magnesium burns

What you need

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

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 5.4: Rusting school truck

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

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. 5.5: Food cooking in a pot

Fig. 5.6: Rusting iron nails

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.

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

Fig. 5.6: Wood burning

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 stick 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: Classifying 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.

Table 5.1. showing differences between physical and chemical changes

Physical Changes	Chemical Changes

Activity of integration

Most of the people in a certain village called Bileafe where much tobacco is grown bought vehicles after tobacco sales. However, no sooner than later many of the vehicles either broke down or they were parked at home since fuel became expensive to afford.

As a student of chemistry, develop a message for the owners of the cars in this village explaining why the vehicles should be kept well even if they are spoilt, where they should be kept, and what kind of change they will undergo if not properly kept.

You can use the resources in Fig. 5.6 to help you develop the message.

Fig. 5.6: Cars parked

Summary

In this chapter, you have learnt that:

- many substances undergo permanent changes when they are heated or burnt, forming new materials while other substances change temporarily.
- Temporary change does not produce any new substance. While, a permanent 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:

  reactants → 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.
-

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 candle burns. Explain how you would find 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 should be able to:
◆ pure substance ◆ element ◆ compound ◆ mixture	▪ *know the criteria for determining whether a substance is pure or not. (k, s)* ▪ *understand that substances are either elements, mixtures or compounds. (u)* ▪ *identify different mixtures and devise ways of separating pure substances from them. (u, s)* ▪ *know that, when added together, some liquids mix while others form two layers. (k)*

Competency: The learner should be able to recognize the characteristics of mixtures and compounds.

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.

Table 6.1: The Periodic Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.01																	2 He Helium 4.00
3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 51.99	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 84.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium 98.91	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.85	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium [208.98]	85 At Astatine 209.98	86 Rn Radon 222.02
87 Fr Francium 223.02	88 Ra Radium 226.03	89-103 Actinides	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennesine [294]	118 Og Oganesson [294]

57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.06	71 Lu Lutetium 174.97
89 Ac Actinium 227.03	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.05	94 Pu Plutonium 244.06	95 Am Americium 243.06	96 Cm Curium 247.07	97 Bk Berkelium 247.07	98 Cf Californium 251.08	99 Es Einsteinium [254]	100 Fm Fermium 257.10	101 Md Mendelevium 258.10	102 No Nobelium 259.10	103 Lr Lawrencium [262]

Questions

1. What is an element?
2. Do you know the names of any of the common elements?
3. Which of these elements do you know?
4. Iron or carbon or sulphur or oxygen?

6.1: Criteria for Determining Purity

Activity 6.1: Investigating 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:

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

Table 6.2. Results showing melting and boiling points

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.
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.
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, 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.

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

Table 6.3. Results showing boiling points of solutions

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 6.3: 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

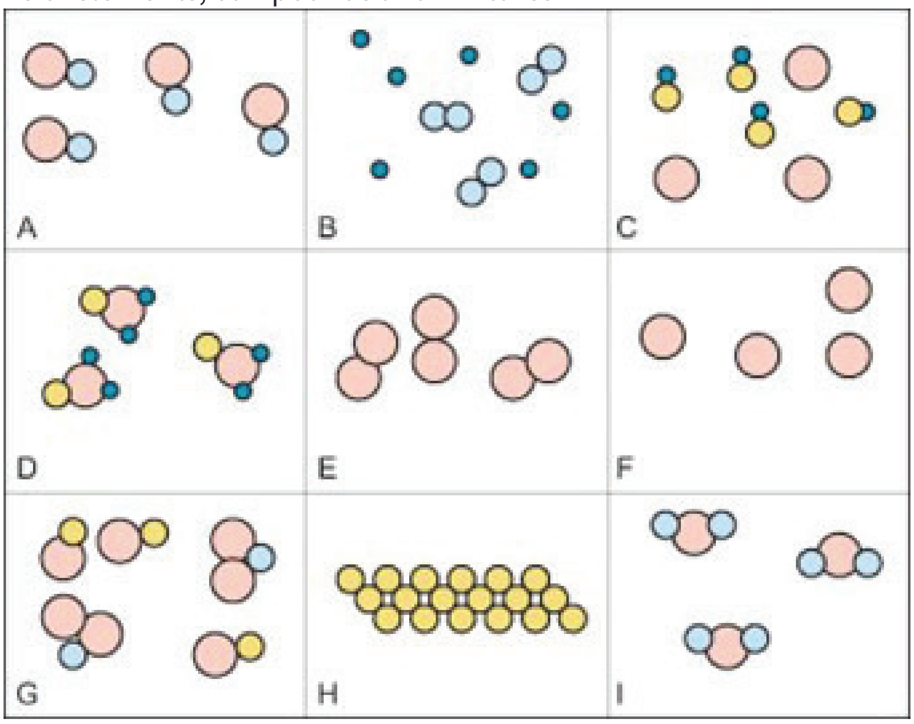


Fig. 6.1: Elements, compounds and mixtures

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 6.4: Splitting 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.

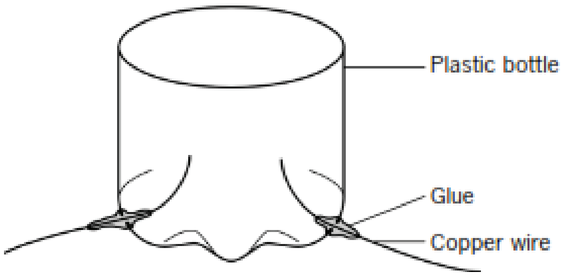


Fig. 6.2. Electrolytic cell

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.

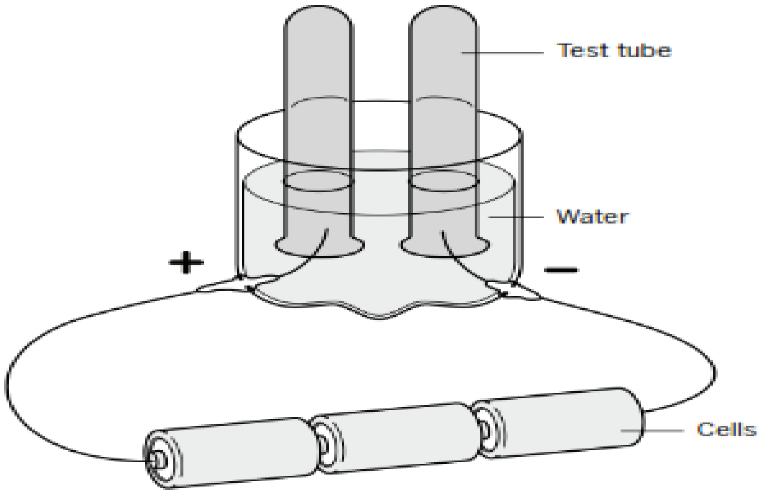


Fig. 6.3: Electrolysis of water

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:

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

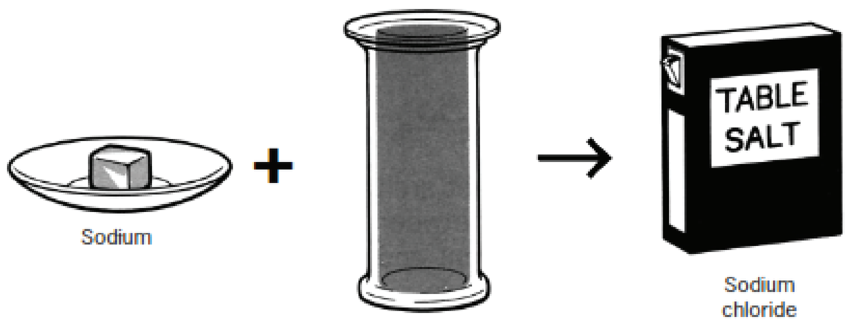


Fig. 6.4: Formation of sodium chloride

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:

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

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 6.5: 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?

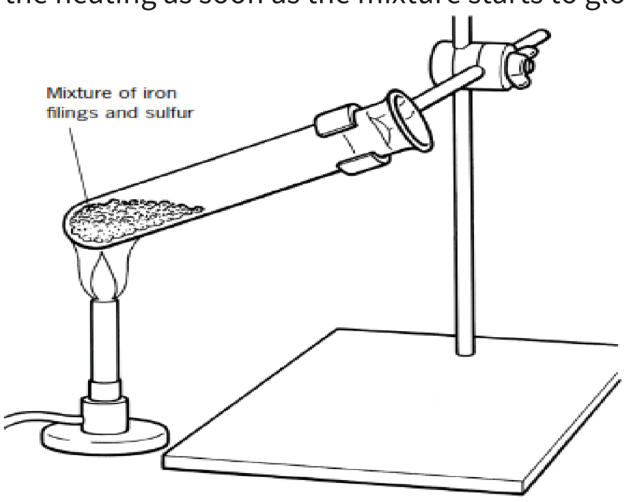


Fig. 6.5: Preparing iron (II) sulphide

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)		

Table 6.4. List of properties of iron filings, sulphur and 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.

Table 6.5: Metals and non-metals

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 6.6: Finding out if non-metal elements burn in air

What you need

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

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.
6. 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.

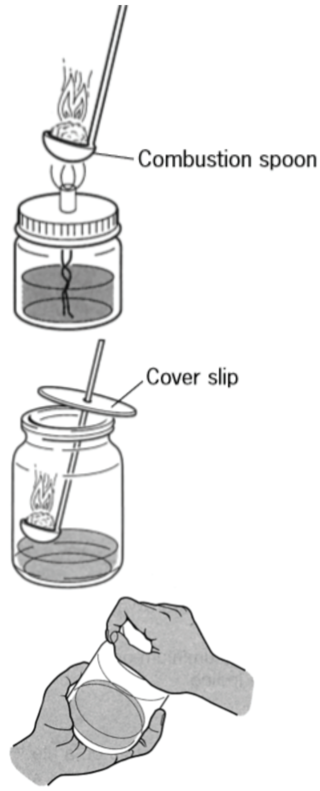


Fig. 6.6: Burning non-metals in air

Table 6.5: Results of testing solutions of oxides of non-metals with litmus paper

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 + oxygen carbon dioxide
Phosphorous		Phosphorous pentoxide	white	Sulphur + oxygen sulphur pentoxide

Activity of Integration

To gain an understanding of mixtures and the concept of separation of mixtures, prepare an article to help feeding mothers in your community to find the element of iron in iron-fortified breakfast cereal flakes. Through this this article, the mothers should be able to see how the iron component of this mixture (cereal) retains its properties and can thus be separated by physical means.

Fig. 6.7: Label on cereal flakes

Summary

In this chapter, you have learnt that:

- All substances are either pure or are mixtures. Mixtures can be purified by a number of methods such as filtration, evaporation, distillation and chromatography.
- Pure substances have sharp melting and boiling points. The melting and boiling points of one pure substance are different from those of all others.
- Substances in everyday life exist as either elements or mixtures or compounds
- Elements cannot be broken down or changed into another substance using chemical means.
- Elements are arranged according to their increasing atomic numbers in the Periodic Table.
- There are 92 elements in nature. These can be classified into groups in the Periodic Table. Elements in the same group are similar to each other.
- The smallest particle that make up the element is called the atom. An atom is the smallest electrically neutral particle of an element which can take part in a chemical reaction.
- A chemical symbol is one or two letters which represent one atom of the element.
- A mixture contains different substances that are not chemically joined to each other. Mixtures can be separated by physical means such as distillation, magnetism, filtration, etc. no energy is given out or absorbed when mixtures are made.
- Compounds are made from elements joined chemically together. Compounds cannot be separated by any chemical means. Energy is given or absorbed out when compounds are made.
- Solutions are mixtures of a solute and a solvent. These can be separated by evaporation, crystallization and distillation.
- Evaporation and crystallisation are used only if the solute is required to be separated from the mixture. Evaporation is a quicker process than crystallisation. Crystallisation results in larger crystals of solute being formed.
- Distillation is used if both solute and solvent are required.
- Filtration, decantation and centrifugation are used to separate insoluble solids from liquids.
- Fractional distillation is used to separate miscible liquids with different boiling points.
- A separating funnel is used to separate immiscible liquids.
- A magnet is used to separate two solids where one is the metal iron.
- Sublimation is used to separate two solids where one solid sublimes on heating.

End – of – Chapter Questions

1 Here is a list of mixtures:
a) maize meal and *salt*
b) dirty *water*
c) *iron* and copper filings
d) *currants* and rice.
Describe, in each case, a process you could use to get the substance in italics in a pure form out of the mixture.

2 If you mixed two substances together and then heated them, describe two observations that you could make if you wanted to know whether a chemical reaction had taken place.

3 Here is part of the label on a packet of potato chips.

Nutritional information	**Per 100 g**
Calcium	100 mg
Magnesium	125 mg
Iron	27 mg
Phosphorus	420 mg

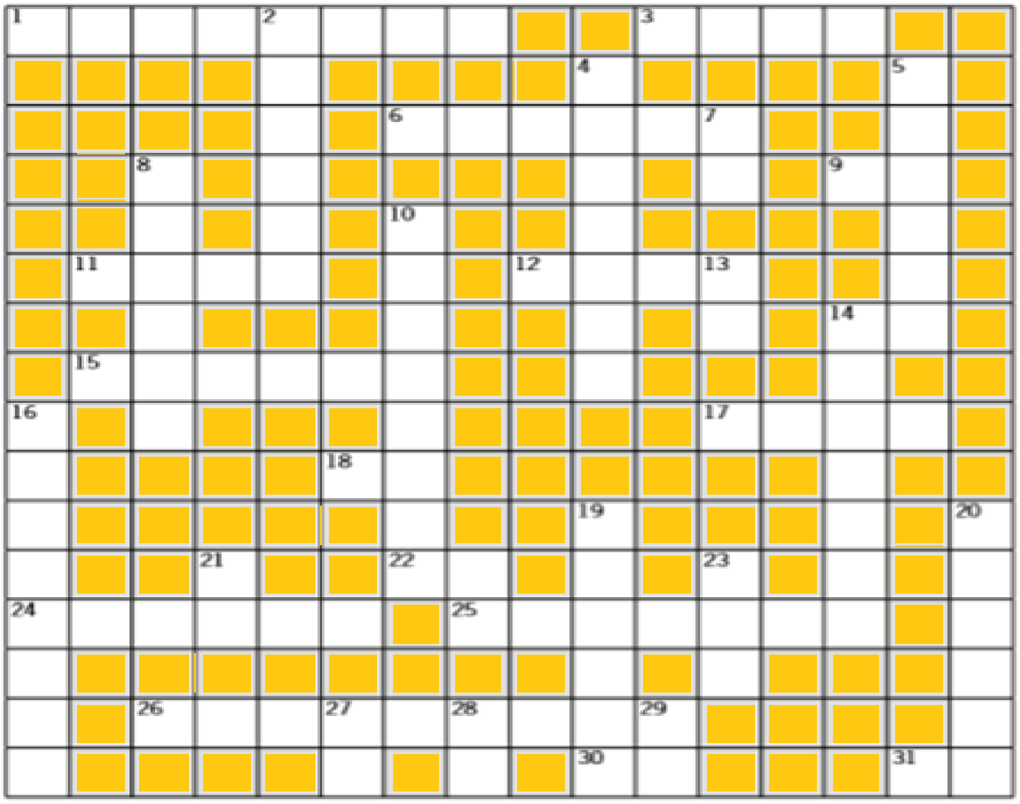
Use **Fig. 6.1**. showing the Periodic Table to answer these questions:
a) Write down the chemical symbols for calcium, magnesium, iron and phosphorus.
b) These substances are all elements, but one is different from the other three. State which one is different and describe what it is that makes it different.

4 Look at the chemicals listed below and answer the questions about them. You can use Fig. 6.1 showing the Periodic Table to help you.

iron	water
sand	oxygen
gold	carbon dioxide
helium	carbon
rust	sea water

a) Name the two metals.
b) Name a gas that is not an element.
c) Name two compounds.
d) Name a mixture.
e) Name a non-metallic element that is a solid.

5 Here is a crossword puzzle to help you remember the names and symbols of some common elements.



i) Write the names of the elements that have the following symbols:

Across

1. H 3. Au 6. Na 11. Fe 12. Zn 15. Cu 17. Pb 24. I 25. Ca 26. K

Down

2. O 4. Li 5. Ag 8. C 10. N 14. U 16. Pt 19. He 20. S 23. Sn

ii) Write down the symbols of the following elements:

Across

9. chlorine 18. a metal that is a liquid 22. neon 30. magnesium 31. bromine

Down

7. manganese 13. cobalt 21. a metal used in coins
27. argon 28. silicon 29. a metal that burns brightly in air

6 What does this term mean? Give an example.
a) filtrate
b) residue

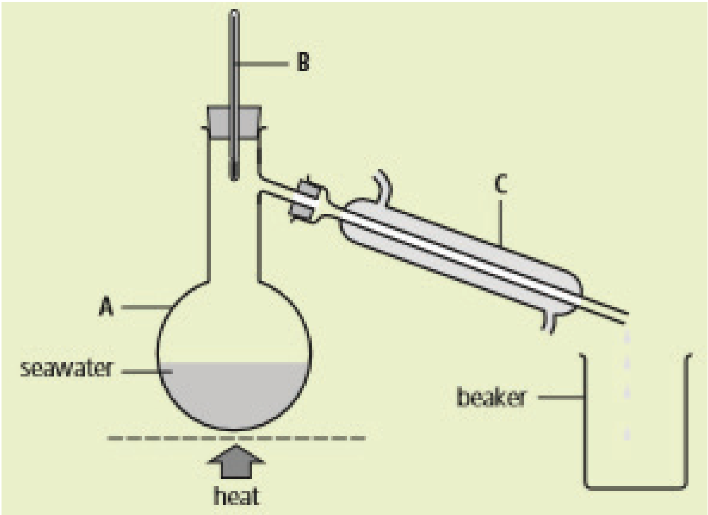
7 You have a solution of sugar in water. You want to obtain the sugar from it.
a) Explain why filtering will not work.
b) Which method will you use instead?

8 Describe how you would crystallise potassium nitrate from its aqueous solution.

9 How would you separate salt and sugar? Mention any special safety precaution you would take.

10 Now see if you can think of a way to get clean sand from a mixture of sand and little bits of iron wire.

11 Seawater can be purified using this apparatus:



a) i) What is the maximum temperature recorded on the thermometer, during the distillation?
   ii) How does this compare to the boiling point of the seawater?
b) In which piece of apparatus does evaporation take place? Give its name.
c) i) Which is the condenser, A, B, or C?
   ii) Where does the supply of cold water enter?
d) Distillation is used rather than filtration, to purify seawater for drinking. Why?

12 Argon, oxygen, and nitrogen are obtained from air by fractional distillation. Liquid air, at -250 °C, is warmed up, and the gases are collected one by one.
   a) Is liquid air a mixture, or a pure substance?
   b) Explain why fractional distillation is used, rather than simple distillation.
   c) During the distillation, nitrogen gas is obtained first, then argon and oxygen. What can you say about the boiling points of these three gases?