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?

Project Work

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

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

1. Observing a particular behaviour.
2. Making immediate conclusions about the 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.

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.

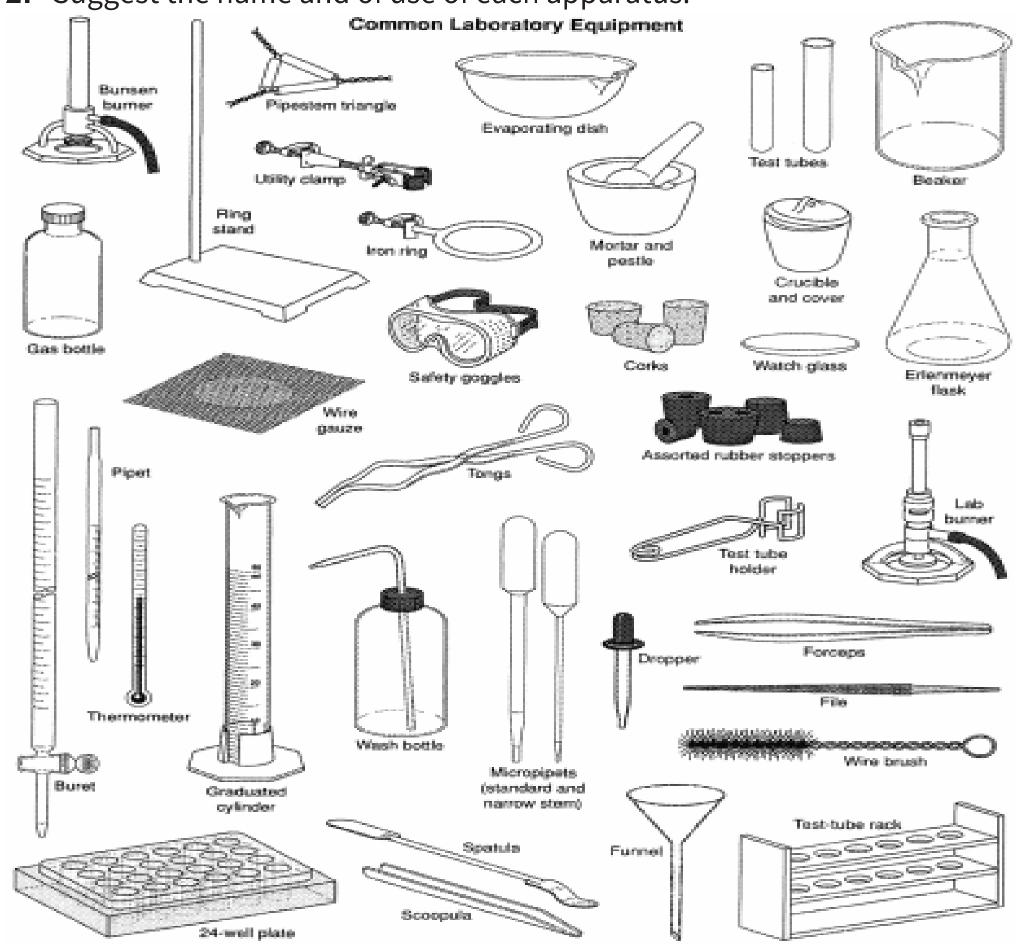


Fig. 2.1: Common laboratory apparatus

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.

$1\ m^3 = 1000\ dm^3$ $\qquad$ $1\ dm^3 = 1000\ cm^3$

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.

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

$1\ L = 1\ dm^3$ $\qquad$ $1\ ml = 1\ cm^3$

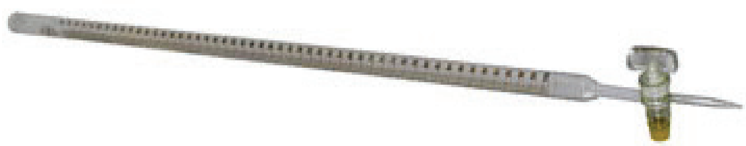
measuring cylinder
beaker

syringe conical flask

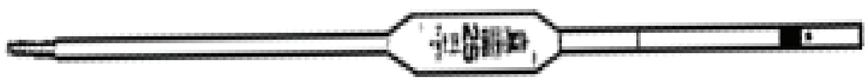
Fig. 2.3: Apparatus that shows approximate volume

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).



burette



volumetric flask

Pipette

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.

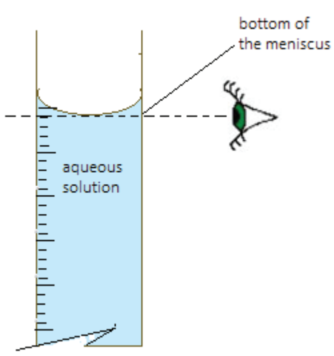


Fig. 2.5a: Meniscus of aqueous solution

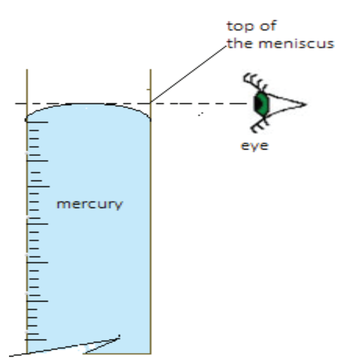


Fig. 2.5b: Meniscus of mercury

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.

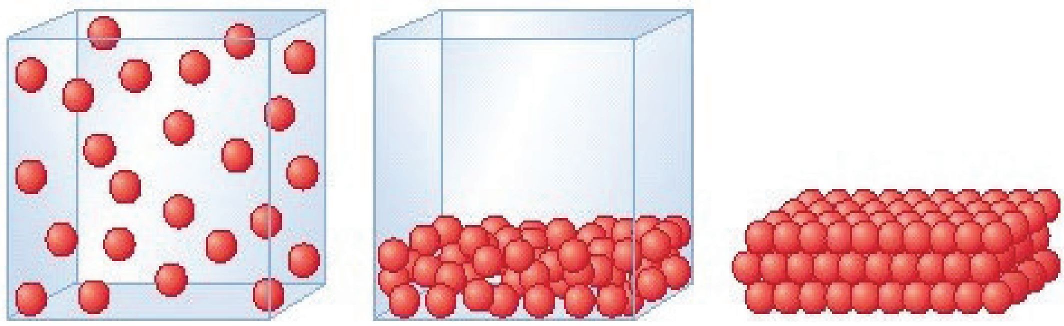
2 What apparatus do we need in order to carry out the following steps in an experiment?
   a) (i) Measure 7ml of water and boil the water.
   (ii) Measure the temperature of the boiling water.
   b) (i) Measure 20g of salt and 100ml of water.
   (ii) Add the salt to the water in a beaker and stir it.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

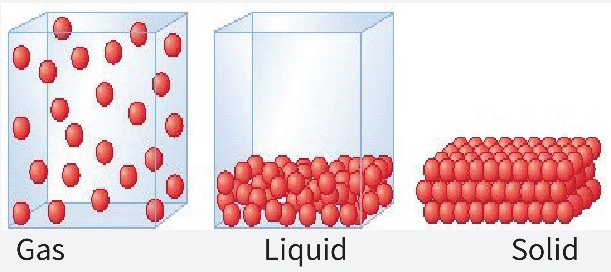


Fig. 3.4: Arrangement of particles in gas, liquid and solid

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.

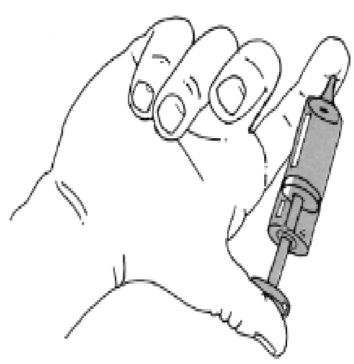


Fig. 3.5: Compressing as or quid

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.

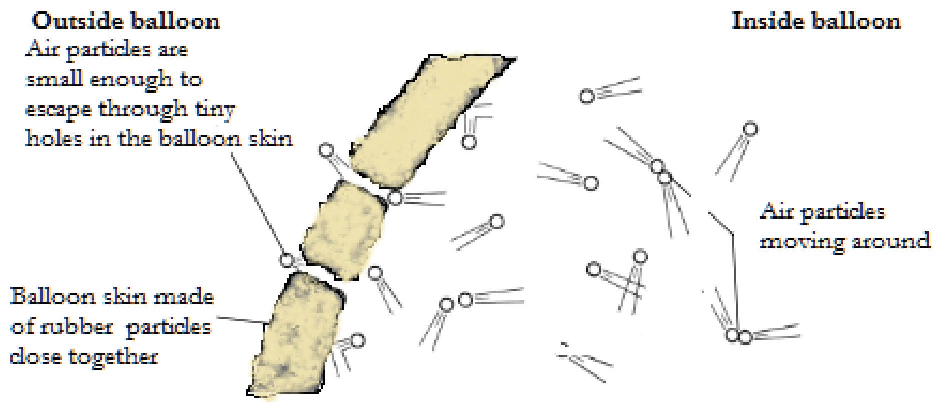


Fig. 3.6: Balloon filled with air

- 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.

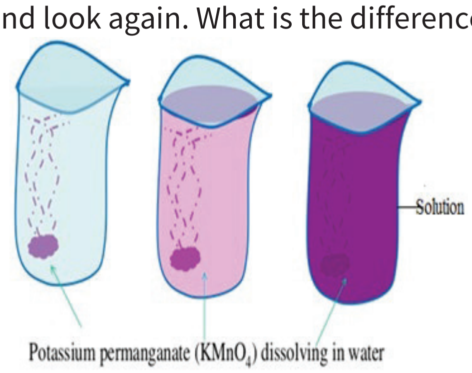


Fig. 3.7: Showing difussion in liquids

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
- Cover plate
- Two empty gas jars

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.

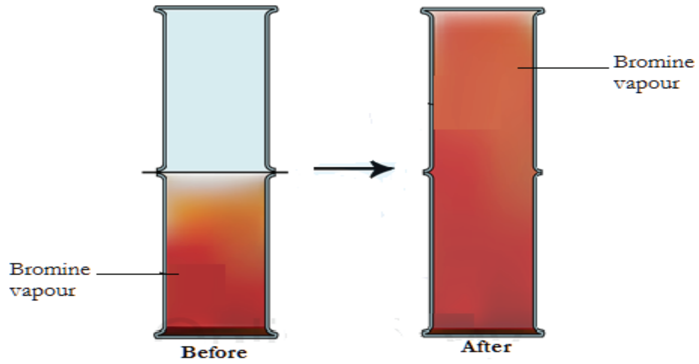


Fig. 3.8: showing diffusion in gases

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.

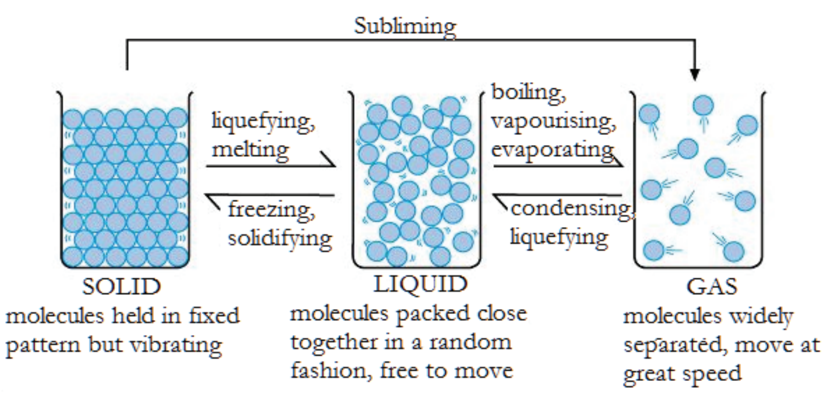


Fig. 3.9: Showing changes of states

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.

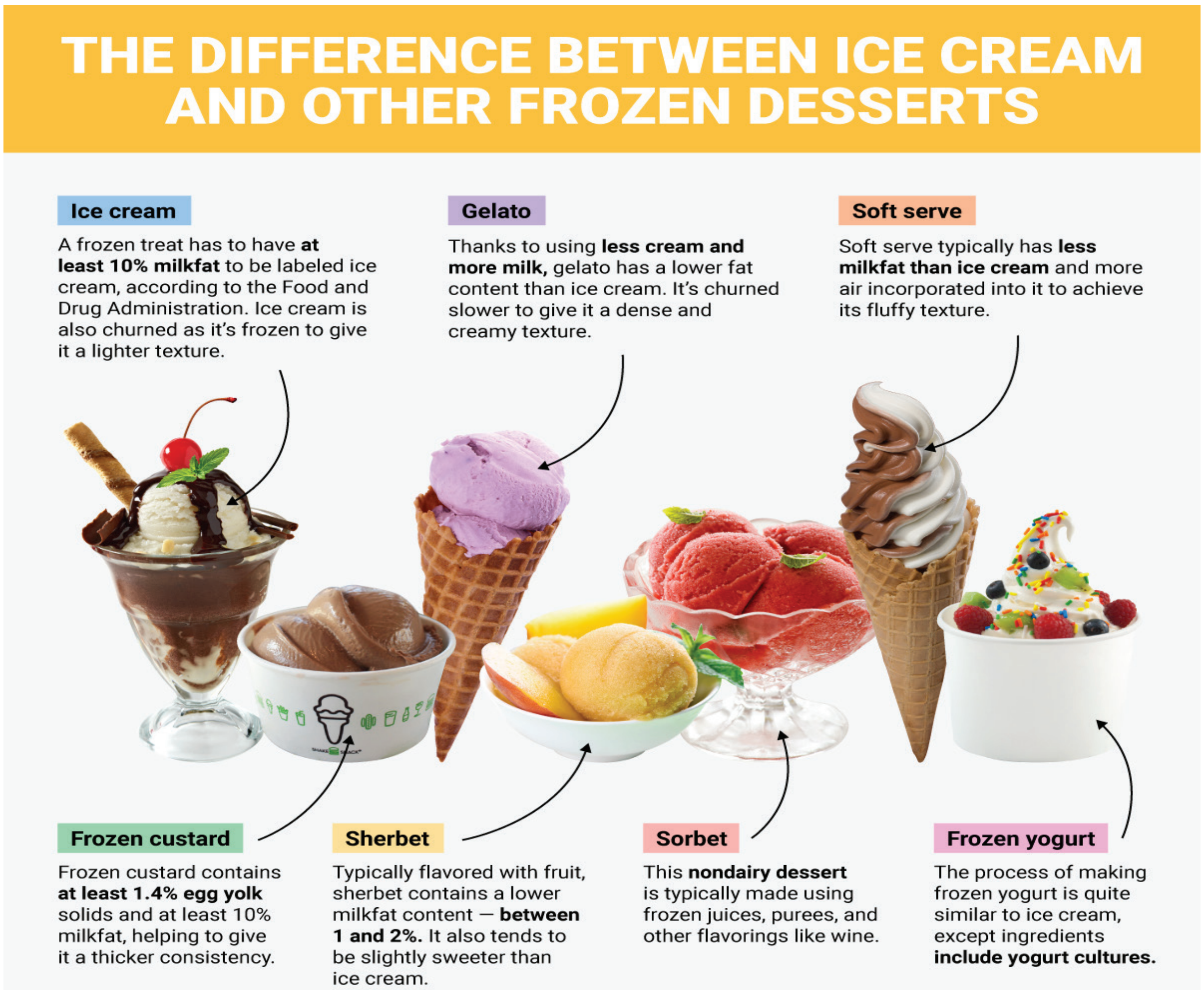


Fig. 3.10: Types of frozen ice cream

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:

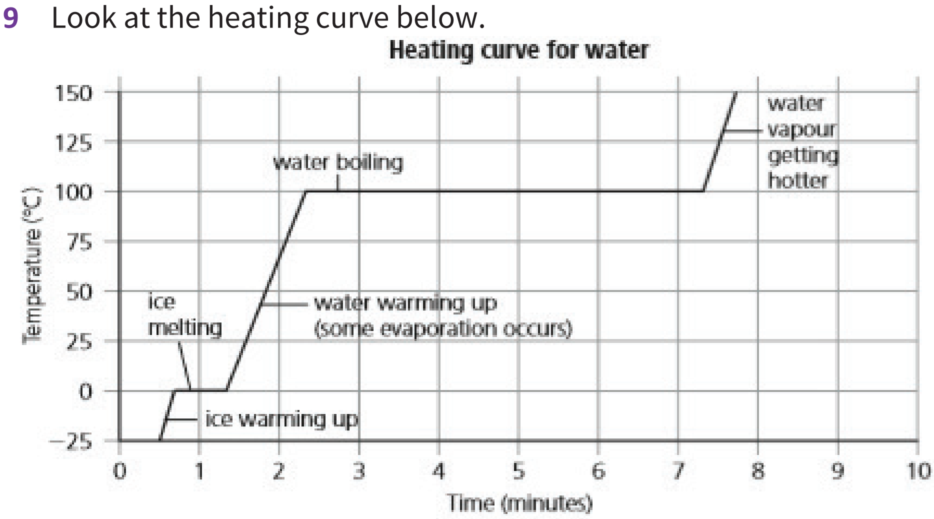
a) boiling?

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.