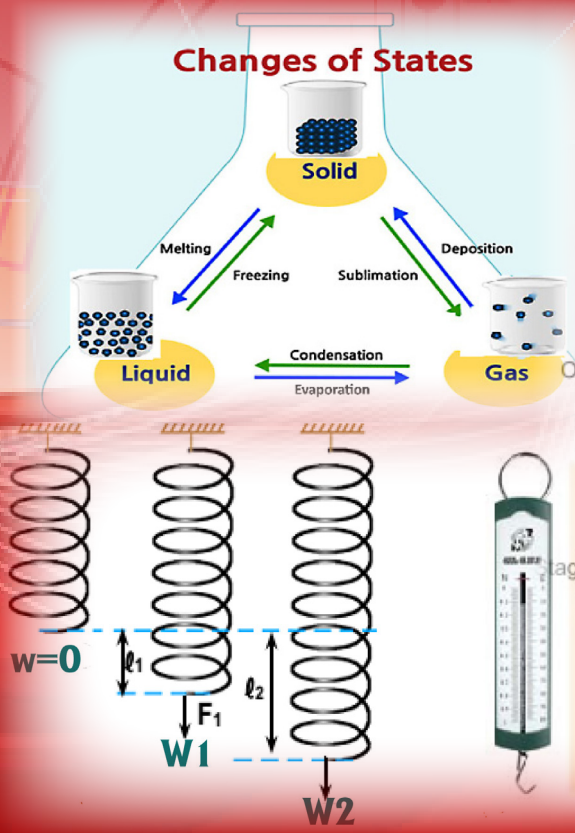
GENERAL SCIENCE

Student Textbook



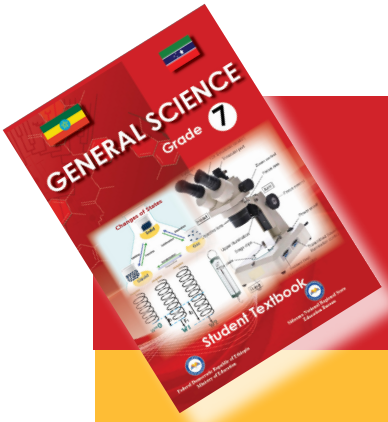


Grade 7

Federal Democratic Republic of Ethiopia
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GENERAL SCIENCE

STUDENT TEXTBOOK

Grade 7

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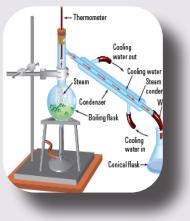
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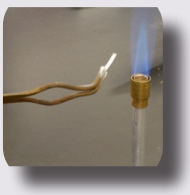
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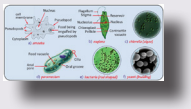
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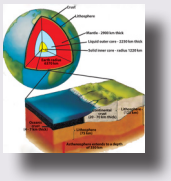
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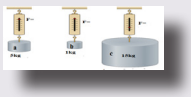
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UNIT ONE

BASIC CONCEPTS OF SCIENCE

Learning Outcomes

At the end of this unit, students will be able to:

- *define science as a body of knowledge and the processes and practices used to add to that body of knowledge;*
- *describe the main branches of science and explain their relationship;*
- *relate how science and technology affect one's beliefs, practices, and ways of thinking;*
- *appreciate the contributions of outstanding scientists to science and technology;*
- *discuss the importance of scientific values in decision making and problem solving;*
- *identify the significant contributions of Ethiopian scientists in science;*
- *identify different laboratory tools;*
- *demonstrate safe ways of using apparatus in the laboratory;*
- *practice precautionary measures in the laboratory;*
- *exhibit knowledge of lab safety rules and procedures; and*
- *identify potential hazards and implement appropriate safety procedures when working in the laboratory.*

Main Contents

1.1. The Nature of Science and its Branches

1.2. Common Laboratory Equipment, Uses, Safety Rules and Procedures in Science Laboratories

Start-up Activity

Be in group of six, discuss with your group members and then present in the class.

1. What do you think science is?
2. What does science deal with?
3. What do you think about the components of science?

Introduction

In lower grades, in Envronmental science subject, you have learned about the definition of science as a branch of knowledge dealt with all living and non-living things in nature. Science consists of three components such as scientific attitude, knowledge and skill. Knowledge of science and facts are verifiable. Existing scientific truth is relative and must be continually tested, evaluated and reconstructed. In this unit, you will learn about the nature of science and its branches, meaning of science, the relationship between science and technology, famous scientist in the world and Ethiopia and common laboratory equipment, uses, safety rules and procedures in science laboratories.

1.1. The Nature of Science and Its Branches

At the end of this section, you will be able to:

- *define science;*
- *describe the main branches of science and explain their relationship;*
- *relate how science and technology affect one's beliefs, practices, and ways of thinking.*
- *appreciate the contributions of outstanding ethiopian scientists to science and technology;*
- *discuss the importance of ethical disciplines in scientific investigations; and*
- *solve the issue of environmental problems in their school compound and its surroundings*

1.1.1. Definition of Science

Activity 1.1.

Be in a group and discuss the following questions

1. What exactly, science is for you?
2. Why science is important?
3. What are things that science does not do?

The word science comes from the Latin word *scientia*, which means 'knowledge'. So, the science is a method of discovering reliable knowledge about nature, which means the learning of already acquired knowledge of the physical world, or developing technology to benefit the human society.

In general, science is a body of organized knowledge obtained about nature through observation, explanation, interpretation and rationalization. Science is a process of thinking and learning about the world around us.

Science provides an ordered way of learning about the nature of things, based on observation and evidence. Through science, we explore our environment, gather knowledge and develop ideas that help us interpret and explain what we see.

1.1.2. Main Branches of Science

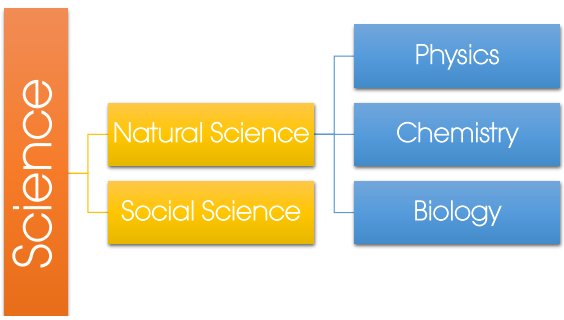
Activity 1.2.

Form a group and then discuss on the following questions

1. Describe the main branches of science and explain their relationship
2. Write the branches of natural sciences by searching from Internet or other sources.

Based on foundation of knowledge, science can be classified as indigenous and conventional sciences. Indigenous science is a science incorporating local people's knowledge and indigenous perspectives. Conventional scientific approaches are commonly recognized as western science. Knowledge in science is not absolute, current knowledge can be changed when a better understanding comes through more observation and investigation of indigeneous knowledge. We humans often ask whom we are, where we come from, how we could live in harmony with the environment. In general science can be classified into two main branches namely natural science and social science.

The main branches of science are given in chart below.



Social science is branch of science that devoted to the study of societies and relationships among individuals within those societies. Example; Geography, History, Economics and etc.

Natural science is the study of nature and natural laws. Natural sciences can be classified into three branches. Such as:

What is Physics?

Physics is the science of systems.

Physics is branch of natural science which describes how the system is placed on the space, the motion of the system, and other physical properties. A person who studies physics is called *Physicist.*

What is Chemistry?

Chemistry is the science of matter and its change.

Chemistry is a branch of natural science that studies the composition, properties, structure and transformation of substances. A person who studies chemistry is called *Chemist.*

What is Biology?

Biology is the science of life.

Biology is a branch of natural science which deals with living organisms, their internal processes, and their relationship to each other and the environment. A person who studies biology is called Biologist.

Exercise 1.1.

Write short answers.

1. What branch of science is most directly concerned with?

   A. the classification of trees?
   B. identifying contaminants in food?
   C. investigating the intensity of light?
   D. the production of plastics?

2. Consider water in a bucket that is kept outdoors. Three students are interested in analyzing this water in the following different aspects:

   I. The first student wants to study the microorganisms that might be found in the water.
   II. The second student wants to investigate the amounts of force required to lift the bucket and to carry it over various distances.
   III. The third student wants to study the tastes, odors and changes of substances when they are dissolved in the water.

   Which one of the areas of studies described above is related to the field of a) chemistry b) biology c) physics

1.1.3. Science and Technology

Science is the systematic study of the structure and behavior of the physical and natural world through observation and experiment and technology is the application of scientific knowledge for practical purposes. Science and technology help each other's advance. Scientific knowledge is used to create new technologies. New technologies often allow scientists to explore nature in different ways and make new discoveries. Scientists use their knowledge to develop technology and technology is use to develop science; so, because of this reason science and technology are an integrated term in today's world.

Activity 1.3.

Form a group and then discuss about the following questions

1. List some applications of science and technology in your daily life.
2. Write some science and technology products in your home, class, or school and environment.

The contributions of science to technology can be seen in the following ways;

1. New knowledge which serves as a direct source of ideas for new technological possibilities;
2. Source of tools and techniques for more efficient engineering design and a knowledge base for evaluation of feasibility of designs;
3. Research instrumentation, laboratory techniques and analytical methods used in research that eventually find their way into design or industrial practices, often through intermediate disciplines;
4. Practice of research as a source for development and assimilation of new human skills and capabilities eventually useful for technology;
5. Creation of a knowledge base that becomes increasingly important in the assessment of technology in terms of its wider social and environmental impacts.

1.1.4. Scientists and Ethical Discipline

Activity 1.4.

Form a group of 5-6 and discuss on the following questions and then present your work to the class.

1. List at least three names of
   a. world scientists.
   b. Ethiopian scientists and write their contribution in science and technology.
2. Can you mention some of the scientists you know?

The Famous World Scientists and their Contributions

Scientist is practitioner of science; an individual who uses scientific method to objectively inquire into the nature of reality. Some famous world scientists and their most remarkable inventions and discoveries:



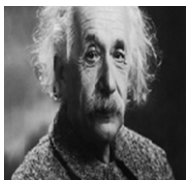
He was an astronomer and a mathematician. He was the one to invent the world's first automobile.

Ferdinand Verbiest (1623 - 1688)



He has made a large number of inventions, but the most well-known one is the electric bulb

Thomas Edison (1847 - 1931)



He was one of the greatest scientists of the 20th century. He was the creator of numerous inventions and theories like theory of relativity, photoelectric effect and the Einstein calculator.

Albert Einstein (1879 - 1955)



She was a Polish physicist and chemist working mainly in France, who was famous for her pioneering research on radioactivity. She was the discovery of the elements polonium and radium. She was the first woman to win a Nobel Prize.

Marie Curie (1867-1934)



Stephen Hawking (1942-2018)

He was an English scientist and received numerous awards, including the Special Fundamental Physics Prize in 2012, the Copley Medal in 2006, and the Albert Einstein Award in 1978. Hawking was known for his work on gravitational singularity theorems in the framework of general relativity, and the theoretical prediction that black holes emit radiation.

The Famous Ethiopian Scientists and their Significant Contributions

Here in Ethiopia we have some very renowned scientists. Their work is known and important not just here in Ethiopia but around the world. Some of them are listed herewith:



Dr Aklilu Lemma (1934-1997)

Dr Aklilu was Ethiopian physician and was co-awarded the 1989 Right Livelihood Award. He collected some live snails from above the washing party and asked one of the women to give him some of her Endod suds. Not long after the suds were put in the snail container, the snails all died. This was the start of years of work for Dr Aklilu and finally he discovered and campaigning relentlessly for an affordable preventative against ***bilharzia***."



Professor Gebisa Ejeta

He is an Ethiopian American plant breeder, geneticist and Professor at Purdue University. Professor Gebissa Ejeta developed other strains of sorghum which are also resistant to the parasitic Striga weed, which candestroy a big percentage of a crop. In 2009, he won the World Food Prize for his major contributions in the production of sorghum.



Professor Yalemtsehay Mekonnen

She is a biologist and an academic member of staff at the Department of Biology, Faculty of Science Addis Ababa University. She is the first female professor from AAU. One of her research areas is the assessment of the impact of chemical pesticide hazard on humans.



Professor TilahunYilma

He is known internationally for the vaccine he developed to help get rid of the terrible cattle disease rinderpest, and for his work on HIV/ AIDS vaccines. Rinderpest arrived in Ethiopia in 1888, carried by three infected cattle brought into the country by Italian soldiers. Within a year 90% of the domestic cattle plus many wild animals such as buffalo, giraffe and antelope died. As a result 30–60% of the people starved. In the 1980s rinderpest became a major problem again. Professor Tilahun worked to develop a vaccine using genetic engineering.

Project 1.1

Form a group of 5-6 and choose one of the scientists and create a role-play for the press release following the news of his/her discovery. Various roles to consider would include: the scientist; media; fellow scientists; and the general public. Alternatively, they could choose an Ethiopian scientist and create a cartoon strip showing their discovery. Values on focus: imbibe good character traits of scientists.

Activity 1.5

Form a group of 5-6 and then

Discuss the importance of ethical disciplines in scientific investigations and share your ideas with your class.

Ethical Disciplines in Scientific Investigations

Scientific work requires highly ethical disciplines. In your next grade level, (grade 8 general science) under chapter one, you will learn in detail about ethical disciplines in scientific investigations. But here some ethical disciplines in scientific investigations are briefly described as follows:

Honesty: Scientists should not fabricate, falsify, or misrepresent data or results. They should be objective, unbiased, and truthful in all aspects of the research process.

Carefulness: Scientists should minimize errors as much as possible as experimental, methodological or systematic and human errors. They should make faithful estimates of the errors that remain.

Openness and Fairness: Scientists should share data, results, methods, ideas, techniques, and tools.

Respect: Scientists should treat colleagues with respect.

Education: Scientists should teach each other what they have learned in their research. They should educate prospective scientists and ensure that they learn how to conduct good science.

Exercise 1.2

Part I: Write True for correct statement and False for wrong statement

1. Scientists used their knowledge to develop technology and then used technology to develop science.
2. Indigenous science is a science incorporating local people's knowledge.
3. Scientists can fabricate false results to the community.
4. Knowledge in science is absolute.

Part II: Choose the correct answer

1. Who was inventer of electric bulb?
   - A. Marie Curie
   - B. Albert Einstein
   - C. Charles Babbage
   - D. Thomas Edison
2. Who discovered an affordable preventing against Bilharzia?
   - A. Ferdinand Verbiest
   - B. Dr. Aklilu Lemma
   - C. Albert Einstein
   - D. Professor Gebisa Ejeta

Part III: Write short answer for the following questions

1. Write at least three areas where science contributes to technology.
2. Write some ethical disciplines required in scientific investigations.

1.2. Common laboratory equipment, uses, safety rules and procedures in science laboratories

At the end of this sub-topic, you will be able to:

- *identify different laboratory tools and their uses;*
- *prepare some laboratory equipment/tools from locally available materials;*
- *demonstrate knowledge of lab safety rules and procedures;*
- *practice precautionary measures in the laboratory;*
- *identify potential hazards when working in the laboratory;*
- *implement appropriate safety procedures when working in the laboratory and*
- *demonstrate the appropriate use of personal protective equipment for a given laboratory activity.*

1.2.1. List and Use of Common Scientific Equipment

Activity 1.6

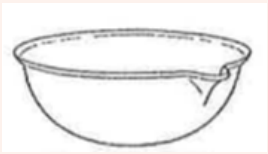
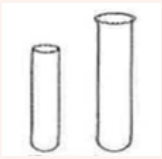
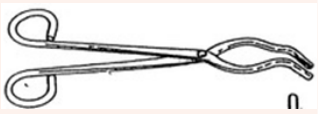
Be in a group and list some common science laboratory equipments and describe their functions, then present in the class.

What is a science laboratory?

A science laboratory is a place where basic experimental skills are learnt only by performing a set of prescribed experiments.

Science laboratory equipment refers to the various equipment and tools that are used by professionals or students working in a laboratory. There are many sciences laboratory equipments. However, some common science laboratory equipment and their functions are described in the table 1.1 below.

Table 1.1. Some common science laboratory equipments and their functions

Name	Picture	Use
Triple beam balance		Obtaining the mass of an object.
Spring balance or newton balance		It is an instrument helpful in measuring the weight of an object.
Evaporating dish		Used to evaporate excess solvents to create a more concentrated solution.
Test tubes		Holds small amounts of liquids for mixing or heating.
Beaker		Holding water (also used to heat liquids)
Tongs		Transport a hot beaker; remove lid from crucible.
Mortar and pestle		Used to grind chemicals to powder.

Thermometer		Used to measure temperature.

1.2.2. Making Laboratory Equipment from Locally Available Material

Since modern laboratory apparatus and chemicals are expensive, the production of laboratory equipment/tools from locally available materials is very essential and economically feasible. It is believed that, using locally available materials, most primary school experimental lessons can be performed in a very short time, often with no or low financial input and without long sessions of preparation. In the section 1.2.1 you have learned, some common science laboratory equpiments. Under this topic, you will learn how to prepare those tools and then you will produce them by using locally available materials. In general, to make science laboratory equipments from locally available materials, the following steps should be taken into consideration:

Step 1: Make a careful study of the modern apparatus in the science laboratory;
Step 2: List and collect necessary locally available materials that can replace some apparatus;
Step 3: Make a design of apparatus in necessary dimensional measurement;
Step 4: Improve the collected materials carefully as you designed in step 3;
Step 5: Test the functioning of the replaced material; and
Step 6: Make any further improvements from the outcome of the test.

Project 1.2

Making funnel by using local available materials

Necessary material: Cutter, Plastic Bottle and Ruler

Procedure

1. Collect 500ml or 600ml plastic bottles
2. Cut the plastic bottle at the height of 6 cm from top to bottom
3. Remove the plastic cap look at figure 1.1.



Figure 1.1. Making a Plastic Funnel

Project 1.3

Be in a group of 5 and then prepare some general science laboratory equipments such as beaker, measuring cylinder, tongs, etc. from locally available materials.

1.2.3. Laboratory safety rules and procedures

Activity 1.7

Form a group:

1. Discuss rules and regulations that should be followed in the science laboratory.
2. Which procedure is correct and which one is wrong? Correct the wrong procedure (s) when you discuss in your group
   - (a) Adding acid to water
   - (b) Adding water to acid
   - (c) Adding solids to hot liquids

Basic laboratory safety rules that provide behavior, hygiene, and safety information to avoid accidents in the laboratory. There are many laboratory safety rules. The most common of them are listed below;

1. Avoid skin and eye contact with all chemicals.
2. Minimize all chemical exposures.
3. Assume that all chemicals of unknown toxicity are highly toxic.
4. Never add water to acid and solids to hot liquids.
5. Never leave containers of chemicals open.
6. Unlabeled chemicals should never be used.
7. Do not taste or intentionally sniff chemicals.

1.2.4. Personal Protective Equipment

Activity 1.8

Form a group:

1. What is personal protective equipment?
2. Mention some personal protective equipment.

Personal protective equipment is specialized clothing or equipment worn for protection against dangerous or infectious materials. Common examples of personal protective equipment include:

Laboratory Coat: is used to protect against splashes and spills.

Footwear: is the shoes used in the laboratory.

Gloves: when handling chemical, physical, or biological hazards that can enter the body through the skin, it is important to wear the proper protective gloves.

Eyewear (Safety goggles): provide the best protection against chemical splashes, vapors, dusts, and mists while working in the laboratory.

Face shield: can be used to protect against impact, dust, particulates, and splashes to the face, eyes, and throat.

1.2.5. Hazard Symbols

Activity 1.9.

Form a group and discuss with your classmate and present in the class.

1. What are the hazard symbols on chemical bottles, electrical gadgets and other materials found in the laboratory?
2. Demonstrate how to handle those materials safely.

Hazard symbols are recognizable symbols designed to warn about hazardous or dangerous materials, locations, or objects including electric currents, poisons, radioactivity, and etc. Depending upon the science laboratory being conducted, a laboratory can be filled with dangerous chemicals, radioactive substances, biological specimens, sharp instruments, breakable glassware, and flammable objects. Thus, those working in laboratory need to be keenly aware of the many dangers associated with these items. In order to maintain a safe workplace and avoid accidents, laboratory safety symbols and signs need to be posted throughout the workplace.

A. **General warning**: It is a warning indicating the presence of hazardous materials in the laboratory.
B. **Biohazard:** It provides warning on laboratory equipment that may contain biohazard materials like blood samples
C. **Flammable material hazard**: Chemicals labeled as flammable have the tendency to ignite and should be store accordingly. Keep the chemicals away from flames, sparks, and oxidizing substances.
D. **Electrical hazard:** It can cause mild tingling and death. Devices labeled as electrical hazards should always be turned off when not in use.
E. **Toxic material hazard:** It is a generic sign for toxic/poisonous substances and can cause severe damage when inhaled, absorbed, or swallowed.
F. **Corrosive material hazard**: Strong chemicals that corrode into your skin and other substances. So, wear protective gear at all times when working with corrosive substance

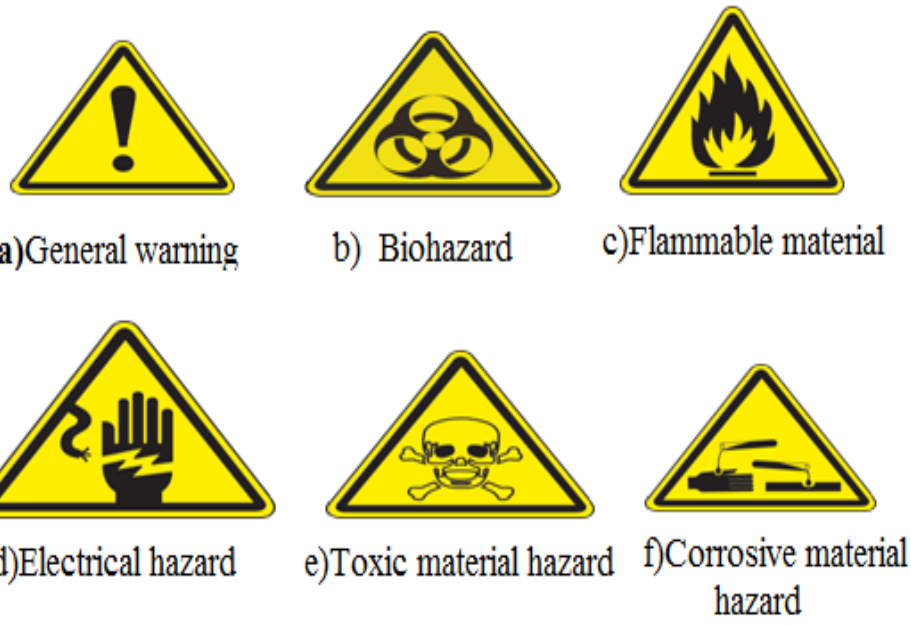


Figure 1.3.; Some Hazards signs in the Science laboratory

Exercise 1.3

Part I: Choose the correct answer from the given alternatives

1. What is the name of following hazards symbol?



   A. Biohazard
   B. Toxic material hazard
   C. Electrical hazard
   D. Irritant

2. Which one of the following is **not** a personal protective equipment?
   A. Safety goggle
   B. Laboratory coat
   C. Test tube
   D. Glove

Part II: Fill in the blank spaces

1. When you handling chemical, physical, or biological hazards, it is recommended to wear the proper protective_____ .
2. _____ provides warning on laboratory equipment that may contain bio hazardous materials like blood samples.

Part III: Write answer for the following questions

1. Write at least five common science laboratory safety rules.
2. Why is eating or drinking in the laboratory being dangerous?

UNIT SUMMARY

- Science is a body of knowledge, which is systematically organized of nature, society and thought and the processes and practices used to add to that body of knowledge.
- Science is divided two main categories such as natural and social sciences.
- Natural science is the study of nature and natural laws.
- Social science is study of the social world constructed between humans.
- Science, technology and innovation each represent a successively larger category of activities which are highly interdependent but distinct.
- Scientist is an individual who uses scientific method to objectively inquire into the nature of reality.
- Scientists use their knowledge to develop technology and then use technology to develop science.
- Scientific work requires highly ethical disciplines such as honesty, carefulness, fairness, respect, education, etc.
- Basic lab safety rules and procedures provide behavior, hygiene, and safety information to avoid accidents in the laboratory.

Key Terms

- Biology
- Chemistry
- Ethical discipline
- Hazard symbol
- Indigenous science
- Natural science
- Non-indigenous science
- Physics
- Safety rule
- Science
- Scientist
- Social science
- Technology

REVIEW EXERCISE

Part I: Write 'True' for the correct statements and 'False' for the wrong statements.

1. Science is merely a collection of facts, concepts, and useful ideas about nature.
2. Natural science is the study of nature and natural laws.
3. Chemistry has no role in solving the problems of mankind.
4. Physics and chemistry do not share common areas of study.
5. Science is not same as technology.
6. Scientists can fabricate false results to the community.
7. Knowledge in science is absolute.

Part II. Match the functions of Laboratory equipments under column "A" with its corresponding specific equipment under column "B".

Column A	Column B
1. Transport a hot beaker; remove lid from crucible.	A. Mortar & pestle
2. Holds small amounts of liquids for mixing or heating.	B. Triple-beam balance
3. Holding water or used to heat liquids.	C. Forceps
4. Used to grind chemicals to powder.	D. Tongs
5. Obtaining the mass of an object.	E. Test tubes
	F. Beaker
	G. Thermometer

Part III. Choose the correct answer from the given alternatives

1. Biology is:

   A. the study of matter.
   B. the study of life and living organisms.
   C. the study of of the motion of system.
   D. the study of the way atoms and molecules react together.

2. Who was known internationally for developing the vaccine for cattle disease Rinder pest?

   A. Professor Gebisa Ejeta
   B. Professor YalemtsehayMekonnen
   C. Professor Ensermu Kalbessa
   D. Professor Tilahun Yilma

3. The branches of natural science studying the composition of compounds, and the processes taking place in organisms, respectively, are:

   A. chemistry and biology
   B. biology and physics
   C. physics and geology
   D. biology and geology

4. Which of the following is **false** about science? Science:

   A. is a limited discipline that studies only naturally occurring events.
   B. does not address the supernatural.
   C. has the answers to all of the questions in the universe.
   D. is the only method that is self-correcting.

5. A famous an Ethiopian scientist who made major contributions in the production of sorghum was:

   A. Dr. Aklilu Lemma
   B. Professor Sebsebe Demissie
   C. Professor Gebisa Ejeta
   D. Dr. Segenet Kelemu

6. World's first automobile was discovered by

   A. Ferdinand Verbiest
   B. John Baird
   C. Stephen Hawking
   D. Marie -Curie

Part IV: Answer the following questions

What new insight about science, technology and scientists did you learn from this unit?

UNIT TWO

MATTER IN OUR SURROUNDINGS

Learning Outcomes

At the end of this unit, students will be able to:

- *use particles theory's postulates to explain properties and behavior of materials;*
- *classify matter as an element, compound, homogeneous mixture, or heterogeneous mixture with regard to its physical properties;*
- *describe the structure of solids, liquids and gases in terms of particle separation, arrangement and types of motion;*
- *differentiate between physical and chemical properties and changes of matter;*
- *appreciate that matter can be classified based on physical or chemical properties;*
- *use properties of matter to identify substances and to separate them; and*
- *demonstrate scientific inquiry skills along this unit.*

Main Contents

2.1. Characteristics and nature of matter
2.2. Physical and chemical properties of matter
2.3. Classification of substances
2.4. Changes around us: Physical and chemical changes
2.5. Separation of mixtures and its application

Start-up Activity

8. Look any materials in your classroom. Of these materials you have observed, which are matter?
9. What is matter?

Introduction

In grade six, you have learned about the general concepts of physical and chemical properties of matter. In this unit, you will learn about characteristics and nature of matter, physical and chemical properties of matter in detail, classification of substances and separation of mixtures and its application. Basically, this unit explains the concept matter, and its composition and changes of matter. Matter is anything that occupies space and has mass. Water, air, sugar, milk, soil, animals, plants and human beings are some examples of matter.

2.1. Characteristics and Nature of Matter

At the end of this section, you will be able to:

- *define matter with examples from day today life;*
- *demonstrate that matter is made up of tiny particles;*
- *state the postulates of the particle theory of matter;*
- *infer the particulate nature of matter from demonstration/ investigation;*
- *explain diffusion and every day effect of diffusion;*
- *describe representation of the arrangement, relative spacing, and relative motion of the particles in each of the three states of matter;*
- *explain compression in terms of distance between particles;*
- *use the terms melting, condensing, and freezing/solidification to describe changes of state; and*
- *use the particulate nature of matter to explain melting, freezing/ solidification, evaporation and condensation.*

2.1.1. Meaning and Properties of matter

Activity 2.1

Form a group and discuss on the following questions

1. Give examples of both matter and non-matter.
2. What are the properties of matter?

In introduction section, you have learned that matter is anything that has mass and occupies space. Things that do not have mass and cannot occupy space are said to be non-matter. Light, sound and heat are examples of non-matter.

Matter possesses different properties. Properties are the characteristics that give a substance's identity and enable us to distinguish one kind of substance from another. No two substances have exactly the same set of properties. To identify a matter, scientists observe two distinct types of properties: physical and chemical properties. You will learn these properties under section 2.2.

2.1.2. Particle theory of matter (Particle model of matter)

Activity 2.2

Form a group and discuss on the following questions:

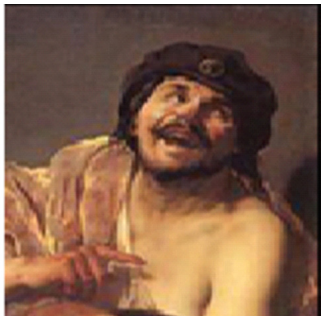
1. What is a particle?
2. What is particle theory of matter?
3. List down some characteristics of particle of matter.

Scientists explain the properties and reactions of chemicals using ideas about particles. Everything around us is made up of tiny pieces of particles. Particle is the smallest portion of matter and it is the building blocks of matter. The relationship between particle and matter is explained by particle theory of matter.

Particle theory of matter states that all matter consists of many, very small particles which are constantly moving or in a continual state of motion.

Historical Note

Democritus' was the first person to develop the idea of particle theory and he suggested that matter is made up of tiny particles too small to be seen.



There are five main ideas in the particle model (postulates of particle theory of matter):

1. All matter is made up of tiny particles.
2. The particles of matter are always moving in constant random motion.
3. The particles have empty spaces between them.
4. Adding heat to matter makes the particles move faster.
5. All particles of one substance are identical.

Illustrations of the particle theory by using diffusion

Diffusion is defined as the movement of atoms, ions, and molecules from a region of high concentration to a region of low concentration, or 'down their concentration gradient'. The role of diffusion is applicable in many where. For example, diffusion concept used when water diffuses or flows, when we pour a color on a glass of water and when inhaling and exhaling air, etc.

Experiment 2.1

Title: Illustrations of diffusion of particles by using perfume.

Objective: *To infer the particulate nature of matter from demonstration/ investigation*

Procedures:

1. Bring perfume to the class room.
2. One voluntary student will spray the perfume in one side of the classroom and then other two students will stand on other side of the class (corner of the class) and smell the odor.

Questions

1. What new odour did you smell?
2. How these odors reach you?
3. Why the particles of the gas quickly move in all directions?

Properties of Solids, Liquids and Gases; and State Change

Matter exists in three states or phases. The solid, liquid and gas are the three states of matter in which any substance can exist, depending on the conditions of temperature and pressure. The particle theory (kinetic theory) of matter can help us to understand these three states of matter and their properties. The properties of solids, liquids and gases are summarized in the table below.

Table 2.1. Properties of solids, liquids and gases

Solids	Liquids	Gas
have a definite volume and shape.	do not have a definite shape, but have a definite volume.	do not have a definite shape and volume.
The particles in a solid are held together strongly.	The particles in a liquid are separated by spaces.	The particles in a gas are separated by much larger spaces.
are difficult to compress.	are difficult to compress or very slightly compressible.	highly compressible.
has high density.	are often denser than gases.	are often low densities.

Change in State

The change of the substance from one state to another state under a given conditions such as temperature and pressure is called change of state of the substance. As a temperature changes, there will be the change of state. As a solid is heated, the particles vibrate faster and faster until they have enough energy to break away from their fixed positions.

During the change of state, particles physical behavior is changed through different processes. The transformation of a solid into a liquid is known as melting and its reverse (from liquid to solid) known as freezing. The change from a liquid to a gas is known as evaporation whereas from a gas to a liquid is known as condensation. The transformation of a solid directly into a gas is known as sublimation while a change from a gas to a solid is known as deposition.

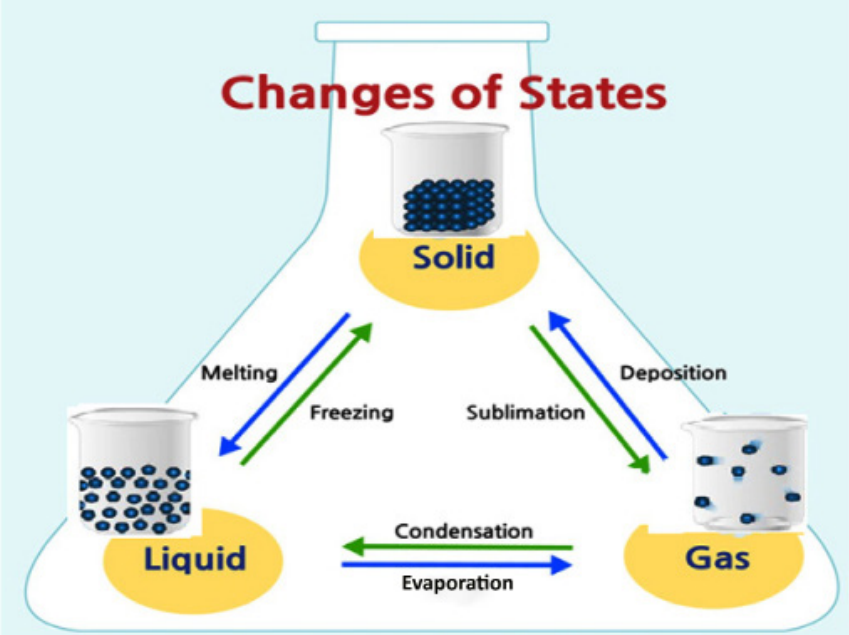


Figure 2.1. Change in physical state

Exercise 2.1

Part I: Write 'True' for the correct statements and 'False' for the wrong statements.

1. Everything on earth is matter.
2. Gases have definite volume and shape.
3. Particles of one substance differ from the particles of other substance.

Part II: Choose the correct answer from the given alternatives

1. Which statement about the particle theory of matter is **true**?
   - **A.** Solid particles are held strongly in one place as a result they are at rest.
   - **B.** The particles in a liquid have more kinetic energy than the particles in a gas.
   - **C.** The particles that make up matter are too small to see without a microscope.
   - **D.** When a solid melts its particles no longer exist.

2. Which of the following is **not** matter?

A. Chalk
B. Heat
C. Television
D. Mobile

3. The process of change from solid to gas is known as:

A. freezing
B. condensation
C. sublimation
D. melting

2.2. Physical and chemical properties of matter

At the end of this section, you will be able to:

- *identify and describe physical Properties;*
- *use physical properties of matter to identify substance;*
- *conduct experiments to identify properties of substances and make group report;*
- *distinguish between physical and chemical properties and give examples; and*
- *identify chemical properties.*

Activity 2.3

Discuss the following questions in groups and then present to the class.

1. What is a physical property?
2. How can you physically identify
   (a) common salt from sugar?
   (b) alcohol from water?

A. Physical Properties

Physical properties are the characteristics of a substance that shows itself without forming a new substance. No two substances have exactly the same set of properties. In general, physical properties of matter can be classified as physical properties detected by sense organ and measurable physical properties.

1. Physical properties detected by sense organs

Some physical properties of the substance that we can identify by our sense organs are: color, odour, taste and texture.

Color: The color of a substance results from its interaction with light. For example, chalk is white, water is colorless, and gold is yellow and so on.

Odour: refers to the property of a substance perceived by the sense of smell. For example water is odourless, flowers are fragrant, and orange smells fruity.

Caution! ***Care has to be taken in smelling substances as they may be harmful***

Taste: refers to physical properties that can be perceived by the taste buds of the tongue. The taste of a substance is usually described by terms like sweet, bitter, sour, salty, and tasteless. For example honey is sweet, lemon is sour and table salt tastes salty.

Caution! ***Tasting can be used to identify substances only if the substance to be tasted is not harmful.***

Activity 2.4

Discuss the following activity in groups and present your ideas to the class.

What apparatus is used to measure the melting point and boiling point of a substance?

2. Measurable Physical Properties

Measurable physical properties are the properties of a substance that can be measured using an appropriate apparatus. Some measurable physical properties are: melting point, boiling point, density and electrical conductivity.

Melting point: is the temperature at which a solid substance changes to its liquid state. For example, the melting point of ice is 0°C.

Boiling point: is the temperature at which the vapor pressure of the liquid equals the surrounding atmospheric pressure. For example, the boiling point of water is 100°C.

Density: is the mass per unit volume of a substance.

$$Density = \frac{Mass\ of\ Substance}{Volume\ of\ substance}$$

$$\rho = \frac{m}{v}$$

Electrical conductivity: is the ability of a substance to conduct electricity. This is a physical property mostly characteristic of metallic substances such as copper, aluminum, iron, silver and zinc.

Experiment 2. 2

Title: Determining the physical properties of a substance

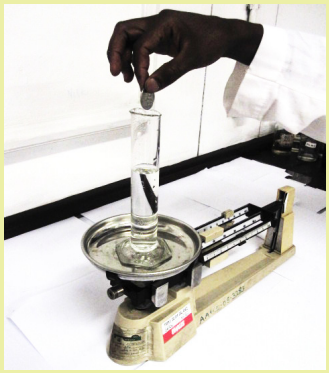
Objective: *To determine the density of substances.*

Materials required: *Three fifty cent coins, nails, beam balance, water and measuring cylinder.*

Part A: Determination of the Density of a Substance

Procedures:

1. Using a beam balance, measure the mass of the three fifty cent coins. Record the mass.
2. Take a measuring cylinder which is large enough for the coin to enter in to it and



Pour water into the measuring cylinder to the 50 mL mark.
drop the three coins into the measuring cylinder turn by turn and see the change in the volume of the water after dropping all the coins as shown in figure 2.2 and take the reading.

Figure 2.2. Determination of density

Observations and analysis:

1. What is the total mass of the three coins?
2. What is the density of a single fifty cent coin?
3. What is the total volume of the three coins?

Experiment 2.3

Title: *Identifying unknown substances based on their physical properties.*

Objective: *To investigate the physical state, color and solubility of substances.*

Materials Required: *Five unknown substance, water, five small beakers, spatula and glass rod.*

Procedures:

1. Examine each of the five substances and record your observation regarding their state and color.
2. Take the five small beakers and add 50 mL water to each beaker. Then add a spatula full of each of the substances to each beaker. Stir the mixture in each of the five beakers with a glass rod and observe the results.

Observation and Analysis:

Copy the following table in your exercise book and record your observations.

Substance	State	color	Solubility in water
A			
B			
C			
D			
E			

Write a report about your observation and present it to the class.

Experiment 2. 4

Title: Identification of metals on the basis of physical properties

Objective: *To identify metals by observing their physical properties.*

Materials Required: *copper, iron, aluminum, and a magnet.*

Procedure:

1. Take a magnet and check if the above metals are attracted by magnet. Which metals are attracted by the magnet and which one of them are not?
2. Examine each metal carefully. Copy the following table in your exercise book and record your observations. Your record should include color, state and whether the metal is light or heavy, magnetic or non-magnetic.

Metals	Observed physical properties			
	Color	State	lightness	Magnetic properties
Cupper				
Iron				
Aluminum				

Observations and Analysis:

i. Which metal can be identified by its reddish-brown color?
ii. Which metal is not attracted by magnet?
iii. Which metal has the highest density?

Write a report and present to the class.

B. Chemical properties

Chemical properties are characteristics of the substance that is observed during a reaction in which the chemical composition or identity of the substance is changed. It describes the ability of a substance to form new substance. Examples of chemical properties include burning of a substance and rusting of iron.

Exercise 2.2

Part I: Write 'True' for the correct statements and 'False' for the incorrect statements.

1. Rusting is the physical property of iron.
2. Two different substances can have the same set of properties.
3. If the identity of some particular substance is completely altered, it shows chemical properties.

Part II: Choose the correct answer

1. Which property of a substance is measurable?
   - A. Density
   - B. Color
   - C. Taste
   - D. Odor
2. The temperature at which a solid changes to its liquid form is:
   - A. boiling point
   - B. melting point
   - C. freezing point
   - D. condensation
3. The physical property of a substance that has no fixed numerical value at a given condition is:
   - A. density
   - B. boiling point
   - C. melting point
   - D. taste

Part III: Given the following physical properties of substances: odour, color, taste, melting point, boiling point and density.

a) Which of these physical properties have constant values under specific condition, such as temperature and pressure?
b) Which physical properties can be recognized directly by our sense organs?
c) Which of these properties are measured using instruments?
d) What will happen to ice kept in a cup for three days?

2.3. Classification of substances

At the end of this section, you will be able to:

- *use the particle theory to describe the difference between pure substances and mixtures;*
- *differentiate between elements and compounds;*
- *classify common elements into metals and non-metals;*
- *investigate the properties of metals and compile a list of general properties;*
- *investigate the properties of non-metals and compile a list of general properties;*
- *describe and classify mixtures into homogenous and heterogeneous;*
- *use models/ particles diagram to show differences between homogenous and heterogeneous; and*
- *describe the relationship among elements, compounds, mixtures, homogenous mixture and heterogeneous mixture.*

Why do scientists need to classify substances?

Scientists need to work with pure substances and apply techniques of purification to get these substances. Understanding the science of a substance would be simpler if it is a pure substance.

Activity 2.5

Discuss the following question in a group and then present to the class.

Name at least 10 kinds of substances that you see or know. Classify the materials you listed as pure substances or mixtures.

There are various ways of classification of substances in science. At this level, we classify substances based on their composition and properties, as pure substances and mixtures.

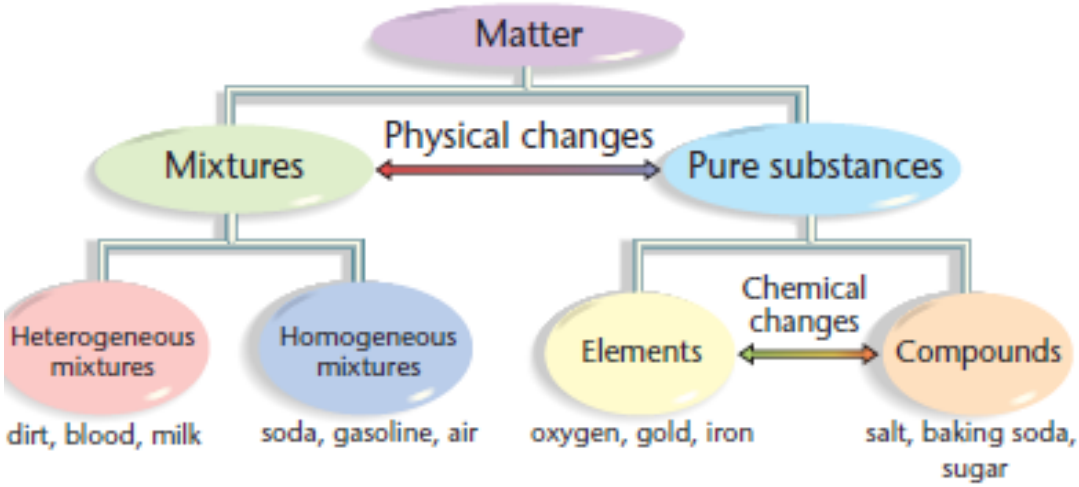


Chart 1. Classification of Substances

1. Pure substances

A pure substance is a form of matter that has constant composition and uniform properties throughout the sample. For example, a block of iron is a pure substance containing only one kind of component. Water is also a pure substance containing two components (hydrogen and oxygen) combined chemically in a definite ratio. Some other common examples of pure substances are oxygen, copper, gold, sugar, table salt and carbon dioxide. Pure substances are classified as elements and compounds depending on the constituent of elements.

Activity 2.6

Discuss the following question in a group and then present to the class.

Consider the following substances: iron, water, oxygen, sugar, copper, gold, table salt, chlorine, tea, suphur, air, tap water, carbon, carbondioxide, hydrogen, salt solution and mercury.

1. Which of them are elements?
2. Which of them are compounds?
3. Which of them are mixtures?

A. Elements

Element is a pure substance that contains only one type of particle (atom), which is the smallest particle of an element. At present, there are 118 known elements. Among these elements, 92 of them occur naturally while the rest are man-made or artificial elements.

How elements might be classified into groups?

Elements are classified as metals, non-metals and metalloids.

Metals

are elements characterized by their shiny appearance (luster), electrical conductivity, malleability, ductility and flexibility. All metals are solids at room temperature except mercury, which is a liquid. They have high melting points and boiling points. Some examples of metals are gold, iron, silver, copper, aluminum, sodium and lead.

Non-metals

are elements that are not shiny, and are non-conductors of heat and electricity. They are not malleable and ductile. Non-metals generally exist as solids or gases at room temperature. Bromine is the only liquid non-metallic element. Non metals have relatively low melting points and boiling points. Carbon, sulphur, fluorine, iodine and phosphorous are some common examples of nonmetals. Most of the non- metals are gases at room temperature such as oxygen, nitrogen chlorine, and etc.

Metalloids

are elements that exhibit some properties of metals and some properties of non-metals. Example: boron, silicon, germanium, arsenic, antimony, tellurium and polonium.

Exercise 2.3

Make discussion for the elements given below and present your answer in the class. iron, oxygen, copper, gold, sulphur, carbon, hydrogen, silver, chlorine, phosphorus, nitrogen, iodine, zinc, aluminum, lead, fluorine, calcium, antimony, silicon, palladium and sodium.

1. Classify the elements as metals, non-metals or metalloids.
2. Write different properties that metals and non- metals show.

B. Compounds

A compound is a pure substance composed of two or more elements that are combined chemically in a definite proportion by mass. A compound can be decomposed into two or more elements by a chemical means. For example, carbon dioxide is a compound since it can be decomposed into carbon and oxygen by a chemical means.

Compound is the chemical combination of two or more elements chemically combined together to give new substances with new properties. This is because each element in a compound does not retain its identity. The properties of a compound are completely different from the properties of elements that make up the compound.

Elements chemically combined with other elements to form compounds. Sodium chloride is formed by the chemical combination of sodium and chlorine elements. Such types of compounds that are formed by the combination of two different elements are called **binary compounds**. Examples of binary compound are sodium chloride, calcium oxide (lime), Carbon dioxide. Most binary compounds contain metallic and nonmetallic elements.

Can you mention other examples of binary compounds?

2. Mixtures

Mixtures are combinations of two or more components in varying proportions and the components retain their identities. Mixtures, unlike compounds, are formed by the physical combination of components. Thus, a mixture does not have constant composition. They can be separated by physical means. Examples: Tap water, ink, salt solution, sugar solution, milk, soil, petroleum, alloys, air, and etc.

Table 2.2. The differences between compound and mixture

Compound	Mixture
A compound has a fixed composition.	Mixture has variable composition.
A compound has a new set of properties.	The components of a mixture retain their properties or identities.
A compound has a definite formula.	A mixture does not have a definite formula.
Formed as a result of chemical change.	Formed as a result of physical change.
Its components can only be separated by chemical means.	Its components can be separated by physical means.

Experiment 2. 5

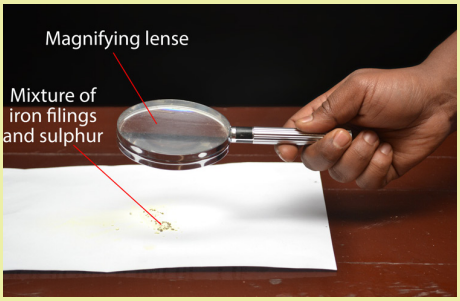
Title: Distinguishing compounds and mixtures.

Objective: *To investigate the difference between a compound and a mixture.*

Materials Required: *Magnet, iron filings, powdered sulphur, test tube, Bunsen burner, magnifying glass, tong and beam balance.*

Part I: Procedures:

1. Mix 10 g of iron filings with 6 g of powdered sulphur. Examine the mixture using a magnifying glass as shown in figure 2.3(a).
2. Place half of this mixture on a sheet of paper. Bring one end of a magnet close to the mixture as shown in figure 2.3(b).
3. Observe the components of the mixture with a magnifying glass.



a. magnifying lenses



b. magnet

Figure 2.3. Separating iron from a mixture of iron and sulphur

Questions

i. What did you observe as you bring the magnet close to the mixture?
ii. What did you observe under the magnifying glass?

part II: Procedures:

1. Place the remaining half of the mixture in a test tube. Heat the test tube strongly for a few minutes as shown in figure 2.4.
2. Put off the flame and remove the test tube. After the reaction stops, break the test tube by plunging the hot end into a beaker of cold water.
3. Take the product formed and powder it. Examine the product under a magnifying glass. Bring a magnet over it.

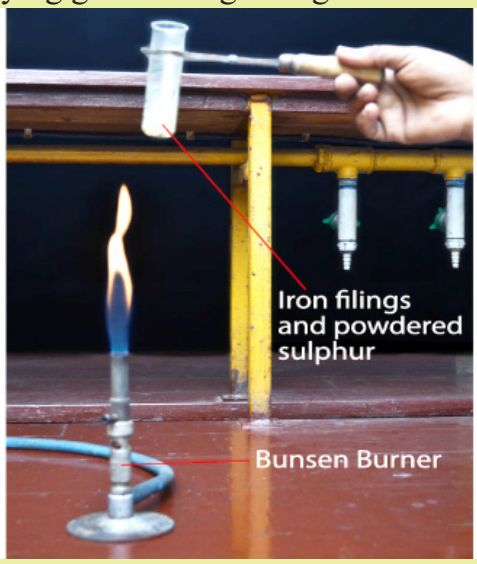


Figure 2.4. The reaction between iron and sulphur

Observations and Analysis:

1. Under a magnifying glass, are the iron filings and sulphur seen separately? Is it possible to attract the iron or sulphur by a magnet? Why?
2. Which part of the experiment (Part I or II) indicates a compound? Give your reason. Which part of the experiment (part I or II) indicates a mixture?

Classifications of Mixtures

Mixtures are classified into two. They are: homogeneous and heterogeneous mixtures.

A. Homogeneous mixture (solution)

What is homogeneous mixture? How it differs from heterogeneous mixtures?

A homogeneous mixture is a mixture in which the composition of the mixture is the same throughout the sample.

B. Heterogeneous mixture

A mixture that does not have a uniform composition throughout the sample is known as a heterogeneous mixture.

Table 2.3. Differences between homogeneous and heterogeneous mixtures

Homogenous mixtures	Heterogeneous mixtures
It has a uniform composition throughout.	It does not have a uniform composition throughout.
It has no visible boundaries of separation between the components.	It has visible boundaries of separation between the components.
Its components cannot be seen by our naked eyes or by microscope.	Its components can be identified by our naked eyes.
It consists of only one phase.	It contains more than one phase.

Exercise 2.4

Part I: Based on the instruction given below, perform the following questions

1. Identify whether the following are pure substances or mixtures.

   (a) Sea water
   (b) Gold
   (c) Chalk
   (d) Oil
   (e) Blood
   (f) Alcohol (ethanol)

2. Classify each of the following as an element, a compound or a mixture.

   (a) Milk
   (b) Ink
   (c) Salt
   (d) Air
   (e) Pure water
   (f) Sugar
   (g) Wood
   (h) Paper

3. Which of the following are homogeneous mixtures, and which of them are heterogeneous mixtures?

   (a) Milk
   (b) Blood
   (c) Soil
   (d) Alloys
   (e) Mixture of salt and sugar
   (f) Sugar dissolved in water
   (g) Mixture of alcohol and water

Part II: Write short answer for the following questions

1. Give two reasons to support why water is a compound but not a mixture.
2. Explain why we classify bottled water, ink, milk, soil and air as mixtures.

2.4. Changes Around Us

At the end of this section, you will be able to:

- *describe physical and chemical change;*
- *distinguish the physical and chemical changes using their characteristics;*
- *conduct some simple activities to show physical and chemical changes and write group report;*
- *observe and describe physical and chemical changes that are important in everyday life; and*
- *identify useful and harmful changes.*

2.4.1. Physical and chemical changes

Activity 2.7

1. What are physical and chemical changes?
2. Observe and record changes occurring in your home and identify whether they are physical or chemical changes.
3. Classify the following changes into physical or chemical change and give your reasons.
   a) Burning of charcoal
   b) Melting of ice
   c) Evaporation of water
   d) Fermentation

The substances in our environment constantly undergo changes. The decay of plants and animals, falling of fruits from trees, rusting of iron, are some of the changes that occur in our environment.

Can you mention other examples of changes you have observed in your daily life?

Most of the changes in substances are classified into physical or chemical changes.

Physical changes

What is a physical change?

A change in which a substance undergoes a change in its physical properties is called a physical change. Physical changes do not alter the composition or identities of the substances.

Physical changes can be classified into three. These are:

I. The changes of state,
II. Solution (dissolution), and
III. Mechanical changes

I. Change of State

We know that matter exists in three physical states or forms: solid, liquid and gaseous states. Change of state is the physical process where matter moves from state to another. Changes like melting, freezing, dissolving and evaporating are state changes. Consider the following changes of states of water.

$$\text{Ice} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{liquid water} \underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}} \text{gas/ steam}$$

By heating or cooling water, it is possible to convert liquid water in either direction. These changes of state indicate that the change is reversible.

II. Solution

The process of dissolving a substance in water to form a solution is a physical change. For example, when common salt is dissolved in water, a clear salt solution is formed. If this mixture is heated, the water is evaporated, and the original salt remains as a residue. Thus, in the process of dissolution, no new substances are produced.

III. Mechanical changes

Mechanical change is the change which involves change in shape and size of objects. Mechanical changes brought about by breaking, hammering, powdering, tearing and cutting of substances are physical changes. Some

example of mechanical changes are powdering of chalk, breaking of the stones in to pieces, tearing of paper, grinding of corn in to powder, breaking of sticks in to small pieces.

Chemical change

Activity 2.8

Among the following, identify chemical changes.

1. Burning of wood
2. Ripening of tomato
3. Boiling water
4. rusting of iron
5. melting of ice

What is a chemical change?

Chemical changes are changes that result in the formation of new substance with entirely new properties. When the substance is chemically changed, the new substance formed would have different composition from the original material. Examples of chemical changes are: burning of paper, digestion of wood, fermentation of grapes, souring of milk, "*tella*" or *"tej"*, decaying of food, etc. Chemical change takes place due to chemical reaction.

Table 2.3. Difference between chemical and physical change

Chemical changes	Physical changes
New substances with new properties are formed.	No new substance is formed (identity of the substance does not change).
It is a change in the chemical property of the substance.	It is a change in the physical property of the substance.
It is difficult to reverse the change.	The change is easy to reverse (It is a reversible process).
Energy change (heat change) is involved.	Energy changes (heat changes) are not necessarily involved.

Experiment 2.6

Title: Melting of sulphur

Objective: *To determine whether the melting of sulphur is a physical or a chemical change.*

Materials required: *Test tube, watch glass, bunsen burner, tong, powdered sulphur*

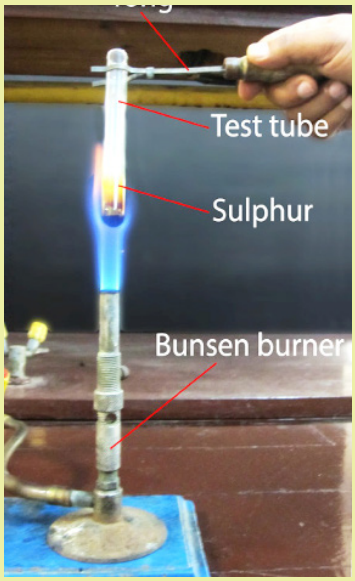


Figure 2.5. Melting of sulphur

Procedure:

1. Put powdered sulphur to half of a test tube of 25ml.
2. Heat the test tube gently until all the sulphur melts as shown in figure 2.5.
3. Observe the color of the molten sulphur
4. Pour the molten sulphur on a watch glass and allow it to cool.
5. Let the watch glass stay for some days, and observe the change again

Observations and Analysis:

i. Name all the colors of sulphur you observed before and after the experiment.
ii. Is there a change? What type of it?

Exercise 2.5

Part I: Write 'True' for the correct statements and 'False' for the incorrect statements.

1. Cutting a block of wood into pieces is a chemical change.
2. Formation of manure from leaves is a physical change.
3. Iron and rust are the same substances.
4. Condensation of steam is not a chemical change.

Part II: Classify the changes involved in the following processes as physical or chemical changes or both.

(a) Photosynthesis
(b) Dissolving sugar in water
(c) Burning of coal
(d) Melting of wax
(e) The compression of a spring
(f) Souring of milk
(g) Beating aluminum to make aluminum foil
(h) Formation of clouds in the atmosphere
(i) Freezing of ice cream
(j) Evaporation of alcohol
(k) Burning a thread of candle
(l) Digestion of food
(m) Melting of iron

2.4.2. Useful and Harmful Changes

Activity 2.9

Make a group and discuss on the following question

1. Give examples of useful and harmful changes.
2. Are all changes useful? Explain with examples.

Many physical and chemical changes are very important in our life. The changes that benefit human beings and makes living environment better is said to be important changes. An example of useful changes are production of clothes, soaps, vehicles, medicine and drugs; growth of plants; construction of buildings; ripening of edible fruits etc.

Harmful changes are changes that adversely affect either human beings and/or living environment. Some harmful changes include earth quakes, volcanic eruption, emission of different gases from vehicles, spoiling of food, rusting of iron, and etc.

2.5. Separation of Mixtures and its Application

At the end of this section, you will be able to:

- *list methods of separation of mixtures;*
- *give some specific examples of mixtures that can be separated by filtration, decantation, simple distillation, magnetic separation and using separatory funnel;*
- *name apparatuses used in decantation, filtration, simple distillation, using separatory funnel;*
- *assemble apparatuses used in decantation, filtration, simple distillation, separatory funnel;*
- *conduct and report on an investigation that uses physical means such as particle size, density, boiling point, solubility and magnetism to separation;*
- *perform simple activities in group to carry out the separation of mixtures using local materials and write a group report;and*
- *compare and evaluate the different ways of separating mixtures from products in community.*

2.5.1. Methods of separation of mixtures

Activity 2.10

Make a group and discuss on the following questions.

1. List the methods of separation of mixture used in your daily life.
2. What method is used to separate fine flour and coarse particles, oil and water, water from sand, and home prepared coffee?

Separation techniques are methods of obtaining pure substances. Most of the substances around us exist in the form of mixtures. However, these mixtures can be separated into their components using various separation techniques. The methods used to separate mixtures are mainly physical processes.

There are many physical methods used to separate mixtures. Some of them are: magnetic separation, decantation, using separatory funnel, filtration, evaporation and distillation.

A. Magnetic separation

Magnetic separation is used to separate magnetic and non magnetic substances in a mixture. If you bring a magnet close to a heterogeneous mixture, the magnetic components are attracted by the magnet and easily attached to it. For example, mixture of sand and iron fillings, sulfur and iron fillings. The iron filings (magnetic component) are attracted by the magnet, while the sand and sulfur do not.

B. Decantation

What technique is used to prepare home-made drinking coffee ("Jebena buna") shown in figure 2.6?



Figure 2.6. Separations by Decantation

Pouring boiled coffee from the pot ('Jebena') to the cup is the method of separation using decantation. This method of separation is used when one component of a mixture is a liquid and the other one is an insoluble solid denser than the liquid component. A mixture of sand and water can also be

separated using decantation. During the decantation process, first the mixture is allowed to stand in a container for some time. The insoluble solid settles down to the bottom of the container. This is called ***sedimentation.***

Experiment 2.7

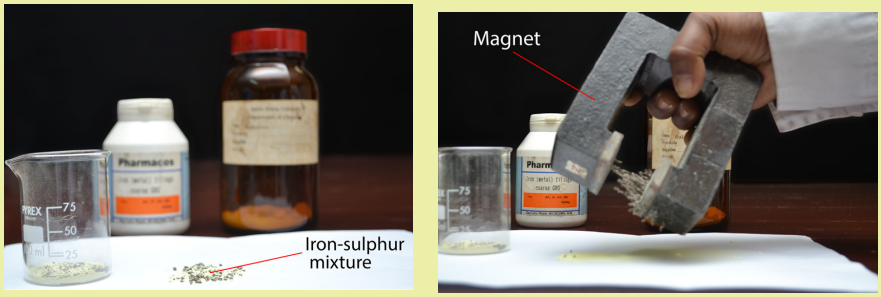
Title: Separation of a mixture using a magnet

Objective: *To separate a mixture of iron filings and sulfur using a magnet.*

Materials Required: *Magnet, iron filings, powdered sulphur, beaker, sheet of paper, spatula.*

Procedures:

1. Take two spatulas of each of iron filings and powdered sulphur, and mix them thoroughly, in a beaker.
2. Place some of this mixture on a sheet of paper as shown in figure 2.7(A).
3. Bring a magnet close to the mixture as shown in figure 2.7(B).



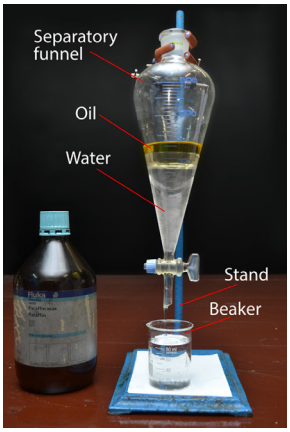
A*Figure 2.7. A) mixture of iron and sulphur B)Magnetic separation the mixture*

Observations and Analysis:

i. Which component of the mixture is attracted to the magnet?
ii. What can you conclude from the experiment?

C. Separation by using separatory funnel

Separatort funnel is used to separate immiscible mixtures. Immiscible liquids



do not mix and thus they form two layers. A mixture of oil and water can be separated using a separatory funnel. When the mixture is poured into a separatory funnel, the oil and water separate into two distinct layers as shown in figure 2.8. Since water is denser than oil, it is collected at the bottom of the funnel.

Figure 2.8. Separating a mixture of oil and water

D. Filtration

Activity 2.11

Form a group and discuss the following concepts

Consider a mixture of water and sand. How can you separate this mixture into individual components?

A filter paper is used to separate insoluble solid from the liquid. It has a lot of fine holes that allow only the liquid to pass through, but not the solid particles.



The liquid which passes through the filter paper is called the filtrate, and the solid which remains on the filter paper is known as the residue. Filtration can be used to separate mixtures like soil and water, sand and salt solution, powdered chalk and water, etc. In practical application, filtration is a key step in the purification of the tap water you drink.

Figure 2.9. Filtration

Experiment 2.8

Title: Filtration

Objective: To separate a mixture of sand and water by filtration.

Materials Required: Beakers, filter paper, funnel, flask, sand.

Procedure:

1. Put sand in beaker containing water, and stir to dissolve it.
2. Pour the mixture into the funnel fitted with a filter paper and collect the filtrate in the flask.
3. Observe the result.

Observations and Analysis:

i. Does the sand dissolve in water?
ii. Which substance is collected in the flask?
iii. Which substance remains on the filter paper?

E. Evaporation

Activity 2.12

Perform the following activity in groups, and present your findings to the class.

Take a beaker with full water; keep it at a place exposed to sunlight. Wait for a day to observe a change.

1. What happened to the level of the water in the beaker? Increased, decreased or remains the same? Explain it.
2. What can you conclude from your observation?

Evaporation is a method used to separate a soluble solid from a liquid in a solution. For example, sea water is a solution of salts. When it is heated on an evaporating dish, the level of the liquid slowly decreases because some of the water changes into vapor. This vapor will then escape into the atmosphere,

leaving behind the salts.

F. Simple distillation

What is distillation?

Distillation is a method of separating the components of a liquid mixture or a soluble solid from a liquid in a solution. It consists of both evaporation (boiling) and condensation processes. In the distillation process, the separation of a mixture is based on the difference in the boiling points of the components.

During distillation, when the mixture is heated in the distillation flask, the liquid with low boiling point is vaporized first. This vapor is passed through a cooling tube, called a condenser, where it is condensed into a liquid as shown in Figure 2.10. The liquid is then collected in a receiver. This clear liquid is known as a distillate.

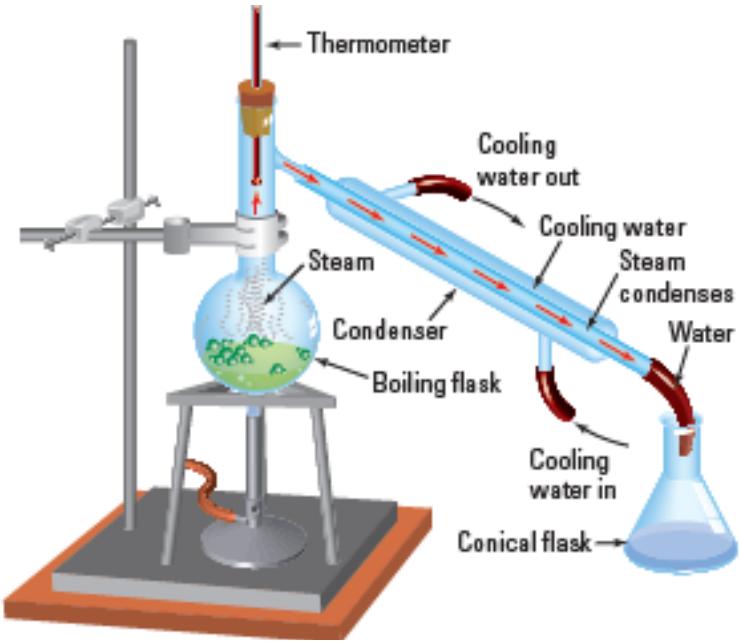


Figure 2.10. Simple distillation

A mixture of two miscible liquids can also be separated by simple distillation.

Liquids which mix with each other to form a solution are called miscible liquids. The mixture of alcohol and water, and the mixture of benzene and oil are some examples of miscible liquids.

Separation of mixtures may require combination of two or more techniques. For example, a mixture of common salt and sand can be separated by using the process of dissolving, filtration and evaporation. The first stage of separation is adding water to the mixture. The salt dissolves in water and forms a solution, but not the sand. Then by using filtration, the sand can be separated from the salt solution. Finally evaporation of the filtrate will cause the water to escape leaving the salt behind.

Experiment 2.10

Title: Simple distillation

Objective: *To separate water from salt solution.*

Materials Required: *Distillation flask, condenser, wire gauze, bunsen burner, conical flask, beaker.*

Procedures:

1. Dissolve about 40 g of common salt in 150 mL of pure water.
2. Set up the distillation apparatus.
3. Add 100 mL of the salt solution into the distillation flask.
4. Put a porous material or sand (boiling chips if there are any) in the flask.
5. Heat the distillation flask gently and observe the results.

Observations and Analysis:

i. What is collected in the receiver (conical flask) and what remains in the distillation flask?
ii. Where evaporation and condensation take place in this experiment?
iii. Why the condenser is connected with tap water in a simple distillation set up?

2.5.2. Separating of mixtures using locally available materials

There are number of ways that mixture can be separated by using local materials. These are:

i. hand pickling process
ii. winnowing process
iii. sieving process

Project 2.1

Make a group and perform the following project then present it to the class.

Part I: Separating mixtures by using locally available materials

1. How river water can be purified by using locally knowledge? Write steps to be followed and present it to the class.
2. How "Areke" can be prepared by locally? What materials are required to prepare? Ask your parents/ nearby shops where liquor prepared/ and write procedures and present it to the class.
3. Discuss with your parents/guardians and elders in your neighborhood on the techniques of separating mixtures like:

   i. wheat from its residue. iii. flour from ground residue.
   ii. mixture of beans and peas.

Part II: Write the short note and present your findings to the class in the form of an oral presentation, a poster display, or multi-media presentation.

The following processes are local method of separating mixtures. Write procedure for each separation process.

a. hand pickling process b. winnowing process
c. Sieving process

Exercise 2.6

How would you separate the following mixtures? Describe the separation techniques in each case.

1. Sand from water
2. Alcohol from water
3. Components in muddy water
4. Hot water and butter
5. Kerosene (Nafta) and water
6. Common salt and clay
7. Two miscible liquids
8. Sand from salt
9. Crushed ice and crushed glass
10. Table salt and charcoal
11. Sugar and sand
12. Oil, water and sand

UNIT SUMMARY

- A substance is a form of matter possessing constant properties under specific conditions.
- Properties of substances are subdivided into physical and chemical properties.
- Physical properties of a substance describe the characteristics of the substance that are related to physical changes.
- Substances can be identified based on their physical properties such as state, color, odor, taste, hardness, density, melting and boiling points.
- Chemical properties describe the characteristics of a substance related to chemical changes.
- Substances can be classified as pure substances and mixtures.
- Elements and compounds are pure substances, and have constant composition and uniform properties.
- An element is a substance that cannot be broken down into simpler form by chemical means. Elements are classified into metals, non metals and metalloids.
- A compound is a substance composed of two or more elements chemically combined in a fixed proportion.
- A mixture is a substance which consists of two or more pure substances that are mixed together physically. Mixtures are classified into homogeneous and heterogeneous mixtures.
- Substances undergo two types of changes: physical and chemical changes. Physical changes are changes that do not result in the formation of new substances with new properties. Chemical changes are the changes in the composition of substances.
- Mixtures can be separated into their components using different methods

such as magnetic separation, filtration, decantation, evaporation and distillation.

Key Terms

- Change in state
- Chemical change
- Compounds
- Decantation
- diffusion
- Distillation
- Elements
- Evaporation
- Filtration
- Heterogeneous mixture
- Homogeneous mixture
- Magnetic separation
- Metalloids
- Metals
- Mixture
- Non-metals
- Physical change
- Properties
- Sedimentation
- Substance

REVIEW EXERCISE

Part I: Write true for the correct statements and false for the wrong statements.

1. A physical change is a change in the composition of a substance.
2. A homogeneous mixture always contains only one phase.
3. Atoms combine chemically to form elements.
4. Two different substances cannot be similar in all physical properties.
5. The ability of iron to conduct electricity is a chemical property of iron.
6. The temperature at which a solid melts is the same as the temperature at which its liquid solidifies.

Part II: Choice the correct answer from the given alternatives.

1. Which one of the following is **not** a pure substance?
   - **A.** Diamond
   - **B.** Water
   - **C.** Oxygen
   - **D.** Milk
2. Which of the following is a compound?
   - **A.** Iron
   - **B.** Blood
   - **C.** Alloy
   - **D.** Sugar
3. Which one of the following does not involve a change of state?
   - **A.** Freezing
   - **B.** Expansion
   - **C.** Melting
   - **D.** Boiling
4. Which one of the following processes does not help in separation of mixtures?
   - **A.** Filtration
   - **B.** Burning
   - **C.** Distillation
   - **D.** Sieving
5. The apparatus used to separate two immiscible liquids is
   - **A.** separatory funnel
   - **B.** condenser
   - **C.** filter funnel
   - **D.** filter paper

6. The two stages that take place during distillation are
   - **A.** filtration followed by evaporation
   - **B.** evaporation followed by condensation
   - **C.** condensation followed by evaporation
   - **D.** filtration followed by condensation

7. The process of settling of suspended particles is known as
   - **A.** decantation
   - **B.** distillation
   - **C.** sedimentation
   - **D.** magnetic separation

8. The substance that cannot be further decomposed by ordinary chemical means is
   - **A.** water
   - **B.** sugar
   - **C.** gold
   - **D.** air

Part III: Give short answers for each of the following questions.

1. Identify whether the following statements describe a physical or a chemical property of a substance.
   - **(a)** Charcoal burns in air to form carbon dioxide.
   - **(b)** Ethyl alcohol boils at 78°C.
   - **(c)** Sulphur is a yellow solid at room temperature.
   - **(d)** Mercury is a silvery-white liquid metal.
   - **(e)** Silver is the best conductor of electricity.
   - **(f)** Iron rusts in the presence of moisture and air to form an oxide.

2. Identify the following changes as physical change or chemical change?
   - **(a)** Hammering aluminum into thin sheets
   - **(b)** Dissolving table salt in water
   - **(c)** Melting gold to make jewelry
   - **(d)** Burning of wood
   - **(e)** Grinding of maize
   - **(f)** Tearing of paper

3. Given samples of the following pairs of substances, name two physical properties that could be used to distinguish between the materials in each pair.

   (a) Copper and lead
   (b) Copper and silver
   (c) Water and benzene
   (d) Sulphur and iron

4. What is the difference between a physical and a chemical change?
5. How could you distinguish a compound from a mixture? Give three characteristics for each.
6. How would you distinguish between homogenous and heterogeneous mixtures? Give three examples for each case.

UNIT THREE

ELEMENTS, COMPOUNDS AND CHEMICAL REACTIONS

Learning Outcomes

At the end of this unit, students will be able to:

- *identify and write symbols of common elements or compounds;*
- *compare elements to compounds and how they are represented by symbols and formulae;*
- *name compounds from the given formula and write formula for the compound from the given name of the compound;*
- *use symbols and chemical formula as a way of communicating information about elements and compounds;*
- *state and apply the law of mass conservation for writing balanced equations;*
- *interpret chemical formula of compounds in terms of the elements present and the ratios of their atoms; and*
- *identify the use of chemical reaction for every day situation of life.*

Main Contents

3.1. Elements and their representation
3.2. Compounds and their representation
3.3. Simple chemical reactions and equations
3.4. Uses of chemical reactions in every day situation.

Start-up activity

Discuss the following and present your opinion to the class.

1. What is an element?
2. Write the name of commonly used elements.

Introduction

Under chapter two, you have learned that substances can be classified as pure substances and mixtures. Pure substances are further classified as elements and compounds. This unit deals with the elements, compounds, chemical reactions and uses of the chemical reactions in everyday life. The unit also gives emphasis for the concepts how the names of elements and compounds can be represented by using chemical symbols and formulae.

3.1. Elements and Their Representation

At the end of this section, you will be able to:

- *define element;*
- *identify symbols of some common elements;*
- *write chemical symbols for common elements;*
- *explain of importance of using symbols.*

Common Elements

You have learned that there are about 118 known elements. An element is a pure substance that cannot be broken down into simpler substances by ordinary chemical means. An element is composed of only one kind of matter (atoms). It is the simplest form of matter. For example, the six common elements that found in the living things are hydrogen, carbon, sulphur, oxygen, nitrogen and phosphorous.

Chemical symbols

Activity 3.1

Discuss the following and present to the class.

1. What is chemical symbol and its representation?
2. Can you mention the names of elements you are familiar with?

In science, each known pure substance, whether an element or compound, has its own unique name, symbol or formula. Scientists use chemical symbols in place of the names of the elements because they are much easier. The symbols and formulas are designed in such a way that they are internationally accepted. Therefore, they enable all Scientists in the world to communicate easily.

Chemical symbol is a shorthand way of representing names of elements or atoms of an element. Symbols are specific for a specific element. No two elements can have the same symbol.

A chemical symbol is usually the first letter of the English or Latin name of the element. Examples: Nitrogen (N), Aluminium (Al), hydrogen (H), oxygen (O), and etc. Chemical symbols are sometimes called atomic symbols.

Why are not all elements symbolized by the first letter of their names?

The names of some elements such as carbon, calcium, chlorine and copper begin with the same letter “C”. Therefore, we cannot use the letter “C” as a symbol for all these elements. Hence, two letters are used for all these elements except one. The first letter “C” is assigned as a symbol for carbon. The other elements are represented by two letter symbols. Thus, the symbols for these elements will be Ca for calcium, and Cl for chlorine.

The first letter of a symbol is always capitalized, but the second letter is small.

The symbols for the 18 elements derived from their English names are given in table 3.1.

Table 3.1. Symbols of 18 elements derived from English names.

Name of Element	Symbol	Name of Element	Symbol
Hydrogen	H	Neon	Ne
Helium	He	Magnesium	Mg
Lithium	Li	Aluminum	Al
Beryllium	Be	Silicon	Si
Boron	B	Phosphorous	P
Carbon	C	Sulphur	S
Nitrogen	N	Chlorine	Cl
Oxygen	O	Argon	Ar
Fluorine	F	Calcium	Ca

Table 3.2. The symbols and Latin names of some elements

Element	Latin word	Symbol
Silver	Argentum	Ag
Sodium	Natrium	Na
Iron	Ferrum	Fe
Lead	Plumbum	Pb
Mercury	Hydrargyrum	Hg
Tin	Stannum	Sn
Gold	Aurum	Au
Potassium	Kalium	K

Importance of using symbols

- Symbols are much easier and quicker to write the name of an element.
- The same symbols are used throughout the world so that chemists all over the world can understand them.
- Symbols stand for a specific element.

Exercise 3.1

Part I: Write a short answer for the following questions

1. What is a chemical symbol for Aluminum?
2. What is the problem if only first letter is taken as the symbol for all elements?
3. For some elements their symbols and names are not related or correspond. Why?

Part II: Fill the missing symbols and names of the elements in the following table.

Name of element	Oxygen		Carbon		Zinc	Barium
Symbol		K		P		

3.2. Compounds and Their Representation

At the end of this section, you will be able to:

- *define compounds;*
- *define meaning of formula and valence number;*
- *write the formulae of simple binary compounds using symbols and valences;*
- *name binary compounds;*
- *describe polyatomic ion;*
- *write the chemical formulas of common compounds that contain polyatomic ions;*
- *name compounds containing polyatomic ions; and*
- *identify the elements and number of atoms in given a chemical formula.*

Compounds

Activity 3.2

Discuss in groups and share your ideas with the rest of the class.

What do the notations, Co and CO represents? Explain their differences.

You have learned that compound is a substance which consists of two or more elements chemically combined together. In order to represent a compound, we combine the symbols of the elements to make a chemical formula.

Chemical Formulas

Chemical formula is the short hand representation of the compound by using symbols of elements. Therefore, it is the symbolic representation of composition of the compounds. Formulas can be classified as formulas of elements and formulas of compounds.

The formula of an element differs from a compound in that elements contain one kind of symbol and can be written in diatomic form whereas the formula of a compound contains the symbols of two or more different elements.

Example

- formula of an element: H_2, Br_2, O_2, and etc.
- formula of a compound: NaCl, HCl, KBr, and etc.

Formulas of Diatomic Elements

Do you know the elements that exist as diatomic molecules?

Molecule of an element is an atom or a group of atoms that exists freely in nature. Accordingly elements may exist as monatomic, diatomic or polyatomic molecules.

The hydrogen molecule is a diatomic molecule because it contains only two atoms. It is represented by the formula H_2. The symbols of other diatomic elements are given in table 3.3.

Table 3.3. Chemical symbols and formulas of diatomic elements

Name	Chemical symbol	Chemical formula
Hydrogen	H	H_2
Nitrogen	N	N_2
Oxygen	O	O_2
Fluorine	F	F_2
Chlorine	Cl	Cl_2
Bromine	Br	Br_2
Iodine	I	I_2

Molecules containing more than two atoms are called polyatomic molecules. Ozone (O_3), Phosphorus (P_4) and Sulphur (S_8) are examples of polyatomic molecules.

Valence Number

Activity 3.3

Discuss in groups and share your ideas with the rest of the class.

1. What is valence number?
2. What are the use of valence number in writing chemical formula?

The combining power of an element is its relative capacity to combine with other elements. This combining power of an element is called valence number. Different elements have different combining powers. It is easy to write the formula of a compound if we know the combining power of the elements or polyatomic ions involved.

In compounds containing hydrogen, whose valence number is 1 combines with element chlorine whose valence number 1; the formula becomes HCl.

One atom of oxygen with valence number 2 combines with two atoms of hydrogen forms water, H_2O.

What is the formula of 1 nitrogen atom and 3 hydrogen atoms?

The valence numbers of most common elements are either 1, 2, or 3. Some elements have more than one valence number, which has different combining powers under different conditions. Table 3.4 illustrates the elements with different valence numbers.

Table 3.4. Valence numbers of some common elements

Element	Valence number 1		Valence number 2		Valence number 3	
	Name	Symbol	Name	Symbol	Name	Symbol
Metals	Lithium	Li	Beryllium	Be	Aluminum	Al
	Sodium	Na	Magnesium	Mg	Iron (III)	Fe(III)
	Potassium	K	Calcium	Ca		
	Copper (I)	Cu (I)	Zinc	zn		
	Silver	Ag	Iron (II)	Fe (II)		
			Cupper (II)	Cu(II)		
Non-metals	Hydrogen	H	Oxygen	O	Nitrogen	N
	Chlorine	Cl	Sulphur	S		
	Bromine	Br				
	Iodine	I				

Exercise 3.2

Answer the following questions.

1. Which of the following elements exists as a diatomic molecule?

   A. Carbon **C.** Bromine

   B. Sulphur **D.** Neon

2. 2.What is the valence number of:

   (a) Sulphur in H_2S? **(c)** Phosphorus in PH_3?

   (b) Carbon in CH_4 ?

Formulas of Binary Compounds

Activity 3.4

Discuss the following questions and share your answer to the class.

How to write formulas of compounds in which the metal and non-metal have the same combining power?

Binary compounds contain atoms of only two different elements. Examples of binary compounds are sodium chloride (NaCl), hydrogen bromide (HBr), copper (II) oxide (CuO), and etc. The formulas of binary compounds in which the metallic and nonmetallic elements have the same valence numbers are simply represented by the symbols of the elements. This is because the combining powers of the elements are balanced.

For example:

- The formula of potassium chloride is KCl because the valence numbers of both K and Cl is 1.
- The formula of calcium oxide is CaO because the valence numbers of both Ca and O is 2.

The method of writing formulas of binary compounds is shown in the following steps:

Step 1. Write down the symbols for the elements in the compound.

Let us consider some examples:

Sodium Oxide	Na	O
Calcium Chloride	Ca	Cl
Aluminum Oxide	Al	O

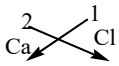
Step 2. Write the valence numbers above the symbols

i. $Na^{1}O^{2}$ ii. $Ca^{2}Cl^{1}$ iii $Al^{3}O^{2}$

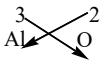
Step 3: Now criss cross the valence numbers and put the numbers below the symbols.



$\Rightarrow Na_2O$, thus, the formula of sodium oxide is Na_2O.



$\Rightarrow CaCl_2$, thus, the formula of calcium chloride is $CaCl_2$.



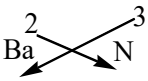
$\Rightarrow Al_2O_3$, thus, the formula of aluminum oxide is Al_2O_3

Note: If the valence numbers of the elements in the compound are equal, simplify and write the simplest formula of the compound. For example, the formula of magnesium oxide is MgO and not Mg_2O_2.

Example: Write the formulas for the following binary compounds.

a. Barium nitride
b. Potassium iodide
c. Magnesium oxide
d. Aluminum chloride

a. Barium has a valence number 2 and nitrogen has a valence number 3. To balance their combining powers, criss cross their valence numbers as follows:

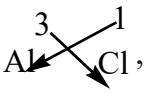


, thus, the formula of barium nitride is Ba_3N_2.

b. Since both potassium and iodine have valence numbers 1, the formula of potassium iodide is KI.

c. Since both magnesium and oxygen have valence numbers 2, the formula of magnesium oxide is MgO.

d. Aluminum has a valence number 3 and chlorine has a valence number 1. To balance their combining powers, criss cross their valence numbers as follows:



, thus, the formula of aluminum chloride is $AlCl_3$.

What is the formula of the compound formed by magnesium and fluorine?

Naming Binary Compounds

Activity 3.5

Make a group and discuss on the following questions.

How the binary compounds are named?

The two constituent elements of binary compounds are usually metals and nonmetals. For example, NaBr, CaO and $AlCl_3$. There are also binary compounds which consist of non-metallic elements only. For example, H_2O, CO_2 and NH_3 .

Rules for Naming Binary Compounds

1. **For binary compounds that consist of metals and non-metals, the metal is named first followed by the non metal.**

2. **The suffix -ide replaces the last letters of the name of the non-metal as shown table.**

Table 3.5. Names of non metallic elements in binary compounds

Non- metallic element	Name in binary compounds
Fluorine	Fluoride (F^-)
Chlorine	Chloride (C^{l-})
Bromine	Bromide (Br^-)
Iodine	Iodide (I^-)
Oxygen	Oxide (O^{2-})
Nitrogen	Nitride (N^{3-})
Sulphur	Sulphide (s^{2-})
Hydrogen	Hydride (H^-)

Examples: potassium iodide (KI), Magnesium nitride (Mg_3N_2), Calcium hydride (CaH_2) etc.

3. If the binary compound consists of non-metallic elements only, we name the first element in the formula followed by the name of the second element with the suffix -ide.

Examples: Hydrogen chloride (HCl), Hydrogen bromide (HBr), etc.

4. If the metal has variable valence numbers, the valence number of the metal used in the formula should be placed in parenthesis using capital Roman numerals after the name of the metal.

Examples: Copper (I) Oxide (Cu_2O), Iron (II) Chloride ($FeCl_2$), iron (III) chloride ($FeCl_3$), and etc.

5. Some compounds are named by using Greek numbers like mono, di-, tri-, tetra-, penta-, etc for one, two, three, four or five numbers respectively.

Consider the following examples:

CO – Carbon monoxide
P_2O_3 – Diphosphorus trioxide
NO_2 – Nitrogen dioxide
N_2O_4 – Dinitrogen tetroxide
SO_2 – Sulphur dioxide

Example:

Name the following binary compounds.

a. $SiCl_4$ b. N_2O_5 c. NF_3

Solutions:

(a) Because there are four chlorine atoms, the name of the compound is silicon tetrachloride.

(b) There are two nitrogen atoms and five oxygen atoms. Thus, the name of the compound is dinitrogen pentoxide.

(c) Since there are three fluorine atoms, the name of the compound is nitrogen trifluoride.

Traditionally, many of compounds are called either by their common names or by names that do not specifically indicate the number of H atoms. Examples:

H_2O - Water
NH_3 - Ammonia
PH_3 - Phosphine
H_2S - Hydrogen sulphide

Exercise 3.3

1. The valence number of a metallic element M is 3. What is the formula of its oxide?
2. Name the following binary compounds

a. Ca_3N_2 d. SO_2 g. $MgBr_2$ j. P_2O_5
b. $AlCl_3$ e. NO h. CO_2 k. SO_3
c. MgS f. PCl_3 i. CaI_2,

Polyatomic Ions

Polyatomic ion is an ion that contain more than one atom. It is a group of atoms that exists in several compounds but does not exist on its own. For example, Nitrate, NO_3^- is polyatomic ion that consists of nitrogen and oxygen atoms but cannot exist itself unless combined with other elements or groups of elements like sodium nitrate ($NaNO_3$). Polyatomic ions are sometimes called radicals. Polyatomic ions and their valence numbers are given in table 3.6.

Table 3.6. Valence numbers of some polyatomic ions.

Valence number 1		Valence number 2		Valence number 3	
Name	Symbol	Name	Symbol	Name	Symbol
Hydroxide	OH^-	Carbonates	CO_3^{2-}	Phosphate	PO_4^{3-}
Nitrate	NO_3^+	suphates	SO_4^{2-}		
Hydrogen carbonate	HCO_3^-				
Hydrogen sulphate	HSO_4^-				
Ammonium	NH_4^+				

Writing chemical formulas and naming simple chemical compounds containing polyatomic ions

To write chemical formula by using atoms with groups or polyatomic ions, different compounds are formed according to the combining power of groups and atoms as written below.

I. When two combining groups (element and poly atomic ion) have the same combining power, the formula will become simply writing symbol of an element and poly atomic ion.

Example KOH, NH_4Cl, NH4NO_3, $KHCO_3$, KOH (potassium hydroxide), NH_4Cl (ammonium chloride), NH_4NO_3 (ammonium nitrate), $KHCO_3$ (potassium hydrogen carbonate), and etc.

II. When two combining groups (element and poly atomic ion) have different combining power, the formula will be written using their valency number or combining power.

Example: KOH, NH_4Cl, NH_4NO_3, $KHCO_3$, and etc.

For example, to write the formula of aluminum sulphate:

Step1. Al SO_4

Step2. Al^3 SO_4^{2}

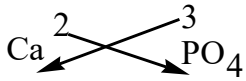
Step3. Al^{3} SO_4^{2} $\Rightarrow Al_2(SO_4)_3$

☞ Thus, the formula of aluminum sulphate is $Al_2(SO_4)_3$.

Example 1:

Write the chemical formula for calcium phosphate.

Calcium has a valence number 2 and phosphate ion has valence number. To balance their combining powers, crisscross their valence numbers as shown below.

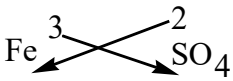


Thus, the formula of calcium phosphate is $Ca_3(PO_4)_2$.

Example 2:

Write the chemical formula for iron (III) sulphate.

Iron (III) has a valence number 3 and sulphate ion has a valence number. To balance their combining powers, crisscross their valence numbers as shown below.

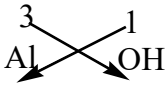


Thus, the formula of iron (III) sulphate is $Fe_2(SO_4)_3$.

Example 3:

Write the chemical formula for aluminuim hydroxide.

Aluminum has a valence number 3 and hydroxide ion has a valence number 1.



Thus, the formula of aluminuim hydroxide is $Al(OH)_3$.

Exercise 3.4

Answer the following questions .

1. Name the following compounds

   a) Li_2SO_4 b) $(NH_4)_3PO_4$ c) $Ca(NO_3)_2$ d) $Fe(NO_3)_2$
   e) $CaCO_3$ f) $Mg(OH)_2$ g) $BaSO_4$ h) $(NH_4)_2SO_4$

2. Write chemical formulas for the following compounds.

   a) *Potassium hydroxide*
   b) *Ammonium Sulphate*
   c) *Magnesium carbonate*
   d) *Magnesium phosphate*

Interpreting formula

Symbols and formulas describe both qualitative and quantitative aspects of the substances.

Qualitatively a symbol represents the identity (kind) of the element. For example, the symbol N represents an atom of nitrogen.

Quantitatively a symbol represents the number of atoms of the elements. For examples, H stands for one atom of hydrogen and Na stands for one atom of sodium.

Qualitatively a formula represents the kinds or types of elements involved in forming a compound. For example, a water molecule, H_2O, contains the elements hydrogen and oxygen.

Quantitatively a formula stands for one molecule (formula unit) of an element or a compound. Examples; CO_2 represents one molecule of carbon dioxide, P_4 indicates one molecule of phosphorous.

A number written in front of a symbol or a formula is called a *coefficient*. It shows the number of atoms or molecules or formula units of the substances.

Examples:

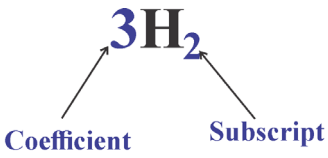
- 3Fe represents 3 atoms of iron
- 2H means 2 atoms of hydrogen (Note that: 2H differs from H_2)
- $5N_2$ means 5 molecules of nitrogen.

Note that the coefficient multiplies the whole atoms of the elements in the formula, not only the first element. For example, $2HNO_3$ represents two molecules of nitric acid which contains 2 atoms of hydrogen, 2 atoms of nitrogen and 6 atoms of oxygen.

Subscripts are used in writing formulas. A *subscript* is a number written at the bottom right hand side of a symbol. In the formula of an element, the subscript

qualitatively shows the element is in a molecular form. For example Cl_2 is a chlorine molecule, P_4 is a phosphorus molecule and S_8 is a sulphur molecule.

Quantitatively a subscript in a formula stands for the number of atoms in the formula. For example, H_2 indicates a molecule of hydrogen which contains 2 hydrogen atoms. The general notation is shown below using hydrogen molecule as an example.



For the formula $3H_2O$, the coefficient 3 shows as there are 3 molecules of water. The subscript 2 shows that there are 2 atoms of hydrogen in a water molecule and 1 oxygen atom in a water molecule. This information is called quantitative information.

Exercise 3.5

1. Fill the blank spaces in the table given below.

No	Chemical symbol or formula	Qualitative meaning	Quantitative meaning
a	$2Cl_2$		
b	$4Cl$		
c	$3S_8$		
d	$5MgF_2$		

2. Quantitatively, the formula $5Br_2$ represents;

A. 5 atoms of bromine
B. 2 molecules of bromine
C. 5 molecules of bromine
D. 10 molecules of bromine

3. Interpret the formulas of;

(a) CaO

(b) $Ca(NO_3)_2$

Project 3.1

Search different materials, such as a science books, and or the internet, or any other materials and discover the formulae of common compounds such as baking soda, vinegar (acetic acid), lime and interpret them in terms of the elements present and the ratios of their atoms.

3.3. Simple chemical reactions and equations

At the end of this section, students will be able to:

- *define chemical reaction and give examples;*
- *describe evidences that show chemical reaction has occurred;*
- *state the law of conservation of mass;*
- *conduct an experiment in group to show simple chemical reaction;*
- *write a chemical equation;*
- *balance simple chemical equation by inspection; and*
- *create and use models of particles to demonstrate balanced equations.*

Simple chemical reaction

Activity 3.6

Discuss in a group and present to the class

1. Describe the various chemical changes that occur in your daily lives.
2. What are evidences that indicate as chemical reactions occurred?

A chemical reaction is a process in which a substance is changed into one or

more new substances. The substances that take part in a chemical reaction are called reactants. The substances formed as a result of a chemical reaction are called products. In a chemical reaction reactants are transformed into products as shown below.

Reactants ⟶ Produts

Always reactants are written on the left side of the arrow and products are written on the right side of the arrow. For reaction that have more than one reactant, the following representation is used.

$$A + B \longrightarrow C + D$$

The plus sign, "+"means "combines with" or "reacts with", The arrow is directed from reactant(s) to product (s) to mean "produces" or "gives" or "yields".

For example, when carbon burns in air (oxygen) it produces carbon dioxide.



Examples of chemical reactions are:

The reaction between hydrogen and oxygen gives water.

Hydrogen + Oxygen → Water (dihydrogen oxide)

$H_2 + O_2 \rightarrow H_2O$

The reaction between calcium and oxygen produces calcium oxide.

Calcium + Oxygen → Calcium oxide

$Ca + O_2 \rightarrow CaO$

Can you write an equation that shows the reaction between sodium and oxygen?

Examples of chemical changes that are brought as a result of chemical reactions are rusting of iron, fermentation, digestion of food, photosynthesis, etc.

Can you give other chemical changes that bring chemical reaction?

There are a number of evidences that show whether chemical reaction has taken place or not. These are, change in color, change in temperature (heat) formation of gases and change in composition.

The Law of Conservation of Mass

The law of conservation of mass states that in all chemical reactions the total mass of the reactants is equal to that of the products. This means atoms cannot be created or destroyed in a chemical reaction. Hence mass is conserved during a chemical reaction. The law of conservation of mass is also known as the law of conservation of atoms. Mass is conserved during a chemical reaction i.e. no atoms are lost or gained but they are simply rearranged.

For example, consider the reaction between magnesium and oxygen to give magnesium oxide as shown below.

$$2Mg + O_2 \rightarrow 2MgO$$

For this reaction before the reaction takes place, the mass of magnesium and the mass of the oxygen are 24g and 32g respectively. The sum of the mass of the magnesium and oxygen is 56. After the reaction takes place, the mass of product MgO is 56 g.

$$2Mg + O_2 \rightarrow 2MgO$$

24g 32g 56g

In this reaction, there 2 magnesium atoms on and two oxygen atoms on the both sides of equation. This implies that atom is conserved. The following experiments illustrate this concept.

Experiment 3.1

Title: Simple chemical reaction.

Objective: *To study simple chemical reaction by burning magnesium in air.*

Materials and Chemicals required: *bunsen burner, match, tong, crucible and magnesium ribbon.*

Procedures:

1. Hold a magnesium ribbon with a tong and heat it on the Bunsen burner
2. Collect the product on the crucible.
3. Record your observations.

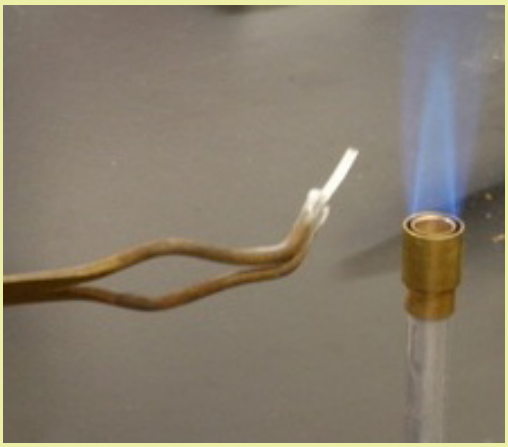


Figure 3.1. Burning of magnesium in air

Observations and Analysis

1. What is the importance of heat for the reaction?
2. What are the reactants?
3. Compare and contrast the properties of the reactants with the product.

Simple Chemical Equations

The representation of a chemical reaction with symbols and formulas of the substances is known as a *chemical equation*.

A chemical equation describes both a qualitative and a quantitative statement of the substances involved in each of the reactant or product.

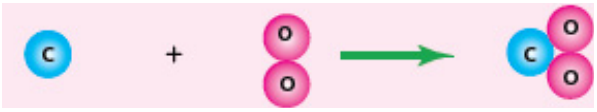
To write the chemical equation for a reaction the word equation is written first.

Example:

Chemical reaction: Burning of carbon

Word equation: Carbon + Oxygen → Carbon dioxide

Chemical equation: $C + O_2 \rightarrow CO_2$



1 atom carbon + 2 atoms oxygen → 1 molecules of carbon dioxide

For the above reaction, one atom of carbon reacts with one molecule of oxygen to form one molecule of carbon dioxide. This chemical equation obeys the law of conservation of mass or matter since it is balanced.

Steps in Writing Simple Chemical Equation

To write a chemical equation for a given reaction the following three steps are very important.

Step1. Write a word equation for the reaction.
Step2. Change the word equation to a chemical equation i.e., write the correct symbol or formula for each reactant and product.
Step3. Balance the equation so that it obeys the law of conservation of mass.

For instance, the chemical equation for the reaction between sodium and oxygen is illustrated as follows;

Step 1: Sodium + Oxygen → Sodium oxide . . . (Word equation)
Step 2: $Na + O_2 \rightarrow Na_2O$ /Chemical Equation . . . (Not balanced)
Step 3: $4Na + O_2 \rightarrow 2Na_2O$ . . . (Balanced chemical equation)

Activity 3.7

Perform the following task in group and present to the class.

Why the chemical equation must be balanced? Give examples of balanced chemical equation.

Note that a chemical equation must represent the experimental facts.

Balancing Chemical Equation

A balanced chemical equation indicates the total number of atoms on the reactant side equal to the total number of atoms on the product side. This follows from the law of conservation of mass.

Chemical equations are balanced by putting the appropriate coefficients before the symbols or formulas of the substances involved in the reaction. There are different methods of balancing chemical equations. Inspection method is the simplest method used to balance simple chemical equations.

Balancing by Inspection Method

This method is a trial and error method of balancing chemical equation. The following rules are to be followed to balance chemical equation by using inspection method.

1. ***Write the word equation for the reaction.***
2. ***Change the word equation to chemical equation.***
3. ***Check those atoms of elements that are not equal on both sides of the equation and balance them by writing appropriate numbers in front of the symbols and formulas.***

Note: Do not change subscripts of any of the reactants or product!

Example 1

Balance the equation for the reaction of hydrogen with oxygen to form water.

Step1: Hydrogen + Oxygen → water

Step2: H_2 + O_2 → H_2O

Oxygen is not balanced because there are 2 atoms of oxygen on the left hand side whereas there is only 1 atom of oxygen on the right hand side.

Step 3: To balance the equation:

i. Put 2 in front of H_2O to balance oxygen as follows.

$$H_2 + O_2 \rightarrow 2H_2O$$

ii. Now put 2 in front of H_2 to balance hydrogen.

$$2H_2 + O_2 \rightarrow 2H_2O \text{ (balanced)}$$

Check:

Reactants	Products
4H atoms	4H atoms
2O atoms	2O atoms

Example 2

Write the balanced chemical equation for the reaction between magnesium and hydrochloric acid to produce magnesium chloride and hydrogen gas.

Magnesium + hydrochloric acid →magnesium chloride+hydrogen gas.

$$Mg + HCl \rightarrow MgCl_2 + H_2$$

To balance the equation: Put 2 in front of the HCl. The rest are already balanced.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Exercise 3.6

Write the balance chemical equation by using inspection method.

1. The reaction between zinc metal with hydrochloric acid to form zinc chloride and hydrogen gas.
2. When carbon reacted with a limited amount of oxygen forms carbon monoxide.
3. The reaction between sodium and oxygen to produce sodium oxide.
4. Burning of sulfur in air to yield sulfur dioxide.
5. The reaction between aluminum and oxygen produces aluminum oxide.
6. Sulphur and oxygen to form sulphur trioxide.
7. Iron and sulphur to form iron (II) sulphide

3.4. Uses of Chemical Reactions in Every Day Situation

At the end of this section, you will be able to:

- *describe the uses of chemical reactions in everyday situation*

Uses of chemical reaction

There are many chemical reactions that take place in our body and in our daily life. But we cannot recognize them. Simple examples of chemical reactions are:

- digestion of food in our stomach is facilitated by hydrochloric acid.
- fermentation in brewing produces carbon dioxide and ethanol/ alcohol.
- combustion of charcoal (carbon) for cooking purpose of food
- soaps and detergents used to wash clothes and bathing.

- breathing is the process of inhaling oxygen and exhaling carbon dioxide to sustain in life; and many more uses of chemical reactions in everyday situations.

Project 3.2

The aim of this project work is to enhance students' knowledge in the area of uses of chemical reactions in every day situation. Discuss in group and give examples of useful chemical reactions using indigenous knowledge and present your finding to the class.

UNIT SUMMARY

- A chemical symbol is a short hand notation for the chemical name of an element.
- The first letter of a symbol is always capitalized, but the next letter is not.
- A chemical formula is the symbolic representation of a substance giving the ratios of different kinds of atoms in it.
- The formula of an element consists of one kind of symbol.
- The formula of a compound consists of two or more kinds of symbols.
- Molecules containing only two atoms are called diatomic molecules.
- Molecules containing more than two atoms are called polyatomic molecules.
- The combining power of an element or polyatomic ion is called valence number.
- A polyatomic ion is a group of atoms that exists in several compounds but does not exist on its own.
- The valence numbers of most common elements or polyatomic ions are either 1, 2 or 3.
- Binary compounds contain atoms of two different elements only.
- The formulas of compounds can be written if the symbols and valence numbers of the constituent elements or polyatomic ions are known.
- Qualitatively a symbol represents the identity of the element.
- Quantitatively a symbol represents the number of atoms of the elements.
- Qualitatively a formula represents the kind of elements involved in making a compound.

- A formula stands for one molecule or formula unit of a molecule or a compound.
- A number in front of a symbol or a formula is called a coefficient.
- A subscript is written on the bottom right hand side of a symbol.
- A chemical reaction is a process by which a substance(s) is/are changed into one or more new substances.
- The substances that take part in a chemical reaction are called reactants.
- In a chemical reaction reactants are transformed into products.
- The method of representing a chemical reaction with the help of symbols and formulas of the substances is known as a chemical equation.
- A balanced chemical equation is an equation in which the total number of atoms of each element on the left hand side is equal to the total number of atoms of the same elements on the right hand side.
- Inspection method is used to balance simple chemical equations.

Key Terms

- Binary compound
- Chemical equation
- Chemical formula
- Chemical reaction
- Coefficient
- Diatomic molecule
- Inspection method
- Law of conservation of mass
- Polyatomic ion
- Polyatomic molecule
- Products
- Reactants
- Subscript
- Symbol
- Valence number
- Word equation

REVIEW EXERCISE

Part I: Write 'True' for the correct statements and 'False' for the wrong statements

1. A symbol stands for one atom of an element.
2. Polyatomic ions can exist in nature by themselves.
3. In a chemical reaction atoms are neither created nor destroyed.
4. N_2 and 2N have the same meaning.
5. A compound contains two or more elements that are chemically combined together.

Part II: Choose the correct answer from the given alternatives.

1. The chemical symbol for phosphorus is

   A. Po
   B. P
   C. Pt
   D. K

2. Which of the following is the correct name of BaB_{r2}?

   A. Boron bromide
   B. Barium bromide
   C. Barium dibromide
   D. Barium (I) bromide

3. Aluminum has a valence number of 3 and sulphur has a valence number of 2. What is the chemical formula for aluminum sulphide?

   A. $Al_2 S$
   B. AlS_3
   C. $Al_3 S_2$
   D. $Al_2 S_3$

4. The name of NO_2 is

   A. Nitrogen monoxide
   B. Nitrogen dioxide
   C. Nitrogen oxide
   D. Mononitrogen oxide

5. Quantitatively the formula $3N_2$ represents

   A. 3 atoms of nitrogen
   B. 2 molecules of nitrogen
   C. 3 molecules of nitrogen
   D. 6 molecules of nitrogen

6. All of the following elements can exist as diatomic molecules except

A. hydrogen
B. oxygen
C. sodium
D. chlorine

7. The Latin name of sodium is

A. Argentum
B. Kalium
C. Natrium
D. Cuprun

8. Consider the following balanced chemical equation;

$$3Mg(OH)_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6H_2O$$

What is the coefficient of water (H_2O)?

A. 1
B. 2
C. 3
D. 6

III. Give short answers for the following questions.

1. Write chemical formulas for the following compounds.

(a) Magnesium iodide
(b) Sulphur trioxide
(c) Copper (II) oxide

2. Name the following compounds

(a) MgH_2
(b) Al_2O_3
(c) NO

3. Write chemical equations for the following reactions and balance them.

(a) Aluminium + Iodine → Aluminium iodide
(b) Potassium + Water → Potassium hydroxide + Hydrogen
(c) Sodium + Oxygen → Sodium Oxide

General Science
Student Textbook
Grade 7

Federal Democratic Republic of Ethiopia
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