MINISTRY OF EDUCATION

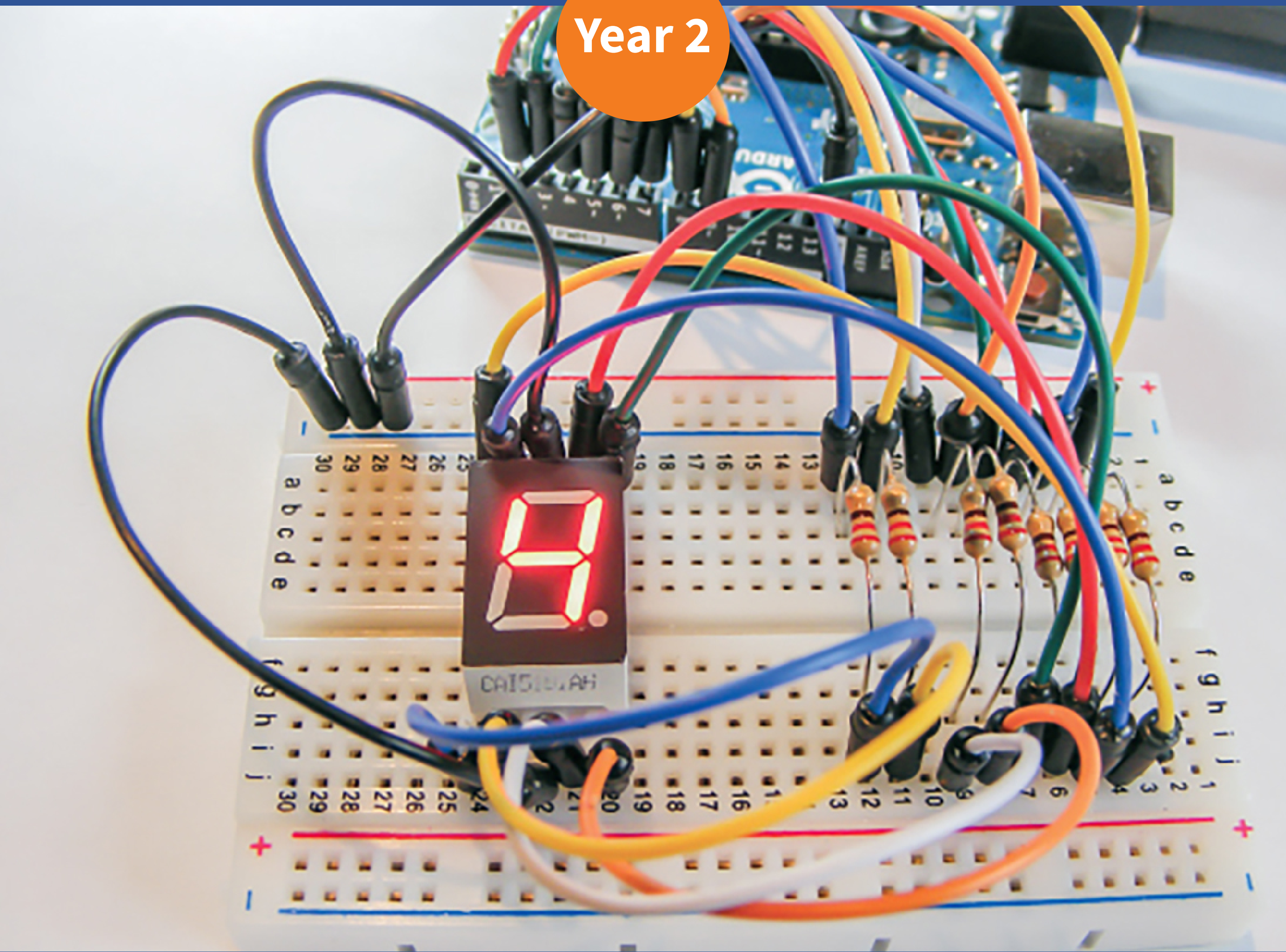
GHANA ASSOCATION OF SCIENCE TEACHERS

(GAST)

General Science

for Senior High Schools

Year 2



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Ghana Education Service (GES)

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CONTENTS

FOREWORD

Ghana's new Senior High School Curriculum aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, knowledge, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, progress to further studies and enter the world of work. This is the first time that Ghana has developed a Senior High School Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

The Ministry of Education is proud to have overseen the production of these Learner Materials which can be used in class and for self-study and revision. These materials have been developed through a partnership between the Ghana Education Service, teacher unions (Ghana National Association of Teachers-GNAT, National Association of Graduate Teacher -NAGRAT and the Pre-Tertiary Teachers Association of Ghana- PRETAG) and National Subject Associations. These materials are informative and of high quality because they have been written by teachers for teachers with the expert backing of each subject association.

I believe that, if used appropriately, these materials will go a long way to transforming our Senior High Schools and developing Ghana so that we become a proud, prosperous and values-driven nation where our people are our greatest national asset.

Haruna Iddrisu MP

Minister for Education

SECTION

1 NATURE OF DIFFERENT LIQUIDS IN LIFE

EXPLORING MATERIALS

Science and Materials in Nature

INTRODUCTION

In this section, you will learn about acids, bases, and how they interact with water. Acids are substances that release hydrogen ions (H^+) and usually taste sour, like lemon juice. Bases accept hydrogen ions or release hydroxide ions (OH^-) and can feel slippery, like soap. Water is neutral and can act as both an acid and a base. We use the pH scale to measure how acidic or basic a solution is, ranging from 0 (strong acid) to 14 (strong base), with 7 being neutral. You'll also learn how acids and bases react to form salts, which are important in everyday products like table salt and fertilisers. Finally, we'll discuss how to measure the concentration of solutions and why controlling pH is important in fields such as agriculture, medicine, and manufacturing.

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

- differentiate among acids, bases and water.
- apply the knowledge of acids and bases in analysing the formation of salts and their uses.
- describe how to measure the concentration of solutions and how to use the pH scale to identify the concentration of acids and bases/alkalis.

KEY IDEAS

- Acids release hydrogen ions (H^+) in water, taste sour, turn blue litmus red whilst Bases accept H^+ ions or produce hydroxide ions (OH^-) in water.
- Neutralisation involves the reaction between acid and base to form salt and water only.
- Molarity (M) measures how strong a solution is (moles per litre), important for controlling acid/base strength. In determining how concentrated solution, consider purpose of solution, types of solution, properties and dilution requirement

- pH Scale helps determine hydrogen ion concentration and ensures product safety and effectiveness.
- Acid-base Indicators are substances used to determine is acidic, basic, or neutral state of a substance
- Acids and bases are used in cleaning products, food preparation, medicine, farming, water treatment, and chemical manufacturing.

ACIDS, ALKALIS/BASES AND WATER

Acids

Let us do this activity to explain what an acid is.

Activity 1.1 Explanation of Acid

Materials needed: lemon juice or vinegar (an acid), water, beaker or clear glass or plastic cup, a spoon and drinking straw(s).

Steps:

1. Half-fill the beaker, clear glass, or plastic cup with water and add one spoonful of lemon juice or vinegar.
2. Dip the drinking straw in the mixture (water and lemon juice or vinegar) and have a taste.
3. If using litmus paper, dip it in the mixture (water and lemon juice or vinegar) to see the colour change.
4. What did you observe?

a. The taste of the water becomes sour

b. Blue litmus paper turns red.

5. Draw your conclusion: example, acids release hydrogen ions (H^+) when they dissolve in water. This is the reason the taste of the water changed and turned blue litmus paper red.

Safety Precautions

1. Do not drink the water.
2. If using a drinking straw, each of you must have one drinking straw.

Acids release hydrogen ions (H^+) when they dissolve in water due to the way their molecules interact with water molecules.

- Acids are made up of molecules that contain hydrogen atoms. For example, hydrochloric acid (HCl) has hydrogen (H) and chlorine (Cl) in its molecule, and vinegar has acetic acid (CH_3COOH).
- When you add an acid to water, the acid molecules start to separate or dissociate. For example, when you put hydrochloric acid (HCl) in water, it breaks apart into hydrogen ions (H^+) and chloride ions (Cl^-): $HCl \rightarrow H^+ + Cl^-$
- The hydrogen ions (H^+) are what make the solution acidic.
- These H^+ ions are very small and have a positive charge. When there are a lot of them in the water, the solution becomes more acidic. The more hydrogen ions (H^+) that are released, the more acidic the solution gets.
- Acids release these H^+ ions easily, which is why they taste sour, can corrode metals, and can cause a burning feeling on the skin when they are concentrated.
- Acids can be classified into organic and inorganic depending on their composition and origin (source).

Organic And Inorganic Acid

Organic Acid: The word "organic" means natural or from living things. Organic acids are acids that come from living things (plants and animals) and contain carbon in their chemical structure. Organic acids are usually found in fruits, vegetables, and other natural sources. — See ***Table 1.1*** and ***Figure 1.1***

Table 1.1: Some organic acids and their sources

Organic acid	Source
Formic acid	Bees (sting)
Lactic acid	Milk/ Yoghurt
Citric acid	Unripe lemon and grapefruit
Palmitic acid	Palm oil
Amino acid	Eggs, meat

Organic acid	Source
Acetic acid	Vinegar
Salicylic acid	Aspirin
Tartaric acid	Grapes
Ascorbic acid	Citrus fruit
Stearic acid	Fats; shea butter, cocoa butter

Figure 1.1: Sources of Organic Acids

Inorganic Acid: The word "inorganic" means not from living things. Inorganic acids are acids that do not come from living things. They are usually made from minerals and do not always contain carbon. These acids are often used in laboratories, factories, and even in car batteries. — See ***Table 1.2*** and ***Figure 1.2***

Table 1.2: Inorganic acids and their formulae

Mineral / inorganic acid	Source
Hydrochloric acid (HCl)	Gastric juice in the stomach
Sulphuric acid (H_2SO_4)	Sulphur dioxide released by volcanoes and industrial processes
Nitric acid (HNO_3)	Forms in the atmosphere during thunderstorms and is a component of acid rain
Phosphoric acid (H_3PO_4)	Present in rainwater, carbonated drinks such as Coca-Cola, Fanta, Bell-cola

Figure 1.2: Sources of inorganic acids

Activity 1.2 Try Work on Organic and Inorganic Acids

Instruction: Write down your answer in your notebook for future reference.

1. Classify the following substances into the table provided below:

   Lemon slices, orange slices, parazone, diluted sulphuric acid solution, vinegar (acetic acid), carbonated drinks, yoghurt, diluted HCl solution.

Organic acids	Inorganic acids

2. What are the reasons for the classification in the above table?

Properties of Acids

Acids have certain characteristics, also known as properties, which make them different from other substances. These properties can be physical and chemical.

Let us find out how acid tastes through an activity!

Activity 1.3 Physical Properties of Acid

Materials needed: five beakers or cups, lemon juice or fruit, vinegar, orange juice or fruit, tomato juice or fruit and pineapple fruit or juice.

Steps:

1. Pour each substance into each beaker and label them clearly. If using the fruit, squeeze the juice into each beaker or cup.
2. Taste a drop of each substance in each beaker or cup.
3. Dip litmus paper in each substance of each beaker or cup.
4. Add water to each substance in each beaker or cup.
5. Record your findings in your notebook for future reference.
6. Now, answer these questions:
   a. Describe the taste of each substance.
   b. Copy and complete the table below:

Substance	Effect of substance on litmus paper (colour change)	
	Blue litmus paper	Red litmus paper
Lemon juice		
Tomato juice		
Orange juice		
Vinegar		
Pineapple juice		

   c. How does the mixture of water and each substance taste?
   d. Give reason to support your answer in question (c) above.
   e. From the activity list two physical properties of acid.

Safety Precautions

1. Label the beakers clearly to avoid mixing the substances up.
2. Wash hands with soap and water after the experiment.

Summary of the physical properties of acid you should know:

1. Acid solutions that are diluted taste sour.
2. Acids have a pH level less than 7.
3. Many acids are corrosive.
4. Acids change blue litmus paper to red

Chemical Properties of Acids

Imagine you have a stomach-ache because your stomach has too much acid in it, which makes you feel a burning sensation. If you take an antacid tablet, which is a base, the base in the tablet will react with the acid in your stomach. The acid and the base cancel each other out, forming salt and water, which makes your stomach feel better. This is called neutralisation reaction. Let us explore another activity!

Activity 1.4 Neutralisation reaction

***Materials needed*:** beaker, test tube, vinegar and baking soda.

Steps:

1. Pour some vinegar in the test tube.
2. Add the baking soda to the test tube containing vinegar and mix.
3. Dip litmus paper into the product formed in the test tube after the reaction.
4. Write your observation and conclusion in your notebook.
5. Record your answers to the following questions in your notebook:
   a. Name the products formed.
   b. What effect does the product formed have on litmus paper?

Safety Precautions

1. Do not eat the product formed.
2. Wash your hands with soap properly after the experiment.

Activity 1.5 Testing of Conductivity of Acidic Solution.

Instruction: This activity should be conducted under the supervision of your teacher or laboratory technician in the laboratory.

***Materials needed*:** battery (6V), light bulb or LED, wires with clips iron nails or metal strips, beaker, distilled water, dilute hydrochloric acid (HCl) solution or vinegar solution and a switch.

Steps:

1. Connect the battery, light bulb, and iron nails or metal strips in a circuit.
2. Place the iron nails or metal strips in a beaker of distilled water and observe what happens.

3. Add some dilute hydrochloric acid (HCl) to the water to form solution.
4. What can you observe? When you dip the electrodes into the acid solution, the light bulb will light up.
5. Draw a conclusion for this activity: This shows that the acid solution can conduct electricity because there are now ions (H^+ and Cl^-) that allow electricity to pass through. — See ***Figure 1.3*** for a set-up.

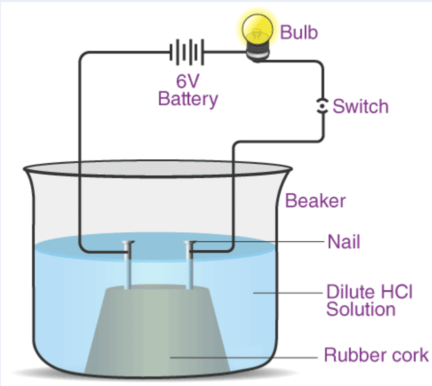


Figure 1.3: Setup of testing conductivity of acid

Summary of some chemical properties of acids:

1. Strong acids can conduct electricity when they are dissolved in water because they release ions that allow electric current to pass through the solution.
2. They also react with bases in a process called neutralisation, where they combine to form salt and water. Example: $HCl + NaOH \rightarrow NaCl + H_2O$

   Acid + Base → Salt + Water
3. Dilute acids react with metallic salts (carbonates) to form salts, water, and Carbon dioxide. Example, $H_2SO_4 + CuCO_3 \rightarrow CuSO_4 + H_2O + CO_2$

   Acid + metallic salt → Carbonate + water + carbon dioxide
6. They react with metals to produce hydrogen gas. Example, $Zn + 2HCl \rightarrow ZnCl_2 + H2$

Uses of Acids in Everyday Life

1. Nitric acid and phosphoric acid are used in the production of fertilisers to help crops grow better.
2. In batteries, sulphuric acid is widely utilised.
3. Many soft drinks contain phosphoric acid as the main ingredient.
4. Sinks and sanitary ware are also cleaned with hydrochloric acid.

5. Sulphuric acid and hydrochloric acid are commonly used in laboratories for chemical experiments and to test materials.
6. Acetylsalicylic Acid (Aspirin) is a common pain reliever and anti-inflammatory drug.

Bases

For easy understanding of basic substances, let us take up an activity!

Activity 1.6 Explanation of Bases or Alkali

Materials needed: baking soda (sodium bicarbonate), soap or liquid detergent, water, small cups or bowls, stirring sticks or rods, paper towels and cotton swabs (for tasting).

Steps:

1. Set up the samples and test the slippery feel.
   a. Pour a small amount of baking soda into a cup and add water to make a solution. Stir well until it dissolves.
   b. In another cup, mix a little bit of liquid soap with water.
   c. Dip a finger into the soap solution and rub it between their fingers.
2. Conclusion: When water mixes with soap, it reacts with water to create a slippery feel. This is because soap is an alkali or base that produces OH^- ions in water.
3. Testing the bitter taste (optional and safe):
   a. Dip a cotton swab into the baking soda solution.
   b. Gently touch it to the tongue.
4. Write your answers in your notebook.
   a. How does the baking soda solution taste?
   b. Look at your environment and write down some common household bases.
   c. How does the soap solution feel between your fingers?
5. Conclusion: A mild bitter taste indicates that the baking soda solution is a base or basic.

Safety Precautions

1. Do not taste any you come across, because some can be harmful.
2. Each of you must use a paper towel for the tasting test.
3. Wash your hands with water and soap after handling the solutions.

Bases produce hydroxide ions (OH^-) when they dissolve in water. These ions make the solution basic or alkaline, just like how acids produce hydrogen ions (H^+) to make a solution acidic.

Common household bases: Baking soda (Sodium Bicarbonate), ammonia, washing soda (Sodium Carbonate), soap, detergents, toothpaste, milk of Magnesia, shampoo, chlorine bleach, chalk (Calcium Carbonate).

Organic and Inorganic Bases

Organic bases are obtained naturally from plants and animals. They produce KOH (Potassium hydroxide). The decomposition of organic matter produces NH3 (ammonia). Examples: Petre, wood ash, cocoa peels, wasp stings.

Inorganic bases are bases prepared in the laboratory. Examples: KOH (Potassium hydroxide), NH4OH (ammonium hydroxide), Ca $(OH)_2$ (Calcium hydroxide).

Activity 1.7 Try Work on Organic and Inorganic Base

1. Classify the following substances into the table provided below: Petre, wood ash, Potassium hydroxide, cocoa peels, wasp stings, ammonium hydroxide, Calcium hydroxide.

Organic bases	Inorganic bases

2. What are the reasons for the classification in the above table?
3. Write down your answers in your notebook for future reference.
4. Share your result with a friend and educate them on the organic and inorganic bases.

Physical Properties of Bases

Remember in activity 1.6, you explored the taste of basic solutions and how basic substance feels when rubbed between fingers. Let us now look at how bases react with litmus paper as a property.

Activity 1.8 Physical Properties of Base

Materials needed: baking soda (sodium bicarbonate), lime water (calcium hydroxide solution) or household ammonia (diluted), water, three clear cups or beakers and red litmus paper.

Steps:

1. Label three cups as A, B, and C.
2. Pour water into each cup.
3. In Cup A, add a small amount of baking soda.
4. In Cup B, pour some lime water or ammonia.
5. Leave Cup C as just water (control sample).
6. Use stirring sticks to mix the substances in Cups A and B until they dissolve.
7. Dip red litmus paper into Cups A, B, and C.
8. Record your observations in your note for future reference.
9. Now, answer the following questions in your note:
   a. Copy and complete the table below:

Substance	Effect of substance on red litmus paper (colour change)	
Baking soda solution		
Lime water or ammonia		
Water		

   b. Give the reason for your answer recorded in the table above.
   c. From the activity, list two physical properties of base.

Explanation

- Baking soda and lime water (or ammonia) turned the red litmus paper blue and showed a basic pH on the indicator. This tells us they are bases.
- Water did not change the colour because it is neutral.

Why did this happen?

- When bases dissolve in water, they release hydroxide ions (OH^-) into the solution.
- Hydroxide ions (OH^-) are what make the solution basic. The more OH^- ions there are, the stronger the base.
- This is why baking soda and lime water can make the red litmus paper turn blue; they produce OH^- ions in water, which are basic.

What is the role of water?

Water helps dissolve the base and allows it to release the hydroxide ions. That's why these substances only become basic when they are mixed with water.

Some physical properties of base

1. Bases have a bitter taste. For example, baking soda and soap taste bitter.
2. They feel slippery or soapy when touched. This is because bases react with the natural oils on the skin.
3. Many bases, like sodium hydroxide ($NaOH$), are solid at room temperature, while others, like ammonia, are usually found in a dissolved, liquid form.
4. Bases turn red litmus paper blue.
5. They also turn phenolphthalein (a chemical indicator) pink.

Chemical properties of bases

1. Bases react with acids in the neutralisation reaction of salt and water.

   Example.

   $HCl + NaOH \rightarrow NaCl + H_2O$

   Acid + Base → Salt + Water

2. Bases and alkalis react with ammonium salt on heating to produce ammonium gas.

   Example.

   $NaOH + (NH4)_2SO_4 \rightarrow Na_2SO_4 + 2NH_3$
3. Bases do not react with metals like acids do
4. Bases conduct electricity when dissolved in water.

Activity 1.9 Testing Conductivity of Basic Solution

Materials needed: two small containers (like beakers or cups), distilled water, baking soda or liquid ammonia (as the base), battery, wires, light bulb or LED, stirring stick and measuring spoon.

Steps:

1. Container one: Fill it with pure water.
2. Container two: Fill it with water, then add a spoonful of baking soda or a few drops of liquid ammonia. Stir until it dissolves.
3. Connect a simple circuit using a battery, wires, and a small light bulb (or LED).
4. Make sure the setup works by testing it with a piece of metal to ensure the bulb lights up.
5. Place the ends of the wires that are connected to the light bulb into the container with pure water.
6. Observe what happens. Example, the light bulb should not light up because pure water does not conduct electricity well.
7. Place the ends of the wires into the container with the baking soda or ammonia solution.
8. Observe what happens. Example, the light bulb should light up, showing that the solution can conduct electricity.
9. Record your observations in your notebook.
10. Research and explain the observation you recorded above: Write down your findings in your notebook

Uses of Base in Everyday Life

1. Baking soda (Sodium Bicarbonate) - used in cooking, cleaning, and as an antacid.
2. Ammonia - found in glass and surface cleaners.
3. Washing soda (Sodium Carbonate) - used in laundry detergents.
4. Soap - for washing hands, dishes, and clothes.
5. Detergents - used for cleaning clothes and surfaces.
6. Toothpaste - helps clean and protect teeth.
7. Milk of Magnesia - a medicine that neutralises stomach acid.
8. Shampoo - cleans hair and can have mild basic properties.
9. Chlorine Bleach - disinfects and whitens clothes.
10. Antacids - relieve indigestion and heartburn.
11. Chalk (Calcium Carbonate) - sometimes used for writing or as a mild abrasive.

Water

Role of water in the dissociation of acids and bases

In our previous activities, six and nine, water played a role in both acidic and basic solutions, making it good electrical conductivity.

Now, let us examine the role of water in the dissociation of the bases and acids!

1. Water plays a key role in the dissociation of acids and bases, which means breaking them apart into smaller parts called ions. When an acid, like hydrochloric acid (HCl), is added to water, it separates into hydrogen ions (H^+) and chloride ions (Cl^-). These hydrogen ions give acids their sour taste and make them conduct electricity.

   Similarly, when a base, like sodium hydroxide (NaOH), dissolves in water, it splits into sodium ions (Na^+) and hydroxide ions (OH^-). These hydroxide ions make the solution feel slippery and help it conduct electricity. Hence, without water acids and bases would not release these ions, so they would not show their usual acidic or basic properties. This is why water is important; it allows acids and bases to dissociate, letting them act in their usual ways. — See ***Figure 1.4***.

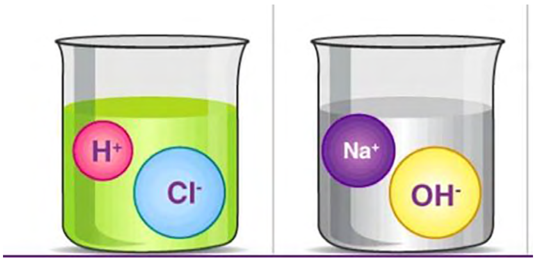


Figure 1.4: Dissociation of Acid and Base in Water

For example, when a dry strip of blue litmus paper is brought near a test tube containing dry hydrogen chloride (HCl) gas, it won't change colour. This shows that there are no hydrogen ions (H^+) present in the dry gas. However, if you moisten the litmus paper with water and then bring it near the gas, the paper turns red. This happens because HCl gas dissolves in water to form H^+ ions, which makes it acidic. Without water, these ions don't form. The same thing happens with bases. If you take a dry piece of solid sodium hydroxide (NaOH) and bring a dry strip of red litmus paper close, there is no colour change. This is because the sodium hydroxide (NaOH) is a hygroscopic compound, which means it can absorb moisture from the air and become wet. When this happens, OH^- ions are released, and the red litmus paper turns blue, showing the basic nature of NaOH. Without water, the OH^- ions are stuck in the solid and don't show any basic properties.

2. Heat-releasing dissolution (Exothermic reaction): When an acid (like sulfuric acid) or a base (like sodium hydroxide) is dissolved in water, the solution becomes hot. This means that the dissolution process releases energy (it is exothermic). A part of this energy is used to break the bonds in the acid or base, which releases H^+ or OH^- ions into the water, allowing the substance to show its acidic or basic nature. — See ***Figure 1.5***.

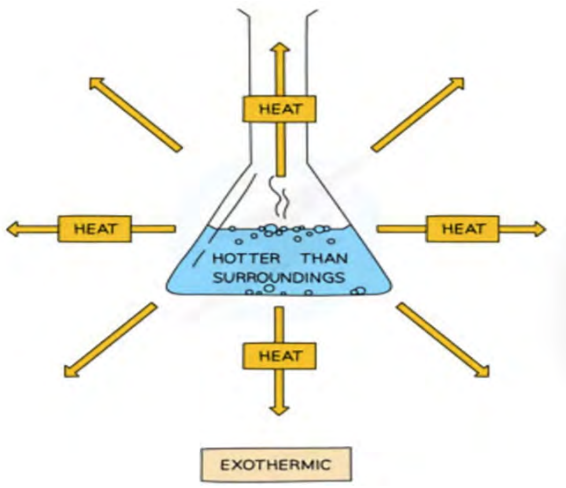


Figure 1.5: Exothermic reaction

Similarities Between Acids and Bases

1. **Conduct Electricity**: When dissolved in water, bases and acids both can conduct electricity. The reason for this is that they separate into charged particles called ions, which enable electric current to flow through the solution. For instance, when in water, sodium hydroxide (NaOH) and hydrochloric acid (HCl) both conduct electricity.
2. **Corrosive Nature**: Because acids and bases may both be corrosive, they can wear down or harm some things, such as skin and metal. If they come into touch with the skin, powerful bases (like sodium hydroxide) and acids (like sulphuric acid) can burn.
3. **Reaction with Water**: Both acids and bases dissolve in water to show their properties. Acids release hydrogen ions (H^+), and bases release hydroxide ions (OH^-) when they dissolve.
4. **Ability to change colour of indicators**: Acids and bases can change the colour of chemical indicators (like litmus paper or universal indicators). Acids turn blue litmus paper red, while bases turn red litmus paper blue. Both can cause colour changes in universal indicators, showing different pH values.
5. **React with each other**: Acids and bases can react with each other in a process called neutralization, producing salt and water. For example, when hydrochloric acid (HCl) reacts with sodium hydroxide (NaOH), they form sodium chloride (table salt) and water (H_2O).

APPLICATION OF ACID AND BASES IN SALT FORMATION

Salts

1. Which main ingredient brings out the taste in food?
2. What other ways do you use salt in everyday life?

A salt is an ionic compound formed when an acid reacts with a base. In the reaction, the H^+ of an acid is replaced by another positively charged particle known as a cation derived from a base while the OH– of a base is replaced by another negatively charged particle known as an anion derived from an acid. Such a reaction is called neutralisation reaction.

Apart from acids and bases, a wide variety of compounds exist as salt (see ***Figure 1.6***). One salt which is mostly used in the kitchen and as table salt is sodium chloride. It is also referred to as common salt. ***Table 1.3*** shows examples of salts and their common names.

Table 1.3: Some salts and their chemical formula

Chemical formula of salt	Common names
$NaCl$	Sodium chloride
KNO_3	Potassium nitrate
$Zn(NO_3)_2$	Zinc nitrate
NH_4Cl	Ammonium chloride
$FeSO_4$	Iron (II) sulphate
NH_4NO_3	Ammonium nitrate
$Ca(HSO_4)_2$	Calcium Hydrogen sulphate
$CuSO_4$	Copper sulphate
$CuCl_2$	Copper (II) chloride
$CuCl$	Copper (I) chloride

Figure 1.6: Samples of Different Types of Salt

Formation of Salts

Salts are formed in reactions involving acids and bases. Such reactions result, typically in the formation of salt and water. Other products such as carbon dioxide may also be formed.

A. **Formation of salt by neutralisation:** A neutralisation reaction is the reaction between an acid and a base to produce salt and water. The general equation of a neutralisation reaction between the acid HA and base BOH is as follows:

- Acid + Base $\longrightarrow$ Salt + Water
- HA + BOH $\longrightarrow$ AB + H_2O where AB is the salt formed.

Formation of water in addition to the salt makes the reaction a neutralisation reaction.

The specific reaction of the activity above is as follows:

- $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

In terms of ions, the equation is as follows:

- $H^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ \; Cl^- + H_2O$

From the above ionic equation, the positive ion or cation of the salt, which is Na^+, comes from the base. Therefore, it is called the **base radical**. The negative ion or anion of the salt, which is Cl^-, comes from the acid. Therefore, it is called the **acid radical**.

How do you think the process of neutralisation can be used to help the human body?

Antacids

These are chemicals which are basic and are used to relieve the body of congestion caused by accumulation of acid in the stomach. The congestion is normally caused by indigestion or eating late evening or at night. The basic chemical, when drank, neutralises the acid to produce a salt. This brings relief to the body.

Antacids are sold with commercial names such as Magacid, Gastracid, Andrews Liver Salt, Gastrone etc.

Figure 1.7: Samples of Antacids

Activity 1.10 Formation of Salt by Acid and Base

Materials needed: vinegar (acetic acid solution), baking soda (Sodium bicarbonate), two clear glass or plastic cups, stirring rod or spoon and pH paper or universal indicator paper (optional, for pH testing)

Steps:

1. Pour a small amount of vinegar (acetic acid solution) in one cup and label A. This will act as your acid solution.
2. Add a small baking soda (Sodium bicarbonate) to the other cup and label B. This will act as your base.
3. Slowly pour the base (baking soda) into the acid solution (vinegar).
4. Stir the mixture gently with a stirring rod or spoon.
5. Briefly explain why precautions must be observed when performing a science experiment.

What to expect/observe

1. Bubbling or fizzing of the reaction mixture indicates the release of carbon dioxide gas. This is a characteristic neutralisation reaction between an acid and a carbonate or hydrogen carbonate.
2. The mixture feels slightly warmer since neutralisation reactions release a little heat into their surroundings. After mixing thoroughly, the final solution contains sodium acetate (salt), water, and carbon dioxide gas:

Test for the salt

1. Test for the pH of the vinegar and baking soda solution by dipping a pH paper or universal indicator into each of them.
2. Test for the pH of the final solution

Hint

After neutralisation, the pH should be closer to neutral (around 7), indicating the formation of a salt solution. For the pH to be exactly 7, combine equal molar amounts of the acid and base.

Safety Precautions

1. Even though the vinegar and baking soda are relatively safe household chemicals, protective clothing must be worn to protect the body from their possible spillage.
2. Any spilled vinegar or baking soda must be cleaned immediately.
3. Since the experiment will produce carbon dioxide gas, it must be performed in a well-ventilated area to ensure the presence of enough oxygen for respiration.

B. **Formation of salt by reaction of acids with metals:** In a reaction between a dilute acid and some metals, a salt is produced along with hydrogen gas.

- Metal + Acid → Salt + Hydrogen
- $Zn(s) + H_2SO4(aq) \rightarrow ZnSO4(aq) + H_2(g)$

Activity 1.11 Reaction Between Dilute H_2SO_4 and Zinc Metal.

Instruction: Perform this activity under supervision of a teacher in a school laboratory.

Materials needed: test tube, zinc granules, dilute H_2SO_4, candle or match box, test tube rack or retort stand with clamp, rubber bung with delivery tube, soap solution in a basin.

Steps:

1. Place a test tube in its rack or in a clamp mounted on a retort stand.
2. Put a few zinc granules in the test tube.
3. Add dilute H_2SO_4 carefully along the sides of the test tube.

4. Plug the mouth of the test tube with a rubber bung fitted with a delivery tube.
5. Dip the end of the delivery tube in a soap solution placed in a shallow basin.
6. Bring a burning candle or matchstick near the mouth of the basin.

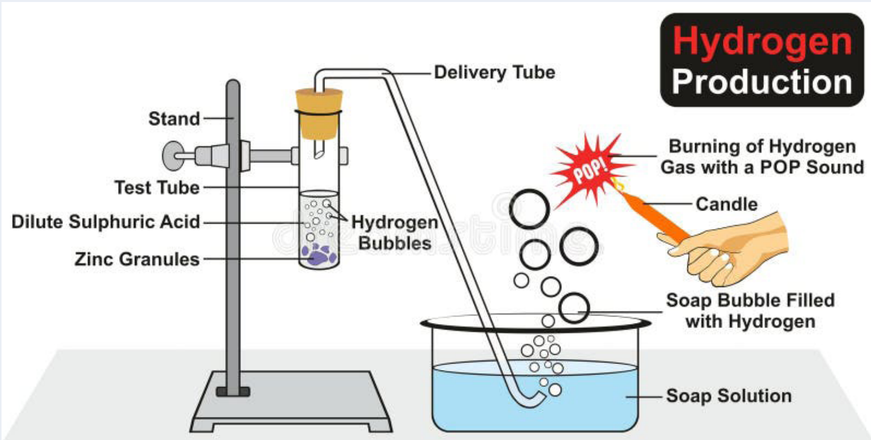


Figure 1.8: Reaction between dilute H2SO4 and zinc

What to see/observe:

i. Bubbles form in the soap solution, indicating that a gas has been released.

ii. When a burning candle or matchstick is brought near the mouth of the basin, the gas in the soap bubbles burns with a 'pop' sound. This confirms that the gas that evolved is hydrogen gas.

Conclusion: The equation of the reaction is $H_2SO_4(aq) + Zn(s) \longrightarrow ZnSO_4(aq) + H_2(g)$

The salt formed is zinc sulphate.

Safety Precautions

1. Wear hand gloves and eye goggles to protect the hand and eyes.
2. Wear protective clothes.
3. Clean any spillage of acid.

C. Formation of salt by reaction of acids with metal carbonates and hydrogen carbonates: Reactions between acids, metal carbonates, or metal hydrogen carbonates (bicarbonates) produce salt together with water and carbon dioxide.

- Metal carbonate or Metal hydrogen carbonate + Acid $\longrightarrow$ Salt + water + carbon dioxide

- $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$
- $NaHCO_3(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

Activity 1.12 Acids React with Carbonates, Releasing CO_2

Materials needed: test tube, boiling tube fitted with cork, thistle funnel, delivery tube, sodium carbonate, sodium hydrogen carbonate, dilute HCl and freshly prepared lime water.

Steps:

1. Place about 0.8 g sodium carbonate in a test tube.
2. Obtain about 12ml of a freshly prepared dilute HCl.
3. Mix them by stirring until they are thoroughly mixed.
4. Plug the test tube with a rubber bung fitted with a thistle funnel and delivery tube.
5. Pour about 2 ml of freshly prepared lime water in a test tube.
6. Dip the delivery tube into the lime water.

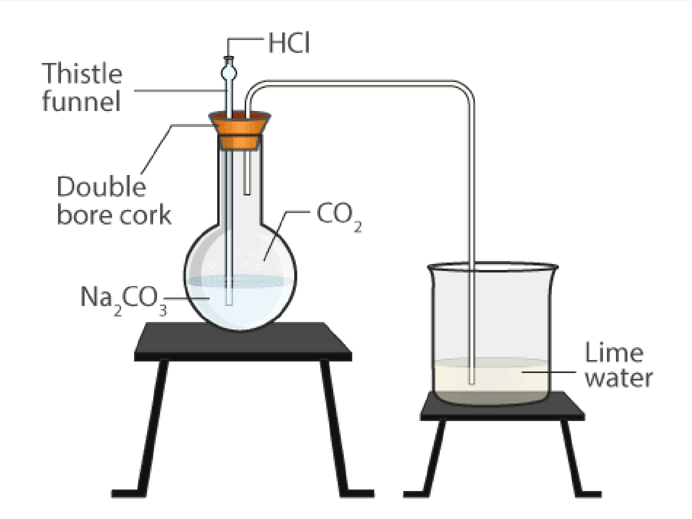


Figure 1.9: Reaction between HCl and Na_2CO3

What to see:

1. There is formation of bubbles in the lime water, indicating the release of a gas.
2. The lime water turns milky, confirming the release of CO_2.

The equation of the reaction is as follows:

- $2HCl(aq) + Na_2CO_3(s) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$
- The salt formed is sodium chloride.

Conclusion: To prove that sodium chloride is the salt formed, litmus paper or a universal indicator can be used to test for the pH of the resultant reaction solution.

Sodium chloride solution is neutral to indicators, hence there will be no colour change of the indicator.

When sodium hydrogen carbonate is used, the same observations will be recorded. However, the equation of the reaction will be as follows:

- $HCl(aq) + NaHCO_3(s)$ $NaCl(aq) + H_2O + CO_2(g)$

Types of Salt

Table 1.5: Types of salt

Types of salt	Description
Normal salt	A salt which is neutral to an indicator. That is to say it neither shows acidic nor basic properties. It is formed from the reaction between a strong acid and a strong base, resulting in a pH of 7. They include chlorides, nitrates, sulphates of metals. Examples are NaCl, K_2SO_4, $CaSO_4$, $Mg_3(NO3)_2$, $MgCl_2$
Acidic salt	Salt which shows acidic properties with an indicator. It is formed from the reaction between a strong acid and a weak base, resulting in a pH lower than 7. Examples of acid salts are NH_4Cl, $NaHSO_4$, $CuSO_4$, $FeCl_2$ etc
Basic salts	Salt which shows basic properties with an indicator. It is formed from the reaction between a weak acid and a strong base, resulting in a pH higher than 7. Examples are $NaHCO_3$, $KHCO_3$, $CaCO_3$, Na_2CO_3 etc.

Why is a normal salt neutral to an indicator? Record your findings in your notebook.

Properties of Salts

1. Soluble salts dissolve in water to form solutions.
   $NaCl(s) + H_2O \longrightarrow NaCl(aq)$
2. Carbonates and hydrogen carbonates react with acids to form salt, water and CO_2.
   $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$
3. Bases react with ammonium salts to form another salt, water and ammonia.
   $NH4Cl(s) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l) + NH_3(g)$
4. Salts decompose on heating to release oxygen gas.
   $2NaNO_3 \longrightarrow 2NaNO_2 + O_2$
5. Neutral/normal salts do not affect an indicator such as litmus paper, litmus solution or universal indicator.

Uses of salts

Activity 1.13 Uses of salt

Write down at least five uses of salt in everyday life activities in your notebook.

Table 1.6: Uses of salts

Use	Explanation
Seasoning and flavouring.	Enhances the taste of food.
Preservation.	Draws water out of food items and inhibits bacterial growth on them.
Industrial uses.	As a raw material to produce chlorine and sodium hydroxide, in the manufacture of soap and other chemical processes.
Treatment of water.	To soften hard water to make it suitable for use.
Textile industry.	As a fixative to help dyes adhere to fibres to produce desirable colour patterns.
Fertilisers.	As an essential component of fertilizers to produce macro and micronutrients.

Use	Explanation
De-icing.	For removing snow from roads, sidewalks and other places where snow may cause slipping and other forms of inconvenience.
Personal care.	To make skin care products due to its cleansing properties.
Household cleanup	To clean stains, sanitise refrigerators, erase watermarks and brighten brass and copper ware.
In the garden	To eliminate the activities of ants, slugs, worms, ivy plants and to control weeds.

Figure 1.10: Some uses of salt

USING THE PH SCALE TO IDENTIFY THE CONCENTRATION OF ACIDS AND BASES/ ALKALIS IN SOLUTION

Activity 1.14 Exploring the Types of Solution

The diagrams below show a mixture of solute and solvent to form a solution. Observe them carefully and discuss the questions with your friends.

Figure 1.11: Formation of solution

1. Describe your observation from Fig. 1.6 above
2. What happens to the solution's appearance if you add more solute?
3. How will you differentiate between solute and solvent to create a uniform solution? Give one example from the diagram
4. Using the diagrams provided, list one example of each type of solution (gaseous, liquid, and solid)

Is there any difference between solid solution, liquid solution and gaseous solution? Let us find out!

- A solid solution is a homogeneous mixture in which the solvent is solid, and the solute is either gas, liquid, or solid. The components are dispersed uniformly at the molecular level. A solid solution is an alloy, such as bronze, in which copper acts as the solvent and tin as the solute.
- A liquid solution is made up of a liquid solvent and a solute, which can be gas, liquid, or solid. These solutions are widespread in everyday situations. For example, saltwater is a liquid solution in which the solvent is water, and the solute is salt.

- A gaseous solution is generated when gases combine with one another to form a homogeneous mixture. In this scenario, the solvent is a gas, while the solute can be gas, liquid, or solid. Air, for example, is a mixture of nitrogen as a solvent and oxygen as a solute, among other gases.

Activity 1.15 Identifying Acid-Base Concentration Using the pH Scale

Materials needed: Use the ***figure 1.12*** to perform this activity

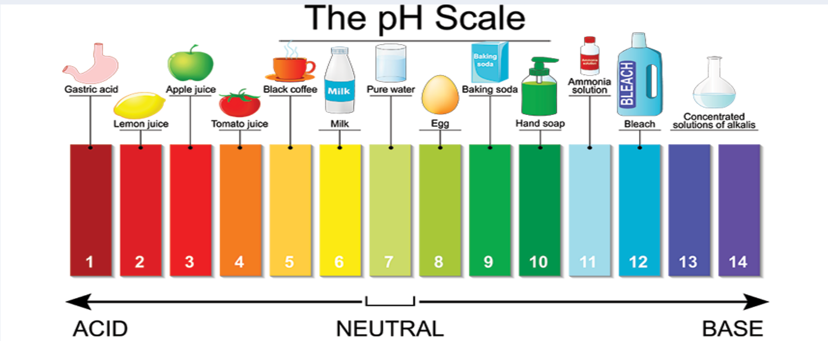


Figure 1.12: Acidity or alkalinity of some household items

Steps:

1. Explain the pH scale (0-14) and its significance in identifying acidity (below 7 is acidic, 7 is neutral, above 7 is basic).
2. Predict which household liquids are acidic based on flavour and prior knowledge.
3. In small groups, test the pH of various liquids using the indicator solution or test strips,
4. Create different concentrations of a base (e.g., baking soda).
5. Measure pH and discuss how concentration affects pH values
6. Record your observations.
7. Share your findings and discuss the strongest acid identified and the pH values recorded.

Questions: Record your answers in your notebook for future reference.

Use the pH scale in ***figure 1.12*** to help you answer these questions:

1. What does the pH scale tell us about acids and bases?
2. Which household liquids do you think are acidic, and why?

3. What pH results did you find for each liquid, and how did they match your predictions?
4. How does changing the concentration of baking soda affect its pH level?
5. Why is it useful to know the pH of common household items?
6. What other indicators can be used to identify the strength of an acidic or alkaline solution?

Hint

Here is a quick overview of some key points to keep in mind from the activity pH scale ranges from 0 to 14; where below 7 is acidic, 7 is neutral, and above 7 is basic. Vinegar, lemon juice, and soda are all examples of sour foods. Higher quantities basic substances increase the pH, making it more basic. Knowing PH of substances helps with the safe usage and reactions of household products in everyday life.

Activity 1.16 Preparation of Sugar Solution

Materials needed: granulated sugar (sucrose, $C_{12}H_{22}O_{11}$), distilled water, balance/ scales, volumetric flask or beaker and stirring rod.

Steps:

1. Calculate the Required Mass of Solute: Decide on the solution's molarity (M) and volume (V).
   - Use the molar mass of sucrose (342.3 g/mol) to calculate the mass
   - Amount substance in moles (n) = M × V
   - Mass = Moles × Molar Mass
   - For example, to prepare 1 dm^3
   - of a 0.5 mol/dm^3
   - sucrose solution:
   - Moles = 0.5 mol/dm^3 × 1 dm^3 = 0.5 mole
   - Mass = 0.5 moles × 342.3 g/mol = 171.15 g
2. Measure 171.15 g of sucrose.
3. Add the sugar to a volumetric flask or beaker. Add distilled water gradually while stirring until the total volume reaches 1 litre.
4. Stir until all the sugar is completely dissolved.

5. Label the container with the concentration and date.

Questions: Put your ideas in your notebook.

1. How can you tell when the sugar has fully dissolved?
2. How does the concentration of sugar solution affect its taste and properties?
3. Why is it important to accurately measure the amount of sugar when preparing a solution?

Activity 1.17 Preparation of a Solution

***Materials needed*:**

- Solute (the substance being dissolved)
- solvent (the liquid in which the solute dissolves)
- a balance/ scales (to measure the mass of the solute accurately)
- volumetric flask (a flask with a marking that indicates the final volume of the solution)
- graduated cylinder (to measure the solvent accurately)
- A stirring rod or magnetic stirrer (to facilitate dissolving the solute)
- distilled or deionized water (recommended as solvent for most chemical solutions)
- safety glasses and gloves (for handling chemicals)

Steps:

1. Calculate the amount of solute needed and the volume of solution you want to prepare (in litres, L).
2. Use the following formula to calculate the mass (m) of solute required:

   $m = C \times V \times M$ Where:

   m = Mass of solute in grams (g)

   C = concentration of the desired solution (mol/dm^3)

   V = Volume of the solution in dm^3

   M = molar mass
3. Carefully weigh out the calculated mass of the solute using a balance.

4. Rinse the volumetric flask with a small amount of solvent to remove impurities.
5. Using a funnel, carefully transfer the weighed solute to a volumetric flask and add a little amount of solvent, gently swirling to aid in dissolving.
6. Rinse the flask with solvent to ensure that all the solute has been transferred, then gradually add distilled water while swirling until it reaches the graduation mark.
7. Using a dropper, adjust the solvent level drop by drop until the bottom of the meniscus matches the mark, then close the flask with a stopper and invert several times to ensure a complete mix.
8. Record your observation into your science notebook for discussion with your friends

Safety Precautions

1. Always use safety goggles, gloves, to protect yourself.
2. Read labels and use funnels or pipettes to avoid spills.
3. Familiarize yourself with the location of safety equipment and protocols in the science laboratory.

Questions: Record your suggested answer in notebook

1. What is the purpose of rinsing the weighing boat or container after transferring the solute to the volumetric flask?
2. Why is it important to add distilled water gradually while swirling the flask?
3. How do you ensure that the bottom of the meniscus is at the correct graduation mark when regulating the volume?
4. What would happen if you filled the volumetric flask beyond the graduation mark?
5. Why is it necessary to reverse the flask several times after sealing it?

How Will You Calculate the Molar Mass of a Solute?

Molar mass is the mass of one mole of a substance, naturally expressed in grams per mole (g/mol). To calculate the molar mass of a solute, you need to sum the atomic masses of all the atoms in its chemical formula. Use the steps below to calculate the molar mass of a compound:

1. Identify and write down the chemical formula of the compound (e.g., H_2O for water)
2. Break down the compound into its constituent elements. For H_2O, the elements are hydrogen (H) and oxygen (O).
3. Atomic mass of each element can be obtained from the periodic table. See *figure 1.13*

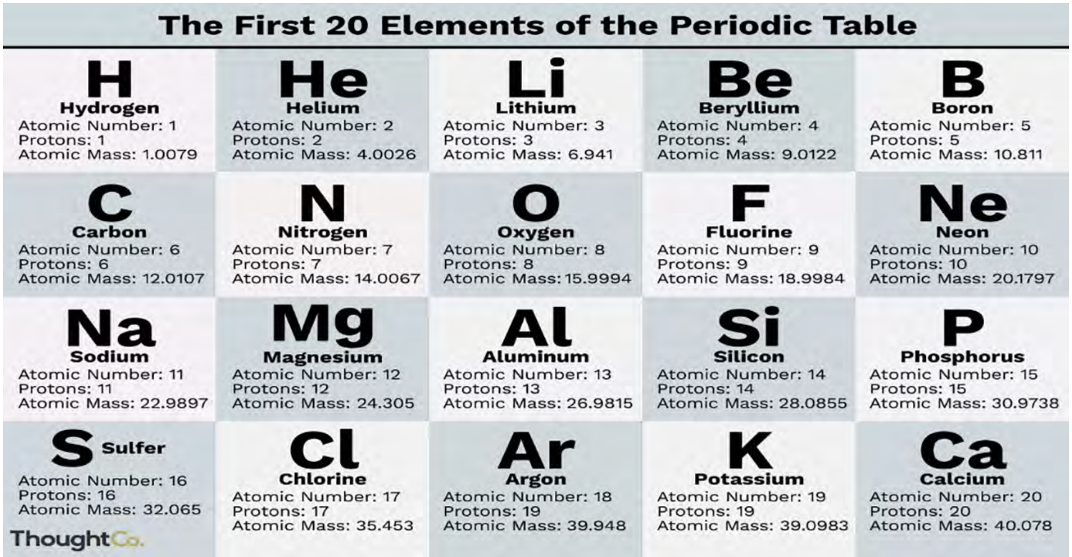


Figure 1.13: Periodic table

Atomic mass of Hydrogen (H) = 1.01 g/mol

Atomic mass of Oxygen (O) = 16.00 g/mol

4. Multiply the atomic mass of each element by the number of times it appears in the formula. Finally, add the total masses of all the elements in the compound.

Worked example 1

Calculate the molar mass of water

- Chemical Formula H_2O:
- Identify the elements in the compound (e.g., H_2O = H and O).
- For each element, multiply its atomic mass by the number of atoms present in the formula. H: 1.01 g/mol × 2 = 2.02 g/m and O: 16.00 g/mol × 1 = 16.00 g/mol
- Total molar mass of H_2O = 2.02 g/mol + 16.00 g/mol = 18.02 g/mol

Worked example 2

Calculate the molar mass of glucose ($C_6H_{12}O_6$)

- Chemical Formula: $C_6H_{12}O_6$
- Find the Atomic Masses:

  Carbon (C): 12.0 g/mol

  Hydrogen (H): 1.0 g/mol

  Oxygen (O): 16.0 g/mol
- Multiply by the Number of Atoms:

  = Molar Mass of $C_6H_{12}O_6$

  = (72.06 x 6) + (12.12 x 12) + (96.00 × 6)

  = **180.18 g/mol**

Worked example 3

Calculate the molar mass of calcium chloride ($CaCl_2$), follow these steps:

- Identify the Elements: Calcium (Ca) and Chlorine (Cl)
- Find atomic masses:

  Calcium (Ca) = 40.08 g/mol

  Chlorine (Cl) = 35.45 g/mol
- Multiply by number of atoms

  Calcium: 40.08 g/mol × 1 = 40.08 g/mol

  Chlorine: 35.45 g/mol × 2 = 70.90 g/mol
- Total molar mass of $CaCl_2$ = 40.08 g/mol + 70.90 g/mol = 110.98 g/mol

Practice the following to check your understanding!

Calculate the molar masses of the following:

a. glucose ($C_6H_{12}O_6$)

b. sodium chloride (NaCl).

Next, you will examine how to prepare dilute solutions and concentrated solutions. To help you with your activity, know that concentration tells us how much solute is in a solution and Molarity (M) = moles of solute over litres of solution.

Activity 1.18 Concentration of Solutions

Materials needed: distilled water, solute (like salt or sugar), volumetric flasks, beakers, graduated cylinders, pipettes, analytical balance and stirring rods

Steps:

1. Preparing a dilute solution:

- **a.** Calculate how much solute you need (e.g., for 1 L of 0.1 M salt).
- **b.** Weigh the amount using an analytical balance (e.g., 5.844 g for NaCl).
- **c.** Dissolve it in some distilled water in a volumetric flask.
- **d.** Add more distilled water until you reach the 1 L mark on the flask.
- **e.** Label the flask with concentration and date.

2. Preparing a concentrated solution:

- **a.** Calculate how much solute you need (e.g., for 500 mL of 2M salt).
- **b.** Weigh out the required amount (e.g., 58.44 g for NaCl).
- **c.** Dissolve it in less water than needed at first, then transfer to a volumetric flask and add water up to the 500 mL mark.

Safety Precautions

1. Wear gloves, and goggles.

2. Know where safety equipment is located

3. Label appropriately

Imagine after your activity, you are to observe the diagram in ***figure 1.14*** and then put your ideas down as you read

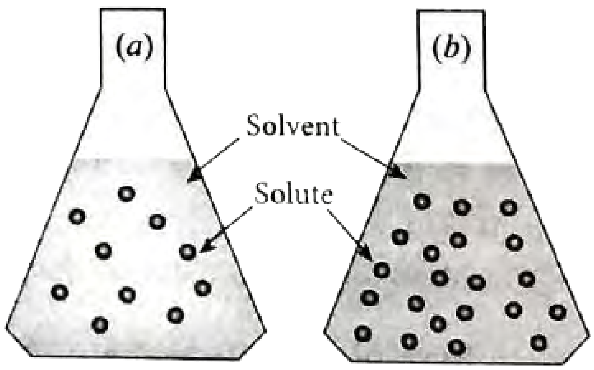


Figure 1.14: Dilute and concentrated solutions

Use ***figure 1.14*** to explore the following questions:

1. Which is a concentrated solution and why?
2. Which is a diluted solution and why?
3. In your own words, how would you explain the terms dilute and concentrated solutions to someone who has never learned about solutions?
4. Why it's important to know the exact concentration of a solution?
5. What differences did you notice between the dilute, medium, and concentrated solutions you prepared? How did these differences help you understand the concept of concentration?
6. Why do you think it is important to quantify the concentration of a solution?
7. If you were to create a new solution, what factors would you consider when determining how concentrated it should be?

What are the Key Characteristics You Should Understand About Concentration?

Concentration (C) is the amount of a substance in a certain volume of solution. We can describe the concentration of the solution in different ways.

Let us investigate the different ways of describing concentration of solution with worked examples and practice the questions to check your understanding!

A. **Mass percentage (w/w):** The mass percentage of a component of a solution is defined as: Mass % of a component $= \frac{\text{Mass of the component solution (g)}}{\text{Total mass of the solution (g)}} \times 100$

Question: Choose the correct answer

What is the mass percentage of a component in a solution if the mass of the component is 25 grams and the total mass of the solution is 200 grams?

A. 10%

B. 12.5%

C. 12.5%

D. 15%

B. Volume percentage (v/v): The volume percentage is defined as:

$$= \frac{\text{Volume of solute}}{\text{Total volume of the solution}} \times 100$$

Question: What is the volume % of rose extract in a solution prepared by dissolving 14.0 cm^3 rose extract in a solvent to make 200 cm^3 of solution?

Solution:

$$\text{Volume percentage} = \frac{\textit{Volume of solute}}{\textit{Total volume of the solution}} \times 100$$

$$= \frac{14.0\text{cm}^3}{200.0\text{ cm}^3} \times 100$$

= 7.0 % Rose solution (v/v)

Choose the correct answer

1. An SHS General science learner prepares a solution by mixing 60 mL of acetic acid with enough water to make a total volume of 500 ml. The value of the volume percent (v/v%) concentration of acetic acid in the solution is

   A. 10%

   B. 12%

   C. 15%

   D. 20%

C. Mass by volume percentage (w/v): The mass-by-volume percentage is another unit commonly used in medicine and pharmacy.

$$\text{Formula} = \frac{\text{Mass of Solute (g)}}{\text{Volume of the solution(mL)}} \times 100$$

Worked Example

What is the mass/volume % of glucose solution prepared by dissolving 50 g glucose in enough water to make 1000 cm^3 of solution?

Solution:

$$= \frac{\text{Mass of Solute (g)}}{\text{Volume of the solution(cm}^3\text{)}} \times 100$$

$$= \frac{50.0g}{1000\text{ cm}^3} \times 100$$

= 5.0 % glucose (w/v)

Question: Write your answers in your notebook.

Determine the mass/volume % of glucose solution prepared by dissolving 30 g glucose in enough water to make 900 cm^3 of solution?

D. **Molarity (concentration in moles per** dm^3**):** Concentration (C) expresses the moles of solute in dm^3 of solution. The most common solution concentration unit used in chemistry is concentration (C).

If you have the mass of the solute, you can calculate the moles using the molar mass of the solute. The formula is:

$$\text{number of moles of a solute (n)} = \frac{mass\ of\ solute(n)}{molar\ mass\ of\ solute(\ M)}$$

Measure the solution's volume in dm^3. If you have the volume in cm^3, convert it to dm^3 by dividing it by 1000.

Calculate the concentration:

Use the formula to find the molarity.

$$\text{Concentration (C)} = \frac{amount\ of\ solute\ (n)}{Volume\ of\ solution\ in\ dm^3(V)}$$

Worked example

Calculate the concentration of a solution made by dissolving 0.0974 moles of NaCl in 1.5 dm^3 of water.

$$\text{Concentration (C)} = \frac{number\ of\ moles}{Volume\ of\ solution\ in\ dm^3(V)}$$

$$= \frac{0.0974\ \text{moles}}{1.5\ \text{dm}^3}$$

$$= 0.065\ \text{mol}\ /\text{dm}^3$$

Questions

Choose the correct answer as you read the questions

1. You have 5 grams of NaCl (sodium chloride) and the molar mass of NaCl is 58.44 g/mol. What number of moles of NaCl do you have?

A. 0.0855 moles

B. 0.0810 moles

C. 0.0825 moles

D. 0.0785 moles

2. How do you convert volume from cm^3 to dm^3?

A. Add 1000

B. Divide by 1000

C. Multiply by 1000

D. Subtract 1000

Activity 1.19 Dilution process

Materials needed: funnel, beaker, dropping pipette, wash bottle, volumetric flask and water.

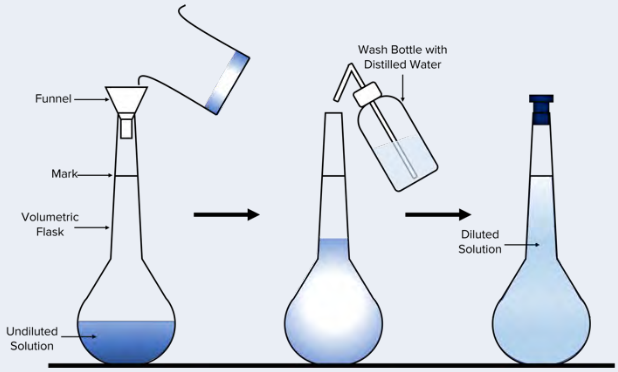


Figure 1.15: Set-up for dilution

Steps:

1. Weigh the container containing the requisite mass of solid using a precise balance. Transfer the solid to a beaker, reweigh it, and calculate the mass difference.
2. To dissolve the solute entirely, add 100 cm^3 of distilled water to the beaker and stir with a glass rod. If required, gradually boil the solution.
3. Fill a 250 cm^3 volumetric flask with the solution using a funnel.
4. Rinse the beaker, glass rod, and funnel to remove any residue.
5. Fill the flask to the mark with distilled water, mix thoroughly by inverting the flask several times, and then use a volumetric pipette to measure 25.0 cm^3 of the original solution into another 250 cm^3 volumetric flask.

Reflect on the following questions from ***Activity 1.20***.

1. What is the purpose of weighing the container before and after adding the solid?
2. How do you ensure the solid is completely dissolved in the distilled water?
3. Why is it important to rinse the beaker, glass rod, and funnel during the transfer process?
4. What steps should be taken to accurately dilute the original solution using a volumetric pipette?

5. How does inverting the flask multiple times help in reaching a homogeneous solution?

Dilution of Solution

Diluting solutions involves raising the volume of a solution while decreasing the concentration without changing the number of moles.

Since the number of moles remains constant, we can use the concentration equation to generate a dilution equation: $\mathbf{C_1V_1 = C_2V_2}$

C_1= **Original Concentration**

V_1= **Original Volume**

C_2= **New Concentration**

V_2= **New Volume**

Worked example

1. 70 cm^3 of water is added to 240 cm^3 of a 0.80 mol dm^{-3} solution of KOH. Calculate the concentration of the diluted solution.

- Using $C_1V_1 = C_2V$
- V2 = V1 + volume of water = 250 + 70 = 320 cm^3
- Making C2 the subject = $\frac{C1V1}{V2}$

$$= \frac{0.80\text{mol dm}^{-3} \times 240\text{cm}^3}{320\text{cm}^3}$$

$$= \mathbf{0.6}\ \text{mol dm}mol/dm^3$$

PH MEASUREMENT

In our previous lesson, we learnt the various pH levels of acidic and basic solutions.

Try these questions: Write your answer in your notebook

1. Why do you do think it is important to know the pH of acidic and basic solution?
2. What do the pH levels indicate about the properties of these substances?
3. How might these substances affect the environment or health based on their pH?

Importance of pH Measurement

1. The pH scale is essential for determining whether a solution is acidic, neutral, or basic. This knowledge is vital for conducting experiments and studying chemical reactions in various scientific fields.
2. Monitoring pH levels in natural water bodies, such as rivers and lakes, helps assess their health. Acidic waters can harm aquatic ecosystems, while excessively basic waters can hinder plant growth. Keeping track of pH is crucial for environmental conservation.
3. Soil pH influences the availability of nutrients for plants. Farmers use pH measurements to optimize soil conditions for specific crops. For example, some crops thrive in acidic soil, while others prefer neutral or alkaline conditions.
4. In the medical field, pH measurement is essential for understanding various bodily functions. For instance, human blood must maintain a specific pH range (7.35-7.45), as deviations can indicate health problems. Additionally, antacids are used to neutralize stomach acidity, and their effectiveness can be monitored through pH levels.
5. Many industries, including food production and pharmaceuticals, rely on pH monitoring to ensure product quality and safety. For example, the pH of food can significantly affect its flavour, preservation, and overall safety.

pH Paper: a special type of paper used to test how acidic or basic a solution is. It is treated with certain chemicals that change colour when they come into contact with liquids of different pH levels. It provides a quick way to find out the acidity or basicity of a solution without needing complex equipment. pH paper is commonly used in schools, laboratories, and even at home (like testing soil or pool water). The pH scale ranges from 0 to 14, where:

a. 0 to 6 indicates acidic solutions (like lemon juice).
b. 7 is neutral (like pure water).
c. 8 to 14 indicates basic or alkaline solutions (like baking soda).

Figure 1.16: pH paper

Activity 1.20 Measuring the pH of Substances Using pH Paper

Materials needed: vinegar, lemon juice, baking soda solution, tap water and pH paper

Steps:

1. Pour the substances each into each beaker and label them A, B, C, and D.
2. Take a strip of pH paper and dip it into each solution one at a time. Make sure to remove the paper after a few seconds.
3. Observe colour changes.
4. Use a pH colour chart (which usually comes with the pH paper) to match the color of the paper to the corresponding pH value.
5. Record your observation in the table below:

Substance	Colour change	pH value
Tap water		
Lemon juice		
Baking soda solution		
Vinegar		

Questions: Write down your answers in your notepad.

1. From activity 22, list the acidic and basic solutions.
2. Explain your answer in (1) above.

pH Meter: an electronic device used to measure the acidity or basicity of a solution. It provides a precise pH reading, which indicates how acidic (pH less than 7) or basic (pH greater than 7) a substance is.

Table 1.7: Types of portable pH meter

Pen testers  **Figure 1.17:** Pen tester	Pen testers are inexpensive pH meters the size of a pocketbook. Pen testers have many uses in the building, hydroponics, food production, and pool or spa care industries.

Handheld meters  **Figure 1.18:** Handheld meter	Handheld meters often have a more robust build and a slightly larger shape than pen testers. With this design, the electrode is constructed independently of the meter. Hand-held meters are designed for usage in the field. Environmental officers use them in field research, aquaculture, agriculture, and water treatment.
Benchtop pH meters  **Figure 1.19:** Benchtop pH mater	The largest of the three pH meter categories are benchtop meters. They can be put on a wall or a desk. They are often the most accurate pH meters, making them ideal for laboratory and professional use. Benchtop pH meters are frequently used in laboratories.

Table 1.8: Types of pH meters based on Usage

Laboratory pH meter  **Figure 1.20:** Laboratory pH meter	It has a large measuring range, is highly accurate, and is versatile.
Industrial pH meter  **Figure 1.21:** Industrial pH meter	A pH meter is a precise tool that measures how acidic or basic a solution is. It combines analogue and digital features for stable, efficient, and accurate readings. With built-in alarms, it can signal if the pH level goes beyond a set range, making it easier to monitor conditions. Its design helps reduce interference, ensuring accurate results in various environments.

Table 1.9: Types of pH meters based on reading

Analog pH meter  **Figure 1.22:** Analog pH meter	An analogue pH meter is the original type of model. A pointer will show the pH level on analogue pH meters. The needle will move toward a number representing the pH level after the measuring electrode has been put into the sample. When using an analogue pH meter, one must be careful to obtain accurate findings. The little pointer is the reason for this.
Digital pH meter  **Figure 1.23:** Digital pH meter	Developed subsequently to analogue meters these have a numerical display or the pH value.

Calibration of pH Meter

pH meters need regular calibration to ensure accurate measurements. Calibration involves adjusting the pH meter using standard pH buffer solutions (pH 4.01, pH 7.00, pH 10.01) to set accurate reference points across the pH scale.

Calibration of a pH meter adjusts the device to account for any shifts in its readings, called electrode drift. This process ensures that the pH meter provides accurate measurements for different solutions, making sure the results are reliable.

Activity 1.21 Demonstration of How to Use pH Meter

Materials needed:

- pH meter (including electrodes: glass pH electrode and reference electrode)
- pH buffer solutions (pH 4.01, pH 7.00, pH 10.01)
- distilled water (for rinsing electrodes)
- sample solutions to measure pH, stirring rod (if needed) and cleaning cloth or tissue

Steps:

1. Turn on the pH Meter. If not already calibrated, perform this as follows:
   - **a.** Obtain pH 4.01, pH 7.00, and pH 10.01 buffer solutions.
   - **b.** Check expiration dates and condition of buffer solutions to ensure accuracy.
   - **c.** Rinse the pH electrode with distilled water and blot dry it with clean tissue.
   - **d.** Immerse the electrode in the pH 7.00 buffer solution.
   - **e.** Allow the reading to stabilise (usually indicated when the display stops changing).
   - **f.** Adjust the pH meter according to the manufacturer's instructions to read pH 7.00.
   - **g.** If necessary, rinse the electrode with distilled water and repeat the calibration process with pH 4.01 and pH 10.01 buffer solutions.
   - **h.** Confirm calibration success by checking readings against buffer solution values.
2. Rinse the pH electrode with distilled water and blot dry between measurements.
3. Stir the sample gently to ensure homogeneity (if needed).
4. Immerse the cleaned and calibrated pH electrode into the sample solution.
5. Allow the reading to stabilise (again, indicated when the display stops changing).
6. Record the pH reading displayed on the pH meter.
7. Rinse the electrode with distilled water and dry it between measurements of different solutions.

After Use:

1. Rinse the pH electrode with distilled water to remove any residue from the sample.
2. Blot dry with a clean tissue or cloth.
3. Store the pH meter with the electrode in a storage solution recommended by the manufacturer to keep it hydrated and extend electrode life.

Safety Precautions

1. Handle sample solutions and electrodes carefully to prevent spills or damage.
2. Follow laboratory safety protocols when working with chemicals and solutions.
3. Keep electrodes clean and free from debris or chemical residues.
4. pH electrodes are delicate; avoid touching sensitive parts and handle with care.
5. Regular calibration is performed to maintain accuracy, especially if the pH meter has not been used recently or after prolonged use.

Questions

1. How does pH meter differ from pH paper?
2. From activities 22 and 23, mention some advantages both pH paper and meter.

Advantages of Using pH Meter

1. pH meters provide more precise readings than pH paper, allowing for detailed measurements of pH levels.
2. They can be calibrated to ensure consistent and accurate results, even for repeated measurements.
3. pH meters can be used for various types of solutions, including those that are opaque or coloured, where pH paper might not work well.
4. Digital pH meters provide instant readings, making them convenient and efficient for quick measurements.

Disadvantages of Using a pH Meter

1. Regular calibration and cleaning of the electrodes are needed to keep the device functioning accurately.
2. pH meters are generally more expensive than pH paper, making them less accessible for casual use.
3. The electrodes in pH meters are sensitive and can break easily, requiring careful handling.
4. Digital pH meters need a power source, such as batteries, which may need frequent replacements.

Question: Record your answer in your science notebook.

What happens when you put red dye in bowl or beaker containing a clear water?

Measuring pH Using an Indicator Solution

A pH indicator is a special dye that changes colour depending on how acidic or basic a solution is. This allows us to determine if a solution is acidic, neutral, or basic just by looking at the colour. These indicators are usually added to the solution or soaked into test paper. However, they can only be used with clear and colourless samples because the colour change needs to be seen clearly.

There are two main methods for using pH indicators:

1. Colour Comparison: Dip the indicator into the solution and then compare its colour to a standard colour chart that shows different pH levels. This helps estimate the pH value.
2. pH Test Paper: Soak paper in an indicator solution, then dip it into the test liquid. Compare the colour change to a standard colour chart to see the pH. Although simple, this method may not be very accurate.

Table 1.10: Types of pH Indicators

Universal Indicators	A pH indicator can show a wide range of pH values, usually from 1 to 14, by displaying different colours. Each colour corresponds to a specific pH level, allowing users to quickly determine whether a solution is acidic, neutral, or basic. For example, red might indicate a strong acid (low pH), green might indicate a neutral substance (pH 7), and blue or purple might show a strong base (high pH).
Specific Indicators	Some pH indicators are designed to change colour only within a specific, narrower pH range. This allows for more precise detection of small changes in acidity or alkalinity. For example, methyl orange changes colour between pH 3.1 to 4.4, and phenolphthalein does so between pH 8.3 to 10.

Several plants and household chemicals can be used as pH indicators, but in a lab setting, the table below shows the most common chemicals used as indicators:

Table 1.11: Effect of pH indicator on substances.

Examples of indicator	Acid Colour	Base Colour	pH Range
Thymol blue (first change)	red	yellow	1.2 - 2.8
Methyl orange	red	yellow	3.2 - 4.4
Bromocresol green	yellow	blue	3.8 - 5.4
Methyl red	yellow	Red	4.8 - 6.0
Bromothymol blue	yellow	Blue	6.0 - 7.6
Phenol red	yellow	Red	6.8- 8.4
Thymol blue (second change)	yellow	Blue	8.0 - 9.6
Phenolphthalein	colourless	Magenta	8.2 -10.0

Activity 1.22 Testing the pH of Substances with Natural Indicator

Materials needed: turmeric powder, water, filter paper and different solutions

Steps:

1. Make a paste of turmeric powder with water.
2. Apply the paste on the filter paper and allow it to dry.
3. Remove the dry powder from the filter paper.
4. Cut the filter paper into small strips.
5. Pour different solutions separately on the strips and note the colour changes.
6. Record the observations in tabular form

Observation: Turmeric paper remains yellow in acidic and neutral solutions but turns brown in alkaline solution

Activity 1.23 Testing the pH using universal indicator paper

Materials needed: universal indicator paper, dilute NaOH, dilute NH4OH, dilute HCl, dilute H2 SO4, vinegar and distilled water

Steps:

1. Take 1cm^3 of dilute HCl, dilute H2SO4, dilute CH3COOH (vinegar), dilute NaOH distilled
2. water in different test tubes.
3. Add 1.5 cm^3 of distilled water.
4. Dip a separate universal indicator paper in each tube and match the colour with colour given on the strip.
5. Note the observations in a table below:

Sample	Colour of universal indicator paper	pH of the solution

Question: Write your answer in your notepad.

Name the indicator used in both activities.

EXTENDED READING

1. Research and watch video on some chemical properties of acids and bases such as reaction with metal, etc.
2. Watch videos online on how pH meter is used to measure pH of solutions.
3. Watch online and repeat steps in activities using red cabbage juice in place of the turmeric as the indicator.

REVIEW QUESTIONS

1. In a tabular form, classify the following into common household items into acidic and basic substances;

   Baking soda, pineapple juice, washing soda, soap detergents, vinegar, toothpaste, milk of Magnesia, chalk, wood ash, Petre, lemon juice, tomato juice, orange juice.

2. Explain the following and give at least two examples each:

   a. Base

   b. Acid.

3. Explain why acidic or basic solution conduct electricity but distilled water cannot.

4. Describe the role of water in the dissociation of acids and bases.

5. How would you use the concept of neutralization to address the problem of indigestion?

6. Briefly explain the principles underlying a neutralization reaction.

7. Identify the various aspects of everyday life where salt can be used.

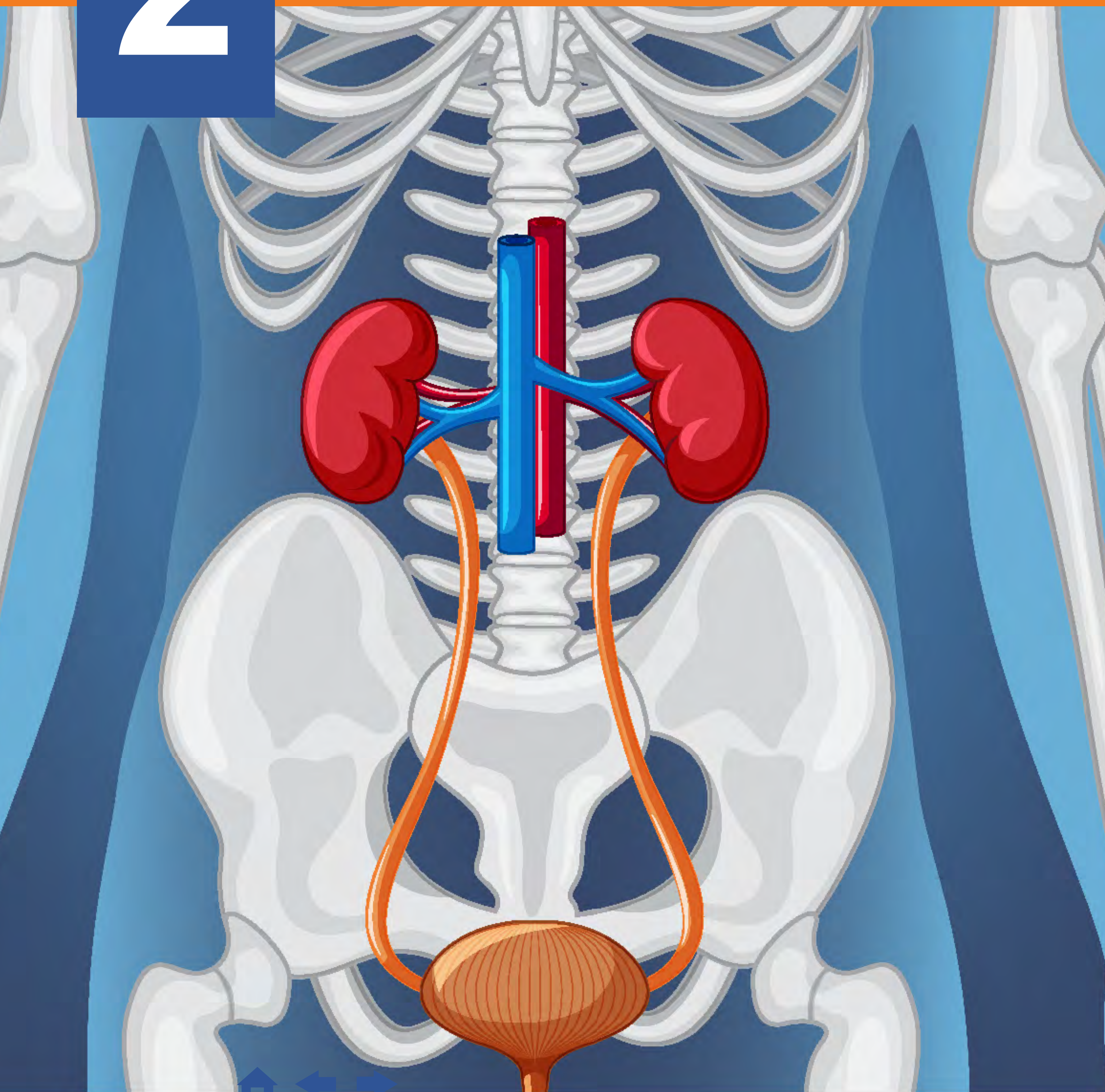
8. Calculate the molar mass of sodium oxide (Na2O).

9. You are doing a lab experiment with a sodium chloride (NaCl) solution. Your teacher gives you a solution with a concentration of 0.1 mol/dm³. You need to measure a certain amount of this solution for your experiment, and you choose to take 200 cm³. How many moles of NaCl are there in the 200 cm³ of solution you measured?

SECTION

2

HUMAN EXCRETORY ORGANS



PROCESSES FOR LIVING

Essentials for Survival

INTRODUCTION

The human excretory system helps to eliminate waste and toxins from the body. This involves regulating various physiological parameters, such as temperature, pH, hydration, and the concentration of ions and nutrients within the body, to ensure optimal functioning and survival. This system is built around numerous main organs, each with its own structure and function. The liver is a crucial excretory organ that processes waste via detoxification and bile synthesis. The skin, which is frequently ignored as an excretory organ, aids in waste elimination via sweat while also providing sensory protection. The kidneys are responsible for filtering blood, reabsorbing vital nutrients, and excreting waste via urine. Meanwhile, the lungs support gas exchange by exhaling CO_2 and controlling blood pH. However, faults within this complex system can cause serious health problems, making knowledge of these processes critical. This overview will look at the form and function of these organs, the mechanisms involved in waste disposal, and the abnormalities that can occur within the human excretory system.

KEY IDEAS

- **Metabolism**: It plays a crucial role in metabolic processes, regulating blood glucose levels by storing and releasing glycogen as needed, thus impacting energy metabolism.
- **Detoxification**: The liver metabolises toxins and drugs, converting them into less harmful substances.
- **Urinary Tract Infections (UTIs)**: Infections can affect various parts of the urinary system, causing pain and urgency and potentially leading to kidney damage if untreated.
- **Blood is filtered in the nephrons**, where waste products and excess substances are separated from essential nutrients and water in the process called filtration.
- **When sweat reaches the surface of our skin**, it evaporates, which means it turns from liquid into gas and goes into the air.

- **Blood tests that measure bilirubin levels** can help diagnose liver diseases, anaemia, and other conditions affecting the bile ducts or liver function.

UNDERSTANDING THE STRUCTURE AND FUNCTION OF HUMAN EXCRETORY ORGANS

1. Why is it important for the body to get rid of waste instead of holding onto everything we eat and drink?
2. Imagine if your house didn't have a trash bin, what might happen? How is this similar to what would happen in your body without excretion?

The human body has a group of organs that work together to remove waste and keep us healthy. These organs make up the excretory system: the liver, skin, lungs, large intestine, and kidneys. Each of these organs has a special role in removing waste:

- **Liver**: Processes and breaks down harmful substances, turning them into safer forms to be removed.
- **Skin**: Releases waste through sweat, which also helps cool us down.
- **Lungs**: Remove carbon dioxide when we breathe out (exhale).
- **Large Intestine**: Removes undigested food as stool.
- **Kidneys**: Filter out extra water and salts, turning them into urine.

Each of these organs are different, but together they work like a team to make sure our body stays clean and balanced. They get help from other parts of the body, like the circulatory system (which moves blood around to carry waste to these organs), the nervous system (which sends messages to tell these organs what to do), and the endocrine system (which releases hormones to keep everything in balance).

By working together, these systems help keep the body's internal environment stable, which is called homeostasis. Homeostasis is like having the perfect balance in the body so everything works as it should.

Activity 1.1 Understanding Excretion

You have been provided with a diagram of the human excretory system during the open STEM activity in your school. Observe the diagram for a few minutes and discuss the different organs with friends.

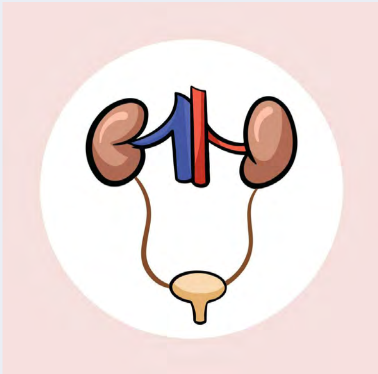


Figure 2.1: Human Urinary System

Questions

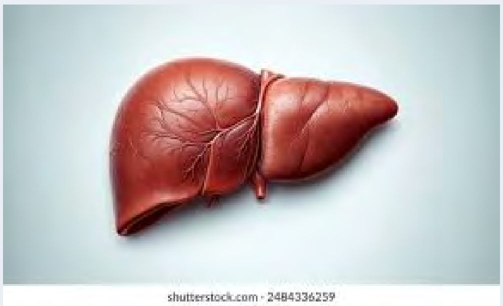
1. What does the diagram represent?
2. Which excretory organ can you find in the diagram
3. How will the diagram help you to explain excretion to your friends?
4. Create key ideas that show metabolic waste, and the organs involved.
5. After creating your ideas, each group is to present your work to the class so that all will learn together. Keep up the great work!

Compare your findings with the following key points:

- Excretion is a biological process in which an organism eliminates metabolic waste from its body. The body eliminates metabolic by-products and harmful substances and regulates bodily water levels, pH, and ionic concentration of blood fluid.
- Excretion is an extremely important mechanism in the human body. Excretion removes all that we consume from our bodies. After eating, the body absorbs all the useful substances and nutrients. The remaining substances are waste, which may be harmful to the body, and is expelled using the body's excretory organs. The human excretory system consists of a pair of kidneys, a pair of ureters, a urinary bladder, and a urethra. These are the main organs that constitute the human excretory system. Apart from them, some other organs help in the excretion as well. They are skin, liver, and lungs.

Activity 2: Identification of Excretory Organs and Their Functions

A group of SHS 2 learners is participating in a science fair project titled "The Great Excretion Challenge." Their task is to create a presentation of the excretory organs: liver, kidneys, lungs, skin, large intestine, and their products. In this project, they encounter "Mr. Waste," a character representing various waste products that need to be expelled from the body. Mr. Waste provides hints about himself and his friends, urea, excess salt, bile pigments, excess water, and carbon dioxide.



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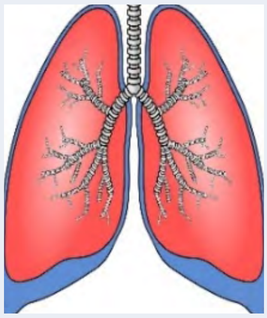

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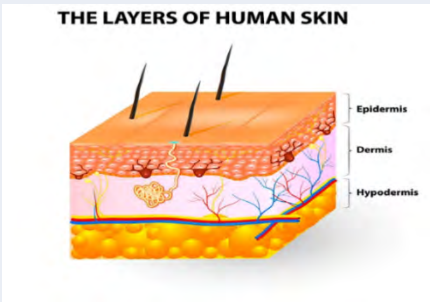

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Questions

Use the table above; showing the excretory organs to help you express your ideas about the key questions. Write down your answers in your notebook.

1. Can you match each waste product with its corresponding organ?
2. What happens if a person's kidneys stop working?
3. Which other organ is not represented?

You have just completed an amazing journey through the "Great Excretion". See ***Table 2.1*** for the key points you should know about the excretory organs and their waste products

Table 2.1: Excretory organs and metabolic waste substances

Excretory organs	Metabolic wastes
Skin	Your skin helps to remove waste through sweat. Sweat contains water, urea, lactic acid, and salts. When you sweat, you not only cool down your body but also get rid of these wastes.
Kidney	The kidneys are like filters for your blood. They remove excess salts, water, and nitrogenous waste (such as urea) by making urine. This is how your body gets rid of waste products that build up in your blood.
Lungs	Your lungs help you breathe out waste in the form of carbon dioxide and water vapor. When you exhale, your body gets rid of carbon dioxide, which is a waste product created when your cells use oxygen to produce energy.
Liver	The liver has many jobs, and one of them is breaking down old red blood cells. It produces bile pigments as a waste product from this process. These pigments eventually leave your body with stool. Nitrogenous Waste: This includes substances like ammonia, uric acid, urea, and trimethylamine oxide. The liver helps change ammonia (which is toxic) into urea, which is then removed by the kidneys
Large intestine	The large intestine helps remove solid waste. It also deals with waste from the liver, such as bilirubin, which gives stool its colour.

Activity 1.3 Exploring Skin Structure and Function

1. Research the three layers of skin: epidermis, dermis, and subcutaneous layer, focusing on their structure and functions.
2. Use online resources such as videos and other resources to learn about the roles of each layer in protection, sensation, and temperature regulation.
3. How does each layer contribute to overall skin health?

4. Create a summary table detailing the structure and functions of each layer.
5. Present your findings to your peers or family.

Let us examine one of the excretory organs, the skin!

Structure of the Skin

The skin has three main layers and each does a different role (see ***Figure 2.2***)

- **Epidermis (Top layer):** This is the thin, outer layer that you can see. It protects us from things in the environment, such as bacteria and sunlight. The epidermis also makes melanin, the pigment that gives our skin its colour.
- **Dermis (Middle layer):** This is the thicker layer under the epidermis. It holds sweat glands (that produce sweat to help cool us down), hair roots, and blood vessels. It's responsible for making sure our skin feels things like touch, pain, and temperature.
- **Hypodermis** (or Subcutaneous layer): This is the bottom layer of the skin, made mostly of fat. It acts like a cushion, protecting our muscles and bones, and helps keep us warm by insulating our body.

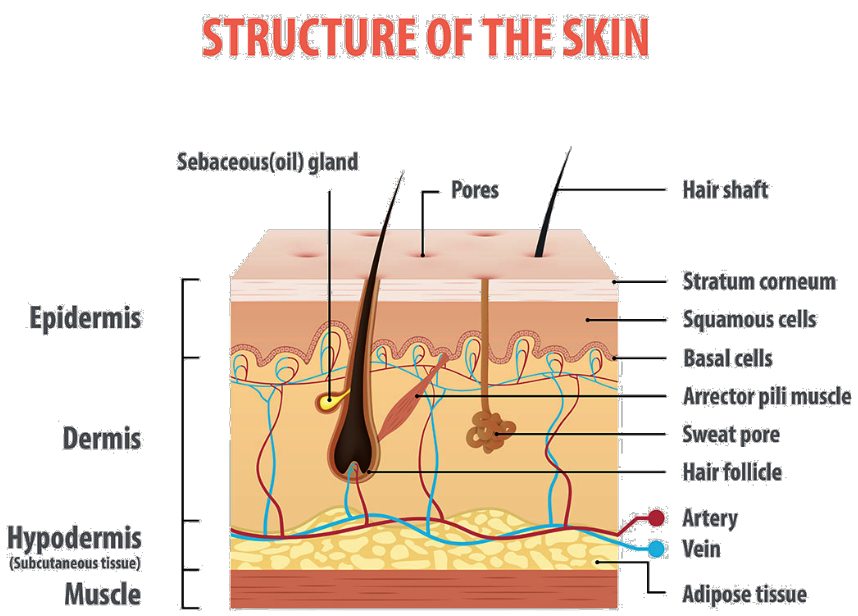


Figure 2.2: Structure of the skin

Processes Involved in Excretion by The Skin

Think of these questions as you read the processes involved in excretion by the skin

1. How do the different types of sweat glands contribute to the body's cooling system and waste removal process?
2. What role does evaporation play in temperature regulation, and how does it relate to the effectiveness of the excretion process through sweat?
3. Explain how understanding skin structure can help in real-life situations (e.g., skincare, health).

Remember the skin plays an important role in getting rid of waste from our bodies through a process called excretion. Here are the key processes involved:

1. **Sweat Production**: Sweat is made by special glands called sweat glands located in the middle layer of the skin (the dermis). There are two types of sweat glands:
    a. Eccrine glands produce a watery sweat all over the body to help cool us down.
    b. Apocrine glands, found in places like our armpits and groin, create a thicker sweat that has a stronger smell.
2. **Diffusion and Filtration:** When sweat is produced, waste products from our blood, such as urea and salt, move out through the sweat glands. This process is called diffusion, where these waste materials pass from the blood into the sweat. The sweat glands also filter out extra salts and electrolytes to keep our body's fluid levels balanced.
3. **Evaporation**: When sweat reaches the surface of our skin, it evaporates, which means it turns from liquid into gas and goes into the air. This evaporation cools our skin and body down, helping to regulate our temperature, especially when we are exercising.

Question: Write down your answer in your notebook.

1. In what ways do the functions of the skin, such as protection, thermoregulation, sensation, excretion, and vitamin D synthesis, contribute to overall health and homeostasis in the human body?

Table 2.2: Functions of the parts of the skin.

Parts	Description
Epidermis	Waterproof Barrier: The skin creates a waterproof layer that stops too much water from leaving the body. This is important because, without this barrier, our body could lose a lot of water just by being exposed to the air. The skin helps keep just the right amount of water inside, which is essential for staying healthy and hydrated. Protection from Germs: The skin also works like a shield that protects the body from harmful germs such as bacteria, viruses, fungi, and other microscopic invaders, called pathogens. These germs can make us sick, so the skin acts as a wall to stop them from getting inside our body. It's like wearing a suit of armour that keeps the body safe from things that could harm it.
Dermis	The skin is strong and flexible, which is important for protecting our body. Strength in the skin comes from a special protein called collagen, which makes it tough and able to resist tearing. This strength helps protect our muscles, bones, and other organs underneath. The skin can stretch and then go back to its normal shape due to another protein in the skin called elastin. Elasticity allows the skin to stretch when we move, grow, or gain weight and then return to its original shape.
Hypodermis	The skin helps keep the body warm by insulating it. This means it conserves heat and helps keep our body temperature stable, even when it's cold outside. This insulation helps our body work at the right temperature to stay healthy.
Hair follicle	The skin is responsible for producing and growing hair through tiny structures called hair follicles. These follicles, found in the skin's deeper layers, create hair by adding cells to the root, pushing the hair upward as it grows. Hair can help protect the skin and keep the body warm.

Parts	Description
Sweat glands	Sweat glands are like tiny faucets in our skin that release sweat when we’re hot. The sweat cools our body down as it evaporates, helping us stay at a comfortable temperature.
Sebaceous gland	These glands make an oily substance called sebum. Sebum keeps our skin and hair soft and prevents them from drying out or cracking. It acts like natural lotion that protects our skin.
Capillaries	Capillaries are tiny blood vessels in our skin. They bring oxygen and nutrients to skin cells to keep them healthy. Capillaries also help control our body temperature by expanding to release heat or narrowing to keep us warm.
Nerves	The nerves in our skin let us feel sensations like touch, pain, heat, cold, and pressure. They’re like messengers, sending signals to our brain so we can react to our surroundings, like pulling away from something hot.
Stratum corneum	This is the tough, outer layer of the skin. It protects us from cuts, harmful chemicals, and germs. It also forms a waterproof barrier that keeps water inside our body and stops water from getting in when we swim or wash our hands.
Melanocytes	These are special cells in our skin that make melanin, which gives our skin its colour. Melanin also protects us from the sun’s UV rays, which can damage our skin.
Adipose or fat tissue	This layer under the skin acts like padding, protecting our muscles and bones from bumps and injuries. It also helps insulate us, keeping us warm, and stores energy for our body to use when needed.

Question: Write down your answers in your notebook.

1. Can you think of specific medications that are significantly affected by first-pass metabolism in this organ?

What are functions of the Skin?

1. **Protection**: The skin serves as a physical barrier against pathogens, chemicals, and environmental damage, providing essential protection to underlying tissues.
2. **Thermoregulation**: It helps regulate body temperature through sweat production and vasodilation or vasoconstriction of blood vessels.
3. **Sensation**: The skin contains sensory receptors that detect pressure, temperature, pain, and touch, aiding in environmental interaction.
4. **Excretion**: Through sweat glands, the skin excretes waste products such as urea, salts, and water, playing a role in managing body fluids and electrolyte balance.
5. **Vitamin D Synthesis**: The skin plays a critical role in making vitamin D upon exposure to sunlight, important for calcium absorption and bone health.

Activity 2.4 Skin Model

What you need: Cardboard paper (different colours if possible, or white paper to colour in), scissors, markers or coloured pencils, glue and labels or small slips of paper

What to do:

1. Cut a thin strip of cardboard paper to represent the epidermis. This is the outermost layer of the skin and acts as a protective barrier.
2. Cut a thicker strip of cardboard paper to represent the dermis layer. This part will show where things like sweat glands, hair follicles, and blood vessels are found.
3. Use a thicker piece of cardboard paper for the subcutaneous layer. This layer contains fat tissue, which insulates the body.
4. Place the epidermis layer on top, the dermis layer in the middle, and the subcutaneous layer at the bottom.
5. Glue each layer in place, stacked from top to bottom, to create a layered model of the skin.
6. Use small cut-out shapes or draw directly on the dermis layer to show structures:
   a. Hair follicles: Draw or add small cardboard pieces for hair follicles.

b. Sweat glands: Use a spiral shape or small circles to represent sweat glands.

c. Blood vessels: Use thin strips of red and blue paper or markers to show blood vessels.

d. In the subcutaneous layer, you can add circles or shapes to represent fat tissue.

ACTIVITY 2.5 Excretory Organs and Waste Products

Here are multiple-choice questions focusing on excretory organs and their waste products, the functions of the skin, and the processes of removing waste from the human body by the skin. Circle the correct answer as you read.

1. Which of the following is a primary excretory organ responsible for the removal of urea from the body?

A. Kidney

B. Liver

C. Lungs

D. Skin

2. Which of the following is NOT a function of the skin?

A. Protection against pathogens

B. Sensation

C. Synthesis of vitamin C

D. Temperature regulation

3. What waste products are mainly excreted through the skin by sweating?

A. Glucose and cholesterol

B. Oxygen and carbon dioxide

C. Proteins and lipids

D. Urea and salts

4. Which type of gland in the skin is primarily responsible for the excretion of waste products?

A. Eccrine and apocrine glands

B. Follicle glands

C. Mammary glands

D. Sebaceous glands

5. How do the three layers of the skin contribute to its overall function?

A. The epidermis absorbs nutrients, the dermis prevents dehydration, and the hypodermis facilitates respiration.

B. The epidermis acts as a barrier, the dermis contains blood vessels and nerves for sensation, and the hypodermis stores fat and anchors the skin.

C. The epidermis provides insulation, the dermis provides the structural integrity, and the hypodermis prevents water loss.

D. The epidermis regulates temperature, the dermis produces sweat, and the hypodermis protects against diseases.

UNDERSTANDING THE STRUCTURE AND FUNCTION OF HUMAN EXCRETORY ORGANS

Liver

The liver is the largest solid organ in the body. It is located below the lungs in the upper right-hand side of the abdomen. It is reddish-brown and shaped approximately like a cone or a wedge. The small end is above the spleen and stomach, and the large end is above the small intestine. — See ***Figure 2.3***

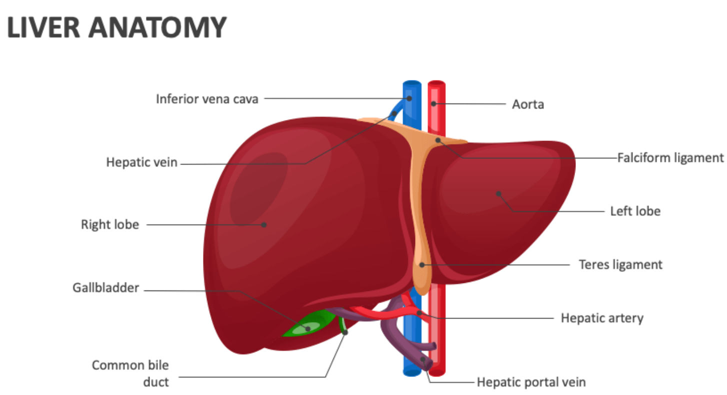


Figure 2.3: Structure of the Liver

The liver consists of four lobes. These are the (larger) right and left lobes and the smaller caudate quadrate lobes. The left and right lobes are divided by the falciform ligament which is sickle shaped. This connects the liver to the abdominal wall.

The lobes of the liver can be divided further into eight segments which consist of thousands of lobules (small lobes). Each of these lobules has a duct flowing towards the common hepatic duct, which drains bile from the liver. — See ***Figure 2.4***

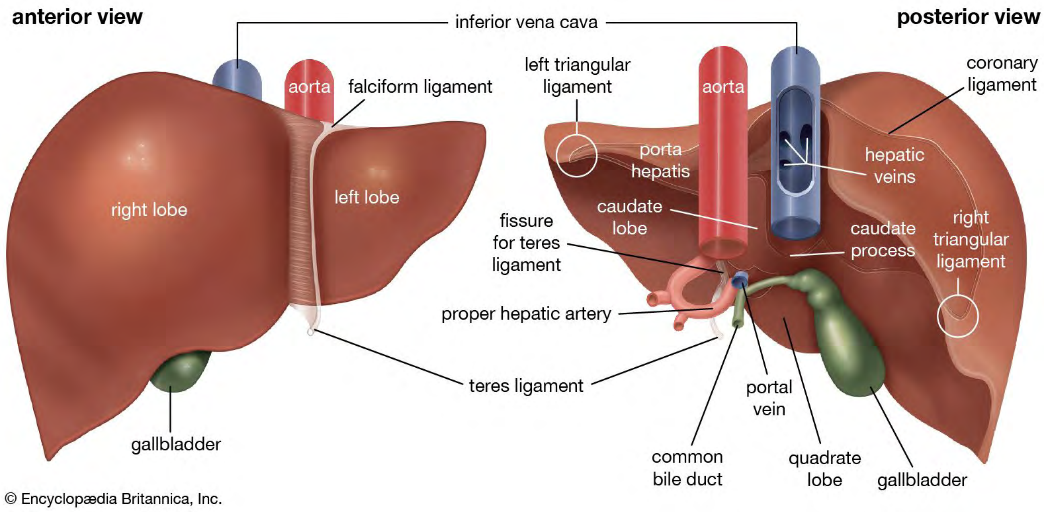


Figure 2.4: Anterior and Posterior Views of the Liver

There are eight hepatic segments. If the patient is supine (laying on their back facing up), and the liver is reflected along its inferior border towards the diaphragm, the segments would be numbered anticlockwise around the porta hepatis. — See ***Figure 2.5***

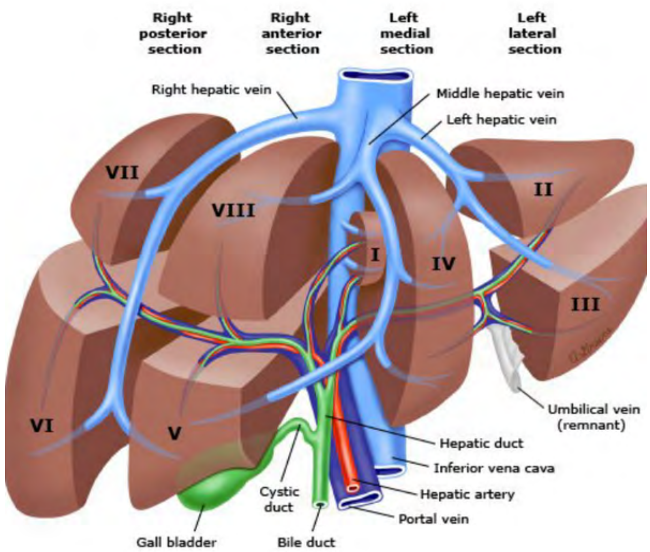


Figure 2.5: Hepatic segments of the liver

The left lobe of the liver is located on the left side of the body. This will be the patient's left, just under the diaphragm. It is generally smaller and more flattened and wedge-shaped than the right lobe. Its upper surface is slightly convex and is moulded on to the diaphragm.

The right lobe of the liver: This is six times the size of the left lobe. It is located predominantly in the right hypochondrium and extends into the epigastrium. It is separated from the left lobe by the falciform ligament on its superior surface and from the caudate lobe by the right sagittal fissure.

Question: Write down your answers in your notebook.

1. How would you create a model of the liver, using suitable materials?

Activity 2.6 How to Create a Liver Model

***What you need*:** Styrofoam block (preferably one large enough to cut into the shape of a liver), red and brown paint or markers, small piece of yellow clay or foam (for the gallbladder), small tubes, straws, or pipe cleaners (to represent blood vessels) and glue

What to do:

1. Cut the Styrofoam block into a roughly triangular shape with rounded edges to resemble the shape of the liver.
2. Smooth any rough edges to make it look more realistic.
3. Paint the Styrofoam brown or dark red and allow the paint to dry completely.
4. Use a small piece of yellow clay or foam to form a small oval shape, representing the gallbladder.
5. Attach the gallbladder to the bottom of the liver model on the right side. Glue it in place to keep it secure.
6. Insert short pieces of straw into the Styrofoam to represent blood vessels (the hepatic artery, portal vein, and hepatic vein).
7. Colour these vessels different colours if possible (e.g., red for the artery, blue for the veins) to distinguish them.
8. Present the model to your peers or family explaining the functions of each part.

Functions of the liver

1. Production of bile, which lowers the surface tension of fats for digestion.

2. Production of blood protein called albumin, which prevents leakage of fluids from the bloodstream and transports hormones, enzymes and vitamins in the body.
3. Removal of toxins and other harmful substances from the blood.
4. Regulation of amino acids to healthy levels.
5. Initiation of clotting of blood, by producing bile to aid vitamin K.
6. Removal of bacteria from the blood to prevent or minimise infections.
7. Storage of vitamins A, D, E and K as well as minerals such as iron and copper.
8. Processing of glucose by removing excess glucose (sugar) from the bloodstream which it stores as glycogen. As needed, it can convert glycogen back into glucose.
9. Production of cholesterol and special proteins to help carry fats through the body.
10. Processing of haemoglobin, for storing its iron content.

Processes Involved in Excretion by the Liver

The liver plays a vital role in excretion by eliminating various waste products and toxins from the body. Below is a table (see ***Table 2.3***) of the key processes involved in this function.

Table 2.3: Excretion by the liver

Process	Explanation
Breakdown of ammonia	Ammonia is a toxic by-product of protein metabolism that occurs throughout the body, especially in the muscles. The liver utilises the urea cycle to convert ammonia into a less toxic substance called urea. Urea is much easier for the kidneys to eliminate through urine.
Elimination of bilirubin	Bilirubin is a yellowish pigment produced during the normal breakdown of red blood cells. The liver captures bilirubin and conjugates it with other molecules, making it water-soluble, and then secretes it into bile.

Process	Explanation
Detoxification	The enzymes of the liver break down or modify harmful substances such as drugs, alcohol and environmental toxins into less harmful forms that can be excreted through bile or urine.
Elimination of excess hormones and other molecules	The liver regulates the levels of various hormones, by breaking them down or excreting them in bile. Additionally, it removes excess molecules like bilirubin and cholesterol from the bloodstream.
Contribution to blood purification	By undertaking excretory processes, the liver plays a crucial role in filtering and purifying the blood by removing waste products, toxins, and excess substances. This maintains a healthy internal environment for the body to function properly.

Activity 2.7 Dissection of the Liver to Identify its Parts (Video)

Research and watch a video of how to dissect a liver. While watching the video, answer the following questions in your notebooks:

1. Name a minimum of five items used in the activity.
2. Write down a minimum of five steps and order what you see being done in the activity.
3. Identify a minimum of six parts of the liver exposed by the dissection.
4. Describe how the parts you have identified are connected one to another.
5. List a minimum of two precautions that were taken in the video.
6. List a minimum of three safety measures adopted in the video.

PROCESSES OF REMOVING WASTE FROM THE HUMAN BODY VIA THE KIDNEY

Activity 2.8 Scenario About the Kidney

Read the scenario carefully.

Imagine your body as a busy city, and your kidneys are two important waste management plants working hard to keep everything running smoothly.

As the day begins, your kidneys start their main job: filtering blood.

The blood enters the kidney through the renal arteries, just like trucks delivering garbage to a recycling centre.

Each kidney has about a million tiny workers called Nephrons, ready to get to work.

As the blood flows through the nephrons, they begin filtering out waste.

They remove things your body doesn't need, such as urea, extra salt, and water.

This is like sorting through trash to keep the good stuff and throwing away what is not needed. The important things, such as sugar and some water, go back into the blood.

Those that are not important turn into urine, which travels from the kidney to the bladder.

Questions: Put down your answers on paper as you read and discuss the scenario.

1. Why is the work of the kidney very important?
2. What happens to the waste that has not been used by the body after the blood has been filtered?
3. How do important things such as sugar and some water, after filtering out waste, get into the blood?

Structure and Function of the Kidney

- **The kidneys are two bean-shaped organs** located in the back of the body, just under the rib cage. They are positioned on either side of the spine, with the right kidney typically sitting lower than the left due to the position of the liver.

- Each kidney has a small gland called the **adrenal gland** sitting on top of it. These glands help the body manage stress and other functions. The kidneys' main job is to clean the blood. They filter out waste and extra water to make urine, which is then removed from the body.
- Internally, the kidney has two main areas: the renal cortex on the outside and the renal medulla on the inside. In the medulla, there are 5-8 triangle-shaped parts called renal pyramids that make urine. These pyramids are separated by sections of connective tissue called renal columns.
- Each pyramid has a tip called a renal papilla, which drains the urine it creates into a small collecting area called a minor calyx. Several minor calyces join together to form a larger area called a major calyx.
- All the major calyces connect to a central space called the renal pelvis, which then leads to the ureter.
- The ureter is the tube that carries urine from the kidney to the bladder. This structure helps the kidney efficiently collect and drain urine from the body. — See ***Figure 2.6***

Our kidneys use a lot of oxygen to do their work, about 25% of the oxygen we breathe in. Oxygen helps kidney cells create energy to keep filtering blood. This energy is in a form called ATP (adenosine triphosphate), which the body uses to perform many tasks.

Kidneys are essential because they help remove waste and keep our blood clean and balanced.

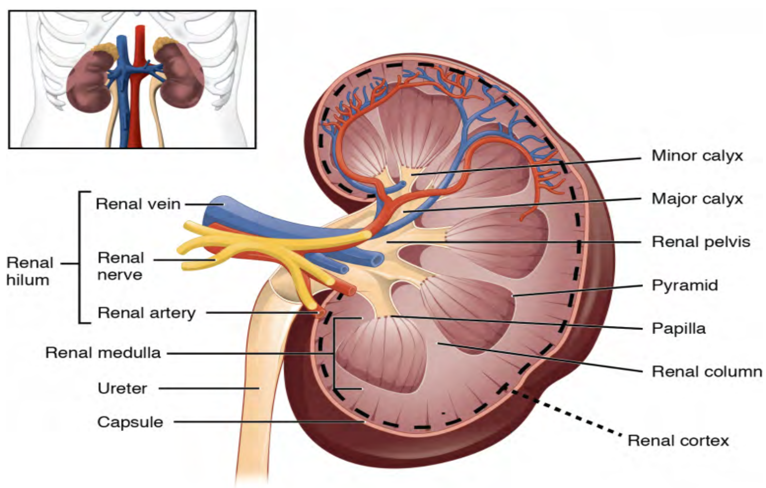


Figure 2.6: Internal structure of the kidney

Questions: Write down your answers in your notebook.

1. What anatomical structures provide protection to the kidney?
2. Name structures found in the renal helium.

Functions of the Different Parts of the Kidney

Table 2.4: The functions of each part of the kidney

Parts	Function
Renal Pelvis	Collects urine from different parts of the kidney and funnels it into the ureter to leave the body.
Renal Vein	Carries cleaned blood (without oxygen) from the kidney back into the bloodstream.
Renal Artery	Brings oxygen-rich blood to the kidney so it can be filtered.
Renal Pyramid	Moves urine from the renal cortex to the renal pelvis.
Renal Medulla	Contains parts of the nephron that help concentrate urine and keep the body's water balanced.
Ureter	A tube that carries urine from the kidney to the bladder.
Capsule	The kidney's tough outer layer that protects it and helps it keep its shape.
Minor Calyx	Collects urine from each renal pyramid.
Major Calyx	Channels urine from minor calyces to the renal pelvis.
Hilum	An entry and exit area for blood vessels, nerves, and urine pathways.
Renal Column	Contains blood vessels and tubules that support the nephrons.
Renal Cortex	The outer part of the kidney where blood is filtered through tiny units called nephrons.

How Blood Flow Through the Kidney

- The kidneys get a lot of blood because they need to filter and clean it. About 25% of the blood pumped by the heart goes to the kidneys. Blood enters the kidneys through renal arteries, which are large blood vessels coming from the heart's main artery, the aorta. These arteries go into the kidney at a part called the renal hilum.

- Inside each kidney, the renal arteries split into smaller arteries that move through the kidney, eventually reaching tiny tubes in the cortex (outer part of the kidney). The smallest of these arteries are called afferent arterioles, which bring blood to a special capillary bed called the glomerulus. The glomerulus is a key part of the kidney's nephrons (tiny units that filter blood). Each kidney has about 1.3 million nephrons, which work together to clean the blood.
- After blood is filtered, the clean blood leaves the kidneys through renal veins that connect to the inferior vena cava (a large vein that returns blood to the heart). Any waste and extra water form a liquid called filtrate. This filtrate goes through the collecting ducts, then into the minor and major calyces, and finally to the renal pelvis, where it's carried to the bladder by the ureters as urine. — See ***figure 2.7***

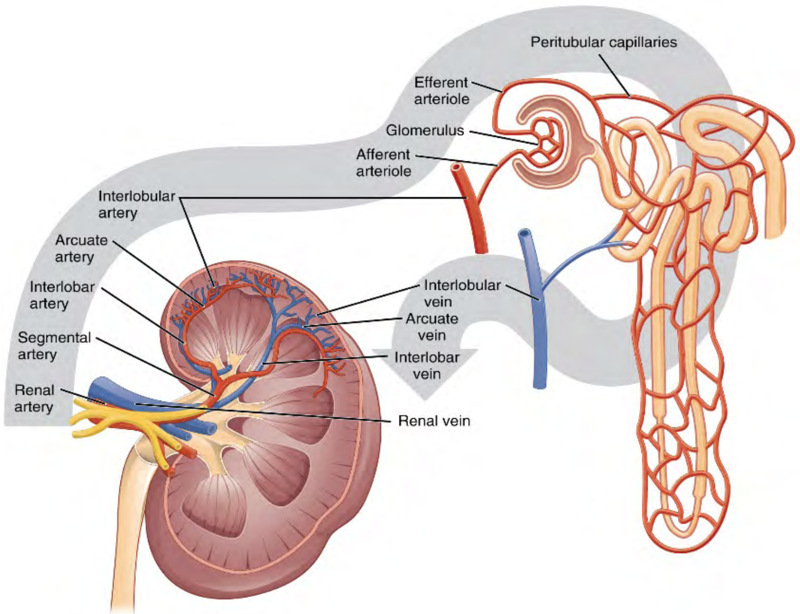


Figure 2.7: Flow of blood in the kidney

Structure of the Nephron

The nephron is the kidney's functional unit, with over a million in each kidney, mostly in the outer layer (renal cortex).

Each nephron filters blood through the renal corpuscle, processes the filtered liquid into urine in the renal tubule, and receives blood through a capillary network. — See ***Figure 2.8***

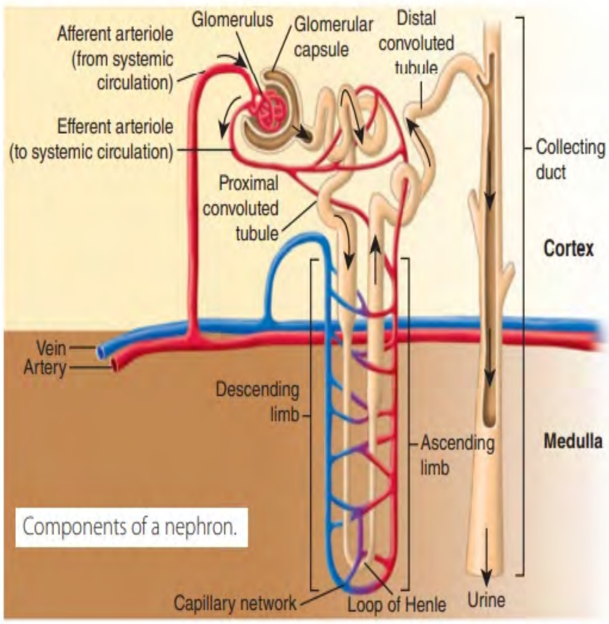


Figure 2.8: Structure of the nephron

Functions of the Parts of Nephron

Table 2.5: Functions of the parts of nephron

Parts	Function
Renal Corpuscle (Glomerulus + Bowman's Capsule)	The renal corpuscle is the starting point for making urine. It filters the blood by pulling out water, glucose, ions, and waste, creating a fluid that will later become urine.
Proximal Convoluted Tubule (PCT)	This part, close to Bowman's Capsule, reabsorbs most of the filtered water, glucose, and nutrients from the fluid back into the blood. This reabsorption is important to keep the body from losing too much water and valuable substances.
Loop of Henle	This U-shaped loop enters the kidney's medulla and helps concentrate urine. The descending part allows water to leave, while the ascending part pumps out salts. This setup helps the body hold onto water when it needs to.

Parts	Function
Distal Convoluted Tubule (DCT)	The DCT fine-tunes urine concentration by absorbing more sodium and water back into the blood and balancing acids and minerals like potassium. This keeps our body’s salt and pH levels balanced.

Renal Filtration

Activity 2.9 Renal filtration

***What you need*:** Two clear plastic bottles, coffee filters or fine cloth, gravel (small pebbles), sand, activated charcoal, water, food colouring (to simulate waste), measuring cups and container or beaker.

What to do:

1. Cut the bottoms off two plastic bottles to create funnels.
2. Place a coffee filter or fine cloth at the bottom of each bottle.
3. In the first bottle, layer the gravel, then sand, and finally activated charcoal. This will simulate the filtration layers of the kidneys.
4. In a separate container, mix water with a few drops of food coloring to represent blood that contains waste products.
5. Pour the coloured water slowly into the top of the first bottle (the one with the filtration layers).
6. Observe how the water passes through the layers and collects in the bottom of the bottle.
7. Place a container under the second bottle to catch the filtered water.
8. After the water has filtered through, observe the clarity of the water in the container.

Questions: Record your answers in your notepad.

1. What changes did you notice in the water after it passed through the filtration layers?
2. How does this experiment relate to how kidneys filter blood in our bodies?
3. Why do you think it’s important for the kidneys to filter out waste?

Urine Formation

Urine formation in the kidneys involves three main steps: filtration, reabsorption, and secretion.

Let us explore the steps!

A. Filtration:

- This process starts in a part of the nephron called the renal corpuscle, which includes the glomerulus (a bundle of tiny blood vessels) and Bowman's capsule (a cup-like structure).
- Blood enters the glomerulus under high pressure, which pushes water, ions, glucose, and waste (like urea) out of the blood and into Bowman's capsule, forming the initial fluid called glomerular filtrate.

B. Reabsorption:

- After filtration, this filtrate flows into the renal tubule.
- The tubule reabsorbs essential nutrients like ions, glucose, and water back into the blood through nearby capillaries, making sure the body doesn't lose useful substances.

C. Secretion:

- During this final stage, waste ions and hydrogen ions move from the capillaries into the renal tubule, where they combine with the remaining filtrate to form urine.
- The urine then flows through the collecting duct, exits the kidney through the renal pelvis, travels down the ureter, and is stored in the bladder.

PROCESSES OF REMOVING WASTE FROM THE HUMAN BODY

Processes Involved in Excretion of Waste by the Lungs

What happens when we breathe in and out? Let us begin with a simple activity!

Activity 2.10 Blow up the Balloon Experiment

***What you need*:** balloons

What to do: Take a deep breath and blow up the balloon.

Questions: Write down your answers in your notepad.

1. What happened to the balloon after blowing it up?
2. What did you put inside the balloon?
3. Why is it important to get rid of carbon dioxide?
4. What would happen if we could not remove carbon dioxide from our bodies?

Now, let us explore how the lungs get rid of metabolic waste from the body!

What Happens During Breathing?

When you breathe in (inhale), your lungs take in air that is rich in oxygen.

When you breathe out (exhale), your lungs push out air that contains carbon dioxide and a little bit of water vapour.

Activity 2.11 Demonstrate That Exhaled Air Contains Water Vapour

***What you need*:** Small mirrors (one for each learner or group)

What to do: Breathe out gently onto the mirror, holding it close to their mouth.

Questions

1. Write your answers in your notebook. What happened to the surface of the mirror?
2. Why do we need oxygen?

Every cell in your body needs energy to function, like a car needs fuel. To get this energy, cells break down a type of sugar called glucose. To release energy from glucose, cells need oxygen. This process is called cellular respiration.

The formula looks like this: Glucose + Oxygen → Energy + Carbon Dioxide + Water

What happens during cellular respiration?

When your cells use oxygen to produce energy, they also create two metabolic waste products: carbon dioxide (CO_2) and water vapour.

The energy produced is what keeps your body moving, thinking, and working. The carbon dioxide and water are not needed, so they need to be removed from the body.

Activity 12: How Do the Lungs Remove Carbon Dioxide (CO_2)

***What to do*:** Research and watch videos online on how the lung removes metabolic waste.

Questions: Record your findings from the research in your notebook.

1. How does diffusion help in gaseous exchange in humans?
2. How do the lungs remove waste?

Inside your lungs, there are tiny air sacs called alveoli. These alveoli are surrounded by blood vessels (capillaries).

When you breathe in, the oxygen goes into the alveoli and then passes into the blood.

At the same time, carbon dioxide from the blood moves into the alveoli. This happens through a process called diffusion, where gases move from where there's a lot of them (high concentration) to where there's less (low concentration). — See ***Figure 2.9***

Exhaling Waste Products

After the carbon dioxide collects in the alveoli, it is pushed out of the body when you breathe out. This is how your body gets rid of carbon dioxide, a waste product.

Water vapor (a bit of moisture) also leaves your body when you exhale. This helps keep your body's water balance in check.

Why is it important to get rid of carbon dioxide?

Getting rid of carbon dioxide is crucial because if it builds up in your body, it can make your blood too acidic, which is dangerous.

The removal of carbon dioxide and water vapor through breathing helps keep your body's systems in balance and ensures your cells can keep making energy.

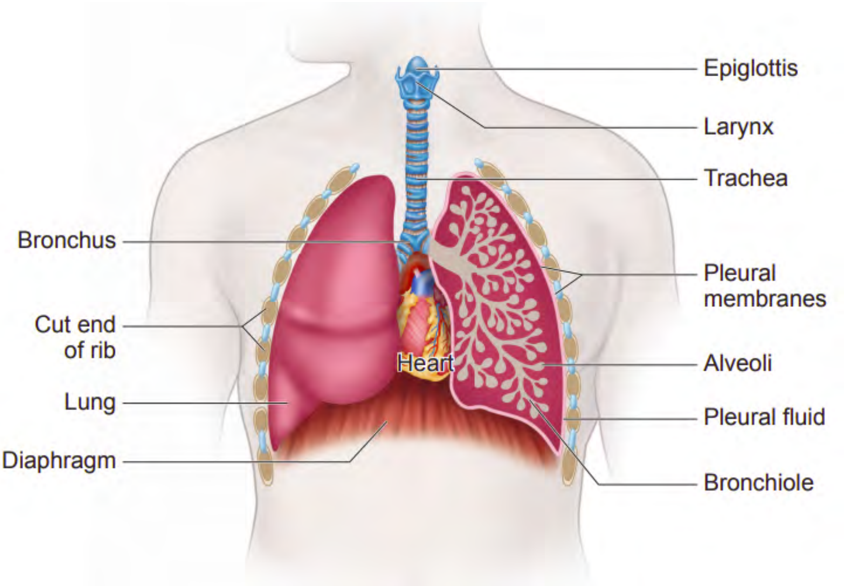


Figure 2.9: Human Respiratory System

Processes Involved in Excretion by the Large Intestine

Let us explore the processes involved in excretion by the large intestine.

Questions: Write down your answer in your notebook.

1. What happens to the leftover food that our body doesn't need?
2. Why is it important for the large intestine to absorb water?
3. What would happen if the large intestine did not absorb water properly?

Activity 2.13 Excretion by the Large Intestine

What to do:

1. Research and watch videos online on how the large intestine removes metabolic waste.
2. Record your findings from the research in your notebook.

3. Answer these questions

a. How does the stool move in the large intestine?

b. How does osmosis help in absorption of water in the large intestine?

4. Share your findings with your peers or family members.

How does the large intestine get rid of waste product?

The large intestine's role is to take the leftover material from the small intestine, absorb water and salts from it, and turn it into solid waste (stool). It then moves the stool to the rectum, where it is stored until you go to the bathroom to get rid of it. This process helps your body save water, stay balanced, and keep things moving smoothly. — See ***Figure 2.10***

1. **Receiving undigested material**: After your food is digested in the small intestine, there are still some parts left that the body can't use. This leftover material, called chyme, moves into the large intestine through a small opening called the ileocecal valve. The chyme contains substances such as fibre (which the body cannot digest), some water, and dead bacteria.
2. **Water absorption**: The main job of the large intestine is to absorb water from the chyme. The walls of the large intestine have special cells that take water out of the chyme, making the material thicker and turning it into a more solid form. This helps prevent the body from losing too much water.
3. **Electrolyte balance**: While absorbing water, the large intestine also takes in electrolytes (salts and minerals) from the chyme. These electrolytes, like sodium and potassium, are important for keeping the body balanced and helping it function properly.
4. **Stool formation**: As more water is absorbed, the leftover material becomes thicker and eventually forms stool (also known as faeces). Stool is made up of things like undigested food (such as fibre), dead cells from your intestines, mucus, and bacteria.
5. **Mass movement and storage**: The large intestine moves the stool slowly towards the end of the digestive system using muscle contractions. These movements are called mass movements. When the stool reaches the last part of the large intestine, called the rectum, it is stored there until it's time to get rid of it.
6. **Elimination (Defecation)**: When the stool reaches the rectum, it pushes against the walls, which makes you feel the need to go to the bathroom. The anal sphincter muscles (muscles at the end of the rectum) relax, and you

use your abdominal muscles to push the stool out of your body through the anus. This is called defecation.

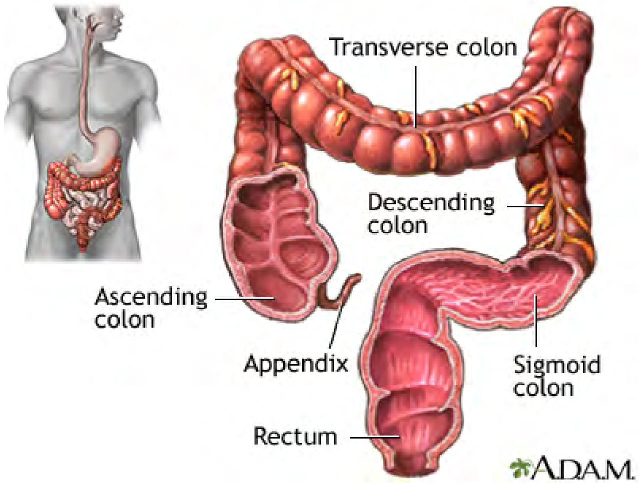


Figure 2.10: Human Large Intestine

Activity 2.14 Inhalation of Oxygen and Exhalation of Carbon Dioxide

What you need: large plastic bottle (1-2 litre size), two small balloons, one large balloon (to represent the diaphragm), two drinking straws, tape or rubber bands and scissors

What to do:

1. Cut off the bottom of the plastic bottle to create an open end. This will allow you to attach the "diaphragm" later.
2. Attach a balloon to the end of each straw. These balloons represent the lungs.
3. Use tape or rubber bands to secure the balloons tightly to the straws, making sure no air can escape.
4. Insert the two straws with the attached balloons through the neck of the bottle. These straws represent the trachea (windpipe) and bronchi leading to the lungs.
5. Use tape to seal the area around the neck of the bottle so that the straws are held in place.
6. Take the large balloon and cut it in half. Discard the top part and keep the bottom part (the rounded end).

7. Stretch this part over the open bottom of the plastic bottle. This will act as the diaphragm, which helps pull air in and push air out.
8. Pull down gently on the diaphragm (the stretched balloon at the bottom of the bottle).
9. Let the diaphragm go and gently push it upwards. The "lungs" will deflate as the air is pushed out.

DISORDERS OF THE HUMAN EXCRETORY SYSTEM

Let us understand some disorders of the excretory system.

Questions: Write your answers in your notebook

1. What happens when a person eats contaminated food?
2. What happens when a person's leg gets fractured?

Disorder

A disorder is a problem or condition that affects how a part of the body works. It means that something is not functioning properly. For example, when a person has a stomach disorder, it means their stomach is not working the way it should, which might cause them to feel sick, have pain, or have trouble digesting food.

Kidney disorders

Perform ***Activity 2.15*** for a better understanding of some kidney disorders.

Activity 2.15 Kidney Disorder (Kidney stones).

What you need: Two clear cups, a spoonful of salt or sugar, water and a stirrer.

What to do:

1. Fill one cup with a small amount of water and dissolve a spoonful of salt or sugar in it.
2. Keep adding more salt or sugar until it no longer dissolves. and you can see tiny crystals forming at the bottom.

Observation: Tiny crystals forming at the bottom.

Questions: Write your answers in your notebook

1. Did you get similar expected results? If not, what resulted to the error and how can it be corrected?
2. What will happen if you add more?
3. How does de-hydration affect the kidney function?

Brief explanation of the activity

This is similar to how kidney stones form. When there is too much mineral and not enough water in the urine, the minerals start to stick together and form crystals, just like kidney stones in the kidneys.

Table 2.6: Disorders of the kidney

Disorder	Description	Causes	Symptoms	Treatment/ Prevention
Glomerulonephritis (GN)	A condition where the tiny filters in the kidneys, called glomeruli, become swollen and irritated	Swelling of glomeruli, the tiny filters in the kidneys by infections, problems with the immune system (when the body attacks itself by mistake)	Blood in the urine, High blood pressure, Edema, protein in urine	Severe cases require dialysis or kidney transplant.
Kidney stones	A condition in which there is a build-up of certain minerals in the urine, like calcium and oxalate in the kidney.	Eating a lot of salty foods Not drinking enough water	Blood in the urine, nausea and vomiting, severe pain in the lower back or side.	Surgery is required for stones, drinking lots of water can help flush them out, reduce severe intake of salt.

Disorder	Description	Causes	Symptoms	Treatment/ Prevention
Acute Kidney Injury (AKI)	It is a sudden and quick loss of kidney function, meaning the kidneys can't filter waste and extra water from the blood like they usually do.	Not having enough water in the body can harm the kidneys. Losing a lot of blood can make it harder for kidneys to do their job. Severe infections:	Less urine: They might not pee as much as usual. Swelling in legs and ankles: Extra fluid in the body can cause parts of the body to swell.	Manage fluid intake. Use diuretics and medicines: Doctors may give medicines to help the person pee more or to control the levels of important minerals like potassium in the blood. Treat infections and avoid harmful medicines. Temporary dialysis: If the kidneys are not working well enough on their own, a machine (dialysis) might be used temporarily to clean the blood.

Disorder	Description	Causes	Symptoms	Treatment/ Prevention
Polycystic Kidney Disease (PKD)	A genetic disorder characterised by the growth of numerous cysts in the kidneys.	Genetic mutations	High blood pressure, back or side pain, blood in urine, and frequent kidney infection	Surgery to remove cysts, drinking plenty of water to prevent kidney stones. - Treat kidney infections, dialysis or kidney transplant.

Skin disorders

A skin disorder is a condition that changes how the skin looks, feels, or works. It can make the skin look different, feel uncomfortable, or stop it from doing its job. Skin disorders can happen for many reasons, like allergies, infections, or even genetics, and they can be mild or more serious, depending on the type and cause — see ***Table 2.7***.

Table 2.7: Disorders of the skin

Disorder	Description	Causes	Symptoms	Prevention/ treatment
Acne	Acne shows up as pimples, blackheads, or cysts when skin pores get clogged.	Hormones boost oil production, clogging pores, and allowing bacteria to grow. Stress, diet, and some medications can worsen it.	You might see pimples, blackheads, or painful lumps on the face, chest, back, or shoulders.	Cleanser and topical creams can help. For severe cases, doctors may prescribe stronger medications. A good skincare routine and healthy diet help manage it.
Eczema	Eczema causes dry, itchy, red patches on the skin that may crack or blister	Often due to genetics, allergies, and weak skin barriers.	Skin can be dry, itchy, and red, especially with exposure to stress or irritants.	Moisturisers soothe and protect, while creams help reduce itching and redness. Severe cases may need stronger medications.

Disorder	Description	Causes	Symptoms	Prevention/ treatment
Psoriasis	This is an autoimmune condition that causes red, scaly patches.	The immune system mistakenly attacks the skin.	Red patches with white scales appear on the elbows, knees, and scalp.	Creams, light therapy, and medications can help reduce symptoms.
Skin Rashes	Red, irritated, or swollen areas on the skin.	Allergies, infections, heat, or contact with irritants like chemicals.	Itching, redness, bumps, and sometimes blisters.	Avoid irritants, apply soothing creams, keep skin clean, and use prescribed treatments for infections.
Atopic Dermatitis	A type of eczema that's very itchy and often linked to allergies.	Like eczema, related to genetics and allergies.	Common on the face, hands, and feet. In babies, it may appear on the cheeks and scalp.	Moisturisers and creams for itching help, and avoiding triggers is essential.

Liver Disorders

Liver disorders are problems that prevent the liver from working as it should. The liver is an important organ that helps our body by cleaning out harmful substances (toxins), making proteins that our body needs, and producing substances for digesting food. When the liver doesn't work properly, it can affect the whole body, because the liver's job is to keep our body healthy and balanced. — See ***Table 2.8***.

Table 2.8: Disorder of the liver

Disorder	Description	Causes	Symptoms	Prevention/ treatment
Hepatitis	Hepatitis is an inflammation of the liver.	Viruses (hepatitis A, B, C), alcohol, drugs, autoimmune reactions.	Tiredness, yellowing of the skin and eyes (jaundice), nausea, stomach pain.	No cure for viral hepatitis, but vaccines can prevent hepatitis A and B. Hepatitis C can be treated with antiviral medication.
Liver cancer	Liver cancer is a type of cancer that begins in the liver, primarily affecting liver cells.	Chronic hepatitis B or C infections, cirrhosis, or exposure to certain toxins.	Weight loss, upper stomach pain, yellowing of the skin, loss of appetite.	Surgery to remove cancerous parts, liver transplant, and protecting the liver from risk factors like hepatitis viruses and toxins.
Cirrhosis	Cirrhosis is a late-stage liver disease characterised by the replacement of healthy liver tissue with scar tissue (fibrosis), which can severely impair the liver's ability to function.	Long-term liver disease causes scarring (like chronic hepatitis or ALD).	Yellow skin, fluid buildup in the abdomen, fatigue, confusion.	Lifestyle changes and medications can help manage symptoms; a liver transplant may be needed in severe cases.

Disorder	Description	Causes	Symptoms	Prevention/ treatment
Autoimmune Hepatitis	Chronic liver disease in which the body's immune system mistakenly attacks healthy liver cells, leading to inflammation and damage.	The immune system mistakenly attacks liver cells; genetics may play a role.	Yellow skin, tiredness, loss of appetite, abdominal pain.	Immunosuppressant medications to help prevent immune system attacks on liver cells.
Non-Alcoholic Fatty Liver Disease (NAFLD)	Liver condition characterised by the accumulation of excess fat in liver cells, occurring in people who drink little to no alcohol	Fat buildup in the liver is unrelated to alcohol. Linked to obesity, diabetes, and high cholesterol.	Often none but can include tiredness or mild upper right abdominal pain.	Weight loss through healthy diet and exercise; managing conditions like diabetes.
Alcoholic Liver Disease (ALD)	This is a liver condition caused by prolonged heavy alcohol consumption, resulting in inflammation, fat buildup in the liver (steatosis), and, over time, severe scarring (fibrosis) or cirrhosis.	Long-term alcohol use damages liver cells, leading to fat buildup and scarring.	Fatigue, loss of appetite, yellow skin (jaundice), swelling in the legs.	The best prevention is to avoid or reduce alcohol. Complete abstinence from alcohol is essential for managing ALD.

Activity 2.16 Disorders of the Excretory Organs

What to do:

1. Familiarise yourselves with the different skin and liver disorders discussed in class. Make note of their symptoms, causes, and treatments.
2. One student will take on the role of the "patient." The rest of the class will act as "doctors."
3. The "patient" will describe one symptom they are experiencing (e.g., "I have a rash on my hand" or "I feel very tired and have jaundice.").
4. The "doctors" will take turns asking one question at a time to determine which disorder the "patient" might have. Examples of questions include:
   - **a.** Is the rash itchy?
   - **b.** Have you consumed a lot of alcohol recently?
   - **c.** Do you have any other symptoms like fatigue or nausea?
5. Once the disorder is correctly identified, the "doctors" will take turns suggesting possible treatments or lifestyle changes for the "patient." For example, "You should avoid alcohol and see a doctor for further tests" for Alcoholic Liver Disease, or "Using moisturisers can help with your rash" for eczema.
6. After the disorder is identified and treatment is suggested, a new "patient" will come to the front with a different symptom. Repeat the process, ensuring different students take turns playing the roles of "patients" and "doctors." Encourage and respect each other's views.

Questions: Write down your answers in your notebook.

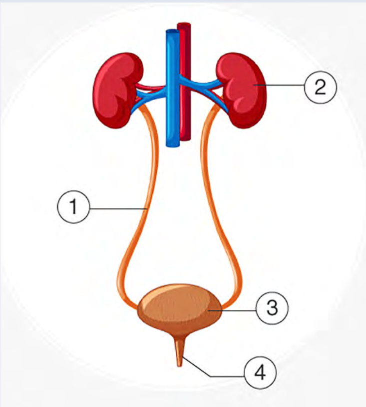
1. What happens to the "lungs" (balloons) when the diaphragm moves down?
2. Why do you think carbon dioxide needs to be removed from our body?
3. How does this activity help us understand the process of breathing?

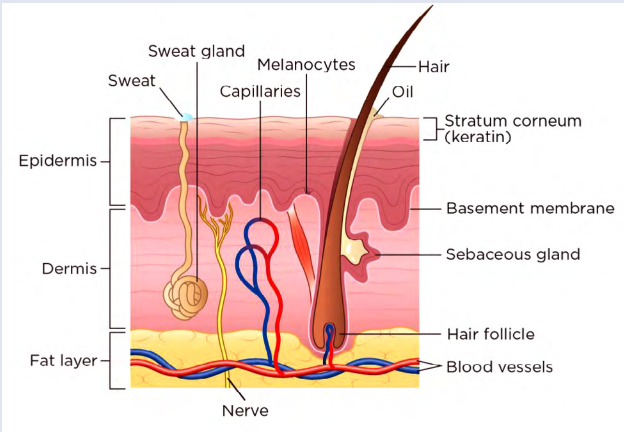
EXTENDED READING

1. Textbooks: “Renal Physiology” by Alfred E. B. G. B. Carr provides comprehensive insights into kidney functions.
2. Online Resources: National Kidney Foundation (www.kidney.org) offers educational materials on kidney health and diseases.
3. Textbooks: “Medical Surgery: An Integrated Approach” covers various excretory system disorders.
4. Online Resources: MedlinePlus (medlineplus.gov) offers information on various health conditions and their effects on the excretory system.

REVIEW QUESTIONS

1. The diagrams below represent the structures of the human body. Study them carefully and answer the questions that follow





A B

   a. Identify the diagram A and B
   b. Name the Label the parts numbered 1,2,3 and 4
   c. How does the skin regulate the body temperature?
   d. How does the epidermis differ from the dermis in terms of structure and function?
   e. What are the three main layers of the skin, and what are the primary functions of each layer?
2. Identify at least four parts of the liver.
3. Describe four functions of the liver.
4. How does the liver excrete waste from the body.
5. What is the outer layer of the kidney called?
   a. **Medulla**
   b. **Cortex**
   c. **Pelvis**
   d. **Ureter**
6. The nephron is a functional unit of the kidney. True or false
7. The __________ is the central cavity of the kidney where urine collects.

8. What are the two main functions of the kidneys?

9. Match the following parts of the kidney with their functions:

(a)	**Parts**	(b)	**Functions**
	Ureter		stores
	Bladder		filters blood
	Nephron		transports urine to the bladder
	Renel medulla		concentrate urine

10. Name the excretory products of the following excretory organs.

a) Lungs

b) Large intestine

11. How does the large intestine eliminate stool from the body?

12. Describe what happens when the following metabolic waste are not remove the body.

a) Faces (stool)

b) Carbon dioxide

SECTION

3 GASEOUS EXCHANGE IN HUMANS

PROCESSES FOR LIVING

Essentials for Survival

INTRODUCTION

The movement of air in humans is necessary for survival because it allows the respiratory system to provide critical oxygen to cells while also removing carbon dioxide, a byproduct of metabolism. Understanding the structure of the lungs, which include the trachea, bronchi, and alveoli, shows how effectively they facilitate gas exchange. Aerobic respiration, the mechanism by which cells convert glucose and oxygen into energy, is strongly dependent on proper lung function. However, smoking can have a serious impact on respiratory health, resulting in conditions such as asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. In this section, you will learn about the movement of air in humans and its importance, the structural components of the lungs, the process of aerobic respiration, and how smoke and common respiratory illnesses affect overall health. This exploration highlights the importance of maintaining respiratory health and encourages awareness and preventive measures against harmful environmental factors.

KEY IDEAS

1. **Exhalation:** Exhalation is the release of air from the lungs and is essential for maintaining respiratory function, occurring as a counterpart to inhalation.
2. **Diaphragm and abdominal muscles**: During exhalation, the diaphragm relaxes and moves upward, while the contraction of abdominal muscles helps push the diaphragm further upward, aiding in air expulsion.
3. **Structure of the lungs**: The lungs are vital respiratory organs consisting of two lobes (left and right), with essential components like the trachea, bronchi, alveoli, and pleura responsible for gas exchange.
4. **Aerobic Respiration:** This process involves using oxygen to convert glucose into energy, underscoring the importance of efficient lung function for energy production in cells.

5. **Disorders:** A disorder is any condition that deviates from normal functioning, affecting different facets of health and well-being, and varying in severity from mild to life-threatening.
6. **Chronic Obstructive Pulmonary Disease (COPD):** a progressive lung disorder characterised by breathing difficulties and other symptoms, highlighting the importance of respiratory health awareness.

MOVEMENT OF AIR IN HUMANS AND ITS IMPORTANCE

Activity 3.1 Breathing Process

What to do: Breathe in and out. What you have just done is taking air in and out of the body.

Questions: Write your answers in your notepad.

1. Do you take time to think before you breathe?
2. Where does the air the go when you breathe in?
3. Where does the air you breathe out come from?

Breathing

Breathing is the process of taking oxygen into the lungs from the atmosphere and taking out carbon dioxide from the lungs into the atmosphere. It is an essential bodily function that allows the body to take in oxygen and remove carbon dioxide from it.

Breathing involves air movement through the respiratory passages and structures to the lungs, where gas exchange occurs. Breathing in is also known as inhalation (inspiration) while breathing out is called exhalation (expiration). Inhalation introduces oxygen into the body while exhalation takes carbon dioxide out of it. Exchange of oxygen and carbon dioxide is vital for the body to function and produce energy. — See ***Figure 3.1.***

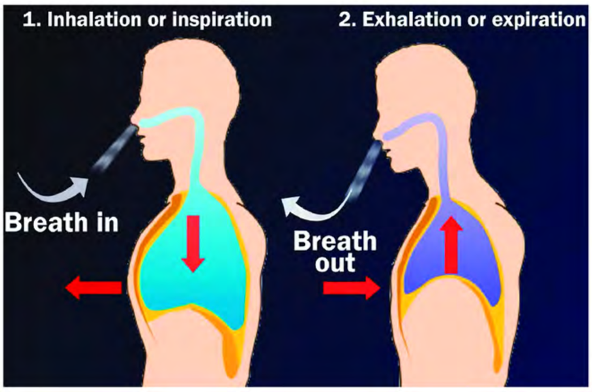


Figure 3.1: Inhalation and Exhalation

Structures and Processes Involved in the Movement of Air

Movement of air in humans involves the actions of structures and various processes. The structures and their functions are as follows:

- **Pharyngeal Cavities**: They are passages provided by the mouth and nose. They are called oral and nasal passages respectively. Both passages warm and moisturise the incoming atmospheric air. The nasal passage is lined with hair cells that help to filter the air by eliminating dust particles, smoke and other colloidal substances from it. The nasal and oral passages are lined with mucous membranes which trap dust, bacteria and viruses from the air. — See ***Figure 3.2.***

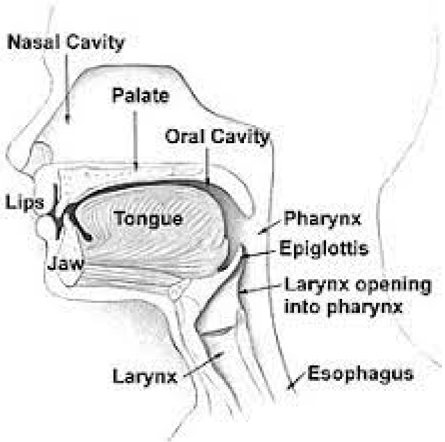


Figure 3.2: Pharyngeal Cavities

- **Trachea**: A cartilaginous tube which connects the pharyngeal cavities to the lungs. It provides a pathway for air to enter and leave the lungs. It is lined with cilia which filters the incoming air further.

- **Bronchi** (one is bronchus): They are branches of the trachea which are embedded in the lungs. They provide a pathway for air to enter and leave the lungs.
- **Bronchioles**: They are numerous branches into which the bronchi divide extensively in the lung, forming a bronchial tree. They ensure that air is carried to every part of the lungs and removed from them as well. — See ***Figure 3.3.***

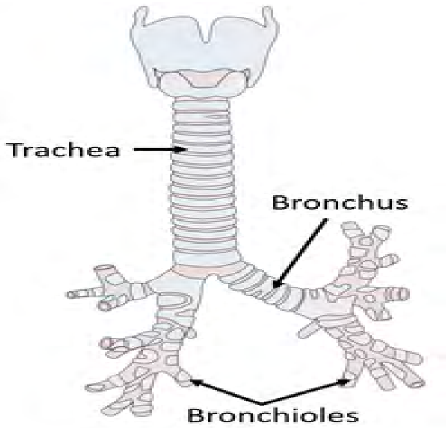


Figure 3.3: Structure of trachea, bronchi and bronchioles

- **Alveoli**: They are sac-like structures into which the bronchioles end. They effect gaseous exchange between bronchioles and the lungs. — See ***Figure 3.4.***

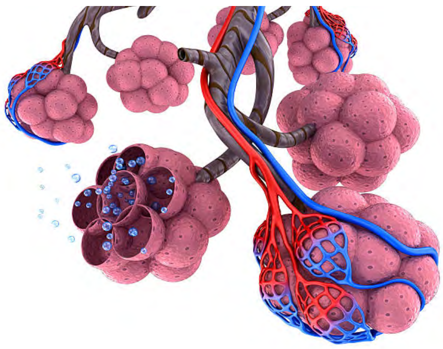


Figure 3.4: Alveoli

Lungs: The lungs are the organs of respiration and make up a large part of the respiratory system. They are a paired cone shaped organ lying in the thoracic cavity, separated from each other by the heart and other structures in the area between them, called mediastinum.

The lungs are connected to the trachea at the upper side by the right and left bronchi. On their lower surface, they are bordered by the diaphragm. The diaphragm is a flat, dome-shaped muscle located at the base of the lungs and thoracic cavity. The lungs are enclosed by layers called pleurae, which are attached to the mediastinum. The inner layer, called visceral pleura, wraps around the lungs and is stuck so tightly to the lungs that it cannot be peeled off. The outer layer, called parietal pleura, lines the inside of the chest wall. There is a very thin space between the layers called the pleural space. A liquid, called pleural fluid, is in the pleural space. The right lung is shorter and wider than the left lung, while the left lung occupies a smaller volume than the right lung. There is an indentation on the surface of the left lung called the cardiac notch. This allows space for the heart. The apex of the lung is the superior region, whereas the base is the inferior region. The lung has three surfaces namely the costal, mediastinal, and diaphragmatic surfaces. The costal surface borders the ribs, the mediastinal surface faces the midline while the diaphragmatic surface borders the diaphragm beneath it. — See ***Figure 3.5.***

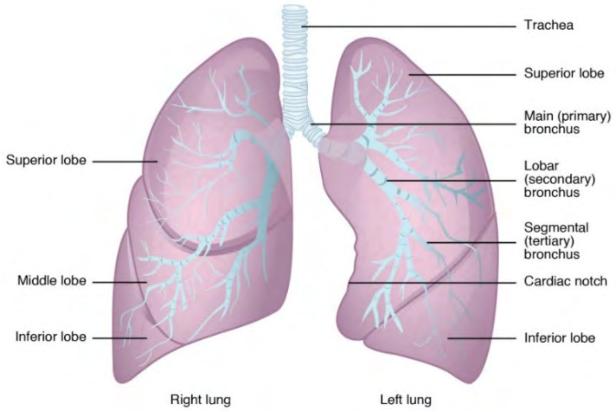


Figure 3.5: Human lungs

Pathway of Air into The Body

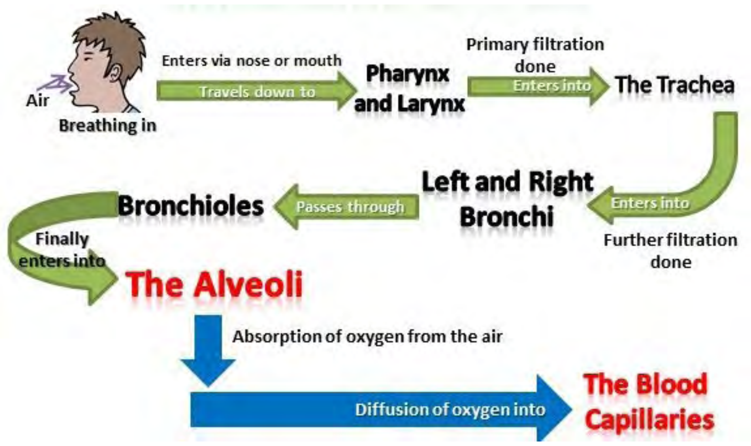


Figure 3.6: Pathway for Inhaled Air

Activity 3.2 Concept Map for Movement of Air in The Body

What to do:

1. Create a concept map for the direction of flow of air into the lungs. — See ***Figure 3.6***
2. Explain why when someone's head is cut off, he or she cannot survive but can survive when the hand is cut off.

What happens to inhaled or inspired air in the body?

Each air sac or alveolus (plural is alveoli) is surrounded by a rich network of fine blood vessels (capillaries). The oxygen in inhaled air passes across the thin lining of the air sacs into the blood vessels. This is known as diffusion. The oxygen in the blood is then carried around the body in the bloodstream, reaching every cell where it is used to power every reaction and process that needs oxygen to break down food to release energy for use by the body. This is known as aerobic respiration.

After the red blood cell has released oxygen in the cells of tissues and organs, it picks up carbon dioxide, which is a major excretory product of aerobic respiration, and transports it to the lungs. Carbon dioxide is expelled from the body through the lungs during the process of exhalation or expiration. — See ***Figures 3.7 to 3.8.***

Question: Why are the alveoli able to carry out gas exchange effectively? Write your answer in your notebook.

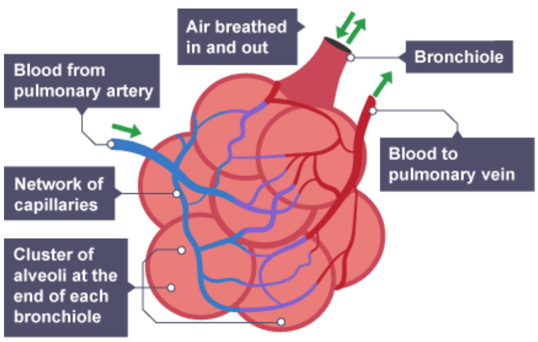


Figure 3.7: Alveoli Surrounded by Blood Capillaries

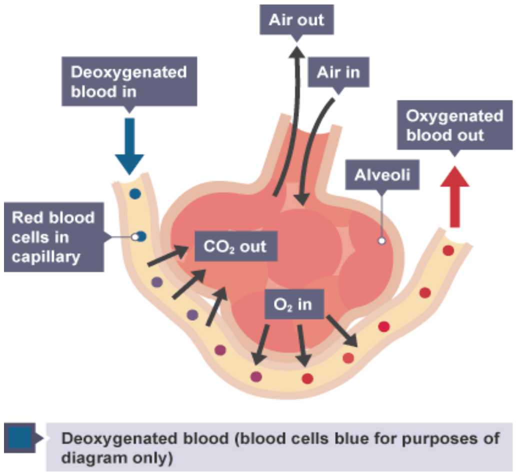


Figure 3.8: Gaseous exchange in alveolus

Activity 3.3 Making a Human Lung Model

***What we need*:** A plastic bottle, some straws, a few balloons, hot glue, a pair of scissors and utility knife.

What to do:

1. Punch a hole in the bottom portion of the bottle with scissors.
2. Cut the bottle into two pieces horizontally with the scissors.
3. Insert one of the scissor blades into the incision that you made so that half of the scissors is inside of the bottle.
4. Hold the bottle firmly in your non-dominant hand, and cut all the way around the side of the bottle with your scissors so that you end up with two halves—one half with the bottle cap and one half with the base.
5. Discard the bottom half of the plastic bottle.
6. Use the utility knife to cut an opening in the bottle cap.
7. Test the bottle cap by trying to fit a plastic straw inside.
8. Cut a plastic straw into three equal lengths with the scissors.
9. Slide the pointed edges of two pieces of straw into the bottom of a larger straw.
10. Glue the junction where the three straws meet, with a hot glue gun.
11. Add hot glue to the inside lip of two balloons and put them on the straws.
12. Slide the open end of the larger straw through the bottle cap.
13. Cut another balloon near the neck with the scissors.

14. Glue the inner neck of the cut balloon and slide it over the bottom of the bottle. This acts as the diaphragm. — See ***Figures 3.9 to 3.10***

Figure 3.9: A Model of Human Lung

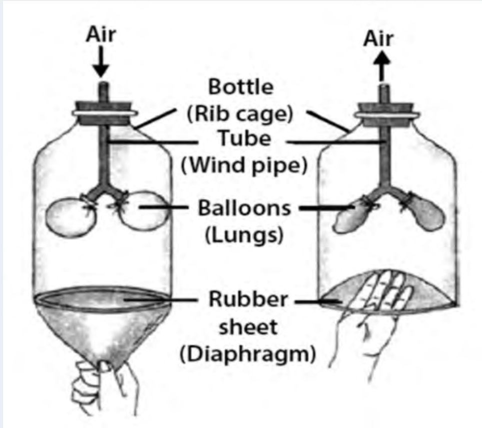


Figure 3.10: Inhalation and Exhalation

Safety Precautions

1. Keep your hand away from the blade.
2. Use a newer, sharper blade so that you don't have to apply as much pressure.
3. Allow all glued parts to dry well.

Mechanism of Inhalation (Inspiration) in Humans

Perform ***Activity 3.4*** to gain a deeper understanding of inhalation!

Activity 3.4 Breathing Mechanisms

What you need: the model made in ***activity 3.3***

What to do:

1. Pull on the skin of the balloon at the bottom and release.
2. Record your observation as you pull on the balloon at the bottom and release it

Questions: Write down your answer in your notebook.

1. What is the difference between inhalation and exhalation?
2. What happens to the diaphragm during inhalation and exhalation processes?

Inhalation (inspiration) Mechanism

- External intercostal muscles contract while internal intercostal muscles relax.
- This causes the rib cage and sternum to move upward and outward.
- The diaphragm contracts, moves down and flattens.
- The volume of the thoracic cavity increases.
- Air pressure in the thoracic cavity becomes lower than atmospheric pressure.
- Air flows from the atmosphere where there is higher pressure into the thoracic cavity where there is lower pressure. — See ***Figure 3.11.***

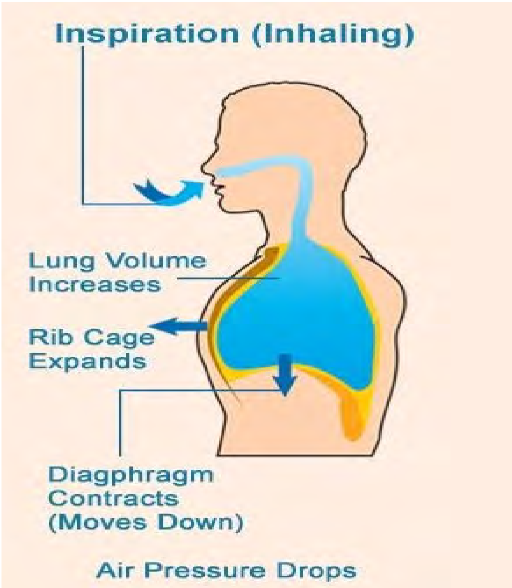


Figure 3.11: Inhalation (inspiration)

Mechanism of Exhalation (expiration) in Humans

Carbon dioxide is expelled from the body by the following respiratory movements and processes in the order as follows:

- External intercostal muscles relax while internal intercostal muscles contract.
- This causes the rib cage and sternum to move down and inward.
- The diaphragm relaxes and moves up to its original dome shape.
- The volume of the thoracic cavity decreases.
- Air pressure in the thoracic cavity becomes higher than atmospheric pressure.

- Air, rich in carbon dioxide, flows from the thoracic cavity where there is higher pressure into the atmosphere where there is lower pressure. — See ***Figure 3.12.***

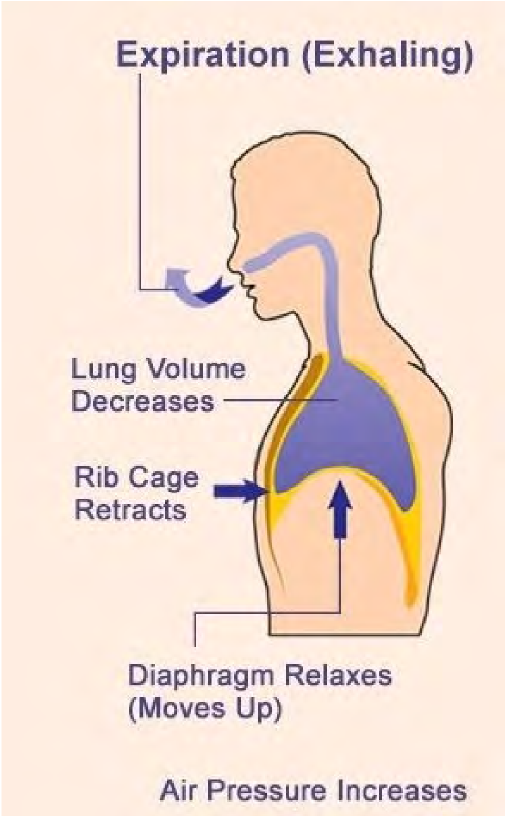


Figure 3.12: Exhalation (expiration)

Differences Between Inhalation and Exhalation

Table 3.1: Differences between inhalation and exhalation

Aspect	Inhalation	Exhalation
Muscles involved	Diaphragm contracts and moves down, external intercostal muscles contract, iInternal intercostal muscles relax.	Diaphragm relaxes and moves up, external intercostal muscles relax, internal intercostal muscles contract.
Volume change	Thoracic cavity expands (increases in width and length)	Thoracic cavity decreases in width and length.

Aspect	Inhalation	Exhalation
Volume of lung	Increases	Decreases
Air pressure in lungs	Decreases	Increases
Air movement	From atmosphere into lungs	From lungs into atmosphere
Energy needs	Active process, needs energy (ATP)	Passive process, needs no energy (ATP)
Breathing cycle	Initiation	Completion
Gas involved	Oxygen	Carbon dioxide
Structural movement	Ribs and sternum move up and outward	Ribs and sternum move down and inward

Importance of Air Movement in Humans

Imagine what would happen to the human body if no air flowed in it. The movement of air in humans is vital for maintaining proper respiratory functions and overall health. The site of exchange is in the alveoli. The movement of air in the human body comes with the following benefits:

1. **Oxygen supply:**
   a. Inhalation brings oxygen-rich air into the lungs, which is absorbed into the bloodstream.
   b. Oxygen is essential for cellular respiration, providing the energy needed for the body's various functions.
2. **Carbon dioxide removal:**
   a. Exhalation removes carbon dioxide from the body, a waste product of cellular respiration.
   b. Efficient air movement ensures that carbon dioxide levels in the body are kept within a healthy range, preventing build-up and potential health issues.

3. **Respiratory homeostasis:**
   a. Air movement helps maintain the body's balance of gases (oxygen and carbon dioxide), which is crucial for preserving the body's pH and other physiological parameters.
   b. Disruptions in air movement can lead to respiratory disorders, such as hypoxia (low oxygen levels) or hypercapnia (high carbon dioxide levels).
4. **Lung function:**
   a. Regular air movement helps to keep the lungs healthy and to function optimally.
   b. It prevents the build-up of mucus and other respiratory secretions, which can impair lung function if not cleared.
5. **Immune system support:**
   a. Air movement helps to filter and remove airborne pathogens, such as bacteria and viruses, from the respiratory system.
   b. This protects the body from respiratory infections and supports the overall immune system.
6. **Physical and mental well-being:**
   a. Efficient air movement improves physical performance by delivering more oxygen to the muscles.
   b. It also reduces stress and anxiety by triggering the relaxation response associated with deeper and slower breathing patterns.

STRUCTURE OF THE LUNGS AND AEROBIC RESPIRATION

The use of lungs and on how cells use oxygen to convert glucose and other nutrients to produce energy carrier.

Activity 3.4 Watch a Video on The Respiratory System

What to do:

1. Watch a short video, model or animation that explains the structure of the respiratory system.
2. Take notes on the key features and functions of each part.

3. Examine the lungs and their components, including the trachea, bronchi, bronchioles and alveoli along with the surrounding blood vessels
4. Create your own labelled illustration of the lungs, ensuring to include trachea, bronchus, bronchiole, lungs and alveolus.
5. Share your work with your peers or family members by discussing the structure, functions, and location of various lung components, and encourage your classmates to ask questions for further discussion.
6. Post your work on your social media platform to encourage others.

Questions: Write your answers in your notebook.

1. Which components of the respiratory system are supported by firm cartilage?
2. Which sections of the respiratory system show flexibility and elasticity?
3. Where in the respiratory system can you find goblet cells and cilia?
4. Explain the roles of alveoli, bronchioles, and cilia.

Respiratory system

The lungs serve as the respiratory organs in our body, facilitating all gas exchange processes. Typically, humans possess a pair of lungs: the left and the right. They are responsible for inhaling oxygen (O_2) and exhaling carbon dioxide (CO_2). The lungs are essential for delivering oxygen to our body, and without this vital function, survival would be impossible within a minute. The main components of the lungs include the trachea, alveoli, bronchi, and pleura.

The parts of the respiratory system made of firm cartilage include the trachea and primary bronchi. The trachea, or windpipe, has C-shaped rings of cartilage that keep it open while allowing some flexibility. The primary bronchi branch off from the trachea into the lungs and have similar cartilage support.

The flexible and elastic parts of the respiratory system are the bronchioles and alveoli. Bronchioles are smaller branches that lead to the alveoli, where gas exchange occurs. They can expand and contract thanks to smooth muscles and elastic fibres in their walls. Alveoli stretch when filled with air and recoil when we exhale, which helps with efficient gas exchange.

Goblet cells and cilia are found in the trachea and bronchi. Goblet cells produce mucus to trap dust and germs, while cilia are tiny hair-like structures that move the mucus upward to keep the airways clean. This process, known as mucociliary clearance, helps maintain respiratory health by preventing infections. — See *figure 3.13* and *table 3.2*

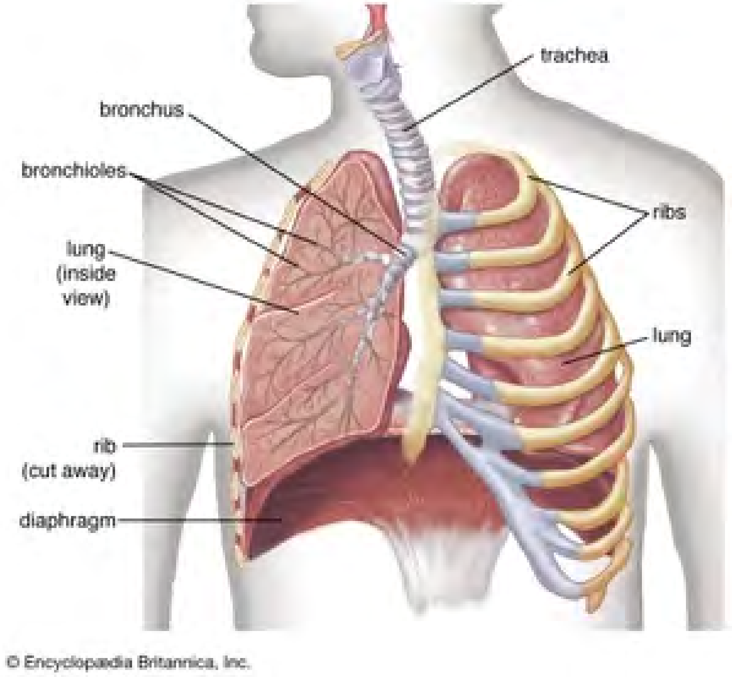


Figure 3.13: Respiratory System of Humans

Table 3.2: Functions of the parts of the respiratory system

Parts	Function
Trachea	The trachea, or windpipe, is a rigid tube that provides a clear airway for air to enter and exit the lungs. It is lined with ciliated mucous membranes that trap dust and debris, keeping the airway clean.
Bronchi	The bronchi are the main air passages that branch off from the trachea into each lung. They further divide into smaller bronchi and play a crucial role in directing air to the lungs while also filtering and humidifying it.
Bronchioles	Bronchioles are the smaller branches of the bronchi that lead to the alveoli. They regulate airflow to the alveoli through constriction and dilation and are lined with smooth muscle to control this process.

Parts	Function
Nasal passages	The nasal passages are responsible for filtering, warming, and humidifying incoming air. They contain mucous membranes and cilia that trap contaminants and provide a moist environment for air before it enters the lungs.
Alveoli	Alveoli are tiny air sacs at the end of the bronchioles where gas exchange occurs. They are surrounded by capillaries, allowing oxygen to diffuse into the blood and carbon dioxide to diffuse out, making them essential for respiration.
Pharyngeal cavities	The pharyngeal cavities (throat) serve as a passageway for both air and food. They play a role in directing air from the nasal passage to the larynx and eventually to the trachea while also aiding in swallowing.
Pleura	It produces a lubricating fluid between the layers, allowing the lungs to smoothly expand and contract during breathing
Diaphragm	It plays a crucial role in breathing by contracting and relaxing. When the diaphragm contracts, it pulls the lungs downward, increasing the chest cavity volume, which creates a low-pressure area. Air rushes in to fill the lungs (inhalation). When the diaphragm relaxes, the chest cavity volume decreases, pushing air out of the lungs (exhalation)

Questions: Record your answers in your notepad.

1. How does the structure of the trachea differ from that of the bronchi and bronchioles, and how do these differences impact their respective functions in the respiratory system?
2. Where are the lungs located in the body?
3. In what ways do you think the location of the lungs in the thoracic cavity influences their ability to function effectively during breathing?

Structure of the Lungs

The lungs are situated in the thoracic cavity, which is a protected space that allows for expansion and contraction during breathing without interference from other organs. This location, surrounded by the ribcage, provides structural support while allowing the diaphragm and intercostal muscles to efficiently change the volume of the thoracic cavity, facilitating airflow into the lungs. Additionally, being near the heart allows for the quick transport of oxygenated blood throughout the body. One specific feature is the alveoli, which are tiny air sacs that dramatically increase the surface area for gas exchange. Their thin walls allow for easy diffusion of oxygen into the blood and carbon dioxide out of the blood. The sheer number of alveoli in the lungs maximises this area, making gas exchange much more efficient. The trachea is a rigid tube supported by C-shaped cartilage rings, which keep it open and allow air to flow freely to the lungs. In contrast, the bronchi have similar cartilage but branch off into smaller bronchioles, which have more smooth muscle and less cartilage. This allows the bronchioles to constrict or dilate to regulate airflow. The increased flexibility in the bronchioles is important for controlling the amount of air that reaches the alveoli.

Activity 3.5 Try Questions

Let us briefly revise some of the concepts we have learnt so far. Below are some statements. You need to state whether they are true or false. These true or false questions can help assess your comprehension of the lung anatomy and associated features.

True or false?

Here are five true or false activity questions based on the provided information:

1. The tracheal walls are strengthened with specialized rings of cartilage known as tracheal cartilage to prevent collapse…
2. Goblet cells in the tracheal walls secrete mucus that helps to trap dust and pathogens…
3. The trachea is lined with ciliated cells that help to trap dust and pathogens further down the respiratory system…
4. The lungs are in the abdominal cavity and are not protected by the rib cage…
5. The terms "left lung" and "right lung" refer to the patient's perspective, meaning the left lung is on the patient's left side…

Activity 3.6 Aerobic Respiration Produces Carbon Dioxide

***What you need*:** Tapes, Beakers, freshly prepared lime water, cardboards and straws.

What to do:

1. Take two test tubes containing equal volumes of freshly prepared lime water.
2. Plug each test tube with a cork fitted with straw.
3. Blow air into one test tube with the help of the straw while leaving the other test tube undisturbed.
4. Discuss your observations with friends or family member and write them in your notebook.

Safety precautions

1. Do not ingest the lime water.
2. Keep the neck of the test tubes tightly plugged.
3. Do not keep the lime water standing for too long before blowing exhaled air into one of them.

Table 3.3: Differences Between Breathing and Respiration

Aspect	Breathing	Respiration
Definition	The physical procedure of inhaling and exhaling air	The biochemical process of bringing out energy from food particles
Process	Includes the exchange of gases (O_2 and CO_2) between the organism and the environment	It involves chemical reactions, mainly oxidation of glucose, to produce energy.
Location	Takes place in the respiratory organs (lungs, gills, etc.).	It takes place in the cells, specifically in the mitochondria.
Voluntary or involuntary	Partially voluntary (e.g., can hold breath) but mostly involuntary.	Completely involuntary; controlled by cellular needs

Aspect	Breathing	Respiration
Purpose	To bring Oxygen into the body and take away Carbon dioxide	To make energy ATP (adenosine triphosphate) essential for cellular activities.
Oxygen Involvement	Oxygen is inhaled into the lungs.	Oxygen is used to oxidise glucose in cells.
Carbon Dioxide	Carbon dioxide is exhaled out of the lungs	Carbon dioxide is produced as a waste product of cellular respiration
Energy Requirement	Does not produce energy but requires energy to function.	Produces energy in the form of ATP (adenosine triphosphate)
Examples	Breathing in humans involves the diaphragm and intercostal muscles	Aerobic respiration, anaerobic respiration (e.g., fermentation).

Aerobic Respiration

The breakdown of organic food substances is a complex process involving many enzymes acting as catalysts. The energy released is in the form of ATP (adenosine triphosphate). Respiration is the breakdown of organic food substances in the living cells to release energy.

Aerobic respiration is the type of respiration which takes place in the presence of oxygen. A lot of energy is produced in this type of respiration. Carbon dioxide and water are produced as by-products. Aerobic respiration can be expressed as:

- $C6H12O6 + 6O2 \rightarrow 6CO2 + 6H_2O$ + energy
- Glucose + oxygen = carbon dioxide + water + energy

Anaerobic respiration is the type of respiration which occurs in the absence of oxygen. A small amount of energy is produced. It occurs in yeast, with alcohol and carbon dioxide produced as a byproduct. Anaerobic respiration is also known as alcohol fermentation.

Importance of Aerobic Respiration

1. Energy Production: The primary role of aerobic respiration is to generate ATP, the main energy source for cells. ATP fuels important cellular functions, including muscle contraction, protein synthesis, and cell division. This process is highly efficient, yielding 36-38 ATP molecules from a single glucose molecule.
2. Production of Carbon Dioxide and Water: Aerobic respiration transforms glucose and oxygen into carbon dioxide and water, which are then expelled from the body as waste. This process is crucial for maintaining the body's acid-base balance, as an increase in carbon dioxide levels can lead to greater acidity in the bloodstream.
3. Heat Generation: Aerobic respiration also produces heat as a byproduct, which helps warm-blooded animals maintain their body temperature.
4. Enhanced Metabolic Efficiency: Aerobic respiration enables organisms to generate more energy from glucose than anaerobic processes, supporting activities that require sustained energy, like endurance exercise.
5. Supports Cellular Repair and Growth: The ATP produced through aerobic respiration is essential for cellular repair, growth, and maintenance, helping processes such as DNA replication and protein repair for healthy cell function.

Questions: Write your answers in your notebook

1. How does aerobic respiration contribute to ATP production, and why is this important for cellular functions?
2. What are the significance and role of carbon dioxide and water as by-products of aerobic respiration in maintaining the body's acid-base balance?
3. In what ways does aerobic respiration enhance metabolic efficiency compared to anaerobic processes, particularly in supporting endurance activities?

EFFECT OF SMOKE AND COMMON RESPIRATORY DISORDERS AND THEIR IMPACT ON HEALTH

Disorders

A disorder is a condition that affects the normal functioning of the body or mind. It is a condition that affects how your body or mind works. It can cause problems with how you feel, think or act. For example; a person with a disorder might have trouble focusing on school, or at work, feeling sad for a long time or having physical symptoms like pain or being tired always.

Disorder can be caused by the environment, our lifestyle and or genetic makeup. It is important to remember that having a disorder is not a person's fault, as many people with disorders can manage them with the right support like health habits, medications and therapy.

Activity 3.7 Exploring the Effect of Smoke on Air Quality

What you need: Two clear plastic jars, filter paper or cotton balls, stopwatch or timer, a lighter or matches and candle.

What to do:

1. Place one potted plant in each jar. Note: these will be your ''smoke and control'' setup.
2. Cover the top of one jar with cotton balls or filter paper (to represent a filtered environment).
3. Leave the other jar open.
4. Light the candle in a well-ventilated area (outside is better)
5. Allow it to burn for a minute.
6. Carefully bring the smoke towards the open jar.
7. Cover the jar immediately afterward to trap the smoke inside.
8. Leave the jar with cotton balls or filter paper uncovered for the same time but make sure no smoke enters it.
9. Leave both jars for a week as you water it regularly and give equal care to both.

10. Observe each day and note any changes in the plants in your notebook.

Questions

1. How did the smoke affect the plant in the open jar compared to the one ion the filtered jar?
2. What might be the implications of smoke exposure for animals and humans in real life?
3. How does smoke pollution affect air quality?

Activity 3.8 Balloon Lung Model to Show Effects of Vaping

What you need:

- Two plastic bottles with the bottoms cut off (can use a plastic water bottle)
- two balloons (to represent lungs)
- cotton balls or tissue pieces (to represent vaping residue)
- rubber bands (to secure balloons to bottle opening)

What to do:

1. Place one balloon inside a plastic bottle and stretch the balloon's open end over the bottle mouth.
2. Secure it with a rubber band.
3. This balloon will represent a healthy lung with no vaping effects.
4. Place some cotton balls or small pieces of tissue inside the second balloon to represent chemicals and particles left by vaping.
5. Place this balloon inside the second bottle, just like before, and stretch its open end over the bottle mouth.
6. Secure it with a rubber band. This balloon represents a lung affected by vaping.
7. Cut a third of the other balloons and make a knot in the necks of them.
8. Stretch the wide opening of the cut balloons over the wide opening of the bottles at the bottom.
9. Pull the knot in the ballon of the first bottle (the "healthy lung") back and release it. The balloon should expand (inflate) and contract (deflate)

easily, simulating how a healthy lung fills with air and releases it smoothly.

10. Pull the knot in the ballon of the first bottle (the “vaped lung”) back and release it.
11. Notice how it is harder to expand because the cotton balls or tissues are in the way, blocking air movement. The balloon may not expand or contract as fully as the first one, just like how vaping can make the lungs stiff and clog the airways.

Question: Write down your ideas on paper as you discuss.

How does vaping affect the lung structure?

Vaping

This is the act of inhaling vapour produced by an electronic device called vape or e-cigarette. These devices heat a liquid often containing substances containing nicotine, flavourings and other chemicals, turning it into a mist (vapour) that users can inhale. Unlike traditional cigarettes, vaping doesn’t burn tobacco, but it can still be harmful to health. It’s important for young people to understand the risks, which includes addiction of the substance nicotine and serious lung disorders.

Effect of Vaping on Lung Structure

1. Swollen or inflammation: chemicals in Vape juice can cause inflammation in the lungs leading to swelling and irritation.
2. Reduced function: Damage to the alveoli can reduce their ability to exchange gases making it harder to breathe.
3. Tar and chemicals: like traditional cigarettes, vaping can introduce harmful substance that accumulate in the lungs leading to reduced lungs capacity and increased risk of infections’
4. Long–term risk: Over time vaping can contribute to chronic respiratory disease or even Chronic Obstructive Pulmonary Disease (COPD).

Effects of Smoking on the Structure of the Lungs

When we smoke, harmful chemicals enter our lungs and can cause serious damage. Some of which are:

1. Damage of tiny hair-like structures called cilia that help sweep away dust and mucus making it harder for your lungs to clear out harmful substances.

2. Irritating the lung tissues leading to inflammation. Swelling that causes discomfort and making it harder for air to flow in and out.
3. Damaging tiny sacs at the end of the airways called alveoli where oxygen and carbon dioxide are exchanged. These air sacs when destroyed, reduce the lungs' ability to take in oxygen and release carbon dioxide leading to a medical condition known as emphysema.
4. Causing the tubes that carry air to your lungs to become small and blocked, making breathing more difficult.

Activity 3.9 The Effects of Smoking on Lung Function

What you need: Two balloons, straws and cotton balls

What to do:

1. Stretch one balloon a few times to make it flexible, representing healthy, elastic lungs that expand easily.
2. Attach a straw to the opening of the balloon. This straw will act like a windpipe through which air enters the lungs.
3. Place a few cotton balls inside the second balloon. These represent the tar and chemicals that build up in the lungs from smoking.
4. Stretch this balloon less than the first one. This balloon should be harder to expand, showing how smoking makes lungs less elastic and stiffer.

Question: Write your answer in your notepad.

How does smoking affects elasticity of the lungs?

Effects of Smoking on the Structure of the Lungs

Smoking has severe and lasting effects on the structure and function of the lungs. Here are some of the ways that smoking changes the lung structure:

1. **Damage to the cilia**
   - Cilia are tiny, hair-like structures that line the airways and help clear out mucus, dust, and harmful particles from the lungs.
   - Effect of Smoking: Chemicals in cigarette smoke paralyse and damage the cilia, making it harder to clear out harmful particles and mucus. This leads to mucus buildup and frequent infections, causing coughing and shortness of breath.

2. **Inflammation and narrowing of the airways**
   - Smoke irritates the airways, causing inflammation and swelling.
   - Effect of Smoking: Over time, this inflammation leads to narrowed airways, which restricts airflow, making breathing more difficult. This narrowing can contribute to chronic bronchitis and other respiratory issues.
3. **Damage to alveoli (Air Sacs)**
   - The alveoli are tiny air sacs in the lungs where oxygen and carbon dioxide are exchanged.
   - Effect of Smoking: Smoking damages the alveoli walls, reducing their ability to expand and contract properly. This reduces the surface area for gas exchange, leading to conditions like emphysema, where the lungs lose their elasticity, making it hard to exhale fully.
4. **Thickened and scarred lung tissue**
   - Continuous exposure to smoke causes thickening and scarring of lung tissue, reducing the lungs' flexibility and ability to take in air.
   - Effect of Smoking: Scarred lung tissue loses its normal function and makes the lungs stiff, reducing their ability to take in oxygen. This condition, known as pulmonary fibrosis, can significantly impact breathing capacity.
5. **Increased Risk of Lung Cancer**
   - Smoking introduces carcinogens (cancer-causing substances) into the lungs, leading to mutations in lung cells. — See ***Figure 3.14.***

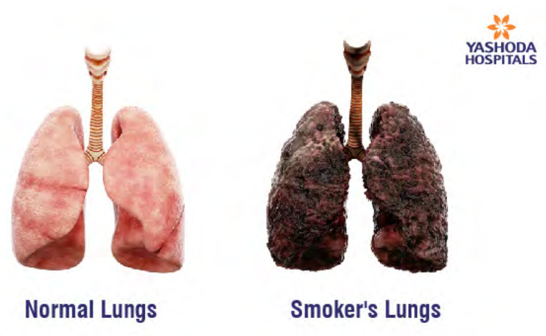


Figure 3.14: Effects of smoking on the lungs

Question: Write your answer in your notebook.

How do the normal lungs differ from the smoker's lungs?

Disorders of the Respiratory System

Asthma: a condition that affects the airways in your lungs. These airways can become inflamed and reduced in making it difficult to breathe.

Table 3.4: Symptoms, causes, effects and treatment of asthma

Symptoms	• Coughing: Which often happens at night or during exercising. • Wheezing: A whistling sound when you breath, especially when breathing out • Shortness of breath: Feeling like you cannot get enough air. • Chest tightness: A discomfort in the chest making it very difficult to breathe.
Causes	• Genetic factors: certain genetic variations can make individuals more likely to develop asthma. • Environmental triggers i. Things like pollen, pet dander, dust mites. ii. Irritants: Smoke, strong odour or air pollution. iii. Weather changes: Cold air or high humidity.
Effects	• Lung function: Asthma can make the lungs lose effective over time making it harder to get enough air. • It can lead to death
Prevention	• Avoid what brings about asthma, for example allergens like dust mites, pollen and pet dander • Smoke: Do not smoke. Avoid places where others are smoking. • Second hand smoke can cause asthma. • Strong smells: Avoid strong perfumes. • Follow your doctor's advice on how to take your medications and checking up regularly. • Keep indoor air clean.

	• Having proper education on asthma helps you to understand its triggers and recognise early symptoms and manage your condition better.
Treatment	• Quick-relief medications (e.g., bronchodilators) to open airways and relieve symptoms during asthma attacks • Controller medications (e.g., inhaled corticosteroids) to reduce inflammation and prevent symptoms • Avoid exposure to triggers • Maintain good respiratory hygiene (e.g., using a spacer with inhalers) • Seek medical attention for severe or persistent symptoms.

Chronic Obstructive Pulmonary Disease (COPD): This is a long- term disease that causes airflow blockage and breathing related problems.

Table 3.5: Symptoms, causes, effects and treatment of Chronic Obstructive Pulmonary Disease (COPD)

Symptoms	• Shortness of breath, especially during physical activity. • A persistent cough, often with mucus • Wheezing (a whistling sound when breathing). • Frequent lung infections
Causes	• Long term exposure to harmful substances. • Smoking cigarettes or using other tobacco products. • Air pollution • Dust and chemicals for workplaces.
Effects	• Breathing difficulties: people with COPD often find it hard to breathe, especially during activities like walking or climbing stairs. • Chronic cough: A constant cough that produces mucus is common. This can be uncomfortable and may disrupt sleep. • Fatigue: Struggling to breathe can lead to tiredness making it difficult to keep up with regular activities.

	• Weight loss: some people with COPD may lose weight because they find it hard to eat or feel less hungry.
Prevention	• Avoid smoking or vaping and exposure to second-hand smoke. • Maintain a healthy lifestyle. • Regular heath checkups • Get vaccinated.
Treatment	• Manage symptoms with supportive care • The use of antibiotics to treat the underlying infection

Pneumonia: an infection in the lungs that makes it difficult to breathe and can cause various symptoms.

Table 3.6: Symptoms, causes, effects and treatment of Pneumonia

Symptoms	• Cough: A long-lasting cough that brings up mucus or phlegm. The mucus may be yellow, green, or even bloody. • Difficulty Breathing: It might be hard to breathe, even while resting. • Chest Pain: A sharp pain in the chest, especially when breathing deeply or coughing. • Fever and Chills: High temperature with shivers and chills. • Fatigue: Feeling very tired and low on energy.
Causes	• Bacteria: Common bacteria like *Streptococcus pneumoniae* can cause it. • Viruses: Flu and other viruses, including COVID-19, can also lead to pneumonia. • Fungi: Fungal infections can cause pneumonia, especially in people with weak immune systems.

Effects	• Difficulty Breathing: Lungs fill with fluid, making it hard to get oxygen. • Complications: It may lead to serious issues, like lung infection with pus or respiratory failure. • Long-Term Effects: Some may recover slowly, with long-lasting breathing problems.
Prevention	• Vaccinations: Get vaccines for flu and pneumococcal disease. • Hygiene: Wash hands well and cover mouth/nose when coughing or sneezing. • Healthy Habits: Avoid smoking and manage health conditions like asthma.
Treatment	• Antibiotics: For bacterial infections. • Supportive Care: Fluids and oxygen to ease symptoms. • Antiviral Medications: If caused by a virus like the flu.

EXTENDED READING

1. Read on other respiratory system disorders such as lung cancer, whooping cough etc online or from other resources.
2. Research and watch videos online on pathway of air in the respiratory system.

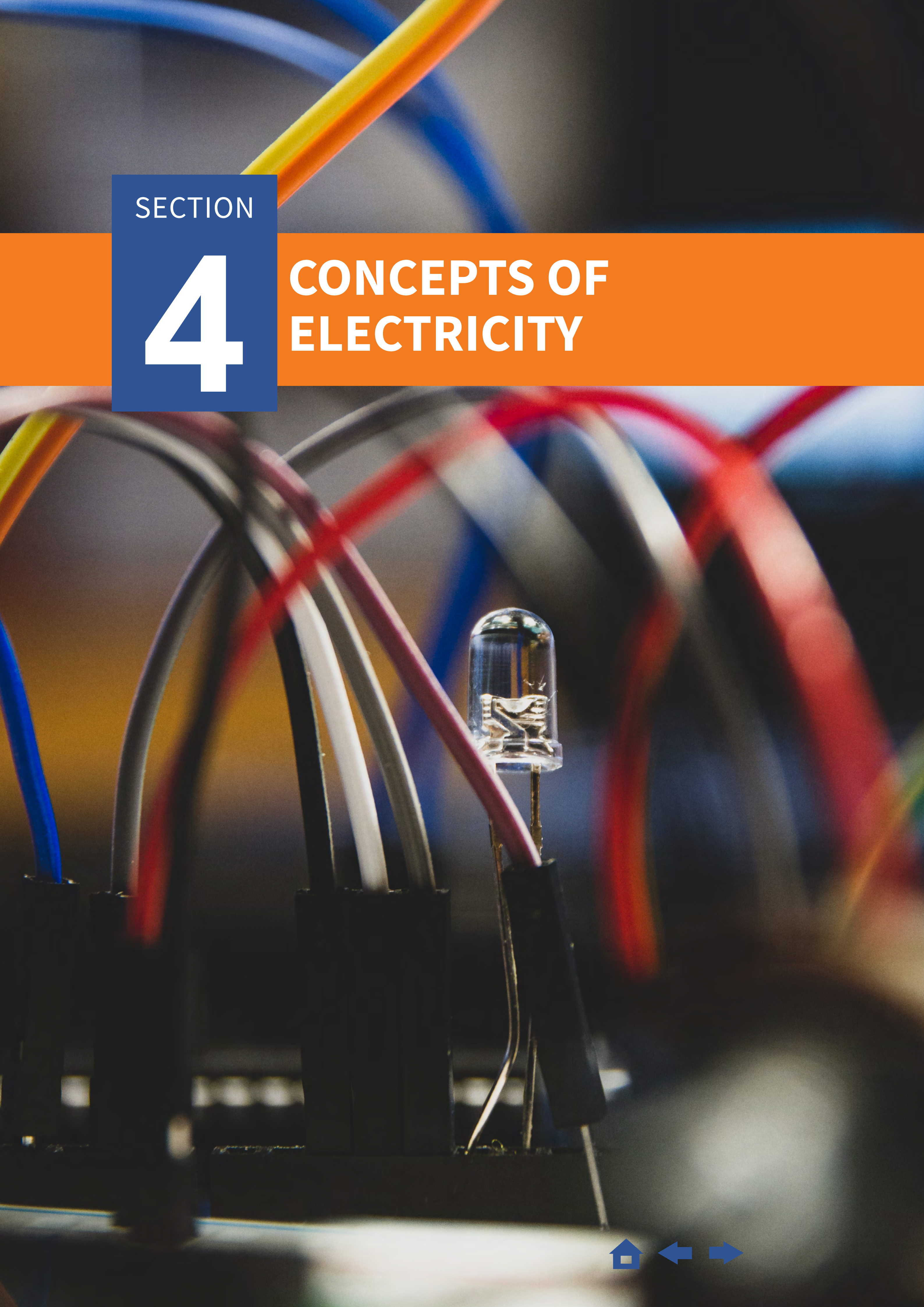
REVIEW QUESTIONS

1. Imagine you are an athlete preparing for a marathon. As you train, your body relies heavily on aerobic respiration to produce the energy needed for long-distance running.
   a. How does the efficient production of ATP during aerobic respiration support your endurance and performance throughout the race?
   b. What impact might an increase in carbon dioxide production have on your performance, and how does your body adjust to maintain acid-base balance during prolonged exercise?
   c. In what ways does the heat generated from aerobic respiration assist in regulating your body temperature while you are running?
2. What is the main cause of smoking –related death worldwide?
   A. Heart disease
   B. Lung cancer
   C. Stroke
   D. All the above
3. Which of the following is a short-term effect of smoking?
   A. Lung cancer
   B. heart disease
   C. shortness of breath
   D. wrinkles on face
4. Which organ is most affected by smoking?
   A. Heart
   B. lung
   C. brain
   D. liver
5. Second hand smoke is harmless. True or False
6. What is Nicotine, and how does it affect the body?
7. Explain the term, breathing.

8. Describe the mechanisms of inhalation and exhalation.
9. Create a concept map of air movement in the human body.

SECTION

4 CONCEPTS OF ELECTRICITY



VIGOUR BEHIND LIFE

POWERING THE FUTURE WITH ENERGY FORMS

INTRODUCTION

Electrical energy and power are fundamental concepts in understanding how electricity functions and is used in our daily lives. Electrical energy refers to the energy carried by moving electric charges through a conductor, which powers devices and appliances, and is measured in joules or kilowatt-hours. Electrical power, on the other hand, is the rate at which electrical energy is consumed or produced, measured in watts, showing how quickly energy is transferred within a circuit.

Transformers play a crucial role in electrical systems by adjusting voltage levels through the principle of electromagnetic induction. They consist of primary and secondary coils wrapped around an iron core, with a changing magnetic field inducing voltage. The ratio of turns between these coils determines if the transformer increases (step-up) or decreases (step-down) voltage. This helps in energy efficiency, minimising power loss during transmission and ensuring safe voltage levels for various applications.

KEY IDEAS

- Electrical Energy: Energy carried by moving electric charges through a conductor, powering devices like lights and appliances. It is measured in joules (J) or kilowatt-hours (kWh).
- Electrical Power: Electrical power is the rate at which electrical energy is used or produced.
- Principle of the Transformer: Works on electromagnetic induction, where an AC current in the primary coil creates a magnetic field, inducing voltage in the secondary coil.
- Electrical circuit: An electrical circuit consists of various components that work together to control and direct the flow of electric current (flow of charged particles) in the way desired by the user.

- Appliance troubleshooting: Appliance troubleshooting is the systematic approach of diagnosing problems in household appliances and finding solutions to fix them.
- Energy audit: An energy audit thoroughly examines energy use in a building to identify inefficiencies and savings opportunities

THE CONCEPT OF ELECTRICAL ENERGY AND POWER

Before you begin with this lesson, give the following questions a thought:

1. Have you imagined what your community would be like without light?
2. Have you experienced lights out at home before?
3. What is the source of power for electrical appliances?

Concept of Electrical Energy

Electricity is a form of energy that comes from the movement of tiny particles called electric charges. These charges move through materials known as conductors, such as metals, creating an electric current. An electric current, which is the flow of charges, is measured in units called amperes (A).

An electric current is powered by voltage, also called electric potential difference. Voltage acts like a "push" that makes electric charges flow through a circuit. A circuit is a pathway for the flow of electric current. It consists of parts like a power source, wires, switches, resistors, and capacitors.

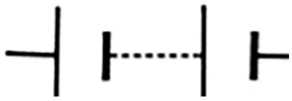
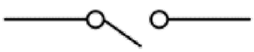
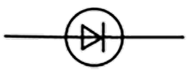
Electricity is generated from different sources. These sources can be renewable, like water (hydro), wind, sunlight (solar), heat from the earth (geothermal), or non-renewable, like coal, oil, natural gas (fossil fuels), and nuclear materials. Once electricity is produced, it travels through wires over long distances to reach homes, schools, and businesses.

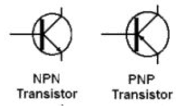
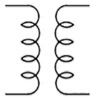
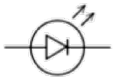
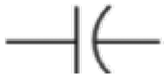
Although electricity is very helpful, it is important to handle it safely. Without care, it can cause harm, such as electric shocks or fires. Always follow safety measures when using electricity.

Components of an Electrical Circuit

Electric circuit components work together to control and direct the flow of electric current (flow of electrons) in the way desired by the user. They are usually represented by symbols in a circuit diagram. Examples of circuit components, their functions and symbols are given in the table below:

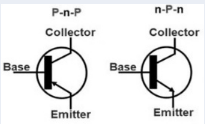
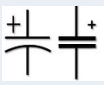
Table 4.1: Components of an electrical circuit

Basic component	Function	Circuit symbol
Battery	Provides direct current (DC) through a chemical reaction.	
Power Supply	Converts AC from the mains to a stable DC voltage	
Connecting wires	Provide a path for current to flow between components	
Light Bulbs	Convert electricity into light	
Switches	For opening or closing a circuit, controlling the current flow.	
Fuses	• Provide overcurrent protection by breaking the circuit if the current exceeds a certain level. • Protect the circuit from high voltages	
Resistors	Control current flow and distribute voltage.	
Inductors:	Store energy in a magnetic field when current flows through them.	
Diodes	Allow current to flow in one direction only.	

Basic component	Function	Circuit symbol
Transistors	Act as switches or amplifiers.	
Ammeter	Measures current flowing a circuit	
Voltmeter	Measures voltage/potential differences in a circuit	
Transformer	Change the voltage level in AC circuits.	
Light emitting diodes	Indicates presence of current flow in a circuit	
Capacitors	Stores electrical charges	

Activity 4.1 Identification of Components of an Electrical Circuit

Copy and complete the following table using the internet and other sources for your research.

Name of circuit component	Symbol	Function
Inductor		Stores electrical energy in a magnetic field.
Transistor		
Transformer		For stepping voltage up and down
		Stores electrical energy in the form of charges.
Variable resistor		

We have all, in one way or the other, seen or used cells and batteries in everyday life (see ***figure 4.1***). We have often used the torchlight at home during lights off or when sent on an errand to light our way.

Figure 4.1: Cells and Batteries

Batteries: Making of electrical cells

Electrical cells, commonly known as batteries, store chemical energy. This can then be converted into other energy forms, based on the energy need of the user. The cell is a fundamental unit of the battery.

The energy stored by the cell is within the bonds of the chemical substance of the cell. This energy can power the energy needs of a wide range of electronic devices. A simple cell consists of two terminals called electrodes, dipped in a container holding a charged liquid substance called electrolyte. In some cells, the container acts as one of the electrodes. Both electrodes are charged. The positively charged electrode is known as an anode while the negatively charged electrode is known as a cathode — see ***Figure 4.2***.

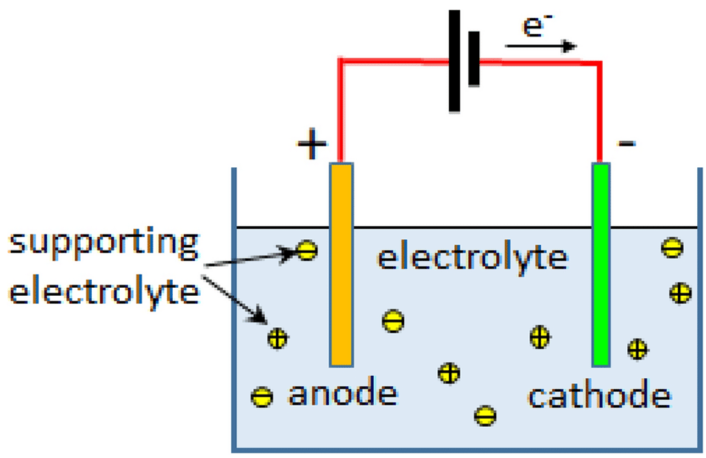


Figure 4.2: A simple zinc-carbon cell

Activity 4.2 Making a Simple Zinc-Carbon Cell

What you need:

- Zinc strip (cathode), Carbon rod (anode)
- Manganese dioxide and carbon (graphite) mixture (cathode paste).
- Ammonium chloride solution (electrolyte).
- Paper or cloth separator and plastic or metal container.

What to do:

1. Place the zinc strip into the container at the bottom (anode).
2. Pour the ammonium chloride solution into the container to submerge the zinc strip.
3. Insert the paper or cloth separator to cover the zinc strip.
4. Apply the cathode paste (manganese dioxide and carbon powder mixture) around the
5. carbon rod.
6. Place the carbon rod with the cathode paste into the container, ensuring the separator
7. separates it from the zinc strip.
8. Seal the container to prevent leakage.
9. Attach metal strips to the zinc strip and carbon rod to create external connections.
10. Connect this battery using crocodile clips to a light-emitting diode (LED), ensuring correct polarity.

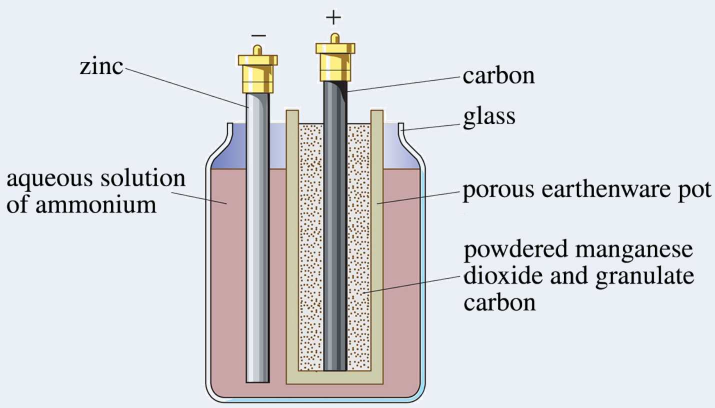


Figure 4.3: A sample of Zinc-Carbon Cell

Observation

The LED will emit some light. The intensity of the light depends on the voltage produced by the cell. Several cells will be required to produce a higher voltage for a brighter light.

Safety precautions

1. Wear the recommended laboratory gear to protect the skin from contact with chemical.
2. Work in a well-ventilated area to avoid inhaling fumes.

Activity 4.3 Making a Cell from a Citrus Fruit

From our previous lessons on acids, bases and salts, explain why molten or aqueous solutions of acids, bases and salts are good electrolytes.

Organise yourselves into groups of no more than five for this activity.

What you need:

- Citrus fruit, e.g., lemon, lime, orange, grapefruit.
- Copper nail, screw, or wire, 5 cm long.
- Zinc nail or screw or galvanized nail about 5 cm long.
- Small holiday light with 5 cm long copper wires to connect to the nails.

What to do:

1. Set the fruit on a table and gently roll it around to soften it up, for the juice to flow inside the fruit without breaking its skin. Alternatively, squeeze the fruit with your hands.
2. Insert the zinc and copper nails into the fruit so that they are about 5 cm apart. Avoid puncturing through the end of the fruit.
3. Remove enough insulation from the copper wires so that you can wrap one around the zinc nail and the other around the copper nail. Use electrical tape or alligator clips to keep the wire from falling off the nails.
4. Connect the second nail — see ***Figure 4.4***.

Observation

When the second nail is connected, the light must come on.

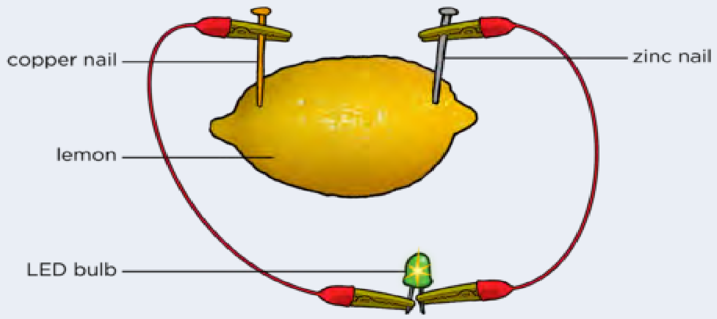


Figure 4.4: A Lemon Cell

How the Lemon Battery Works

1. The copper and zinc metals act as positive (anode) and negative (cathode) battery terminals respectively.
2. The zinc metal reacts with the acidic lemon juice (citric acid) to produce zinc ions (Zn2+) and electrons (2e-). The zinc ions go into solution in the lemon juice while the electrons remain on the metal.
3. The wires of the small light bulb are electrical conductors. When they are used to connect the copper and zinc, the electrons that have built upon the zinc flow into the wire. The flow of electrons causes the flow of electric current or electricity which lights the light bulb.
4. Eventually, the electrons make it to the copper. If the electrons didn't go any farther, they'd eventually build up so that there wouldn't be a potential difference between the zinc and the copper. If this happened, the flow of electricity would stop. However, that won't happen because the copper is in contact with the lemon.
5. The electrons accumulating on the copper terminal react with hydrogen ions (H+) floating free in the acidic juice to form hydrogen atoms. The hydrogen atoms bond to each other to form hydrogen gas.

In our previous activity, we built simple cells, now let us move further and build a functional electrical circuit.

Activity 4.4 Virtual Functional Electrical Circuit

What to do:

1. Carry out research using the internet and other sources and create a chart or poster on how to construct electrical circuit.
2. Think about the steps involved in constructing a functional electrical circuit.
3. Share your findings with your peers for discussion and feedback.

Activity 4.5 Constructing Functional Electrical Circuit

Note

This activity should be conducted under the supervision of a teacher.

What you need: power source (battery or power supply), conductors (wires), load (LED, motor, etc.), control devices (switches), protective devices (resistors, fuses), breadboard or PCB (for assembly), multimeter (for testing), wire strippers, soldering iron and solder (if using PCB), pliers and screwdrivers and insulating tape or heat shrink tubing.

What to do:

1. Planning and design:
   - **a.** Define the purpose by determining the goal of your circuit (e.g., lighting a LED, powering a motor).
   - **b.** b. Create a schematic diagram by drawing a circuit diagram showing all components and their connections.
   - **c.** List all necessary components needed, e.g. resistors, capacitors, power source, etc.
   - **d.** Specify the values (e.g., resistor values in Ohms) and ratings (e.g., voltage and current) for each component.
2. Preparing the components:
   - **a.** Verify that all components are working and rated for your circuit.
   - **b.** Cut wires to the necessary lengths and strip the ends for connections.
3. Build the circuit:
   - **a.** Use a breadboard by placing components on the breadboard according to your schematic diagram. Use jumper wires to connect

components as per the circuit diagram. Ensure all connections match your schematic diagram.

b. Use software or a pre-made design for the PCB layout.

c. Create the PCB if you're making it yourself or order it from a manufacturer.

d. Insert components into the PCB holes.

e. Solder each component led to the PCB pads, ensuring solid electrical connections.

f. Inspect solder joints: Check for cold solder joints or bridges that could cause shorts.

4. Testing:

a. Check for correct placement and secure connections.

b. Power the circuit with a lower voltage (if possible) to check for obvious issues.

c. A multimeter measures voltages and currents at different points in the circuit.

d. If the circuit does not work, recheck connections and component orientations. Look for short or open circuits.

5. Final assembly and safety:

a. Ensure all components are securely mounted.

b. Use insulating tape or heat shrink tubing to cover exposed wires and prevent shorts.

c. If the circuit will be used in a specific environment, consider placing it in an enclosure to protect it.

Activity 4.6 Constructing a Simple LED Circuit

What you need: 9V battery, LED (any colour), resistor (330 Ω suitable for a 9v battery and standard led), breadboard, connecting wires, multimeter (for testing), battery clip (for connecting the 9v battery to the breadboard), wire strippers and pliers (optional).

What to do:

1. Insert the Resistor:

- Place one end of the resistor in one row on the breadboard.
- Place the other end of the resistor in the next row over.

2. Connect the LED:
   - Insert the longer leg (anode (+)) of the LED into the same row as one end of the resistor. (You can twist them if there is no bread board or connect them with wire)
   - Insert the shorter leg (cathode (−)) of the LED into a separate row.

3. Connect the Battery:
   - Take the battery clip and connect the red wire (positive) to the row with the free end of the resistor.
   - Connect the black wire (negative) to the row with the LED's shorter leg (cathode).

4. Power On: Attach the battery to the battery clip. — see ***Figures 4.5*** to 4.6.

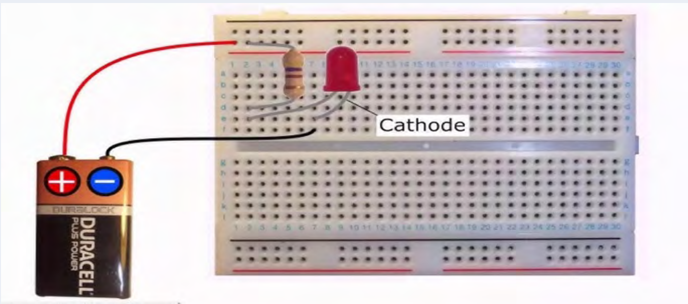


Figure 4.5: A simple LED circuit

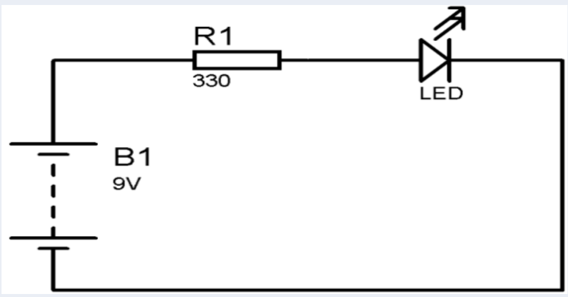


Figure 4.6: A Simple LED Circuit Diagram

Observation

The LED should emit light when the circuit is powered. If it does not, recheck connections and component orientations.

Safety Precautions

1. Ensure all connections are secure before powering the circuit.
2. Do not touch live wires or components with bare hands.

3. Disconnect power before adjusting the circuit.

Test yourself!

1. Why is it necessary to use a resistor in this circuit, and what might happen if it is not included?
2. How does the orientation of the LED's anode and cathode affect the circuit's operation? What will happen if they are connected incorrectly?
3. What does the voltage drop across the LED tell us about how energy is used in the circuit?
4. If you measured no current or the LED did not light up, what steps would you take to troubleshoot the circuit?

Explanation And Calculation of Electric Current, Resistance and Voltage

Electric current: happens when electric charges move or flow in one direction. In materials such as metals, which are good conductors, these charges are carried by free electrons. Metals have a structure where the outer electrons of their atoms are loosely held. These electrons break away and move freely within the metal. This movement of electrons creates an electric current. When the metal atoms lose these electrons, they become positively charged. Copper and silver are among the best materials for conducting electric current.

An electric current is the rate at which electric charge flows. If the current stays the same over time, we can calculate it using this formula:

$Q = I \times t$ Where:

I = the current (in amperes, A),

Q = the electric charge (in coulombs, C),

t = the time (in seconds, s).

If the current changes over time, this formula gives the average current. On a graph of charge (y-axis) versus time (x-axis), the slope (or gradient) of the line tells you the current at a specific moment.

Voltage: a measure of how much energy a charge has at a specific point in a circuit. It's like how high up a ball is before it falls. Voltage is always measured between two points, and one of those points is often chosen as a reference point called "ground." Voltage is also called electromotive force (emf).

If there is a potential difference between two points, it means that the charge has different amounts of energy at each point. A voltage drop happens when the charge loses energy, while an emf means the charge gets more energy.

To find the energy transferred in a circuit, you can use this formula: $E = V \times Q$

Where:

E is the energy transferred (in joules, J),

V is the voltage or potential difference (in volts, V),

Q is the charge that flows through the circuit (in coulombs, C).

Resistance: Electrical resistance is a measure of the opposition to flow of current in an electrical circuit. The electrical resistance of a conductor is dependent on the following factors:

- The cross-sectional area of the conductor
- Length of the conductor
- The material of the conductor
- The temperature of the conducting material

Electrical resistance is directly proportional to length (L) of the conductor and inversely proportional to the cross-sectional area (A). It is given by the following relation:

$R = \frac{\rho L}{A}$ Where:

R = resistance (in ohm, Ω),

ρ = resistivity of the material (in ohmmeter, Ω)

L = length of material (in meter, m)

A = cross-sectional area of material (in squared meter m^2).

Question: Write your answer in your notebook.

1. How are electric current, resistance and voltage related?

Next, you will examine Ohm's law which brings together electric current, resistance and voltage proportionally.

Extension activity: Research on Ohm's law using the internet and other sources. Make notes of your findings and engage in a class discussion to share what you have learnt.

Now, let us do it together!

Ohm's law

Ohm's Law states that, at constant temperature, the electric current flowing in a conducting material is directly proportional to the applied voltage and inversely proportional to the resistance. Mathematically, for a wide variety of substances, $I \propto V$.

- At a constant temperature, resistance, R, of any given conductor remains constant.
- This implies $IR = V$ or $V = IR$
- Note that for different conductors, R varies according to their characteristics (nature of material and dimensions).
- From $V = IR$, $R = V/I$, where V is in volt (V) and I in ampere (A).
- Then, the unit of $R = VA^{-1}$. This is called ohm (Ω)

Now, examine the following worked examples in pairs:

Worked Examples:

1. What is the voltage if a component with a resistance of 25 Ω has a current of 250 amperes flowing through it?

   Solution:

   $V = I \times R$

   $V = (250)\,(25) = 6{,}250$ volts

2. What is the current produced by a voltage of 240 V through a resistance of 0.2 Ω?

   Solution:

   $I = \frac{V}{I}$

   $I = \frac{240}{0.2} = 1200\,A$

3. What voltage is necessary to produce a current of 200 amperes through a resistance of 100 Ω?

   Solution:

   $V = I \times R$

   $V = 200 \times 100 = 20000$ volts (V)

4. What resistance would produce a current of 120 amps from a 6-V battery?

Solution:

$R = \frac{V}{I}$

$I = \frac{6}{120} = 0.05\text{ohms } (\Omega)$

Activity 4.7 Explanation of Ohms law

What you need:

- Power Source (Battery or DC Power Supply)
- Three Different Resistors (with different resistance values)
- Multimeter (to measure current and voltage)
- One Breadboard, connecting wires, alligator clips (optional) and switch (optional)

What to do:

1. Set up the circuit:

a. Connect the battery to the breadboard.

b. Insert the resistor (start with the lowest value resistor) into the breadboard.

c. Connect the multimeter in series to measure the current and in parallel to measure the voltage across the resistor.

2. Measure current and voltage:

a. Turn on the power supply and measure the current (I) flowing through the resistor and the voltage (V) across the resistor.

b. Record the values for voltage (V) and current (I).

3. Change the resistance:

a. Swap the resistor with a medium-resistance and a high-resistance resistor.

b. For each resistor, measure and record the current and voltage again.

c. Calculate Resistance for each resistor using the Ohm's Law:

$R = \frac{V}{I}$

4. Compare your calculated resistance with the actual value printed on the resistor.

Answer the following questions in your notebook:

1. How close are the values?
2. What happens when the resistance increases?
3. What happens when the voltage increases?
4. Why is Ohm's Law important?

Series and Parallel Connections

Most circuit components have more than one path by which they receive electricity. These components are commonly connected in a circuit in one of two ways. These are series and parallel connections.

Series connection

A series connection has the following characteristics:

1. Single path: There is only one path for the electric current to flow through the circuit.
2. Same current: The current is the same through all components in the circuit. That is to say all circuit components share the same source current.
3. Voltage drops: The voltage drops across each component can be different, and depends on the resistance or capacitance of that component.
4. Total resistance: The total resistance of the circuit is the sum of the individual resistances.
5. Total voltage: The total voltage of the circuit is the sum of the individual voltage drops.
6. Broken circuit: If the circuit is broken at any point, no current will flow.
7. Components arranged in a line: The components are arranged in a line, with the positive end of each component connected to the negative end of the previous component.

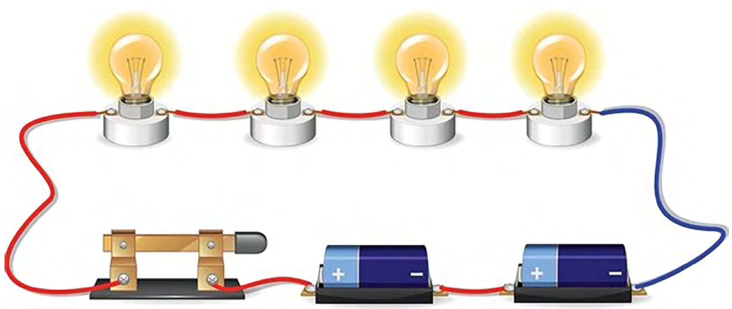


Figure 4.7: An Electric Circuit Connected in Series

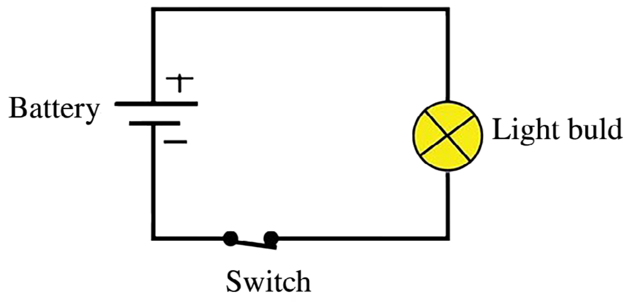


Figure 4.8: A schematic series circuit connection

To save time in drawing circuits, we will need to use diagrams as shown in Figure 1.6 above. The symbols for each component can be found in the table at the beginning of this

section. In any of these circuits, the precise shapes of the wires that connect the elements don't really matter. We only need to care about the circuit components and how they are connected to other components in the circuit.

Resistors in a Series Circuit

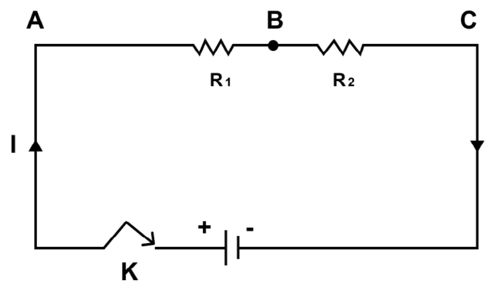


Figure 4.9: Resistors in series

Consider the resistors R_1 and R_2 in the schematic series circuit in ***Figure 4.9***.

- The same current flows through both resistors. Then according to Ohm's law, the drops in potential across the two resistors are IR1 and IR2.
- If the gain in potential across the battery is V, then the sum of these potential drops must be equal to V.
- So then, IR1 + IR2 = V ⇒ V = I (R1 + R2) = IRT where the equivalent resistance (RT) of the pair is the sum, R1 + R2.
- For an N number of resistors in series then, the equivalent resistance given by:

  $R_T = R_1 + R_2 + R_3 + \ldots R_N$.

Current in a series circuit

Consider the following resistors in series. Let I_1, I_2 and I_3 be the current flowing through R_1, R_2 and R_3 respectively.

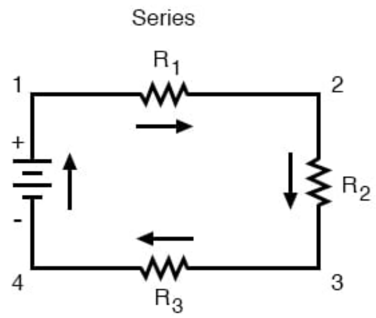


Figure 4.10: Total current in a series circuit

Then due to Kirchhoff's first law, the same current passes through all resistors. Thus, total current, $I_T = I_1 = I_2 = I_3$. To find the current in the circuit, we apply Ohm's law. Since $I = \frac{V}{R}$, that implies $I_T = \frac{V_T}{R_T}$, where V_T and R_T are total voltage and resistance respectively.

Voltage in a series circuit

The voltage applied to a series circuit is equal to the sum of the individual voltage drops." This simply means that the voltage drops must add up to the voltage coming from the battery or batteries.

Thus, for an N number of loads with a total voltage V_T of the circuit,

$V_T = V_1 + V_2 + V_3 + \ldots\ldots V_N.$

Worked Examples

1. In a series circuit with resistors of 8Ω and 12Ω, and a voltage supply of 40V, calculate the voltage drop across each resistor.

   Solution:

   $R_T = 8 + 12 = 20\ \Omega$

   Current (I)

   $I = \frac{V}{R}$

   $= \frac{40}{20} = 2A$

Voltage drops across 8Ω resistor: V = I × R.

V = 2 × 8 = 16V.

Voltage drops across 12Ω resistor: V = I × R.

V = 2 ×12 = 24V.

2. A series circuit has two resistors, 10Ω and 20 power supply. Calculate the current through the circuit.

Solution:

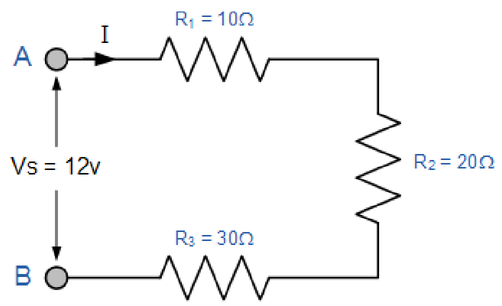
Total resistance: R{total} = 10 + 20 = 30 Ω.

Current (I)

$I = \frac{V}{R}$

$I = \frac{60}{30} = 2A$

3. Calculate the total resistance in the circuit below.

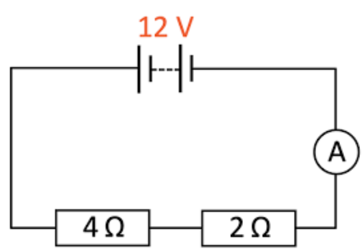


Solution:

Total resistance, $R_T = R_1 + R_{2\,+}R_3$

$R_T = 10 + 20 + 30 = 60\Omega.$

4.



What is the total resistance of the circuit above?

Solution:

Total resistance, $R_T = (4 + 2)\ \Omega = 6\Omega.$

Activity 4.8 Demonstrate Voltage in a Series Circuit

***What you need*:** battery (e.g., 9V), three resistors (or light bulbs) with different resistance values, connecting wires, multimeter (to measure voltage), breadboard (optional) and switch (optional)

What to do:

1. Build a simple Series circuit:
   a. Connect the battery, resistor 1, resistor 2, and resistor 3 in series using wires.
   b. The positive terminal of the battery should be connected to one end of resistor 1, and the other end of resistor 1 should be connected to the second resistor, and so on.
2. Use the multimeter to measure the total voltage across the entire circuit (across the battery). The total voltage should equal the battery voltage.
3. Measure the voltage drop across each resistor. Note the readings for each resistor.
4. Add the voltage drops across the resistors. Find that the sum of the individual voltage drops equals the total voltage supplied by the battery.

Answer the following questions in your notebooks:

1. What happens to the voltage drop if a resistor is added or removed from the series circuit?
2. How does the resistance of each component affect the voltage drop across it?

Parallel Circuit

A parallel circuit is a way of connecting electrical components in a circuit so that they form multiple paths for current flow. In a parallel circuit, all components are connected across each other (see ***Figure 4.11***). It has the following characteristics:

1. Multiple paths: Has more than one path for current to flow through.
2. Same voltage: The voltage across each component is the same.
3. Total current: The total current flowing from the source is equal to the sum of the currents through each path.
4. Branched pathways: Devices are connected along branched pathways.

5. Resistance: The total resistance decreases as the number of branches increases.
6. Current division: Current divides among the branches of the circuit.
7. Current recombination: Current recombines on the other side of the components to the same total current.
8. Broken path: If one of the parallel paths is broken, current will continue to flow in the other paths.
9. Battery life: If batteries are connected in parallel, the battery life is multiplied by the number of batteries.

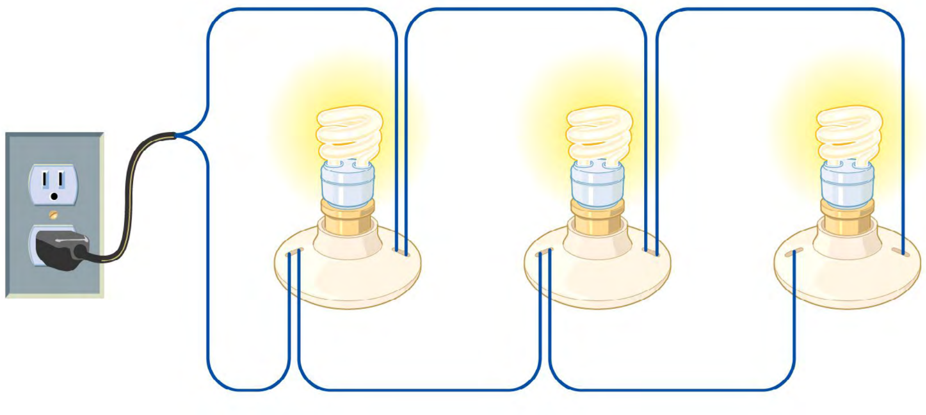


Figure 4.11: Loads (lamps) connected in parallel

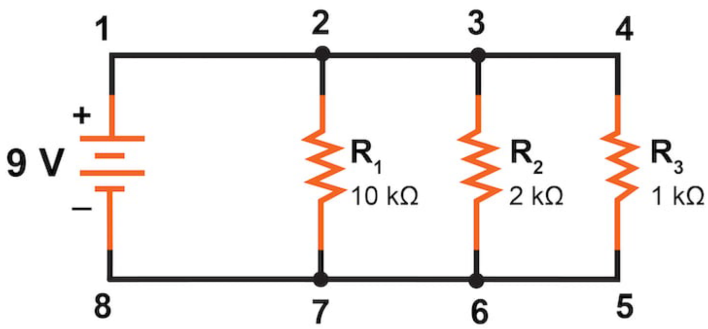


Figure 4.12: Diagram of a parallel circuit

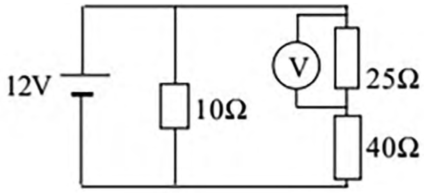
Resistors in a parallel circuit

For an N number of resistors connected in parallel,

total resistance, $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Worked Examples

1. Use the diagram below to answer the question.



Given the voltmeter shown in the above diagram can be taken to have an infinite resistance find:

a. the total resistance of the circuit.

b. the current drawn from the cell.

c. the reading on the voltmeter.

Solution

a. First, work out a series combination, then combine with 10Ω resistance. Work in this order as the 10Ω is in parallel with both 25Ω and 40Ω.

Total resistance in series = 25 + 40 = 65Ω. This is in parallel with the 10Ω resistance.

Total resistance of the circuit, $\frac{1}{R_T} = \frac{1}{10} + \frac{1}{65}$

$$R_T = \frac{10 \times 65}{65 + 10}$$

$$= \frac{650}{75}$$

$$= 8.67\Omega.$$

b. The total current is the voltage supply divided by the total resistance:

Current (I) $\quad I = \frac{V}{RT}$

$$= \frac{12}{8.67}$$

$$= 1.38A$$

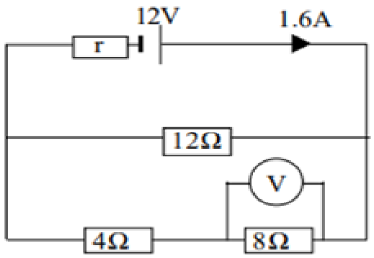
c. The current through the final branch of the circuit is:

Current(I) $I = \frac{V}{R}$

$= \frac{12}{65}$

$= 0.18A$

2. Use the diagram below to answer the question.



What is the total resistance of the circuit?

Solution:

Total resistance in series = 4 + 8 = 12Ω. This is in parallel with the 12Ω resistance.

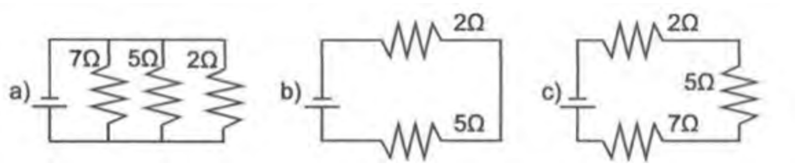
Total resistance of the circuit $= \frac{1}{R_T} = \frac{1}{12} + \frac{1}{12}$

$R_T = \frac{12 \times 12}{12 + 12}$

$= \frac{144}{24}$

$= 6\ \Omega.$

3. Determine the equivalent (total) resistance for each of the following circuits below.



Solution

a. $\frac{1}{R_T} = \frac{1}{7} + \frac{1}{5} + \frac{1}{2} = \frac{59}{70} = 1.2\Omega$

b. RT = 2 + 5 = 7Ω

c. RT = 2 + 5 + 7 = 14Ω.

Activity 4.9 Parallel Arrangement of Resistors in Electrical Circuit

What you need: breadboard, resistors, wires, multimeter

What to do:

1. Connect resistors in parallel on a breadboard.
2. Measure the voltage across each resistor to confirm they are the same.
3. Measure the total current by placing the ammeter in series with the power source and the current through each resistor by placing the ammeter in series with each resistor in turn.
4. Calculate the equivalent resistance and compare it with the measured values.

Power

Power is the rate at which work is done, or energy is transferred over time. It is a measure of how quickly energy is used or produced. The standard unit of power is the watt (W). This is equivalent to one joule per second (J/s).

- The formula for power is: $Power = \frac{Workdone}{Time\ taken}$
- In terms of energy, $Power = \frac{Energy\ transfered}{Time\ taken}$
- In symbols, $P = \frac{W}{t}$

Where:

P is power (in watts, W),

W is work done, or energy transferred (in joules, J)

t is time (in seconds, s).

Worked Example

If the power rating of an incandescent light bulb is 60 watts (W) and the bulb is used for 5 hours a day, what is its total energy used per day?

Solution

60 W × 5 hours = 300 Watt-hours (Wh)

or 60 W × (5 × 60 × 60) s

= 1,080,000 Joules (J)

Electrical Power

In electrical circuits, power is the rate at which electrical energy is consumed or produced by a component, such as a resistor, motor, or generator.

The formula for electrical power is: $P = V \times I$

Where: P = power (in watts, W), V = voltage (in volts, V) and I = current (in amperes, A).

For resistive loads, the power can also be expressed by combining the formula above with Ohm's Law ($V = I \times R$). Thus, $P = I^2 \times R$. Also, $P = \frac{V^2}{R}$

Worked Examples

1. A kettle rated at 2000 W boils water in 5 minutes. Calculate the energy used by the kettle.

   Solution

   Energy = *Elecrical power* × *time*

   Energy = 2000W × 300s

   = 600000J

   The kettle converts 600,000 joules of electrical energy into heat energy.

2. A phone charger operates at 5 V and draws 2 A of current. Calculate the power consumed by the phone charger.

   Solution

   $P = VI = 5 \times 2 = 10W.$

   The charger consumes 10 watts of power to charge the phone.

3. An electric heater consumes 1500W of power and operates on a voltage of 240V. Calculate the current through the heater.

   Solution

   $P = IV$

   Current (I): $I = P \div V$

   Substitute the values:

   $I = 1500W \div 240$

   $= 6.25A.$

   Therefore, current through the heater is 6.25 amperes.

Appliance Troubleshooting

Appliance troubleshooting is the systematic approach of diagnosing problems in household appliances and finding solutions to fix them. This can involve inspecting the appliance for obvious issues, performing tests, and following steps to identify and resolve the malfunction. Troubleshooting household appliances can help identify and resolve common issues without professional assistance.

Components of appliance troubleshooting

1. Observation: Look for visible signs of damage, wear and tear, or anything unusual (e.g., frayed wires, broken parts, leaks).
2. Power check: Ensure the appliance receives power by checking the power cord, plug, and outlet. Test the outlet with another device to confirm it's working.
3. Reset and restart: Some appliances have a reset button. Turning the appliance off and on or using the reset function can sometimes resolve minor issues.
4. Consult the manual: The appliance's user manual often contains troubleshooting tips and solutions for common problems specific to the model.
5. Basic tests: Perform basic tests to check the functionality of the appliance's components. This can include testing switches, fuses, and other easily accessible parts.
6. Sound and smell: Pay attention to unusual sounds or smells which can indicate specific issues (e.g., a burning smell could indicate an electrical problem).
7. Error codes: Modern appliances often display error codes when something goes wrong. Refer to the manual to understand the error code and follow the recommended steps to address it.

Activity 4.10 Role Play Client and Electrical Engineer

What to do:

1. Conduct this activity with a peer or a family member, where one partner acts as a 'client' and the other acts as an 'electrical engineer'.
2. The client will present an issue they are facing with a common household appliance. The engineer must describe what the trouble shooting process might look like for that.

3. Use the table below as a template to conduct this activity. The first one has been completed for you:

Table 4.2: Steps in troubleshooting common appliances

Common issues of household appliances	Troubleshooting steps
Refrigerator	**Not cooling:** 1. Check temperature settings. 2. Clean condenser coils. 3. Ensure door seals are intact. 4. Verify vents inside the fridge are not blocked. 5. Check the drain pan and water supply line for leaks. **Leaking water:** 1. Check the drain pan for overflow. 2. Inspect the water supply line for leaks. 3. Clear any clogs in the defrost drain. **Unusual noises:** 1. Ensure the refrigerator is level. 2. Check for loose components inside the fridge or freezer.
Washing machine	
Dishwasher	
Oven/stove	
Microwave	
Safety precautions of household appliances	

ENERGY AUDITS AND SAVINGS PLANS

An energy audit is a careful check of how energy is used in a building to find ways to save energy and reduce waste. It involves looking at energy use, inspecting systems, and analysing how energy flows. The goal is to use less energy without reducing the things we need the energy for, like lighting, heating, or cooling. An energy audit is an important step in creating a plan to manage and save energy better.

Sources of Electrical Energy

Electricity can be made in many ways, using different sources of energy. These sources can be divided into two groups:

1. Non-renewable energy sources
2. Renewable energy sources.

Non-Renewable energy sources

Non-renewable energy sources are types of energy that come from natural resources that take millions of years to form. These resources, like coal, oil, and natural gas, are used up faster than they can be replaced. Once they are gone, we cannot get more of them for a very long time.

1. Coal: Coal is burnt to make heat. The heat boils water to create steam, which spins turbines to make electricity.
2. Natural Gas: Natural gas is burnt to make heat, which produces steam or directly spins turbines to generate electricity.
3. Oil: Oil is burnt in power plants to heat water and create steam, which spins turbines to generate electricity.

Renewable energy sources

Renewable energy sources are types of energy that come from natural resources that can be replaced and will not run out. These resources, like sunlight, wind, water, and plants and animal body parts. They are always available and can be used over and over again. They are also cleaner and better for the environment than non-renewable energy sources.

1. Nuclear Power: Special materials like uranium are split into smaller parts, a process called nuclear fission. This releases heat, which creates steam to spin turbines and produce electricity.

2. Hydropower: Flowing water, like from a river or dam, spins turbines connected to generators to make electricity — see ***Figure 4.14***
3. Wind Power: Wind turbines use the power of moving air to turn their blades, which generates electricity.
4. Solar Power (Photovoltaic): Solar panels use sunlight to directly produce electricity using special materials called semiconductors — see ***Figure 4.13***.
5. Concentrated Solar Power (CSP): Mirrors focus sunlight onto a fluid, heating it to create steam. The steam then spins turbines to make electricity.
6. Geothermal Energy: Heat from deep inside the Earth is used to create steam, which spins turbines to generate electricity.
7. Biomass: Organic materials like wood or crop waste are burnt or turned into fuels to produce steam that drives turbines and generates electricity.
8. Tidal and Wave Energy: The energy from ocean tides and waves is used to spin turbines and make electricity.
9. Hydrogen Fuel Cells: Hydrogen gas reacts with oxygen to produce electricity and water.

Figure 4.13: Solar Energy

Figure 4.14: Hydroelectric Power

Energy Losses: Heating Effects of Electric Current

When electricity flows through a wire, the wire gets warm or even hot. This is called the heating effect of electric current, or joule heating. It happens because the tiny particles carrying electricity (called electrons) bump into other particles inside the wire. These bumps make the particles in the wire move faster, which causes the wire to heat up.

How does it work?

- Electric current flows through a conductor (like a wire).
- The electrons (tiny moving charges) collide with the atoms of the wire.
- These collisions make the wire's atoms vibrate more, producing heat.
- As a result, the conductor's temperature increases.

Examples of heating effects in everyday life

a. Electric heaters: Used in stoves, irons, and room heaters. The current heats up a wire or coil inside, which warms the air or surface around it.

b. Light Bulbs: In old-style incandescent bulbs, the electric current heats up a thin wire (filament) until it glows, producing light and heat.

c. Fuses: Fuses are safety devices in electrical systems. They contain a thin wire that melts when the current is too high, breaking the circuit to prevent damage.

Figure 4.15: Appliances using heating effect of current

Problems caused by heating in electric circuits

1. Energy Loss: When wires heat up, some electrical energy is turned into heat energy. This means less energy is available to power devices. This can be a big issue with long wires, like the ones carrying electricity to your home.
2. Damage to components: Too much heat can damage wires and electrical parts, causing devices to stop working or even start on fire.

To prevent this, devices often use cooling systems like fans or metal pieces (called heat sinks) to carry away the heat.

Activity 4.11 Heating Effect of Electric Current

***What you need*:**

- A battery or electric cell, small light bulb, a switch, connecting wires
- thermometer (optional, to measure temperature changes)
- Heat-resistant gloves (to protect your hands)
- A heat-resistant surface (like a tile or piece of glass)

What to do:

1. Set up the circuit

a. Connect the battery, light bulb, switch, and wires to create a simple circuit.

b. Make sure the switch is part of the circuit so you can turn the current on and off.

c. Place the setup on a heat-resistant surface to keep things safe.

2. Check the bulb before turning it on

a. Keep the switch off.

b. The bulb will not glow, and it will feel cool or at room temperature when you touch it.

3. Turn on the circuit.

a. Flip the switch to on so that current flows through the bulb.

b. Watch the bulb light up. This shows that electrical energy is being converted into light and heat.

4. Feel the bulb after it glows

a. Let the bulb glow for one-two minutes, then turn the switch off.

b. Carefully touch the bulb using heat-resistant gloves.

c. You will notice that the bulb is warmer than it was before.

Safety Precautions

a. Always use heat-resistant gloves when touching the bulb after it has been on.

b. Make sure the wires are connected properly to avoid sparks or short circuits.

c. Be careful with the battery and wires to prevent electric shocks.

d. Perform the experiment on a heat-resistant surface to prevent any damage.

Reflect on the following questions, record your observations and answers in your notebook.

1. If the bulb did not glow or heat up, what could be wrong with the circuit?
2. How does the heating effect of electric current relate to energy efficiency in electrical devices?
3. What could happen if we left the bulb glowing for a long time without turning it off?
4. Why does the bulb's temperature increase when the switch is turned on?
5. What would happen if we used a larger bulb or a higher voltage battery?

Electrical Energy in The Home

Calculate the energy consumed by meter reading: Electrical energy is the energy we use when we turn on lights, use TVs, or charge our phones. At home, we measure this energy using a device called an electric meter. It shows how much energy we use in a unit called kilowatt-hour (kWh).

What is a kWh?

One kilowatt-hour means you used 1,000 watts of power for one hour. For example:

A 1,000-watt heater running for 1 hour = 1 kWh.

A 100-watt light bulb running for 10 hours = 1 kWh.

How to Calculate Energy Used

Look at the numbers on your meter before and after you use electricity.

Subtract the earlier number from the later number to find out how much energy you used.

For example:

Meter reading at start: 50 kWh.

Meter reading at end: 70 kWh.

Energy used: 70 - 50 = 20 kWh.

Your electricity bill is calculated based on how many kWh you used.

Saving energy, like turning off lights when not needed, can lower your bill and help the environment.

Hint

1 kWh = 3,600,000 Joules of energy. That is enough to light up a 100-watt bulb for 10 hours

Activity 4.12 Measuring Energy Consumption of Home Appliances

***What you need*:** Fan and lamp or a hairdryer

What to do:

1. Choose a few small household appliances such as a fan, a lamp, or a hairdryer. Use a plug in power meter (or use the same energy consumption formula) to measure how much energy each appliance consumes over a specific period.
2. Record the power rating (in watts) for each appliance (fan might be 40 W, a hair dryer might be 1200 W)
3. Turn on each appliance for a set amount of time (for example 30 minutes) and calculate how much energy each appliance uses during that time.
4. Share your experience and findings with your peers or family members.

Worked Examples

1. A television rated at 150 watts is used for 5 hours a day. Calculate the energy consumed in kilowatt-hours (kWh) for a week.

Solution

Power of appliance (P): 150 W = 0.15 kW

Time of usage per day (t): 5 hours

Energy per day (E): $E = P \times t$

$= 0.15 \text{ kW} \times 5 \text{ hours}$

$= 0.75 \text{ kWh}$

Energy for a week: $7 = 0.75 \text{ kWh} \times 7$

$= 5.25 \text{ kWh}$

Therefore, the television consumes 5.25 kWh of energy in a week.

2. A washing machine has a power rating of 2 kW and is used for 2 hours per load. If the electricity cost is Ghc 0.12 per kWh, find the cost of running the washing machine for 5 loads.

   Solution

   Power of appliance (P): 2 kW

   Time per load (t): 2 hours

   Energy per load (E): $E = P \times t$

   $= 2 \text{ kW} \times 2 \text{ hours}$

   $= 4 \text{ kWh}$

   Total energy for 5 loads: $E = 4 \text{ kWh} \times 5$

   $= 20 \text{ kWh}$

   Cost of electricity = Total energy × Rate per kWh

   $= 20 \text{ kWh} \times 0.12$

   = Ghc 2.40

   Hence, the cost of running the washing machine for 5 loads is Ghc 2.40.

3. A refrigerator operates 24 hours a day with a power rating of 200 W. Calculate the total energy used in one year (365 days).

   Solution

   Power of appliance (P): $200 \text{ W} = 0.2 \text{ kW}$

   Time per day (t): 24 hours

   Energy per day (E): $= P \times t$

   $= 0.2 \text{ kW} \times 24 \text{ hours}$

   $= 4.8 \text{ kWh}$

   Energy per year = Energy per day × 365

   $= 4.8 \text{ kWh} \times 365$

   $= 1{,}752 \text{ kWh}$

   So, the refrigerator uses 1,752 kWh of energy in a year.

Types of Meters

Analog Meter

Digital Meter

Smart Meter

Figure 4.16: Different types of meters

How to Read Your Meter

Analog meter reading

1. Identify the dials: Analog meters typically have five dials, each numbered from 0 to
2. Read each Dial: Start from the left and read each dial in sequence. Note that some dials rotate clockwise while others rotate counterclockwise.
3. Record the numbers: Write down the number that each pointer is closest to. If the pointer is between two numbers, record the lower number.
4. Calculate usage: Subtract the previous reading from the current reading to determine the kWh used.
5. For example, if the previous reading was 12345 kWh and the current reading is 12400 kWh, you have used 55 kWh.

Digital meter reading

1. Locate the display: Digital meters have a screen that displays the total kWh used.
2. Record the number: Simply write down the number displayed. There are no dials or complex readings to interpret, making digital meters user-friendly.

Smart meter reading

Smart meters can vary by brand, but the process is generally similar.

Check the display: Smart meters will have a digital display showing the total kWh.

Energy Audit Process

An energy audit helps us find out how much energy a building uses and where we might be wasting energy. It's like checking how well our home, school, or building uses electricity, so we can find ways to save energy and money.

1. Getting started (Initial Assessment):
   a. First, gather information about the building. How big is it? How old is it? What is it used for?
   b. Look at electricity and energy bills from the past year. These bills show how much energy was used and if there are any changes during different seasons, like using heaters in winter or fans in summer.
2. Checking the building (Walkthrough Inspection):
   a. Walk around the building to see how energy is being used.
   b. Check lights, heaters, air conditioners, refrigerators, windows, and doors.
   c. Look for problems like lights being left on, gaps in doors or windows where air leaks out, or old appliances that use too much energy.
3. Detailed testing (Detailed Analysis):
   a. Use special tools to measure how much energy different devices or systems use.
   b. Find out which appliances, like heaters or air conditioners, use the most energy.
   c. Check for places where heat escapes (like gaps in the walls or windows) or where there's poor insulation.
4. How people use energy (Evaluate occupant behaviour):
   a. Observe how people use energy in the building.
   b. Talk to them or ask questions to find out if they forget to turn off lights, leave appliances running, or use heaters and coolers too much.
   c. Consider habits during different times of the year or work shifts.
5. Sharing the Results (Report Findings):
   a. Write a report about what was found during the audit.
   b. Show where energy is being wasted and suggest simple ways to fix it, like switching to energy-efficient bulbs or sealing gaps in doors and windows.

c. Prioritize the changes that save the most energy and are easy to do.

Activity 4.13 Energy Audit Investigation

Review this scenario:

The school administration wants to reduce energy consumption and costs. They have formed an energy Audit team consisting of students, teachers, and facilities staff.

As members of the energy Audit team, conduct an energy audit of the school and energy saving measures.

What to do:

1. Look at a section of the school (e.g. classroom, library, cafeteria).
2. Take a walk-through inspection observing energy usage and identifying areas for improvement.
3. Record your findings on the worksheet named Energy Audit worksheet with the heading; Area, Energy usage and Recommendations.

Reflect on the following questions:

1. What are the most energy-intensive areas in the school?
2. How can they reduce energy consumption?
3. What are the cost and benefits of energy-efficient solutions?

Home Energy Savings Plan

Saving energy at home means using less electricity or fuel while still staying comfortable. A home energy savings plan helps you figure out where you can save energy, what to change, and how to track your progress.

Set clear goals

Start by deciding what you want to achieve. Your goals should be:

1. Specific: Know exactly what you want to do.
2. Measurable: You can check your progress.
3. Achievable: Make sure your goals are possible.
4. Relevant: Focus on energy-saving tasks.
5. Time-bound: Set a deadline.

Activity 4.14 Identify Energy-Saving Opportunities

Based on an initial assessment of your home, identify areas where energy savings can be achieved. Common areas include:

Table 4.3: Energy saving plan

Area	What to do	Why it helps
Lighting	1. Replace Bulbs: Use energy-saving LED or CFL bulbs instead of old ones.	Saves electricity and lasts longer.
	2. Use sensors: Install motion sensors or timers to control lights.	Lights turn off when not needed, saving energy.
	3. Maximize natural Light: Open windows and clean them to let in more sunlight.	Reduces the need for artificial lighting.
Heating, Ventilation, and Air Conditioning (HVAC)	1. Regular Maintenance: Check and clean your heating and cooling systems regularly.	Keeps them running smoothly and uses less energy.
	2. Programmable Thermostats: Use smart thermostats to set temperatures for different times.	Saves energy by heating or cooling only when needed.
	3. Improve Insulation: Add insulation to walls, attics, or basements.	Keeps your home warm in winter and cool in summer, using less energy.
	4. Seal Leaks: Close gaps around windows and doors to stop air from escaping.	Prevents energy loss and keeps rooms comfortable.

Area	What to do	Why it helps
Appliances and Electronics	1. Upgrade Appliances: Get modern appliances with energy-saving ratings.	Uses less electricity than older models.
	2. Use Power Strips: Plug many devices into a single power strip to easily switch them off.	Stops devices from wasting electricity when not in use.
	3. Unplug Devices: Unplug gadgets like chargers and TVs when not in use.	Prevents "phantom power" (electricity used even when off).
Water Heating	1. Insulate Water Heater: Wrap your water heater and pipes in insulation.	Keeps water hotter for longer and reduces energy use.
	2. Install Low-Flow Fixtures: Use water-saving faucets and showerheads.	Uses less hot water, saving energy and water.
	3. Lower Temperature Settings: Keep your water heater at 120°F (safe and efficient).	Saves energy while keeping water hot enough.
Building Envelope	1. Improve Insulation: Add insulation to walls, attics, or basements.	Helps maintain indoor temperatures, saving energy.
	2. Energy-Efficient Windows: Replace old windows with double or triple-pane ones.	Prevents heat from escaping or entering, saving energy.
	3. Seal Openings: Fix cracks and gaps around windows and doors.	Stops air drafts and reduces energy loss.

Example of home energy saving plan

Goal: Reduce energy consumption by 20% within one year.

Table 4.4: Example of energy saving plan in the home.

Timeframe	What to Do	Why It Helps
Short-Term (0-3 Months)	1. Use LED Bulbs: Change all old bulbs to energy-saving LED ones.	Uses less electricity and lasts longer.
	2. Install Smart Thermostats: Set the temperature automatically for mornings, nights, etc.	Saves energy by heating or cooling only when needed
	3. Teach Energy-Saving Habits: Share tips with your family, like turning off lights when leaving a room.	Helps everyone work together to save energy.
	4. Unplug Devices: Unplug chargers and devices when not in use.	Stops electricity from being wasted by devices in standby mode
Medium-Term (3-6 Months)	1. Upgrade Appliances: Replace old fridges, TVs, and washing machines with energy-efficient ones.	Uses less energy for the same tasks.
	2. Seal Windows and Doors: Close gaps or cracks where air escapes.	Keeps rooms warm in winter and cool in summer without extra energy.
	3. Install Low-Flow Fixtures: Use water-saving showerheads and faucets.	Saves water and the energy used to heat it.
	4. Insulate Water Heater: Wrap your water heater and pipes to keep heat in.	Keeps water warm for longer, reducing energy use.
Long-Term (6-12 Months)	1. Add Insulation: Improve insulation in walls, attics, and basements.	Maintains comfortable temperatures using less energy.

Timeframe	What to Do	Why It Helps
	2. Replace Windows: Use energy-efficient windows that stop heat from escaping.	Saves energy during both hot and cold seasons.
	3. Install Solar Panels: Use sunlight to create your own electricity.	Reduces dependence on non-renewable energy sources.
	4. Apply for Incentives: Look for government rebates or programs to save money on upgrades.	Makes it easier to afford energy-saving improvements.

PRINCIPLE OF TRANSFORMER AND ITS FUNCTION

Electromagnetic induction: The method through which a changing magnetic field generates a voltage in a conductor.

Primary winding: The coil that is connected to the power source input.

Secondary winding: The coil is connected to the output circuit where the modified voltage is required.

Core: The magnetic component that improves the efficiency of the magnetic flux connection between the primary and secondary coils.

Transformer

A transformer is an electrical device that changes the voltage of an alternating current (AC). It can either increase (step-up) or decrease (step-down) the voltage to make it suitable for different uses.

A transformer is like a special kind of electric machine that helps change the power level to make it just right for different uses. For example, it can make power stronger to send it far away or make it safer for use at home. — See ***Figure 4.17***

Figure 4.17: A transformer

Activity 4.15 Electromagnetic Induction in a Transformer

What you need: wire coil, magnet and small light bulb.

What to do:

1. Connect the small light bulb to the wire coil.
2. Move the magnet quickly in and out of the coil. — See ***Figure 4.18***

Observation: The light bulb flickers.

Conclusion: The movement creates a small amount of electric power that can make the light bulb flicker. This demonstrates the principle of electromagnetic induction. This is like what happens in a transformer. Moving electricity in the primary coil makes a magnetic field, which then makes electricity in the secondary coil.

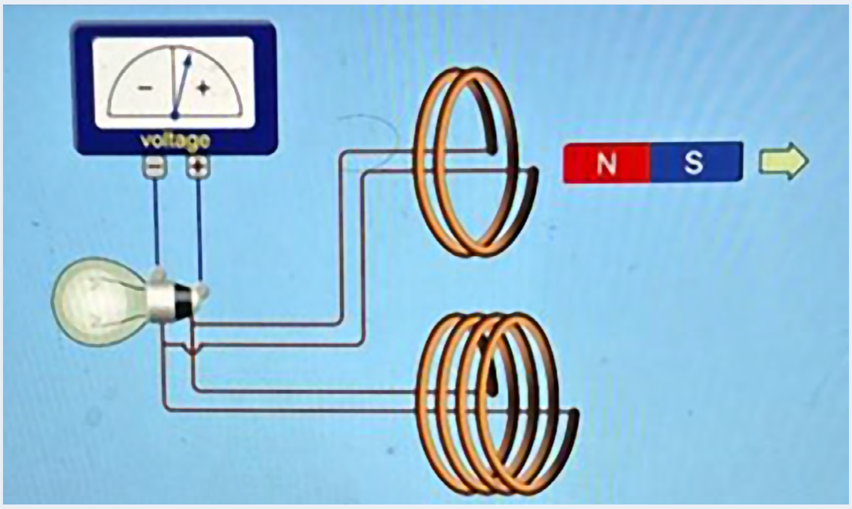


Figure 4.18: Producing Current by Electromagnetic Induction

Activity 4.16 How a transformer works

***What you need*:** battery-operated electromagnet or coil of wire and iron rod, small light bulb or LED and connecting wires

What to do:

1. Wrap a coil of wire around a metal core (like a nail or bolt).
2. Connect the ends of the wire to a battery to create an electromagnet field.
3. Bring the coil close to another coil connected to a light bulb.
4. Quickly connect and disconnect the battery to show how the changing magnetic field induces a current in the second coil.

Observation: The bulb will glow shortly.

Conclusion: This shows that a changing current in the primary coil induces current in the secondary coil, like how a transformer works.

How transformer works

Think of a transformer as a box with two coils of wire:

- Primary Coil: This is the coil that gets power from a power source like a power plant.
- Secondary Coil: This is the coil that sends the power out, but at a different strength.

Both coils are wrapped around a middle piece called a core, which is usually made of iron. The core helps pass the "energy message" between the coils.

The primary coil receives an electric current from a power source. This current moves back and forth quickly (alternating current, or AC).

When the current moves through the primary coil, it creates a magnetic field in the iron core. The magnetic field spreads to the secondary coil and causes an electric current to appear there too. This current has the same type of power, but it might be stronger or weaker, depending on how the coils are arranged.

Types of Transformers

Step-down transformer

Imagine you have a big water pipe (the primary winding) that carries a lot of water (voltage), and a smaller pipe (the secondary winding) that carries less water. A step-down transformer works by taking the large amount of water ~(voltage) from the big pipe and squeezing it through the smaller pipe, but the smaller pipe carries the water more slowly, or at a higher flow (current).

In a transformer, there are wires instead of pipes, but the idea is similar. The primary winding (the big pipe) has lots of coils (or turns of wire), and the secondary winding (the small pipe) has fewer coils. This reduces the voltage (like reducing the pressure in the water pipe) but increases the current (the amount of water flowing through the small pipe).

In simple terms, a step-down transformer takes high voltage from the primary side, reduces it, and sends it out with more current on the secondary side. This is useful for powering things like home appliances safely. The step-down transformer has a larger number of turns in the primary winding and a smaller number of turns in the secondary winding.

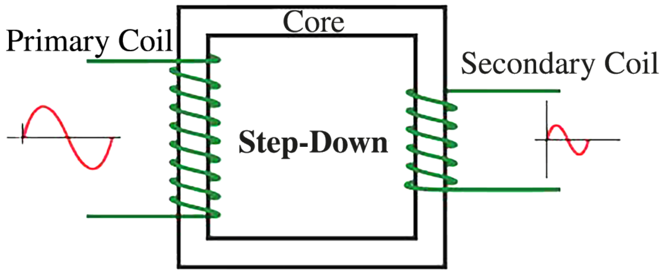


Figure 4.19: Step-down Transformer

Step-up transformer

A step-up transformer works the opposite way of the step-down transformer. It takes low voltage (like a small water flow) from the primary side and increases the voltage (raises the water pressure). It does this by using more coils (turns of wire) on the secondary side than on the primary side. This means that when the voltage increases, the current (or flow of electricity) decreases.

Imagine that when you increase the pressure of water in a pipe, the amount of water flowing through the pipe becomes less, but the water can travel farther.

The reason we use step-up transformers is to send electricity over long distances more efficiently. When the voltage is increased, the current is reduced, which prevents the wires from heating up too much. This makes the energy transfer safer and more efficient, especially when the electricity must travel from power stations to homes or businesses.

A step-up transformer takes a low voltage, increases it to a higher voltage, and reduces the current to make the transfer of electricity over long distances safer and more efficient.

The step-up transformer has a smaller number of turns in the primary winding and a larger number of turns in the secondary winding.

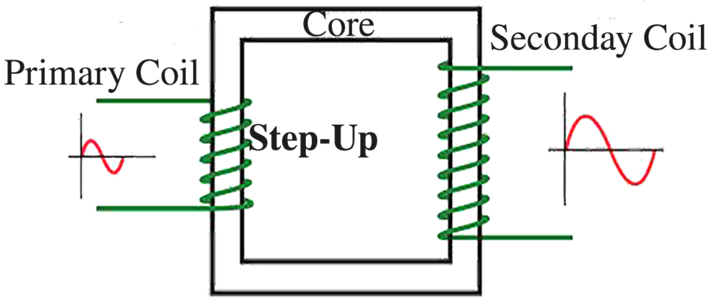


Figure 4.20: Step-up Transformer

Activity 4.17 Simulating a Step-Down Transformer

What you need:

- Two coils of wire (one with more turns and one with fewer turns)
- One small light bulb (representing a load or device that uses electricity)
- One battery (to represent the power source)
- Electrical tape, connecting wires
- A ruler or measuring tape (to measure the number of turns in each coil)

What to do:

1. Take two coils of wire. Coil the first one with more turns of wire (about 20-30 turns) and the second coil with fewer turns of wire (about 10 turns).

2. Set Up the First Circuit (Simulate Step-Down Transformer):

a. Connect the first coil (with more turns) to the battery using the connecting wires. Attach the light bulb in series with the coil.

b. Turn on the circuit and observe the brightness of the light bulb. It should be bright because the voltage is higher, and the current is lower.

c. Now, swap the first coil (with more turns) with the second coil (with fewer turns). Connect the second coil (with fewer turns) to the battery and light bulb in the same way.

d. Turn on the circuit and observe the light bulb again.

Reflect on the following questions and answer them in your notebook.

1. Why did the light bulb get dimmer?

2. What would happen if both coils had the same number of turns?

3. Explain how step-down transformers are used in everyday life, such as in power supplies for home appliances.

Record your observations in terms of changes in the brightness of the bulb in your notebook.

Safety Precaution

Use proper connections in your circuit set up.

Activity 4.18 Building a Step-Down Transformer

What you need:

- Iron core (you can take this from an old transformer or buy one)
- Insulated copper wire (this is the wire we will wrap around the core, use different thicknesses for the primary and secondary coils)
- Wire cutters/strippers (to cut and strip the wire)
- Soldering iron and solder (to connect the wires safely)
- Electrical tape (to insulate the connections)
- AC signal generator (to provide the alternating current to the primary coil)
- Multimeter (to measure the voltage)

What to do:

1. Calculate the Turns Ratio

a. You need to calculate how many turns of wire you will have on each coil.

For a 1:2 step-down transformer, the primary coil will have twice as many turns as the secondary coil. For example, if the secondary coil has 10 turns, the primary coil should have 20 turns.

2. Prepare the Core

a. Place the iron core on a flat surface. This core will help the electricity move through the wire and change the voltage.

b. Make sure the core is clean, with no dust or debris, to ensure it works properly.

3. Wind the Coils

a. Primary Coil: Take the insulated copper wire and wrap it around one side of the iron core. The number of turns should match the calculation you made. For example, if you're using a 1:2 step-down ratio and the secondary coil has 10 turns, the primary coil will have 20 turns. Leave some extra wire at the ends for connecting it to the power source.

b. Secondary Coil: Next, wrap the secondary coil on the opposite side of the core. The number of turns should be half of the primary coil.

For example, if you have 20 turns in the primary coil, you will wind 10 turns in the secondary coil.

4. Connect the leads

a. Carefully connect the ends of the primary coil to the AC signal generator. This is the source of electricity that will go through the primary coil.

b. Connect the ends of the secondary coil to the multimeter (to measure the voltage output).

c. Use a soldering iron to make the connections. Be careful and use electrical tape to insulate the wires so they don't touch each other or cause any short circuits.

5. Test the Transformer

a. Once the coils are connected, turn on the AC signal generator to send a low voltage (2V AC) into the primary coil.

b. Measure the output voltage across the secondary coil using the multimeter. The output voltage should be lower than the input voltage, according to the number of turns in the coils. For example, if you used a 1:2 ratio (primary coil = 20 turns, secondary coil = 10 turns), the output voltage should be about half of the input voltage. If the primary coil has 2V, the secondary should have approximately 1V

Reflect on the following questions and write your answers in a notebook:

1. What did you observe? If your experiment was correct, the voltage measured on the secondary coil should be lower than the voltage on the primary coil.

2. What do you think would happen if there was a problem with the primary coil of a transformer?

3. How would it affect the secondary coil and the voltage output?

Safety Precautions

1. Do not exceed a 1:10 ratio of turns in the primary and secondary coils. This is important to keep the experiment safe.

2. Do not exceed an input voltage of 2V AC. The power supply must be locked to ensure this. This low voltage is safe for the experiment.

EXTENDED READINGS

1. Introduction to electrical safety:

   https://www.hse.gov.uk/electricity/precautions.htm

2. Power rating for common appliances:

   https://www.altestore.com/pages/power-ratings-for-common-appliances?srsltid=AfmBOoo72Jhrok8vp_CC1HPu_ho8annLWSPLsl_B_n9H3s72JgFdxCco

REVIEW QUESTIONS

1. What are the functions of step-up and step-down transformers?
2. How do step-up and down transformers work?
3. How could we design a transformer to make sure it works as efficiently as possible? What materials or methods might make it better.
4. Give the units for voltage, current, power and charge.
5. A resistor has a resistance of 10 Ohms, and the current flowing through it is 2 Amps. What is the voltage across the resistor?
6. Describe the steps involved in troubleshooting household appliances.

Section 5 BUOYANCY FORCE

VIGOUR BEHIND LIFE

Forces Acting on Substances and Mechanisms In Real Life

INTRODUCTION

Upthrust, also known as buoyancy, is a fundamental principle that explains why objects float or sink in a fluid, such as water. It is the upward force exerted on an object submerged in a fluid, counteracting the weight of the object. This phenomenon is described by Archimedes' principle, which states that the upthrust on an object is equal to the weight of the fluid it displaces. When an object is placed in a fluid, it displaces a volume of fluid equal to its own submerged volume. If the upthrust is greater than or equal to the object's weight, the object will float; if it is less, the object will sink. The concepts of upthrust and flotation are essential in understanding various applications, ranging from designing ships and submarines to understanding natural occurrences such as why certain animals can swim. Overall, these principles play a crucial role in both engineering and natural environments.

KEY IDEAS

- Archimedes' Principle: States that the upthrust on a submerged object equals the weight of the fluid displaced.
- The upward force exerted by a fluid on an immersed object, determining whether it floats or sinks, is called Buoyant Force:
- An object floats if its density is less than the fluid's density; it sinks if its density is greater.
- An object displaces a volume of fluid equal to its submerged volume, affecting the upthrust it experiences.
- Buoyancy principles are vital in shipbuilding, underwater exploration, and aviation design.
- Factors such as shape, material, and load distribution affect how well an object floats and its stability in the water.

THE RELATIONSHIP BETWEEN UPTHRUST AND THE LAW OF FLOTATION

Activity 5.1 Demonstrating Upthrust (buoyancy)

***What you need*:** A clear container (like a large glass or plastic bottle), water and a small object (like a rubber ball, stone, or piece of fruit)

What to do:

1. Fill the container with water until it is about three-quarters full.
2. Take the small object you have. Hold it above the water and think about how heavy it feels and what it looks like.
3. Now, gently place the object into the water. Watch closely to see what happens. Does it sink or float?

   Let us talk about what you observed. The object experiences a force called upthrust from the water, which pushes it upward. If the object floats, this means the upthrust is equal to or greater than its weight. If it sinks, the weight is greater than the upthrust.
4. Try using different objects you can find around you. Note down those that float and those that sink. Think about why that might be—what do you notice about their materials or shapes?

Great job! Now you understand how upthrust works and why some objects float while others sink. Keep experimenting and observing the world around you!

Activity 5.2 Understanding Upthrust

Observe ***Figure 5.1*** and discuss the questions with peers.

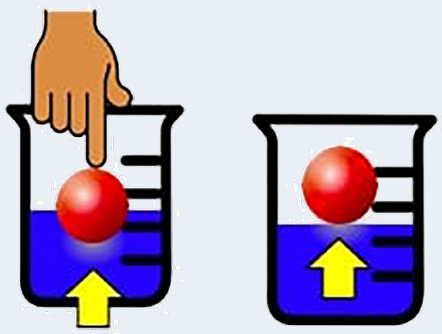


Figure 5.1: Image showing Upward Force

Questions: Write your answers in your notebook.

1. What is upthrust? State one example of upthrust in action.
2. How can you observe upthrust in everyday life?
3. How does fluid density affect buoyant force?
4. What happens when an object is fully or partially submerged?

Upthrust Force

Upthrust, or buoyant force, is the upward force that a fluid (a liquid or gas) exerts on an object that is placed in it. This force works against the object's weight and helps it float in some situations. You can see upthrust when a rubber duck floats in water, as it rises up against the downward pull of gravity.

- Higher fluid density increases the buoyant force, making it easier for objects to float. A fully submerged object experiences maximum upthrust, while a partially submerged object experiences less, affecting its ability to float.
- A boat floats because it displaces a weight of water equal to its own weight, demonstrating upthrust.
- When an object is submerged in a fluid, there is a pressure difference between the top and bottom of the object, which creates this upward force. This phenomenon is described by Archimedes' principle, which states that the buoyant force acting on an object submerged in a fluid is equal to the weight of the fluid the object displaces.
- The amount of upthrust depends on both the density of the fluid and the volume of the object that is under the fluid.

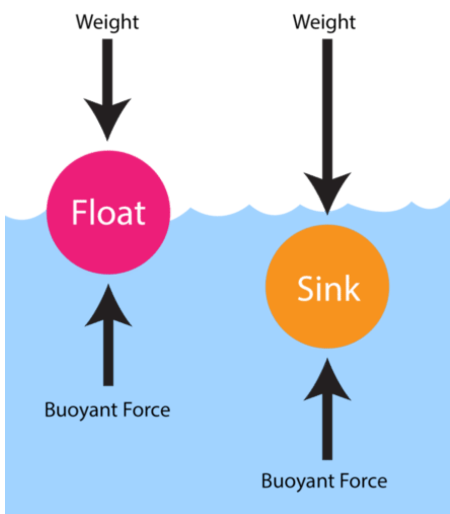


Figure 5.2: Upthrust vs. object weight in fluid

When an object is placed in a fluid, it experiences both its weight pulling it down and the upthrust pushing it upward. If the upthrust is greater than the object's weight, the object will float. If the weight is greater, the object will sink. Thus, the relationship between upthrust and an object's weight determines whether the object will sink or float in the fluid.

Buoyancy is a force that moves an object upward — see ***Figure 4.2***. This upward force occurs when the object is immersed (either fully or partially) in a fluid that has a measurable density. Buoyant force is measured in Newtons (N) by International System of Units (SI).

Basic understanding of buoyancy, density, fluids, and the Archimedes Principle is necessary for understanding how things float.

Question: Write your answer in your notebook.

1. Why do things float or sink?

   An object will float when it is less dense than the fluid in which it is immersed. This buoyant force is referred to as positive buoyancy. When an object is denser than the fluid it displaces, the object will sink because its weight is greater than the buoyant force. This buoyant force is referred to as negative buoyancy. An object is neutrally buoyant when its density is equal to the density of the fluid in which it is immersed, resulting in the buoyant force balancing the force of gravity that would otherwise cause the object to sink or rise. An object that has neutral buoyancy will neither sink nor rise. — See ***Figure 4.3***. **Flotation is the state** of an object being suspended in a fluid, neither sinking nor completely submerged.

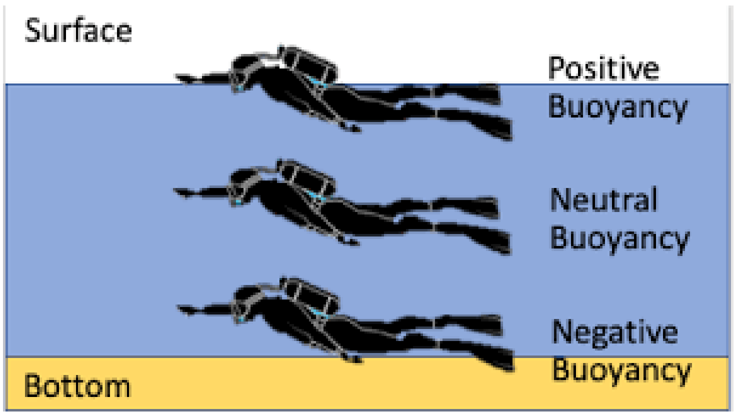


Figure 5.3: Positive, Negative and Neutral Buoyancy

Activity 5.3 Building Examples (Prototypes) of Ships, Canoes and Boat

What you need:

- Aluminium foil (large sheets)
- Modelling clay (optional)
- Shallow pan or tub filled with water
- Tape (optional)
- Scissors (optional, for cutting foil)
- Pencils or markers (optional, for decoration)

What to do:

1. Take a sheet of aluminium foil and fold it lengthwise several times to form a long, strong strip.
2. Gently curve the strip upward in the centre to create the shape of a canoe, pinching the ends to make pointed tips if desired.
3. Pinch small pieces of modelling clay and place them inside the bottom of the canoe for added weight and stability, securing them with tape if needed.
4. Take another sheet of aluminium foil, fold it in half to form a square, then fold the square diagonally to create a triangle.
5. Slightly open the triangle and fold the bottom corners toward the top point to shape the hull, ensuring it has a pointed front and flat bottom. Use tape to reinforce the folds.
6. Use markers or pens to decorate your canoe and ship with details like windows
7. Carefully place your examples (prototypes) of canoe and ship in a pan filled with water.
8. Observe whether they float and how much water they displace. Adjust the modelling clay in the canoe to see how it affects stability and try changing the ship's body shape to see how it influences water displacement.

Figure 5.4: Example of Aluminium Foil Boat

Questions: Record your answers in your notebook.

1. How does the shape of your canoe help it float?
2. What effect does adding modelling clay have on the canoe's stability?
3. How does modifying the body shape of your ship change its performance in the water?
4. Which design floated better, the canoe or the ship, and why do you think that is?
5. What is water displacement, and how can you observe it with your designs?
6. How do the materials used (aluminium foil, clay) influence the buoyancy of your floating models?

Concept of Buoyancy

Read these key points to help support your understanding of the concepts of buoyancy, upthrust, and design as they relate to your prototypes of ships, canoes and boats. The shape of the designs affects how water is displaced. A wider base offers more stability and buoyancy, allowing the object to float better. The canoe's curved shape helps it slice through the water, while the ship's hull design can affect how evenly it sits on the surface. Adding weight, such as modelling clay, can increase stability up to a point by lowering the centre of gravity. However, too much weight may cause the canoe to sink. The right amount of weight helps the canoe remain upright and balanced in the water. The performance may vary based on design and weight. Typically, if designed well, both can float effectively. However, if one has a better shape for water displacement or more stability due to weight distribution, it will perform better. You should note how much water each design displaced when placed in the water. An object that floats in water will displace a volume of water equal to its weight. If an object sinks, less water is displaced than the object's weight, demonstrating the principle of buoyancy. The materials (aluminium foil and modelling clay) are lightweight and can be moulded easily. Aluminium foil, being light and flexible, allowed for easy shaping into hollow forms, supporting buoyancy. Modelling clay provided additional weight and stability but needed to be balanced carefully to prevent sinking.

Activity 5.4 Exploring Buoyancy, Upthrust, Density, Mass, and Volume

What you need: Blocks made of wood, metal, or plastic (hollow or solid), container filled with water, ruler and weighing scales.

What to do:

1. Use the weighing scales to find the mass of each block and write it down in a table in kilograms (kg).
2. Carefully place one block in the water and observe whether it floats or sinks. If it floats, proceed to the next steps.
3. Use the ruler to measure how deep the floating block is submerged under the water. Calculate the volume of the water that is displaced using the formula: Volume = Depth (m) × Width (m) × Length (m)
4. Multiply the volume of displaced water by the density of water (which is 1000 kg/m^3) to find out how much mass of water has been displaced.
5. To see if the block is buoyant, compare its weight with the weight of the displaced water.
6. Use this formula to calculate weight:

   Weight (N) = Mass (kg) x Acceleration due to gravity (ms^{-2})

Note

(On Earth, g = 9.81 N/kg or ms^{-2})

Safety Precautions

1. Use weighing scales and tools gently to avoid breakage or injury.
2. Prevent spills and clean up any water immediately to avoid slipping.
3. Dispose of materials properly according to school rules.

Density

Density is defined as mass per unit volume.

Mathematically, $\rho = m/V$, where ρ = density, m = mass and V = volume.

An object will float in a fluid if it is less dense than that fluid. On the other hand, it will sink if it has a higher density. When you put an object in water, it pushes some of the water out of the way (this is called displacing water). If the object is less dense than the water, the weight of the water it displaces is heavier than the object itself. This creates a buoyant force, which pushes the object up, making it float. However, if the object is denser than the water, its weight is heavier than the buoyant force, causing it to sink.

Volume

Volume is the amount of space an object takes up. If an object has a larger volume, it displaces more fluid, which increases the buoyant force. So, even if an object is made from a heavy material, if it has a large volume, it can push enough fluid out of the way to create a buoyant force strong enough to support its weight. The shape and design of an object can help it increase its volume without making it too heavy, which lowers its overall density. For example, steel is normally denser than water, so a solid steel block would sink. However, a steel ship has a big hull that holds a lot of air, which increases its volume without adding much weight. This makes the ship's overall density less than that of water, allowing it to float. An object will float in a fluid if its density is less than the density of the fluid. Conversely, it will sink if its density exceeds that of the fluid. When an object is placed in a fluid, it displaces a fluid volume. If the object is less dense than the fluid, the weight of the displaced fluid is greater than the object's weight, resulting in a net upward buoyant force that causes the object to float. If the object is denser, the weight of the object is greater than the buoyant force, and it sinks.

Questions: Write down your answers in your notebook.

1. What two forces are acting on the boat when it is floating in water, and how do they interact?
2. How does the weight of the displaced water contribute to the buoyant force that keeps the boat afloat?
3. What does the law of flotation state about the relationship between the weight of the boat and the upthrust?

The two forces acting on the boat are the weight of the boat, which acts downward due to gravity, and the upthrust (buoyant force), which is the weight of the displaced water acting upward. These forces interact such that when the upthrust equals the weight of the boat, the boat remains floating in equilibrium. The weight of the displaced water creates upthrust, or buoyant force. When the boat is placed in water, it pushes some water out of the way (displaces it). The weight of the water that is displaced acts upward against the boat, and if this upward force (upthrust) is equal to the weight of the boat, the boat will float. The law of flotation states that a floating object will remain buoyant and stable on a fluid's surface as long as the upthrust (the weight of the displaced fluid) equals the weight of the object. When these two forces are in balance, the object floats.

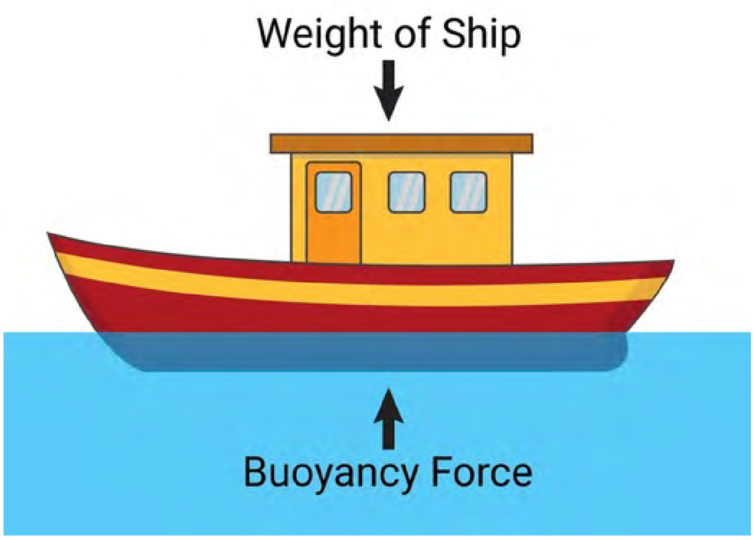


Figure 5.5: A floating object

Worked Examples

Calculating weight and upthrust

1. Calculate weight:

   Formula: Weight (N) = Mass (kg) × Gravitational Field Strength (N/kg)

   Given mass = 2 kg, and g = 9.81 N/kg

   Weight = 2 kg × 9.81 N/kg = **19.62 N**

2. Determining Volume of Water Displaced:

   If the block is fully submerged (then volume of displaced water = volume of object) and measures 0.5 m (length) × 0.2 m (width) × 0.1 m (height):
   Volume = Length × Width × Height = 0.5 m x 0.2 m × 0.1 m = **0.01 m^3**

3. Calculating mass of displaced Water:

   Density of water = 1000 kg/m^3

   Mass of displaced water = Volume × Density

   $= 0.01\ m^3 \times 1000\ kg/m^3$

   $= 10\ kg$

4. Finding upthrust:

   Weight of displaced water = mass of displaced water × acceleration due to gravity (g)

   Weight = 10 kg × 9.81 N/kg = **98.1 N**

   Since the weight of the block (19.62 N) is less than the upthrust (98.1 N), it will float.

Comparing Densities

You have two blocks: one made of metal (mass = 3 kg) and another made of plastic (mass = 1 kg).

Steps to Compare Densities:

Calculate the volume of each block:

Metal block: Measures 0.3 m × 0.2 m × 0.1 m

Volume = 0.3 m × 0.2 m × 0.1 m

$= 0.006\ m^3$

Plastic block: Measures 0.2 m × 0.2 m × 0.05 m

Volume = 0.2 m × 0.2 m × 0.05 m

$= 0.002\ m^3$

Calculate Density of each block:

Metal: Density $= \frac{Mass}{Volume}$

$= \frac{3}{0.006}$

$= 500\ kg/m^3$

Plastic: Density $= \frac{Mass}{Volume}$

$= \frac{1}{.002}$

$= 500\ kg/m^3$

Questions: Write down your answers in your notebook.

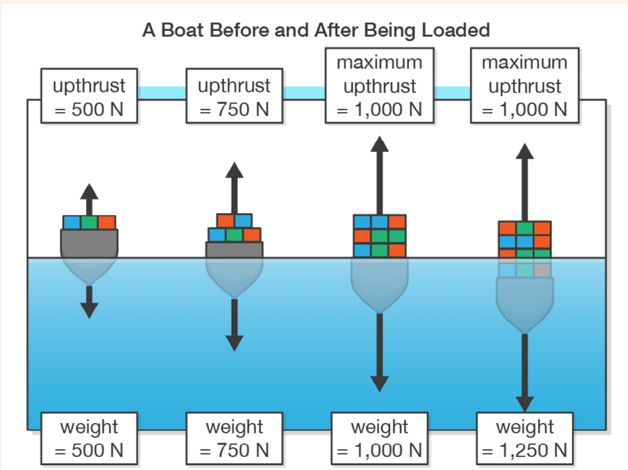
Let us briefly revise some of the concepts we have learnt so far. Below are some multiple-choice questions focusing on the relationship between upthrust and the law of flotation. These questions can help check your comprehension of upthrust and the law of flotation. Circle the correct answer as you read.

1. What is density?
   - **A.** The amount of mass in a given volume
   - **B.** The force that keeps objects afloat
   - **C.** The total volume of an object
   - **D.** The weight of an object

2. Which formula is used to calculate the weight of an object?
   - **A.** Weight $= \frac{\text{Mass}}{\text{Volume}}$
   - **B.** Weight $=$ Mass $\times$ Density
   - **C.** Weight $=$ Mass $\times$ Gravitational Field Strength
   - **D.** Weight $=$ Volume $\times$ Density

3. An object will float in a fluid if its density is:
   - **A.** Greater than the fluid's density.
   - **B.** Equal to the fluid's density.
   - **C.** Less than the fluid's density.
   - **D.** Always heavier than the fluid.

4. What happens to a boat that is gradually filled with cargo, as shown in Fig 5 below, in terms of its position in the water before and after being loaded?



   - **A.** Finally, if too much cargo is added, the boat may sink completely.
   - **B.** The boat will capsize if its weight exceeds the buoyant force.

C. The boat will displace more water as it fills with cargo.
D. The boat will sink lower in the water as it gains weight.

5. Which of the following statements about buoyancy is true?
   A. Buoyancy depends on the volume of fluid displaced.
   B. Buoyancy is always greater than weight.
   C. Buoyancy is the same as mass.
   D. Buoyancy only applies to solid objects.

6. If you have a block of wood and a block of metal, both with the same volume, which statement is true?
   A. Both blocks have the same density.
   B. The metal block is denser than the wood block.
   C. The wood block has a higher density than the metal block.
   D. The wood block is heavier than the metal block.

7. What does the law of flotation state?
   A. All fluids have the same density.
   B. All objects will sink.
   C. An object will float if it is heavy.
   D. An object will float when the weight of the water displaced equals its weight.

Read the scenario below and use it to answer question 8 and 9

Emmanuel has a small toy boat made of plastic that she wants to test in her pool. The boat has a mass of 0.3 kg and dimensions of 30 cm long, 10 cm wide, and 5 cm tall. Emma places the boat in the water and observes how it floats. As the boat is placed in the pool, it displaces a certain volume of water, and Emma wonders how upthrust affects whether the boat will sink or float.

8. What is the main reason the toy boat floats in the pool?
   A. The boat is heavier than the water it displaces.
   B. The boat is made of plastic, which cannot sink.
   C. The pool is shallow, preventing the boat from sinking.
   D. The upthrust (buoyant force) acting on the boat is equal to its weight.

9. If Emma adds a weight of 0.2 kg to the boat, what will likely happen to the boat when it is placed back in the water?
   A. The boat will float higher in the water.

B. The boat will remain at the same level in the water.

C. The buoyant force will increase, making the boat float better.

D. The upthrust will decrease, causing the boat to sink.

Activity 5.5 Application of The Law of Flotation in Real Life

Observe ***Figure 5.6*** below and write your answers in your notebook as you read the questions following it:

Figure 5.6: Canoe

Write your answer in your notebook and share with your peers.

1. How do canoes utilize flotation to remain on the surface? What adjustments can help maintain buoyancy
2. What impact does the canoe's design have on its flotation and efficiency?
3. How does the canoe's density compare to water when floating? What conditions must be satisfied for it to float?
4. Which design features enhance a canoe's stability in the water?
5. How does weight distribution within a canoe influence its flotation? What measures can ensure stability?
6. How do the materials used in constructing a canoe affect its buoyancy?

Canoes: stay afloat by using the principle of flotation, which requires them to maintain buoyancy. To achieve this, it's important to load items properly and distribute the weight evenly inside the canoe. The shape and design of a canoe are essential for its buoyancy and efficiency. A wide, stable hull helps distribute the weight and keeps the canoe from sinking, while a streamlined shape allows it to move more easily through the water. For a canoe to float, its density must be lower than that of the water. It will remain on the surface for as long as the total weight of the canoe and its contents is equal to the weight of the water it displaces. Key design features that enhance stability include a wide, flat bottom and a shape that evenly distributes weight to prevent tipping. When a canoe is loaded with gear and passengers, it displaces more water because its overall weight increases. For the canoe to stay afloat, the weight of the displaced water must match the combined weight of the canoe and its cargo. The materials used to build a canoe, such as wood, fiberglass, or aluminium, also affect its buoyancy. Lighter materials improve flotation, while heavier materials need careful design to maintain buoyancy.

Many other devices also rely on the law of flotation in real life. ***Table 5.1*** lists some examples and ***Figures 5.7 to 5.9*** provide diagrams.

Table 5.1: Some Water and Air Vessels That Depend on The Law of Floatation

Device	Link to flotation	How it floats
Ships and boat	The design and building of ships and boats rest on the law of flotation to keep them buoyant and even in water.	Ships float due to Archimedes' principle. When a ship enters the water, it pushes down and displaces water, creating an upward force called upthrust. Despite being made of heavy steel, ships have wide bottoms and air-filled compartments that help them displace their own weight of water to stay afloat.
Submarines	Ballast tanks regulate buoyancy by changing their water volume.	Submarines utilise Archimedes' principle to control their depth in water. They have ballast tanks on each side that can fill or empty to change how much water they displace. To sink, a submarine fills its ballast tanks with water, increasing its density, while to rise, it expels water from these tanks to become less dense and float.

Device	Link to flotation	How it floats
Hot air balloons	Hot-air balloons and airships are commonly used in air conveyance, working based on the principles of buoyancy.	A hot air balloon has three key parts: the burner, the balloon, and the basket, with the burner heating propane gas to warm the air inside the balloon. As the air expands and becomes less dense than the surrounding air, the balloon rises, while the pilot can lower it by opening a parachute valve to let cooler air in or by reducing the fuel burned to cool the air inside.

Figure 5.7: Ghana Navy- ship

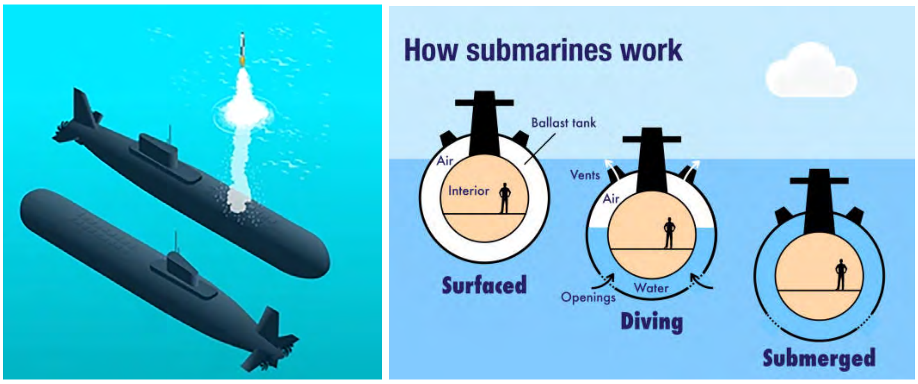


Figure 5.8: Submarine Sinking and Rising

Figure 5.9: Hot Air Balloon Floating in Air

EXTENDED READING

1. Phet Interactive Simulations - Density & Buoyancy - Offers interactive simulations that allow students to visualize concepts related to density and buoyancy.
2. The Science Book: Big Ideas Simply Explained" (DK Publishing)
3. YouTube - Ted-Ed: Search for videos like "How Do Boats Float?" which explain the principles of buoyancy and density in a fun and engaging way.

REVIEW QUESTIONS

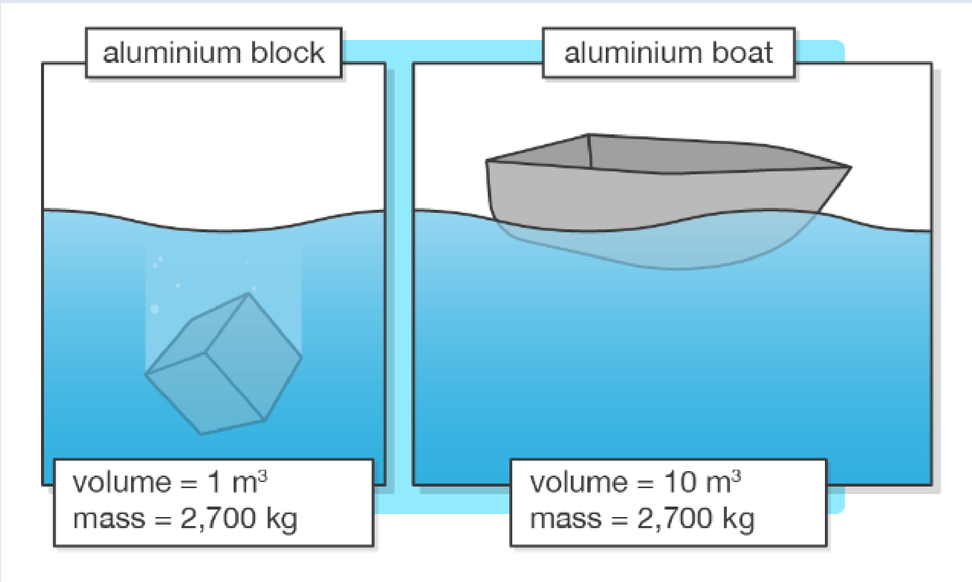
1. The volume of a small ball is calculated to be $25cm^3$ and it weighs 30g in water. Will this ball sink or float in water. Show calculation.
2. Three identical sized blocks of lead, aluminium and zinc are submerged in water. Given that at room temperature:

   Density of aluminium = $2.7g/cm^3$

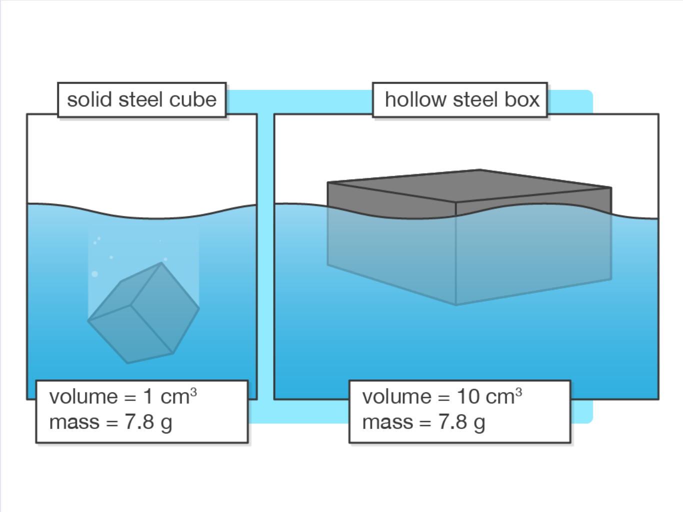
   Density of lead = $11.29g/cm^3$

   Density of Zinc = $7.13g/cm^3$

   How would you compare the buoyant force on lead block, buoyant force on aluminium and buoyant force on zinc block?
3. Write down three examples of devices that use the law of flotation in real life
4. What is the function of ballast tanks in a submarine? How does changing water levels affect buoyancy?
5. How do the materials used in boat construction affect buoyancy?
6. A block of aluminium is placed into water and sinks. A second block of aluminium with the same mass is moulded into a boat, placed into water and floats. Explain why the block sinks while the boat floats.



7. A cube of steel and a hollow steel box have the same mass and are both immersed in water. Sort the statements into an explanation of why the cube sinks but the box floats.



8. In what way is upthrust different from flotation?

9. Create a brief presentation on three key factors to consider when designing a fishing canoe to ensure safety, stability, and functionality on the water.

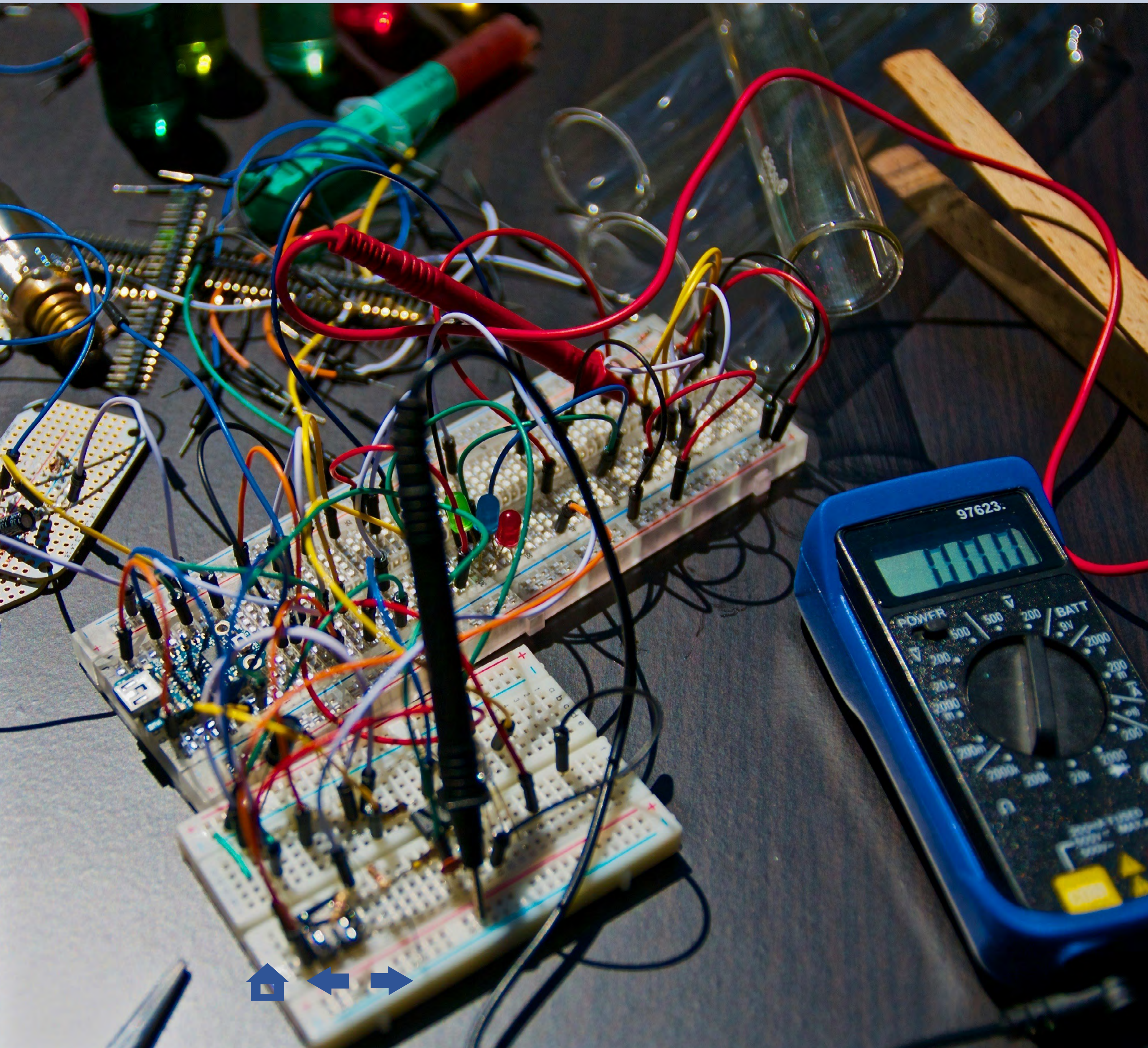
10. An object floats if it has a lower density than the fluid it's placed into. Name two materials in the table that will float in water.

Densities of some substances

Substance	Density (kg/m3)
Cardboard	700
Wood	850
Water	1000
Aluminium	2,700
Lead	11,300
Gold	19,300

Section

6 ELECTRONICS



VIGOUR BEHIND LIFE

Consumer Electronics

INTRODUCTION

Designing a simple phone charger is a great way to learn about electronics. It helps you understand how important components, like LEDs (small lights) and diodes, work to control the flow of electricity. These parts make sure the charger delivers power efficiently to the phone. You will also learn about a concept called "doping" in materials called semiconductors. Doping means adding tiny amounts of other materials to improve how electricity flows through them. This process is used to create important parts of electronics, like diodes and transistors, which are found in almost every gadget we use. By studying this, you will see how small changes at the basic level of electronics can lead to big improvements in technology.

KEY IDEAS

- Conductors allow electricity (e.g., Copper), insulators prevent it (e.g., Rubber), and semiconductors can do both.
- Doping is when we mix tiny amounts of other materials into a semiconductor to make it better at carrying electricity.
- n-type doping adds extra negative charges (electrons), while p-type doping creates "holes" that act like positive charges to help electricity flow.
- Doping increases conductivity and enhances the performance of semiconductor devices.
- Electronic components for building phone charger include voltage regulator, capacitors, diodes, resistors, USB connectors etc.
- Safety precautions in building phones include proper handling of soldering irons, working in a well-ventilated area.

PRINCIPLE OF DOPING BEHAVIOUR ABOUT SEMICONDUCTORS

Activity 6.1 Explaining Conductors, Insulators, And Semiconductors.

What you need: battery (9V or smaller), LED (light-emitting diode), wires with alligator clips, small bulb or buzzer and different materials to test: Copper wire, Aluminium foil, rubber band, plastic ruler, glass piece, and silicon chip (if available).

What to do:

1. Set up the circuit:
   a. Connect the battery, LED, and wires to form a simple circuit.
   b. Leave a small gap in the circuit where you can test the materials.
2. Test conductors:
   a. Place a Copper wire in the gap and observe the LED or bulb.
   b. The LED will light up because the Copper wire allows electricity to flow easily.
   c. Repeat with Aluminium foil and write down the result.
3. Test insulators:
   a. Replace the conductor with a rubber band, plastic ruler, or glass piece.
   b. Observe that the LED does not light up because these materials block electricity.
4. Test a semiconductor:
   a. If a small Silicon chip or similar semiconductor is available, test it in the gap.
   b. The LED might light up faintly or under certain conditions (e.g., heating the chip slightly), showing that semiconductors allow some electricity to flow under specific conditions.

Questions: Write down your answers in your notebook

1. What are the differences between conductors, insulators, and semiconductors?
2. Why are electrical cables covered with rubber?

3. Why did the LED light up with conductors?
4. Why didn't the LED light up with insulators?
5. How did the semiconductor behave differently?

What are Solid Materials?

Solid materials can be grouped into three types: conductors, insulators, and semiconductors based on how well they allow electricity flow through them.

Conductors

Conductors allow electricity to flow very easily. This is because they have many free electrons (tiny particles that carry electricity) moving around.

Examples: Metals such as Copper, Aluminium, and Silver are excellent conductors because their atomic structure has "loose" electrons that move freely, creating a "sea of electrons."

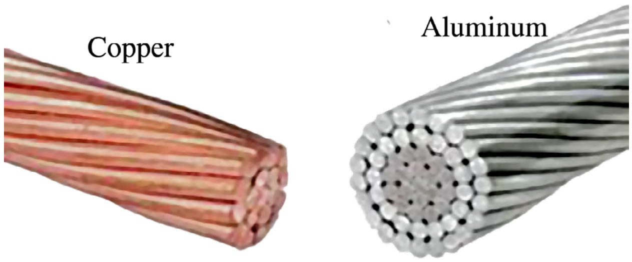


Figure 6.1: Conductors

Insulators

Insulators prevent the flow of electricity. This is because their electrons are tightly held by their atoms, so they cannot move freely to carry electricity.

Examples: Materials such as rubber, glass, and ceramics are insulators because they have a very high resistance to electricity.

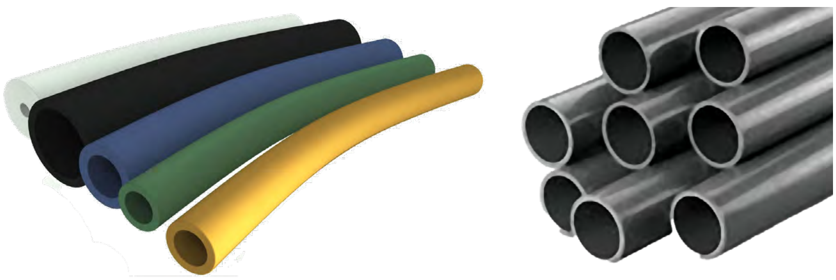


Figure 6.2: Insulators – Rubber tubing

Semiconductors

Semiconductors can behave like both conductors and insulators, depending on the situation. They only conduct electricity under certain conditions, like when they are heated, exposed to light, or when special materials (impurities) are added to them.

Semiconductors have a special atomic structure that makes them perfect for controlling electricity in electronic devices. Scientists can change how semiconductors behave by "doping" them, which means adding tiny amounts of other materials to make them better at carrying electricity.

Examples: The most common semiconductor is Silicon (used in computer chips).

Other examples include Germanium and Gallium Arsenide.

Doping

Doping is when we add small amounts of other materials (impurities) into a pure semiconductor to change how it conducts electricity.

This process is important because it allows us to control the behaviour of semiconductors, which are used in many electronic devices like phones and computers.

Doping improves the performance of semiconductor devices and helps control how they work in electronics, making them more efficient and responsive.

Types of Doping

N-type Doping

We add a material with more electrons than the semiconductor (e.g., Phosphorus with five electrons, added to Silicon with 4 electrons). This creates extra free electrons, which help electricity flow easily.

The material becomes negatively charged (n-type) because of the extra electrons.

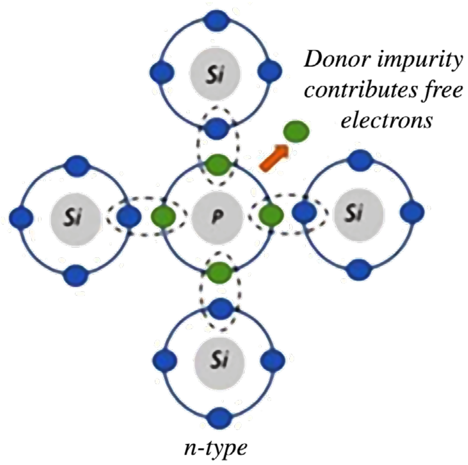


Figure 6.3: N-type doping

P-type doping

We add a material with fewer electrons than the semiconductor (e.g., Boron with three electrons, added to Silicon). This creates "holes" or spaces where electrons are missing, which act like positive charges.

The material becomes positively charged (p-type) because of the holes.

Holes are not really carrying electricity. It just looks like they are because electrons move and leave empty spaces behind.

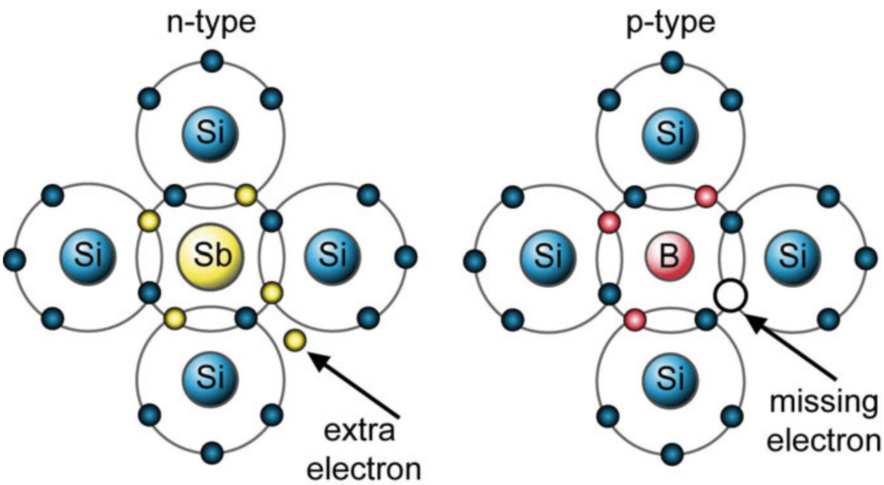


Figure 6.4: P-type doping

Effects of Doping

1. Doping changes how well semiconductors can carry electricity.
2. In n-type semiconductors, adding electrons makes it easier for electricity to flow.
3. In p-type semiconductors, creating holes also makes electricity flow, but the holes act like positive charge carriers.

Activity 6.2 Exploring Doping and its Effects on Electrical Conductivity

What you need:

- 9V battery
- LED (light-emitting diode)
- Wires with alligator clips
- Small pieces of conductive material (e.g., copper wire, aluminium foil)
- Non-conductive materials (e.g., rubber, plastic)

- Small pieces of n-type and p-type materials (represented by simple objects like coloured paper or cardboard with labels)
- Multimeter (optional, for measuring voltage)

What to do:

1. Prepare the circuit:

a. Set up a basic circuit with the LED and the 9V battery using the alligator clips and wires.

b. Ensure the LED lights up, confirming that electricity is flowing through the circuit.

2. Simulate n-type doping:

a. Open the circuit by disconnecting one of the wires connecting the LED to the battery.

b. Place the piece of copper wire or aluminium foil where the circuit was opened, bridging the gap.

c. Use the alligator clips to secure the foil or wire firmly in place.

d. Once the copper or foil is connected, close the circuit again and observe the LED.

e. Observe that the LED shines brightly because the extra electrons help the current flow easily.

f. Open the circuit by disconnecting one of the wires.

g. Place the piece of plastic (or any insulating material) in the gap where the circuit was opened.

h. Secure the plastic in place using the alligator clips, even though it doesn't conduct electricity.

i. Close the circuit and observe what to the LED.

j. This simulates the behaviour of p-type material, where conductivity depends on "holes" rather than free electrons.

3. Test Conductivity: Use a multimeter, measure the voltage across the circuit while using n-type and p-type materials to see how the conductivity changes.

Questions: Write your answers in notebook and discuss it with your group members

1. What happens when you use a conductive material such as copper wire in the circuit?
2. What happens when you use a non-conductive material, for example rubber or plastic?
3. Why is doping important in semiconductors?
4. Which type of doping (n-type or p-type) made the LED brighter?

Formation of a p-n Junction

A p-type material (which has "holes" or spaces where electrons are missing) is joined with an n-type material (which has extra electrons). At the point where these two materials meet, electrons from the n-type side move to fill the holes on the p-type side.

This movement creates a special area called the depletion region, where there are no free electrons or holes. The depletion region also creates an electric field that acts like a barrier to stop further movement of charges.

How it works with voltage

The behaviour of the diode changes depending on how we connect the voltage.

1. Forward Bias (Letting electricity flow): If we connect the positive end of a battery to the p-type side and the negative end to the n-type side, the electric field barrier gets smaller. This allows electrons to cross the junction and create a current. The diode is now conducting electricity and works like an open gate.

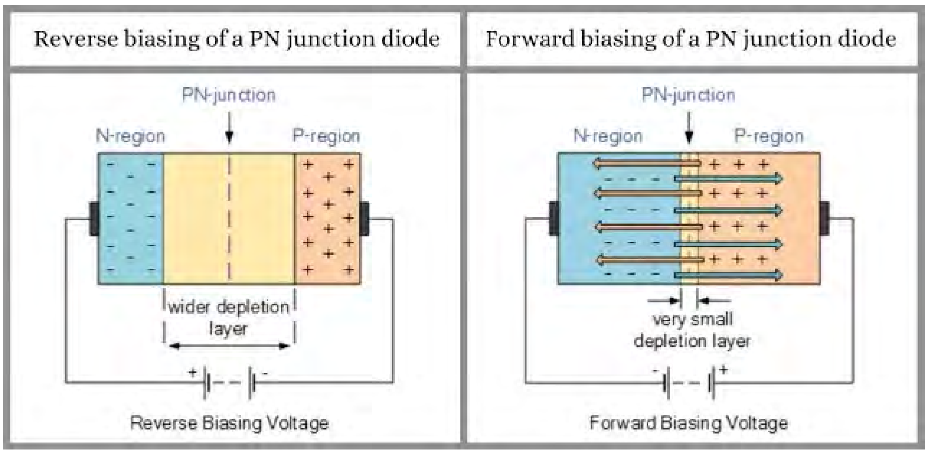


Figure 6.5: Forward biasing a p-n junction diode

2. Reverse bias (stopping electricity flow): If we reverse the connection (positive to the n-type and negative to the p-type), the electric field barrier gets bigger. No electrons can cross, so the diode blocks electricity like a closed gate. The diode is now an insulator.

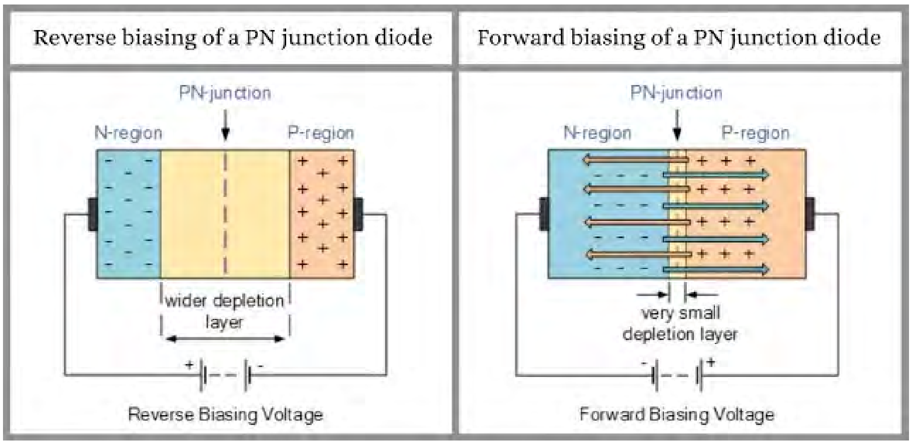


Figure 6.6: Reverse biasing a p-n junction diode

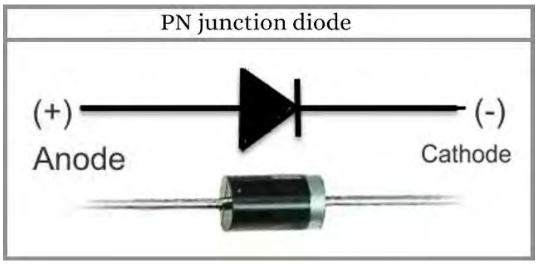


Figure 6.7: p-n junction diode

Activity 6.3 P-N Junction

What you need:

- A small breadboard, p-n junction diode
- A 9V battery or low-voltage DC power supply
- A resistor (e.g., 330 ohms), LED (light-emitting diode)
- Connecting wires and multimeter (optional, for measuring current/ voltage)

What to do:

1. Set up the circuit

a. Connect the p-n junction diode in series with the resistor and the LED on the breadboard.

- **b.** Ensure the diode is oriented correctly.
- **c.** The anode (positive side) should face the LED.
- **d.** The cathode (negative side) should face the resistor.
- **e.** Connect the circuit to the 9V battery.

2. Test forward bias:
   - **a.** Connect the positive terminal of the battery to the p-type side (anode) and the negative terminal to the n-type side (cathode).
   - **b.** Observe the LED. It should light up, showing that the current is flowing.

3. Test reverse bias:
   - **a.** Reverse the battery connections (positive to the n-type side and negative to the p-type side).
   - **b.** Observe the LED. It should not light up, showing that the current is blocked.

4. Optional Measurement: Use a multimeter to measure current in forward and reverse bias conditions to see the difference.

Reflect on the following questions and share your answers with your peers or family:

1. **a.** What might happen to a circuit if a diode is placed the wrong way around?

b. How would adding a larger resistor to the circuit affect the LED's brightness?

2. If the LED does not light up in forward bias, what steps would you take to troubleshoot the circuit?

3. What could happen if we try to apply too much voltage across the diode in reverse bias?

4. Why is the diode considered an important building block of modern electronics?

5. How does this activity help you understand the working of electronic devices?

Applications of P-N Junction Diodes in Consumer Electronics

1. Rectifiers: Diodes are used in devices like phone chargers and adapters to change AC (alternating current) from wall outlets into DC (direct current), which is needed to power gadgets like phones and laptops. — See ***Figure 6.8***.

Figure 6.8: Laptop and Phones

2. Switching devices: In digital electronics, diodes act like small switches that turn on or off to control the flow of electricity, helping devices like computers and TVs work efficiently.

Figure 6.9: Television

3. Light-Emitting Diodes (LEDs): LEDs are special types of diodes. When electricity flows through them, light is produced at the p-n junction. This is why LEDs are used in devices like lights, TV screens, and car headlights.
4. Photodetectors: Diodes can also sense light and turn it into electricity. This is how devices like cameras, solar panels, and automatic lights work by detecting and using light.
5. Voltage regulation
6. Overvoltage protection

Questions

Here are multiple choice questions on N-Type Doping, P-Type doping, semiconductors, insulators, and conductors to help you assess your understanding of the concepts.

Circle the correct answer.

1. What is the main purpose of doping a semiconductor?
- **A.** To change its colour
- **B.** To decrease its temperature
- **C.** To increase its electrical conductivity
- **D.** To make it a better insulator

2. Which type of doping involves adding elements that have fewer valence electrons than the semiconductor?
- **A.** Both N-type and P-type doping
- **B.** No doping at all
- **C.** N-type doping
- **D.** P-type doping

3. What is a characteristic property of insulators?
- **A.** They allow electricity to flow easily.
- **B.** They are always made of metals.
- **C.** They can be used to conduct heat.
- **D.** They have high resistance to electric current.

4. In an N-type semiconductor, which type of charge carriers are primarily responsible for conduction?
- **A.** Electrons
- **B.** Holes
- **C.** Neutrons
- **D.** Protons

5. Which material is typically considered a good conductor of electricity?
- **A.** Copper
- **B.** Glass
- **C.** Rubber
- **D.** Wood

6. What type of semiconductor is formed when doped with Boron?

A. Both

B. Neither

C. n-type

D. p-type

EXPERIMENTING WITH LED AND DIODE CIRCUITS TO BUILD PHONE CHARGERS

See ***Table 6.1*** for electronic components for building phone chargers

Table 6.1: Electronic components for building phone chargers

Components	Function
Diodes	Diodes allow electricity to flow in only one direction. They prevent electricity from flowing backward, which could damage the circuit.
Light-emitting Diodes (LEDs)	LEDs are special diodes that light up when current passes through them. They are often used to show the status of a device (e.g., whether it's powered on, charging, or fully charged). When choosing an LED, you consider things like its brightness, colour, and how much power it can handle.
Resistors	Resistors control the flow of electricity. They reduce or limit the amount of current passing through a circuit, helping protect other components from damage. **Note:** You select a resistor based on how much resistance is needed for the circuit and how much power it can handle without overheating.
Capacitors	Capacitors store electrical energy and release it when needed. They help smooth out fluctuations in voltage, making the power supply more stable.
Inductors	Inductors store energy in a magnetic field and are used in certain devices like DC-DC converters to change (step up or step down) the voltage.

Components	Function
Transformers	Transformers are used to change the voltage of alternating current (AC) from a high voltage (like from the wall outlet) to a lower, safer voltage that can be used by electronic devices like phone chargers. The transformer's size and power depend on how much voltage it needs to change.
Voltage regulators	Voltage regulators make sure that the voltage output remains stable, even if the voltage from the power source changes. This ensures that your device receives the correct voltage to function properly, no matter what happens with the input power.
USB Connectors	USB connectors are the plugs and ports that allow devices like chargers to connect to phones, computers, and other gadgets
Breadboard	A breadboard is a tool used to build and test circuits without needing to solder (permanently attach) the components. You can quickly place components like resistors, capacitors, and wires on a breadboard to make and test different electronic circuits. It's like a "testing ground" for circuits before making them permanent.

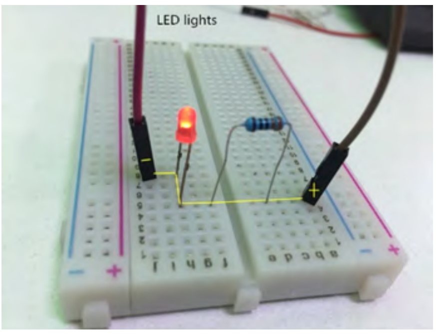


Figure 6.10: Breadboard circuit diagram

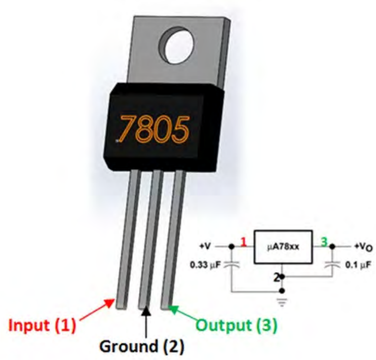


Figure 6.11: Voltage Regulator

Steps Involved in Building a Phone Charger

Activity 6.4 Building Phoner Charger

Here is a simplified explanation of how to design and build a homemade charger circuit.

1. Design the circuit layout

a. Plan how everything fits together. Think of it like drawing a map of where each part goes.

b. You need to decide where to put the voltage regulator, capacitors, diodes, and connectors.

2. Gather the components:

a. Get all the pieces you need to build your circuit. Here's a list of the components:

i. Voltage Regulator

ii. Capacitors

iii. Diodes

iv. USB Connector

v. Resistor.

vi. LED (Light-emitting Diode

vii. Wires

3. Assemble the circuit

a. Connect the Voltage Regulator: This is the part that makes sure the voltage is just right for your phone. First, connect the input of the voltage regulator to the DC power source (like a battery or wall adapter).

b. Add capacitors:

i. The first capacitor (0.33 µF) should be connected across the input terminals. It helps to reduce noise (unwanted signals).

ii. The second capacitor (0.1 µF) should be connected across the output terminals to help stabilize the output.

c. Connect the Output to the USB Connector: The output from the voltage regulator goes to the VCC pin on the USB connector. This is the part where your phone will connect to get power.

4. Rectification (if using AC): If you are using AC (alternating current) from a wall outlet, you need to convert it to DC (direct current) using rectifier diodes. This step turns the electricity into the kind that your phone can use.

Diodes only let electricity flow in one direction, so they act like a one-way valve for electricity.

5. LED indicators

a. LED with a Resistor: You need to show if your charger is working, so add an LED light. This will light up when the charger is on.

b. Current-limiting resistor: This part is needed to make sure the LED does not burn out from too much electricity.

6. Connections: Make sure all the ground connections (the negative sides of the components) are connected together. This is like making sure all the parts of the circuit share the same "common ground" so they can work together.

7. Test the Circuit

a. Before making everything permanent, test your circuit on a breadboard. This is like a temporary setup that you can use to see if everything works.

b. Use a multimeter to measure the output voltage. Make sure it matches the voltage your phone needs (usually 5V for charging).

8. Finalise and solder the circuit

a. If everything works during testing, it's time to solder the parts onto a printed circuit board (PCB). This will hold all the components in place permanently.

b. Make sure the connections are secure and that no wires are touching where they shouldn't (to avoid short circuits).

9. Enclosure: Finally, place the finished circuit inside a suitable enclosure. This is like a case that protects your circuit from damage. Make sure there are holes for the USB connectors and the power input.

Important Note

- Never use a homemade charger to charge personal or work devices, because it could break your device or void its warranty.
- Make sure your workspace is clean, so you can easily find parts and tools. Keep it dry to avoid electrical shocks, and make sure you have enough light to see what you're doing.

Reflect on the following question and share your answers with your peers:

a. Explain why the charger is enclosed by an insulator not a conductor.

b. What are the electronic components needed to build a phone charger and their function?

c. What safety precautions need to be followed when building a phone charger?

Safety Precautions

1. Always use a surface that does not conduct electricity, like an anti-static mat, to prevent accidents.
2. Avoid Touching components with bare Hands:
3. Use tools that are insulated, meaning their handles are covered with non-conductive material. This helps prevent electrical shorts (where electricity flows where it should not).
4. Soldering irons get very hot, so always use them with care.
5. Work in a well-ventilated area, and make sure the iron is in good condition.
6. Don't breathe in the smoke from the soldering process, as it can be harmful.
7. Always disconnect the power before you make any changes to the circuit. This will prevent accidental shocks or damage to the circuit.
8. Before powering on your circuit, double-check all connections to make sure there are no shorts (where wires or components accidentally touch and cause a malfunction).
9. Use a multimeter to test that everything is connected correctly, and that electricity is flowing in the right direction.

10. Some parts, like the voltage regulator, can get hot. Use heat sinks to prevent them from getting too hot and damaging other parts.

11. Make sure sensitive components (like capacitors) are not too close to heat sources (like soldering irons) to avoid damaging them.

12. Add fuses for protection

13. When you first test your circuit, use a low power supply to make sure everything is working. If there are any problems, it will be safer to fix them with lower power.

14. Once you're sure the circuit is stable, you can gradually increase the power to the full level to avoid damaging any parts.

15. Once your circuit is working, place it in a protective casing (like a plastic box). This will protect the circuit from dust, damage, and prevent accidental electric shocks.

REVIEW QUESTIONS

1. Explain the following terms with two examples each:
   a. conductors
   b. insulators
   c. semiconductors
   2. Describe how a diode works in a simple circuit.
3. Why is it important for a diode to control the flow of current in one direction?
4. Explain how does it protect your circuit from damage.
5. Identify four electronic components for building phone charger.
6. Explain four safety precautions in building phone charger.

Section

7 PATHOGENIC DISEASES

RELATIONSHIPS WITH THE ENVIRONMENT

The Human Body and Health

INTRODUCTION

Healthy organisms work best when their physical and chemical processes function together smoothly. However, some organisms, known as pathogens, can cause illnesses. Pathogens include bacteria, viruses, fungi, and parasites. They enter our bodies, grow, and disturb normal functions, leading to various health issues and symptoms. Some diseases caused by these pathogens can spread from one person to another, making them infectious. To Recognise and fight disease you need to understand pathogen related diseases. This will help you keep yourself and others safe and healthy. In this section, we will explore common diseases in your community, how they affect different groups of people, their early signs and symptoms, practical prevention strategies, like practicing good hygiene, getting vaccinated, and using public health services, to help protect ourselves and others from illness.

KEY IDEAS

- Scientists study how diseases spread, affect people, and how to stop them. This is called epidemiology. This helps create public health plans to protect communities.
- Pathogen is a microorganism that is able to cause disease in a plant, animal, insect, water, etc.
- Tuberculosis is caused by the bacterium Mycobacterium tuberculosis, which spreads through the air when a person with active TB coughs, talks, or sneezes without covering the mouth.
- Cholera is caused by the bacterium Vibrio cholerae, often transmitted through contact with the bacterium in contaminated water or food.
- Typhoid fever is a life-threatening bacterial infection caused by Salmonella typhi bacteria which is mostly transmitted through contaminated food or water and widespread in areas with poor sanitation and hygiene practices.

- Identification of pathogenic fungi assists in the identification of over 100 of the most significant organisms of medical importance.

PATHOGENIC DISEASES

A healthy person is one where all the body's processes work together properly. However, some organisms such as bacteria, viruses, fungi, or parasites, can survive and even grow inside people or animals, disturbing the body processes from functioning well. These organisms are called pathogens, and when they cause an infection, they are called infectious agents. Pathogens can cause different diseases, and each type of pathogen is responsible for specific types of illnesses. For example, bacteria may cause an infection like strep throat, while viruses can cause a cold or the flu.

Activity 7.1 Identification of Pathogenic Diseases

***What you need*:** chart paper or A4 sheets and markers or pens

What to do:

1. Brainstorm and discuss what is meant by pathogenic diseases.
2. Write down examples of common diseases you know.
3. For each disease, create a poster on the type of pathogen that causes it, how it is transmitted and the importance of hygiene in preventing infections
4. Present your poster to friends or family members for discussion.

Questions: Write the answers in your notebook and share with your group members.

1. How do pathogens enter our body?
2. How do we prevent pathogens from entering a cell.

A disease is any condition that affects the proper functioning of the body and the state of mind. Some diseases are mild, like a sore throat or stomach upset, while others can be very serious, such as cancer. Diseases can impact different parts of the body and can be caused by several factors, including:

- Infections: These occur when pathogens like bacteria, viruses, fungi, or parasites invade the body.

- Genetic Factors: Some diseases are inherited from parents through genes, which can affect how the body functions.
- Environmental Factors: Things like pollution, toxins, and unhealthy lifestyle choices such as a poor diet and not exercising, can contribute to diseases.
- Immune System Issues: If the immune system is weak or doesn't work properly, it can lead to various health problems.

A pathogenic disease is a type of illness specifically caused by a pathogen, which is an organism that can invade the body and disturb its normal functions. Pathogens include bacteria, viruses, fungi, and parasites that can cause infections in humans and other living things. These diseases can spread in different ways and affect health by disrupting how the body works. Unlike other diseases that can result from genetic problems, autoimmune conditions, or environmental factors, pathogenic diseases specifically involve agents that can cause infections. For example, diseases such as tuberculosis, Salmonella infection, strep throat, influenza (the flu), HIV/AIDS, COVID-19, athlete's foot, candidiasis (yeast infection), malaria, giardiasis, and hookworm infection are all caused by pathogens.

Pathogenic diseases can enter our bodies in different ways. ***Table 7.1*** provides descriptions of how this might happen.

Table 7.1: Characteristics of pathogenic diseases

Characteristics	Description
What causes them (Causative agent)	Pathogenic diseases are caused by microorganisms like bacteria, viruses, fungi, or parasites that can make people sick.
How they Spread (Transmission mode)	• Direct Contact: Through touching, hugging, or close physical contact. • Indirect Contact: By touching contaminated surfaces or objects. • Airborne: Through tiny droplets in the air when someone coughs or sneezes. • Through Insects bites: for example, mosquitoes spreading diseases (e.g., malaria). • Contaminated Food or Water: Eating or drinking unsafe food or water.

Characteristics	Description
What happens inside the body:	Pathogens enter the body, multiply, and sometimes harm tissues and organs. The damage depends on the type of pathogen and how the body fights it.
Time before symptoms appear (Incubation Period)	After exposure to a pathogen, it takes some time (called the incubation period) for symptoms to show. During this time, the pathogen spreads in the body.
Symptoms:	Pathogenic diseases can cause different symptoms, like fever, coughing, or more serious problems like organ damage or nerve issues, depending on the infection.
How the body fights back (Host Response)	The body's immune system works to destroy the pathogen, often causing swelling, redness, or other reactions. A strong immune response can help recover faster.
How easily they spread:	Some diseases spread quickly between people, while others do not. How contagious a disease is, depends on the pathogen and how it spreads.
How to prevent them:	• Vaccination: To protect against specific diseases. • Hygiene: Washing hands regularly and keeping things clean. • Safe food and water: Eating properly cooked food and drinking clean water. • Protect yourself: Using mosquito nets or wearing masks when needed.
How they are treated:	• Bacteria: Treated with antibiotics. • Viruses: Sometimes treated with antiviral medicine. • Fungi and parasites: Treated with special medicines. • Rest and fluids can also help during recovery.

Characteristics	Description
Studying diseases:	Scientists study how diseases spread, affect people, and how to stop them. This is called epidemiology and helps create public health plans to protect communities.

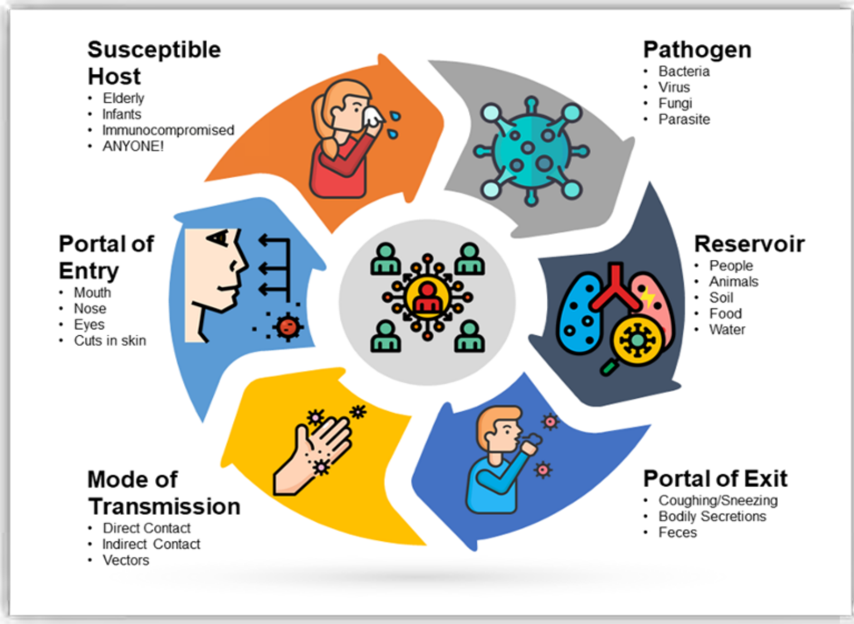


Figure 7.1: Mode of Transmission of Pathogens

Causes of Pathogenic Diseases

1. Bacteria: Tiny, single-celled organisms that can cause infections like strep throat and food poisoning. See ***Table 7.5***.
2. Viruses: Even smaller than bacteria, they take over living cells to reproduce, causing diseases like the flu or measles. See ***Table 7.4***.
3. Fungi: These include organisms like mould and yeasts, which can cause skin infections or athlete's foot.
4. Parasites: These live on or inside the body and take nutrients from their host, causing diseases like malaria.
5. Contact with animals: Some diseases, called zoonotic diseases, spread from animals to humans, like rabies.
6. Contaminated food and water: Eating or drinking food or water that has germs can lead to diseases like cholera or typhoid.

Symptoms of Pathogenic Diseases

Different pathogens, including bacteria, viruses, fungi, and parasites, cause pathogenic diseases. Each type of pathogen can cause a range of symptoms depending on the specific disease and the body systems affected. ***Table 7.2*** contains some common symptoms associated with each type of pathogenic disease.

Table 7.2: Types of infection and their symptoms

Type of infections	General symptoms
Bacterial infections	• Fever • Sore throat • Pain and swelling (e.g., in wounds or joints) • Stomach upset, for example diarrhoea
Viral infections	• Cough and runny nose (e.g., in colds or flu) • Tiredness or weakness • Rashes on the skin • Fever
Fungal infections	• Itchy skin or scalp. • Red or flaky patches on the skin • Pain or swelling around infected nails.
Parasitic infections	• Stomach cramps • Diarrhoea • Itchy skin (from bites or rashes) • Feeling weak or tired

Activity 7.2 Symptom sorting game

What you need:

- Cards with different symptoms written on them (e.g., “Fever,” “Itchy skin,” “Cough and runny nose”).
- Four labelled containers or spaces (one for each type of pathogen: bacteria, virus, fungi, parasite).

What to do:

1. Take a set of symptom cards.
2. Read the symptoms and identify which type of pathogen causes them.
3. Place your cards in the appropriate container/space (e.g., "Fever" under "Virus").
4. Share your answers with your friends and discuss why each symptom matches the specific pathogen.

Questions: Write your answers in your notepad

1. What differences did you notice between symptoms caused by parasites and those caused by fungi?
2. If you were a doctor and a patient came to you with cough, runny nose, and fever, what would you consider first as the possible cause? Why?

Preventing pathogenic diseases

This requires keeping clean, staying safe, and seeking medical help when needed. Some ways to stop infections caused by bacteria, viruses, fungi, and parasites — see ***Table 7.3***.

Table 7.3: Preventive Measures for Pathogenic Diseases

Strategy	Specific Measures
Hand hygiene	• Wash hands regularly with soap under running water. • Use hand sanitizer (with at least 60% alcohol) when soap is unavailable.
Avoid risky behaviours	• Use insect repellent and mosquito nets to avoid insect bites. • Avoid sharing personal items like toothbrushes and razors.
Respiratory hygiene	• Cover mouth and nose with a tissue or elbow when coughing or sneezing • Dispose of tissues properly and wash hands after use

Strategy	Specific Measures
Food safety	• Wash fruits and vegetables before eating. • Cook meat, poultry, and seafood thoroughly. • Use separate cutting boards for raw and cooked foods.
Vaccinations	• Get routine immunizations for diseases like measles and the flu. • Take travel-specific vaccines for diseases like yellow fever or typhoid
Clean environment	• Disinfect surfaces regularly, especially in kitchens and bathrooms. • Ensure clean water supply and proper waste disposal
Healthy lifestyle	• Maintain a balanced diet, regular exercise, and adequate sleep. • Stay hydrated and avoid unhealthy habits.

Table 7.4: Symptoms, causes, transmission, and prevention of common virial diseases

Disease	Causative Organism	Mode of Transmission	Symptoms	Prevention/ Cure
Influenza (Flu)	Influenza virus	Airborne (coughing, sneezing); direct or indirect contact	Fever, chills, cough, sore throat, body aches, fatigue	Vaccination, hand hygiene, avoid close contact with sick people
Hepatitis B	Hepatitis B virus	Blood, sexual contact, sharing needles	Jaundice, abdominal pain, fatigue, dark urine	Vaccination, safe sex, avoid sharing needles

Disease	Causative Organism	Mode of Transmission	Symptoms	Prevention/ Cure
Chickenpox	Varicella-zoster virus	Airborne droplets, direct contact with sores	Fever, itchy rash, fatigue	Vaccination, avoid close contact with infected individuals
Measles	Measles virus	Airborne droplets, direct contact	High fever, cough, runny nose, rash	Vaccination, isolation of infected individuals
Dengue Fever	Dengue virus	Mosquito bites (Aedes mosquito)	High fever, severe headache, joint pain, rash	Avoid mosquito bites, use insect repellents, eliminate mosquito breeding grounds
HIV/AIDS	Human Immunodeficiency Virus (HIV)	Blood, sexual contact, mother-to-child transmission	Fatigue, weight loss, recurrent infections	Safe sex, avoid sharing needles, proper screening of blood
COVID-19	SARS-CoV-2	Airborne droplets, surface contact	Fever, cough, difficulty breathing, fatigue, loss of taste/smell	Vaccination, mask-wearing, hand hygiene, social distancing
Polio	Poliovirus	Contaminated food and water, person-to-person contact	Fever, fatigue, muscle weakness, paralysis in severe cases	Vaccination, maintaining clean water and sanitation

Disease	Causative Organism	Mode of Transmission	Symptoms	Prevention/ Cure
Rabies	Rabies virus	Bite or scratch from infected animals	Fever, headache, muscle weakness, difficulty swallowing, paralysis	Vaccinate pets, avoid stray animals, seek immediate treatment after exposure

Table 7.5: Symptoms, causes, transmission, and prevention of common bacterial diseases

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
(TB)	*Mycobacterium tuberculosis*	Airborne droplets (coughing, sneezing)	Persistent cough, chest pain, fever, weight loss	Vaccination (BCG), avoid close contact with infected individuals, proper ventilation
Typhoid Fever	*Salmonella typhi*	Contaminated food and water	High fever, abdominal pain, diarrhoea or constipation, fatigue	Safe drinking water, proper sanitation, vaccination
Cholera	*Vibrio cholerae*	Contaminated food and water	Severe watery diarrhoea, dehydration, vomiting	Access to clean water, proper sanitation, hygiene practices

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Pneumonia	*Streptococcus pneumoniae*	Airborne droplets	Fever, chest pain, difficulty breathing, cough with phlegm	Vaccination, hand hygiene, avoiding close contact with infected individuals
Whooping Cough	*Bordetella pertussis*	Airborne droplets	Severe coughing fits, vomiting after cough, exhaustion	Vaccination (DTaP), practicing good hygiene
Leprosy	*Mycobacterium leprae*	Prolonged close contact with infected individuals	Skin lesions, numbness, muscle weakness	Early treatment, avoid prolonged contact with untreated patients
Plague	*Yersinia pestis*	Flea bites, contact with infected animals	Fever, swollen lymph nodes, chills, fatigue	Avoid flea bites, control rodent populations, early treatment
Meningitis	*Neisseria meningitidis*	Close contact, respiratory droplets	Stiff neck, fever, headache, nausea, sensitivity to light	Vaccination, avoid close contact with infected individuals

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Tetanus	*Clostridium tetani*	Wound infection by contaminated soil	Muscle stiffness, lockjaw, difficulty swallowing	Vaccination (DTaP or Tdap), proper wound care
Strep Throat	*Streptococcus pyogenes*	Airborne droplets, close contact	Sore throat, fever, swollen lymph nodes, difficulty swallowing	Hand hygiene, avoid sharing personal items, avoid close contact with infected individuals

Table 7.6: Protozoan diseases: symptoms, causes, transmission, prevention.

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Malaria	Plasmodium species (*P. falciparum, P. vivax*)	Bite of infected Anopheles mosquitoes	Fever, chills, sweating, headache, muscle pain, fatigue	Use insecticide-treated bed nets, antimalarial drugs, eliminate standing water, use insect repellents
Amoebiasis	*Entamoeba histolytica*	Contaminated food and water	Diarrhoea (sometimes with blood), abdominal pain, fever, fatigue	Drink safe water, proper sanitation, wash fruits and vegetables thoroughly

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Giardiasis	*Giardia lamblia*	Contaminated water or food, person-to-person contact	Diarrhoea, abdominal cramps, nausea, weight loss	Drink safe water, good hygiene practices, avoid contact with infected individuals
Leishmaniasis	*Leishmania species*	Bite of infected sandflies	Skin sores, fever, weight loss, swollen spleen or liver (visceral form)	Use insect repellents, wear protective clothing, sleep under treated nets
Sleeping Sickness	*Trypanosoma brucei*	Bite of infected tsetse flies	Fever, headache, joint pain, confusion, difficulty sleeping (late stage)	Avoid tsetse fly bites, use insect repellents, wear protective clothing
Toxoplasmosis	*Toxoplasma gondii*	Contact with infected cat faeces, undercooked meat	Mild flu-like symptoms, swollen lymph nodes, muscle aches (severe in immuno-compromised individuals)	Cook meat thoroughly, avoid contact with cat litter, wash hands after handling raw meat

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Cryptosporid-iosis	*Cryptosporid-ium species*	Contaminated water, close contact with infected individuals	Watery diarrhoea, stomach cramps, nausea, weight loss	Drink safe water, practice good hygiene, avoid swimming in contaminated pools
Trichomoni-asis	*Trichomonas vaginalis*	Sexual contact	Vaginal discharge, itching, discomfort during urination or intercourse	Practice safe sex, use condoms, seek early medical treatment.

Table 7.7: Symptoms, causes, transmission, and prevention of common helminthic worm diseases

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Ascariasis	*Ascaris lumbricoides* (roundworm)	Ingestion of eggs from contaminated food, water, or soil	Abdominal pain, nausea, weight loss, intestinal blockage, coughing (if larvae migrate to lungs)	Wash hands before eating, avoid contaminated food, use clean water, improve sanitation
Schistosomi-asis	Schistosoma species (blood fluke)	Contact with contaminated freshwater	Rash, fever, chills, muscle pain, abdominal pain, blood in urine or stool	Avoid swimming in contaminated water, use clean water, control snail populations

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Hookworm Infection	*Ancylostoma duodenale, Necator americanus*	Skin penetration by larvae in contaminated soil	Anaemia, fatigue, abdominal pain, itching at infection site, diarrhoea	Wear shoes in areas with contaminated soil, avoid walking barefoot, proper disposal of human waste
Tapeworm infection	Taenia species (e.g., *T. solium, T. saginata*)	Ingestion of undercooked or raw meat (beef or pork) containing larvae	Mild abdominal discomfort, weight loss, nausea, visible segments in stool	Cook meat thoroughly, inspect meat for cysts, practice good food hygiene
Lymphatic Filariasis	*Wuchereria bancrofti*, Brugia species	Bite of infected mosquitoes	Swelling in limbs (el-ephantiasis), fever, pain, lymph node inflammation	Use insect repellents, sleep under mosquito nets, eliminate mosquito breeding sites
Trichinosis	*Trichinella spiralis*	Ingestion of undercooked pork containing larvae	Muscle pain, fever, swelling around eyes, diarrhoea, fatigue	Cook pork to safe temperatures, avoid consuming undercooked meat

Disease	Causative organism	Mode of transmission	Symptoms	Prevention
Pinworm Infection	*Enterobius vermicularis* (pinworm)	Ingestion of eggs from contaminated hands, surfaces, or objects	Itching around the anus, restless sleep, irritability	Wash hands frequently, keep fingernails short, wash bedding and clothing regularly
Guinea Worm Disease	*Dracunculus medinensis*	Drinking contaminated water containing water fleas	Painful blisters on the skin, fever, swelling at worm emergence site	Drink clean, filtered water, avoid contaminated water, use water treatment methods

Activity 7.3 Patient Case Challenge

***What you need*:**

- Whiteboard or poster paper
- Markers
- Printed symptom lists (optional for reference)
- "Patient case cards" (printed or written on index cards)

What to do:

1. Work in two groups, A and B.
2. Each group will take turns creating patient cases with symptoms, and the other group will guess the pathogen causing the disease.
3. Group A will work together to combine symptoms from different diseases caused by different pathogens (bacteria, viruses, fungi, parasites, or helminths).

a. Write down your "patient case" on a sheet of paper. Each case should include a list of symptoms (at least 3–5 symptoms).
b. Example of a patient case (Group A): Symptoms: fever, sore throat, cough, runny nose, body aches.

4. Group B will read the symptoms and write down the type of pathogen (bacteria, virus, fungus, parasite, or helminth) that could be causing the disease. Discuss as a group and write down the specific disease in their notebook.
5. Group B creates a new patient case, and group A guess the pathogen causing the disease.

After the activity, reflect on the following questions as a class:

1. What are some common symptoms of diseases caused by various pathogens?
2. How can you stay safe from the pathogens we discussed?
3. Why is it important to identify disease symptoms early?
4. What types of pathogens can cause illnesses, like bacteria and viruses?
5. How can we stop the spread of diseases from these pathogens?
6. How will this activity help you in everyday life?

PATHOGENIC DISEASES WITHIN THE COMMUNITY

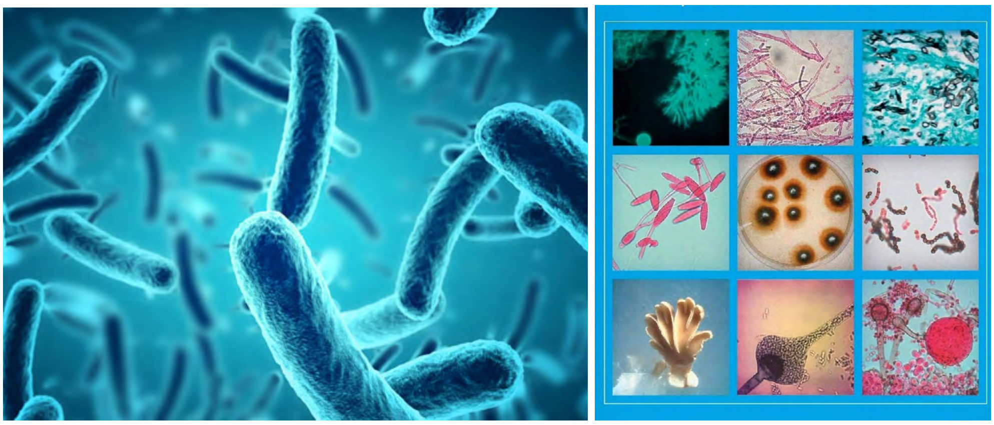


Figure 7.2: Fungi and bacteria pathogenic

Let us begin with some activities!

Activity 7.4 Exploring Pathogenic Disease

What you need:

Videos:https://www.youtube.com/watch?v=dG8CEyJhB_A, Science textbooks, reliable websites, note pad or computer and pictures

What to do:

1. Watch any educational videos to learn about diseases.
2. Read the chapters in your textbooks that explain diseases and pathogens.
3. Look up information on dependable websites such as GHS, WHO for more details.
4. Look at pictures of different pathogens and symptoms to help you understand what they look like.
5. Write down important points, explanations, and examples as you gather information in your note pads
6. Present your findings to your peers or family.

Activity 7.5 Causes, Symptoms and Prevention of Pathogenic Diseases

What you need:

- Microscope, microscope Slides, pathogen samples (e.g. bacteria, viruses, or fungi)
- Gloves, safety goggles, notebook, pen, computer
- Hand soap and sanitizer, waste disposal container and labels.

What to do:

1. Prepare slides containing samples of different pathogens that you can see under a microscope.
2. Observe the pathogens and write down their characteristics, such as their size, shape, and how they move.
3. Discuss the causes, symptoms, and how common pathogenic diseases are spread.
4. Explain how to prevent these diseases by getting vaccinated and maintaining good hygiene.

5. Dispose of used slides and gloves in waste disposal container.
6. Label slides and note down the type of pathogen being observed

Safety Precautions

1. Always wear gloves and safety goggles to protect your hands and eyes when handling slides or observing pathogens under the microscope.
2. Make sure to wash your hands thoroughly with soap and water before and after handling any materials to prevent contamination.
3. Be cautious when using microscopes and sharp tools to avoid accidents or injuries.
4. Do not touch your face, mouth, or eyes while working with pathogens to minimise the risk of infection or contamination.

Questions: Write your answers in your notebook as you read the questions.

1. Why are hygienic practices important in preventing pathogenic diseases?
2. Compare and contrast the differences in appearance and behaviour of various types of pathogens.
3. How will the importance of early detection, treatment, and control of pathogenic diseases help healthy life?
4. Explain the causes of pathogenic diseases
5. List specific diseases caused by pathogens, such as malaria, the flu, or tuberculosis.
6. What prevention methods can people use to avoid getting infected by a pathogen?

Understanding pathogenic diseases within the community (see ***Table 7.8***) is important for several reasons. Let us explore some of these reasons!

i. Prevention: Knowing about these diseases helps us take preventive actions, such as getting vaccinated, practicing good hygiene, and understanding how infections spread.
ii. Treatment: Understanding how diseases work leads to better treatments and medications to fight infections.
iii. Public health: Awareness of these diseases supports public health efforts that help control outbreaks and improve community health.
iv. Personal choices: Individuals can make informed decisions about their lifestyle to lower their risk of getting sick.

v. Education: By studying infectious diseases and their characteristics, we can learn how they impact human health and the environment, which helps develop effective prevention and control strategies

Table 7.8: Causes, Symptoms, and Prevention of Pathogenic Diseases

Disease	Cause	Symptoms	Prevention
Malaria	Plasmodium parasites	Headache, nausea, muscle pain, chills, fever, weakness, possible anaemia, body aches, vomiting or diarrhoea, and abdominal pain may occur.	Using mosquito nets and repellents is essential. It is important to avoid allowing water to collect in drains or open areas to stop mosquitoes from breeding.
Cholera	*Vibrio cholerae*	Profuse diarrhoea that can lead to dehydration, frequent vomiting, which can further contribute to fluid loss, painful cramps in the abdomen.	Ensure access to clean water and proper sanitation, wash hands regularly with soap and clean water. Get vaccinated if traveling to cholera-prone areas
Tuberculosis (TB)	*Mycobacterium tuberculosis*	Coughing up blood or phlegm, chest pain. Unintentional, weight loss sweating at night, fever, fatigue, decreased appetite.	Get vaccinated with the Bacillus Calmette-Guérin (BCG) vaccine, which offers some protection against and stay away from people with active TB. Ensure good airflow in crowded areas. TB.

Disease	Cause	Symptoms	Prevention
Typhoid fever	*Salmonella typhi* bacteria	A high, persistent fever up to 104°F (40°C), severe headaches are common, general tiredness and weakness are typical, discomfort and pain in the abdomen.	Typhoid vaccines are recommended for travellers going to high-risk areas and for those who are in close contact with infected individuals. It is important to get vaccinated to help prevent the spread of the disease and protect your health.
The common cold	Rhinoviruses	Common cold symptoms may include runny or stuffy nose, sore throat, cough, sneezing, mild headache, and fatigue.	Wash your hands regularly with soap and water for at least 20 seconds, especially after blowing your nose, coughing, or sneezing, and avoid close contact with infected individuals while not sharing personal items like utensils, towels, or cups.

Disease	Cause	Symptoms	Prevention
Measles	Virus	A dry cough that can continue throughout the illness. A distinctive red, blotchy rash that typically appears a few days after the fever begins, starting on the face and spreading to the rest of the body.	The MMR (measles, mumps, rubella) vaccine protects against measles, given in two doses at 12-15 months and 4-6 years of age. Good hygiene practices, like regular hand washing and covering the mouth when coughing or sneezing, also help prevent measles.
Hepatitis	Viral infections	Fatigue d. Flu-like symptoms (fever, muscle or joint aches) e. Jaundice (yellowing of the skin and eyes) f. Dark urine g. Pale stool h. Abdominal pain, particularly near the liver (right upper quadrant) i. Loss of appetite j. Nausea and vomiting	Ensure that blood products are screened for Hepatitis B and C viruses. Be sure that food is cooked properly and drinking water is safe, especially in regions where Hepatitis A and E are prevalent Do not share needles or personal items such as razors and toothbrushes that can be contaminated with blood.

Disease	Cause	Symptoms	Prevention
HIV/AIDS	HIV (Human Immunodeficiency Virus)	fever, fatigue, sore throat, swollen lymph nodes, and muscle aches. ongoing weakness, fatigue, and significant weight loss,	Do not share needles or syringes that have been used by someone with HIV Blood Transfusions: Do not receive blood products from an HIV-positive donor Be careful you do not accidentally expose yourself to HIV-infected blood (such as through a needlestick injury in healthcare settings)

Questions

Let us briefly review some of the concepts we have learned so far. Below are multiple-choice questions focusing on the relationship between pathogenic diseases, their examples, and causes. These questions will help assess your understanding of pathogenic diseases. Circle the correct answer as you read.

1. How do pathogens typically enter the human body?
   - **A.** Drinking clean water
   - **B.** Eating healthy foods
   - **C.** Getting enough sleep
   - **D.** Through cuts and wounds

2. Why is vaccination important in preventing diseases?
   - **A.** It guarantees you will never get sick
   - **B.** It helps the body recognize and fight pathogens
   - **C.** It makes you sick
   - **D.** It replaces the need for hygiene

3. In what way can good hygiene practices help control the spread of diseases?
   - **A.** They have no impact on disease spread
   - **B.** They help pathogens grow faster
   - **C.** They keep pathogens from transferring between people
   - **D.** They make you tired

4. Which of the following is an example of a pathogenic disease caused by a virus?
   - **A.** Athlete's foot
   - **B.** Influenza (the flu)
   - **C.** Strep throat
   - **D.** Tuberculosis

5. How can understanding the symptoms of pathogenic diseases benefit individuals?
   - **A.** It allows people to ignore diseases
   - **B.** It has no benefits at all
   - **C.** It helps them identify illnesses early and seek treatment
   - **D.** It makes them more likely to spread germs

Myths and Misconceptions

Myths and Misconceptions About Viral Pathogenic Diseases

Viral pathogenic diseases are often surrounded by myths and misconceptions, which can make it harder to effectively prevent and treatment them. Here are some of the common myths and misconceptions about viral diseases and the realities behind them:

Table 7.9: Myths and Misconceptions About Viral Pathogenic Diseases

Myth	Reality
All viruses are highly contagious	Not all viruses spread easily. Some require specific conditions for transmission.
Antibiotics can treat viral infections	Antibiotics are effective against bacterial infections, not viral ones.

Myth	Reality
You can only get a virus once	Some viruses can infect a person more than once due to mutations.
Vaccines cause the diseases they are meant to prevent	Vaccines contain weakened or inactivated parts of the virus, which cannot cause the disease.
Natural remedies can cure viral infections	Natural remedies may alleviate symptoms but not cure viral infections.
Viral infections are always severe	The severity of viral infections varies widely.
only dirty environments cause viral infections	People can contract viral infections in various settings, including clean environments.
You cannot spread a virus if you don't have symptoms	Some viruses can be transmitted by asymptomatic carriers.
Flu is just a bad cold	The flu is a more serious disease than the common cold.
Herd immunity can be achieved without vaccination	Relying on natural infection to achieve herd immunity can be dangerous.
Viruses can only be transmitted during outbreaks	Viruses can be transmitted anytime, not just during outbreaks.

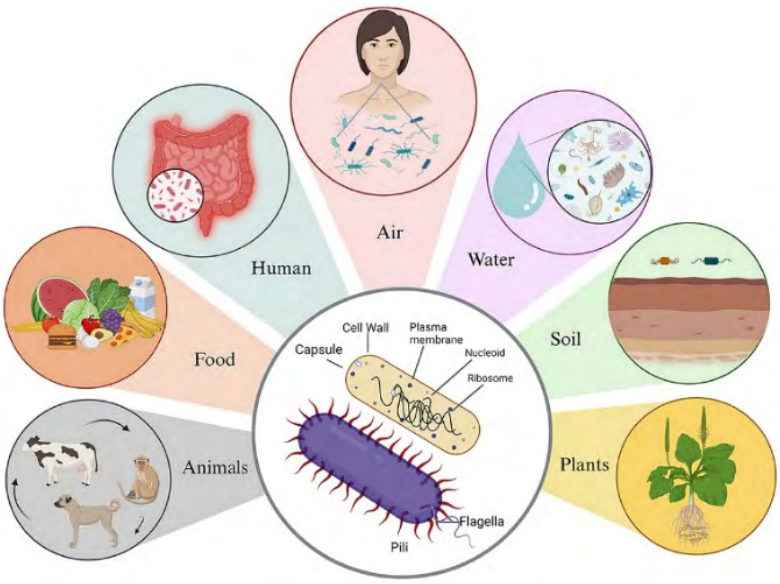


Figure 7.3: Bacteria found in various environments

Questions

Use ***Figure** 7.3* showing bacteria found in various environments to help you express your ideas about the key questions. Write down your answers in your notebook.

1. What are common myths about bacterial infections, and why is it important to understand the truth?
2. How do bacterial infections and fungal infections differ in treatment, and what myths exist about antibiotics?
3. What are examples of helpful bacteria, and why are they essential for our health?
4. Why is it important to understand that antibiotics only work on bacterial infections and not on viruses?
5. What is a fungal infection, and what organisms cause it?
6. Where can fungal infections occur in the body, and which areas are most commonly affected?

Myths and Misconceptions About Bacterial Pathogenic Diseases

Bacterial diseases are often surrounded by myths that can lead to misunderstandings about how to prevent and treat them. First, not all bacteria are harmful; many are beneficial for processes like digestion. Secondly, antibiotics work only for bacterial infections, not for viruses such as the flu, and using them incorrectly can lead to antibiotic resistance. Additionally, while vaccines are often associated with viral diseases, there are also vaccines for bacterial diseases like diphtheria and whooping cough. Moreover, bacterial immunity does not last forever; some infections can return or change over time. Finally, it's important to remember that bacteria cannot be completely eliminated from the environment, and misusing antibiotics can lead to serious health issues.

Table 7.10: Myths and misconceptions about bacterial pathogenic diseases

Myths	Reality
All bacteria are harmful	Many bacteria are beneficial for human health.
Antibiotics are effective against all types of infections	Antibiotics only work against bacterial infections.

Myths	Reality
Antibiotics always cure infections	Treatment success depends on factors like proper usage and bacterial resistance.
Bacteria can become resistant to antibiotics overnight	Resistance develops gradually through genetic changes.
Antibiotic resistance is solely due to overprescription	Misuse, agricultural use, and poor infection control also contribute.
Vaccines are only for viral diseases	Vaccines exist for some bacterial diseases (e.g., diphtheria, tetanus).
Once you have had a bacterial infection, you are immune for life	Immunity can wane, and some bacteria have varying strains.
Poor hygiene is the only cause of bacterial infections	Other factors like genetics and underlying health conditions also play a role.
Bacterial infections are always contagious	Not all bacterial infections are easily transmitted.
Bacterial diseases are rare and not a significant threat	Bacterial diseases remain a major global health concern.
Natural remedies are as effective as antibiotics	Natural remedies may offer support, but they are not substitutes for antibiotics in serious cases.
Bacteria can be eliminated from the environment	Bacteria are ubiquitous and cannot be completely eradicated.
Hand sanitizers eliminate all bacteria	Hand sanitizers reduce bacterial numbers but may not eliminate all types.
Antibiotics are safe to use without medical supervision	Misuse can lead to serious consequences, including resistance.
A higher dose of antibiotics will always be more effective	Higher doses don't always improve efficacy and may increase side effects.

Myths and Misconceptions About Fungal Pathogenic Diseases

Fungal infections are not just rare and limited to people with weak immune systems; they can also affect healthy individuals, for example athlete's foot and ringworm. Unlike bacterial infections, fungal infections require different treatments because antifungal medicines target fungi, while antibiotics target bacteria. Fungal infections can be hidden and affect internal organs rather than just showing up on the skin, such as invasive fungal infections like candidiasis affecting the bloodstream. Some fungi can be inhaled from soil, but you do not always need direct contact to get a fungal infection. While over-the-counter creams can help with some fungal infections, more serious ones usually need prescription medications. Many fungal infections are not very contagious and often require direct contact to spread, unlike viral or bacterial infections. Finally, fungi can cause infections beyond just skin and nails; they can also lead to severe illnesses affecting the lungs and other internal organs.

Table 7.11: Myths and misconceptions of fungal pathogenic diseases

Myths	Reality
Fungal infections are rare and only affect immunocompromised individuals	Fungal infections can affect anyone, although they are more common in those with weakened immune systems.
Fungal infections are just like bacterial infections	Fungal infections require different treatments (antifungals) than bacterial infections (antibiotics).
Fungal infections are always visible on the skin	Systemic fungal infections can affect internal organs without external signs.
You can get a fungal infection from direct contact with soil	Some fungal infections can be contracted by inhaling spores, not always through direct contact.
Fungal infections are easily treated with over-the-counter medications	Severe or systemic fungal infections often require prescription medications.
Fungal infections are contagious like viral or bacterial infections	Many fungal infections are not highly contagious and require close or prolonged exposure.

Myths	**Reality**
You can get a fungal infection from wearing shoes or socks	Fungal infections thrive in moist environments, not solely caused by wearing shoes.
Natural remedies are always effective for treating fungal infections	Natural remedies may offer some relief, but antifungal medications are often necessary.
Fungi only cause diseases in the skin and nails	Fungi can cause systemic infections affecting internal organs.
Fungal infections are always serious and life-threatening	Many fungal infections are mild and easily treatable.
Fungi cannot develop resistance to antifungal medications	Fungi can develop resistance to antifungal medications.
Fungal infections can be prevented with good hygiene alone	Good hygiene helps, but systemic infections may require additional preventive measures.
If you have a fungal infection, it will always show symptoms	Some fungal infections may be asymptomatic or have subtle symptoms.
All fungal infections require long-term treatment	Treatment duration varies depending on the type and severity of the infection.
You can only get fungal infections from outdoors	Fungal infections can originate from both indoor and outdoor environments.

Activity 7.5 Researching How to Prevent a Parthenogenic Disease

What to do:

1. Using the internet and other resources, research how to prevent a parthenogenic disease that has been allocated to your group by your teacher.

2. Write up your findings and to cover:

a. a minimum of three ways of the preventing the disease.

b. three myths and misconceptions of a fungal pathogenic disease.

c. the causes and symptoms of the disease.

3. Present your findings to your peers or family and educate them on how to prevent pathogenic diseases.

Questions

Here are multiple-choice questions focusing on misconceptions and myths surrounding fungal and bacteria pathogenic diseases. Circle the correct answer as you read before the next focal area.

1. Why do some people believe that natural remedies can completely treat fungal infections?

A. They are regulated by health organizations.

B. They are the only treatment option available.

C. They can help alleviate symptoms but are not always cures for infections.

D. They have been proven more effective than antifungal medicines.

2. How does the misconception that all bacteria are harmful affect public health practices?

A. It does not affect health practices at all.

B. It encourages people to avoid all bacteria, leading to overuse of disinfectants.

C. It helps people understand the role of beneficial bacteria.

D. It leads to more research on bacterial benefits.

3. In what way can believing that antibiotics work against viral infections harm patient health?

A. It will not harm their health at all.

B. Patients may misuse antibiotics, leading to antibiotic resistance and treatment failure.

C. Patients will have fewer bacterial infections.

D. Patients will recover faster.

4. Why is it important to identify and correct misconceptions about fungal and bacterial infections in the community?
   - **A.** It encourages people to avoid all hospitals.
   - **B.** It fosters better health practices, reduces the spread of disease, and improves overall public health.
   - **C.** It helps in treating infections with home remedies.
   - **D.** It makes people less aware of disease transmission.

5. How can education about the differences between fungal and bacterial infections lead to better health outcomes?
   - **A.** It allows communities to disregard all types of infections.
   - **B.** It encourages people to rely on natural remedies only.
   - **C.** It has no impact on health outcomes.
   - **D.** Understanding their differences helps people seek appropriate treatments, reducing illness and improving recovery.

6. Which statement about bacteria is a common myth?
   - **A.** All bacteria are harmful and cause diseases.
   - **B.** Bacteria are found in the environment.
   - **C.** Bacteria can help with digestion.
   - **D.** Some bacteria are beneficial for health.

EXTENDED READING

1. Watch videos on pathogenic diseases such as Tuberculosis, cholera and their mode of transmission.
2. Read on how vaccines are prepared and their importance in preventing and controlling of pathogenic diseases
3. Do further search on why people have misconceptions on bacterial and fungal pathogenic diseases.

REVIEW QUESTIONS

1. What are pathogens, and how do they cause diseases?
2. Name two personal hygiene practices that help prevent the spread of pathogenic diseases.
3. How does vaccination in preventing pathogenic diseases?
4. How do public health measures help control the spread of pathogenic diseases?
5. In what three areas can we use knowledge about pathogenic diseases in real life?
6. A group of SHS 2 learners is participating in a science fair project called "Meet the Pathogen friends," where they will explore different pathogenic diseases. They meet a fun character named Professor Pathogen, who represents various pathogens like bacteria, viruses, parasites, and fungi. Professor Pathogen provides clues about his "friends," such as a bacterium that causes food poisoning or a virus that spreads through coughing and sneezing. Each group will create a poster about their assigned pathogen, including its symptoms, how it spreads, and prevention methods. They will investigate the causes of the disease (including microorganisms and environmental factors), its symptoms, and any misconceptions related to the disease.
   a. Why is it important to understand how a pathogen spreads?
   b. What misconceptions might people have about infectious diseases?
   c. How can knowledge about pathogens help in making healthy choices?

Section

8 INDIGENOUS BEVERAGES

RELATIONSHIPS WITH THE ENVIRONMENT

TECHNOLOGY IN LOCAL INDUSTRIES

INTRODUCTION

In this section, you will explore the production of indigenous beverages, including Sobolo (Hibiscus Tea), Pito, Nmedaa, Asana, and palm wine. These drinks are not only a testament to rich cultural heritage but also showcase traditional craftsmanship. Sobolo, known for its vibrant red colour and refreshing taste, is made from dried hibiscus petals infused with spices and sweeteners. Pito, a fermented beverage brewed from sorghum or millet, highlights the intricacies of fermentation science. Nmedaa, often made from maize, further emphasises the diversity of ingredients used in these beverages, while palm wine, derived from the sap of palm trees, illustrates natural fermentation processes that yield distinct flavours. Exploring the scientific processes behind these indigenous drinks involves understanding extraction methods, fermentation techniques, and the complex interactions between ingredients like acids and sugars. This journey will deepen our appreciation for the craftsmanship and cultural significance embedded in these cherished beverages.

KEY IDEAS

- Indigenous beverages are crafted from ingredients that are naturally found in the area. These can include fruits, grains, roots, herbs, and various plant materials.
- The selection of raw materials, like hibiscus petals for Sobolo or sorghum for Pito, is important. These ingredients affect the flavour and nutrition of the drink.
- Many indigenous drinks are made through fermentation, a process where sugars are turned into alcohol and gas by tiny organisms. Understanding this process helps create better flavours.
- How we get flavours and colours from ingredients is key. Different methods, like boiling or steeping, can change how strong and tasty the final drink is.

- The acidity of a beverage affects its taste and how long it lasts. Keeping the right pH balance improves flavour and helps preserve the drink.
- Temperature matters in making drinks. It can impact how flavours develop and how well fermentation works, leading to better quality beverages.

THE SCIENCE INVOLVED IN THE PRODUCTION OF INDIGENOUS BEVERAGES

Indigenous Beverages

Indigenous beverages are traditional drinks rooted in the cultural and historical practices of local communities. These beverages are often made using locally sourced ingredients and methods passed down through generations, reflecting the unique heritage and identity of a region.

Characteristics of Indigenous Beverages

1. Locally sourced ingredients: Indigenous beverages are made from ingredients that are naturally available in the region. This includes fruits, grains, roots, herbs, and other plant materials.
2. Traditional preparation methods: The methods used to prepare these beverages are traditional and often involve fermentation, brewing, distillation, or simple extraction techniques.
3. Traditional technology: The technical know-how of methods of preparation as well as tools used originate from the traditional mentality of the indigenous people.
4. Cultural significance: These drinks often hold cultural, religious, or social importance. They are typically consumed during festivals, rituals, or communal gatherings.
5. Nutritional and medicinal benefits: Many indigenous beverages are known for their health benefits, providing essential nutrients, probiotics, or medicinal properties.

Indigenous Beverages and Their Distinguishing Features

1. **Sobolo**

   Sobolo is made from hibiscus leaves and infused with ginger, pineapple juices, and any spices of your choice giving it a sharp, unique taste. It is typically served chilled and pairs well with meals. Some bars have created cocktails using sobolo, making it a popular and favourite drink among Ghanaians.

2. **Brukina**

   Brukina, also known as 'deger' or 'nunu' in parts of West Africa, is a fermented beverage made from cow milk and millet. A touch of sugar and salt is added for a distinctive taste, and peanuts can be included for extra flavour. Burkina is rich in nutrients like magnesium, calcium, manganese, tryptophan, phosphorus, fibre, vitamin B, and antioxidants.

3. **Asaana**

   Asaana, often called the African Coca-Cola, is a popular non-alcoholic caramelised corn drink made from fermented corn and caramelised sugar, with a taste like malt. Large ice cubes are added to keep it chilled.

4. **Pito**

   Pito is a fermented African beverage like beer made from millet or sorghum, or a combination of both. The grains are soaked, dried, milled, mixed with water, boiled, and left to ferment. Before serving, Pito is strained and has a slightly sweet and sour taste, ranging from amber to dark brown. Traditionally served in a calabash, it is often drunk from regular cups. Pito is usually bought directly from the households where it is brewed and is an important income source for rural households. It is mainly enjoyed at gatherings like marriages, naming ceremonies, and burials.

5. **Palm Wine**

   Palm wine is an alcoholic drink is obtained from the sap of a palm tree. Tappers climb the trees to extract the sap, or the tree is fell down. Which is then left to ferment with airborne yeast. The extraction involves inserting a small fire into a fallen palm tree's trunk to release the sap, which is collected in jars. The sap ferments quickly, developing an alcohol content like regular beer within two hours.

6. **Ginger Drink**

   The ginger drink is a pure, spicy ginger beverage. Various flavourings can be added for a unique twist. It is particularly good for colds and sore throats.

7. **Lamugin**

   Although like the ginger drink, Lamugin is different as it is prepared by blending ginger with other ingredients such as lemon, soaked cloves, and water.

8. **Akpeteshie**

   Akpeteshie is a stronger alcoholic beverage than whiskey and is often considered Ghana's national spirit. It is made by distilling palm wine or sugar cane and has a rich history.

9. **Mahewu**

   Mahewu is a fermented maize drink that is slightly sour and non-alcoholic. It is made by fermenting maize porridge and is often consumed as a refreshing and nutritious beverage.

10. **Nmedaa**

    Nmedaa, a caramelised sugar maize drink that do not undergo fermentation after been prepared.

Activity 8.1 Indigenous Beverages

What to do:

1. Conduct research on indigenous beverages. Use the following guiding questions as you research:
   a. What are indigenous beverages?
   b. Why are they known as indigenous beverages?
   c. What are their characteristics?
   d. Name some of them and the localities where they are predominantly prepared.
   e. Do any of the beverages have cultural significance?
   f. What are the traditional methods used to prepare some of these beverages?
   g. What scientific processes are involved in their production?
2. Prepare a digital presentation and share your findings with the class. Include pictures and diagrams to make your presentation interesting.

Activity 8.2 Locality of Indigenous Beverage

What to do:

1. Carry out research into the localities where the local beverages are predominantly prepared.
2. After the research, copy and complete the table below:

Local Beverage	Locality where predominantly prepared
Sobolo	Most communities in Southern Ghana
Brukina	Fulani and Zongo communities.
Asana	
Pito	
Palm wine	Communities where there is oil palm.
Ginger drink	
Lamugin	
Akpeteshie	Throughout Ghana
Mahewu	
Nmedaa	

Scientific Processes Involved in The Production of Indigenous Beverages

1. **Fermentation**

   This is a key process in creating many traditional beverages. This biological mechanism converts sugars into alcohol and carbon dioxide using micro-organisms like yeast and bacteria. There are two types of fermentation used. These are:

   a. Ethanol Fermentation: This method is widely used to produce alcoholic beverages such as palm wine, traditional beers, and fruit-based fermentation. Baking yeast transform glucose into ethanol and CO_2.

   b. Lactic Acid Fermentation: This process is utilised in making non-alcoholic fermented beverages, including traditional fermented milk drinks (such as kefir) and certain vegetable-based drinks. Lactic acid bacteria (like Lactobacillus species) convert sugars into lactic acid, which acts as a preservative and gives the beverage a sour flavour.

2. Distillation

This creates spirits from fermented beverages by heating the liquid to separate alcohol from water and other components based on their differing boiling points.

Activity 8.3 Distillation Process

What is needed

- Heat source (such as a hot plate), Heat-resistant flask (Erlenmeyer or round-bottom)
- Distillation apparatus (condenser and collection flask)
- Thermometer, rubber tubing, ice and water
- Alcohol-water mixture (e.g., a small amount of rubbing alcohol diluted with water)
- Clamps and stands, safety goggles and gloves

What to do

a. Secure the heat-resistant flask on a stand using a clamp.

b. Attach the distillation condenser to the flask. Ensure the condenser is properly connected to allow the vapour to pass through and condense into the collection flask.

c. Connect rubber tubing to the condenser's water inlet and outlet.

d. Place the inlet tube into a container of cold water with ice to keep the condenser cool. The outlet tube should lead to a drain or another container.

e. Place the thermometer in the flask, ensuring that its bulb is immersed in the liquid but not touching the bottom.

f. Pour the alcohol-water mixture into the heat-resistant flask and note its initial temperature.

g. Turn on the heat source and gradually heat the mixture. Observe the temperature rise.

h. As the mixture heats up, the alcohol (which has a lower boiling point than water) will start to evaporate first.

i. The vapour will travel up into the condenser, which will cool down and condense into liquid form.

j. Collect the condensed liquid (distillate) in the collection flask.

Observation

a. Monitor the temperature closely. When the alcohol is boiling, the temperature will remain relatively steady and then start to rise again as the water begins to boil.

b. Collect the distillate at different temperature intervals to observe the separation of alcohol and water.

Explanation: This hands-on activity demonstrates the principle of distillation, where a mixture is separated based on the different boiling points of its components. As the mixture heats up, the component with the lower boiling point (alcohol) evaporates first. The vapour then travels through the condenser, which cools and returns to a liquid state, separating it from the component with a higher boiling point (water).

Safety Precautions

a. Always wear safety gear to avoid splashes or spills.

b. Ensure the heat source is stable and does not come into direct contact with flammable materials.

c. To avoid inhaling vapours, experiment in a well-ventilated area or under a fume hood.

d. Be cautious with the glassware and heat sources to prevent burns or breakages.

3. **Pasteurisation**

   Involves heating beverages to a specific temperature to eliminate harmful micro-organisms without significantly altering the taste. This technique is used to prolong the shelf life of both alcoholic and non-alcoholic drinks.

4. **Filtration**

   Its processes are used to remove solid particles, yeast, and other impurities to enhance the clarity and stability of the beverage. This can involve physical filters, and clarification might use substances like bentonite or egg whites.

5. **Carbonation**

   Is the process which adds carbon dioxide to a beverage either naturally during fermentation or artificially. This process is commonly used to produce sparkling wines and traditional sodas.

6. **Brewing**

   Brewing indigenous beverages combines traditional techniques with scientific principles, involving the transformation of raw ingredients into flavourful drinks through fermentation and other biochemical processes

Activity 8.4 Field Trip to a Local Brewery

What to do:

1. Visit a local industry or brewery that produces indigenous beverages with a supervisor.
2. Before the visit, prepare questions and hypotheses about the processes you expect to see during your visit.
3. Make notes of your observation and engage in a discussion with your class to share your learnings and insights.

PRODUCTION OF INDIGENOUS BEVERAGES SUCH AS ASANA

Have you tasted the delicacy of a locally brewed drink called asana? It has other equally interesting names such as “liha”, “elewonyo”, “ekuleme” and “sanakoe”. Irrespective of the name, the taste remains the same. Have you taken your time to really discover how it is been prepared?

What is Asana/elewonyo/liha/ekuleme drink?

Asana, often called the “African Coca-Cola,” is a popular non-alcoholic caramelised corn drink made from fermented corn and caramelised sugar, with a taste like malt. Large ice cubes are added to keep it chilled for a better drinking sensation.

Figure 8.1: Chilled asana on display

Figure 8.2: Chilled asana being served

Question: Write your answer in your notebook.

What are the scientific processes involved in the production of asana?

Scientific Processes Involved in Asana Drink Production

1. Cleaning and soaking: Thoroughly wash the grains to remove debris and stones and soak them in water for 48-72 hours. This causes hydration and activation of enzymes within the grains, initiating the germination process.
2. Germination (Malting): Covering and maintaining moisture allows the grains to sprout. This causes the enzymatic breakdown of starches into simpler sugars, which are essential for fermentation.
3. Drying: Drying the sprouted grains to halt the germination process. It also preserves the enzymatic activity while making the grains suitable for storage and milling.
4. Caramelisation: Melting and browning sugar in a pot. This thermal decomposition of sugar molecules results in complex flavours and colour changes.
5. Dissolution: Adding hot water to caramelised sugar creates a syrup without crystallisation.
6. Mashing: Mixing powdered grains with water and boiling. This softens the grains.
7. Boiling: Heat the mixture for one hour. This sterilises the mixture and extracts flavours and sugars from the malted grains.
8. Filtration: Strain the boiled mixture through metal mesh and cheesecloth. This removes solid particles, resulting in a clear liquid.

Activity 8.5 Guest Speaker Session

What to do:

1. Inform your teacher or parent to arrange a guest speaker session where a traditional local beverage maker or resource person will deliver a lecture on the local beverages.
2. As you listen to the lecture, make notes and jot down any questions you may have.
3. Engage in a discussion after the session with your peers or family to share your insights and thoughts.

Activity 8.5 Production of Asana

What you need:

- 200 grams dry corn kernels.
- 100 grams sugar for caramel
- Sugar/sweetener to taste and milk (optional)

Dry corn

Sample of Sugar

Figure 8.3: Ingredients for Asana Production

What to do:

1. Soak corn kernels in 2 litres of water for 2 days, making sure to change the water on the second morning.
2. Place corn kernels on a kitchen towel and then on a flat wide sieve (similar to a winnower) or a flat surface and leave covered in a dark dry place to germinate. This could take between 2-4 days.

3. Dry the sprouted kernels in the sun for about 6 hours and then sprinkle with water and wrap tightly in old newspapers. Store in a dark, dry, and cool place for one day.
4. Break up the kernels into smaller pieces by pulsing in a blender or a food processor. Sieve into a bowl and keep both flour and larger chunks of corn.
5. Boil the larger, broken chunks of corn in about 1 litre of water for about 30 minutes, strain and leave to cool.
6. Roast the flour in a pan over low to medium heat until flour is dark brown in colour.
7. Mix strained liquid and roasted corn flour and leave overnight to slightly ferment.
8. In a pan, make the caramel by melting sugar until it is pale brown to dark brown.
9. Mix the caramel with the slightly fermented liquid and add more sugar if needed.
10. Bottle it and keep in a refrigerator.

Figure 8.4: Soaked corn kernels

Figure 8.5: Sprouted corn kernels

Figure 8.6: Water from soaked corn

PRODUCTION OF INDIGENOUS BEVERAGES SUCH AS SOBOLO

Sobolo (Hibiscus Tea)

Sobolo, also known as zobo, is a local Ghanaian drink which is made from hibiscus leaves. It is infused with ginger, pineapple juices and other spices of your choice giving it a sharp, unique taste. It is typically served chilled and pairs well with meals. Some bars have created cocktails using sobolo, making it a popular and favourite drink in Ghana. Currently, sobolo is one of the popular local drinks enjoyed in Ghana.

Response from madam Adobea (aka Maame Sobolo), a popular sobolo maker and seller, during a field trip to her facility indicates that, juices added to the sobolo drink are mainly citrus and it is optional. A spice of your choice is also added for a unique personal touch.

Figure 8.7: Sobolo or zobo drink

Activity 8.6 Preparation of Sobolo (Hibiscus tea)

What we need:

- One pineapple
- One cup of dates
- Two cups of hibiscus

- Water
- Sugar/sweetener to taste

Spices that can be added by choice are:

- Two large thumbs of ginger (peeled)
- Fifteen grains of Selim
- Seven African nutmeg
- Two tablespoons of cloves
- Two dried chillies
- One tablespoon of black peppercorn
- One tablespoon of grains of paradise

What to do:

1. Prepping Ingredients

   a. Clean the pineapple by soaking it in water and vinegar for 2-3 minutes.

   b. While the pineapple is soaking, soak the dates in warm water until they are soft, then drain.

   c. Remove a few leaves from the pineapple crown and peel it. (d) Cut the pineapple into chunks, removing the core.

2. Making the Drink

   a. Blend the pineapple chunks with ginger, spices, and dates until smooth.

   b. In a pot, combine the pineapple leaves, skin, blended mixture, and spices with 10 cups of water. Bring to boil without covering the pot to prevent splashing.

   c. Once the water begins to boil, add the hibiscus leaves and reduce the heat to maintain a rolling boil, allowing the mixture to soak.

   d. Soak the mixture for at least 30 minutes, then turn off the stove.

   e. Add sugar to taste.

   f. Allow the drink to cool to room temperature.

   g. Strain the drink using a fine mesh strainer.

   h. Bottle the drink and store it in a refrigerator.

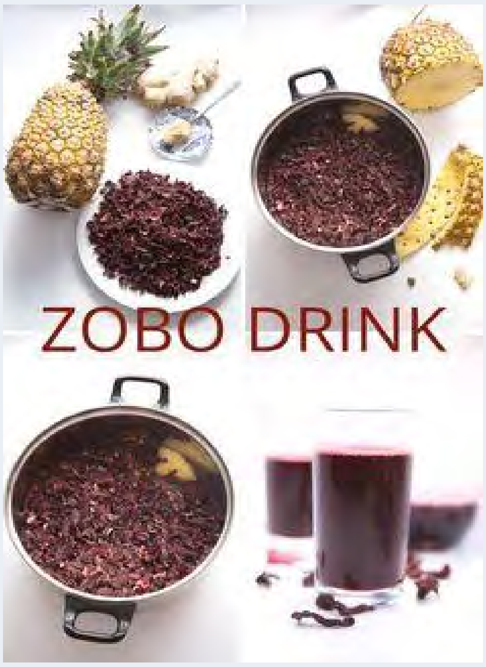


Figure 8.8: Some ingredients for sobolo/zobo drink

Scientific Processes Involved in Sobolo Production

1. Cleaning: Clean the pineapple by soaking it in a water and vinegar solution for 2-3 minutes. The vinegar's acetic acid kills bacteria and removes pesticides from the surface of the pineapple.
2. Soaking: This hydrates and softens the dates, making them easier to blend.
3. Blending: This process mechanically breaks the fruit and spices into a homogenous mixture, facilitating flavour extraction and nutrient release.
4. Boiling: The heat facilitates the extraction of flavours and beneficial compounds from the ingredients.

EXTENDED READING

1. Process and Product Characterization of Aliha, A Maize-Based Ghanaian Indigenous Fermented Beverage: https://onlinelibrary.wiley.com/doi/10.1155/2022/5604342
2. New Strategies to Improve Quality of Alcoholic Beverages: Non-Alcoholic Beverages: Innovations, Trends & Market Insights
3. Read more on Ghanaian local drinks from notes and online.

REVIEW QUESTIONS

1. Identify the ingredients for the preparation of sobolo
2. Explain the scientific processes involved in sobolo production
3. Demonstrate how sobolo is produced using the necessary ingredients and materials.
4. Identify ingredients for the preparation of asaana/elewonyo/liha/ekuleme.
5. Explain the scientific processes involved in asaana/elewonyo/liha/ekuleme.
6. Demonstrate how asaana/elewonyo/liha/ekuleme is produced using the necessary ingredients and materials.

REFERENCES

1. Ahmad, S. (2023). Physiology, Liver. In StatPearls. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK535438/
2. BBC Bitesize. (2021). The respiratory system: Structure and function. Retrieved November 1, 2024, from https://www.bbc.co.uk/bitesize/articles/zbhcg7h
3. BBC Bitesize. (n.d.). Respiratory system revision. Retrieved November 1, 2024, from https://www.bbc.co.uk/bitesize/guides/zyptv9q/revision/4
4. Blikai. (n.d.). What 7805 voltage regulator IC is and how it works. Blikai. Retrieved November 19, 2024, from https://www.blikai.com/blog/what-7805-voltage-regulator-ic-is-and-how-it-works
5. Britannica, T. Editors of Encyclopaedia. (n.d.). Human respiratory system. In Encyclopaedia Britannica. Retrieved November 1, 2024, from https://www.britannica.com/science/human-respiratory-syste
6. BYJU'S. (n.d.). Ohm's law. Retrieved November 21, 2024, from https://byjus.com/physics/ohms-law/
7. Centers for Disease Control and Prevention. (n.d.). Hand hygiene in healthcare settings. Retrieved from https://www.cdc.gov/handhygiene/index.html
8. Circuitspedia. (n.d.). PN junction diode: Depletion region. Circuitspedia. Retrieved November 19, 2024, from https://circuitspedia.com/pn-junction-diode-depletion-region/
9. Dyer, J. (2021). The respiratory system. Kenhub. Retrieved November 1, 2024, from https://www.kenhub.com/en/library/anatomy/the-respiratory-system
10. EFY Enterprises Pvt Ltd. (n.d.). Step-down transformer: Working and applications. Electronics For You. https://www.electronicsforu.com/technology-trends/learn-electronics/step-down-transformer-working
11. Elecrow. (n.d.). How to use a breadboard for beginners. Elecrow. Retrieved November 19, 2024, from https://www.elecrow.com/blog/how-to-use-a-breadboard-for-beginners.html

12. GeeksforGeeks. (n.d.). Real-life applications of diodes. GeeksforGeeks. Retrieved November 19, 2024, from https://www.geeksforgeeks.org/real-life-applications-of-diodes/
13. GeeksforGeeks. (n.d.). Series vs parallel circuits. Retrieved November 21, 2024, from https://www.geeksforgeeks.org/series-vs-parallel-circuits/
14. Ginger & Sea Salt. (n.d.). Liha: Sprouted corn drink. Retrieved November 21, 2024, from https://gingerandseasalt.com/liha-sprouted-corn-drink/
15. Ginger & Sea Salt. (n.d.). Sobolo: Hibiscus flower drink. Retrieved November 21, 2024, from https://gingerandseasalt.com/sobolo-hibiscus-flower-drink/
16. Grant Transformers. (n.d.). Differences between step-up and step-down transformers. Grant Transformers. https://grant-transformers.com.au/differences-between-step-up-and-step-down-transformers/
17. Kharazmi, A., & Zand, M. (2014). An overview of the anatomy and physiology of the human lung. PMCID, 4382809. https://pmc.ncbi.nlm.nih.gov/articles/PMC4382809/
18. Mayo Clinic. (n.d.). Infectious diseases: Overview. Retrieved from https://www.mayoclinic.org/diseases-conditions/infectious-diseasesv
19. MITK12Videos. (2015, June 4). Why can we regrow a liver (but not a limb)? https://www.youtube.com/watch?v=erMCADOJcHk&feature=youtu.be
20. Modern Ghana. (n.d.). How to prepare asaana (caramelized corn drink) at home. Retrieved November 21, 2024, from https://www.modernghana.com/lifestyle/10392/how-to-prepare-asaana-caramelizedcorn-drink-at-home.html
21. OpenStax. (2021). Acid-base equilibria. In Chemistry 1e. Retrieved from https://chem.libretexts.org/Bookshelves/General_Chemistry/Chemistry_1e_(OpenSTAX)/14%3A_Acid-Base_Equilibria
22. Oregon State University. (n.d.). 25.1 Internal and external anatomy of the kidney. Open Oregon State: Anatomy and Physiology. https://open.oregonstate.education/aandp/chapter/25-1-internal-and-external-anatomy-of-the-kidney/
23. Oregon State University. (n.d.). 25.2 Microscopic anatomy of the kidney: Anatomy of the nephron. Open Oregon State: Anatomy and Physiology.

https://open.oregonstate.education/aandp/chapter/25-2-microscopic-anatomy-of-the-kidney-anatomy-of-the-nephron/

24. Pandai. (n.d.). KSSM - Chapter 10: Water and the dissociation of acids and bases. Retrieved October 24, 2024, from https://app.pandai.org/note/read/kssm-ch-10-06-01/KSSM-F4-CH-06-01
25. Pharmacy 180. (n.d.). Structures of the nephron. https://www.pharmacy180.com/article/structures-of-the-nephron-3669/
26. POPSUGAR Fitness. (2014, February 7). Are sports drinks good for you? | Fit or Fiction. YouTube.
27. Save My Exams. (n.d.). Role of the intercostal muscles and diaphragm. Retrieved November 1, 2024, from https://www.savemyexams.com/igcse/biology_double-science/edexcel/19/revision-notes/2-structure--function-in-living-organisms/gas-exchange/2-47-role-of-the-intercostal-muscles-and-diaphragm/
28. Study Page. (n.d.). Water and dissociation of acids & bases. Retrieved October 24, 2024, from https://www.studypage.in/general-science/water-and-dissociation-of-acids-bases#google_vignette
29. TED-Ed. (2018, May 15). Why do we sweat? – John Murnan. YouTube. https://www.youtube.com/watch?v=fctH_1NuqCQ&feature=youtu.be
30. The Canadian African. (n.d.). Sobolo: Spiced hibiscus drink. Retrieved November 21, 2024, from https://thecanadianafrican.com/sobolo-spiced-hibiscus-drink/
31. Vedantu. (n.d.). Are there similarities between acids and bases? Retrieved October 24, 2024, from https://www.vedantu.com/question-answer/are-the-similarities-between-acids-and-bases-class-8-chemistry-cbse-60abd15c30cccf5f3f28dd19
32. Wikipedia contributors. (2024, October 25). Lobes of liver. Wikipedia. https://en.wikipedia.org/wiki/Lobes_of_liver
33. Wikipedia contributors. (n.d.). Lung. In Wikipedia, The Free Encyclopedia. Retrieved November 1, 2024, from https://en.wikipedia.org/wiki/Lung
34. Wikipedia contributors. (n.d.). Sources of electrical energy. In Wikipedia. Retrieved November 21, 2024, from https://en.wikipedia.org/wiki/Sources_of_electrical_energy

35. World Health Organization. (n.d.). Vaccines and immunization: What is vaccination? Retrieved from https://www.who.int/health-topics/vaccines-and-immunization

GLOSSARY

Aerobic: A type of activity or process that requires oxygen. For example, aerobic respiration is when cells use oxygen to produce energy.

Alternating Current (AC): An electric current that reverses direction periodically. In most homes, the electricity supplied is AC, which changes direction many times per second.

Alveoli: Tiny air sacs in the lungs where oxygen and carbon dioxide exchange occur. Alveoli help oxygen enter the blood.

Ammonia: A toxic waste product produced when the body breaks down proteins. The liver converts ammonia into urea, a less harmful substance that is excreted by the kidneys in urine.

Anion: A negatively charged ion that forms when an atom or molecule gains one or more electrons.

Antacid: A substance, typically a base, used to neutralize stomach acidity, providing relief from heartburn or indigestion.

Antibiotics: Medications used to treat bacterial infections by killing bacteria or inhibiting their growth; ineffective against viral and fungal infections.

Aqueous Solution: A solution in which water is the solvent, commonly used in chemistry to describe solutions involving ionic and molecular compounds.

Archimedes' Principle: A principle stating that the buoyant force acting on a submerged object is equal to the weight of the fluid displaced by that object.

Aromatic: Having a pleasant and distinctive smell. Many of the spices used in Sobolo (ginger, cloves, Selim, nutmeg, etc.) are highly aromatic, contributing significantly to the overall flavour and aroma of the final drink.

Bacteria: Single-celled microorganisms that can be beneficial or harmful; some bacteria cause infections, while others are essential for processes like digestion.

Bile: A digestive fluid produced by the liver that helps break down fats in the food we eat. It is stored in the gallbladder and released into the small intestine during digestion.

Broken Circuit: A circuit where the path is interrupted or disconnected, stopping the flow of electric current completely. This can happen if one component in a series circuit is removed or damaged.

Bronchi: The two large tubes that branch off from the trachea, each leading to one lung, carrying air in and out.

Bronchioles: Small branches of the bronchi that spread throughout the lungs and end in tiny air sacs called alveoli.

Buoyant Object: An object that can float in a fluid due to its design or density being less than that of the fluid.

Caramelisation: Melting and browning sugar to create special flavours and colours.

Cation: A positively charged ion that results from the loss of one or more electrons from an atom or molecule.

Concentration: The amount of a substance (solute) present in a given volume of solution, typically expressed in molarity (moles per litre).

Conductor: A material that allows electricity to flow easily because it has free-moving electrons. Examples: Copper, Aluminium.

Consistency: The process of making sure beverages taste the same every time by quality checks.

Contagiousness: The ability of a disease to spread from one person to another, depending on the transmission mode and the survival capacity of the pathogen outside the host.

Core: A magnetic material (usually iron) in the centre of a transformer that helps to guide the magnetic field between the primary and secondary coils, enhancing energy transfer.

Crop Yield: The total quantity of crop produce harvested from a given area of land, typically measured in tons per hectare or bushels per acre.

Current: The flow of electric charge through a circuit. In a series circuit, the current remains the same throughout all components.

De-icing: The process of removing ice or snow from surfaces, typically using chemicals or heating methods to lower the freezing point of water and prevent accumulation

Density: The mass per unit volume of a substance, typically measured in kilograms per cubic meter (kg/m^3), influencing whether an object will float or sink.

Dermis: The thick, inner layer of the skin that contains blood vessels, nerve endings, sweat glands, and hair follicles. It provides strength, flexibility, and sensation.

Detoxification: The process by which the liver breaks down and removes harmful substances, such as drugs, alcohol, and toxins, from the bloodstream, making them less harmful or easier to eliminate.

Dialysis: A medical treatment that uses a machine to filter waste and extra water from the blood when the kidneys can't do so effectively.

Diffusion: The movement of particles from a high concentration to a low concentration. In the lungs, oxygen and carbon dioxide move across membranes through diffusion.

Dilution: The process of reducing the concentration of a solute in a solution, usually by adding more solvent.

Direct Current (DC): An electric current that flows in one direction only. It is commonly used in batteries and electronic devices.

Disease: a condition that affects how the body normally works, causing specific symptoms or signs of illness

Displacement: The volume of fluid that is moved aside when an object is immersed in it, which directly relates to the upthrust experienced by the object.

Dissociation: The process by which a compound breaks down into its constituent ions or simpler molecules in a solution, often seen in ionic compounds dissolving in water.

Diuretics: Medications that help the body get rid of excess fluid by increasing urine production.

Doping: The process of adding small amounts of other materials (impurities) to a semiconductor to improve its ability to conduct electricity.

Electron: A subatomic particle with a negative charge that orbits the nucleus of an atom; it plays a key role in chemical bonding and electricity.

Energy Audit: A check-up to see how much energy a home or building uses. It helps find places where energy is being wasted and suggests ways to save energy.

Excretion: The process by which the body eliminates waste products and harmful substances from its systems. This is essential for maintaining health and homeostasis.

Exhalation (Expiration): The act of breathing out. This is when carbon dioxide leaves the lungs.

Extracting flavours: Different methods, like boiling or steeping, help get flavours and colours from ingredients.

Fermentation: The chemical breakdown of complex organic compounds into simpler substances by microorganisms, such as bacteria or yeast.

Floatation device: An object designed to provide buoyancy and keep a person or object afloat, such as life jackets or rafts.

Flotation: The ability of an object to remain on the surface of a fluid without sinking, determined by the balance of forces acting on it.

Fluid: A substance that can flow, including liquids and gases, which exerts pressure and buoyancy.

Forward bias: A condition where the diode allows electricity to flow because the positive side is connected to the p-type material and the negative side to the n-type material.

Fungi: A group of organisms including yeasts and moulds that can cause diseases (mycosis) in plants and animals, including humans.

Fuse: A small safety device in an electrical circuit that breaks and stops the flow of electricity if too much current flows through. This protects the circuit and devices from damage.

Germination: The process by which a seed or spore begins to grow and develop into a new plant. In this process, germination of corn kernels is crucial as it initiates the enzymatic processes that will later contribute to the flavour and texture of the final drink.

Hand hygiene: The practice of keeping hands clean by washing with soap and water or using hand sanitizer to prevent the spread of germs and infections.

Heat sink: a device that absorbs and removes heat from electronic components to prevent them from overheating. For example, it keeps parts like voltage regulators or computer processors cool by releasing heat into the air.

Hepatic Vein: A blood vessel that carries deoxygenated blood away from the liver and back to the heart. It helps transport nutrients and waste products processed by the liver.

Homeostasis: The body's ability to maintain a stable internal environment, ensuring that all physiological systems function optimally.

Immunity: The body's ability to resist or fight off infections caused by pathogens through the immune system's response

Incubation period: The time between exposure to a pathogen and the appearance of symptoms, during which the pathogen multiplies and spreads within the host.

Inhalation (Inspiration): The act of breathing in. When we inhale, oxygen enters the lungs.

Insulation: Material used in walls, roofs, and floors to keep heat inside during winter and outside during summer. It helps save energy by reducing the need for heating or cooling.

Insulator: A material that blocks the flow of electricity because its electrons are tightly held.

Kilowatt-hour (kWh): A unit of energy that shows how much electricity you use. For example, if a device uses 1 kilowatt (1000 watts) of power for 1 hour, it uses 1 kWh of energy.

LED (Light-Emitting Diode): A type of diode that produces light when electricity flows through it. Commonly used in lights, screens, and car headlights.

Liver: The largest solid organ in the body, located in the upper right abdomen. It is responsible for many vital functions, including producing bile, detoxifying harmful substances, and regulating nutrients in the blood.

Load: The weight or mass added to an object, which can affect its buoyancy and stability in water.

Managing pH levels: Acidity affects taste; keeping the right pH balance improves flavour.

Mashing: To crush or grind something into a pulp. While not explicitly mentioned, the process of breaking up the sprouted corn kernels into smaller pieces using a blender or food processor can be considered a form of mashing. This step is essential for extracting the maximum flavour and nutrients from the corn.

Molar Mass: The mass of one mole of a substance, expressed in grams per mole (g/mol), calculated by summing the atomic masses of all atoms in its molecular formula.

Mole: A fundamental unit in chemistry that represents a quantity of substance; one mole contains approximately (6.022 \times 10^ {23}) entities (atoms, molecules, ions, etc.).

Multimeter: A tool used to measure electrical properties like voltage, current, and resistance in a circuit. It helps check if a circuit is working correctly or find problems.

N-type Semiconductor: A semiconductor doped with materials that add extra electrons, making it negatively charged. Example: Silicon doped with Phosphorus.

Nephron: The functional unit of the kidney responsible for filtering blood and producing urine. Each kidney contains about a million nephrons.

Neutralisation: A chemical reaction in which an acid and a base react to form water and a salt, typically resulting in a solution that is neither acidic nor basic.

Occupant behaviour: How people use energy in a building, like turning lights on and off, using appliances, or adjusting heaters and coolers. These habits can affect energy consumption.

Oedema: Swelling caused by excess fluid trapped in the body's tissues, often seen in kidney problems.

P-N Junction: The point where a p-type and an n-type semiconductor meet, forming a special region that controls the flow of electricity.

P-type Semiconductor: A semiconductor doped with materials that create "holes" (missing electrons), making it positively charged. Example: Silicon doped with Boron.

Pathogen: An organism, such as a bacteria or fungus, that can cause disease by invading and damaging the host's tissues.

Pathogen: Microorganisms such as bacteria, viruses, fungi, or parasites that invade the body, multiply, and cause diseases by disrupting normal bodily functions.

pH Scale: A logarithmic scale ranging from 0 to 14 that measures the acidity or alkalinity of a solution, with values below 7 indicating acidity, 7 being neutral, and above 7 indicating alkalinity.

Pharyngeal: Related to the pharynx, which is the part of the throat behind the mouth and nose that helps with swallowing and breathing.

Photodetector: A device that uses diodes to sense light and convert it into electricity, used in cameras and solar panels.

Primary Coil: The coil in a transformer that receives the input voltage (from the power source). It creates a magnetic field around the core.

Prophylactic Antibiotics: Preventive antibiotics given to individuals in certain situations, such as before surgery, to prevent bacterial infections.

Pulmonary: Refers to anything related to the lungs.

Pulmonary: Related to the lungs. The pulmonary system includes all parts of the body that help with breathing.

Quality checks: Regularly test ingredients and final drinks to ensure they taste good.

Rectifier: A device that uses diodes to convert alternating current (AC) into direct current (DC), used in phone chargers and adapters.

Resistance: The property of a material or component that slows down the flow of electric current. In a series circuit, the total resistance is the sum of all individual resistances.

Respiratory hygiene: Actions such as covering your mouth and nose when sneezing or coughing to prevent the spread of airborne germs.

Reverse bias: A condition where the diode blocks electricity because the positive side is connected to the n-type material and the negative side to the p-type material.

Roasting: Cooking food, typically meat or vegetables, by dry heat in an oven or over an open fire. Roasting the corn flour is a crucial step in this recipe, as it develops the rich, nutty flavour that characterizes the final drink.

Sanitation: Practices that promote cleanliness and hygiene, such as proper sewage disposal and maintaining clean living environments, to prevent the spread of diseases.

Secondary Coil: The coil in a transformer that receives the induced voltage from the magnetic field created by the primary coil. The secondary coil delivers the output voltage to the load or device.

Semiconductor: A material that can act as a conductor or an insulator, depending on the conditions (like heat or light). Examples: Silicon, Germanium.

Series Circuit: A type of electrical circuit where all components are connected in a single path, allowing electric current to flow through one route only.

Sieve: A utensil or mesh with a network of small holes used for straining liquids or separating solids from liquids. Sieving is used multiple times in this process, such as separating the sprouted corn kernels from the sprouting medium, separating the corn flour from larger pieces, and straining the boiled corn liquid.

Smart Meter: A digital device that measures how much electricity or gas is used. It sends this information to the energy company automatically and displays it on a screen for easy reading.

Soluble: Capable of being dissolved in a solvent (usually water) to form a solution.

Stability: The ability of a floating object to return to its original position after being tilted or disturbed, often influenced by its centre of gravity.

Steeping: Soaking ingredients in hot water to draw out their taste.

Submergence: The state of being completely or partially covered by a fluid, affecting the amount of fluid displaced and the resultant buoyancy.

Sweat Glands: Specialized glands in the skin that produce sweat to help cool the body and excrete waste products like urea and salts. There are two main types: eccrine glands and apocrine glands.

Symptoms: Signs that indicate a health issue. For example, blood in the urine, high blood pressure, and swelling can be symptoms of kidney disorders.

Tissue: A group of similar cells that work together to perform a specific function in the body.

Trachea: Also known as the windpipe, it's the tube that connects the throat to the lungs, allowing air to flow in and out.

Treatment: Medical care provided to manage or cure a disease or disorder. For kidney disorders, this may include medications, surgery, or lifestyle changes like drinking more water.

Upthrust (Buoyant Force): The upward force exerted by a fluid on an object submerged in it, counteracting the object's weight.

Vaccination: A medical procedure where a vaccine is given to boost the immune system and protect against specific diseases.

Vector control: Measures taken to manage or reduce populations of disease-carrying organisms like mosquitoes and ticks to prevent diseases like malaria and dengue fever.

Ventilation: The movement of air in and out of the lungs. This is how oxygen enters and carbon dioxide exits the body.

Voltage Drop: The reduction in voltage as electric current passes through a component, like a resistor or a bulb, in the circuit.

Volume: The amount of space occupied by an object or substance, typically measured in cubic units (such as cubic meters, litres, or gallons). In the context of fluids and buoyancy, the volume of an object determines how much fluid it displaces when submerged, which affects the upthrust or buoyant force acting upon it.

Weight: The force exerted on an object due to gravity, which is balanced by the buoyant force when an object floats.

Zoonotic diseases: Diseases that are transmitted from animals to humans, often caused by bacteria, viruses, or parasites found in animals.

This book is intended to be used for the Year Two General Science Senior High School (SHS) Curriculum. It contains information and activities to support teachers to deliver the curriculum in the classroom as well as additional exercises to support learners' selfstudy and revision. Learners can use the review questions to assess their understanding and explore concepts and additional content in their own time using the extended reading list provided.

All materials can be accessed electronically from the Ministry of Education's Curriculum Microsite.

[Scan the QR Code to visit the website]

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