Orient BlackSwan

Inspired CHEMISTRY

For the CISCE curriculum

NEP Compliant inside

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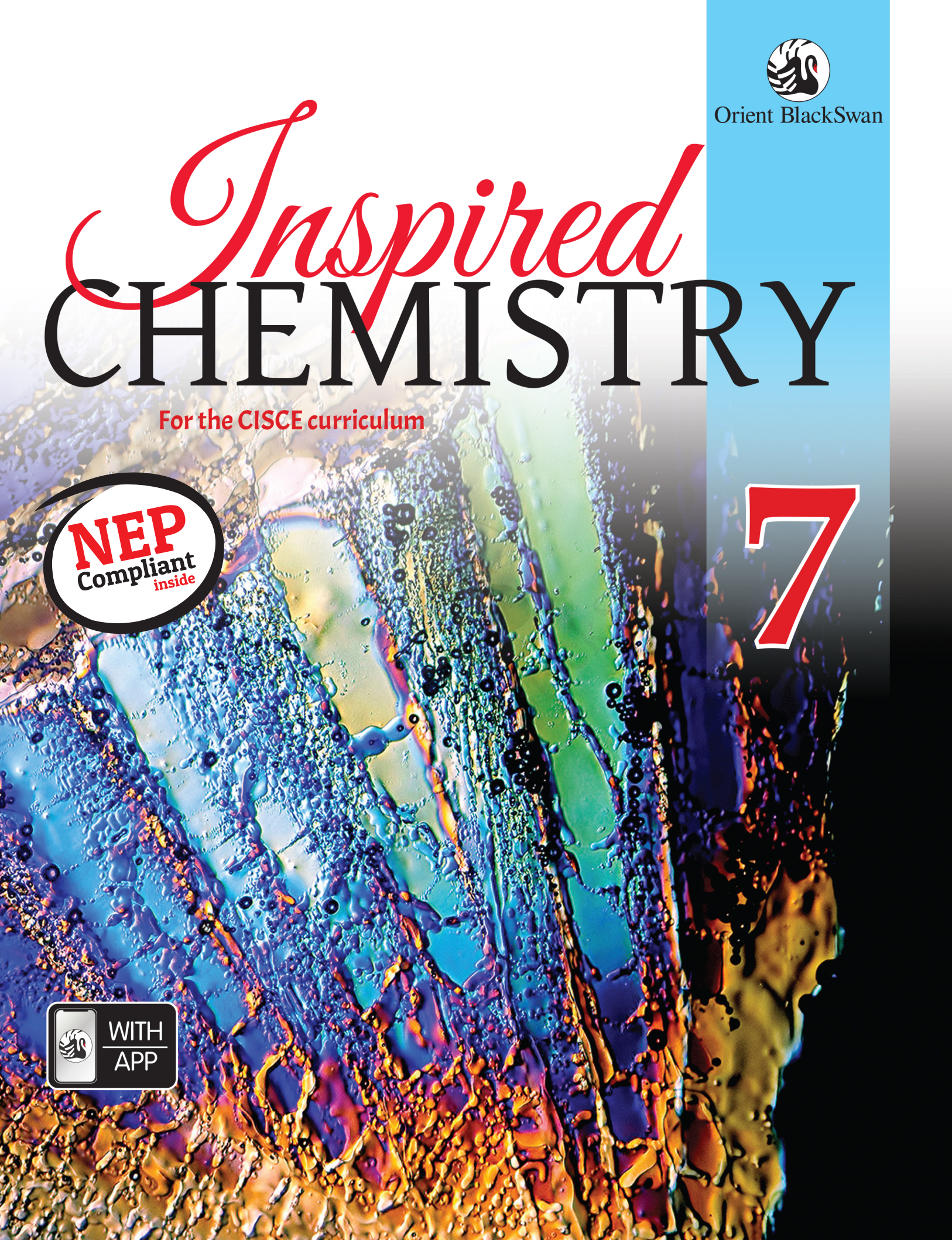

WITH APP

Inspired CHEMISTRY

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Orient BlackSwan

Inspired Chemistry

has been developed in accordance with the CISCE Upper Primary Science (Chemistry) curriculum. Its aims are:

- to enable students to relate their daily life experiences and science by following a practical, thematic approach
- to focus on the development of scientific temper through skill and process development
- to encourage knowledge construction through information collection, organisation and reflection

Students' book

- complete syllabus coverage
- carefully graded text
- appropriate, well-labelled illustrations and photographs
- appropriate activities and exercises

Let's learn

Learning outcomes
encourage students to take responsibility for their learning

Get going
helps focus and direct students' attention to the lesson

Activities
help students learn through practical exercises

Stop and check
provides checkpoints for teachers and students to evaluate progress

Spotlight
focuses on important topics in greater detail

Go further
provides additional, interesting, relevant information

SciTech
links scientific concepts with real-life occurrences and applications

Eco corner
presents issues that are an environmental concern

Let's revise

In a nutshell
is a comprehensive revision corner

Concept map
is a graphic presentation of concepts linked logically

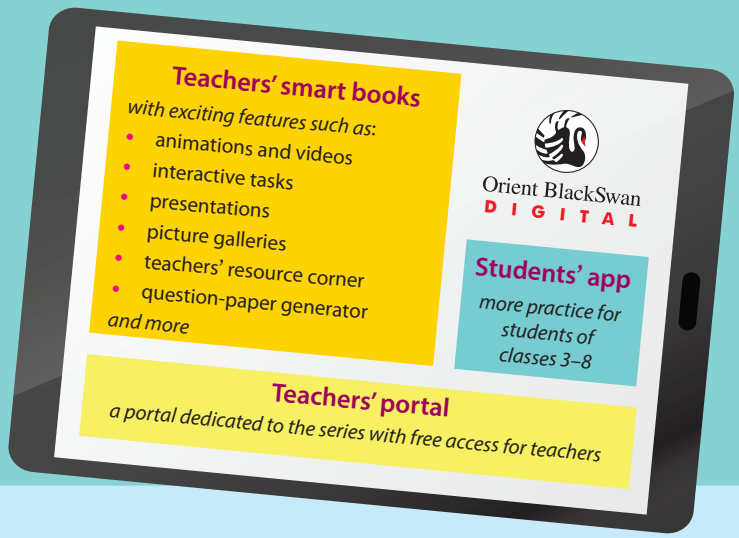
Summary
lists the main points of the lesson briefly

Keywords
lists important words and their definitions

Glossary
presents important words for quick revision at the end of the book

Teachers' resource packs

- lesson plans
- question bank with answers
- worksheets with answer key
- question papers with answer key
- answer key to the exercises in the students' book



Let's apply

Checkpoint
covers a variety of exercises (objective type, short answer and long answer)

Think and answer
encourages students to develop higher-order thinking skills necessary for the 21st century

Picture study
offers picture-based questions that encourage students to observe, identify and relate concepts to real life

Hands-on
offers a variety of projects that reinforce 21st century skills through experiments, model-making, discussion, role play, research work, report writing and so on

Subject integration
presents additional activities explicitly linking multiple subjects

Life skills and values
help children develop skills needed for everyday life and values needed to be well-adjusted members of society

Let's know more

Scientist in focus
describes the life and work of famous scientists to inspire students

Heritage corner
presents exciting and accurate information on India's scientific heritage

Internet links
provides sources for further study and research

Career watch
presents novel ideas for a career in science and technology

Let's work

- *Worksheets* a workbook corner with worksheets covering all lessons
- *Test papers* based on the ICSE pattern

CONTENTS

3 Elements, Compounds and Mixtures

Learning outcomes

By the end of this theme, you will be able to:

- identify substances as elements, compounds or mixtures
- differentiate between compounds and mixtures
- provide examples of elements, compounds and mixtures from daily life
- discuss different techniques for the separation of components of mixtures
- justify the reason for the use of a particular technique in the separation of a mixture
- explain chromatography and its importance

Get going

When you look at the bucket, you can probably guess that it is made of iron. What about some other common substances, such as the water in the bucket or the bright red paint on the pump? By looking at them can you tell if they are made of a single substance or a combination of many substances?

Spotlight

*A **pure substance** has only one kind of substance.* It is uniform or **homogeneous** in properties and appearance. Examples are the elements iron and oxygen, and the compounds water and salt. *An **impure substance** has one or more pure substances mixed in any proportion.* It may be homogeneous or **heterogeneous** in properties and appearance. Some examples are muddy water, air, and a mixture of salt and sand or salt and pepper.

INTRODUCTION

You have already learnt that substances are made of matter. We will take a closer look at substances and classify them beyond identifying their state as solid, liquid or gas. You will recall that substances can be classified as elements, compounds or mixtures on the basis of their properties and constituents.

Elements and compounds are pure substance, whereas mixtures are impure substances.

Elements and Compounds

ELEMENTS

If you take a piece of copper and keep breaking it to get smaller and smaller pieces, the smallest particle you get will display the same properties displayed by a big bar of copper. We say that copper is an **element**. *An element is a pure substance that cannot be converted into a simpler substance by any physical or chemical process.* The smallest particle that makes up an element is called an **atom**.

Hydrogen, oxygen, iron, carbon, sulphur, aluminium, copper, silver, gold and lead are some more examples of elements. Currently, we have identified 118 elements. Of these, 92 elements occur in nature, while the remaining 26 are synthetic.

Periodic Table

From the mid-1700s, chemists were involved in identifying elements. They tried to classify or arrange them in different ways. In 1869, the Russian chemist Dmitri Mendeleev classified all the elements known at that time in the form of a table based on their properties. This has come to be known as the **periodic table**. A simplified version of this table showing just the first 20 elements is given in Table 3.2 in a following section.

The property used to arrange elements in this table is of immense use to chemists in understanding the behaviour of elements.

Symbols of Elements

For ease of writing, each element is represented by a **symbol** or chemical symbol. The symbol is a kind of abbreviation, and is derived from the name of the element. There are different ways in which the symbol is arrived at.

- The first letter of the name, written in capitals, is used as the symbol, for example, oxygen (O), hydrogen (H), carbon (C), nitrogen (N), sulphur (S) and iodine (I).
- If the names of two or more elements start with the same first letter, two letters are used to form the symbol, with the second letter written in small letters, for example, beryllium (Be), bromine (Br) and barium (Ba), and calcium (Ca) and cobalt (Co).
- If the first two letters are the same, some other letter is taken and written in small letters, for example, magnesium (Mg) and manganese (Mn), and zinc (Zn) and zirconium (Zr).
- The symbols of some elements are very different from their names in English. These symbols have been derived from their names in other languages such as Latin. Some examples are mercury (Hg from *hydrargyrum*), iron (Fe from *ferrum*), sodium (Na from *natrium*) and potassium (K from *kalium*).

Table 3.1 Symbols of some elements derived from their names in other languages

Element	Name in other language	Symbol
silver	argentum	Ag
gold	aurum	Au
copper	cuprum	Cu
iron	ferrum	Fe
potassium	kalium	K
sodium	natrium	Na
lead	plumbum	Pb
tungsten	wolfram	W

Classification of Elements

The elements are broadly divided into four classes based on their properties—metals, non-metals, metalloids and inert or noble gases. These classes of elements have unique properties.

Metals Most of the elements we know are metals. They are solids that are good conductors of heat and electricity. Some examples are aluminium, iron, copper, silver, gold and lead.

Non-metals They are very few in comparison to metals. We know of 12 non-metals. Most of them are gases. Some examples are hydrogen, oxygen, nitrogen, carbon, sulphur, chlorine and phosphorus.

Metalloids These elements show some properties of metals and some of non-metals. They are hard solids and find use as semiconductors. Some examples are boron, silicon, germanium, arsenic, antimony and tellurium.

Inert gases Though these gases are included with the non-metals, they actually belong in a separate group as they are extremely unreactive. Helium, neon, argon, krypton, xenon and radon are inert gases.

Table 3.3 lists some elements and their uses.

Go further...

More than 25 elements are found in living things. The six elements that are most common are called the CHNOPS elements—carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur.

- Our bones contain calcium. Calcium is also present in milk and chalk.
- Chlorophyll in plants contains magnesium.
- Haemoglobin, present in our blood, contains iron.

Table 3.2 Names and symbols of the first 20 elements

1 H hydrogen							2 He helium
3 Li lithium	4 Be beryllium	5 B boron	6 C carbon	7 N nitrogen	8 O oxygen	9 F fluorine	10 Ne neon
11 Na sodium	12 Mg magnesium	13 Al aluminium	14 Si silicon	15 P phosphorus	16 S sulphur	17 Cl chlorine	18 Ar argon
19 K potassium	20 Ca calcium						

metal non-metal metalloid noble gas

Table 3.3 Some common elements and their uses

Element	Type	Uses
hydrogen	non-metal, gas	• It is present in water; it is also an essential part of most substances found in living things. • It is present in fertilisers, plastics and pharmaceuticals. • It is seen as the clean fuel of the future.
carbon	non-metal, solid	• It is essential for life; it is present in all living things and substances such as fossil fuels that are derived from living things. It is taken in as carbon dioxide by plants and as carbohydrates by animals. • It is used in pencils, electric motors, tennis rackets, rockets and aeroplanes. • Diamond, a form of carbon, is used to make jewellery.
nitrogen	non-metal, gas	• It forms an essential part of proteins and DNA. • It is present in fertilisers, nitric acid, synthetic fibres and explosives. • It is used in the food industry as a non-reactive gas in packaging.
oxygen	non-metal, gas	• It is present in water and, along with carbon and hydrogen, in almost all substances in living things. • It is essential for all living things for respiration and is important for combustion.
neon	non-metal, gas	• It is used to make neon signs for advertisements since it glows with a reddish-orange colour when electricity is passed through it.
sodium	metal, solid	• It is present in common salt (sodium chloride), baking powder (sodium bicarbonate), washing soda (sodium carbonate) and fertilisers (soda ash). • It is essential for the transmission of signals along nerves and helps the body regulate water levels.
magnesium	metal, solid	• It is present in chlorophyll and in our bones. • It is used to make strong and lightweight alloys used in automobiles, aircraft, cameras and so on. • Since it burns brightly, it is used to make sparklers and other fireworks.

Stop and check

Answer the following questions.

1. What is an element?
2. Name the table into which Mendeleev arranged all the elements.
3. How are elements represented?
4. Name the different types of elements.
5. Name the elements whose symbols are F, Si, Ne, Li, P, Al.
6. Write the symbol for the elements chlorine, calcium, beryllium, nickel, helium and oxygen.

COMPOUNDS

A compound is also a pure substance.

- *A compound is a chemical made up of two or more elements that have combined chemically in a fixed proportion.*
- Compounds are formed through **chemical reactions**.
- The properties of a compound may be very different from those of the elements that make it up.
- Energy is absorbed or released during the formation of a compound.

Activity 3.1

Aim: To distinguish between elements and compounds

Classify the following substances as elements or compounds. (Recall what you have learnt in class 6.)

oxygen, hydrogen, water, beryllium, argon, sand, rust, tungsten, carbon, salt, sugar, ammonia, ozone, gold

CHEMICAL FORMULAE

Atoms usually do not exist by themselves. They combine with other atoms to form molecules. A molecule is represented by a **chemical formula**, which shows the elements present as well as the number of atoms of each element in that molecule.

Molecules of elements include O_2 (oxygen), H_2 (hydrogen) and P_4 (phosphorus). The formulae of some compounds are given in Table 3.4. You will study more about chemical formulae in the following lesson.

Table 3.4 Some common compounds and their constituents

Compound	Formula	Elements present	Compound	Formula	Elements present
sodium chloride (common salt)	NaCl	sodium, chlorine	ammonia	NH_3	nitrogen, hydrogen
potassium iodide	KI	potassium, iodine	calcium carbonate (chalk)	$CaCO_3$	calcium, carbon, oxygen
water	H_2O	hydrogen, oxygen	iron oxide (rust)	Fe_2O_3	iron, oxygen
carbon dioxide	CO_2	carbon, oxygen	calcium sulphate (plaster of Paris)	$CaSO_4$	calcium, sulphur, oxygen
silica (sand)	SiO_2	silicon, oxygen	glucose (a sugar)	$C_6H_{12}O_6$	carbon, hydrogen, oxygen

CHECKPOINT

A. Choose the correct option.

1. Sodium, potassium and aluminium are examples of _____.
   a) metals b) non-metals
   c) metalloids d) noble gases

2. _____ is a non-metal.
   a) Sulphur b) Zinc
   c) Silicon d) Magnesium

3. _____ is a metalloid.
   a) Krypton b) Silver
   c) Oxygen d) Germanium

4. Cl_2 is a/an _____.
   i. element ii. molecule iii. atom
   a) only (i) b) only (ii)
   c) (i) and (ii) d) (i) and (iii)

B. Fill in the blanks.

1. Pure substances include _____ and _____.
2. Mendeleev arranged the elements in the _____ _____.
3. The basic unit of an element is the _____.
4. _____ is the Latin name of silver.
5. A molecule of a compound is made of two or more _____.
6. NaCl is _____ chloride and KCl is _____ chloride.
7. Rust is the compound _____ _____.

C. Say if the statements are true or false.

1. There are more metals than non-metals in nature.
2. All the elements in the periodic table occur naturally.
3. Hydrogen and nitrogen are inert gases.
4. Water and carbon dioxide are examples of compounds.
5. A compound has the same properties as the elements present in it.

D. Form similar pairs of words.

1. *sodium* and *metal* / *silicon* and _____
2. *nitrogen* and *gas* / *carbon* and _____
3. *carbon* and *C* / *fluorine* and _____

E. Give one word for the following.

1. A substance that contains identical atoms
2. A substance that contains molecules made up of non-identical atoms

F. Short-answer questions

1. What are elements? Give examples.
2. Give two examples each of elements whose symbols are derived from the following.
   i. the first letter of their name
   ii. any two letters of their name
   iii. their name in another language
3. Give the formula for chalk, common salt and sugar.
4. Identify if these are elements or compounds. SiO_2, H_2, H_2O, NaCl, O_2

G. Long-answer questions

1. How are the elements in the periodic table classified? Give three examples under each class.
2. What is the significance of a symbol?
3. Give four characteristics of a compound.
4. Give three differences between elements and compounds.

Mixtures

Most of the substances we use in the house, school or elsewhere are not pure elements or compounds. They have other substances mixed in them. They are therefore **mixtures**.

A mixture is a substance produced by adding together elements, compounds or both, in any proportion, without any chemical change taking place.

For example, if we add salt to pepper powder, we know that no chemical reaction takes place. Similarly, if sugar and sand, chalk powder and water, coffee and milk, or yoghurt and water are added together, no change is noticed in the components. Since more than one substance is present in a mixture, it is not a pure substance.

HOMOGENEOUS AND HETEROGENEOUS MIXTURES

The appearance of a mixture can be uniform or otherwise. *A uniform mixture is called a* ***homogeneous mixture.*** In a homogeneous mixture, the components cannot be seen apart in the mixture. Some examples are mixtures of water and vinegar, sugar and water, and salt and water.

A mixture that is not uniform is called a ***heterogeneous mixture.*** The components can be seen as separate entities in the mixture. Some examples are mixtures of salt and pepper, sand and water, and oil and water. Tap water, milk, fruit juice and buttermilk are also heterogeneous though they may seem uniform to the naked eye.

Fig. 3.1 Copper nitrate solution (homogeneous)

Fig. 3.2 Salad (heterogeneous)

Table 3.5 Differences between homogeneous and heterogeneous mixtures

Homogeneous mixture	Heterogeneous mixture
uniform in appearance and properties	not uniform in appearance or properties
components cannot be seen apart	components can be seen apart
Examples: mixtures of water and vinegar, and sugar and water.	Examples: mixtures of salt and pepper, and sand and water.

Activity 3.2

Aim: To prepare homogeneous and heterogeneous mixtures

Method

1. Take salt in a small bowl and add pepper powder to it. Mix the components well. You will observe that the final mixture does not have a uniform appearance as the specks of salt and pepper can be seen separately. This is an example of a heterogeneous mixture.
2. Take water in a beaker. Add a spoon of sugar to the water and stir well. The sugar will dissolve in the water and the resulting solution will have a uniform appearance. This is an example of a homogeneous mixture.

CHARACTERISTICS OF MIXTURES

- A mixture is an impure substance.
- The appearance of a mixture can be homogeneous or heterogeneous.
- The components of a mixture can be added together in any proportion.
- A mixture cannot be represented by a formula.
- A mixture has the characteristics of all the components.
- A mixture does not have fixed characteristics such as boiling or melting points.

Spotlight

- The preparation of a mixture can involve the generation or absorption of energy. Dissolve glucose in water. The water becomes cool because the process absorbs energy. On the other hand, the dissolution of washing soda (sodium carbonate) in water gives out energy and makes the solution warm. (You can observe this by taking detergent in your hand and adding water to it.)
- The components of a mixture may not be easy to separate. For example, the gold used in jewellery has other metals mixed in it. The purification of this gold is a difficult process involving many physical and chemical reactions.

Activity 3.3

Aim: To show that a solution of salt in water is a mixture

Materials required: salt, water, glass, china dish, Bunsen burner

Method: Add a teaspoon of salt to the water. Stir well until the salt dissolves. Taste a drop of the solution. Heat the salt solution in a dish.

Observations and conclusions: The salt solution is homogeneous. This is a mixture for the following reasons.

- It is salty to taste, just like salt. The solution is a clear liquid like water.
- The components were not measured and can be added in any ratio.

In this case, the components (salt and water) can be easily separated by physical methods such as evaporation or distillation.

Fig. 3.3 Preparing a salt solution

Activity 3.4

(Teacher demonstration)

Aim: To compare the properties of compounds and mixtures

Materials required: iron filings, sulphur powder, watch glass, magnet, measuring spoon, china dish, carbon disulphide, Bunsen burner, stand

Method

1. Mix some iron filings and yellow sulphur powder in a watch glass.
2. Mix 7 g of iron and 4 g of sulphur in a china dish. Heat the china dish. Stop the heating when a black mass forms.

Fig. 3.4 A magnet attracts the iron in the mixture.

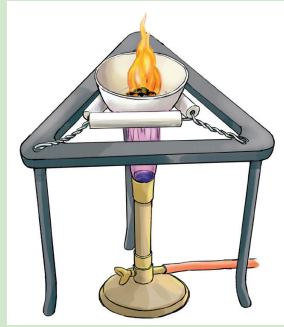


Fig. 3.5 Formation of iron sulphide

Observations and conclusions: In part 1, when a magnet is brought near the mixture, the iron filings get attracted and cling to it. If a drop of carbon disulphide is added to a pinch of the mixture, the sulphur alone dissolves. The mixture shows the properties of its components.

In part 2, a chemical reaction takes place in the presence of heat. The black mass is iron sulphide, a compound. If a magnet is brought near the iron sulphide or if carbon disulphide is added, there is no effect. This shows that iron sulphide is a compound, and is formed only when the components are taken in a fixed proportion and heated.

Table 3.6 Differences between compounds and mixtures

Compound	Mixture
It is a pure substance that is homogeneous.	It is an impure substance that can be homogeneous or heterogeneous.
It is a result of a chemical reaction between elements or compounds or both.	It is a result of elements or compounds or both being added without any chemical reaction.
The components are taken in a fixed proportion.	The components are taken in any proportion.
It has a definite formula.	It cannot be represented by a formula.
It is made up of identical molecules. Each molecule is made up of two or more atoms of elements.	It does not contain identical molecules but those of the substances mixed together.
Its properties are different from those of its components.	The properties of the components are retained.
It has fixed characteristics such as boiling and melting points.	The characteristics depend on those of the components.

TYPES OF MIXTURES BASED ON PHYSICAL STATES OF THE COMPONENTS

It is important to study the different types of mixtures, as the methods used to separate the components depend on the kinds of components used, and the physical state of the components.

Fig. 3.6 Brass is an alloy (solid–solid mixture) of copper and zinc

Table 3.7 Types of mixtures

State of the components	Type of mixture	Examples
solid–solid	homogeneous	alloys (for example, brass, bronze)
	heterogeneous	spice powders, salad, soil
solid–liquid	homogeneous	sugar and water, in milk
	heterogeneous	sand and water, salt and oil
solid–gas	heterogeneous	dust particles in air
liquid–liquid	homogeneous	ink and water
	heterogeneous	oil and water
liquid–gas	homogeneous	oxygen dissolved in water
	heterogeneous	mist (droplets of water mixed in air)
gas–gas	homogeneous	mixture of nitrogen and oxygen
	heterogeneous	water vapour in air

Stop and check

Answer the following questions.

1. Are these mixtures homogeneous or heterogeneous?
   i. A mixture of different kinds of seeds
   ii. A mixture of milk and water
2. Give three ways in which salt water is different from pure water.
3. Give an example each of a solid–solid mixture, solid–liquid mixture and liquid–liquid mixture.

SEPARATION OF THE COMPONENTS OF MIXTURES

Need for Separating the Components of Mixtures

Many substances that we need are found mixed with others. We have to separate the components for many purposes:

- To remove harmful or undesirable substances. For example, contaminants are removed from water to make it drinkable. Food grains, salt, sugar and spices are cleaned to remove harmful substances such as mud, stones, fertilisers and pesticides.
- To obtain useful substances. Salt is separated from seawater. Metals such as gold are separated from rocks.
- To prepare pure substances. For example, pure water is required to manufacture medicines and other pure chemicals. Pure silicon is used to manufacture chips used in electronic items.

Methods of Separation

To recover pure substances, the right method of separation has to be used. Let us consider the different types of mixtures and what methods can be used to separate their components.

Solid–solid mixtures

Handpicking If the amount of mixture is limited and the impurities are large and few, the impurities can be picked out of the mixture by hand. Stones can be picked from rice and different coloured beads separated by this method.

Sieving If the quantity of mixture is large and the particles of the components are small but of different sizes, the mixture can be passed through a sieve with holes of an appropriate size. The smaller particles pass through and the larger particles are retained in the sieve.

Fig. 3.7 Handpicking

Fig. 3.8 Sieving

Magnetic separation This method is used when one of the components of a mixture is magnetic in nature, such as iron filings. A magnet can be used to attract the iron particles, leaving behind the other component.

Sublimation This method can be used when one of the solids sublimes, such as ammonium chloride (NH_4Cl) or iodine.

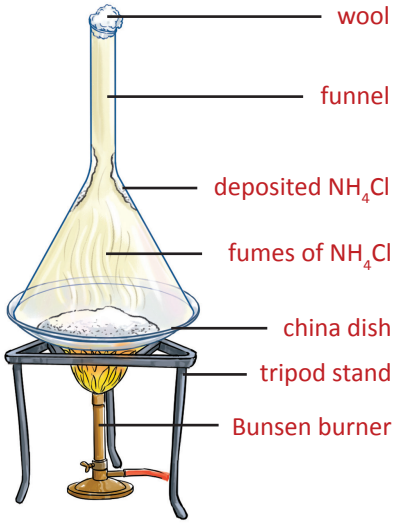


Fig. 3.9 Sublimation

Threshing and winnowing The difference in the weights of the components is used here. Bundles of wheat or paddy stalks are beaten against a surface to separate the grains sticking to the stalks. This is known as **threshing**.

In **winnowing**, the grain–husk mixture is allowed to fall slowly from a height.

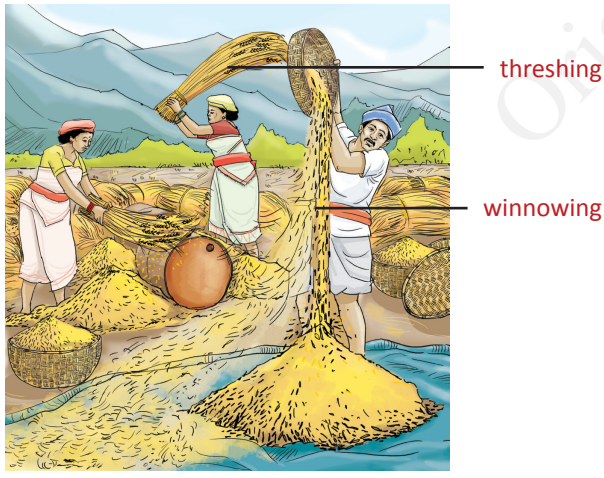


Fig. 3.10 Threshing and winnowing

The lighter husks are blown away while the heavier grains fall to the ground.

Gravitational method This method is used when one of the components is lighter than water and the other is heavier than water. For example, when a mixture of sand and sawdust is put in water, the sand settles at the bottom while the sawdust floats on the water.

Solvent extraction This method is used if one of the components is soluble in a liquid. Such a liquid is added to the mixture and the soluble component dissolves in it. After removing the insoluble component by filtration, the solution is evaporated to recover the soluble component. A mixture of salt and sand can be separated this way by adding water to dissolve the salt.

Solid–liquid mixtures

Sedimentation and decantation This method is used when one component is heavier than the other, since the heavier substance always settles at the bottom as a **sediment**, with the liquid component forming the **supernatant**.

Sedimentation is used in the purification of water for drinking. Water pumped out of lakes and rivers is allowed to stand in large tanks. The heavier solid particles settle to the bottom. The water above is clearer and is purified further.

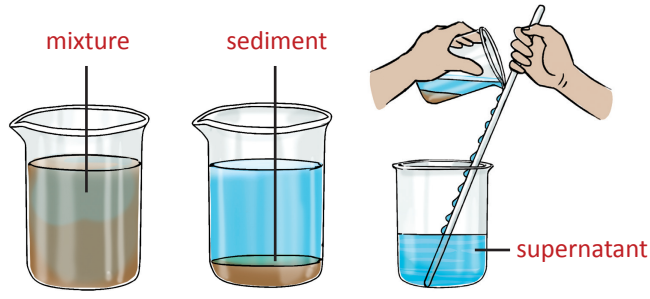


Fig. 3.11 Sedimentation and decantation

Filtration This method is used when the solid component floats on the liquid component or is suspended in it. Filter paper is placed in a funnel and the mixture is poured gently into it. The solid component is left on the filter paper as the **residue** and the liquid flows down the funnel into a beaker below as the **filtrate**. The wet filter paper is carefully placed on a watch glass to dry out. Then the solid can be gently scraped off the paper.

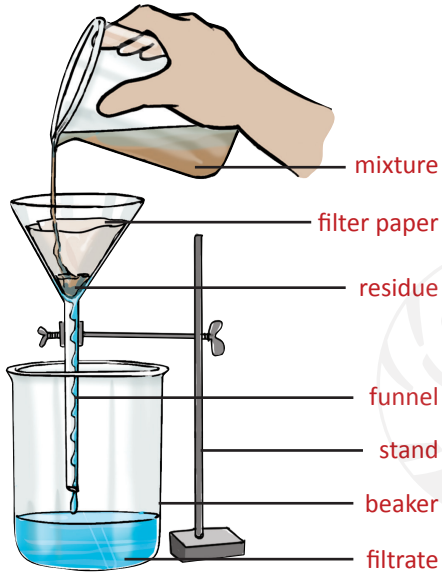


Fig. 3.12 Filtration

Evaporation It is an important method for separating a soluble solid from a solution. The solution is heated so that the solvent evaporates and the solute is left behind. Only the solute can be recovered using this method since the solvent escapes into the air. Salt is separated from seawater by evaporation.

Crystallisation This process is used when a component of a mixture solidifies into crystals while the other component evaporates. For example, a solution of copper sulphate and water is heated till most of the water evaporates and a saturated solution is formed. The solution is then cooled and the copper sulphate separates into crystals.

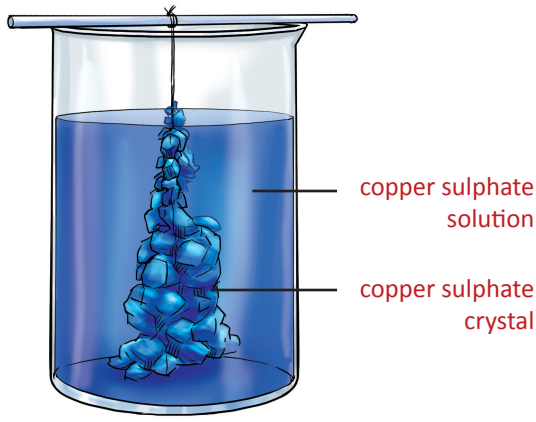


Fig. 3.13 Crystallisation

SciTech

Many of the methods of separation mentioned here are used regularly in our kitchens. We remove stones from rice by handpicking and insects from flour by sieving. Tea leaves are removed from a mixture of milk and tea by filtration with a strainer and butter is removed from cream by centrifugation.

Centrifugation This method is used when the components of a mixture differ in density. For example, when cream (a mixture of water, proteins and fats) is churned vigorously, the fat floats to the top as butter and is then easily removed.

Liquid–liquid mixtures

Separating funnel This apparatus is used to separate immiscible liquids. The separating funnel is open at the top and bottom.

The nozzle[1] at the bottom is closed with a stopcock. The mixture is poured into a separating funnel and allowed to rest. It separates into two distinct layers, with the lighter liquid in the upper layer. The liquid in the lower layer is drained into a beaker by opening the nozzle. The liquid in the upper layer remains in the separating funnel. A mixture of kerosene or oil (upper layer) and water (lower layer) can be separated by this method.

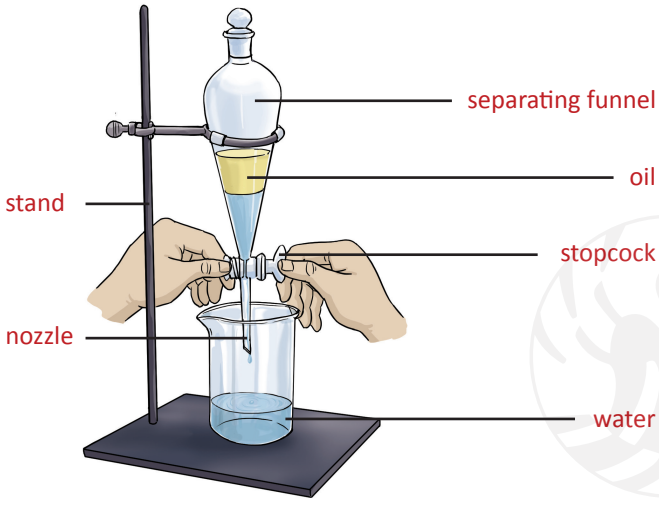


Fig. 3.14 Separating oil and water using a separating funnel

Distillation This process is used to separate the components of a solid–liquid mixture or a mixture of miscible liquids that have very different boiling points. A pure liquid is separated from a mixture by evaporating the liquid first and then condensing its vapours. At its boiling point, the liquid is completely converted to vapour, while the other solid or liquid remains behind. On cooling the vapours, the pure liquid is obtained. It is called the **distillate**.

[1]**nozzle** an opening at the end of a tube or container

This method is utilised in the purification of water, desalination of seawater and production of alcohol.

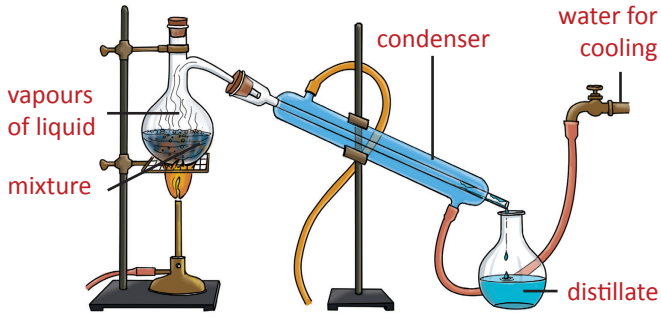


Fig. 3.15 Distillation

Fractional distillation This is similar to distillation, except that the process of boiling and condensing is repeated many times to separate liquids with boiling points close to each other. A distillation flask is connected to a long column called a **fractionating column** with a tube leading out at the top of the column. It is cool at the upper end of the column. When the mixture is heated, all components of the mixture boil and the vapours rise up into the fractionating column. As they rise up, the vapours meet cool air and condense. The liquid with the highest boiling point condenses first and falls back into the flask, while that with the lowest boiling point condenses at the top (coolest) part of the column and is led out through the tube. The distillate is removed and distilled again.

Alcohol and water are separated by this method. The boiling point of alcohol is 78.5 °C. So it boils first and is collected as the distillate. The distillate is distilled repeatedly till a mixture of 95% alcohol with 5% water is obtained.

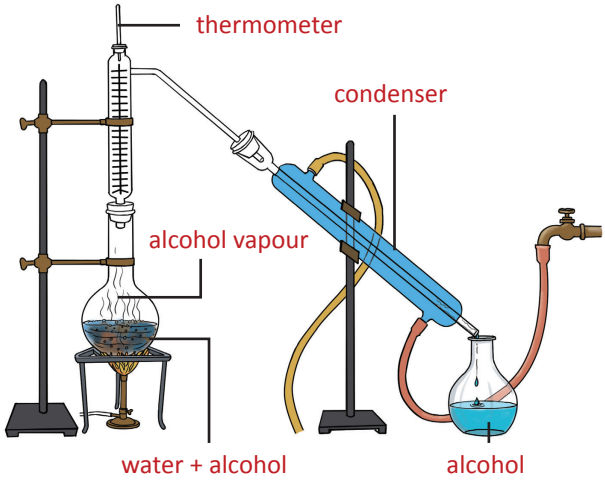


Fig. 3.16 Fractional distillation

Crude oil is also separated into its components (such as petrol, kerosene and diesel) using fractional distillation.

Chromatography This technique was originally used to separate a mixture into its chemical components based on colour, but is now used more widely. The principle behind chromatography is the capacity of a chemical to be adsorbed[2] on a **medium**. The rates of adsorption of different chemicals on a medium vary.

There are two important components or **phases** in chromatography. The **stationary phase** is the medium onto which the components of the mixture are adsorbed. The **mobile phase** is the solvent in which the components of the mixture dissolve, and which carries these components.

Paper chromatography is the simplest type of chromatography. Carry out Activity 3.5 to see how it is used to separate mixtures.

Activity 3.5

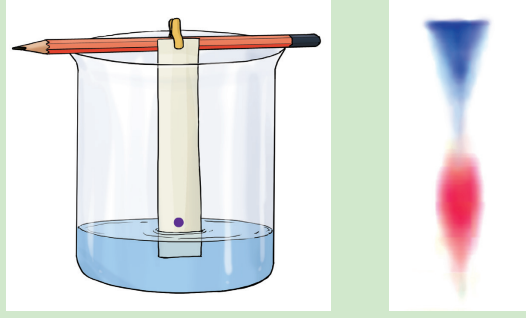
Aim: To separate components of ink using chromatography

Materials required: Whatman no. 1 filter paper (stationary phase), water (mobile phase), beaker, marker pen, clip, pencil

Method

1. Mark a line near the lower end of the filter paper strip.
2. Place a dot on the line with the marker pen.
3. Take water in the beaker.
4. Suspend the filter paper strip such that the line with the dot is just above the level of the water.

Observations and conclusions: Water starts rising up the filter paper. As it crosses the ink drop, it dissolves the substances in the ink and continues to rise. The different colours in the ink soon separate on the filter paper. This is because different substances move at different rates on the filter paper. The component with the highest rate of adsorption will be adsorbed first and form the lowest layer, while that with the lowest rate of adsorption will be adsorbed last and form the layer farthest from the line.



a. experiment setup b. chromatogram

Fig. 3.17 Separating components of a mixture using chromatography

[2]**adsorb** hold another substance on its surface

Paper chromatography is useful for a number of reasons.

- Even a very small quantity of the mixture can be separated.
- Components that are close to each other in physical and chemical properties can be separated.

Combinations of methods

A combination of methods is used in many cases to get pure substances. For example, to get clean drinking water from sources of water, sedimentation and filtration along with other processes are carried out. Similarly, while making tea at home, sedimentation, decantation and filtration are carried out to remove the tea powder.

Career watch

Forensic chemist

Forensic chemistry is the study of various substances found at the scene of crime. It involves the knowledge of various substances, their reactions and methods of separation. This helps to identify chemicals, drugs, explosives, poisons and so on. To enter this field, you should study chemistry, and gain some experience in biology and mathematics as well. You may then have to study forensic science.

CHECKPOINT

A. Choose the correct option.

1. A homogeneous mixture of a substance and water is called a/an _____.
   a) alloy b) compound
   c) distillate d) solution
2. A mixture of solids that are of different sizes can be separated by _____.
   a) winnowing b) filtration
   c) sieving d) evaporation
3. The liquid obtained after decantation is called _____.
   a) sublimate b) supernatant
   c) filtrate d) distillate
4. A separating funnel is used to separate _____.
   a) solids of different sizes
   b) a solid from a liquid
   c) immiscible liquids
   d) different coloured solutions

B. Say if the statements are true or false.

1. Distillation is used to obtain a pure liquid.
2. A mixture can be made only by adding compounds together.
3. A mixture of chalk powder and stones can be separated by filtration.

C. Differentiate between the terms.

1. Homogeneous and heterogeneous mixtures
2. Compounds and mixtures

D. Short-answer questions

1. Give three characteristics of mixtures.
2. On what basis will you choose a method of separation?
3. Identify the method of separation.
   i. sand and pebbles
   ii. sulphur and iodine
   iii. soil and water

iv. kerosene, salt and water
v. petrol and kerosene

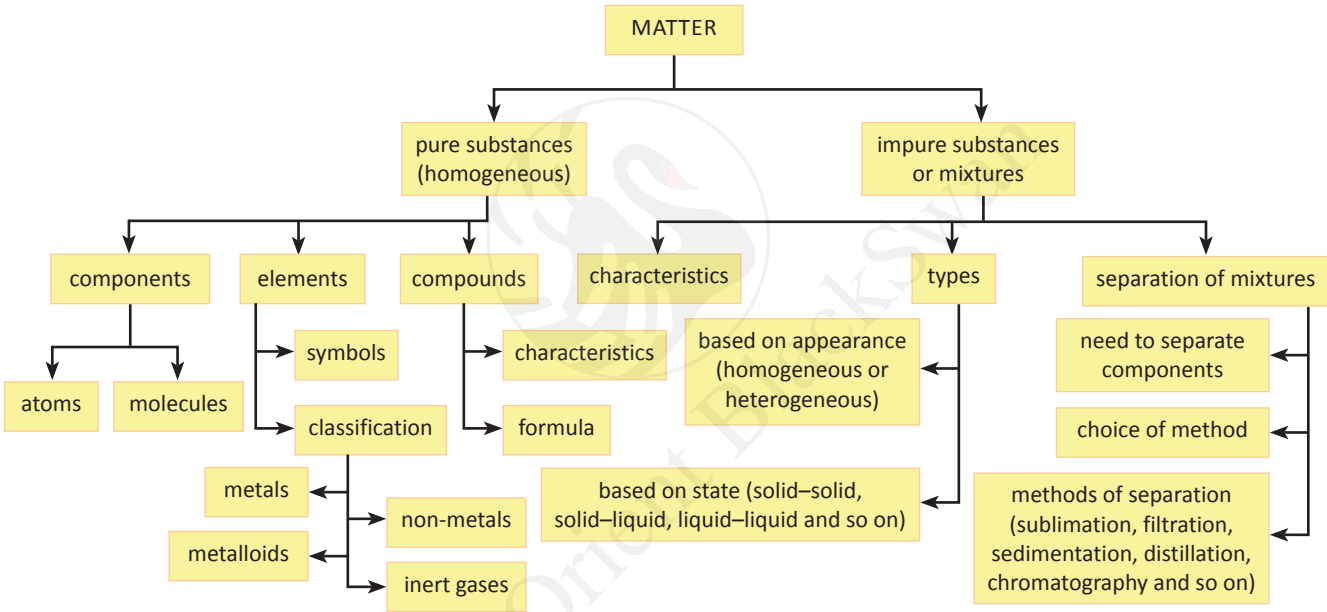
4. Identify the principle of separation.
   i. raw rice and lentils
   ii. sulphur and iron filings
   iii. sand and sawdust
   iv. oil and water
   v. ammonium chloride, salt and sand
5. What is the advantage of using separation by distillation over evaporation?
6. What are the two phases used in chromatography?
7. What is the principle of chromatography?

E. Long-answer questions

1. Explain the setup and process for separating salt from water by distillation.
2. How is fractional distillation used to separate a mixture of alcohol and water?
3. How is paper chromatography used to separate the components of ink?
4. Why do we need to separate mixtures?

In a nutshell

CONCEPT MAP



SUMMARY

- The materials around us are made up of elements, compounds and mixtures.
- Elements and compounds are pure substances, whereas mixtures are impure substances.
- Elements cannot be broken down into simpler substances.
- Elements are classified as metals, non-metals, metalloids and inert gases.
- Elements are made up of molecules of one kind of atom. The molecules of a compound are made up of atoms of two or more elements.
- An element is represented by a symbol.
- A molecule is represented by a formula. This formula gives the symbols of all the elements present in one molecule, and their number.
- Compounds are formed by chemical reactions.

- A mixture is made by adding together elements or compounds or both.
- Mixtures can be of different types—solid–solid, solid–liquid, liquid–liquid and so on.
- The method of separation used to separate components of a mixture depends on the physical state of the components and their physical properties.
- Sieving, evaporation, distillation, fractional distillation and chromatography are some physical methods of separation of the components of a mixture.

KEYWORDS

atom the smallest unit of an element

chromatography a technique used to separate the components of a mixture based on the rates of adsorption of the components

compound a substance formed of two or more elements chemically

distillate a liquid component of a mixture obtained after evaporation and condensation in distillation

distillation the process of converting a liquid in a mixture to the gaseous state by boiling and then condensing the vapours to get pure liquid

element a substance that cannot be broken down to a simpler substance

filtrate the substance that is collected below the strainer after filtration

filtration the process of separating the insoluble solid component from the liquid component of a mixture by passing the mixture through filter paper

fractional distillation the process of repeated distillation using a fractionating column to separate miscible liquids whose boiling points are close

formula a short form of representing a compound, including the symbols of all the elements present in a molecule of the compound, and the number of atoms of each element

immiscible (of liquids) do not mix, or cannot be mixed to form a homogeneous solution

mixture an impure substance made of two elements or compounds or both added together

miscible (of liquids) can mix or be mixed to form a homogeneous mixture

mobile phase the solvent in which the components of a mixture dissolve, and which carries these components in chromatography

molecule the smallest unit of matter that exists independently in nature; it is made of one or more atoms

periodic table a table, first prepared by Mendeleev, that lists all the elements in a structured manner

residue the substance that remains in the strainer after filtration

sediment the heavier substance that settles at the bottom of a solution in sedimentation

separating funnel an apparatus that is open at both ends, has a stopcock at the bottom and is used to separate immiscible liquids

stationary phase the medium onto which the components of the mixture are adsorbed in chromatography

supernatant the clear liquid that is present above the sediment in sedimentation

symbol a standard abbreviation used to represent an element

threshing the process of beating stalks of crop plants to separate the grain

winnowing the process of dropping a mixture of grain and impurities (including husk) from a height so that the lighter impurities are blown away by the wind while the heavier grains fall to the ground

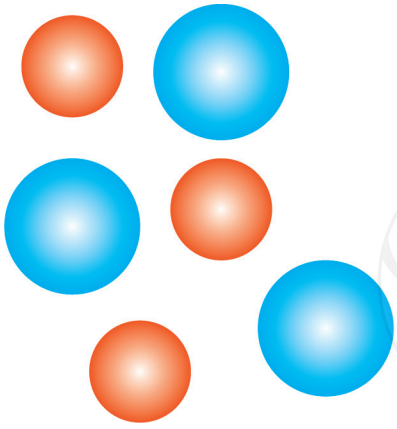
Think and Answer

1. What is common to the following processes? (*Hint*: What is the principle involved?)
   i. winnowing, gravitational separation, centrifugation
   ii. sedimentation and filtration, using a separating funnel
   iii. sieving, filtration
2. You are given a mixture of white chalk powder, common salt and ammonium chloride, all of which are white powders. How will you obtain all the components separately?

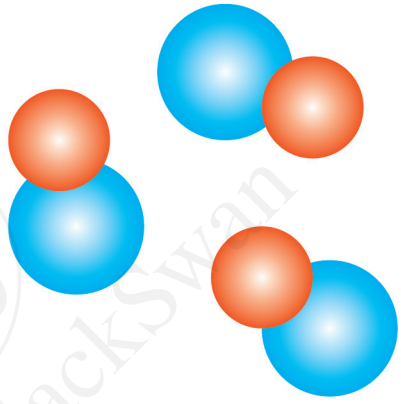
Picture Study

Which picture represents a compound and which represents a mixture?

i.



ii.



Life Skills and Values

We should drink clean water and eat hygienic food. The water we get in the pipes at home is often not clean. It contains dirt and bacteria. By attaching a filter to the tap, solid impurities can be separated. Boiling or passing the water through a water purifier will remove bacteria and other impurities.

Hands-on

1. Find out more about five elements that are essential for good health. Find out how the body gets these elements. Write a short report.
2. Prepare a list of five solid–solid, solid–liquid and liquid–liquid mixtures used in your house.
3. Separate a mixture of salt and water at home. Write details of the experiment in your notebook.
4. Form groups of four. Each person should select one separation technique useful in the separation of a two- or three-component mixture. Explain and discuss in class the reason for preferring this technique.

Subject Integration

(Geography)

Identify 10 elements in your surroundings that are commonly used. Find out where these elements occur in nature, and mark those places on a map of India. Explore further and find out where the largest deposits of these elements are found in the world. This exercise is meant to help you understand how materials are brought from far and near to make essential items.

Scientist in Focus

Marie Curie

Marie Curie was born in Poland and dedicated her life to the study of radioactivity along with her husband. She discovered the elements radium and polonium. She also studied the nature and compounds of radium. This element came to be used in the field of medicine. She was awarded the Nobel Prize in Chemistry in 1911 for this research. As she had also been awarded the Nobel Prize in Physics in 1903, she was the first person to receive the Nobel Prize twice.

Internet Links

https://www.bbc.com/bitesize/guides/zt2hpv4/revision/
http://www.rsc.org/periodic-table

Heritage Corner

Crucible steel

Crucible steel is steel made by melting pig iron (cast iron), iron, and sometimes steel, along with sand, glass, ashes and other substances, in a crucible (a kind of container used to heat substances to high temperatures). Wootz steel was the first form of crucible steel, developed in India around 300 BCE. It was widely exported to the Middle East, where it was used to produce Damascus steel, which was much sought after throughout the world. Indian wootz steel was the first high-quality steel that was produced.

Inspired CHEMISTRY

For the CISCE curriculum

CLASS 7

Orient BlackSwan

The National Education Policy (NEP) 2020 emphasises certain crucial parameters based on content and pedagogy. The Inspired Chemistry series provides a rich range of exercises and activities for each of the parameters. Here is a quick reference guide to some of the examples in this book.

The Inspired Chemistry series is mapped perfectly to the National Education Policy 2020.

21st Century Skills

A broad set of skills, knowledge, work habits and character traits that are important for success in the 21st century

The NEP parameters	Features	Page nos.
The 4Cs		
Critical Thinking	Think and Answer	69
Collaboration	Hands-on	104
Communication	Hands-on	43
Social and Emotional Learning	Life Skills and Values (2)	24
	Life Skills and Values	85
Multiple Intelligences	Subject Integration (4)	104
	Activity 1.4	3
	Hands-on	25

Experiential/ Constructivist Approach

Learners construct their knowledge, based on what they already know, through experience or by doing and reflection

The NEP parameters	Features	Page nos.
Experiential/Constructivist Approach	Activity 6.1	72
	Activity 6.4	76
	Hands-on (Guided activity)	69

Integrated Approach

An approach to teaching and learning that works by connecting knowledge and skills across the curriculum, by bringing real life examples to the classroom

The NEP parameters	Features	Page nos.
Subject Integration	Subject Integration (Physics)	56
	Subject Integration (Physics, Geography)	85
	Subject Integration (Physics, Geography)	104
Art Integration	Subject Integration (4)	104
Health and Wellness	Life Skills and Values	43
	Life Skills and Values	104
	Life Skills and Values (2)	69
Values	Scitech	37
	Life Skills and Values (1)	69
Life Skills	Hands-on	43
	Life Skills and Values (1)	25

Sustainable Development Goals

A framework of 17 global goals designed to be a blueprint to achieve a better and more sustainable future for all

The NEP parameters	Features	Page nos.
Sustainable Development Goals	Eco Corner	6
	Life Skills and Values	9
	Picture Study	103

India Knowledge

A strong focus on ancient knowledge from India, traditional values, modern developments and future aspirations

The NEP parameters	Features	Page nos.
Know more about India	Heritage Corner	104
	Heritage Corner	25
	Heritage Corner	85

Digital Integration

The use of digital tools to enhance and support the teaching–learning process

ICT/Digital resources

Orient BlackSwan Smart App - Interactive Tasks and Games for Practice and Revision

Teachers' Smart Book - Flipbook, Animations, Videos, Presentations, Picture Galleries, Interactive Tasks, Embedded Questions, Lesson Plans, Students' Book Answer Key, Worksheets with Answer Key, Question Paper Generator

Teacher Empowerment

Teachers' Resource Pack - Lesson Plans, Students' Book Answer Key, Question Bank with Answer Key, Worksheets with Answer Key, Test Papers

Teachers' Portal - Chapter e-Book, Presentations, Picture Galleries, Animations, Videos, Students' Book Answer Key, Worksheets with Answer Key, Interactive Tasks, Lesson Plans, Question Bank with Answer Key

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