Chemistry

for Secondary Schools

Student's Book

Form One

Tanzania Institute of Education

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for Secondary Schools

Student's Book

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Preface

This textbook, *Chemistry for Secondary Schools*, is written specifically for Form One students in the United Republic of Tanzania. It is prepared in accordance with the 2007 Chemistry Syllabus for Secondary Schools, Form I–IV, issued by the then, Ministry of Education and Vocational Training.

The book consists of seven chapters, namely Introduction to Chemistry, Laboratory techniques and safety, Heat sources and flames, Scientific method, Matter, Elements, compounds and mixtures, and Air, combustion, firefighting and rusting. The chapters comprise of illustrations, activities, tasks, projects, and exercises. You are encouraged to do all the activities, projects, and exercises together with any other assignment provided. Doing so, will promote the development of the intended competencies.

Tanzania Institute of Education

Chapter One

Introduction to Chemistry

Introduction

Chemistry is fundamental to our world. It plays great roles in our everyday life activities and touches almost every aspect of our lives in many ways. In this chapter, you will learn about the concept of chemistry, items made by applications of chemistry and importance of chemistry in real life. The competencies developed through learning chemistry will enable you to apply chemistry knowledge, skills, and principles to solve daily life problems related to various things, including food, clothing, shelter, clean air, water, energy, soil, and changing natural resources of the Earth to useful substances.

Concept of chemistry

Chemistry is a branch of science that deals with the composition, structure and properties of matter. It also involves chemical reactions and how they affect matter. *Matter* is anything that has mass and occupies space. It includes the materials or substances of nature which make up our environment.

Chemistry is divided into different areas such as *analytical chemistry*, *inorganic chemistry*, *organic chemistry, physical chemistry,* and *biochemistry*. Analytical chemistry deals with studies and uses of instruments and methods used to separate, identify, and quantify chemical species in matter. Inorganic chemistry deals with properties and behaviour of inorganic compounds. Organic chemistry deals with carbon compounds. Physical chemistry is concerned with the relations between the physical properties of substances and their chemical composition and transformations. Biochemistry deals with the study of chemical processes that occur in living things.

The people who study chemistry are called *chemists*. In studying and applying the knowledge and skills of this subject, chemists use various principles and theories from chemistry and other related science disciplines including physics, biology, and mathematics. Since chemistry is a science that involves experiments and practical works, chemists have to acquire *scientific skills* in order to be successful in obtaining facts and verifying them. These skills include:

1. Careful and thorough observations;
2. Accurate recording of what has been observed;

3. Organising the observed and recorded informations;
4. Repeating tests to make sure observations are accurate;
5. Drawing conclusion from observations; and
6. Predicting possible outcomes of similar experiments.

Therefore, chemistry students should acquire these skills so as to be able to think more clearly, logically, and even critically.

Items made by applications of chemistry

Task

1. Collect varieties of items that are commonly found at home and school, such as soaps, detergents, soft drinks, plastics, shoe polish, table salt (common salt), food, cosmetics, baking powder, soil, pen, and notebook.
2. Classify them into those produced through chemical processes and those which are not produced through chemical processes.

Many of the products that are obtained by the applications of chemistry are common to us. These products are processed through various fields such as agriculture, medicine, and manufacturing industries including food and beverage industries, construction materials industries, home care products and cosmetics industries, and pharmaceutical industries. Some of the products are given in Table 1.1.

Table 1.1: *Examples of products made through the applications of chemistry*

Field	Examples of products/items
Agriculture	Fertilisers, pesticides, and animal vaccines
Medicine and pharmacy	Drugs, vaccines, and food supplements
Home care products and cosmetics industries	Detergents, perfumes, shampoos, creams, soaps, shoe polish, toothpastes, disinfectants, and insecticides
Food and beverage industries	Soft drinks, sugar, common salt, yeast, baking powder, and canned foods
Construction materials industries	Paints, varnishes, cement, plastics, and iron sheets
Textile industries	Clothes, dyes, and packaging materials
Transport	Fuels, lubricants (oil and grease), coolants, and tyres
Chemical industries	Industrial chemicals and laboratory chemicals

Exercise 1.1

1. Identify ten substances made by applications of chemistry.
2. How is chemistry used in your community?
3. With examples of chemical substances, explain how chemistry is commonly applied at your home.

Importance of chemistry in life

Activity 1.1

Aim: To find out the importance of chemistry.

Requirements:

(a) Items such as chemically preserved foods, cosmetics, dyes, medicines, and paints

(b) Science books, newspapers, and journals showing chemically processed items such as fertilisers, insecticides, beverages, soaps, and detergents

Procedure

1. Collect different items produced or preserved using chemical methods such as bottled or canned foods, cosmetics, and paints.
2. Collect science books, newspapers, and journals that show pictures of chemically processed items such as fertilisers, insecticides, beverages, soaps and detergents.

Question

How are the collected items and those shown in the pictures, important in your daily life?

Chemistry is an important subject due to its wide applications in life. It is applied at home, for example, during cooking, bathing, and washing using soap. The knowledge and skills of chemistry are also very important in our daily lives as they are widely applied in different areas. These areas include; agriculture, medicine, pharmacy, and manufacturing industries which include food and beverage industries, textile industries, chemical industries, paper industries, transport industries, communication industries, and home care products and cosmetics industries.

Agriculture

Agriculture is the practice of growing crops and keeping animals. Farmers use many products made through chemical processes to obtain better agricultural yields. These products include fertilisers, pesticides, animal vaccines, and processed animal feeds. Fertilisers are used to improve the quality and quantity of crops and yields. Some of the fertilisers are shown in Figure 1.1.

Figure 1.1: *Fertilisers*

Pesticides are used for destroying or controlling insects or other organisms harmful to crops, or animals, or products. Pesticides are sprayed or sprinkled on crops to destroy pests. Figure 1.2 shows a farmer spraying pesticides on the crops.

Figure 1.2: *Spraying pesticides on crops*

Pesticides are also used in animal dips (Figure 1.3) to kill pests such as ticks that attack animals.

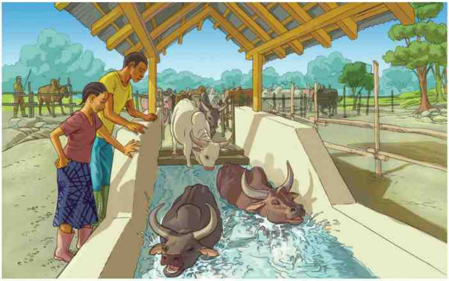


Figure 1.3: *Animal dip*

Animal vaccines are used to protect animals from diseases. Figure 1.4 shows a dog being vaccinated.

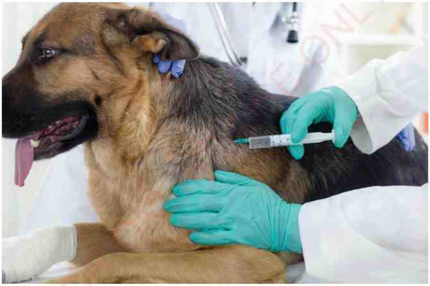


Figure 1.4: *Vaccinating a dog*

Medicines

The field of medicine is very important in our lives. It ensures our well-being through the prevention and treatment of diseases. Chemically produced substances in the forms of vaccines and medicines are used in this field. Medicines are found in medical stores and pharmacies. Some medicines are shown in Figure 1.5.

Figure 1.5: *Medicines in a pharmacy*

Manufacturing industries

Manufacturing industries such as textile industries, chemical industries, paper industries, food and beverage industries, transport industries, communication industries, plastic manufacturing industries, and construction materials industries rely heavily on chemical processes. Most of the machine parts are made of metals, plastics, and rubber. These materials are produced through chemical processes. Raw materials from different sources are also processed chemically to obtain products. Examples of such products are cement, plastic containers, fabrics, chemicals, rubber, and paper. Figure 1.6 shows some of the products manufactured using various chemical sources and processes.

Figure 1.6: *Some of the products from the manufacturing industries*

Food and beverage industries

The food and beverage industries have benefited a lot from chemical processes and products. Among the processes is the preservation of foods, especially those which are canned or bottled. Examples of chemicals commonly used as food preservatives are common salt, nitrates, nitrites, citric acid, and alcohol. Chemically preserved food stuffs last longer than those unpreserved. Some foods which are preserved using chemicals are shown in Figure 1.7.

Figure 1.7: *Canned and bottled foods*

Chemistry is also useful in preparations of baked foods such as bread, cakes, rock buns, and biscuits (Figure 1.8).

Figure 1.8: *Examples of baked foods*

Transport

Fuels and lubricants used in motor vehicles, aircrafts, motorcycles, ships, and other means of transportation are produced by chemical processes. Their parts such as engines, batteries, and tyres are made through chemical processes. Other materials such as seals, plastics, paints, coolants, carpets, and seat covers found in the means of transport are also made through chemical processes. Figure 1.9 shows a car engine with its associated parts made up by application of chemistry.

Figure 1.9: *Car engine and its associated parts*

Communication

Letters, newspapers and magazines are written using papers and ink that are manufactured through chemical processes. Telephones, radios, televisions, and computers rely much on wires, batteries, chemicals, and other materials that are chemically manufactured. Figure 1.10 indicates some of the communication media whose components are made by chemical processes.

Figure 1.10: *Some of the communication media*

Home care products and cosmetics

Home care products are used to make home and its surroundings clean and more comfortable to live in. They include soaps, detergents, disinfectants, paints, air fresheners, and polish. All these products are made chemically. Some home care products are shown in Figure 1.11.

Figure 1.11: *Examples of home care products*

Cosmetics are also produced chemically. They are used to improve one's physical appearance or odour. Such products include deodorants, lotions, lipsticks, and face foundation creams (Figure 1.12).

Figure 1.12: *Examples of cosmetics*

Chemistry for professional development

Chemistry is an important subject in many careers. Chemists find employment opportunities in schools, hospitals, research centres, testing laboratories, energy sector, pharmaceutical industries, chemical industries, food processing industries, biotechnology firms, and other manufacturing industries. This means that a person studying chemistry with other subjects can become a doctor, chemist, pharmacist, chemical engineer, chemical analyst, laboratory technician, laboratory scientist, nurse, researcher, teacher or other professions. The skills acquired in chemistry are very valuable in such professions.

Chapter summary

1. Chemistry is a branch of science that deals with the composition, structure and properties of matter, and the changes that matter undergoes.
2. Matter is anything that has mass and occupies space.
3. A lot of materials and objects are made by applications of the knowledge of chemistry. The materials and objects include soaps and detergents, foods and drinks, medicines, fuels, and cosmetics.
4. Chemistry is important because it is applied in many fields such as agriculture, medicines, food and beverage industries, home care and cosmetic industries, research, transport, communications, and other areas.
5. The skills acquired in chemistry can enable a person to become a doctor, chemist, pharmacist, chemical analyst, chemical engineer, teacher, laboratory technician, nurse, researcher or other professions.

Revision exercise 1

Choose the correct answer in items 1–7.

1. Chemistry is a study of
   (a) the composition, properties and structure of matter.
   (b) experiments only.
   (c) research base.
   (d) chemicals and equipment in laboratories.
2. What is the name given to a chemistry expert?
   (a) Geologist
   (b) Chemist
   (c) Chemical
   (d) Scientist
3. Vaccines are chemical substances used to:
   (a) cure animals and human beings from diseases.

(b) protect animals and human beings from diseases.

(c) introduce vitamins and proteins in animals.

(d) make animals grow faster than normal growing.

4. Which of the following groups consists of home care products?

(a) Yeast, plastics, and disinfectants

(b) Paints, air fresheners, and petrol

(c) Rubbers, clothes, and soaps

(d) Detergents, disinfectants, and air fresheners

5. Which branch of Chemistry deals with the study of carbon and its compounds?

(a) Inorganic Chemistry

(b) Organic Chemistry

(c) Biochemistry

(d) Analytical Chemistry

6. A person at home can apply chemistry in:

(a) weighing cassava and maize flour.

(b) weeding flowers in a garden.

(c) cooking food in a kitchen.

(d) dusting the floor in a house

7. Identify the skill not acquired during chemistry study

(a) careful and thorough observations.

(b) accurate recording of what has been observed.

(c) drawing conclusions from observations.

(d) thorough observations and map reading skill.

8. List down four careers in which chemistry is applied.

9. Mention any five products that are chemically manufactured.

10. Explain seven areas where chemistry is applied.

11. How would life be if there was no chemistry at all?

12. Fill in the following table by giving any three products that are made by the applications of chemistry in each of the fields shown.

Field	Products
(a) Medicine	
(b) Transport	
(c) Agriculture	
(d) Food and beverage industries	
(e) Textile industry	

13. Write one-page narrative notes giving the importance of chemistry in your daily life.

14. Which chemical substances are used at your home?

15. Explain the roles of chemistry in the following fields:
   (a) Agriculture
   (b) Human health
   (c) Manufacturing industry
   (d) Transport
   (e) Communication

Chapter Two

Laboratory techniques and safety

Introduction

Most of the chemistry experiments in schools take place in a special room called laboratory. A laboratory is a special room or building designed and used for scientific experiments (Figure 2.1). In this chapter, you will learn about laboratory rules and safety measures, First Aid, and basic chemistry laboratory apparatus and their uses. The competencies developed will enable you to protect yourself in the laboratory and apply the best ways of handling apparatus and chemicals.

Figure 2.1: *Example of a school laboratory*

Laboratory rules and safety measures

Safety in the laboratory is of great importance to both students and teachers. This is because the experiments performed in the chemistry laboratory usually involve the use of delicated or complicated equipment and harmful chemicals. Experiments should be conducted in the laboratory by following proper procedures. It is important to follow laboratory rules in order to have successful practical activities in the laboratory and to avoid some hazards.

Laboratory rules

A laboratory rule is a statement that explains what to do or not to do in the laboratory. In this section, you will learn about laboratory rules to be followed before, during, and after practical activities.

Laboratory rules before practical activities

The following are the laboratory rules to be followed before the practical activities:

1. Do not enter in the laboratory without the permission or presence of the teacher or laboratory technician.
2. Dress appropriately for the laboratory activities. Wear a laboratory coat. Do not wear loose or floppy clothing. Tie back long hair. Roll up long sleeves. Do not wear shorts, sandals or walk barefooted.
3. Keep the windows open for proper ventilation.
4. Identify and note locations of all exits.

Laboratory rules during practical activities

The following are the laboratory rules to be followed during the practical activities:

1. Read the instructions carefully before you start any activity.
2. If you do not understand something, ask your teacher or the laboratory technician before proceeding.
3. Read the labels on chemical containers to be sure you have the right substance. Do not interchange labels.
4. Do not eat, drink, smoke, play or run in the laboratory.
5. Do not taste or smell a chemical or anything unless you have been advised on how to do it.
6. Use the fume chamber when carrying out experiments which produce harmful gases and vapours.
7. Perform the intended experiments only. Do not set up your own experiments or interfere with someone's experiment.
8. Do not spill liquids on the floor.

9. Report any breakages or accidents to the teacher or laboratory technician immediately.

10. When heating substances, direct the mouth of the test tube away from you and others. Do not point burners or hot substances towards yourself or other people.

11. Use a lighter or wooden splint to light burners. Do not use papers. Always strike the match before turning on the gas tap.

12. In case of a gas leakage, turn off all the gas taps and open the windows. Leave the room immediately.

13. Do not touch any electrical equipment with wet hands.

14. Do not use dirty, cracked or broken apparatus.

15. Turn off any gas or water taps that are not in use.

16. Do not remove any chemical or equipment from the laboratory without permission.

17. Replace covers and stoppers on the containers after using the chemicals.

18. Keep inflammable substances away from open flames.

19. Wash off any chemical spills on your skin or clothes with plenty of clean water.

Laboratory rules after practical activities

The following are laboratory rules to be followed after practical activities:

1. Appropriately dispose off any wastes. Use the litter bins and not the sink to dispose any solid waste. Do not return unused substances to their original containers.

2. Clean up the equipment and store it safely.

3. Turn off gas and water taps.

4. Clean the working surfaces, benches, and sinks.

5. Wash your hands with soap and running water.

Project

1. In groups, make a chart of at least ten important laboratory rules. You can use pictures, signs, and artwork in your charts. The best chart will be pinned up on the laboratory noticeboard.
2. Why should laboratory rules be obeyed by everyone?

Laboratory safety measures

Laboratory activities will always involve some measures of risks. It is important for you to put these risks to minimum levels so as to protect yourself and your surroundings. Therefore, it is reasonable to put in place safety measures to minimise or eliminate injuries and exposure to harmful substances.

The following are some of the safety measures to be considered in the laboratory:

1. The laboratory should be equipped with working fire extinguishers and other equipment with clear instructions on how to use them in case of fire.
2. Cupboards, storage cabinets, and drawers should have locks. This is to ensure that one does not accidentally get into contact with harmful substances or interfere with the equipment/apparatus.
3. Containers for chemicals should be checked regularly to ensure that they do not leak. They should have secured stoppers or covers when the chemicals are not in use.
4. Stored chemicals should be inspected regularly to ensure that they are not expired.
5. All apparatus should be checked regularly to ensure that they are safe for use.
6. All people using the laboratory should wear appropriate protective clothing to minimise exposure to hazards.
7. All chemicals should be well-labelled to prevent accidental use of wrong substances.
8. Emergency exits should be present, easy to access and use. Doors should open outward.

9. There should be a manual or instruction guide on how to treat spills of different chemical substances.
10. Chemical spills should be cleaned immediately.
11. The fume chamber should be labelled. It should be kept in good working conditions to minimise unexpected gas leaks or emissions.
12. Gas cylinders should be labelled, well stored and supported. They should always be in good working conditions.
13. Each laboratory should contain a First Aid kit with all the necessary items.
14. Refrigerators and freezers used in the laboratory should be labelled "*For chemical use only*" to avoid contamination with other substances. They should be clean and free of any spills.
15. Equipment for monitoring accidents such as fire should be installed to give alerts of any possible dangers.
16. Chemicals that can easily react with each other should never be stored together.

Handling chemicals safely

Working in the chemistry laboratory needs great care because most of the chemicals are potential poisons. Some chemicals are hazardous and can cause death. Chemicals in the school laboratory are not always safe, therefore, you should know their hazards by checking the *safety signs* labelled on their containers. All chemicals which are not correctly labelled should be removed from the laboratory and destroyed using proper methods.

Safety signs

Some safety signs have words and clear messages, while many rely on visual symbols to warn for the potential hazards. On chemical containers, symbols are used specifically for labelling chemicals that are hazardous (Figure 2.2). It is important to take note of these signs to ensure safety in the laboratory. For example, the container of nitric acid has the symbol for corrosive substance. That symbol indicates that the chemical corrodes substances such as metals, clothes, books, tables, and burns human skin. Table 2.1 shows interpretations of some safety symbols.

Figure 2.2: *Some safety signs on chemical containers*

Table 2.1: *Interpretations of some safety signs*

S/N	Sign	Meaning
1.	 Corrosive	Corrodes surfaces as well as the human skin
2.	 Toxic	Poisonous and can cause death

Table 2.1: *(continued)*

S/N	Sign	Meaning
3.	 Oxidant	Readily gives off oxygen or other oxidising materials. May intensify fire and cause explosions
4.	 Flammable/inflammable	Catches fire easily
5.	 Explosive	Blasts easily
6.	 Caution	Hazardous, can cause damage to organs from a short-term exposure
7.	 Health hazard	Hazardous, can cause serious long-term health effects such as cancer, breathing difficulties, and damaging organs

Task 2.1

1. Draw any four safety signs and indicate their meaning.
2. Collect various chemical containers from the laboratory. Observe safety signs on each container. Draw a table of two columns. In one column, draw the safety signs, and in the other column write down the meaning of the corresponding signs.
3. Which safety sign is most common?
4. Where else can you find such safety signs?

Activity 2.1

Aim: To demonstrate possible danger in the laboratory.

Requirements: Concentrated sulphuric acid, white tiles, and the following items: pieces of paper, cloth, and pieces of metals

Caution: Sulphuric acid is highly corrosive.

Procedure

1. Place the items on separate white tiles.
2. Using a dropper, pour a few drops of concentrated sulphuric acid onto each item on a white tile. Be very careful not to spill the acid on yourself, your clothes or on the worktable.
3. Observe and record the results.

Questions

1. What happened when a few drops of concentrated sulphuric acid came into contact with each item?
2. How do your observations demonstrate the possible hazards in the laboratory?

Exercise 2.1

1. What do you understand by the term laboratory?
2. List down ten laboratory rules which you should obey during practical activities.
3. Why should chemicals in the laboratory be labelled and well closed after use?
4. Give reasons to support each of the following statements:
   (a) A laboratory should be equipped with working fire extinguishers.
   (b) A laboratory should have large windows.
   (c) Chemicals which are not correctly labelled should not be used in the laboratory.

First Aid

First Aid is an immediate help given to a person who is sick or injured before professional medical assistance is available. It is important to learn the basics of First Aid because accidents can occur in the laboratory. The First Aid helps to:

1. reduce the likelihood of death.
2. shorten the recovery time.
3. prevent permanent disability.
4. reduce pain.
5. prevent the victim's condition from getting worse.

Causes of accidents in the laboratory

There are various causes of accidents in the laboratory. These include:

1. Failure to follow the right procedure for the given experiments that can lead to explosion and damage of equipment.
2. Spilled liquids left on the floor may cause slipping and falling.
3. Chemical spills and exposure that can lead to burns and damage to body parts such as eyes and skin.
4. Wrong use of equipment that can result in breakage, and in turn lead to cuts.

5. Accidental swallowing of harmful chemicals.

6. Improper disposal of chemical wastes that may result in explosions, burns and even fires.

7. Poor ventilation in the laboratory may cause poisoning by inhaling harmful gases, and fainting due to lack of oxygen.

8. Gas leakage from taps or cylinders may lead to fires or even explosions. The cylinders may leak after a faulty refill or due to a faulty regulator.

9. Use of wrong reagents, due to wrong labelling or use of expired reagents, may cause burns, poisoning or damage to equipment.

10. Electric shock can occur if electrical appliances are not plugged properly or are touched with wet hands.

11. Lack of adequate information on procedure and hazards related to certain practical activities or reactants may result in burns or explosions.

12. Eating or drinking in the laboratory may cause poisoning through contamination of food or drinks, or inhalation of harmful vapours while eating or drinking. Food particles or spilled drinks can damage apparatus or contaminate the chemicals.

First Aid kit

A First Aid kit is a box that contains items used to give help to a sick or injured person. An example of the First Aid kit is shown in Figure 2.3.

Figure 2.3: *First Aid kit*

Every laboratory should have a First Aid kit. The kit can be bought or schools can assemble their own kits. The main items in the First Aid kit and their uses are listed in Table 2.2.

Table 2.2: *Components of First Aid kit and their uses*

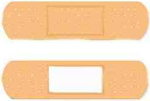
S/N	Item	Photograph	Use
1.	First Aid guide		Contains guidelines on how to use the items in the First Aid kit
2.	Plaster or adhesive bandage		Covering small cuts or wounds to protect them from dirt and germs
3.	Sterile gauze		Covering wounds to protect them from dirt and germs
4.	Antiseptic		Cleaning wounds to kill germs

Table 2.2: *(continued)*

S/N	Item	Photograph	Use
5.	Soap		Washing hands, wounds, and equipment
6.	Razor blade or scissor	 	Cutting dressing materials
7.	Safety pin		Securing bandages
8.	Bandage		Keeping dressings in place and immobilising injured limbs
9.	Cotton wool		Cleaning and drying wounds
10.	Clinical thermometer		Measuring the body temperature

Table 2.2: *(continued)*

S/N	Item	Photograph	Use
11.	Disposable sterile gloves		Covering the hands to avoid infecting wounds and to prevent direct contact with a victim's body fluids
12.	Petroleum jelly		Smoothing dry, cracked and sore skin
13.	Liniment		Reducing muscle pains
14.	Torch		Source of light
15.	Whistle		Blown to call for help
16.	Painkiller		Relieving pain

Table 2.2: *(continued)*

S/N	Item	Photograph	Use
17.	Gentian violet		Treating fungal infections of the skin and mouth. Also used for the treatment of serious heat burns
18.	Iodine tincture		Preventing infections in fresh cuts, burns and scrapes

First Aid procedure

Physical injuries and even sudden illness may occur in the laboratory due to accidents caused by different sources, such as gas leakage, fire, liquid and chemical spills or incorrect use of apparatus. These can result into burns, electric shock, poisoning, damage to equipment, explosion, falls, fainting or cuts. Such emergencies require urgent attention and First Aid must be administered. However, it is important to consider your own safety, even when you provide First Aid to another person. The following are some of the situations/conditions that may require First Aid and the procedure to follow in giving help.

Suffocation

Suffocation is a condition in which the lungs are not getting enough oxygen causing difficulty in breathing. Foam can also appear in the mouth and nostrils. The victim may eventually lose consciousness. Some chemical substances such as sulphur dioxide gas and nitric acid vapour can cause suffocation when inhaled, leading to breathing difficulties.

Procedure

1. Remove the cause if possible, or remove the victim from the cause of suffocation.
2. Ensure the victim's airways are open for air to reach the lungs. Do this by placing the victim on his or her back. With one hand on the victim's

forehead and the other on the chin, tilt the head backwards in order to open the airways as shown in Figure 2.4.

Figure 2.4: *Tilting the victims head*

3. Blow air into the victim's airways using a clean material such as piece of cloth or paper (Figure 2.5) and compress the chest with both hands. Do not use mouth to mouth *resuscitation* as it can cause infections.

4. Keep the victim warm using a light blanket.

5. Take the victim to a nearby health care facility.

Figure 2.5: *Blowing air into the victim's airways*

Burns

Burns are injuries resulting from the body coming into contact with heat or harmful chemicals. Burns usually cause blisters on the skin, and if severe, the skin becomes charred and peels off. This causes a lot of pains and may result into infections. Burns caused by hot liquids or vapour are called *scalds*.

Procedure

1. Lay the victim down and if possible, protect the burnt area from coming into contact with the ground.
2. Gently pour cold water on the burn for about 10 minutes to cool it and reduce pains. If the burn is severe, immediately call for medical help.
3. Check breathing and pulse, and be prepared to blow air into the victim's airways, if necessary.
4. Gently remove any jewellery, shoes or burnt clothing from the injured area. Loosen any tight clothing. Do not remove any clothing that is sticking to the skin.
5. Cover the burn with a sterile gauze and wrap it loosely to avoid pressure on the skin. Do not use fluffy cotton. Bandaging the wound reduces pain and prevents infections.
6. Give the victim a pain reliever.
7. Take the victim to a nearby health care facility.

Caution

(a) Do not use ice as it further damages the skin.

(b) Do not apply ointment or butter to the burn since this prevents proper healing.

(c) Do not break any blisters as that can cause infections.

(d) Burns to the face and in the mouth or throat are serious as they cause rapid inflammation of the air passage and may cause suffocation. In such cases, seek medical help immediately.

Choking

Choking is the blockage of the upper part of the airways by food or drink or other objects. This prevents proper breathing. Signs of choking include difficulty in speaking and breathing.

Procedure

1. Encourage the victim to cough up the object.
2. If the object remains stuck, give firm but gentle taps between the shoulder blades.
3. If the object is still stuck, perform the *Heimlich manoeuvre*. This procedure involves the following:

   (a) Make the person lean forward slightly and stand behind him or her as shown in Figure 2.6.

Figure 2.6: *Standing behind the leaning forward victim*

   (b) Make a fist with one hand and put your arms around the person. Grasp your fist with the other hand near the top of the victim's stomach as shown in Figure 2.7.

Figure 2.7: *Grasped fist placed near the top of the victim's stomach*

(c) Press your fist into the victim's abdomen and make quick upward thrusts to dislodge the object (Figure 2.8).

Figure 2.8: *Thrusting to dislodge the object*

(d) Repeat the thrusts until the object comes out.

(e) Take the victim to a nearby health care facility.

Bruises

A bruise is a skin injury that causes a change in colour of the skin. It is usually caused by a blow (hard hit) or impact that damages the blood vessels that are below the skin. Blood from the damaged vessels collects near the surface of the skin.

Procedure

1. Apply a cold compress such as a cloth dipped in cold water or ice wrapped in a cloth to the injury. Keep the compress on the injury for 20 to 30 minutes. This helps to reduce the swelling and speeds up recovery.
2. If the bruise is on the leg or foot and it covers a large area, keep the leg elevated as much as possible for the first 24 hours.
3. After 48 hours, apply a warm clean cloth to the bruise for 10 minutes, three times a day. This will help to increase blood flow to the affected area and thus speed up the healing.

Shock

Shock is a condition in which the body system is unable to take enough blood to the vital organs. The vital organs include the heart, lungs and brain. Shock is common with many injuries, regardless of how severe they are.

A victim of shock usually has a fast pulse rate and pale skin, lip and fingernails.

The skin becomes cool and moist, while the limbs may tremble and become weak. As shock develops, the victim may experience nausea and even vomiting. Eventually, the victim may become restless, anxious, aggressive, and finally unconscious.

Procedure

1. Control any cause of shock that can be put right, such as external bleeding.
2. Lay the victim down, then put him or her in a shock position as shown in Figure 2.9. If the victim vomits, turn him or her over to the side.

Figure 2.9: *Victim placed in shock position*

3. Loosen tight clothing, laces, and belts.
4. Maintain the victim's body temperature using warm covering, but do not overheat.
5. Be prepared to blow air into the victim's airways using a clean material as described under suffocation.
6. Take the victim to a nearby health care facility.

Electric shock

An electric shock occurs when a person comes into contact with electricity and it may result into injury or even death. Injuries may be burns or physical injuries that result from being shocked by the electric current.

Procedure

1. Put off the main switch.
2. Break the contact between the electrical source and the victim using a dry wooden stick or any other material that does not conduct electricity.
3. Check whether the victim is breathing. If breathing has stopped, begin blowing air into the victim's airways using a clean material.
4. If the victim is breathing but is unconscious, put him or her in the recovery position as shown in Figure 2.10.

Figure 2.10: *Victim placed in the recovery position*

5. Administer First Aid for burns, shock or other injuries the victim may have sustained.
6. Take the victim to a nearby health care facility.

Caution: Do not either touch a person who is still in contact with electric current or go near the area if high voltage electricity is suspected. Instead, call for help immediately.

Fainting

Fainting is a sudden loss of consciousness caused by lack of sufficient blood and oxygen to the brain. The victim feels weak, sweats and then falls down.

Procedure

1. Loosen or remove any tight clothing from the victim.
2. Lay down the victim on his or her back.
3. Raise the legs of the victim to increase the flow of blood to the brain.
4. Ensure that the victim is in an open place with plenty of air.
5. Take the victim to a nearby health care facility immediately, if the victim does not recover in a few minutes.

Bleeding

Bleeding is the loss of blood and usually occurs from a visible wound. It can also be from an internal organ. Bleeding may be light or severe. Excessive loss of blood can cause death.

Light bleeding

Procedure

1. Wear protective gloves for prevention of any infections.
2. Place the victim in a comfortable resting position.
3. Elevate the injured part.
4. Gently, but thoroughly clean the wound using clean water and antiseptic or common salt. Cover the wound using a sterile gauze. Gently clean the surrounding skin and dry it using sterile dressing (Figure 2.11).

Figure 2.11: *Cleaning a light bleeding wound*

5. Dress the wound and bandage it.

6. If the bleeding continues, take the victim to a nearby health facility.

Severe bleeding

Procedure

1. Wear protective gloves for prevention of any infections.

2. Use your fingers to apply direct pressure onto the bleeding point for five to fifteen minutes. If the wound area is large, press the sides of the wound together gently but firmly. This should be done only if there is no fracture.

3. Raise the injured part and support it in a comfortable position that does not cause pain. This should not be done if a fracture is suspected or if it causes pain.

4. Carefully clean the wound, but do not remove any object stuck in the wound as this would lead to more bleeding.

5. Place a sterile gauze on the wound and press it down firmly. Cover it with a pad of soft material and hold it in position using a firm bandage as shown in Figure 2.12.

6. Take the victim to a nearby health care facility.

Figure 2.12: *Dressing a severe bleeding wound*

Nose bleeding

Procedure

1. Loosen clothing around the neck and chest.
2. Let the victim sit with the head tipped slightly forward.
3. Let the victim pinch in the nose and ask him or her to breath through the mouth for few minutes.
4. Place a wet piece of cloth at the back of the victim's neck.
5. When bleeding stops, gently clean the nostrils.
6. If the bleeding continues, take the victim to a nearby health care facility.

Poisoning

Poison is any substance that can harm the body if swallowed, inhaled or absorbed into the body through the skin. Poisons include laboratory chemicals, drugs, and medicines. Some of the poisons are indicated in Figure 2.13.

Figure 2.13: *Poisonous substances*

Some of the symptoms of poisoning are nausea, vomiting, abdominal cramps, pain, difficulty in breathing, diarrhoea, and abnormal skin colour.

Procedure

1. Call for medical assistance immediately.
2. Meanwhile, find out what caused the poisoning.
3. If the poison is in the eye:
   (a) Wash the eye with a lot of clean water.
   (b) Ask the victim to blink as much as possible.
   (c) Do not rub the eye.
4. If the poison is on the skin:
   (a) Remove any clothing from the affected part.
   (b) Wash the affected area thoroughly with a lot of water.
   (c) Do not apply any ointment.
5. If the poison has been swallowed:
   (a) Induce vomiting if the poison is non-corrosive. Non-corrosive substances include medicines. This can be done by putting your fingers in the victim's throat.
   (b) Do not induce vomiting if the poison is corrosive. Corrosive substances include kerosene, bleach, detergents, laboratory acids, bases, disinfectants, and certain toiletries.
6. If the poison has been inhaled, move the person to where there is plenty of fresh air. Make sure you protect yourself from inhaling the poison.

Vomiting

Vomiting is a forceful discharge of the contents of the stomach through the mouth. It can result from food poisoning, drinking contaminated water, inhaling poisonous fumes, or over-eating.

Procedure

1. Give the victim lots of clear fluids, including an oral rehydration drink.

2. Get medical assistance to a nearby health care facility if:
   (a) there is persistent vomiting.
   (b) the victim vomits blood.
   (c) the victim has high fever.
   (d) the victim is very dehydrated. This will be observed when the mouth and skin become very dry.

Exercise 2.2

1. Differentiate between First Aid and First Aid kit.
2. Name ten components of the First Aid kit and state their uses.
3. List any five possible causes of accidents in school laboratories.
4. How can you help a fellow student who has been burnt with chemicals in the laboratory?
5. Explain the importance of giving First Aid to victims of accidents.
6. How can you help a person who is bleeding severely?
7. How will you give First Aid to a person who has fainted?
8. If your family member has a burn, how can you help him/her?

Basic chemistry laboratory apparatus

Chemistry laboratory apparatus are special tools or equipment that are used in the laboratory. They are used for various purposes such as measuring, testing, heating, filtering, grinding, and holding.

Apparatus for measuring

The following are some of the apparatus used for measuring volume, temperature, mass, weight, and time:

Pipette

A pipette (Figure 2.14) is a narrow glass tube into which small amounts of liquids are sucked for transfer to other containers. It is used to measure specific volumes of liquids.

Figure 2.14: *Pipette*

Measuring cylinder

A measuring cylinder (Figure 2.15) is a glass or plastic apparatus that is graduated to measure volumes of liquids.

Figure 2.15: *Measuring cylinder*

Burette

A burette (Figure 2.16) is used to accurately measure and dispense liquids. It is commonly used in titration.

Figure 2.16: *Burette*

Measuring syringe

A measuring syringe (Figure 2.17) is used for sucking in and measuring volumes of liquids or gases.

Figure 2.17: *Measuring syringe*

Thermometer

A thermometer is an instrument used to measure and indicate the temperature of substances. The thermometer is able to measure temperature values that range from negative to positive values. Different thermometers have different temperature ranges. An example of a thermometer is shown in Figure 2.18.

Figure 2.18: *Thermometer*

Triple beam balance

A triple beam balance (Figure 2.19) is used to measure mass. It has three beams that carry the weights. On one side there is a pan on which the object to be weighed is placed. Each of the three masses are slid along the beams to weigh the object.

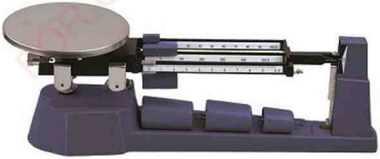


Figure 2.19: *Triple beam balance*

Electronic balance

An electronic balance is used to measure the mass of substances. It gives more accurate readings than the beam balance. An example of the electronic balance is shown in Figure 2.20.

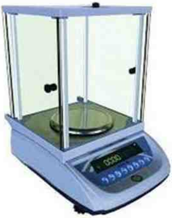


Figure 2.20: *Electronic balance*

Spring balance

Spring balance (Figure 2.21) is used to measure the weight of an object. The object to be measured is hanged on a fixed spring at one end with a hook.

Figure 2.21: *Spring balance*

Stopwatch

This is a special watch that is used to accurately measure time during laboratory experiments. Examples of stopwatches are shown in Figure 2.22.

Figure 2.22: *Examples of stopwatches*

Apparatus for testing

The following are some of the chemistry laboratory apparatus used for various laboratory testing:

Beaker

A beaker is a container used for holding, heating, and mixing liquids. It can be made of glass or plastic materials. A glass beaker can be used for both measuring and heating, liquids, while a plastic beaker is not used for heating. The beaker cannot measure liquids accurately, but can be used to estimate their volumes. An example of a glass beaker is shown in Figure 2.23.

Figure 2.23: *Beaker*

Test tube

Test tubes are used for holding chemicals or heating substances for short periods of time. They are also used when testing some simple chemical reactions. Figure 2.24 shows some test tubes.

Figure 2.24: *Test tubes*

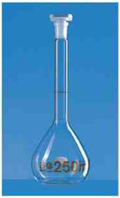
Dropper

A dropper (Figure 2.25) is used to add liquids drop by drop during an experiment.

Figure 2.25: *Dropper*

Flasks

There are different types of flasks used in laboratory. These include the volumetric flask, round-bottomed flask, flat-bottomed flask, conical flask, and distilling flasks (Figure 2.26). They are used for measuring and holding liquids during experiments.



Volumetric flask

Round-bottomed flask

Flat-bottomed flask

Conical flask

Distilling flask

Figure 2.26: *Different types of flasks*

Watch glass

This is a very shallow circular glass container (Figure 2.27) used as a surface to hold substances that are being weighed or observed, and as a cover of a beaker.

Figure 2.27: *Watch glasses*

Gas jar

This is a glass container (Figure 2.28) used for collecting and testing the properties of gases during experiments.

Figure 2.28: *Gas jar*

Thistle funnel

This is a glass funnel with a wide top and a long stem (Figure 2.29). It is used to add small volumes of liquid reagents to an exact point during experiments.

Figure 2.29: *Thistle funnel*

Apparatus for heating

The following apparatus are used when heating substances:

Burners and lamps

Burners and lamps are used for heating substances in the laboratory. Examples are the spirit lamp, Bunsen burner, gas stove, and kerosene stove (Figure 2.30).

Spirit lamp

Bunsen burner

Gas stove

Kerosene burner

Figure 2.30: *Examples of heating apparatus*

Boiling tube

A boiling tube (Figure 2.31) is a hard and large test tube used to heat substances that should be heated strongly. It is also used when the amount of a substance is too large to be contained in a test tube.

Figure 2.31: *Boiling tube*

Tripod stand

A tripod stand is a support platform that has three legs (Figure 2.32). It is usually placed above the burner when heating or boiling substances.

Figure 2.32: *Tripod stand*

Wire gauze

A wire gauze (Figure 2.33), is usually placed on top of a tripod stand. The flask or beaker is placed on the wire gauze during heating. The wire gauze helps to spread out the flame and heat the substance evenly.

Figure 2.33: *Wire gauze*

Crucible

A crucible (Figure 2.34) is a container in which substances can be heated to very high temperatures. It is made of porcelain or non-reactive materials.

Figure. 2.34: *Crucible and lid*

Evaporating dish

An evaporating dish is a shallow bowl with a curled lip commonly made of porcelain. It is used to heat and evaporate liquids and solutions. It can be heated to very high temperatures. Examples of evaporating dishes are shown in Figure 2.35.

Figure 2.35: *Evaporating dishes*

Deflagrating spoon

A deflagrating spoon (Figure 2.36) is a long-handled spoon used to heat small amounts of substances inside a gas jar. Its cover prevents escaping of gas from a gas jar during burning.

Figure 2.36: *Deflagrating spoon*

Apparatus for filtering

The following apparatus are usually used for filtering substances:

Filter funnel

A filter funnel is a device that is wide at the top and narrow at the bottom (Figure 2.37). It is used to filter substances.

Figure 2. 37: *Filter funnel*

Filter paper

A filter paper is a piece of porous paper (Figure 2.38) used for filtering liquids especially in chemical processes. It is usually folded into a cone shape and placed in a filter funnel to separate solids from liquids.

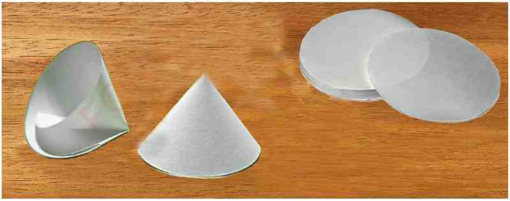


Figure 2.38: *Filter papers*

Apparatus for grinding

Mortar and pestle (Figure 2.39) are used for crushing or grinding substances. A mortar is a small hard bowl, while a pestle is a small heavy tool used for crushing things.

Figure 2.39: *Mortar and pestle*

Apparatus for holding

The following apparatus are used for supporting or holding other apparatus:

Test tube rack

A test tube rack (Figure 2.40) is an apparatus that is specially designed for placing test tubes so that they do not roll or break.

Figure 2.40: *Test tube rack*

Test tube holder

A test tube holder (Figure 2.41) is an apparatus that is used for holding a test tube while heating.

Figure 2.41: *Test tube holder*

Retort stand and clamp

Retort stand and clamp (Figure 2.42) are used to hold apparatus such as burettes during experiments. The clamp can be adjusted to an appropriate height from the base of the retort stand.

Figure 2.42: *Retort stand with clamp*

Tongs

This is a tool used to hold hot substances and apparatus during experiment. See Figure 2.43.

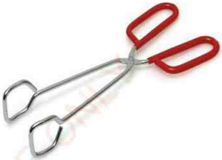


Figure 2.43: *Pair of tongs*

Apparatus for storage

The following containers are used for storing substances in chemistry laboratories:

Reagent bottles

These are bottles that are used to store different chemicals (Figure 2.44). Each reagent bottle is therefore labelled to show the chemical substance it contains.

Figure 2.44: *Reagent bottles with their stoppers*

Plastic wash bottle

A plastic wash bottle (Figure 2.45) is a container which is used to store distilled water used for washings.

Figure 2.45: *Plastic wash bottle*

Apparatus for scooping

Scooping is the picking up of a substance especially in powder form using a spoon. A spatula (Figure 2.46) is an apparatus used for scooping a small quantity of powder or crystalline chemicals.

Figure 2.46: *Spatula*

Apparatus for safety

Safety goggles (Figure 2.47) are used to protect the eyes from chemical spills, strong light and harmful vapour in the laboratory.

Figure 2.47: *Safety goggles*

Task 2.2

1. In groups, study the apparatus in your chemistry laboratory. Make a list of all the apparatus and classify them according to what they are made of, for example, *Apparatus made of glass, Apparatus made of wood,* and *Apparatus made of plastic.*

2. Classify the apparatus according to their uses. For example, apparatus used for storing liquids, apparatus used for storing solids, and apparatus used for measuring. Present your classification in a table as follows:

Apparatus for storing liquids	Apparatus for storing solids	Apparatus used for measuring

3. Select any 10 laboratory apparatus and draw them.

Activity 2.2

Aim: To measure the volume of a liquid using different apparatus.

Requirements: Pipettes, burettes, measuring cylinders, beakers, and coloured water

Procedure

1. Pour some coloured water into two beakers.

2. Measure 20 cm^3 of the coloured water from one of the beakers using a pipette. Be careful not to suck the water into your mouth. Alternatively, you can use a pipette filler.

   Note: The pipette must be cleaned after each use to avoid spreading germs if sucking was done by using mouth. Clean the pipette before letting anyone else use it.

3. Pour the measured coloured water into a measuring cylinder labelled A. Look at the scale on the side of the cylinder. Each number is a measurement in cubic centimeters. Did you measure the correct amount?

4. Pour some coloured water into a burette. Read the volume of the water from the scale shown on the side of the burette. Write down your reading, for example, 10 cm^3. This is V_1 as shown in Figure 2.48(a).

5. Measure the required volume V by opening the burette tap and carefully let the water out into a measuring cylinder labelled B until the level of the water reaches final volume, V_2. In this case, V_2 is 30 cm^3 (Figure 2.48(b)). Close the tap.

Note: To get the final volume, V_2 add the initial volume, V_1 and the required volume, V (That is 10 cm^3 + 20 cm^3 = 30 cm^3)

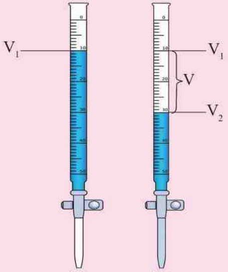


Figure 2.48: *Measuring volume of a liquid using a burette*

Question

What is the volume of the coloured water in each of the measuring cylinders?

Note: Measuring the volume of a liquid using a pipette is not difficult provided the liquid does not pass the mark near the top end of the pipette. Most pipettes used in school laboratories are made to an accuracy of one drop when they are used correctly. Measuring the volume of a liquid using a burette is not as direct as in the case of a pipette. It involves taking the initial reading of the level of the liquid in the burette. This is followed by draining the liquid to the required level (final volume). The measured volume is obtained by taking the difference between the final and initial readings.

Activity 2.3

Aim: To measure the temperature of liquids.

Requirements: Thermometer, beakers, tripod stand, wire gauze, stopwatch, pair of tongs, water, source of heat, and ice or fridge

Procedure

1. Pour some tap water into two beakers. Measure the temperature of the water by dipping a thermometer in each of the beakers for one minute.
2. Remove the thermometer and record the temperature.
3. Place the first beaker in a fridge or in a bucket of cold water or ice cubes. Let it remain there for about 20 minutes.
4. Remove the beaker from the fridge or bucket of cold water or ice cubes, and dip a thermometer in the water for one minute. Record the temperature.
5. Place a wire gauze on a tripod stand.
6. Place a Bunsen burner under the tripod stand and light it.
7. Place the second beaker on the wire gauze and heat for five minutes.
8. Turn off the Bunsen burner.
9. Dip the thermometer in the second beaker for one minute without touching the bottom of the beaker. Record the temperature.

Questions

1. What was the reading on the thermometer when placed in:
   (a) tap water?
   (b) water from the fridge?
   (c) heated water?
2. What ranges of temperature can the thermometer give readings?

Activity 2.4

Aim: To measure the masses of different substances.

Requirements: Triple beam or an electronic balance, watch glasses, various items such as salt, sugar, flour, cooking fat, erasers, and sand.

Procedure

1. Place an empty watch glass on the weighing balance. Note down its mass. This will be (m_1).
2. Place one item provided on measured watch glass and measure the mass of watch glass with the item. This will be (m_2).
3. Repeat steps 1 and 2 for all the items provided. Record your data in the following table:

S/N	Mass of watch glass (m_1)	Mass of watch glass + item (m_2)
1.		
2.		

4. Calculate the mass of each item.

Exercise 2.3

1. Give the meaning of the term apparatus.
2. Draw and name four apparatus which can be used for testing in the laboratory.
3. Explain the uses of the following laboratory apparatus:
   (a) Burette
   (b) Dropper
   (c) Flask
   (d) Filter paper
   (e) Safety goggles
4. Explain the importance of handling safely the laboratory apparatus.

Chapter summary

1. A chemistry laboratory is a special room where chemical experiments are carried out.
2. Chemical safety signs are safety symbols found on chemical containers in the laboratory or store.
3. First Aid is the help given to a sick or injured person before professional medical help is available.
4. A First Aid kit is a box that contains items used to give First Aid to a sick or injured person.
5. Apparatus are special tools and equipment that are used in a laboratory.

Revision exercise 2

Choose the correct answer in items 1–10.

1. The following apparatus is used to keep test tubes in the laboratory:
   (a) Beaker
   (b) Test tube rack
   (c) Stand and clamp
   (d) Basin for test tubes
2. What are the apparatus used to grind the granules of a certain chemical to fine powder?
   (a) Pestle and filter funnel
   (b) Round-bottomed flask and trough
   (c) Mortar and pestle
   (d) Bunsen burner and filter paper
3. Access to safety equipment should never be blocked by any object because:
   (a) it is just a simple law.
   (b) there must be spaces for people to move around in the laboratory.
   (c) the equipment is used every day.
   (d) it is important to reach safety equipment quickly in case of an accident.

4. A form one student saw the 'flammable' sign on a box and made the following possible interpretations. Which one is the most correct?
   (a) The box contained firewood
   (b) The box contained papers
   (c) The box had radioactive materials
   (d) The box contained spirit used in lamps

5. Why is loose or floppy clothing not allowed in the laboratory?
   (a) It will move fast.
   (b) It will get wet when water splashes.
   (c) It may catch fire or cause one to fall.
   (d) It causes poor ventilation in the body.

6. Before a practical session,
   (a) do not enter in the laboratory without permission.
   (b) do not taste or smell chemicals.
   (c) report any accident however small it may be.
   (d) do not use dirty, cracked or broken apparatus.

7. Identify the name given to burns caused by hot liquids or vapour.
   (a) Injuries
   (b) Scars
   (c) Scalds
   (d) Wounds

8. Suffocation is a condition in which the lungs
   (a) do not exhale enough oxygen.
   (b) do not inhale enough oxygen.
   (c) do not inhale enough carbon dioxide.
   (d) do not exhale enough carbon dioxide.

9. Fainting is a sudden loss of
   (a) consciousness.
   (b) confidence.
   (c) weight of the body.
   (d) water in the body.

10. The following are chemistry laboratory apparatus, EXCEPT
    (a) crucible and lid, evaporating dish and filter funnel.
    (b) wire gauze, test tube rack, and deflagrating spoon.
    (c) burette, pipette and conical flask.
    (d) microscope, drawing board and prism.

11. Match the following apparatus and their uses by writing the letter of the apparatus and its Roman number of its corresponding use:

Apparatus	Uses
(a) Test tube	(i) Holding, heating and estimating the volume of liquids
(b) Flasks	(ii) Measuring the mass of chemicals in the laboratory
(c) Measuring syringe	(iii) Holding substances that are being weighed or observed
(d) Beaker	(iv) Usually placed above the Bunsen burner with a wire gauze during heating or boiling
(e) Electronic balance	(v) Produces non-luminous flame used for strong heating
(f) Watch glass	(vi) Holding chemicals and heating small portions of the chemicals in liquid or solid form
(g) Tripod stand	(vii) Used with a clamp to support apparatus like round-bottomed flask during experiments
(h) Retort stand	(viii) Adding reagents into flasks with small openings during experiments
(i) Thistle funnel	(ix) Holding liquids and solids during experiments
(j) Bunsen burner	(x) Sucking in and measuring volumes of liquids
	(xi) Titrating chemicals

12. Who is responsible to receive the report of all accidents which occur in the laboratory?
13. What is the function of plastic wash bottle?
14. If chemicals get into your eyes, what first thing will you do?
15. Why is it necessary to familiarise yourself with the laboratory apparatus?
16. In which other areas do you find the safety signs?
17. Why are the safety signs so important?
18. A chemistry laboratory must have safety measures. Give reasons.
19. Why should the chemistry laboratory exits open outwards?
20. How would you help a person with bruise caused by a hard hit?

Chapter Three

Heat sources and flames

Introduction

Heat is the condition of being hot. It is a form of energy that is very useful in our day-to-day life activities. Heat is obtained from different sources, both natural and artificial. The sun is the major natural source of heat. Other natural sources of heat are natural hot springs, biomass, coal, petroleum, and natural gas. Artificial sources of heat are those that are man-made. In chemistry laboratories, heat from various sources, especially artificial sources is used. When you light up the sources of heat, they produce heat and flames. The heat is needed to enable different chemical processes to take place during experiments. In this chapter, you will learn about different heat sources and flames. The competencies developed will enable you to use heat from various sources appropriately.

Heat sources in the laboratory

There are varieties of heat sources that can be used in a chemistry laboratory. These include spirit burner, Bunsen burner, gas stove, and kerosene stove. All of these heat sources need fuel to light up. For example, the Bunsen burner needs a gaseous fuel, and the kerosene stove needs kerosene. Some sources of heat such as charcoal burner, candle, and electric heater are not commonly used in the laboratory.

Task

1. In groups, discuss different sources of heat that you know.
2. From the different sources of heat you identified, discuss the sources of heat that are commonly used in the laboratory.
3. Which sources of heat are not commonly used in your school laboratory? Explain.

Flames

A flame is a zone or region of burning gases that produces heat and light. It is the visible glowing part of fire. The flame is formed as a result of burning a fuel. The colour and temperature of the flame depends on the type of the fuel used, source of the flame and the oxygen supply. Flames are classified depending on the light they produce. There are two types of flames; luminous and non-luminous flames.

The luminous flame is bright and yellow in colour (Figure 3.1). Although the luminous flame requires oxygen when burning, the oxygen supply is usually not enough to completely burn up the fuel. For this reason, it produces a black substance known as soot. The luminous flame is called a *safety flame* because it is easily seen, therefore, is less likely to cause accidents.

Figure 3.1: *Luminous flame*

The non-luminous flame is blue in colour (Figure 3.2). This is because there is a sufficient supply of oxygen, and so the fuel burns completely. Such a flame does not produce any soot. It produces more heat than the luminous flame. The non-luminous flame can easily cause accidents in the laboratory since one may not be aware that the burner is on.

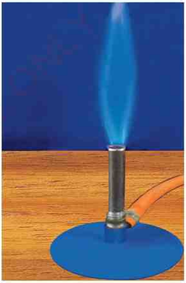


Figure 3.2: *Non-luminous flame*

Different heat sources produce different flames (Figure 3.3). For example, the candle and the spirit lamp produce luminous flames, whereas the gas stove produces a non-luminous flame.

Figure 3.3: *Different flames produced by different heat sources*

Activity 3.1

Aim: To produce different types of flames from different heat sources.

Requirements: Matchbox, various heat sources such as charcoal burner, candle, kerosene stove, spirit burner, gas stove, tin lamp, and the Bunsen burner

Procedure

1. Light up all the different heat sources provided. Care should be taken when handling and lighting up the various heat sources.
2. Your teacher will demonstrate how different types of flames can be produced.
3. Repeat what your teacher has demonstrated. Ask for help from your teacher if you face any difficulties.

Questions

1. What types of flames are produced by the different heat sources?
2. Which heat sources produce more heat?
3. Make a table as shown below and classify the different flames produced from the various heat sources.

Source of heat	Type of flame

Bunsen burner

A Bunsen burner is a laboratory heat source consisting of a vertical metal tube connected to a gas source. The burner is named after the German chemist and physicist, Robert Bunsen, who invented it in 1855. The Bunsen burner is able to produce a very hot flame of temperatures up to 1000 °C from a mixture of gas and air. The air is let in through adjustable holes at the base of the vertical metal tube known as *barrel* or *chimney*. The collar is used for adjustment. Other parts of the Bunsen burner include the jet, gas inlet, and the base. Figure 3.4 shows the parts of the Bunsen burner.

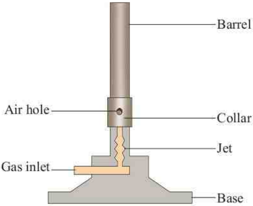


Figure 3.4: *Parts of the Bunsen burner*

How the Bunsen burner works

Gas enters the burner through a tube connected to a jet inside the base. Air enters the burner through the adjustable air holes at the base. The amount of air coming in can be varied by turning the collar. At the top of the barrel, the mixture of gas and air burns to produce a flame. The type of flame obtained depends on the amount of oxygen available for burning. When the air holes are closed, there is less oxygen supply and the flame is luminous. When they are partly open, there is more oxygen supply and the flame is medium. When the air holes are fully open, there is enough oxygen supply and the flame is non-luminous. Figure 3.5 shows the two types of flames obtained after adjustment of the air holes of the Bunsen burner.

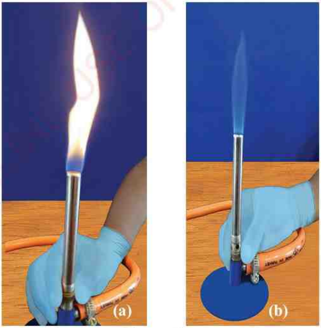


Figure 3.5: *Types of flames when the air holes are (a) closed (b) opened*

Activity 3.2

Aim: To light a Bunsen burner.

Requirements: Matchbox or lighter and Bunsen burner

Procedure

1. Close the air holes of the burner. Connect the burner to the gas tubing.
2. Light a match or wooden splint and hold it on top of the barrel.
3. Slowly turn on the gas. The gas will light up if the tap is connected properly to the tubing. Ask for your teacher's assistance if it does not light up.
4. Open the air holes halfway and then fully. Record your observations.

Caution: Keep your face away from the tip of the barrel when you light the Bunsen burner.

Questions

1. What happened to the flame when you opened the air holes halfway?
2. What happened to the flame when the air holes were fully opened?

Note: Burning back or striking back is an event that occurs when a gas burns at the jet. It occurs when lighting the Bunsen burner while the air holes are open. This can be corrected by turning off the gas supply, then relight the burner.

Parts of flames

Both luminous and non-luminous flames have different parts. The luminous flame consists of four parts, namely thin outer zone, yellow middle zone, inner unburnt zone and blue outer zone as shown in Figure 3.6.

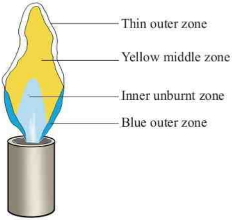


Figure 3.6: *Parts of a luminous flame*

The non-luminous flame has three parts; the colourless inner zone, blue-green middle zone and the pale purple-blue outer zone as shown in Figure 3.7. Inner zone is the region of unburnt gas. The blue-green middle zone is the region where part of the gas burns because there is no enough air to burn all the gas completely. The hottest part is at the tip of this region. Complete burning of the gas occurs in the pale purple-blue zone.

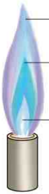


Figure 3.7: *Parts of a non-luminous flame*

Exercise 3.1

1. What is the difference between artificial and natural sources of heat?
2. Which sources of heat are commonly used in the laboratory?
3. How will you light a Bunsen burner?
4. How would you use a Bunsen burner to produce different types of flames?
5. What are the functions of the air holes and barrel in the Bunsen burner?

Characteristics of flames

Heat sources produce either a luminous flame or non-luminous flame. These flames have different characteristics. Table 3.1 summarises some of the characteristics of the luminous and non-luminous flames.

Table 3.1: *Characteristics of luminous and non-luminous flames*

S/N	Luminous flame	Non-luminous flame
1.	Yellow in colour	Blue in colour
2.	Produces soot	Does not produce soot
3.	Produces less heat	Produces more heat
4.	Burns quietly	Burns with a roaring noise

Activity 3.3

Aim: To identify the characteristics of luminous flame and non-luminous flame.

Procedure

Put a tick (✓) against each property presented in Table 3.2 to show where it belongs. The first one has been done for you as an example.

Table 3.2: *Characteristics of flames of a Bunsen burner*

S/N	Properties of the flame	Luminous flame	Non-luminous flame
1.	Is bright yellow in colour	✓	
2.	Is light blue in colour		
3.	Is not sooty		
4.	Is sooty		
5.	Is steady		
6.	Is not steady		
7.	Is not very hot (produces less heat)		
8.	Is very hot (produces more heat)		
9.	Produces more light		
10.	Has unlimited access to oxygen		
11.	Has limited access to oxygen		
12.	Is wavy and brightly visible		
13.	Is hardly visible and less wavy		
14.	Is formed when the air-hole is fully open		
15.	Is formed when the air-hole is closed		
16.	Has three conspicuous zones		
17.	Has four conspicuous zones		

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Uses of different types of flames

Different types of flames are normally used for different purposes. The following are some of the uses of flames:

Luminous flame

The luminous flame is mainly used for lighting because it is bright. It is also not very hot, therefore, it is safer for lighting than the non-luminous flame. Some heat sources such as tin lamp and hurricane lamp produce luminous flames as shown in Figure 3.8.

Hurricane lamp

Tin lamp

Figure 3.8: *Luminous flames from different heat sources*

Non-luminous flame

The following are some of the ways in which the non-luminous flame is used:

1. The flame is used for heating purposes because it gives a lot of heat. Most heating in the laboratory is done using a Bunsen burner. The hottest part of the flame is at the tip (the blue-green middle zone). A liquefied petroleum gas (LPG) burner may at times be used in the laboratory since it produces non-luminous flame.

2. The non-luminous flame is used in the flame test of certain chemical substances. The flame test involves introducing a sample of the desired substance to the non-luminous flame and observing the colour change. The flame colour can indicate what components the substance is made of. For example, sodium produces yellow flame and calcium produces brick red flame.

3. Non-luminous flame is suitable for welding (Figure 3.9) because it is very hot. Welding is the joining together of metal pieces or parts by heating their surfaces and pressing them together.

Figure 3.9: *Welding of a car bonnet*

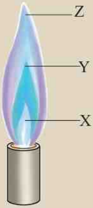
4. A non-luminous flame is suitable for cooking because it gives enough heat and it does not produce soot.

Chapter summary

1. Heat is the condition of being hot. It is a form of energy widely used in the chemistry laboratory.
2. A flame is a zone or region of burning gases that produces heat and light.
3. There are two main types of flames, the luminous flame and non-luminous flame.
4. The luminous flame is yellow in colour, produces soot, and is less hot than non-luminous flame.
5. The non-luminous flame is blue in colour, does not produce soot, and gives more heat.
6. A Bunsen burner is the most commonly used source of heat in the laboratory.

Revision exercise 3

1. Study the given Bunsen burner flame and answer the following questions:



   (a) Is the flame luminous or non-luminous? Explain.

   (b) How can you adjust the Bunsen burner to get this flame?

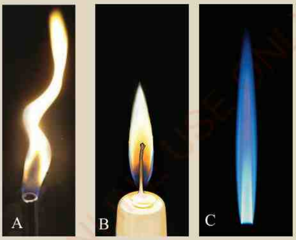
   (c) Which letter in the flame represents the;

      (i) region of unburnt gas?

      (ii) hottest part of the flame?

      (iii) region where all the gas is burnt with air mainly supplied from outside the chimney?

2. Study carefully the following figures and identify the types of flames labelled A, B, and C:



3. The following are the steps to follow in lighting of the Bunsen burner. However, the steps are not in the correct order. Re-write them in the correct sequence.

   (a) To extinguish the flame, turn off the gas tap to stop the gas flow.

   (b) Light the gas at the top of the barrel with a lighted match stick.

   (c) Turn the collar to close the air hole completely.

   (d) Keep your face away from the top of the barrel.

   (e) Adjust the gas tap until the supply of gas is enough for a flame.

(f) Turn on the gas fully to ensure that plenty of the gas enters the burner.

4. Write **TRUE** for a correct statement and **FALSE** for an incorrect statement about flames.
   (a) A yellow flame is obtained when air holes of the Bunsen burner are open.
   (b) The luminous flame has an irregular shape.
   (c) A luminous flame is hotter than a non-luminous flame.
   (d) A blue flame is obtained when the air holes of the Bunsen burner are closed.
   (e) A roaring flame is obtained when the air holes of the Bunsen burner are completely open.
   (f) The yellow colour of a luminous flame is due to the presence of hot carbon particles.
   (g) A non-luminous flame looks similar to a candle flame.
   (h) The non-luminous flame may reach temperatures as high as 1000 °C.
   (i) The dark zone of a luminous flame consists of unburnt gas.
   (j) The hottest part of a non-luminous flame is just over the tip of the dark zone.
   (k) The luminous flame produces less heat than the non-luminous flame.
5. Which part of a flame tends to have the lowest temperature?
6. In what ways is a luminous flame important?
7. Why is it necessary to use wire gauze when boiling a liquid in a beaker?
8. Name four sources of heat that can be used in the laboratory.
9. Name two sources of heat that can produce luminous flames.
10. The non-luminous flame is used in different areas. Give three such areas and explain why the flame is preferred by the users in those areas.
11. Why is a luminous flame preferred for lighting than a non-luminous flame? Give two reasons.

Chapter Four

Scientific method

Introduction

The world is associated with various challenges in many areas such as agriculture, health, and environment. The solutions to these challenges are obtained through various approaches. Scientists use a scientific method to find reliable answers and solutions to the challenges encountered in real life. In this chapter, you will learn about the concepts of the scientific method, main steps of the scientific method, significance and applications of the scientific method. The competencies developed will enable you to apply the scientific method to carry out various investigations in chemistry and science in general.

Concept of the scientific method

When you face problems in day-to-day life, you usually follow certain steps to solve them. For example, when you are sick, you normally go to hospital. At the hospital, the following are likely to take place: The doctor asks you some questions to know the symptoms of your problem. The doctor examines you and then refers for some tests before prescribing suitable medicine. The doctor has to be sure of what you are suffering from before prescribing the right medicine. Doctors follow certain steps in order to make the right diagnosis and therefore, give the right medication. If the medicines given do not work after the prescribed period, you have to go back to the hospital for further diagnosis.

Science uses certain steps or guidelines to answer questions or solve problems. This organised set of guidelines is referred to as the *scientific method*. Experiments are carried out to find answers to scientific questions. The findings from the experiments help to solve scientific problems.

Main steps of the scientific method

The scientific method is a way of studying a problem systematically to find answers and solutions. The following steps are taken when carrying out scientific method:

1. Problem identification;
2. Formulation of hypothesis;

3. Experimentation and observation;
4. Data collection/recording;
5. Data analysis and interpretation;
6. Drawing conclusion; and
7. Reporting results

1. Problem identification

This is the first step in the scientific method. You make an observation about something and ask questions about what you have noticed. For example, you may wonder whether temperature affects the solubility of salt in water. The problem you want to investigate may be: *Does temperature affect the solubility of ammonium chloride in water?* That becomes your problem for investigation.

2. Formulation of hypothesis

The next step after identifying a problem is formulation of a hypothesis. A hypothesis is a possible explanation to the question you asked. It is your best possible answer to the question you asked. For example, for the above identified problem, a possible explanation could be, *Temperature does not affect the solubility of ammonium chloride in water.*

3. Experimentation and observation

This is a third step in the scientific method. Since you want to test whether your hypothesis is correct or not, you carry out a test or an experiment. This enables you to observe what actually happens. To design a suitable experiment, you must find out the factors that affect the problem you want to investigate. These factors are called *variables*. They can change or be changed during the experiment. Such factors include temperature, pressure, volume, amount of substance, speed, and light.

There are three types of variables. These are:

Dependent variables: These are the factors in the experiment that change their values when the values of the other variables change. They are factors being measured.

Independent variables: These are the factors which are manipulated so as to obtain different values for comparison.

Controlled variables: These are the factors in the experiment that do not change; they are kept constant. They do not affect the outcomes of the experiments.

For example, in the experiment on the solubility of ammonium chloride, you can identify variables as follows:

(a) The *solubility* of ammonium chloride is the factor under investigation. It is the *dependent variable*.

(b) The *temperature* of water is the factor that is varied. It is an *independent variable*.

(c) The *amount of water* used is kept constant. It is the controlled variable.

To find out the answer to the question in step 1 of the scientific method, dissolve different amounts of salt in a specific volume of water, while altering the temperature of the water to see if the salt dissolves completely at any given temperature.

4. Data collection/recording

This step involves collecting and recording what you have observed during the experiment. For the experiment on solubility of ammonium chloride, the results can be recorded in a table form as shown in Table 4.1.

Table 4.1: *Solubility of ammonium chloride at different temperatures*

Temperature of water (°C)	20	30	40	50	60
Amount of salt dissolved in given volume of water					

5. Data analysis and interpretation

After recording the data, you look for similarities or differences and trends or patterns of the data and give explanations. This is what is known as analysis and interpretation of data. The trends or patterns will help you to make conclusion. For instance, in the solubility experiment, you may notice that more amounts of ammonium chloride dissolved when the temperature of water was systematically raised. This is because raising the temperature increases the ability of water to take in more salt.

6. Drawing conclusion

A conclusion is a summary of the results of the experiment and a statement of how the results relate to the hypothesis. The results may either prove or disprove the hypothesis that had been formulated earlier. A second experiment may be carried out to ensure the results obtained are reliable. From the solubility experiment, you may conclude that: *Temperature increases the solubility of ammonium chloride.* This disagrees with the formulated hypothesis.

7. Reporting results

Scientists communicate their results to others in a report. They can present the results to the scientific community by publishing their report in a journal or at seminars, conferences, workshops, and meetings.

Note: If your results do not support the hypothesis:

(a) Do not leave out the experimental results.

(b) Give possible reasons for the difference between your hypothesis and the experimental results.

(c) Give ideas for further investigations to find answers to the problem.

The summary of the steps in the scientific method is shown in Figure 4.1.

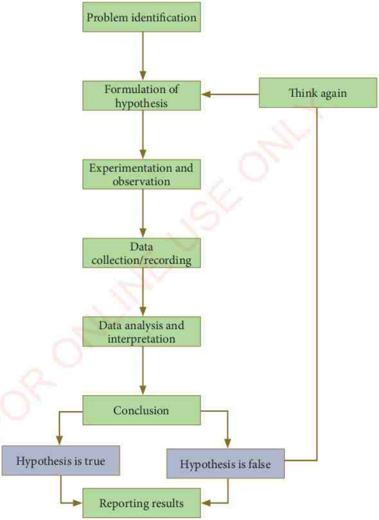


Figure 4.1: *Steps in the scientific method*

Activity 4.1

Aim: To find out if temperature affects the solubility of salt.

Requirements: Beakers, burner, thermometer, ammonium chloride crystals, glass rod, water, spatula, tripod stand, and wire gauze

Procedure

Note: Before you start, formulate a hypothesis for the experiment.

1. Pour 50 cm^3 of water in a beaker and use a thermometer to measure its temperature. Note down the temperature.
2. Put a spatulaful of salt in the beaker (step 1) and stir until all the salt dissolves. Continue adding the amount of salt, a spatulaful at a time, until no more salt dissolves. Record the number of spatulafuls of salt that completely dissolve in the 50 cm^3 of water at room temperature.
3. Place the beaker containing the salt solution on a wire gauze placed on a tripod stand.
4. Dip the thermometer into the solution and heat the solution until the temperature of the solution rises by 10 ºC. Record this temperature.
5. Meanwhile, add a spatulaful of salt into the solution being heated and record the total number of spatulafuls of salt that completely dissolved in the solution.
6. Repeat steps 4 and 5 three times, each time raising the temperature by 10 °C more than the previous one. Record your results in a table.

Note: Make sure the thermometer does not touch the bottom of the beaker which is in direct contact with the heat source. Instead, it should be dipped in the solution.

Questions

1. What hypothesis did you formulate?
2. What were the variables in the experiment?
3. Does the experiment support your hypothesis?

Significance of the scientific method

The scientific method minimises bias. It brings answers of the scientific problems based on experimental results and not personal experiences and cultural beliefs. Furthermore, the scientific method provides results which stick to facts and not guessing. It also provides confident results which are replicable and can be proved.

Project

1. In groups, draw charts that show all the steps in the scientific method. Use coloured markers and manila papers to make them presentable.
2. Suppose the pond water in your area is contaminated and has caused diseases to the people. How would you solve this problem using the scientific method?

Applications of the scientific method

The scientific method is used to find the logical solutions of different problems. The scientific method is used by many people such as scientists, historians, investigators, doctors, engineers, students as well as anyone else who wants to rationally solve a problem. The scientific method is also used in many areas that involve seeking solutions to different scientific problems. Therefore, it can be applied in the following areas:

1. *Carrying out experiments:* An experiment is a scientific test that is done in order to study what happens and to gain new knowledge.
2. *Project work:* A project is a planned piece of work that involves careful study of a subject matter or a problem over a period of time, so as to find information on the subject or problem.
3. *Field study:* A field study involves doing practical work in real environment in order to find answers to problems and to test hypotheses. A field study is also known as *field work*.

Exercise 4.1

1. What do you understand by the following terms?
   (a) Scientific method
   (b) Hypothesis

(c) Experiment

(d) Controlled variable

2. Which of the following statements are incorrect? Give reason(s)

(a) Observations can be made by using sense organs.

(b) Scientists are more likely to believe something if there is experimental data that supports it.

(c) Controlled variables change throughout the experiment.

3. Distinguish between dependent variable and independent variable.

Chapter summary

1. The scientific method is an organised set of guidelines used to solve scientific problems.

2. The main steps in the scientific method are:

(i) Problem identification;

(ii) Formulation of hypothesis;

(iii) Experimentation and observation;

(iv) Data collection/recording;

(v) Data analysis and interpretation;

(vi) Drawing conclusions; and

(vii) Reporting results.

3. A hypothesis is a suggested answer to a question or a problem. It is the scientist's best possible answer.

4. An experiment is a test done to find out if the formulated hypothesis is true or false.

5. The factors that affect the problem being investigated are called *variables*.

6. There are three types of variables that affect the problem being investigated in an experiment. These are:

(a) Dependent variable(s);

(b) Independent variable(s); and

(c) Controlled variable(s).

Revision exercise 4

Choose the correct answer in items 1–4.

1. The first step in the scientific method is
   (a) data analysis.
   (b) problem identification.
   (c) hypothesis formulation.
   (d) data interpretation.

2. The step in the scientific method that gives the summary of the results of the experiment is
   (a) drawing conclusion.
   (b) report writing.
   (c) data analysis.
   (d) data collection.

3. Factors in an experiment that can be manipulated to get desired results are called
   (a) controlled variables.
   (b) manipulated variables.
   (c) dependent variables.
   (d) independent variables.

4. What should be done if the results obtained from an experiment do not support the hypothesis?
   (a) The experiment should be changed.
   (b) The results should be left out.
   (c) Ideas for further testing to find a solution should be given.
   (d) A new problem should be identified.

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5. Write **TRUE** for a correct statement and **FALSE** for an incorrect statement.
   (a) Hypotheses are true statements after long term experimentation.
   (b) A suitable experiment must consider the factors that may affect the problem under investigation.
   (c) The scientific method is only used in project work.

6. What are the advantages of using the scientific method in doing science experiments?

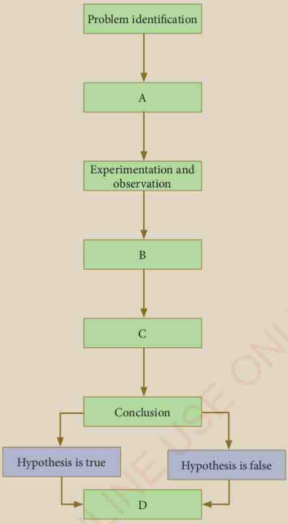
7. How is the scientific method applied in treatments of sick persons?

8. What would happen if there were no experiments?

9. Explain any three problems or facts at home or at school whose answers can be found using the scientific method.

10. Assume most students in your class fail to perform a certain chemistry experiment assigned by the teacher.
    (a) Identify a problem that you can investigate.
    (b) Formulate the hypothesis.
    (c) List down a dependent variable, an independent variable, and a controlled variable in your investigation.
    (d) Design an experiment to test your variables.

11. (a) Copy the following flowchart of the scientific method and fill in the missing steps.



(b) Briefly explain the purpose of each step in the scientific method.

Chapter Five

Matter

Introduction

Matter includes different materials such as water, air, metals, plants and animals. The entire universe is composed of matter. Matter can be found either as a solid, liquid or gas. An understanding of matter creates the way for understanding its nature and how it can be used. In this chapter, you will learn about the concept of matter, states of matter, as well as physical and chemical changes. The competencies developed will enable you to deal with nature and the properties of matter.

Concept of matter

Matter is anything that has mass and occupies space. Mass is a measure of the quantity of matter in an object. It is usually measured in kilograms or grams. The fact that matter occupies space means that it has real physical existence. Matter is everything that is found within our environment. It may be made of a pure substance or a mixture of substances. It includes all things such as stones, vegetation, air, food, water and even our bodies.

States of matter

Matter can exist in one of the three physical states, namely solid, liquid, and gas. The state of matter depends largely on temperature and pressure. For example, at a temperature below 0 ºC, water exists as solid (ice). As the temperature rises, ice changes into liquid, and the liquid changes to vapour (gas). The reverse is possible when the temperature is lowered. The liquids and gases are classified as *fluids*.

Solids

A solid is a substance that has a definite shape and size. It is usually hard and not easily deformed. Solids have definite volume. Examples of solids are stone, firewood, cooking pot, pencil, chalk, sand, and charcoal. Figure 5.1 shows examples of solids.

Figure 5.1: *Examples of solids*

Liquids

Liquid substances flow easily and have specific (fixed) volume. A liquid takes the shape of the container holding it. Examples of liquids include paints, water, juice, milk, blood, oil, and alcohol. Examples of liquids are shown in Figure 5.2.

Figure 5.2: *Examples of liquids*

Gases

Gases have no specific shape or size. They easily flow and expand indefinitely to occupy the space in which they are held. Examples of gases are oxygen, hydrogen, carbon dioxide, and chlorine. Figure 5.3 shows balloons filled with gases.

Figure 5.3: *Balloons filled with gases (air)*

Activity 5.1

Aim: To investigate the properties of matter.

Requirements: Beakers, electronic balance, stones, pieces of chalk, pieces of wood, metal, papers, balloons, and liquids such as water and milk.

Procedure

1. Collect different items like stones, pieces of chalk, paper, water, milk, ink, and balloons.
2. Carefully observe all the objects you have collected. Use your sense of sight to make your observations on the following:
   (a) Size
   (b) Shape
3. Take two beakers, label them as A and B, weigh each beaker and record its mass.

4. Fill beaker A with water and re-weigh it. Record the mass and the volume of water.
5. Fill beaker B with milk and re-weigh it. Record the mass and volume of milk.
6. Weigh the solids, one at a time and note the mass of each solid.
7. Take the solids, one at a time and dip them into the beaker filled with water.
8. Take note of the volume and mass of water displaced.
9. Weigh a balloon that is not inflated and record its mass.
10. Blow air into the balloon and note its mass.

Questions

1. Do all the substances have mass? Explain.
2. Why did the solids displace some water in the beaker?
3. How would you define matter?

Exercise 5.1

1. What are the conditions for a substance to be called matter?
2. Why are liquids and gases categorised as fluids?
3. Describe solids, liquids, and gases in terms of shape and volume.
4. Why do gases expand more than solids for the same increase in temperature?

Changes in states of matter

Matter may change its state from one form to another. For example, when heated, some solids melt to become liquids, while liquids change into gases (vapour). In some cases, the reverse of this takes place. The gas may be cooled or condensed to form liquid. The liquid may be cooled further, or frozen to form a solid. An example of a substance that exists in the three states of matter is water. Figure 5.4 shows the relationship between the three states of matter.

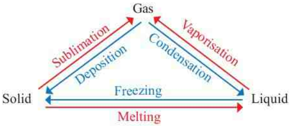


Figure 5.4: *The relationship between the three states of matter*

Melting and freezing

Melting is a process that causes a substance to change from a solid to a liquid. When a solid is heated, the particles gain energy and vibrate fast. Eventually, they break free from their fixed positions and begin to move in clusters. The temperature at which a solid changes to liquid at standard atmospheric pressure is called *melting point*. The temperature at the melting point remains constant until the entire solid has changed to a liquid. The melting point of a solid explains how strongly its particles are held together. Substances with high melting points have strong forces of attraction between their particles. Those with low melting points have weak forces of attraction between their particles.

Freezing is the opposite of melting. The temperature at which a liquid changes to solid is called *freezing point*. For any particular substance, the melting point is the same as its freezing point. The freezing point of pure water is 0 °C, which is also the melting point of ice. Freezing point is slightly affected by changes in atmospheric pressure.

Boiling and evaporation

Boiling is the change of a liquid to vapour. If the liquid is heated, the particles will move around fast as their average kinetic energy increases. Some of the particles at the surface of the liquid gain enough kinetic energy to escape into the air. As more of the liquid particles escape to form a gas, the liquid is said to evaporate. At the boiling point of the liquid, all the particles have enough kinetic energy to escape. The temperature at which the vapour pressure is equal to the atmospheric pressure is called the *boiling point*. The boiling point describes how strongly the particles are held together in the liquid. Liquids with high boiling points have stronger forces of attraction between their particles than liquids with low boiling points. The boiling point of a liquid is very much affected by atmospheric pressure. At low pressures, water may boil even at room temperature. When a gas is cooled, the average kinetic energy of the particles decreases and the particles come closer. The forces of attraction between the particles become significant and cause the gas to condense into a liquid. When a liquid is cooled, it freezes to form a solid. Figure 5.5 shows the three states of water.

Figure 5.5: *States of water*

Sublimation

Sublimation occurs when a solid is heated and changes directly into a gas. In sublimation, a solid does not pass through the liquid state instead, it changes directly into a gas. The direct change of a gas to a solid is called *deposition*. In sublimation and deposition, the liquid state is bypassed.

Activity 5.2

Aim: To investigate the changes of matter from one state to another.

Requirements: Condenser, source of heat, beaker, and ice cubes

Procedure

1. Put some ice cubes in a beaker and heat. Carefully observe the changes that take place.
2. Heat the substance further until it changes into vapour.
3. Pass the vapour through a condenser. Record your observations.

Questions

1. What was the shape of the ice before heating?
2. What was the shape of the substance formed after melting of an ice?
3. What happened when water was heated above its boiling point?
4. What happened when the vapour was passed through the condenser?

Exercise 5.2

1. Describe melting and freezing according to the states of matter.
2. What do you understand by the following terms?
   (a) Melting point,
   (b) Freezing point,
   (c) Boiling point,
   (d) Evaporation,
   (e) Sublimation, and
   (f) Deposition.
3. Explain the differences between evaporation and boiling.
4. Why do cold foods not smell from a distance?
5. Differentiate between sublimation and deposition.

Importance of changes of states of matter

The importance of matter changing from one state to another can be explained in terms of the following:

Water cycle

Water cycle describes a continuous process that drives the movements of water on, above, and below the surface of the Earth. The ability of water to change from liquid to gas (vapour), from vapour to clouds, and finally to rain is important to climatic conditions. Rain is formed through this process.

Refrigeration

Refrigeration involves the use of refrigerants. The refrigerants are chemicals found in refrigerators whose changes in state involve the changes in energy. The changes of state from liquid to vapour absorb energy from the surroundings, and thus, cause the cooling effect. Air conditioners work in the same principle.

Refinery

Petroleum refinery and distillery work under the principle that liquids can change to vapour and then the vapour can be cooled to liquids. While simple distillation is employed in distilleries, fractional distillation is employed in petroleum refineries.

Metallurgy

Metallurgy involves the extraction and purification of metals from their ores and the manufacture of alloys. The changes of state from solid to liquid and back to solid make metallurgy possible.

Steam engines

A steam engine uses steam as working fluid to perform work. Steam engines were used in the early trains and ships. The change of state from liquid water to steam makes steam engines operate.

Drying of materials

Drying of materials occurs when the liquid contained changes to vapour. An example is when wet clothes are exposed to the sun to dry.

Particulate nature of matter

For a long time, matter was thought to be continuous. Later, it was discovered that matter is made up of particles. This was proved by a phenomenon known as the *Brownian motion* (Figure 5.6) which can be observed in liquids and solids.

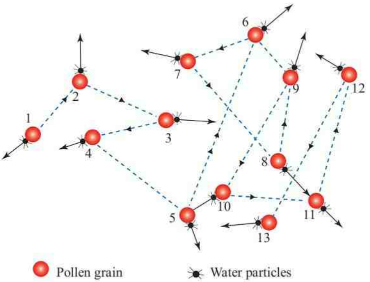


Figure 5.6: *Brownian motion*

The Brownian motion

In 1827, a botanist called Robert Brown observed through a microscope that pollen grains suspended in water move short distances in an irregular zigzag manner as shown in Figure 5.6. This is because they are constantly bombarded by water particles. This shows that matter is particulate in nature. Other examples which show that matter is made up of particles that are in constant motion include the spread of the smell of the food being cooked from the kitchen to a considerable distance, diffusion of potassium permanganate particles in water, and the spread of the perfume due to diffusion of the perfume vapours into the air. *Diffusion* is the movement of particles from an area of high concentration to that of low concentration.

Activity 5.3

Aim: To demonstrate Brownian motion.

Requirements: Pollen grains, distilled water, light microscope, microscope slide, and dropper

Procedure

1. Put a drop of distilled water on a microscope slide.
2. Put some pollen grains on top of the drop of water.
3. Place the slide under a microscope and observe any movement of the pollen grains.

Questions

1. Is the movement patterned or random?
2. Why do the pollen grains move in this manner?

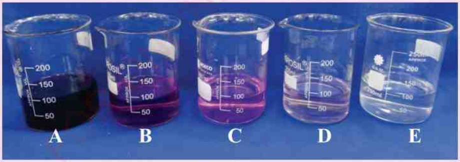
Activity 5.4

Aim: To demonstrate that solids are made of particles.

Requirements: Beakers, pipette, stirring rod, potassium permanganate, and water

Procedure

1. Dissolve about 0.5 g of potassium permanganate crystals in 100 cm^3 of water in a beaker. Stir to ensure that potassium permanganate has dissolved completely. Label it beaker A.
2. Using a pipette, measure about 20 cm^3 of the solution and pour it into another beaker. Label it beaker B.
3. Add water to this solution until it gets to the 100 cm^3 mark.
4. Obtain 20 cm^3 of the solution you have made in step 3 and put it in a beaker labelled C. Add water to it up to the 100 cm^3 mark.
5. Repeat this process two times more, each time taking 20 cm^3 of the previous solution and adding water up to the 100 cm^3 mark. Label the beakers D and E consecutively.



Questions

1. Which solution has the highest colour intensity?
2. Which solution has the lowest colour intensity?

3. What conclusion can you make from this experiment?
4. How does this experiment prove that substances are made up of small particles?

Activity 5.5

Aim: To show that liquids are made of particles.

Requirements: Watch glasses, ether, and perfume

Procedure

1. Place a few drops of ether on a watch glass.
2. Move some distance away from the watch glass containing ether.
3. Use your senses to detect what happens after a short time.
4. Spray perfume at one corner of the classroom and use your senses to detect what happens.

Questions

1. Why was the smell of ether detected at different points in the laboratory?
2. Can you smell the perfume from any corner of the classroom? Explain.

Behaviour of particles in matter

Matter is made up of small particles. The behaviour of these particles differ in the three states of matter. The particles in the gaseous state are far apart from each other with no regular order (Figure 5.7).

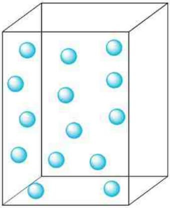


Figure 5.7: *Arrangement of particles in gases*

Particles in the liquid state are close together, but they also have no definite order (Figure 5.8).

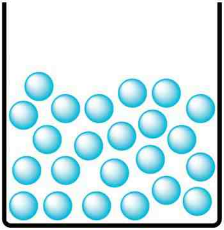


Figure 5.8: *Arrangement of particles in liquids*

Particles in the solid state are firmly packed together, (Figure 5.9).

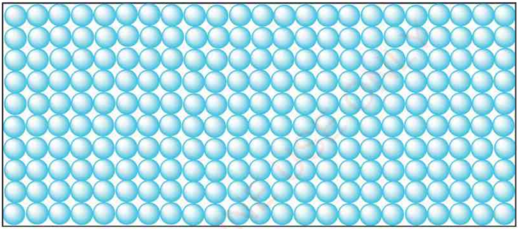


Figure 5.9: *Arrangement of particles in a solid*

Liquids and solids are in a compressed or condensed state because the particles are very close together. A summary of the different properties of gases, liquids and solids is given in Table 5.1.

Table 5.1: *Different properties of gases, liquids and solids*

Property	Gas	Liquid	Solid
Shape	Has no definite shape, fills the shape of the container	Takes the shape of its container	Retains a fixed shape
Movement of particles	Particles move past one another	Particles move or slide past one another	Rigid-particles are locked into place; no movement except vibrations
Compressibility	Compressible	Not easily compressible	Not easily compressible
Spaces between particles	A lot of free space between particles	Little free space between particles	No free space between particles
Flow	Flows easily	Flows easily	Does not flow easily
Volume	Takes the volume of its container	Has a fixed volume	Has a fixed volume

Kinetic nature of matter

The particles of matter tend to display different characteristics depending on the physical state of the substance. Solids keep their shapes and are not easily squashed (compressed) or stretched, and so they tend to retain their volume. This is because the particles are packed so closely together that they can only vibrate but not move. The more energy they have, the more they vibrate. Heating can provide this energy, so that at a certain temperature, they vibrate so much that their regular arrangements break down. At this point (the melting point) the solid melts and changes to a liquid (Figure 5.10).

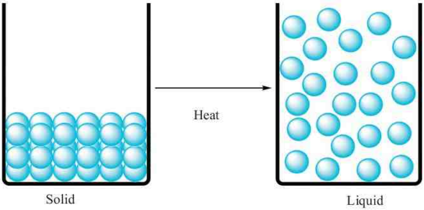


Figure 5.10: *Heating solid into liquid*

Liquids take the shapes of the containers they are poured into. They cannot be compressed since the particles are still close together. However, the particles in liquids have some spaces between them and can move around or slide past each other. If energy (heat) is applied to a liquid, the particles move about fast until a temperature called the boiling point is reached. The particles now have enough energy and the liquid changes to vapour (gas) (Figure 5.11).

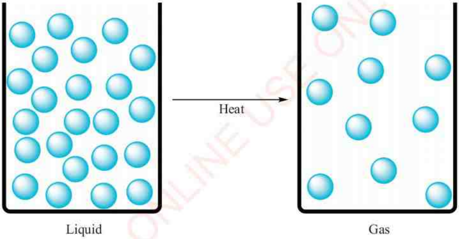


Figure 5.11: *Heating liquid into vapour (gas)*

The particles in gases have large spaces between them, and therefore, gases can be compressed. The way particles behave in solids, liquids, and gases is called the kinetic molecular behaviour.

Activity 5.6

Aim: To demonstrate the kinetic nature of matter.

Procedure

1. In groups, sit closely together so that your shoulders touch.
2. Can you individually move about freely?
3. Move into an empty classroom and walk slowly around the room while your hand touches on another's shoulder. How far are you able to move around?
4. Go out of your classroom and move around without touching each other. How far are you able to move?

Question

Compare your movements in steps 1-3 to the movements of particles in the three states of matter.

Physical and chemical changes

There are two major types of change, which are physical changes and chemical changes. Physical changes affect the physical properties of matter, while chemical changes affect the chemical properties of matter.

Characteristics of physical and chemical changes

Physical changes do not change the identity of the substance. Examples physical changes include; tearing, crushing, melting, dissolving, freezing, evaporation, condensation, and sublimation. Chemical changes cause a substance to change completely. Such changes include; rusting, burning, decaying, rotting, fermentation of fruits, and souring of milk.

The main factor that distinguishes a physical change from a chemical change is whether or not the change results into formation of a new substance.

Activity 5.7

Aim: To demonstrate types of changes in matter.

Requirements: Beaker, evaporating dish, source of heat, crucible, sugar, water, candle wax, and paper

Procedure

1. Pour water into a beaker. Dissolve some sugar in it. Pour the solution in an evaporating dish and evaporate the water. Allow the remaining solid to cool. What is the remaining solid? Does it look like the sugar you dissolved?
2. Heat some candle wax in a crucible until it melts. Let it cool. Is the final product different from the initial one?
3. Completely burn a piece of paper. What is the final product? Is it the same as the initial substance?
4. Put some sugar in a crucible, heat and let it melt completely until it changes colour. Is the final product the same as the initial substance?

Questions

1. Which observations were physical changes? Give reasons.
2. Which observations were chemical changes? Give reasons.
3. Describe the characteristics of each type of the changes.

Task

Categorise the following changes as either chemical or physical changes:

(a) Aluminium foil is cut into half

(b) Milk turns sour

(c) Clay is moulded into a new shape

(d) Butter melts on warm toast

(e) Nails or iron sheets rust

(f) Water evaporates from the surface of the ocean

(g) Wood is burnt

(h) The juice in a bottle freezes

(i) Food scraps are turned into compost in a compost pit

Task *(continued)*

(j) Drying of wet clothes

(k) A match is lit

(l) Digestion of food in the body

(m) Dissolving sugar in water

(n) Grinding a piece of chalk

(o) Food is cooked

(p) Melting of ice

(q) Jewellery tarnishes (changes colour)

The differences between physical changes and chemical changes are described in Table 5.2.

Table 5.2: *Differences between physical changes and chemical changes*

Physical changes	Chemical changes
Affect only physical properties of matter	Affect both physical and chemical properties of matter including its composition
Are temporary changes	Are permanent changes
Are easily reversible, which means the original substance can be recovered	Are irreversible, which means the original substance cannot be recovered
No new substance is formed	New substances are formed
The molecules are rearranged while their actual compositions remain same.	The molecular compositions of a substance completely change.
No energy is produced or absorbed	Energy is produced or absorbed

Chapter summary

1. Matter is anything that has mass and occupies space.
2. Mass is a measure of the quantity of matter in an object.
3. The three states of matter are solid, liquid and gas.
4. A solid is a substance that does not flow easily and retains its shape and size.

5. A liquid is a substance that flows, retains its volume but takes the shape of the container in which it is held.
6. A gas is a substance that has neither definite shape nor size.
7. Sublimation is the change of state of matter from a solid state directly to a gas or vapour without passing through a liquid state.
8. Matter is made up of particles that are able to display some forms of movements.
9. Diffusion is the movement of particles from an area of high concentration to an area of low concentration.
10. Brownian motion refers to the random movements of particles suspended in a liquid or gas.
11. The kinetic molecular behaviour is the way particles behave in solids, liquids, and gases.
12. Physical changes are reversible. They only affect the physical properties of substances, such as shape and state.
13. Chemical changes are irreversible. They affect the chemical properties of substances.
14. A chemical change results in the production of new substances, while a physical change does not.

Revision exercise 5

Choose the correct answer in items 1–4.

1. Which of the following is an example of a chemical change?
   (a) Melting butter
   (b) Breaking glass
   (c) Mixing milk and water
   (d) Burning leaves
2. The change of state from a vapour (gas) to liquid is called
   (a) evaporation.

(b) melting.
(c) condensation.
(d) sublimation.

3. Which of the following substances occupies the shape of the container?
(a) Solid
(b) Particle
(c) Liquid
(d) Crystal

4. When water freezes, it undergoes
(a) a physical change.
(b) vaporisation.
(c) a chemical change.
(d) sublimation.

5. What do you understand by the term matter?

6. When a metal such as copper is heated, it expands. Explain what happens to the metal particles during expansion.

7. Why do gases expand more than solids for the same increase in temperature?

8. When a container of coffee is opened in a room, people in different parts of the room may notice its smell. Use the kinetic theory of matter to explain how this happens.

9. Once you open a freezer, you may find an ice on its walls. How does the ice form?

10. What are the differences between physical change and chemical change?

11. What types of changes are these?
(a) Burning charcoal
(b) Cloud changing into rain
(c) Rusting of iron
(d) Magnetising of iron
(e) Melting of ice

(f) Heating an iron rod

(g) Rotting of mangoes

(h) Decaying of teeth

12. Write short notes on the following:

(a) Melting point

(b) Boiling point

(c) Freezing point

(d) Deposition

(e) Sublimation

(f) Evaporation

13. Explain the following phenomena based on the idea of particles:

(a) It is easy to pour a liquid.

(b) A gas will completely fill any container.

(c) A solid expands when heated.

Chapter Six

Elements, compounds and mixtures

Introduction

Everything in the universe is composed of one or more elements. Elements are the building units of compounds. When compounds combine physically, they form mixtures. In this chapter, you will learn about elements and their chemical symbols, compounds, mixtures, and separation of mixtures. The competencies developed will enable you to demonstrate the chemical compositions and separation methods of various substances encountered in real life.

Elements and symbols

Matter is made up of substances called *elements*. An element is a pure chemical substance which cannot be split into simpler substances by a simple chemical process. Today, there are 118 known chemical elements, most of which occur naturally, while a few are man-made. There may be discoveries of new elements in the future. Common examples of elements are sodium, potassium, magnesium, sulphur, carbon, iron, silver, gold, copper, oxygen, nitrogen, and hydrogen. Some common elements are shown in Figure 6.1.

Figure 6.1: *Some common elements*

Names and symbols of elements

Elements have names that are usually represented by letters, commonly known as *chemical symbols*. The chemical symbols are abbreviations or short representations of the names of elements. The use of symbols has made it easier for chemists, other scientists and students in studying chemistry and other sciences. Chemical symbols are often derived from the Latin or Greek names of the elements and may not have much similarity to the common English names. For example, the symbol for sodium is Na which is derived from the Latin name *Natrium* and the symbol for gold is Au which is derived from the Latin name *Aurum*. Chemical symbols are generated using certain criteria. The first letter representing a chemical element must always be a capital letter. Chemical symbols are written according to the rules of the International Union of Pure and Applied Chemistry (IUPAC).

Criteria for assigning chemical symbols

The following are the criteria used for assigning chemical symbols:

1. An element may be represented by a chemical symbol that is derived from the first letter of its English name. See examples in Table 6.1.

Table 6.1: *Some elements with chemical symbols derived from the first letter of their English names*

Name	Chemical symbol
Boron	B
Carbon	C
Fluorine	F
Hydrogen	H
Iodine	I
Nitrogen	N
Oxygen	O
Phosphorus	P
Sulphur	S
Vanadium	V
Yttrium	Y

2. Names of different elements may have the same first letter, for example cobalt, copper and calcium. It is thus necessary to differentiate the elements. In this case, another letter, usually the second or third from the name, is used together with the first one (Table 6.2). The first letter will be capital, while the second will be a small letter.

Table 6.2: *Chemical symbols of some elements with two letters from their English names*

Name	Chemical symbol
Aluminium	Al
Argon	Ar
Beryllium	Be
Calcium	Ca
Chlorine	Cl
Cobalt	Co
Helium	He
Lithium	Li
Magnesium	Mg
Manganese	Mn
Neon	Ne
Silicon	Si

3. In some cases, the chemical symbols are derived from Latin names instead of the common English names. Examples of elements with chemical symbols derived from Latin names are given in Table 6.3.

Table 6.3: *Examples of elements with chemical symbols derived from their Latin names*

Name	Latin name	Chemical symbol
Antimony	*Stibium*	Sb
Copper	*Cuprum*	Cu
Gold	*Aurum*	Au
Iron	*Ferrum*	Fe
Lead	*Plumbum*	Pb
Mercury	*Hydrargyrum*	Hg
Potassium	*Kalium*	K
Silver	*Argentum*	Ag
Sodium	*Natrium*	Na
Tin	*Stannum*	Sn
Tungsten	*Wolfram*	W

Significance of chemical symbols

The use of chemical symbols has made it easier for chemists and other people to:

1. quickly understand the elements being referred to, instead of memorising the full names.
2. write chemical equations in abbreviated forms instead of writing each element in its full name.
3. know the name of the element. For example, the symbol Cu represents copper.
4. distinguish one element from the other.

Metals and non-metals

Elements can be classified into metals and non-metals. Examples of metals are copper, sodium, zinc, aluminium, and iron. Examples of non-metals are sulphur, carbon, and hydrogen. In principle, metals are different from non-metals. The characteristics used to differentiate metals from non-metals are presented in Table 6.4.

Table 6.4: *Characteristics of metals and non-metals*

S/N	Metals	Non-metals
1.	Are good conductors of electricity	They are poor conductors of electricity. They are insulators.
2.	Are good conductors of heat. That is why cooking pots, pans, and utensils are made of metals like iron and aluminium.	Are poor conductors of heat
3.	Have high melting points and boiling points	Have low melting points and boiling points
4.	Do not have flexibility and have high tensile strength	Have low tensile strength
5.	Are good conductors of sound. They are sonorous. That means they produce a typical metallic sound when hit with something.	Are poor conductors of sound. They are not sonorous.
6.	Are ductile, which means that they can be drawn into thin wires	Are not ductile. They cannot be drawn into thin wires
7.	Are malleable, which means that they can be hammered into thin sheets	Are not malleable
8.	Are lustrous. They produce shining surfaces when cut.	Are non-lustrous except a few such as diamond

Note: There are exceptions to the above generalisations. Diamond is a non-metal, but has very high melting point and boiling point. Graphite is also a non-metal, but it is a good conductor of heat and electricity. Diamond and graphite are forms of carbon. The metals which have different characteristics from those described in Table 6.4 include sodium, potassium, and mercury. These elements are light metals with very low melting points and boiling points. Metals are usually solid at room temperature, but mercury is usually in liquid form.

Exercise 6.1

1. What are the differences between metals and non-metals?
2. Why are cooking pots, pans, and utensils made of metals?
3. Iron materials make sound when they are hit. Explain.
4. When you touch a metal during cold weather you feel that it is cold, but when you touch a metal during hot weather you feel it is hot. Explain.

Compounds and mixtures

A *compound* is a pure substance made up of two or more elements in a chemical combination. Examples of compounds are common salt, water, and sugar. The combinations are always in fixed ratios. For example, carbon dioxide is a compound which is made up of two parts of oxygen for each part of carbon.

A *mixture* is a physical combination of two or more substances in any ratio. Since mixtures are not chemically combined, they can be separated by physical means. The mixtures can be liquid-liquid (for example, oil and water), solid-liquid (for example, muddy water) or solid-solid (for example, sand and salt).

Mixtures can be homogeneous or heterogeneous. A *homogeneous* mixture has uniform composition, appearance and properties. An example is a small amount of common salt dissolved in a glass of water. After stirring, every section of the solution is identical in composition, appearance, and physical properties. A *heterogeneous* mixture has different compositions, appearance and properties at various points in the mixture. For example, when sulphur powder and iron filings are mixed, they form a heterogeneous mixture. The mixture is physically combined and can be separated using a magnet bar as shown in Figure 6.2.

Figure 6.2: *Magnetic separation of a mixture of sulphur and iron filings*

Task 6.1

The following are substances that are made up of two or more components: common salt, mud, juices, milk, water, and soft drinks.

1. Classify the above listed items as either compounds or mixtures.
2. Discuss each item and give reasons for classifying it as a compound or a mixture.

Activity 6.1

Aim: To compare the properties of a mixture and a compound.

Requirements: Test tubes, stoppers, test tube rack, mortar and pestle, burner, retort stand and clamp, spatula, sheets of paper, powdered sulphur, magnet, coarse and fine powdered iron filings, dilute hydrochloric acid, and a balance

Procedure

1. Take a spatulaful of powdered sulphur and mix it with a spatulaful of coarse powdered iron in a clean and dry test tube. Stopper the test tube and shake it well.
2. Take out half of the mixture and put it on a sheet of paper.
3. Place a magnet near the mixture and observe what happens. Record your observation.
4. Pour dilute hydrochloric acid in the test tube containing the remaining mixture. Record your observation.
5. Take 8 g of sulphur and 14 g of fine powdered iron filings and put them in a clean and dry test tube, put a stopper onto it and shake the test tube to mix the two substances thoroughly.
6. Take out half of the mixture, put it in another test tube and add dilute hydrochloric acid. Record your observation.
7. Attach the test tube containing the remaining mixture to a clamp on a retort stand and put it in a fume chamber. Heat the mixture with the burner until it starts to glow. Record your observation. Remove the heat and allow the contents in the test tube to cool.

8. Crack a sample in the test tube and put the contents on a sheet of paper. Make sure that you do not have any glass pieces mixed in. Place a magnet near the compound and record your observation.

9. Put the compound in a mortar. Grind the contents to fine powder using a pestle. Divide the contents into two different test tubes.

10. Add some water to the first test tube and shake vigorously. Wait for two minutes and then record your observation.

11. Place the second test tube in the fume chamber. Add dilute hydrochloric acid until the test tube is half full. **Caution:** The gas being produced is poisonous in high concentrations, so smell it very carefully by wafting it towards your nose. Observe and make accurate notes. Give explanations for your observation.

Questions

1. Describe what takes place when a magnet is placed near a mixture of sulphur and iron. Is it the same as shown in Figure 6.2?

2. What happens when dilute hydrochloric acid is added to a test tube containing a mixture of iron and sulphur?

3. What product is formed when a mixture of iron and sulphur is heated? What happens when a magnet is placed near the product on cooling? Explain your answer.

4. Describe what takes place when dilute hydrochloric acid is added to the product formed when the mixture of iron and sulphur is heated.

Mixtures and compounds have different properties. Table 6.5 shows some of the differences between mixtures and compounds.

Table 6.5: *Differences between mixtures and compounds*

S/N	Mixtures	Compounds
1.	The components can be separated from one another by physical methods.	The constituent elements cannot be separated by physical methods, but can be separated by chemical methods.
2.	Mixtures may vary widely in compositions. The components are mixed in any proportions.	Compounds have always definite/fixed compositions by mass of the elements. The proportions are fixed.
3.	No chemical change occurs when mixtures are formed	Chemical changes are involved when new substances (compounds) are formed
4.	The properties of mixtures are those of the individual components.	The properties of compounds are very different from those of the individual elements.
5.	Components may be seen separately	Components cannot be seen separately

Exercise 6.2

1. Give the importance of having the rules for assigning chemical symbols.
2. What are the uses of chemical symbols?
3. Table salt is a compound. Explain.
4. Muddy water is a mixture. Explain.
5. Differentiate between compounds and elements.
6. Write the symbol for each of the following elements:

   (a) Bromine (b) Helium (c) Nitrogen
   (d) Oxygen (e) Sulphur (f) Lithium
   (g) Carbon (h) Silicon (i) Boron
   (j) Beryllium

Solutions, suspensions and emulsions

Liquid mixtures can be described as solutions, suspensions or emulsions, depending on their compositions.

Solutions

A *solution* is a homogeneous mixture of two or more substances which are solvent and solute. A *solvent* is the component of the solution that dissolves the solute. It is the component that is usually present in large amount in a solution. A *solute* is the component in solution that is dissolved in the solvent. It is the component that is usually present in small amount in a solution. For example, when water dissolves sugar, the solution of sugar and water is formed. Sugar is the solute and water is the solvent.

Activity 6.2

Aim: To make solutions.

Requirements: Beakers, water, common salt, sugar, and glucose

Procedure

1. Put each solid in a different beaker.
2. Add water to every beaker and stir until no more solid can be seen. What do you observe?

Question

Comment on the types of mixtures formed.

Types of solutions

A solution can either be unsaturated, saturated or supersaturated. An *unsaturated* solution is the one in which the solvent can dissolve more solute at a given temperature and pressure. A *saturated* solution is the one in which the solvent can dissolve no more solute at a given temperature and pressure. A *supersaturated* solution is the one that holds more solute than the maximum amount it can dissolve at a given temperature and pressure.

Activity 6.3

Aim: To distinguish among the saturated, unsaturated, and supersaturated solutions.

Requirements: Beaker, Bunsen burner, tripod stand, spatula, glass rod, trough, and common salt

Procedure

1. Measure about 100 cm^3 of water and pour it in a beaker.
2. Add a spatulaful of the common salt in the beaker and stir.
3. Does the salt dissolve?
4. Continue adding more salt to the solution and stirring until no more salt can dissolve.
5. Place the solution on the tripod stand and heat gently. Continue stirring while heating.
6. Stop heating when the salt dissolves.
7. Place the beaker in a trough that is half-filled with cold water and allow to cool for 5 minutes. Record your observation.

Note: Saturation depends on temperature. As the temperature increases, the kinetic energy of water molecules increases and this creates more space for dissolving more solute particles.

Questions

1. What type of solution is formed when a spatulaful of table salt dissolves in 100 cm^3 of water?
2. What type of solution is obtained at room temperature when no more salt can dissolve?
3. What name is given to the final solution?

Applications of saturation

The concept of saturation can be applied when:

1. separating certain mixtures in laboratories.
2. extracting some minerals, such as extracting common salt from sea water.

Classification of solutions into the three states of matter

There are various types of solutions. They may be solid, liquid or gaseous solutions. The solutes and solvents can be in any state, that is, liquid, solid or gas. Examples of solutions are listed in Table 6.6.

Table 6.6: *Examples of types of solutions*

Solute	Solvent	Examples
Solid	Gas	Naphthalene slowly sublimes in air to form a solution
Solid	Liquid	Sugar in water and salts in water
Solid	Solid	Steel and other metal alloys
Liquid	Gas	Chloroform in nitrogen gas
Liquid	Liquid	Ethanol (alcohol) in water and various hydrocarbons in each other (petroleum)
Liquid	Solid	Mercury in gold and hexane in paraffin wax
Gas	Gas	Oxygen and other gases in air
Gas	Liquid	Carbon dioxide in water (carbonated water)
Gas	Solid	Hydrogen in metals

Task 6.2

Identify the various solutions available at your school and home. Classify them into solid, liquid, and gaseous solutions.

Uses of solvents

Solvents have a wide range of uses, especially in homes, institutions such as schools and colleges, hotels, and in manufacturing industries. They are usually used in cleaning. This is because they form a solution with the dirt (solute). The solvents are also used during varnish removal, stain removal, bleaching, thinning paints, and degreasing. Moreover, solvents are used in chemical synthesis (manufacturing). Water is the most common solvent as it has the capacity to dissolve many solutes. Figure 6.3 shows examples of solvents in containers.

Figure 6.3: *Solvents in containers*

Suspensions

A *suspension* is a heterogeneous mixture of a liquid (solvent) and fine particles of a solid. The solute particles do not dissolve, but get suspended in the solvent. When the suspension is not disturbed, the solute particles are slightly visible and will settle. For example, when you add flour into water during cooking, you have to keep on stirring, otherwise the flour will settle. Other examples of suspensions are; muddy water, blood, sand particles suspended in water, and chalk powder suspended in water. The suspensions composed of either liquid droplets or fine solid particles floating in a gas are called aerosols.

Suspensions are used in many aspects in our lives. Most of them are stored in containers with the instructions *'Shake well before use'*. They include medicines (syrups), body sprays, and insecticides. Examples of commonly used suspensions are shown in Figure 6.4.

Figure 6.4: *Containers with commonly used suspensions*

Activity 6.4

Aim: To prepare suspensions.

Requirements: Mud, water, chalk powder, copper carbonate, beakers, and glass rod

Procedure

1. Put each of the solid substances in a separate beaker.
2. Add enough water to cover and stir until the solid mixes with the water.

3. Leave the mixture to settle. What do you observe?

Question

Give other real-life situations where you can find suspensions.

Table 6.7 presents the differences between solutions and suspensions.

Table 6.7: *Differences between solutions and suspensions*

S/N	Solutions	Suspensions
1.	Homogeneous mixtures	Heterogeneous mixtures
2.	Transparent/clear	Opaque/not clear
3.	Solute particles completely dissolved in a solvent	Solute particles settle if the suspension is undisturbed
4.	Components can be separated by evaporation	Components can be separated by filtration

Emulsions

An emulsion is a mixture of liquids that do not completely mix with each other. Liquids that do not mix are said to be *immiscible,* whereas those that mix are *miscible.* An emulsion is usually formed from two liquids, one water-based liquid and the other oil-based liquid. When shaken, the oily liquid forms droplets suspended in the water-based liquid. The harder the emulsion is shaken, the smaller the droplets, so that the emulsion may appear to be a homogeneous solution.

The following are examples of emulsions:

(a) Milk, which contains drops of butterfat in water; and

(b) Emulsion paint, which contains drops of coloured oils in water.

Separation of mixtures

Many mixtures contain useful substances mixed with unwanted materials (impurities). In order to obtain the useful substances, chemists often separate the mixtures using different methods. The separation depends on what is in the mixture and the properties of the substances present. Some of the methods of separating mixtures are decantation, filtration, evaporation, distillation, layer separation, sublimation, chromatography, and solvent extraction.

Decantation

The waters in the oceans, lakes, rivers, ponds, and dams are heterogeneous mixtures that contain sand and other insoluble matter that later settle at the bottom when the water is calm. This process of some of the components of a mixture settling at the bottom is called *sedimentation*. It is the first step in decantation. *Decantation* is the process of separating a heterogeneous mixture of a liquid and a solid by pouring out the liquid only and leaving the solid at the bottom of the container. This method works well when the solid component is made up of large particles. If the particles are small, the process may not give separation.

Activity 6.5

Aim: To separate substances by decantation.

Requirements: Muddy water, and beakers

Procedure

1. Put some muddy water in a beaker and let it stand for some time.
2. Carefully pour out the clear water from the top into another beaker as shown in Figure 6.5.

Questions

1. What do you observe when the muddy water is left to stand for some time?
2. Give real-life situations where decantation is applicable.

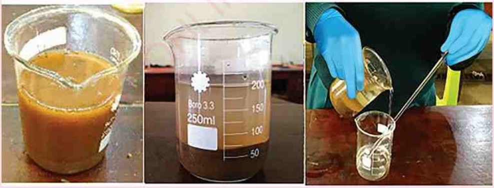


Figure 6.5: *Decantation of muddy water*

Filtration

This is the method used to separate a heterogeneous mixture of a solid and a liquid. Some chemical reactions produce insoluble solids in liquid and the mixture can be separated by this method. The solid is separated from the liquid using a porous filter, such as filter paper. The solid obtained is the *residue,* and the liquid is the *filtrate*.

Activity 6.6

Aim: To separate substances by filtration.

Requirements: Sand, water, filter paper, filter funnel, conical flask, retort stand, and clamp

Procedure

1. Fold the filter paper to form a cone shape as shown in Figure 6.6.

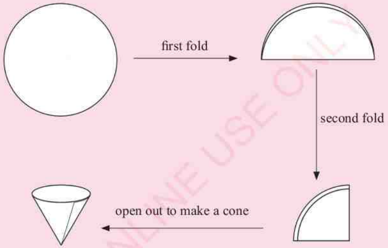


Figure 6.6: *Steps in folding a filter paper*

2. Place the folded filter paper into the filter funnel.
3. Put some sand and water in a beaker to make a mixture.
4. Pour the mixture of sand and water into the filter funnel connected with the mouth of a conical flask.

5. Leave the experiment to proceed as shown in Figure 6.7.

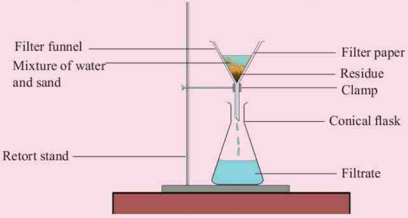


Figure 6.7: *Filtration of a mixture*

Questions

1. What is the nature of the filtrate obtained?
2. Which component of the mixture is the residue?

Evaporation

Evaporation is the process of separating a solute from a liquid solution through heating. During evaporation, the solvent is converted from liquid to gas through heating as shown in Figure 6.8. The solute remains as a residue. For example, when a solution of common salt and water is heated, the water evaporates, and common salt remains as a residue.

Figure 6.8: *Separation of a mixture by evaporation*

Activity 6.7

Aim: To separate substances by evaporation.

Requirements: Evaporating dish, beaker, tripod stand, Bunsen burner, wire gauze, and salt solution

Procedure

1. Pour some of the salt solution into the evaporating dish and place it on a wire gauze on a tripod stand.
2. Heat the solution until almost all the water evaporates.
3. Let the mixture cool completely.

Question

What do you observe as the solution cools?

Distillation

Distillation refers to the process of separating the components of a mixture by heating a liquid to suitable temperature until it forms vapour (a gas), and then cooling it back to liquid. The liquid from a cooled vapour is called the *distillate*. There are two types of distillation; simple distillation and fractional distillation.

Simple distillation

This is a process of obtaining a single liquid from a suspension or solution by boiling the mixture to obtain vapour, and then condensing it back to a liquid. An example is distilling water from muddy water (Figure 6.9). The condenser helps to cool the vapour by means of the water that flows in and out of the condenser. The distillate obtained is clean water, and therefore, it is colourless.

Activity 6.8

Aim: To recover clean water from muddy water.

Requirements: Liebig condenser, distilling flask, beaker, thermometer, burner, retort stand, stopper, tripod stand, wire gauze, muddy water, and source of running water

Procedure

1. Set up the apparatus as shown in Figure 6.9.
2. Pour the muddy water into the flat-bottomed flask, stopper it and insert a thermometer through the stopper.
3. Heat the mixture until it vaporises and a clear liquid collects in the beaker as you run water through the Liebig condenser.

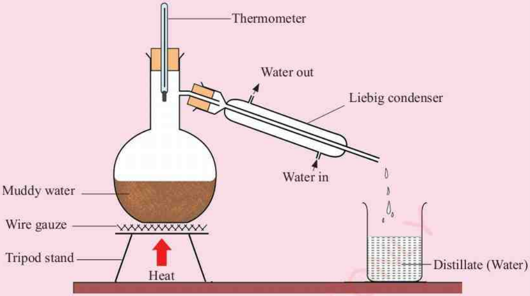


Figure 6.9: *Simple distillation of muddy water*

Questions

1. What role does the Liebig condenser play?
2. What is the colour of the distillate?
3. If you do not have a Liebig condenser, what will you use to carry out this simple distillation?

Fractional distillation

This is a method of separating a homogeneous mixture of two or more liquids by means of a fractionating column. The liquids are said to be miscible. A mixture of ethanol and water is a good example. Since the liquids have a reasonable difference in boiling points, the solution can be separated by careful heating. The fractionating column separates the two liquids, the one with a lower boiling point moves to the upper part of the column and distills over. The liquid with the lower boiling point is collected first as a distillate. Each component collected is known as a *fraction*. Figure 6.10 shows the set-up of fractional distillation.

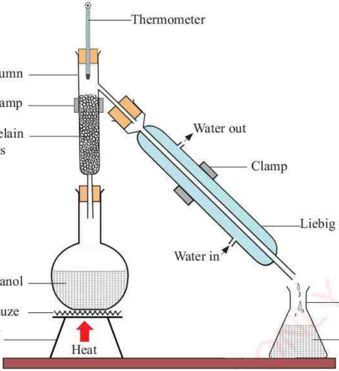


Figure 6.10: *Fractional distillation*

Activity 6.9

Aim: To separate two miscible liquids.

Requirements: Condenser, fractionating column, beakers, distillation flasks, retort stands and clamps, thermometer, burner, tripod stand, wire gauze, conical flask, ethanol, and water

Procedure

1. The experiment is set up as shown in Figure 6.10. Note that, the setting of this experiment can be done by a teacher or a technician.

2. The ethanol and water mixture is heated. Note the temperature at which the first liquid is distilled. Record all your observations.

Questions

1. Which liquid distills first and at what temperature?
2. What role does the fractionating column play?

Layer separation

This method is used for separating immiscible liquids using a separating funnel. Immiscible liquids are those that do not mix, but form distinct layers when put together. The most dense liquid settles at the bottom, while the least dense remains at the top of the separating funnel. By opening the tap, the liquid at the bottom is let out first into an empty beaker (Figure 6.11).

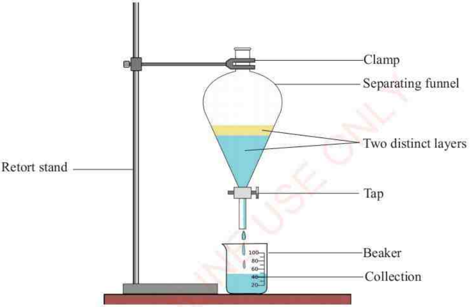


Figure 6.11: *Separating immiscible liquids*

Activity 6.10

Aim: To separate immiscible liquids.

Requirements: Separating funnel, kerosene, cooking oil, beakers, stirrer, water, stopper, and retort stand with a clamp

Procedure

1. Pour water into a beaker.
2. Add kerosene and stir using a stirrer.
3. Pour the mixture into a separating funnel and wait for some few minutes.
4. What do you observe?
5. Open the tap of the separating funnel slowly and drain away the liquid at the bottom first into an empty beaker.
6. Repeat steps 1 to 5 with water and cooking oil.

Question

Which liquid did you drain first? Give reasons.

Sublimation

Sublimation is the process whereby a solid changes its state directly to a gas, usually on heating. The solid that forms when the vapour cools is called a *sublimate*. This process can be used to separate mixtures in which one of the substances sublimes. Iodine and ammonium chloride are among the few compounds that change directly from solid to gas when heated. The reverse process of vapour changing to solid on cooling is called *deposition*.

Activity 6.11

Aim: To separate mixtures by sublimation.

Requirements: Beakers, wire gauze, tripod stand, burner, round-bottomed flask, iodine, ammonium chloride, sand, common salt, and ice

Note: These experiments should be carried out in a fume chamber.

Procedure

1. Place a mixture of iodine and sand in a beaker.
2. Put some ice in a round-bottomed flask.
3. Set the apparatus as shown in Figure 6.12.
4. Heat the mixture and note what happens.

5. Repeat the experiment using a mixture of common salt and ammonium chloride.

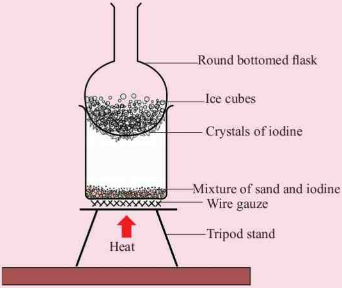


Figure 6.12: *Sublimation*

Questions

1. What happened when the mixture of iodine and sand was heated?
2. What happened when the mixture of common salt and ammonium chloride was heated?
3. Why were ice cubes put into round bottomed flask?

Chromatography

Chromatography is the process of separating mixtures using a solvent and an immobile substance. The moving solvent is called a *mobile phase* and may be a liquid or gas. The immobile substance is called a *stationary phase*, which is either a solid or a liquid supported on a solid. The mobile phase flows through the stationary phase and carries the components of the mixture with it. Different components travel, and are separated at different rates. The substance that is separated during chromatography is called *analyte*. There are different types of chromatography, such as paper chromatography, thin layer chromatography, and gas chromatography. In paper chromatography, the stationary phase is a very uniform adsorbent paper. The mobile phase is a suitable liquid solvent or mixture of solvents.

Activity 6.12

Aim: To carry out simple paper chromatography.

Requirements: Filter paper, beakers, ink extracts from leaves, acetone or ethanol, and watch glass

Procedure

1. Take a rectangular piece of filter paper of a size that can fit in a beaker when placed upright.
2. Draw two straight lines one at the base and another at the upper part.
3. Mark three areas on the base line, and on each mark put a drop of different plant extracts. Label the spots A, B, and C, and make sure there is space between the spots.
4. Place the paper, baseline first, into a beaker containing acetone or ethanol and cover with a watch glass.
5. When the acetone or ethanol has risen to the top of the paper, remove the paper from the beaker and place it in a dry beaker. Leave it to stand for about 30 minutes.
6. Mark the levels to which the pigments have risen for each spot. See Figure 6.13.

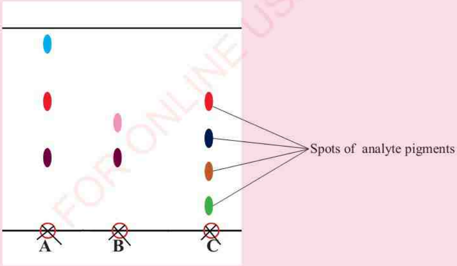


Figure 6.13: *Paper chromatography*

Questions

1. Which mixture separated fast?
2. Which mixture has the highest number of components?

Uses of chromatography

Chromatography is used in many different ways. It is used to separate components of a mixture, and for identification and quantification of different chemical substances. It can be used by security agents and medical personnel to analyse drugs in blood and urine samples. Causes of pollution in water, soil, air, and organisms can also be detected using chromatography. Figure 6.14 summarises some of the uses of chromatography.

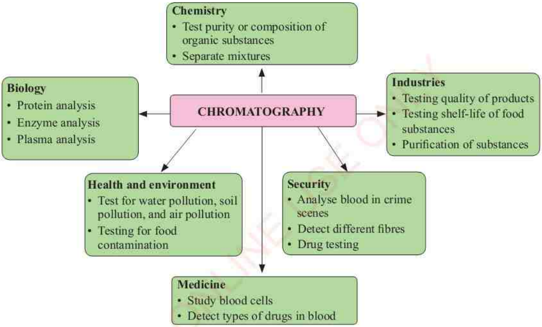


Figure 6.14: *Some of the uses of chromatography*

Solvent extraction

This is the process of separating components of a mixture using a solvent that dissolves selected components. For example, extracting essential oils from plant seeds using a liquid that dissolves the oils. The extracted oils are then distilled to let the solvent evaporate. Another example is preparation of tea which involves extracting tea components from tea leaves using hot water.

Note: In solvent extraction, the following conditions should be considered:

(a) The solvent chosen should dissolve the component of interest.

(b) The solvent must not react with the component of interest.

(c) The solution formed between the component of interest and the chosen solvent must be easily separated.

Activity 6.13

Aim: To extract oil from groundnuts.

Requirements: Ethanol, groundnuts, mortar and pestle, fractionating column and beaker

Procedure

1. Crush a handful of groundnuts in the mortar.
2. Pour in about 200 cm^3 of the ethanol and mix well.
3. Allow to settle for a while then decant the liquid into a beaker.
4. Use fractional distillation to separate the ethanol from the oil.

Question

Why is fractional distillation used to separate the ethanol from the oil?

Activity 6.14

Aim: To demonstrate the applications of separation of mixtures.

Requirements: Fruit pulp (various fruits), milk, saucepan, clean water, filter funnel, filter paper, beakers, and muddy water

Procedure

1. Mix the fruit pulp with some water and filter into a beaker.
2. Pour some of the muddy water in the filter and collect the clean water.
3. Boil milk in a saucepan, let it cool and extract the cream by filtering.

Question

How can you apply the knowledge of separating mixtures in everyday life?

Project

In groups, note down as many elements as possible and write their corresponding chemical symbols and Latin names, where applicable. Arrange them in alphabetical order on a manila paper. Present your findings to the rest of the class.

Chapter summary

1. An element is a pure substance that cannot be broken into simpler substances by ordinary chemical means.
2. Chemical symbols are representations of elements using letters.
3. The first letter of the chemical symbol must always be a capital letter.
4. Elements that have identical first letters are usually differentiated by a second or a third letter. The second or third letter is taken from any of the letters in the element's name, usually the second letter, and is always a small letter.
5. Chemical symbols are derived from the Latin names or Greek names of the elements and some English names.
6. A compound is a pure substance made up of two or more elements in a chemical combination.
7. A mixture is a physical combination of two or more substances in any proportion.
8. A solution is a homogeneous mixture composed of a solute dissolved in a solvent.
9. A suspension is a heterogeneous mixture of liquid and fine solid particles.
10. The methods of separating mixtures are determined by the components of interest. One or more methods can be used to obtain the components of interest out of the mixtures.

11. Liquid-solid mixtures can be separated by evaporation, decantation, distillation, or filtration.
12. Liquid-liquid mixtures can be separated using fractional distillation, separating funnel, or chromatography.
13. Solid-solid mixtures can be separated using a variety of methods such as using a magnet, sublimation, by using a suitable solvent, and by winnowing.

Revision exercise 6

Choose the correct answer in items 1–10.

1. When a substance is heated and it changes from a solid directly to vapour, the process is called
   (a) condensation.
   (b) sublimation.
   (c) deposition.
   (d) melting.
2. Syrups are examples of
   (a) solutions.
   (b) suspensions.
   (c) homogeneous mixtures.
   (d) filtrates.
3. Sugar and water are mixed to give a solution, what name is given to sugar in the solution?
   (a) Solute
   (b) Solvent
   (c) Suspension
   (d) Solution
4. Two immiscible liquids are easily separated using
   (a) condenser.
   (b) fractionating column.
   (c) filter funnel.
   (d) separating funnel.

5. Which among the following chemical symbols represents sodium element?
   (a) S
   (b) Na
   (c) Sd
   (d) So

6. What is the Latin name of potassium?
   (a) Kalium
   (b) Kaliam
   (c) Kadium
   (d) Karium

7. When a small amount of common salt is dissolved in water, the mixture so formed is
   (a) homogeneous.
   (b) Immiscible.
   (c) Heterogenous.
   (d) suspension.

8. What is the best way of separating iron filings from sulphur powder?
   (a) Separating funnel
   (b) Evaporation
   (c) Magnet
   (d) Winnowing

9. The following are the uses of solvents, EXCEPT
   (a) cleaning.
   (b) stain removal.
   (c) bleaching agent.
   (d) greasing.

10. Which process among the following is involved in decantation?
   (a) Sedimentation
   (b) Melting
   (c) Saturation
   (d) Distillation

11. Write **TRUE** for a correct statement and **FALSE** for an incorrect statement.
    (a) A magnet can be used to separate iron filings from sulphur powder.
    (b) An unsaturated solution is one in which the solvent has less than the maximum amount of solute that it can dissolve at a given temperature.
    (c) Solutions can only be in liquid form.
    (d) You can obtain sugar crystals from a solution by decantation.
    (e) Ethanol and water are miscible.
    (f) Sublimation is the process by which a substance changes from a solid to a liquid form.
    (g) Emulsion is a clear solution.
    (h) Distillation is a process of separating a mixture of substances with different boiling points.
    (i) A compound is a pure substance made up of two or more elements in a chemical form.
    (j) The first letter of the chemical symbol must be a capital letter.
12. What do you understand by the following terms:
    (a) Solvent
    (b) Mixture
    (c) Compound
    (d) Filtrate
    (e) Chromatography
    (f) Element
13. List down five elements with their corresponding chemical symbols which start with letter 'C'.
14. List six elements that derive their symbols from their Latin names.
15. Name the process that can be used to separate each of the following substances:
    (a) Iodine and sand
    (b) Kerosene and water
    (c) A mixture of petrol and diesel

(d) A mixture of sulphur and iron filings

(e) Oil from seeds

16. Briefly explain how can you differentiate between a solution and a suspension just by their appearance.

17. Give an example for each of the following types of solution states:

    (a) Liquid

    (b) Solid

    (c) Gas

18. Differentiate between unsaturated solution and saturated solution.

19. Why can the saturated sugar solution dissolve more sugar after being heated?

20. Are the formations of homogeneous colourless solutions always physical changes? Explain your answer.

21. What changes or events do we encounter in our daily lives that are good examples of physical changes and chemical changes?

22. How are solutions, suspensions, and emulsions used in daily life?

23. Give two examples of solvent extraction processes that take place at home.

24. Describe two examples where simple distillation is used in daily life.

25. How is evaporation process applied at home?

26. In which areas can you apply the knowledge of chromatography?

Chapter Seven

Air, combustion, firefighting, and rusting

Introduction

Air is very important in our lives and daily activities. Without air, there is no life. Air is composed of various components. The components of air are associated with combustion, firefighting, and rusting. In this chapter, you will learn about air and its composition, combustion, firefighting, and rusting. The competencies developed will enable you to apply combustion in various activities such as cooking and burning of waste, protect yourself from fire accidents, and protect iron materials from rusting.

Composition of air

Air is a colourless, homogeneous mixture of gases. It is odourless and tasteless. The components of air include; nitrogen, oxygen, carbon dioxide, and noble gases. The noble gases include; helium, neon, argon, krypton, and xenon. Water vapour and dust particles are also present in the air. Air may sometimes contain traces of impurities such as carbon monoxide, nitrogen dioxide, sulphur dioxide, and hydrogen sulphide. These impurities come from various sources, including mining activities, construction, motor vehicles and industries. The existence of these impurities in air leads to air pollution.

The different gases composing air are present in various proportions by volume. Table 7.1 summarises the approximate volumes in percentages of the main gases in air.

Table 7.1: *Composition of air*

Gas	Approximate percentage (%)
Nitrogen	78
Oxygen	21
Noble gases	0.94
Carbon dioxide	0.03
Water vapour	0-4

The percentage of water vapour in the air is not constant and varies depending on factors like weather and geographical location.

Tests for gases in air

It is possible to test for the presence of some of the gases found in air. For instance, carbon dioxide gas reacts with lime water (calcium hydroxide) to form white precipitates of calcium carbonate and water as follows:

Calcium hydroxide + Carbon dioxide gas ⟶ Calcium carbonate + Water

This reaction is slow at room temperature, and it takes few days to completion. Water vapour in air reacts with white anhydrous copper(II) sulphate forming blue hydrated copper(II) sulphate (Figure 7.1). This reaction can be expressed as follows:

Water vapour + Anhydrous copper(II) sulphate ⟶ Hydrated copper(II) sulphate
(White) (Blue)

Figure 7.1: *White anhydrous copper(II) sulphate (A) and blue hydrated copper(II) sulphate (B)*

The presence of oxygen gas in air can be tested using copper turnings. Oxygen gas in air reacts with copper turnings under heat to form copper oxide. This reaction can be expressed as follows:

$$\text{Copper turnings (brown)} + \text{Oxygen gas} \xrightarrow{\text{heat}} \text{Copper oxide (black)}$$

Activity 7.1

Aim: To test for the presence of carbon dioxide in air.

Requirements: Watch glass, clear lime water (calcium hydroxide), test tube, and stopper

Procedure

1. Put some lime water on a watch glass.
2. Put a little amount of lime water in a test tube and cover with a stopper.
3. Leave the set-ups in the open air for about five days and then observe carefully.

Questions

1. What happened to the lime water on the watch glass?
2. What happened to the lime water in the test tube?

Activity 7.2

Aim: To test for the presence of water vapour in air.

Requirements: Watch glass, anhydrous copper(II) sulphate, test tube, and stopper

Procedure

1. Place some anhydrous copper(II) sulphate on a watch glass.
2. Put a little of the anhydrous copper(II) sulphate in a test tube and cover with a stopper.
3. Leave the set-ups in steps 1 and 2 to stay for some time. Record your observations.

Question

What caused the changes you observed in this experiment?

Activity 7.3

Aim: To determine the presence and proportion of oxygen in air.

Requirements: Two syringes of the same size, glass tube, glass wool, copper turnings, and source of heat

Procedure

1. Set up the apparatus as shown in Figure 7.2.

Figure 7.2: *Experimental set-up to show the proportion of oxygen in air*

2. Pass a known volume of air (10 cm^3) from syringe A over heated copper turnings into syringe B that contains no air.
3. Pass the air in syringe B back to syringe A.
4. Repeat the steps 2 and 3 several times until all the copper turnings become black.
5. Allow the apparatus to cool by removing the source of heat.
6. Continue passing the air from one syringe to the other until there is no change in the volume of air.
7. Record your observations as shown in the following table and work out the percentage of the oxygen in, for example, 10 cm^3 of air:

Initial amount of air	10 cm^3
Final amount of air	x cm^3
Amount of oxygen used up in the reaction	$(10 - x)$ cm^3
Percentage of oxygen in 10 cm^3 of air	$\frac{(10 - x)}{10} \times 100$

Question

What is the reason for the changes?

Project

In groups, draw pie charts to illustrate the proportions of the gases that make up air. Make your drawings very neat. The best pie chart should be pinned up in the classroom for reference.

Combustion

Combustion is a chemical reaction that involves the burning of a substance usually in the presence of oxygen. During combustion, energy is produced in the form of heat and light. Combustion can take place in the open or closed systems. An example of an open system is an open fire, and for closed systems are car engine and charcoal making. Materials that catch fire and burn are said to be *combustible*. Different materials are combustible but some burn up faster than others.

Activity 7.4

Aim: To demonstrate how combustion occurs.

Requirements: Pieces of paper, candles, magnesium ribbon, wood, dry grass, large crucible, kerosene, and spirit

Procedure

1. Light the candle and observe how it burns.
2. Take each of the other items, one at a time, and place them in the crucible.
3. Light them up and observe how each burns.

Caution! Fires can cause accidents, and hence safety measures must be observed. Kerosene and spirit should be in very little amounts.

Question

How did the different materials burn?

Applications of combustion

Combustion is applied in many areas including those summarised in Table 7.2. Figure 7.3 also shows some applications of combustion.

Table 7.2: *Some areas and applications of combustion*

Areas	Examples of applications
Laboratories	1. During experiments, for example, flames are used in various ways in chemical reactions. 2. Drying of apparatus, for example glasswares
Homes	1. Combustion of fuels such as natural gas, wood, coal, and kerosene used for household purposes such as cooking and heating 2. Burning of wastes 3. Warming of houses during cold weather
Industries	1. During welding and smelting 2. Incinerators for burning wastes 3. During production of energy in thermal power plants 4. For production of heat which produces steam in large boilers
Transport	In internal combustion engines of vehicles such as cars, aircrafts, ships, motorcycles, and rockets

Cooking

Burning waste/incineration

Boiling

Smelting

Figure 7.3: *Some applications of combustion*

Exercise 7. 1

1. Mention the components of air and their percentages.
2. Air is a mixture and not a compound. Explain.
3. List any five noble gases.
4. Explain the difference between combustion and heating.
5. (a) List down other areas where combustion is applied.

   (b) In each case, mention the combustible materials.

Firefighting

Fire is the state at which an ignited material combines with oxygen and gives off light, heat, and flame. Fire possesses one of the greatest risks to human life. Fatal fires may start accidentally or intentionally and call for measures to combat such fires. *Firefighting* is the extinguishing of harmful fires. Materials which are used to put out fires are called *fire extinguishers*.

Fires can be classified according to the types of materials that burn. For this reason, each type of fire will need appropriate firefighting techniques and materials. The use of a wrong fire extinguisher for a particular fire can result in the fire spreading instead of being put out. Table 7.3 shows the classification of different fires according to the burning materials and the corresponding appropriate extinguishers.

Table 7.3: *Classification of fires and the appropriate extinguishers*

Class	Burning materials	Appropriate fire extinguishers
A	Ordinary solid combustible materials such as paper, wood, and clothing	• Use water • Any type of portable fire extinguisher except carbon dioxide
B	Flammable liquids such as petrol, alcohol, kerosene, and oil-based paints	• If the fire is small, use a fire blanket or sand • If the fire is large, use dry powder, foam or carbon dioxide extinguisher
C	Flammable gases such as butane and propane	• Dry powder extinguisher • Carbon dioxide extinguisher
D	Combustible metals such as magnesium, sodium, and lithium, especially in powder form	• Dry powder extinguisher • Foam extinguisher
F	Cooking oils and fats	• Wet chemical extinguishers

Note: Fires caused by electricity are not given their own full classes as they can fall into any of the classifications. After all, it is not the electricity that burns but the surrounding material that has been set alight by the electric current. Electricity can be a source of any of the fire classes A, B, C, D and F. Normally, the fire caused by an electrical fault is extinguished based on the burning material. Thus, dry powder, carbon dioxide gas, and dry sand can be used to extinguish these fires. Before extinguishing the fire caused by an electrical fault, the main electrical switch should be turned off.

Components needed to start a fire

Heat, oxygen, and fuel are the main components needed to start a fire. The three components are usually referred to as the *fire triangle* as illustrated in Figure 7.4. For a fire to start, a source of ignition (heat), oxygen, and fuel are required in suitable proportions. If any of them is missing, no fire will start or continue burning. Firefighting usually involves eliminating at least one of the three components in the fire triangle. Most firefighting equipment work by cutting off the oxygen supply to the fire to effectively extinguish it.

Note: A fuel is a substance that releases energy when burning. Examples of fuels are wood, charcoal, gas, kerosene, petrol, diesel, and coal.

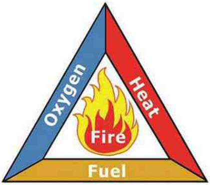


Figure 7.4: *Fire triangle*

Portable fire extinguishers

A portable fire extinguisher is the one that can be easily moved from one place to another. It is usually hung in an upright position in automobiles and on walls of buildings such as schools and public buildings. A portable extinguisher consists of a metal container that contains the extinguishing agent (substance) stored at high pressure. Different portable fire extinguishers are shown in Figure 7.5.

Figure 7.5: *Types of portable fire extinguishers*

Portable fire extinguishers should have ratings or codes on them. This means the extinguisher has a good firefighting capacity for specific classes of fires. Table 7.4 shows the different types of fire extinguishers, the chemical compositions of the extinguishing agents and the classes of fire for which they are either suitable or unsuitable.

Table 7.4: *Chemical composition of the extinguishing agents of different portable fire extinguishers*

Type of fire extinguishers	Chemical composition of agents	Suitable for	Not suitable for
Air pressurised water (APW)	Ordinary tap water pressurised by air	Class A fire	Fire classes B, C, and D (will spread the flame)
Dry chemical (DC)	Fine sodium bicarbonate powder pressurised by nitrogen	Classes A, B, and C fires	Aircraft and electronics fires (corrosive to metals such as aluminium) **Note:** Although it is safe to use indoors, it can obscure vision.
Carbon dioxide	Non- flammable carbon dioxide gas under extreme high pressure	Classes B and C fires, and fire caused by electrical faults	Class A fire (material can re-ignite)
Halon	Bromochloro-difluoro-methane	Class A fire and fire caused by electrical faults	Classes B and C fires (least suitable)
Foam	Proteins and fluoro-proteins	Classes A and B fires	Fire caused by electrical faults
Wet chemical	Potassium acetate	Class F fire	Fires caused by electrical faults
ABC	Monoammonium phosphate with a nitrogen carrier	Classes A, B, and C fires	Fire on electronic equipment

Note: For small class A fire (of combustible solids), water can be used to easily put out the flames. Fires that involve flammable liquids should be put out using sand or fire blanket. These cut off the oxygen supply. Water should never be used to put out class B (flammable liquids) fires since it would spread the flame. Water is denser than flammable liquids, hence when poured, flammable liquids float above it.

How to use a portable fire extinguisher

Portable fire extinguishers should be used in the right ways to quickly put out dangerous fires. The extinguisher should aim at a base part of a flame. Figure 7.6 shows parts of a flame.

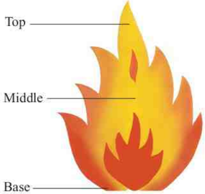


Figure 7.6: *Parts of a flame*

The following are the stages to be followed during putting out fire using a portable fire extinguisher (Figure 7.7).

1. Remove the safety pin

2. Hold the discharge hose of the carbon dioxide gas or dry powder and focus at the base of the fire.

3. Squeeze the top lever to release the extinguishing agent

4. Sweep from side to side until the fire is extinguished.

Figure 7.7: *How to use the portable fire extinguisher*

Precautions

The following precautions should be taken when using portable fire extinguishers:

1. Keep a reasonable distance (at least 1.5 metres) from the fire as it may suddenly change direction.
2. For a person on fire, use a fire blanket instead of portable fire extinguisher.
3. Do not test a portable fire extinguisher at your school without permission.
4. Do not return a used portable fire extinguisher to the wall.
5. When a fire gets out of control, abandon it and notify the nearest firefighting squad (fire brigade).

Activity 7.5

Aim: To extinguish small fires using the appropriate fire extinguisher.

Requirements: Large crucible, sand bucket, portable fire extinguishers such as carbon dioxide and wet chemical fire extinguishers, combustible materials such as kerosene, paper, candle, and cooking oil

Procedure

1. Put some pieces of paper in a large crucible.
2. Light them carefully. This should be done in outdoors under supervision of your teacher or laboratory technician.

   Caution: Fire can cause accidents, therefore, safety measures must be observed.
3. Use the right fire extinguisher to put out the fire.
4. Repeat the steps 1, 2, and 3 using different combustible materials, one at a time.

Questions

1. Did you use the right fire extinguisher to put out each fire? What did you observe?
2. Why is water not suitable for extinguishing fires caused by flammable liquids?

Exercise 7. 2

1. What is fire?
2. Suppose a truck carrying kerosene gets an accident, and unfortunately fire breaks out, suggest;
   (a) the suitable fire extinguisher to use.
   (b) the fire extinguisher not suitable for use.
3. State the burning materials in each of the following classes of fire:
   (a) Class A
   (b) Class B
   (c) Class C
4. A form one student reads a statement from a certain book that, "if the clothes worn by your friend catch fire, cover them with a fire blanket". Why a fire blanket is to be used in that case?

Rusting

Rusting is a chemical process that occurs on the surface of iron materials and forms a reddish-brown coating. The reddish-brown coating is called *rust*. Figure 7.8 shows rusted iron sheets.

Figure 7.8: *Rusted iron sheets*

Conditions necessary for rusting

There are three conditions that are necessary for rusting to take place, namely iron, oxygen and water. Therefore, rusting occurs only when iron is exposed to air containing oxygen and water. This reaction can be expressed as:

$$\text{Iron} + \text{Water} + \text{Oxygen gas} \longrightarrow \text{Rust}$$

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Activity 7.6

Aim: To demonstrate conditions necessary for rusting of iron nails.

Requirements: Iron nails, oil, cotton wool, four test tubes, water, and anhydrous calcium chloride

Procedure

1. Label four dry test tubes, A, B, C, and D.
2. Put two new iron nails in each test tube.
3. Insert some cotton wool in test tube A and add about 5 cm^3 of tap water to make the cotton wool wet.
4. Add about 10 cm^3 of boiled tap water to test tube B followed by 3 cm^3 of oil.
5. Insert some cotton wool in test tube C and place some crystals of anhydrous calcium chloride on the cotton wool.
6. Do not put anything in test tube D except nails.
7. Leave the set-up as shown in Figure 7.9, open to the air for three days.

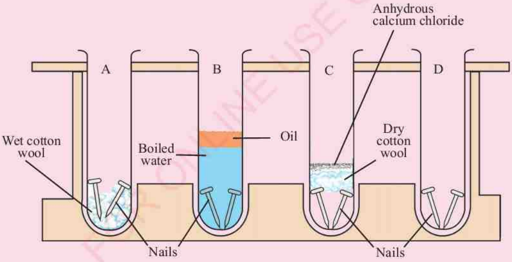


Figure 7.9: *A set-up to demonstrate the rusting of iron nails*

Questions

1. What was observed in each test tube after three days?
2. Why was the water in the test tube B boiled, then covered with oil?
3. What was the function of anhydrous calcium chloride in test tube C?
4. From the results of the experiment, state the conditions necessary for rusting to occur.

Methods of preventing rusting

Rusting can cause harm to iron materials. To prevent iron from rusting, we should ensure that both air and water do not come into contact with the iron. Some of the methods which are used to prevent rusting include; painting, oiling, galvanising, tin plating, and use of silica gel.

Painting

This is the coating of substances such as metals with a special pigment or paint. Items that are made of iron are usually painted to make them last longer. The paint coating prevents oxygen and water from coming into contact with the iron material. Figure 7.10 shows painted metal pipes.

Figure 7.10: *Painted metal pipes*

Oiling

This involves coating iron with oil. Some machine parts can be protected from rusting by oiling regularly or keeping in oil as shown in Figure 7.11.

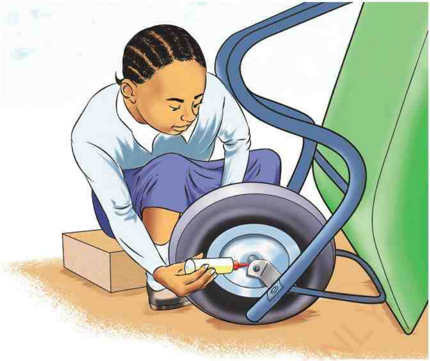


Figure 7.11: *Oiling machine parts*

Galvanisation

This is the process of coating iron material or steel with zinc. Zinc protects iron by reacting with oxygen to form an impermeable coat of zinc oxide. Figure 7.12 shows galvanised iron sheets.

Figure 7.12: *Galvanised iron sheets*

Tin plating

This is the coating of iron material with tin. Tin cans (Figure 7.13) are made of iron, but their inside walls are coated with a thin layer of tin. This makes them suitable for canning of foods.

Figure 7.13: *Tin cans*

Use of silica gel

Silica is a chemical containing silicon found in sand and rocks. Silica gel is a substance in the form of grains, and it absorbs moisture. Some fragile instruments such as cameras have iron and steel parts. These cannot be protected by painting, oiling, galvanising or even tin plating. Most often, a small bag of silica gel as shown in Figure 7.14, is put inside the bag carrying the instrument to absorb any moisture that may cause rusting.

Figure 7.14: *Silica gel*

Sacrificial anode

In this method, a more reactive metal than iron is attached to the protected material and will be consumed in favour of it. Therefore, it requires regular replacement for the protection to be maintained.

Exercise 7. 3

1. When iron sheets are exposed to wet air for a long time, they turn brown in colour. Explain.
2. Why are commodities like hand bags and camera bags for sale packed with silica gel?
3. Explain the effects of rusting in your environment.

Chapter summary

1. Air is a colourless homogeneous mixture of gases in the atmosphere.
2. The main components of air are nitrogen, oxygen, carbon dioxide, and noble gases.
3. Combustion is a chemical reaction that involves the burning of a substance usually in the presence of oxygen.
4. The components needed to start fire are fuel, oxygen, and heat.
5. Fire is the state of combustion in which ignited materials combine with oxygen to give off light, heat, and flame.
6. Firefighting is the extinguishing of hazardous/harmful fires.
7. Rusting is a chemical process that occurs on the surface of iron materials in the presence of oxygen and water.
8. In order for rusting of iron to occur, water (moisture) and oxygen must be present.
9. Methods of preventing rusting include painting, oiling, galvanisation, tin plating, and use of silica gel.

Revision exercise 7

Choose the correct answer in items 1–5.

1. Which term describes a rapid chemical reaction that releases energy in the form of light and heat?
   (a) Ignition
   (b) Reactivity
   (c) Combustion
   (d) Heating

2. What is the percentage composition of oxygen in air?
   (a) 7.8%
   (b) 21%
   (c) 78%
   (d) 2.1%

3. What type of fire is caused by burning of cooking oils and fats?
   (a) Class A
   (b) Class F
   (c) Class B
   (d) Class C

4. What type of fire occurs over the surface of flammable liquids?
   (a) Class A
   (b) Class C
   (c) Class B
   (d) Class D

5. The fire triangle consists of heat, fuel, and
   (a) carbon.
   (b) nitrogen.
   (c) hydrogen.
   (d) oxygen.

6. Fill in the blanks in the following statements:

   (a) Iron, _______, and _______ are necessary for rusting to take place.

   (b) Combustion is a chemical reaction between a substance and usually oxygen to produce heat, ______, and ______.

   (c) The process of coating iron or steel with zinc is known as______.

   (d) An APW fire extinguisher contains________ pressurised with______.

   (e) Materials that catch fire and burn easily are called ______.

7. Match each item from column A with its corresponding item in column B.

Column A	Column B
(a) Class F fire	(i) Coating iron material or steel with zinc
(b) Combustibles	(ii) Fire caused by flammable gas
(c) Rust	(iii) A gas with the highest percentage by volume in air
(d) Nitrogen	(iv) Refers to components needed to start a fire
(e) Fire triangle	(v) Materials that produce heat on burning
(f) Galvanising	(vi) Fire resulting from burning fats and oils
(g) Class C fire	(vii) Reddish-brown coating on iron material exposed to moisture
	(viii) Fire caused by flammable liquids
	(ix) A gas necessary for iron to rust

8. What are the four main components of air?

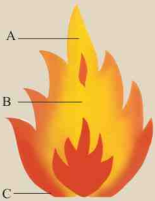
9. What are the similarities and differences between combustion and rusting?

10. Briefly explain four methods used in preventing rusting of iron materials.

11. State the chemical composition of the extinguishing agents of each of the following portable fire extinguishers:

(a) Dry chemical extinguisher
(b) Carbon dioxide extinguisher
(c) Wet chemical extinguisher
(d) ABC extinguisher
(e) Foam extinguisher

12. A student wants to put out a hazardous fire, whose flame is shown in the given diagram.



(a) State which part of the flame should the student aim to extinguish the fire.
(b) Why is it not advisable to aim at the other two positions of the flame?

13. A student was preparing food for the family using hot oils on a frying pan. Accidentally, the pan tipped over and a huge fire spread on the kitchen floor.
(a) Which fire extinguishers would be suitable for putting out the fire? Explain.
(b) Which fire extinguishers would not be suitable for putting out the fire? Explain.

14. With the aid of diagrams, illustrate how a portable fire extinguisher should be used.

15. Why is it not advised to use water for extinguishing classes B and C fires?

Glossary

Aerosol	Is a suspension of fine solid particles or liquid droplets in air or another gas.
Analysis	The process of examining data in detail so as to understand it.
Analytical chemistry	Is concerned with studies and uses of instruments and methods used to separate, identify, and quantify matter.
Apparatus	A special tool or equipment used in a laboratory.
Artificial	Man made, not natural.
Atmosphere	The layers of gases surrounding a planet or other celestial body.
Barrel	Is a cylindrical tube, forming part of an object such as a Bunsen burner.
Beaker	A cylindrical glass or plastic container used for holding and mixing liquids. The glass beaker is also used for heating.
Boiling point	The temperature at which a liquid changes to a gas (vapour) at standard atmospheric pressure.
Brownian motion	The random movement of particles in a liquid or gas.
Bunsen burner	A small adjustable gas burner used in laboratories.
Chemical change	A change that affects the chemical properties of substances in which new products are formed.
Chemical process	Is a method or means of changing one or more chemical compounds. Such a chemical process involves chemical reactions.
Chemical symbol	Representation of an element using letters.
Chemical safety signs	Safety symbols found on chemical containers or places where hazardous chemicals are found.
Chemist	A scientist who studies chemistry.
Chemistry	A branch of science that deals with the composition, structure and properties of matter.
Chromatography	The process of separating the components of a mixture by passing it in solution or suspension

	through a medium in which the components move at different rates.
Collar	A band near the base of a Bunsen burner that can be rotated to control air supply to the burner.
Combustible	Ignites and burns easily.
Combustion	The burning of a substance usually in the presence of oxygen.
Compound	A substance that consists of two or more elements that are chemically combined.
Compression	The action of being condensed or reduction in volume.
Conclusion	A summary of the results of an experiment.
Condensation	The cooling of vapour or gas to form liquid.
Contaminant	Any potentially harmful substance in the environment.
Controlled variable	The factor in an experiment that is kept constant and does not affect the outcomes of the experiment.
Cosmetics	Products used for cleansing, beautifying, promoting attractiveness or altering one's appearance.
Data	Information that is analysed so as to make decisions after experimentation.
Decantation	Process of carefully pouring a liquid from a container, leaving the sediments at the bottom of the container.
Decomposition	The breaking down of a chemical compound into elements or smaller compounds.
Dependent variable	The factor in an experiment that changes its value as other variables change.
Detergent	A liquid or solid compound or mixture of compounds used for cleaning.
Diffusion	The movement of particles from an area of high concentration to one of low concentration.
Disinfect	To make clean and free from infections, especially by use of chemical substances.

Distillation	The process of separating a liquid mixture into its components by boiling it to evaporation, then condensing the resulting vapour to obtain one of the components.
Element	A pure substance that cannot be split into simpler substances by a simple chemical process.
Emulsion	A mixture of liquids that do not dissolve each other or mix well.
Evaporation	The process of turning from a liquid to a vapour or gas.
Experiment	A scientific procedure undertaken to make a discovery, test a hypothesis or demonstrate a known fact.
Fertilisers	Chemicals or natural substances added to soil to increase its fertility.
Fire extinguisher	An apparatus used to put out fire.
Fire triangle	The three components that must all be present for fire to start.
First Aid	Help given to a sick or injured person until professional medical help is available.
First Aid kit	A box that contains items used to give help to sick or injured person.
Flame	A region of burning gases that produces heat and light.
Fractionating column	Apparatus used in the distillation of liquid mixtures to separate them into their components or fractions.
Fume chamber	A ventilated enclosure in a laboratory in which potentially harmful experiments are done to limit exposure to dangerous fumes.
Gas	A fluid (not a liquid) with no definite shape or volume, but that is able to expand indefinitely.
Hazard	Something that could be dangerous or could cause damage.
Heat	The condition of being hot.
Heat energy	The energy supplied to particles of matter and that results in an increase in temperature and a faster movement of particles.

Heimlich manoeuvre	A First Aid procedure for dislodging an obstruction from a person's throat. Repeated thrusts are applied to the abdomen, near the top of the stomach.
Heterogeneous	Non-uniform in composition, appearance, and properties.
Homogeneous	Uniform in composition, appearance, and properties.
Hydrated	Containing water molecules in its chemical structure.
Hypothesis	A possible explanation to a scientific question.
Immiscible	Not mixing well or not forming a homogeneous mixture when mixed.
Independent variable	The factor in an experiment that is manipulated or changed to obtain different value (s) for comparison.
Inorganic chemistry	Is concerned with properties and behaviour of inorganic compounds. Example of inorganic compounds are water and salts.
Interpretation	An explanation of the meaning or importance of something.
Kinetic molecular behaviour	The manner in which particles in matter behave.
Laboratory	A special room or building used for scientific experiments.
Liquefy	To make or to become liquid.
Liquid	A fluid (not a gas) with a definite volume, but that takes the shape of the container holding it.
Luminous flame	The yellow flame of a burner that has a limited supply of oxygen and which produces soot.
Mass	A measure of the quantity of matter in an object.
Matter	Anything that has mass and occupies space.
Melting point	The temperature at which a solid changes to a liquid at standard atmospheric pressure.
Metal	A hard, usually shiny, material that is a good conductor of heat and electricity.
Miscible	Capable of being mixed very well.

Mixture	A physical combination of two or more substances in any ratio.
Molecule	Is a group of two or more atoms held together by chemical bonds.
Non-luminous flame	The blue flame of a burner with an adequate supply of oxygen and which produces more heat than the luminous flame.
Organic chemistry	Is the area of chemistry that studies carbon compounds.
Particulate matter	Relating to or in the form of very tiny particles.
Pharmacy	A facility or location where drugs and other medical services are sold or dispensed. Or, the science or practice of the preparation and dispensing of medical drugs.
Physical change	A change that affects only the physical properties of a substance.
Physical chemistry	A branch of chemistry concerned with the way in which the physical properties of substances depend on and influence their chemical structures, properties and reactions.
Problem	A scientific question to be answered.
Properties	A set of attributes or settings that are used to describe an object.
Reagent	A substance that takes part in a chemical reaction.
Recovery position	A position used to prevent an unconscious person from choking. The body is placed such that the face is downwards and slightly to the side supported by bent limbs.
Resuscitate	To revive an unconscious person.
Rust	A reddish-brown substance that forms on the surface of iron materials due to a chemical reaction with water and air.
Saturated	A solution that contains as much solute as it can dissolve at a particular temperature.
Scientific method	The organised set of guidelines used in science to answer questions or solve problems.

Shock position	A position used when a person experiences shock. The person lies on the back with the legs elevated about 8-12 inches above the head to help blood flow to the heart.
Solid	A substance that has a definite shape and volume.
Solubility	The degree to which a substance dissolves in a solvent to make a solution.
Solute	The component of a solution that is dissolved in the solvent.
Solution	A homogeneous mixture of two or more substances in which one of the substances is a solvent and the other is a solute.
Solvent	The component of a solution that dissolves the other substance(s).
Solvent extraction	Separation of compounds from materials using liquids in which they are soluble.
Soot	A black substance produced by the incomplete burning of matter.
Spirit lamp	A lamp that burns volatile spirits used in some laboratories for heating purposes.
Sublimation	The change of state of matter from solid directly to gas.
Suspension	A heterogeneous mixture of a liquid and finely divided solids in which the solids do not dissolve in the liquid but are suspended in it.
Temperature	The degree of hotness or coldness of a body or an environment which can be measured using a thermometer.
Thermometer	An instrument used for measuring temperature.
Vaccine	A substance used to provide immunity against one or several diseases.

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Appendix

Below are the safety signs that can be found in the laboratory. These safety signs must be obeyed to ensure all activities are carried out safely in the laboratory.

 No entry	 Explosive	 High voltage	 Unsafe water
 No smoking	 Corrosive	 Health hazard	 Exit
 Caution	 Flammable/ inflammable	 Strong radiation	 Eye protection required
 Fragile	 Toxic	 Biohazard	 Eye and face protection required

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