KEMENTERIAN PENDIDIKAN MALAYSIA

DUAL LANGUAGE PROGRAMME

# ADDITIONAL SCIENCE

FORM 5

KURIKULUM STANDARD SEKOLAH MENENGAH
KSSM
KEMENTERIAN PENDIDIKAN MALAYSIA

# RUKUN NEGARA

**Bahawasanya Negara Kita Malaysia**
mendukung cita-cita hendak;

Mencapai perpaduan yang lebih erat dalam kalangan
seluruh masyarakatnya;

Memelihara satu cara hidup demokrasi;

Mencipta satu masyarakat yang adil di mana kemakmuran negara
akan dapat dinikmati bersama secara adil dan saksama;

Menjamin satu cara yang liberal terhadap
tradisi-tradisi kebudayaannya yang kaya dan pelbagai corak;

Membina satu masyarakat progresif yang akan menggunakan
sains dan teknologi moden;

MAKA KAMI, rakyat Malaysia,
berikrar akan menumpukan
seluruh tenaga dan usaha kami untuk mencapai cita-cita tersebut
berdasarkan prinsip-prinsip yang berikut:

**KEPERCAYAAN KEPADA TUHAN**
**KESETIAAN KEPADA RAJA DAN NEGARA**
**KELUHURAN PERLEMBAGAAN**
**KEDAULATAN UNDANG-UNDANG**
**KESOPANAN DAN KESUSILAAN**

(Sumber: Jabatan Penerangan, Kementerian Komunikasi dan Multimedia Malaysia)

KURIKULUM STANDARD SEKOLAH MENENGAH
*DUAL LANGUAGE PROGRAMME*

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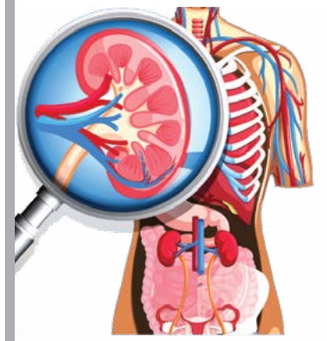
# CONTENTS







# INTRODUCTION

The **Form 5 Additional Science** textbook is written based on the latest Ministry of Education Malaysia (KPM) curriculum, *Dokumen Standard Kurikulum dan Pentaksiran* (DSKP) for Form 4 and 5. The objectives of this subject are to inculcate interests and develop students' creativity through experience and investigation. These will assist them to master the knowledge of science and technology as well as scientific and moral attitude to enable them to solve the problems and make decisions in their daily lives, in line with the 21st century education needs.

Therefore, this book is written by focusing on the process of mastering the skills and knowledge of science through student-centred learning. In line with this aim, this book uses a variety of approaches, such as investigation, experimental, project-based learning, problem-based learning, cooperative learning, contextual learning and future learning.

In the process of writing the book, we also took into consideration ways to improve students' thinking skills especially in building higher order thinking skills (HOTS). This is to produce students who are creative and innovative. The priority is also given to develop values such as patriotism and citizenship.

This book is structured as the following:

**Theme Introduction**

This book consists of four (4) themes and each theme contains several chapters.

**Chapter Introduction**

This book consists of eight (8) chapters and each chapter starts with a stimulus that is printed in double spread.

The special features are as follow:

**Science Info**

Delivers additional information that relates to the learning topic.

**Be Careful!**

A reminder to students about things that can be dangerous while performing experiments or laboratory activities.

**Mind Challenge**

Questions that challenge students' mind.

**Wonderful Malaysia**

Delivers information about patriotic elements, cultures or achievements of Malaysians in the world arena.

**Formative Exercises**

Formative assessments to ensure that students will master the content standard.

**Science Profession**

Provides information on professions related to science.

**Value**

Cultivates positive attitude and values in students.

**Science is Easy!**

Tips or steps to remember science facts.

**HOTS**

The HOTS questions test the students' ability to apply knowledge, proficiency and value in making an emphasis and reflection in problem solving, decision making, innovating and creating.

1.1.1

Learning Standard following *Dokumen Standard Kurikulum dan Pentaksiran (DSKP).*

**Digital components**

In line with digital development, the book also includes QR code.

VIDEO

INFORMATION

ATTACHMENT



Types of activities in this book:


**21st Century Learning**

PAK 21

21st century skills include:

- Thinking and problem solving skills.
- Interpersonal and self-directional skills.
- Information and communication skills.

**STEM (Science, Technology, Engineering and Mathematics)**

Apply and integrate the knowledge, skills and value through the inquiry approach, project-based learning and problem-based learning in the real-world context in STEM subjects which are Science, Technology, Engineering and Mathematics. This approach attracts students to venture into STEM-related career.

**Green Technology Module CETREE CHEMICAL**

Develop Higher Order Thinking Skills (HOTS) based on inquiry activities, projects, data analyses, and assessments through challenging activities. Each module contains guides, students' worksheets, interactive materials, stimulations and tests.

Notes: *Modul Teknologi Hijau*, prepared by CETREE USM, is only available in Bahasa Melayu.

At the end of each chapter, the followings are included:

### Summary

The formula of learning in the form of a concept map that helps students to understand the chapter.

### Self-reflection

The checklist is concise and assesses students' learning.

### Summative Practice

Assessment to test the understanding and mastery of students. The questions consist of various levels of Low Order Thinking Skills (LOTS) and High Order Thinking Skills (HOTS).

**Check answers**

Scan QR code to get the answer suggested for the chapter.

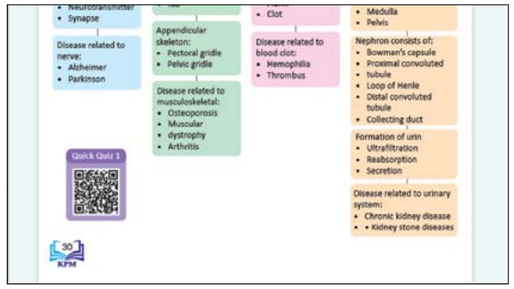
**Quick Quiz 1**

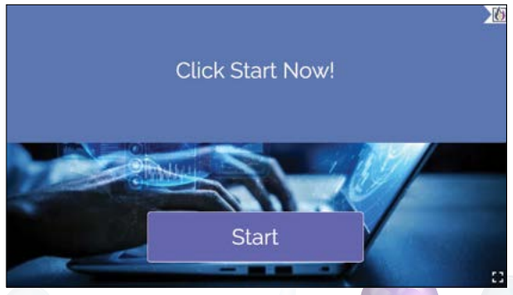
Scan QR code to answer interactive quiz at the end of the chapter.

Guide to answer interactive quiz:

**Step 1**
Scan QR code that has a Quick Quiz icon.

**Step 2**
Click Start button.






# THEME 1

# MAINTENANCE AND CONTINUITY OF LIFE

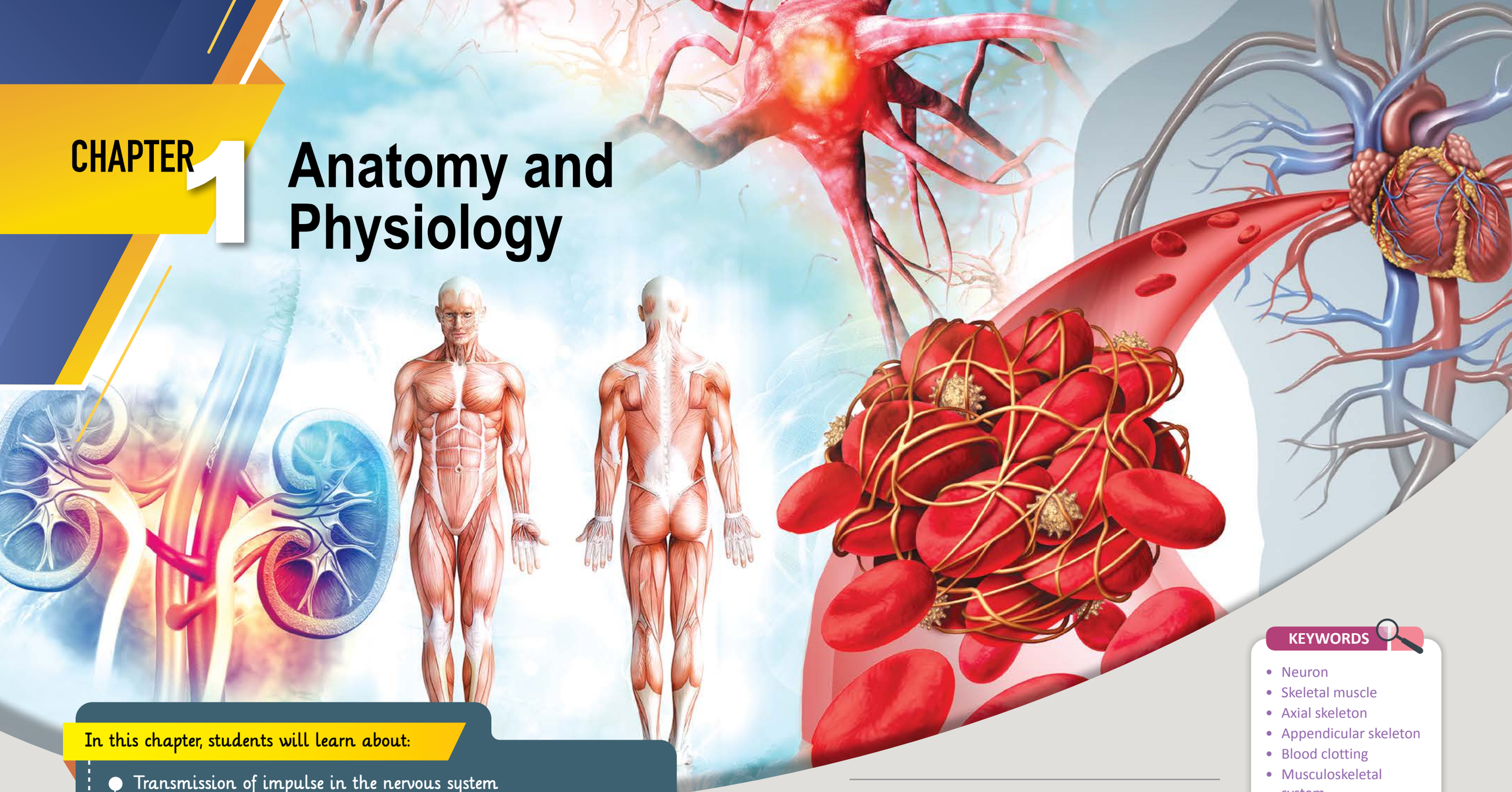
This theme explains human's anatomy and physiology which covers four parts in human's body system, which are nervous system, musculoskeletal system, circulatory system and urinary system.

Nervous system explains how impulse being transmitted across neurons. Musculoskeletal system studies about human skeleton, muscles, ligaments and tendon actions during muscle movements. Circulatory system focuses on the mechanism of blood clotting. The urinary system studies the structure and urine production process.

In this theme, students also study about diseases related to these four systems.

CHAPTER 1

# Anatomy and Physiology



**In this chapter, students will learn about:**

- Transmission of impulse in the nervous system
- Skeletal muscle movement in the musculoskeletal system
- Blood clotting mechanism in the blood circulatory system
- Urine production in the urinary system

Faiz accidentally touched a hot tray. He quickly moved his hand. How did he receive information to move his hand? What is the system involved in this situation besides nervous system?

**KEYWORDS**

- Neuron
- Skeletal muscle
- Axial skeleton
- Appendicular skeleton
- Blood clotting
- Musculoskeletal system
- Circulatory system
- Nervous system
- Urinary system

# 1.1 Transmission of Impulse in the Nervous System

Have you ever thought how information is sent in the human body's system? What are the systems involved? When there are stimulations such as needle pricking the finger, the receptor inside the human body will detect it. There are **six types of receptors**, that are:

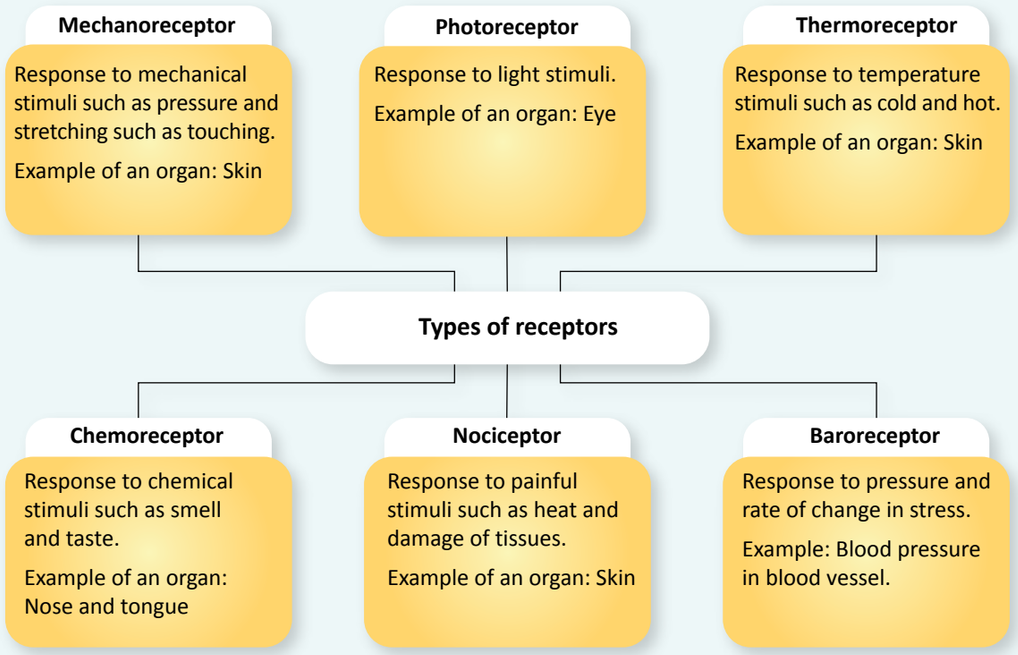



**Figure 1.1** Types of receptors

When the receptors detect the stimulus, the received information is transmitted to the brain through the nervous system for the brain to interpret in order to respond to the stimulus detected. The organs that carry out responses from the stimulus are known as **effectors**. There are two types of effectors which are **muscles** and **glands**. All receptors and effectors are connected to the nervous system by neuron.

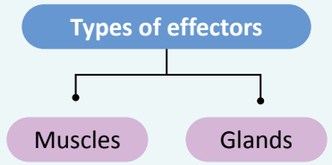



**Figure 1.2** Types of effectors

## Types, Structures and Functions of Neuron

### Type and Function of Neuron

The nervous system consists of nervous cell named neuron. The message that a neuron carries is in the form of an electrical signal called a nerve impulse.

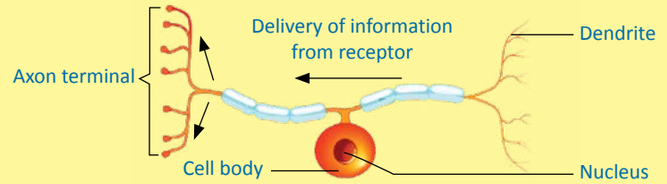




There are **three types of neurons** which are connected to send nervous impulse in the nervous system.

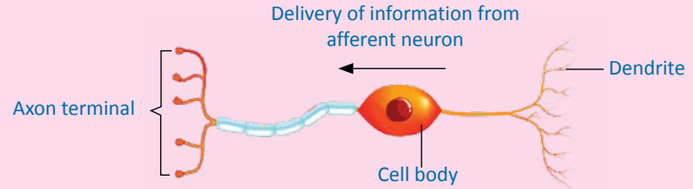
**Afferent Neuron**

- Carries nerve impulse from receptor to central nervous system (brain and spinal cord).
- Found in the dorsal root of the spinal cord.




**Interneuron**

- Carries nerve impulse from an afferent neuron to an efferent neuron.
- Found in the central nervous system.




**Efferent Neuron**

- Carries nerve impulse from central nervous system to effectors (muscles and glands).
- Found in ventral roots of the spinal cord.

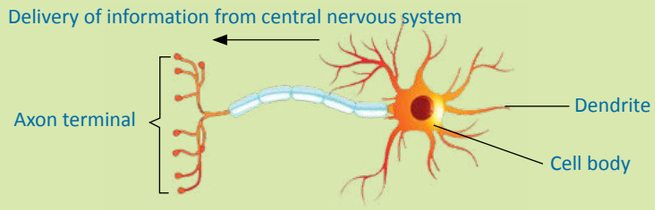



**Figure 1.3** Types of neurons

### Structure of a Neuron

Each neuron consists of a cell body that contains nucleus and cytoplasm that has thread like extensions called dendron or axon as in Figure 1.4.

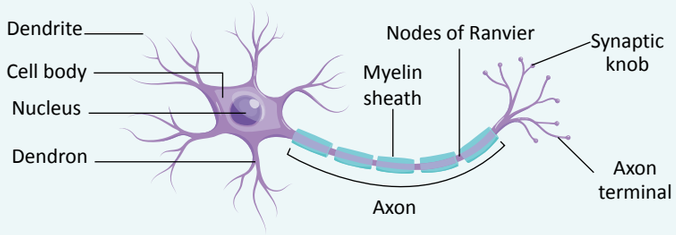



**Figure 1.4** Structure of a neuron

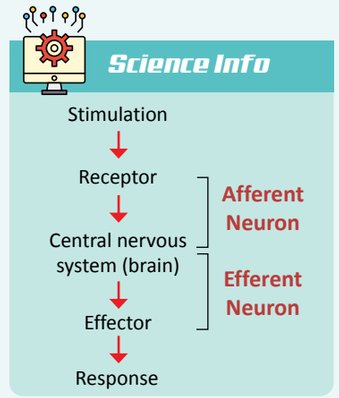


**Table 1.1** Structure of neuron and its function

| Neuron structure | Function |
|---|---|
| Cell body | Integrates signals and coordinates metabolism activity. |
| Dendron | Transmits nerve impulse from dendrites to cell body. |
| Axon | Transmits nerve impulse away from the cell body. |
| Dendrite | Receives nerve impulses. |
| Myelin sheath | Insulates nerve impulses, protects nerve fibres from injury and supplies nutrients to neurons. |
| Nodes of Ranvier | Enables nerve impulses to jump from one Nodes of Ranvier to the next Nodes of Ranvier. |
| Nucleus | Controls neuron activities. |
| Axon terminal | Sends nerve impulse out from cell body to the synaptic knob. |
| Synaptic knob | Sends signals to muscle cells, glandular cells or other dendrite neurons. |

The transmissions of nerve impulse occur in two ways:

**1** Impulse transmission along the neuron in the form of **electrical signal** which involves change of charge in membrane.

**2** Impulse transmission across the synapse in the form of **chemical signal** which involves neurotransmitter.

**Figure 1.5** Nerve impulse transmissions

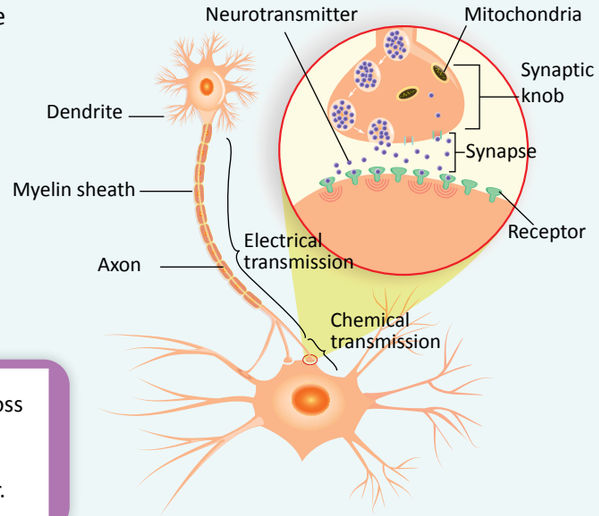



**Figure 1.6** Types of nerve impulse transmissions

### Activity 1.1

**Aim:** To create a mind map to recall the types, structures and functions of neurons and also the transmission of nerve impulse.

**Instruction:**

1. Create a mind map to help you to recall the types, structures and functions of neurons and the transmission of nerve impulse.
2. Share your findings with your friends.





## The Process of Nerve Transmission along the Neuron

Neurons are not connected to each other. There are narrow gaps between the axon terminal and dendrite of adjacent neuron which is called a **synapse** as in Figure 1.7.

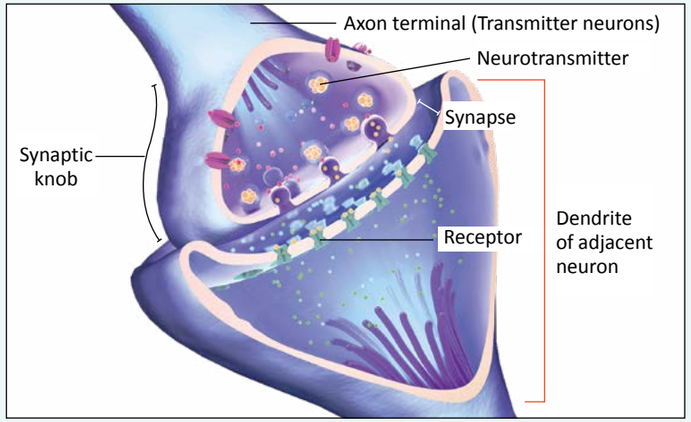


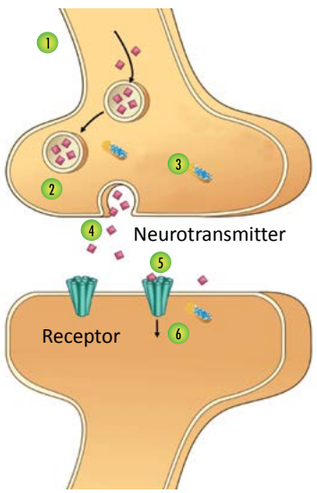

**Figure 1.7** Nerve impulse across synapse

**Science is Easy!**

Electrical impulse
↓
Synapse
↓
Chemical impulse
↓
Electrical impulse

Nerve impulse from transmitter neurons can only be carried across the synapse by chemical impulse. The axon terminal has a swollen part called a synaptic knob which contains a lot of synaptic vesicles and mitochondria. The synaptic vesicle is filled with chemicals called neurotransmitters.

The process of transmission across synapse is in Figure 1.8. Synapses keep the transmission of nerve impulse in one direction only.




1. **Nerve impulse** reaches to **synaptic knob** in axon terminal.
2. **Synaptic vesicle** is stimulated and releases neurotransmitters into the synapse.
3. **Mitochondria** generates energy for nerve impulse across the synapse.
4. **Neurotransmitters** permeate across the synapse to the dendrites of the receiving neurons.
5. The binding of **neurotransmitters** and the **receptors** generate a new electrical impulse.
6. **Transmission of impulse** across the synapse involves conversion of **electrical** impulse into **chemical** impulse, and then reconversion of **chemical** impulse into **electrical** impulse.

**Figure 1.8** The process of transmission of nerve impulses across the synapses

Activity in the synapse may increase or decrease the potential for nerve impulse action. It depends on the types of synapse. There are two types of synapses, namely excitatory synapse and inhibitory synapse as in Figure 1.9.

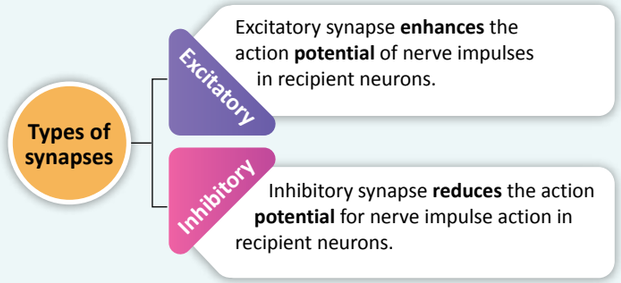



**Figure 1.9** Types of synapses

In each synapse, there are two neurotransmitters that is an excitatory neurotransmitter and an inhibitory neurotransmitter.

**Table 1.2** Types of neurotransmitters

| Excitatory neurotransmitter | Inhibitory neurotransmitter |
|---|---|
| • Acetylcholine<br>• Dopamine<br>• Histamine | • Gamma-aminobutyric asid (GABA)<br>• Glycine |

Acetylcholine is an example of excitatory neurotransmitter. Acetylcholine is synthesised from choline and acetyl coenzyme A in the cytoplasm of synaptic terminal and stored in the synaptic vesicle. Acetylcholine is abundant in neuromuscular and neurons in the brain. It is a neurotransmitter that activates muscle movement as well as brain intelligence. Reduction in acetylcholine secretion causes difficulty in controlling muscle movement, lack of intelligence, loss of memory and lack of focus.

GABA is an inhibitory neurotransmitter. It acts to prevent and reduce nerve impulses. The role of GABA is important in sensory, cognitive and motor control. For example, GABA helps control fear and guidance when the nerve impulses become too much. Psychiatric and neurological disorders often occur because of changes in GABA levels. Low levels of GABA can cause anxiety, depression, schizophrenia and extreme sleep disorders.

## Effects of Pesticides and Drugs on Nerve Function

**Pesticides** are chemicals or mixtures of chemicals used to control pests in agriculture industry. **Drugs** are chemicals that can change a person's body function and behaviour.

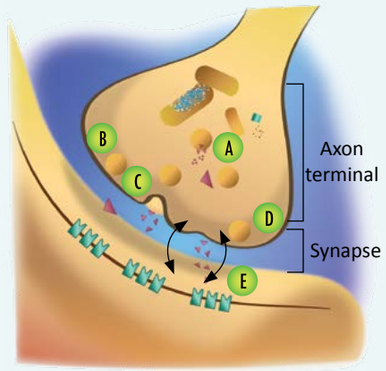

**Photograph 1.1** Pesticide

1.1.2 1.1.3





Figure 1.10 shows the effects of pesticides and drugs on neurotransmitters.




A Leak of neurotransmitter from vesicle to cytoplasm.
B Block transmitter from being released into synapse.
C Increase transmitter release into synapse.
D Inhibit transmitter synthesis.
E Prevent the transmission of neuro transmitters at the adjacent neuron receptors.

**Figure 1.10** The effects of drugs and pesticides on neurotransmitter

If there is a disruption in the neurotransmitters in the human nervous system, it will certainly affect the whole system of the human body.

The effects of taking drugs excessively and prolong exposure to pesticides can affect heart rate, respiratory rate and blood pressure.

There are two types of drugs; stimulant drugs and calming drugs.

- **Stimulant drugs** accelerate the stimulation of the body's nervous system and give addictive effect.
- **Calming drugs** slow down the activity of the central nervous system which can cause memory loss and lack of concentration.

**Science Info**

Pesticides can enter our body through:

- skin pore
- respiratory tract
- food

### Activity 1.2

**Aim:** To study the effects of pesticides and drugs on human nervous system.

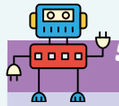
**Instruction:**

1. Do an active reading on the effects of pesticides and drugs on the transmission of impulse synapse.
2. Explain in details the effects of pesticides and drugs on impulse transmission in synapse such as:
   (a) modification of neurotransmitter storage and release.
   (b) modification of neurotransmitter interactions in synapses.
   (c) reabsorption and destruction of neurotransmitter affects.
   (d) neurotransmitter replacement.
3. Design a brochure.
4. Share your work with your friends and teachers.

1.1.3

## Neurological Diseases

Ageing is one of the causes of neurological diseases such as Alzheimer's and Parkinson's. Let's look at the features of these diseases in Figure 1.11.



**Science Profession**

Physiotherapists help Parkinson's patients with exercise therapy.

**Neurological Diseases**

| Alzheimer's disease | Parkinson's disease |
|---|---|
| Neurological disease | Progressive disorders in the central nervous system |
| **Causes:**<br>• shrinkage of brain tissues<br>• lack of neurotransmitters (acetylcholine) in brain | **Causes:**<br>• hardening of the cerebral arteries<br>• reduced level of neurotransmission (dopamine) in the brain |
| **Factors:**<br>• ageing process<br>• genetic or inherited factor<br>• lifestyle and environment such as smoking | **Factors:**<br>• ageing process<br>• lifestyle and environment |
| **Symptoms:**<br>• loss of memory<br>• deterioration of thought<br>• poor concentration | **Symptoms:**<br>• trembling movement<br>• weakness of the muscle<br>• body balance issues and coordination disorders |
|  Healthy and normal brain<br>  Alzheimer's patient's brain<br>  Cross section of a normal brain<br>  Cross section of an Alzheimer's patient's brain |  Patient with tremor |

**Figure 1.11** Neurological diseases





### Activity 1.3

According to the Alzheimer's Disease Foundation Malaysia (2016), there are 50 000 people reported to have this disease in Malaysia. Usually this disease is not reported because it is thought to be common due to increased age factors.

**Aim:** To study Alzheimer's disease among Malaysians.

**Instruction:**

1. Based on the above statement, conduct a study on Alzheimer's disease among Malaysians.
2. Collect information from printed and electronic materials.
3. You can also visit the Neurology Unit of the hospital and the senior care centre.
4. Prepare your folio based on the following format:
   - (a) Title
   - (b) Objective
   - (c) Content
     - (i) Explain Alzheimer's disease.
     - (ii) State the problem experienced by Alzheimer's elderly patients.
     - (iii) Provide report on activities undertaken to assist inpatient at care centres.
   - (d) Conclusion
     - (i) Explain what you have learned from this visit.
     - (ii) What moral values have you gained from this visit?

### Activity 1.4

**Aim:** To study Alzheimer's and Parkinson's diseases.

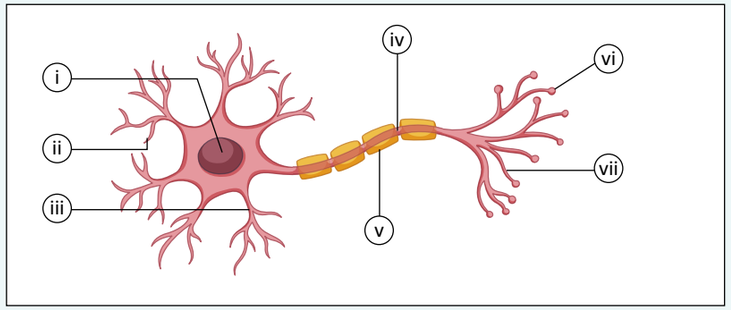
**Instruction:**

1. Create a multimedia presentation and conduct a sharing session with friends at your school and local community about Alzheimer's and Parkinson's diseases in the following aspects:
   - (a) symptoms
   - (b) causes of illness
   - (c) methods of treatment and handling of patients
   - (d) prevention actions

## Formative Exercise 1.1

1. Figure below shows a neuron.

   (a) Label the following neuron structure:




   (b) State how the information is transmitted along the neuron.

2. Give **two** examples of diseases related to the nervous system.
3. What is the difference between Alzheimer's and Parkinson's diseases?
4. What is the meaning of drug and pesticide abuse?
5. What are the effects of drugs that disrupt neurotransmitter in the nervous system?

# 1.2 Skeletal Muscle Movement in the Musculoskeletal System

The ability to move from one place to another is one of the humans speciality. Human's movement such as walking, running and jumping is through musculoskeletal system. Imagine how difficult it would be if we were unable to move.



**Photograph 1.2** Example of human movement





## Necessity for Support and Locomotion in Human

Why does human need to move? Is there any necessity for support and locomotion in human?

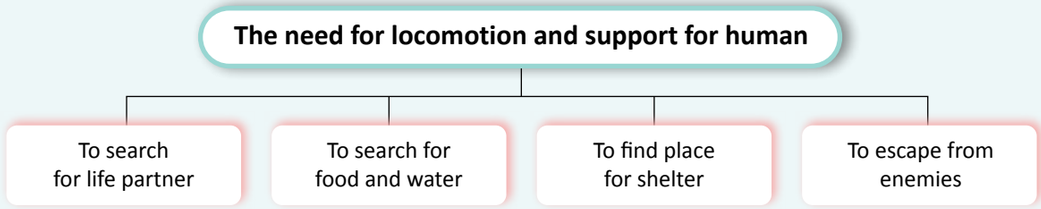



**Figure 1.12** The need for locomotion and support for human

## Axial and Appendicular Skeleton in Human Skeletal System

The human skeleton consists of 206 bones with variety of sizes and shapes. There are two parts of skeleton; **axial skeleton** and **appendicular skeleton**. Figure 1.13 shows the human skeleton system.

Axial skeleton consists of skull, vertebral column, and ribcage. Axial skeleton is the skeleton that supports the main part of the body.

### Axial Skeleton

#### Skull

(a) Consists of cranial bones and facial bones.

(b) Cranial bones are made up of flat bones fused together to form immovable joint and protect the brain.

(c) The facial bones give the shape of the face and provide eye sockets for the eyeballs to be located.

(d) The lower jaw bone or mandible, forms movable joint with cranium to allow the mouth to open and close.

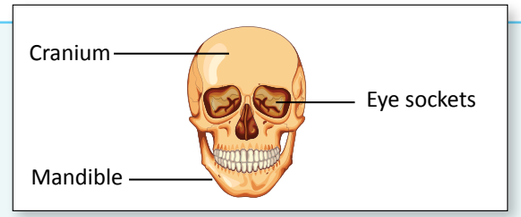



**Figure 1.14** Skull

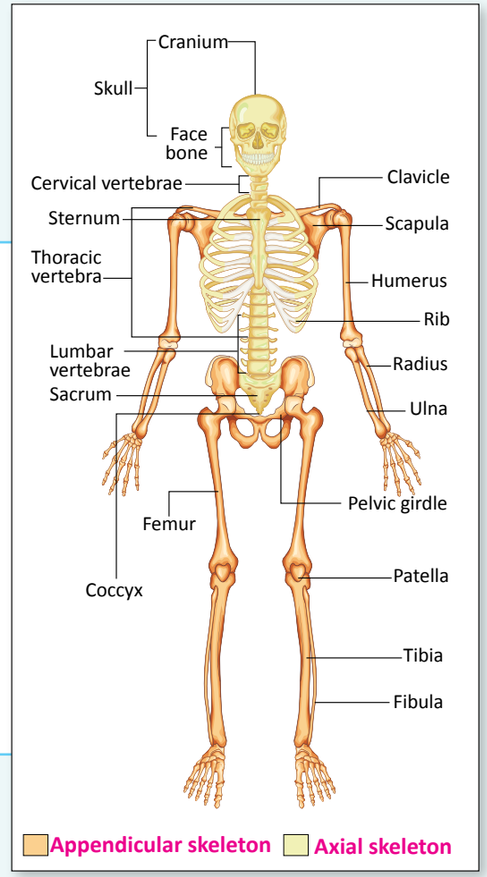



**Figure 1.13** Human skeletal system

1.2.1 1.2.2

## Vertebral Column

(a) Vertebral column consists of 33 small vertebral bones or vertebrae which are attached together by joints to form a slightly curved, strong and flexible column.

(b) It works to support the skull and protect the spinal nerves that are in the spinal cord.

(c) The cartilage disc sandwiched between each pair of vertebrae as in Figure 1.15 is to absorb shock and reduce friction when we move.

(d) Each vertebral column has centrum, neural canal and several bony processes as in Figure 1.16.

(e) Each structure has the following functions:

- Centrum is a solid structure that supports and withstands compression.
- Neural canal is the cavity in the middle of the vertebra to accommodate the spinal cord.
- Spinous process and transverse process provide a surface for muscle attachment.
- Superior articular process is a surface to intersect with other vertebrae.
- Vertebral arch protects the spinal cord.

(f) Vertebral column has five different types of vertebrae as in Figure 1.17.

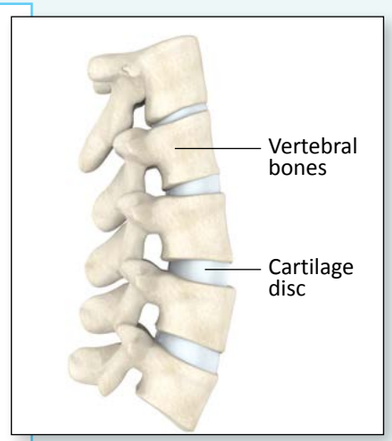



**Figure 1.15** Cartilage disc

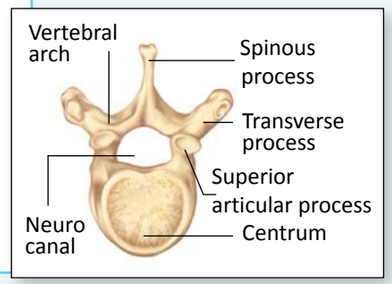



**Figure 1.16** Vertebral bones

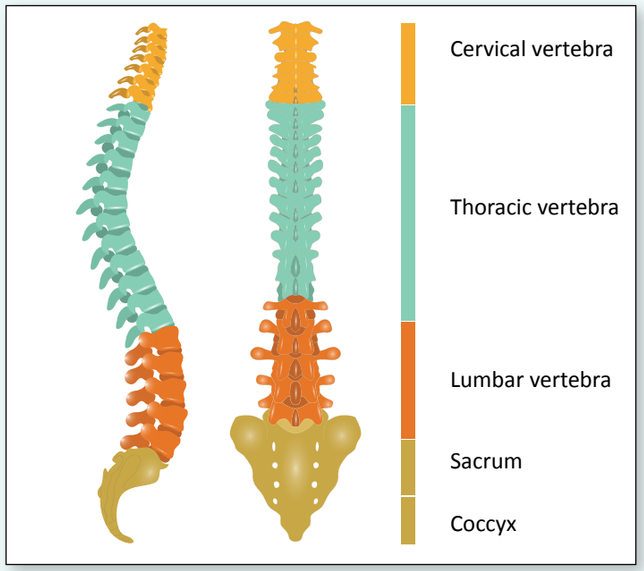



**Figure 1.17** Five parts of vertebral column

**Science Info**

The amount of bones in a newborn baby is 270. These numbers decrease when the baby grows up because some bones merged such as sacrum and coccyx.





Let's look at the five types of vertebrae.

### Cervical vertebrae

(a) There are seven cervical vertebrae.

(b) It has a pair of vertebrarterial canals as in Figure 1.18.

(c) The first cervical vertebra is the atlas and has no centrum as in Figure 1.19. However, it has short spinous process and with a thin and wide transverse process to allow us to nod our heads.

(d) Second cervical vertebra is the axis and has odontoid process to allow us to move our head, for example to say "no" as in Figure 1.20.

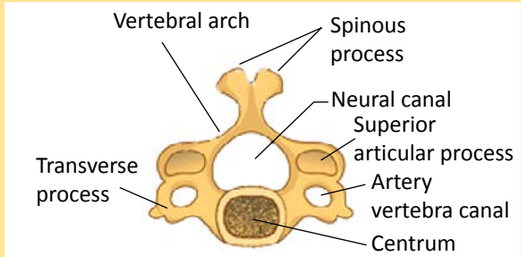



**Figure 1.18** Cervical vertebra

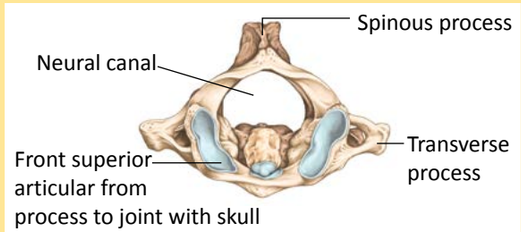



**Figure 1.19** Atlas vertebra

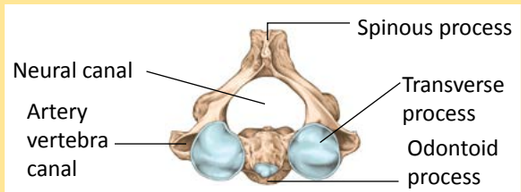



**Figure 1.20** Vertebra axis

### Thoracic vertebrae

(a) There are 12 thoracic vertebrae.

(b) They possess long, backwardly pointing spinous processes and short transverse processes.

(c) Spinous process is for attachment of muscles, ligaments and supports the head and neck.

(d) Centrum is bigger compared to cervical vertebrae.

(e) The transverse process articulate with the ribs as in Figure 1.22.

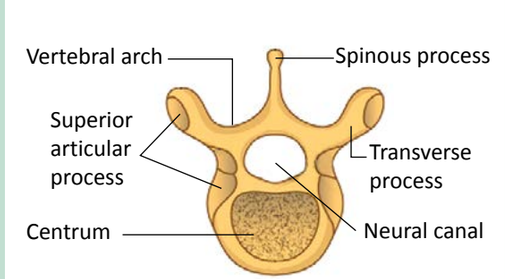



**Figure 1.21** Thoracic vertebra

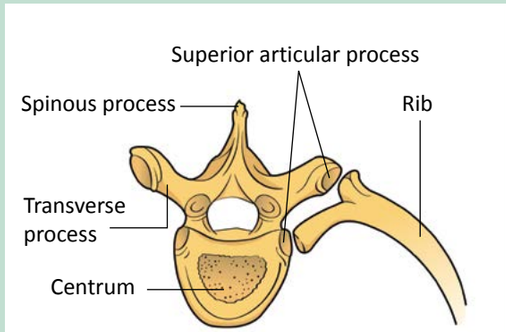



**Figure 1.22** Joints between thoracic vertebra and rib

## Lumbar vertebrae

(a) There are five lumbar vertebrae and are the biggest vertebrae in vertebral column.

(b) It has short spinous process and long and thin transverse process.

(c) The spinous process and transverse process provide a space for muscles of the back attach to the spine.

(d) It has a short and big centrum.

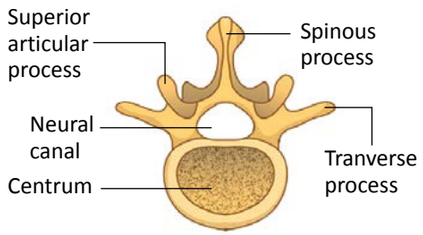



**Figure 1.23** Lumbar vertebra

## Sacrum

(a) Consists of five vertebrae fused together to form a board triangular structure as in Figure 1.24.

(b) All five vertebrae have small and fused together spinous process.

(c) It has four canals that allow blood vessel and nerve to pass through it.

(d) It has transverse process for attachment with pelvic girdle.

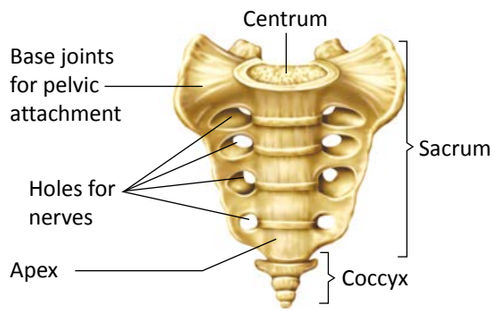



**Figure 1.24** Sacrum

## Coccyx

(a) Consists of four vertebral bones which are fused together to form a sharp triangular structure as in Figure 1.25.

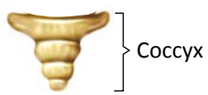



**Figure 1.25** Coccyx

## Ribcage

The ribcage is made up of 12 pairs of ribs and they articulate with the sternum. Not all ribs articulate with the sternum. The first seven pairs are known as true ribs and articulate with sternum through cartilage. Another three pairs are known as false ribs and articulate to the sternum through the seventh ribs. The 11th and 12th pairs are known as floating ribs and do not articulate with the sternum.

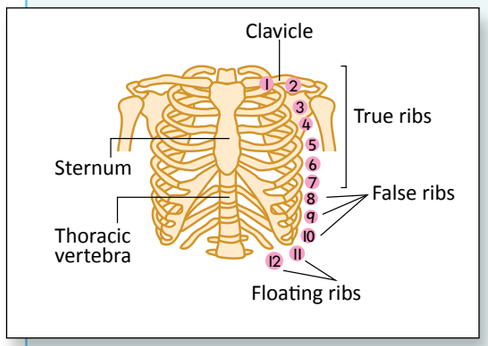



**Figure 1.26** Ventral view of ribcage





## Appendicular Skeleton

Appendicular skeleton consists of pectoral and pelvic girdle.

### Pectoral girdle

(a) Pectoral girdle consists of clavicle, scapula, humerus, radius, ulna, carpals, metacarpals and phalanges.

(b) Clavicle is a long and slender rod-shaped bone located at the left and right of the neck.

(c) Scapula is a flat, triangular-shaped bone located at the dorsal part of the body.

(d) The upper end humerus articulates with the scapula and clavicle. The lower end humerus articulates with radius and ulna. Radius and ulna articulate with humerus and carpals.

(e) Carpals make a wrist of the hand with eight bones that is arranged in two rows. This arrangement allows the hand to twist.

(f) Metacarpals make a palm of hand with five small bones.

(g) Phalanges are finger bones which consist of 14 bones. Each finger has three phalanges except for the thumb which only has two phalanges.

**Science Info**

Pectoral girdle is also known as forelimb, while pelvic girdle is known as hind limb.

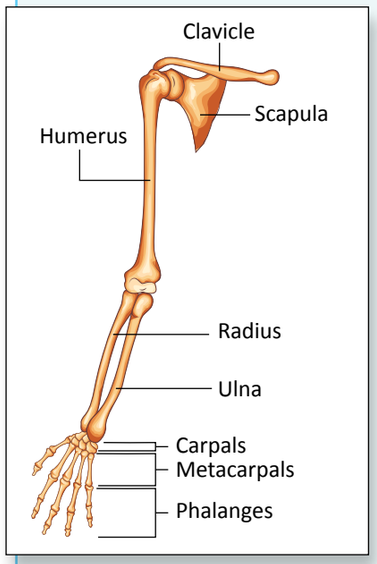



**Figure 1.27** Pectoral girdle

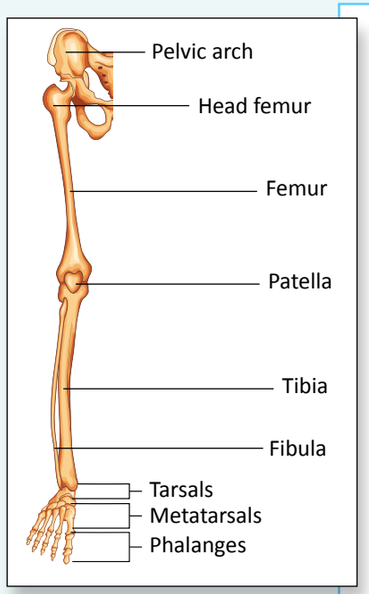



**Figure 1.28** Pelvic girdle

### Pelvic girdle

(a) Pelvic girdle consists of femur, patella, tibia, fibula, tarsals, metatarsals, phalanges and a pair of pelvic arch, comprising three bones; ilium, ischium and pubis.

(b) Pelvic girdle provides a connection between the axial skeleton and the hind limbs.

(c) The pelvic arch forms joint with the femur head on the side and connects on the anterior part to the sacrum.

(d) The femur is the longest, heaviest and strongest bone in the human body.

(e) Patella or knee cap is located in front of the articulate between femur and tibia.

(f) Calf bone is made up of tibia and fibula. Tibia is bigger compared to fibula. Tarsus is an ankle bone made up of seven bones.

(g) Five bones of metatarsals make up a foot and 14 phalanges forming the toe.

### Activity 1.5

**Aim:** To identify the structure of human skeleton.

**Instruction:**

1. Identify the structure of human skeleton using the human skeleton model or Freeware Human Anatomy Atlas application on smartphone or tablet.
2. Present your work in front of the class.

## Creation of a Model that Describes the Actions and Functions of the Muscles, Ligament and Tendons during the Movement of the Human Body

After identifying the axial and appendicular skeleton, can you imagine how the limbs would function and move?

INFORMATION

Action of muscle, ligament dan tendon

### Activity 1.6

**Aim:** Create a model of the action of muscles, tendons and ligaments in the movement of limbs.

**Materials:** Ice cream stick, rubber band, iron wire, long balloons, thread, screws and thumbtacks.

**Instruction:**

1. Create a Forelimb Model as shown in Figure 1.29 using the material listed.
2. Move ice cream stick K to an angle less than 90° against ice cream stick L. Then, move ice cream stick K greater than 90°.
3. Observe the condition of the two balloons as you perform step 2.

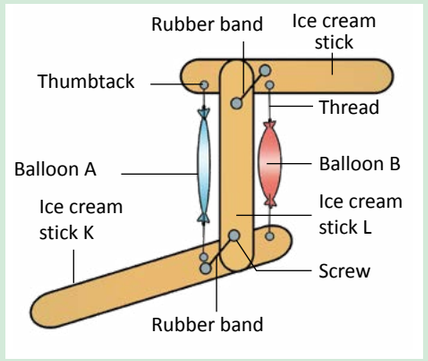



**Figure 1.29**

**Discussion:**

1. What part of the human body can be represented by:
   (a) balloon (c) ice cream stick K
   (b) thread (d) ice cream stick L
2. Describe how the limbs can be bent and straightened.
3. Where does the muscle get the energy to move the arms?

**Conclusion:** State your conclusion from this activity.

From Activity 1.6, can you identify other structures involved in the movement of human limbs?





## Experiment to Test the Strength of Bone

### Experiment 1.1

**Problem statement:** Does bone density affect its strength?

**Aim:** To identify the strength of bone by using glass tube model.

**Hypothesis:** The higher the density of the bone, the stronger it becomes.

**Manipulated variable:** Type of glass tube

**Responding variable:** Number of weight supported

**Constant variable:** Length of glass rod and glass tube.

**Material:** Thread.

**Apparatus:** Two retort stands, 30 cm glass rod, 30 cm glass tube and 500 g weight.

**Be Careful!**

- Be careful when putting the weight on the glass rod and glass tube.
- Be careful with broken glass.

**Procedure:**

1. Place two retort stands at a specified distance.
2. Place the glass rod between the two retort stands as in Figure 1.30.
3. Determine the midpoint of the length of the glass rod.
4. Hang the weight at the midpoint.
5. Add the weight one at a time until the glass rod is broken.
6. Record the weight used to break the glass rod in Table 1.3.
7. Repeat the experiment by replacing the glass rod with a glass tube.
8. Repeat steps 2 to 6.

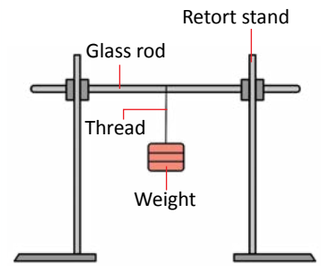



**Figure 1.30**

INFORMATION

Bone strength

**Observation:**

**Table 1.3**

| Type of bone model | Total weight supported |
|---|---|
| Glass rod | |
| Glass tube | |

**Discussion:**

1. Based on the observation in Table 1.3, state which type of bone is stronger.
2. State the relationship between density and strength of bone.

**Conclusion:** Is the hypothesis accepted? State your conclusion.

## Experiment to Test the Relationship between Calcium Composition and Bone Density

### Experiment 1.2

**Problem statement:** What is the correlation between calcium content in bone and bone density?

**Aim:** To identify the relationship between calcium composition in bone and bone strength.

**Hypothesis:** The higher the calcium composition, the higher the density of the bone.

**Manipulated variable:** Type of solution

**Responding variable:** Condition of bone after soaking in solution

**Constant variable:** Type of bone used

**Materials:** Chicken bones (drumstick), vinegar and distilled water.

**Apparatus:** Beaker and clamp.

**Procedure:**

1. Label beaker A and B.
2. Fill beaker A with vinegar and beaker B with distilled water.
3. Place chicken bones in both beakers.
4. Soak chicken bones for three days.
5. After three days, remove both chicken bones and rinse with distilled water.
6. Bend both chicken bones using your hands.
7. Record your observation in Table 1.4.

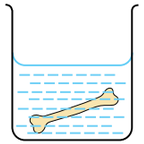



**Figure 1.31**

**Observation:**

**Table 1.4**

| Beaker | Flexibility |
|---|---|
| A (Soak in the vinegar) | |
| B (Soak in the distilled water) | |

**Discussion:**

1. Based on Table 1.4, bone in which beaker is stronger? Give your reasons.
2. Why vinegar is used for this experiment?
3. State the relationship between composition of calcium and density of bone.
4. What is the relationship between calcium content in the bone with the strength of bone?

**Conclusion:** Is the hypothesis accepted? State your conclusion.

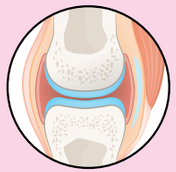
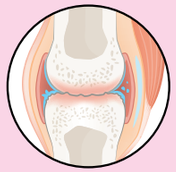




## Diseases Related to Musculoskeletal System

An impaired musculoskeletal system may result from an unbalanced diet, poor posture, the process of ageing and genetic factors. These factors cause diseases such as osteoporosis, muscular dystrophy and arthritis.

**Table 1.5** Diseases related to musculoskeletal system

| Problems in musculoskeletal system | Symptoms | Causes | Treatments and ways to prevent |
|---|---|---|---|
| **Osteoporosis**<br>  <br>Healthy bone<br>  <br>Osteoporosis | • Bones become porous.<br>• Bones become light and easily cracked. | • Lack of vitamin D, calcium and phosphorus.<br>• For women who have gone through menopause, no more secretions of estrogen hormone. | • Take a high calcium diet such as milk, cheese and anchovies.<br>• Do antigravity exercises like jumping to help increase bone mass. |
| **Muscular dystrophy**<br>  <br>Healthy muscle<br>Muscular dystrophy | • Muscles degeneration and become weak, sufferer unable to move his limbs. | • Genetic disease because of mutant gene on chromosome X. | • There is no specific treatment for this disease.<br>• For time being, the doctor injects steroids into the damaged muscles to strengthen the muscles but it does not solve this problem. |
| **Arthritis**<br>  <br>Normal joint<br>  <br>Arthritis joint | • Degeneration or inflammation of joint.<br>• Joints become swollen, stiff and painful. | • Deposition of uric acid in the joint.<br>• Inflammation of synovial membrane.<br>• Wear and tear of cartilage inside the joints. | • Ensuring ideal weight and maintaining a balanced diet.<br>• Glucosamine intake to aid in the development of cartilage in the elderly. |

### Activity 1.7

**Aim:** Communicate about disease related to musculoskeletal system.

**Instruction:**

1. Carry out this activity in groups.
2. Gather information about diseases related to musculoskeletal system, which are osteoporosis, muscular cramp, muscular dystrophy and arthritis including symptoms, causes, treatments and ways to prevent.
3. Present the information to the class.

### Formative Exercise 1.2

1. State the need of movement and support for human.
2. List **five** types of vertebrae.
3. Gives examples of diseases related to the musculoskeletal system.
4. How can osteoporosis be prevented?

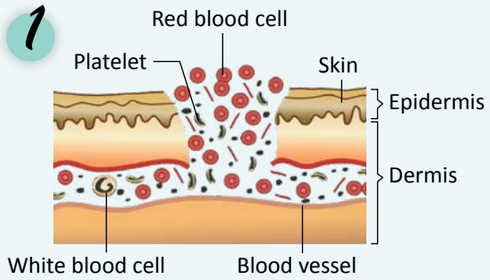
# 1.3 Mechanism of Blood Clotting in Circulatory System

## Blood Clotting Mechanism

The blood circulation system in humans is a closed system where blood is constantly flowing through the blood vessels. Blood that flows through the artery has the proper pressure to allow blood to flow through the body. Blood also contains essentials such as nutrients, hormones and oxygen that need to be transported to the cells.

Loss of blood due to injury can cause low blood pressure and inhibit nutrients and oxygen to be transported to the cells. This condition can be fatal if it does not immediately stop the loss of blood. Besides avoiding low blood pressure, can you point out the importance of blood clotting?

1




When injury occurs or blood vessel gets cut, the blood flows out. The blood vessels around the wound immediately constrict to reduce blood loss. Collagen fibres in the wall of the blood vessels causes platelet to accumulate in the wound.

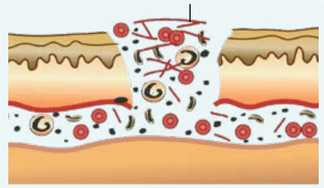
1.2.6 1.3.1





2

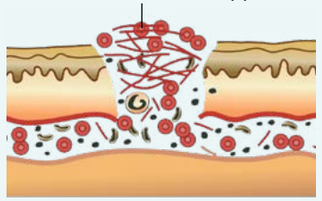
Fibrin forms a meshwork of threads



The meshwork of platelet forms fibrin tissue that will temporarily close the wound. Platelet secretes thrombokinase that stimulates prothrombin to turn into thrombin in the presence of calcium ions. Thrombin converts fibrinogen to fibrin.

3

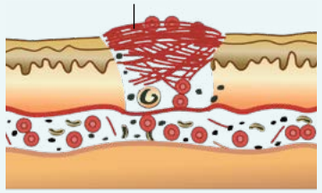
Red blood cell trapped



Red blood cells trapped with platelets in this tissue will form blood clots.

4

Blood clot



Blood clots become hard. The healing process of the injured tissue takes place beneath it and forms a scab that eventually dries and peels when the wound has healed.

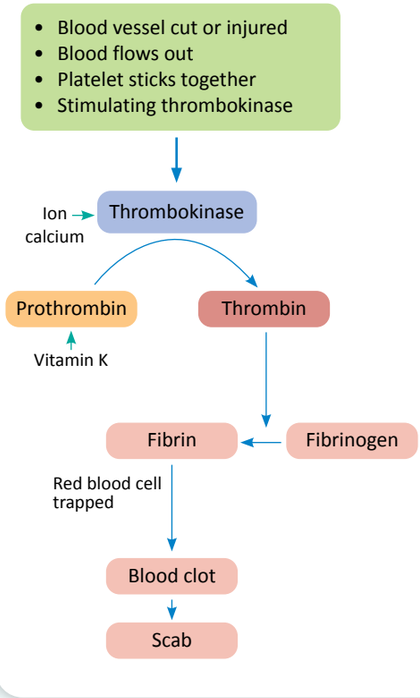



**Figure 1.32** Blood clotting mechanism

INFORMATION

Importance of blood clotting mechanism

### Activity 1.8

**Aim:** To explain about blood clotting mechanism.

**Instruction:**

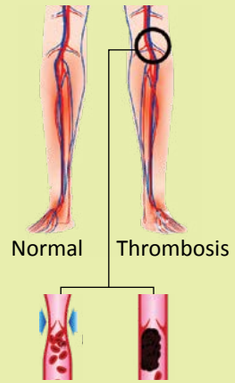
1. Gather information about blood clotting mechanism from several resources.
2. Draw a suitable schematic diagram to illustrate the mechanism of blood clotting. Present your work to the class.

1.3.1

## Relationship between Blood Clotting and Health

Some diseases occur because of impaired blood clotting mechanism which are haemophilia and thrombosis as shown in Table 1.6.

**Table 1.6** Relationship between blood clotting and health

| Diseases related to blood clotting | Symptoms | Causes of disease | Treatments and ways to prevent |
|---|---|---|---|
| **Haemophilia**<br>  <br>Normal<br>  <br>Haemophilia | • The patient's blood does not clot quickly.<br>• If an injury happens, significant blood loss occurs.<br>• Patients will also experience internal or subcutaneous bleeding, especially in the joints. | • Genetic disease occurs in the presence of recessive alleles on the X chromosome.<br>• Blood clotting deficiency factors. | • Avoid strenuous activities that can cause injury.<br>• Treat bleeding immediately.<br>• Undergo blood clotting factor replacement treatment. |
| **Thrombosis**<br>  <br>Normal Thrombosis | • Blood clots in the arteries or veins interfere with blood flow.<br>• Swelling in the legs especially in the calves or arms, pain or numbness and stiffness, reddish skin and warm when touched. | • The accumulation of fat in the bloodstream causes the blood vessels to narrow and eventually clogged.<br>• Smoking.<br>• Drink alcohol.<br>• Obesity.<br>• Lack of exercise. | • Exercise or move regularly.<br>• Practise a balanced diet.<br>• Stop smoking.<br>• Stop drinking alcohol.<br>• Maintain an ideal weight. |

### Activity 1.9

**Aim:** Study on blood clotting disease.

**Instruction:**

1. Work in small groups.
2. Gather information about impaired blood clotting mechanisms such as haemophilia and thrombosis including:
   (a) symptoms
   (b) causes of disease
   (c) patient treatments and handling methods
   (d) ways to prevent
3. Create a multimedia presentation based on your study.
4. Share it with your classmates.





### Formative Exercise 1.3

1. Explain the blood clotting mechanism.
2. What is thrombosis?
3. Compare and contrast haemophilia and thrombosis diseases.

# 1.4 Urine Formation in the Urinary System

## Structure and Function of Urinary System

The urinary system is a group of organs that removes excess water and unnecessary substances from the body as urine. The organs involved are the kidneys, ureters, urinary bladder and urethra.

Kidneys serve as osmoregulatory and excretory organs. Both kidneys are nut-shaped and located in the dorsal part of the abdominal cavity as in Figure 1.33 (a). Each kidney consists of the cortex on the outside, the medulla on the inside and the pelvis connected to the ureter as in Figure 1.33 (b). In each kidney, there are millions of very fine tubules called nephrons as in Figure 1.33 (c).

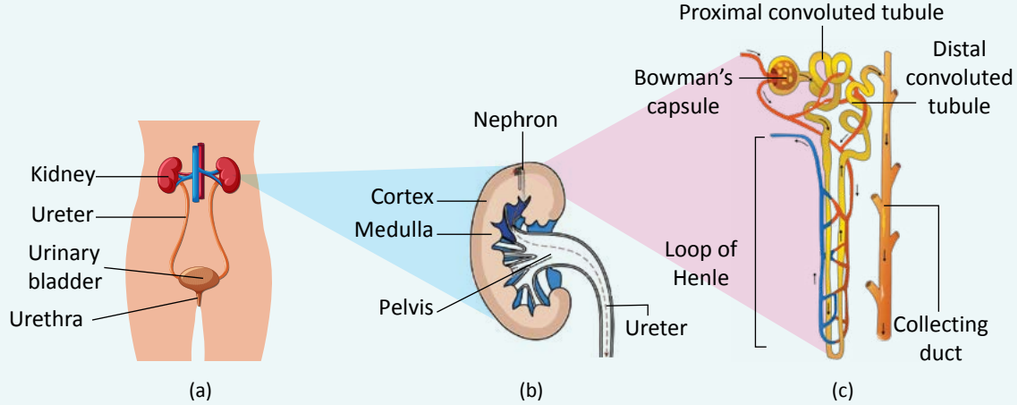



**Figure 1.33** Urinary system in human body

**Table 1.7** Explanation on nephron structure

| Nephron structure | Explanation |
|---|---|
| Bowman's capsule | Cup-shaped and begins in the cortex. |
| Proximal convoluted tubule | The tubule connected to Bowman's capsule. |
| Loop of Henle | U-shaped loop in medulla. |
| Distal convoluted tubule | Connected to collecting duct. |

In the Bowman's capsule, there is a network of capillaries called the glomerulus. The glomerulus is made up of afferent arteriole and efferent arteriole. Afferent arteriole brings in blood while the efferent arteriole draws blood out of the glomerulus as in Figure 1.34.

How does nephron produce urine? The formation of the urine involves three processes namely ultrafiltration, reabsorption and secretion.

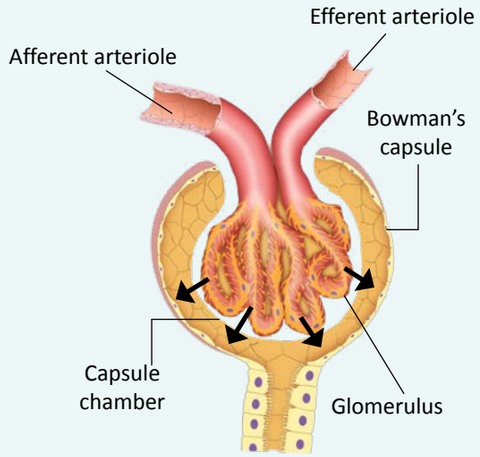



**Figure 1.34** Ultrafiltration process at glomerulus

## Urine Formation

**Table 1.8** Explanation on process structure in urine formation

| Process | Involved structure | Explanation |
|---|---|---|
| **Ultrafiltration** | Glomerulus and Bowman's capsule | • The blood is under high pressure when it reaches nephron.<br>• The diameter of the efferent arteriole that is smaller than the afferent arteriole produces high pressure in the glomerulus.<br>• As a result from high hydrostatic pressure in the glomerulus, most of the blood component filtrate out from the glomerulus to the Bowman's capsule.<br>• The components in the glomerular filtrate are water, glucose, amino acids, mineral salts and urea. |
| **Reabsorption** | Proximal convoluted tubule | • The glomerular filtrate passes along the proximal convoluted tubule.<br>• Glucose, amino acids and mineral salts are reabsorbed into the blood capillaries by diffusion.<br>• 65% of the water reabsorbed by osmosis.<br>• Concentration of urea increases because urea is not reabsorbed into blood capillaries. |
| | Loop of Henle | • 20% of the water is reabsorbed into the blood capillaries by osmosis.<br>• The mineral salts are reabsorbed. |
| | Distal convoluted tubule and collecting duct | • Reabsorption of water and mineral salts only. |
| **Secretion** | Distal convoluted tubule | • Waste products such as urea, uric acid and ammonia are pumped out of the blood capillaries into the distal convoluted tubule.<br>• Drugs, alcohol and other toxic substances are also secreted out of the blood capillaries by diffusion. |
| | Collecting duct | • The final glomerular filtrate which remains in the collecting duct is called urine.<br>• Urine consists of:<br>(a) 96% water<br>(b) 2.5% nitrogenous wastes such as urea, uric acid, ammonia and creatinine<br>(c) 1.5% mineral salts and other trace elements such as bile pigments<br>• Urine is channelled into the pelvis and carried out of the kidney by the ureter to the urinary bladder before it is excreted through the urethra. |





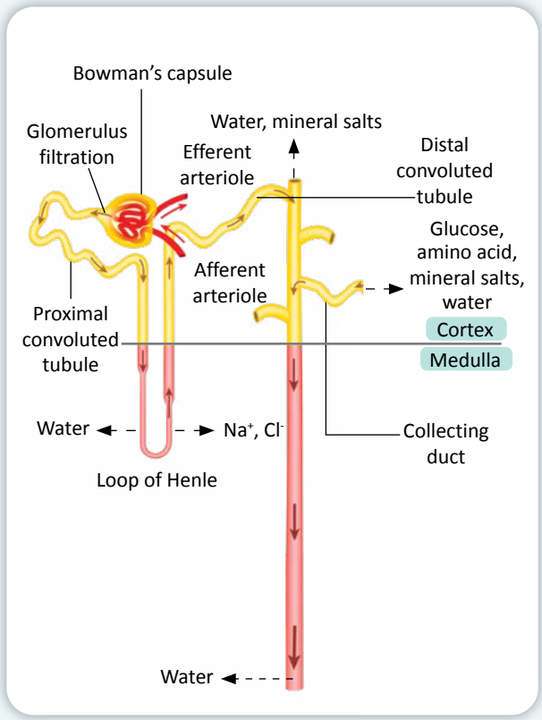



**Figure 1.35** Nephron structure and urine formation

### Activity 1.10

**Aim:** Explain the structure and function of the urinary system.

**Instruction:**

1. Use the model, chart or scan the QR code, discuss the organs involved in the urinary system and its function in the urine formation.
2. Share your findings with your friends.

ATTACHMENT

Urinary system model

### Value

Appreciate God's blessing

- Be grateful for healthy kidneys.

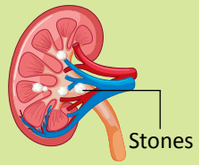
### Mind Challenge

Discuss the kidney activity load if you eat too much salty food.

## Diseases Related to Urinary System

What happens if kidney fails to function? Kidneys cannot carry out their functions as excretory organs if metabolic waste such as urea, excess water and mineral salts are not excreted from the body. This will contribute to diseases related to the urinary system as shown in Table 1.9.

**Table 1.9** Symptom, cause of disease, treatment and patient management for disease related to urinary system

| Diseases | Symptoms | Causes | Treatment methods | Patient management |
|---|---|---|---|---|
| **Chronic kidney disease**<br>  <br>Healthy kidney<br>  <br>Chronic kidney | • The kidney and urinary tract fail to function normally.<br>• Easy to get tired.<br>• Swelling at foot (edema).<br>• High blood pressure. | • Urinary tract infection causes scarring in the kidney.<br>• Urine excretion fails and causes kidney damage.<br>• Kidney abnormalities from birth. | • Dialysis.<br>• Kidney transplant. | • Reduce intake of high-fat dairy and nuts high in phosphorus.<br>• Reduce water and salt intake. |
| **Kidney stone disease**<br>  <br>Healthy kidney<br>  <br>Kidney with stones | • Blood in the urine.<br>• Pain when urinating.<br>• Feeling pain around the back of the body and not due to posture changes. | • Formed when high concentrations of certain substances in the urine cause the kidney stone to form.<br>• Less water consumption. | • Small surgery to remove kidney stone. | • Consume at least 2 litres of water per day.<br>• Reduce consumption of high purine foods such as red meat, seafood and alcohol.<br>• Take medication as recommended by your doctor. |





### Haemodialysis

Haemodialysis is a process whereby a dialysis machine is used to remove metabolic waste such as urea and excess mineral salts using machine dialysis. Figure 1.36 shows how a dialysis machine works during haemodialysis.

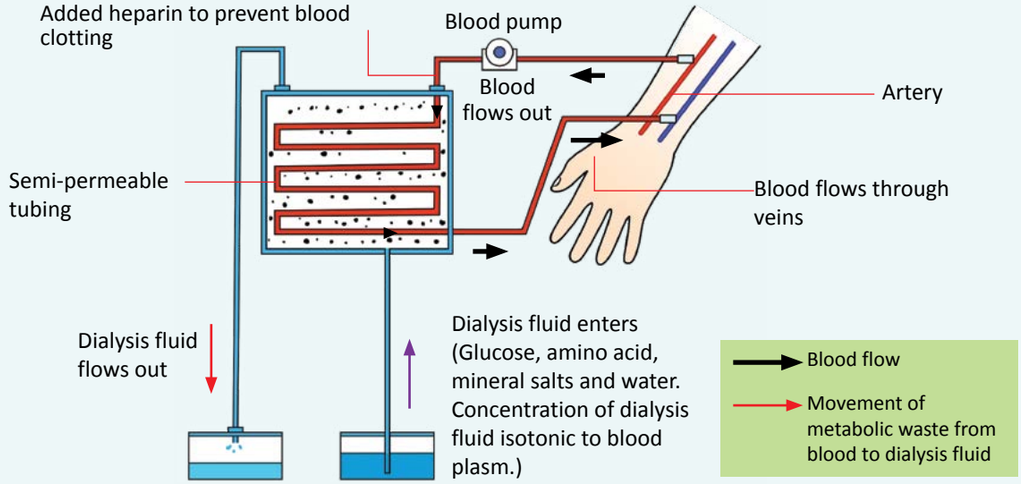



**Figure 1.36** Dialysis machine action

- During haemodialysis, the blood from the radial artery in the patient's arm passes into the dialysis machine.
- Blood flows through a semi-permeable tubing that is filled with dialysis fluid.
- The urea and mineral salts which are higher in concentration in the blood diffuse across the tubing walls into the dialysis fluid.
- After the completion of dialysis, the blood flows back to patient's body through the veins of the same hand.

### Activity 1.11

**Aim:** To communicate about diseases related to urinary tract.

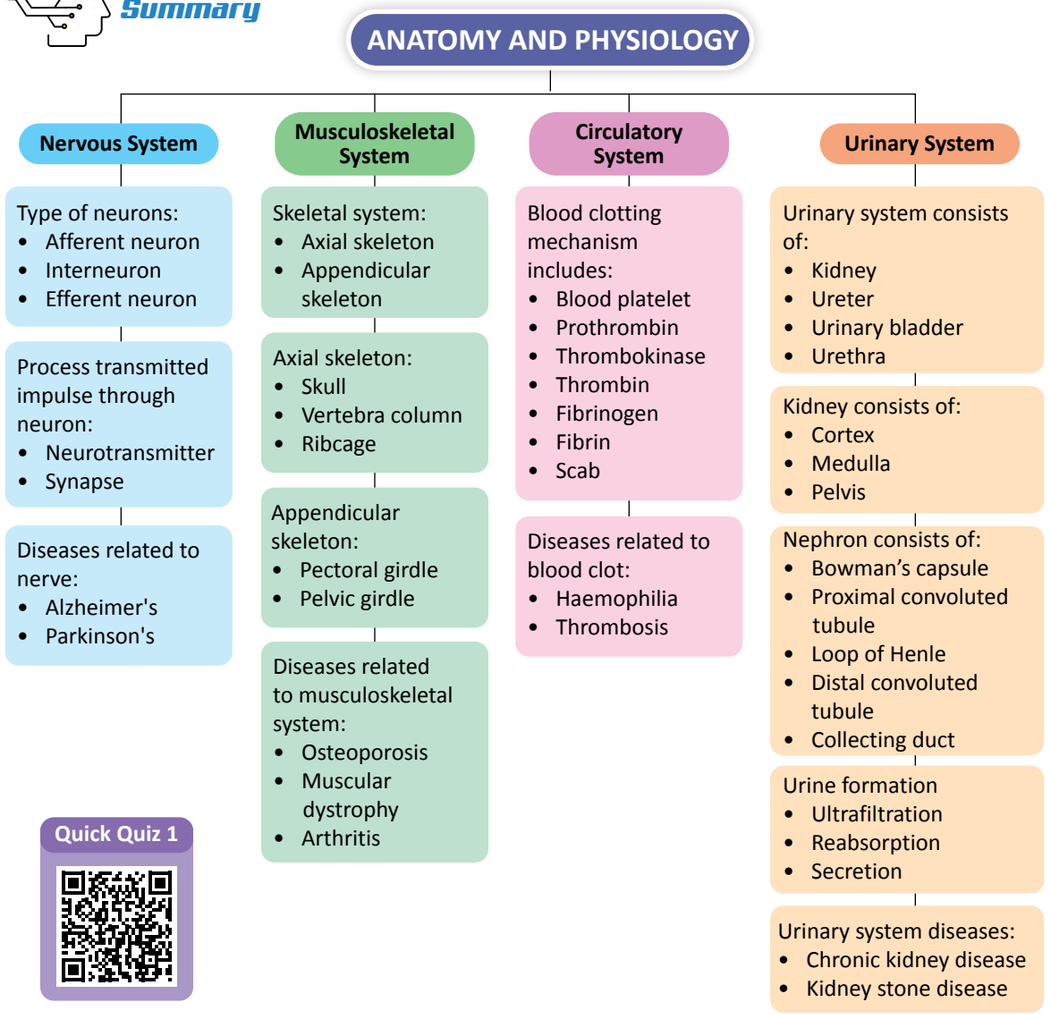
**Instruction:**

1. Carry out this activity in groups.
2. Gather information about urinary system diseases through active reading or contact the person in charge at the Health Department.
3. Produce a brochure on the urinary system diseases such as kidney failure and formation of kidney stone.
4. Your brochure should contain the following information:
   (a) symptoms
   (b) causes of diseases
   (c) treatment method and handling of patients
   (d) use of haemodialysis machines
   (e) ways to prevent

## Formative Exercise 1.4

1. What are the organs involved in human urinary system?
2. Explain the structure of a kidney.
3. What are the processes involved in urine formation?
4. How does ultrafiltration occur?
5. Explain what would happen if someone's kidney failed to function.
6. Explain the process of haemodialysis.

## Summary




Quick Quiz 1





## Self-reflection

After studying this chapter, students will be able to:

### 1.1 Transmission of Impulse in the Nervous System

- Explain the types, structures and functions of the neurons.
- Communicate about the transmission of impulse across neurons.
- Describe the effects of pesticides and drugs on nerve function.
- Communicate about neurological diseases.

### 1.2 Skeletal Muscle Movement in the Musculoskeletal System

- Describe the need for movement and support in human.
- Identify the axial and appendicular skeletons in the human skeletal system.
- Design a model that describes the actions and functions of muscles, ligaments and tendons during the movement of human limbs.
- Carry out an experiment to test the strength of the bone.
- Carry out an experiment to test the relationship between the calcium composition and bone density.
- Communicate about diseases related to the musculoskeletal system.

### 1.3 Blood Clotting Mechanism in the Blood Circulatory System

- Explain the mechanism of blood clotting.
- Relate blood clotting to human health.

### 1.4 Urine Production in the Urinary System

- Explain the structure and function of the urinary system.
- Communicate about urinary system related diseases.

## Summative Practice 1

1. Figure 1 shows two different neurons, P and Q.

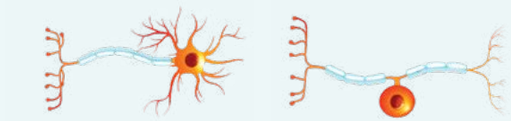



**Figure 1**

(a) Name neuron P and Q.

(b) Explain the differences between neuron P and Q.

2. Figure 2 shows the transmission of nerve impulse from neuron X to neuron Y.

(a) Explain how to ensure the transmission of nerve impulses from neuron X to neuron Y is in one direction.

(b) Explain the effect of excessive use of painkillers on the transmission of nerve impulses from neuron X to neuron Y.

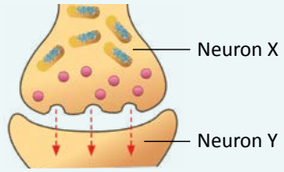



**Figure 2**

3. Figure 3 shows two students playing badminton in a tournament.

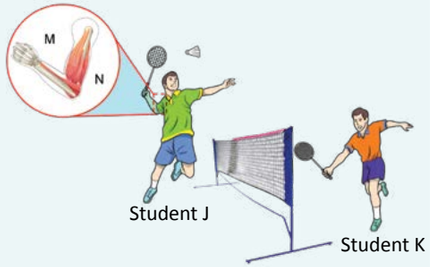



**Figure 3**

(a) Explain the movements of M muscle and N muscle to bend student J's arm.

(b) Student K immediately responds by returning the shuttlecock to student J. Explain the impulse transmission in this situation.

4. Figure 4 shows the graph of bone mass against age for women with osteoporosis.

(a) Explain phase X and phase Y based on the graph.

(b) Suggest and explain steps to be taken to prevent the disease.

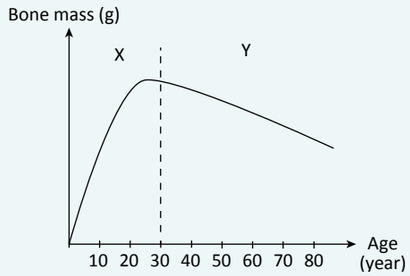



**Figure 4**

5. Figure 5 shows the process of blood clotting mechanism.

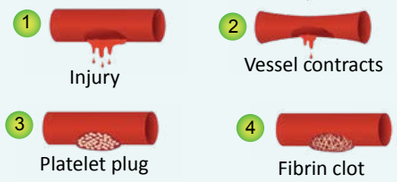



**Figure 5**

Based on the figure, explain how the mechanism of blood clotting helps to prevent infection in the event of injury.

**Check answers**



# THEME 2

# EXPLORATION OF ELEMENTS IN NATURE

This theme includes four chapters that begin with salts. In this chapter, focus is given to various processes causing chemical changes to the material, such as acid-base reaction, electrolysis, oxidation and recognition of ions.

Next, the chapter on carbon compounds in daily life explains the chemical properties of palm oil and managing used palm oil using green technology. While the chapter on energy and chemical change studies the action of light, heat and electricity in a process of chemical change. The final chapter in this theme emphasises a wide range of advanced materials and their impacts on quality of life.

CHAPTER 2

# Salts

In this chapter, students will learn about:

- Salts
- Qualitative analysis of salt

A student's foot was injured while playing futsal with his friends. When he was treated at the hospital, his foot was wrapped with a substance called calcium sulphate. Calcium sulphate is an insoluble salt. How to prepare insoluble salt?

**KEYWORDS**

- Cation
- Anion
- Soluble salts
- Insoluble salts
- Quantitative
- Qualitative
- Soluble salt solution

# 2.1 Salts

Salts exist naturally all around us. We use salts in food and in other daily necessities. Can you name the salt that we use in our daily lives?

Salts are formed through the neutralisation process. Salts contain cation from a base bonded with an anion from an acid. Figure 2.1 shows the formation of sodium chloride (NaCl) salt through the neutralisation process.

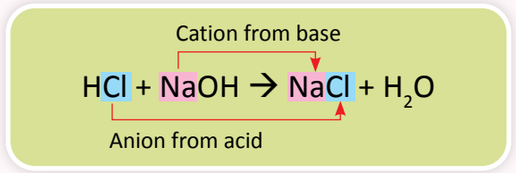



**Figure 2.1** The formation of NaCl salt through the neutralisation process

## The Meaning of Salts and its Use in Daily Life

Salts are **ionic compounds** that are formed when **hydrogen ions in the acid** are replaced by a **metal ion** or **ammonium ion ($NH_4^+$)**. Examples of salts produced when $H^+$ ions in the acid are replaced by a metal ion or $NH_4^+$ is shown in Table 2.1.

**Table 2.1** Examples of salts produced from $H^+$ ions in acid

| Acids | Common name of salt | Examples of salts |
|---|---|---|
| Hydrochloric acid (HCl) | Chloride salts | Sodium chloride (NaCl), ammonium chloride ($NH_4Cl$) |
| Nitric acid ($HNO_3$) | Nitrate salts | Lead(II) nitrate $Pb(NO_3)_2$, magnesium nitrate $Mg(NO_3)_2$ |
| Sulphuric acid ($H_2SO_4$) | Sulphate salts | Iron(II) sulphate ($FeSO_4$), potassium sulphate ($K_2SO_4$) |
| Carbonic acid ($H_2CO_3$) | Carbonate salts | Calcium carbonate ($CaCO_3$), sodium carbonate ($Na_2CO_3$) |

### Uses of Salts in Daily Life

Salts exist naturally in a limestone cave as stalactites and stalagmites that consist of calcium carbonate, $CaCO_3$. Salts also exist as minerals in the Earth's crust, for example, galena (lead(II) sulphide, PbS) and marble, $CaCO_3$.

On top of that, salts also play an important role in our daily lives. Let's look at the various examples.





**Food preparation**

1. Sodium chloride (NaCl) is used to give a salty taste in food.
2. Monosodium glutamate (MSG) is used as a food flavour enhancer.
3. Baking soda or sodium bicarbonate ($NaHCO_3$) is used to make cake and bread to rise.



**Food preservation**

Sodium benzoate ($C_6H_5COONa$) is used to preserve food such as tomato sauce, chilli sauce and jam.

**Agriculture**

Nitrate salts such as potassium nitrate ($KNO_3$), sodium nitrate ($NaNO_3$) and ammonium salts such as ammonium nitrate ($NH_4NO_3$) and ammonium sulphate $(NH_4)_2SO_4$ are used as nitrogenous fertilizers.



**Medical**

1. Antacids containing calcium carbonate ($CaCO_3$) is used to reduce stomach acidity of gastric patients.
2. Plaster of Paris that contains calcium sulphate ($CaSO_4$) is used to support broken bones.

**Other uses**

1. Fluoridated toothpaste containing tin(II) fluoride ($SnF_2$) can strengthen tooth enamel.
2. Silver bromide (AgBr) is used in the photography production of black and white film.

# Preparation of Soluble Salts and Insoluble Salts

## Soluble Salts and Insoluble Salts

Solubility refers to the ability of a substance dissolved in solvent. Some salts are soluble in water while others are insoluble. Solubility of salts in the water depends on the type of cation and anion as shown in Table 2.2.

**Table 2.2** Solubility of salts in water

| Types of salts | Solubility in water |
|---|---|
| Sodium, potassium and ammonium salts | All soluble |
| Nitrate salts | All soluble |
| Chloride salts | All soluble except $PbCl_2$, AgCl, $HgCl_2$ |
| Sulphate salts | All soluble except $PbSO_4$, $BaSO_4$, $CaSO_4$ |
| Carbonate salts | All insolube except $Na_2CO_3$, $K_2CO_3$, $(NH_4)_2CO_3$ |

## Preparation of Soluble Salts

There are several ways to prepare a soluble salt depending on the type of salt.

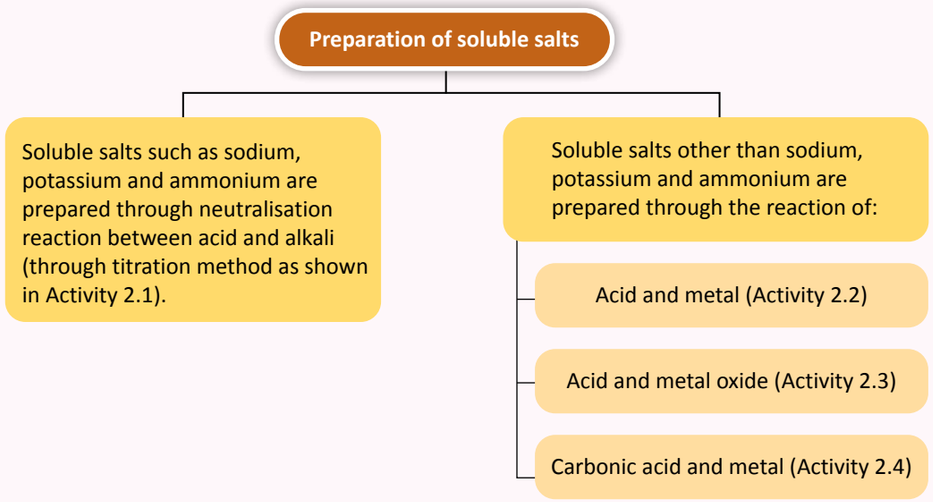



**Figure 2.2** Preparation of soluble salts





Let's do Activity 2.1 until Activity 2.4 to understand the preparation of soluble salts.

### Activity 2.1

**Aim:** To prepare sodium chloride through the reaction of an acid and an alkali.

**Materials:** 2.0 mol $dm^{-3}$ hydrochloric acid, 2.0 mol $dm^{-3}$ sodium hydroxide solution, distilled water and phenolphthalein indicator.

**Apparatus:** Pipette, pipette filler, burette, retort stand with clamp, conical flask, filter funnel, tripod stand, filter paper, glass rod, Bunsen burner, white tile, evaporating dish and clay triangle.

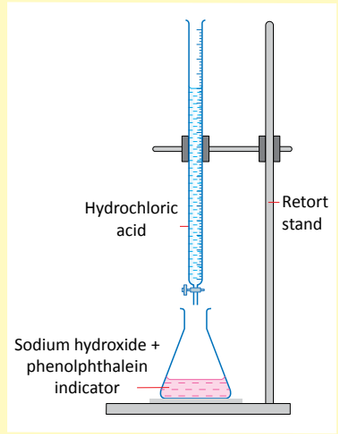



**Figure 2.3**

**Instruction:**

1. Measure 25 $cm^3$ of 2.0 mol $dm^{-3}$ of sodium hydroxide solution using a pipette and transfer it into a conical flask.
2. Add three drops of phenolphthalein indicator until the solution turns pink.
3. Fill the burette with hydrochloric acid solution and record the initial reading.
4. Titrate the hydrochloric acid solution into the conical flask and swirl the conical flask until the colour of the mixture becomes colourless. Record the final reading of the burette.
5. Record the difference in volume of hydrochloric acid by using the following formula:

   Final burette reading – initial burette reading = V $cm^3$
6. Repeat the experiment by mixing 25 $cm^3$ of sodium hydroxide with V $cm^3$ of hydrochloric acid from the burette without using phenolphthalein indicator.
7. Pour the neutralised solution into an evaporating dish.
8. Heat the solution to one-third of the initial volume (until the solution becomes saturated).
9. Let the solution cool at room temperature for crystallisation to occur.
10. Filter the contents of the evaporating dish and rinse the crystals obtained with distilled water.
11. Dry the salt crystals by pressing them between two pieces of filter papers.

**Discussion:**

1. Write the chemical equations of the acid and alkali involved.
2. Why is the experiment being repeated without using phenolphthalein indicator?
3. Why does the salt solution is not heated until dry?

**Be Careful!**

During titration, burette is usually filled with acid, not alkali. This is because alkali can form crystals in the burette pipe at its tip.

## Activity 2.2

**Aim:** To prepare iron(II) chloride through the reaction of acid with metal.

**Materials:** Iron powder, 1.0 mol $dm^{-3}$ hydrochloric acid and distilled water.

**Apparatus:** Beaker, Bunsen burner, wire gauze, glass rod, conical flask, filter funnel, filter paper, tripod stand, evaporating dish, spatula and clay triangle.

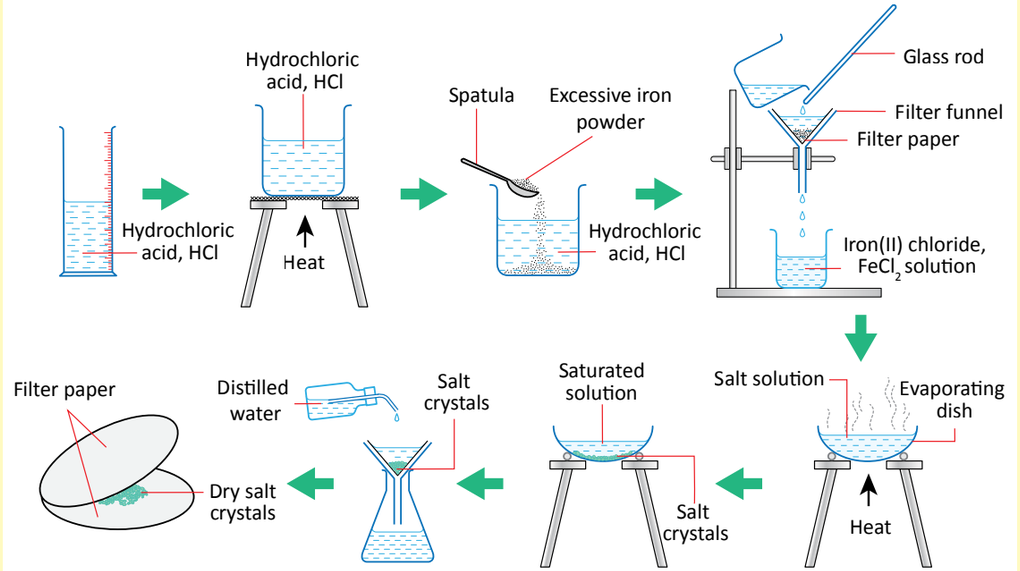



**Figure 2.4**

**Instruction:**

1. Measure 50 $cm^3$ of 1.0 mol $dm^{-3}$ of hydrochloric acid and pour into a beaker.
2. Heat the hydrochloric acid solution slowly.
3. Add excessive iron powder into hydrochloric acid until the iron powder cannot dissolve anymore.
4. Filter the solution to remove excess iron.
5. Pour the solution into evaporating dish. Heat the filtrate until the volume is one-third of the initial volume.
6. Let the filtrate cool at room temperature for crystallisation to occur.
7. Filter the content of the evaporating dish and rinse the crystals obtained with distilled water.
8. Dry the salt crystals by pressing them between two pieces of filter papers.

**Discussion:**

1. Write the chemical equation for the reaction.
2. Write the ionic equation for the reaction.
3. What is the colour of the crystals formed?





## Activity 2.3

**Aim:** To prepare copper(II) chloride through the reaction of acid with metal oxide.

**Materials:** 1.0 mol $dm^{-3}$ hydrochloric acid, copper(II) powder oxide powder and distilled water.

**Apparatus:** Bunsen burner, beaker, wire gauze, glass rod, conical flask, filter funnel, filter paper, tripod stand, evaporating dish, spatula and clay triangle.

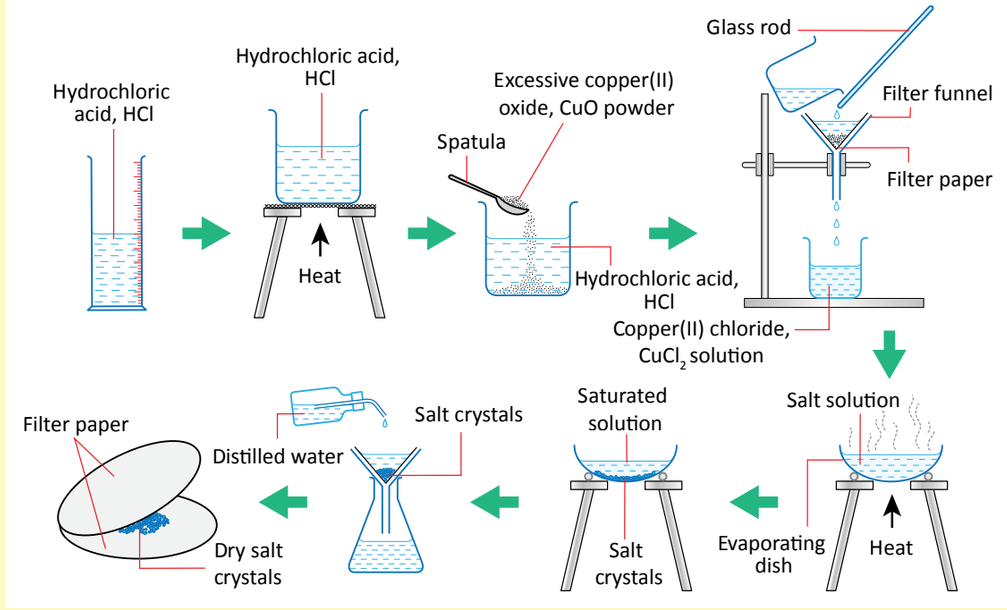



**Figure 2.5**

**Instruction:**

1. Measure 50 $cm^3$ of 1.0 mol $dm^{-3}$ of hydrochloric acid and pour into a beaker.
2. Heat the hydrochloric acid solution slowly.
3. Add excessive copper(II) oxide powder into the hydrochloric acid until copper(II) oxide powder cannot dissolve anymore.
4. Filter the solution to get rid of excess copper(II) oxide powder.
5. Pour the solution into the evaporating dish. Heat the filtrate until the volume becomes one-third of the initial volume.
6. Let the filtrate cool at room temperature for crystallisation to occur.
7. Filter the content of the evaporating dish and rinse the crystals obtained with distilled water.
8. Dry the salt crystals by pressing them between two pieces of filter papers.

**Discussion:**

1. Write the chemical equation for the reaction.
2. Write the ionic equation for the reaction.
3. What is the colour of the crystals formed?

## Activity 2.4

**Aim:** To prepare magnesium chloride through the reaction of acid with metal carbonate.

**Materials:** 1.0 mol $dm^{-3}$ hydrochloric acid and magnesium carbonate powder.

**Apparatus:** Bunsen burner, beaker, wire gauze, glass rod, conical flask, filter funnel, filter paper, tripod stand, evaporating dish, spatula and clay triangle.

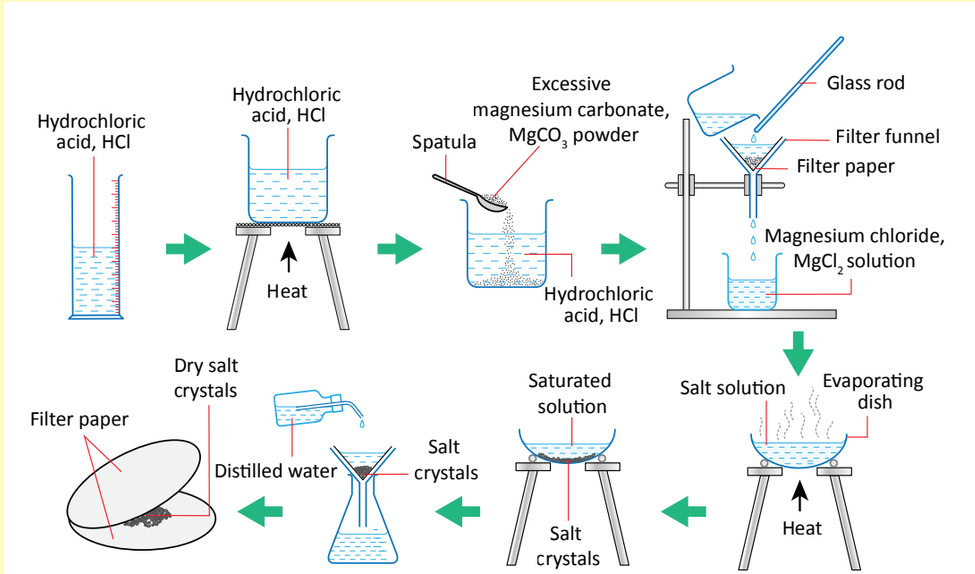



**Figure 2.6**

**Instruction:**

1. Measure 50 $cm^3$ of 1.0 mol $dm^{-3}$ of hydrochloric acid and pour into a beaker.
2. Heat the hydrochloric acid solution slowly.
3. Add excessive magnesium carbonate powder into hydrochloric acid until magnesium carbonate cannot dissolve anymore.
4. Filter the mixture to remove excess magnesium carbonate powder.
5. Pour the solution into evaporating dish. Heat the filtrate until the volume is one-third of the initial volume.
6. Let the filtrate cool at room temperature for crystallisation to occur.
7. Filter the content of the evaporating dish and rinse the crystals obtained with distilled water.
8. Dry the salt crystals by pressing them between two pieces of filter papers.

**Discussion:**

1. Write the chemical equation for the reaction.
2. Write the ionic equation for the reaction.
3. Name the gas produced when magnesium carbonate powder is added to the hydrochloric acid.





**Preparation of insoluble salts through precipitation method or double decomposition reaction**

**Example: Lead(II) iodide**

**Cation**

Identify the aqueous solution that supplies $Pb^{2+}$ ion, for example, nitrate solution $Pb(NO_3)_2$ (because all nitrate salts dissolve in water).

**Anion**

Identify the aqueous solution that supplies $I^-$ ion, for example, potassium or sodium solution KI or NaI (because all potassium and sodium salts dissolve in water).

$Pb^{2+}$ $I^-$

Lead(II) iodide (yellow precipitate)

Guide to write ionic equation

Chemical equation:

$Pb(NO_3)_2 + 2\,NaI \rightarrow PbI_2 + 2\,NaNO_3$

| $Pb^{2+}$ | $NO_3^-$ | $Na^+$ | $I^-$ | $PbI_2$ | $Na^+$ | $NO_3^-$ |
|---|---|---|---|---|---|---|
| Lead(II) nitrate ions | | Sodium iodide ions | | $PbI_2$ yellow precipitate | Sodium nitrate ions | |

Since $Na^+$ ion and $NO_3^-$ ion were spectator ions that did not face any changes in the reaction, these ions were repealed.

Ionic equation:

$Pb^{2+} + 2I^- \rightarrow PbI_2$

### Activity 2.5

**Aim:** To prepare insoluble salt of lead(II) iodide through double decomposition reaction.

**Materials:** 0.5 mol $dm^{-3}$ of lead(II) nitrate solution, 0.5 mol $dm^{-3}$ of potassium iodide solution and distilled water.

**Apparatus:** Beaker, glass rod, conical flask, filter funnel, spatula and filter paper.

**Instruction:**

1. Scan QR code to see apparatus arrangement for this activity.
2. Measure 25 $cm^3$ of 0.5 mol $dm^{-3}$ of lead(II) nitrate solution and pour into a beaker.
3. Measure 25 $cm^3$ of 0.5 mol $dm^{-3}$of potassium iodide solution and pour into a beaker containing lead(II) nitrate.
4. Stir the mixture using a glass rod.
5. Filter the precipitate formed and rinse the crystals obtained with distilled water.
6. Dry the precipitate by pressing them between two pieces of filter papers.

ATTACHMENT

**Discussion:**

1. Write the chemical equation of the reaction.
2. Write the ionic equation of the reaction.

## Solubility of Nitrate, Sulphate, Carbonate and Chloride Salts in Water

Preliminary observations on the **physical properties of salts** such as **colour** and **solubility of the salts** give information about the **cations** and **anions** that may be present. Let's do Experiment 2.1 to compare the **solubility of salts in water**.

### Experiment 2.1

**Problem statement:** Do all salts dissolve in water?

**Aim:** To differentiate the solubility of nitrate, sulphate, carbonate and chloride salts in water.

**Hypothesis:** Some salts are soluble in water and some are not.

**Manipulated variable:** Type of salts

**Responding variable:** Solubility of salts in water

**Constant variable:** The volume and temperature of water, mass of salt

**Materials:** Distilled water, ammonium chloride, aluminium nitrate, calcium carbonate, potassium nitrate, magnesium sulphate, magnesium carbonate, zinc sulphate, zinc nitrate, lead(II) chloride, lead(II) sulphate, lead(II) carbonate, copper(II) chloride, copper(II) sulphate, copper(II) carbonate, iron(II) sulphate and iron(II) chloride.

**Apparatus:** Beaker, measuring cylinder, glass rod and spatula.





**Procedure:**

1. Observe each salt and record the colour of solid salts.
2. Measure 50 $cm^3$ distilled water and pour into a beaker.
3. Add one spatula of ammonium chloride into a beaker and stir the mixture using glass rod.
4. Record your observations.
5. Repeat the experiment by replacing ammonium chloride with other salts.

**Discussion:** Specify the colour of the solution and the solubility for each salt tested.

**Conclusion:** What conclusion can you make?

## Importance of Salt Purification Process

Salt crystals formed may contain impurities. Soluble salts that are **not pure** can be purified through **recrystallisation process**.

Do you know about the need for a salt purification process? Salt purification process is carried out to produce salt that is one hundred percent pure through recrystallisation method that needs to be repeated several times. Activity 2.6 is a **recrystallisation method of sodium chloride**.

### Activity 2.6

**Aim:** To purify sodium chloride through recrystallisation method.

**Materials:** Crystal of sodium chloride and distilled water.

**Apparatus:** Beaker, filter funnel, wire gauze, tripod stand, filter paper, wire gauze, glass rod, Bunsen burner, evaporating dish, spatula and clay triangle.

**Instruction:**

1. Scan QR code to see apparatus arrangement for this activity.
2. Put the crystal of sodium chloride into a beaker and add 10 $cm^3$ of distilled water.
3. Heat the mixture and add distilled water little by little until all the salt is dissolved.
4. Filter the hot solution into a clean beaker.
5. Pour the solution into an evaporating dish. Heat the filtrate until one-third of the initial volume.
6. Cool the filtrate at room temperature for crystallisation to occur.
7. Filter the content of the evaporating dish to obtain the crystals and rinse them with distilled water.
8. Dry the salt crystals by pressing them between two pieces of filter papers.

ATTACHMENT

### Physical Properties of Salt Crystal

**The form of salt crystals is similar** to table salt but **different in size**. Size of the salt crystals depends on the **rate of crystallisation**. Rapid crystallisation process produces small crystal and vice versa. Salt crystals have the following physical properties:

- regular geometric shapes, such as cube.
- flat surface, straight sides and sharp corners.
- fixed angle between two adjacent surfaces.

**Photograph 2.1** Salt crystal of copper(II) sulphate

## Solving Quantitative Problems in Stoichiometric Reaction

**Example 1**

Calculate the mass of aluminum sulphate produced from the reaction of 0.3 mol sulphuric acid with excess aluminum oxide.
[Relative atomic mass: O = 16, Al = 27, S = 32]

**Solution:**

**Step 1**

Write a balanced chemical equation.

$$3H_2SO_4 + Al_2O_3 \rightarrow Al_2(SO_4)_3 + 3H_2O$$

**Step 2**

Find the mol ratio of $H_2SO_4$ to $Al_2(SO_4)_3$ from the chemical equation.

$$\frac{\text{Number of moles of } Al_2(SO_4)_3}{\text{Number of moles of } H_2SO_4} = \frac{1}{3}$$

**Step 3**

Use the mole ratio to find the mole of $Al_2(SO_4)_3$ produced in the reaction.

Number of moles of $Al_2(SO_4)_3$

$= \frac{1}{3} \times$ number of moles of $H_2SO_4$

$= \frac{1}{3} \times 0.3$

$= 0.1$ mol

**Step 4**

Convert the mole of $Al_2(SO_4)_3$ to mass

Relative molecular mass of $Al_2(SO_4)_3$

$= 2(27) + 3(32) + 12(16)$

$= 342$

Mass of $Al_2(SO_4)_3$

= number of moles × relative molecular mass

$= 0.1 \times 342$

$=$ **34.2 g**



2.1.4 2.1.5



**Example 2**

2.0 g of sodium hydroxide reacts with sulphuric acid. What is the mass of sodium sulphate produced?
[Relative atomic mass: H = 1, O = 16, Na = 23]

**Solution:**

**Step 1**

Write a balanced chemical equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

**Step 2**

Convert the mass of NaOH to mole.

Relative molecular mass of NaOH $= 23 + 16 + 1$
$= 40$

Number of moles of NaOH $= \frac{2}{40}$
$= 0.05$ mol

**Step 3**

Find the mol ratio of $Na_2SO_4$ to NaOH from the chemical equation.

$$\frac{\text{Number of moles of } Na_2SO_4}{\text{Number of moles of NaOH}} = \frac{1}{2}$$

**Step 4**

Use the mole ratio to find the mole of $Na_2SO_4$ produced in the reaction.

Number of moles of $Na_2SO_4 = \frac{1}{2} \times 0.05$
$= 0.025$ mol

**Step 5**

Convert the mole of the $Na_2SO_4$ to mass.

Relative molecular mass $Na_2SO_4$
$= (23 \times 2) + 32 + (16 \times 4)$
$= 142$

Mass of $Na_2SO_4$
= number of moles × relative molecular mass
$= 0.025$ mol $\times 142$
$=$ **3.55 g**

**Example 3**

What is the volume of carbon dioxide released at s.t.p. when 2.1 g of magnesium carbonate reacts with hydrochloric acid?
[Relative atomic mass: C = 12, O = 16, Mg = 24; 1 mol of gas occupies 22.4 $dm^3$ at s.t.p.]

**Solution:**

**Step 1**

Write a balanced chemical equation.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

**Step 2**

Convert the mass of $MgCO_3$ to mole.

Relative molecular mass of $MgCO_3 = 24 + 12 + (16 \times 3)$
$= 84$

Number of moles of $MgCO_3 = \frac{2.1}{84}$
$= 0.025$ mol

**Step 3**

Find the mol ratio of $CO_2$ to $MgCO_3$ from the chemical equation.

$$\frac{\text{Number of moles of } CO_2}{\text{Number of moles of } MgCO_3} = \frac{1}{1}$$

**Step 4**

Use the mole ratio to find the mole of $CO_2$ produced in the reaction.

Number of moles of $CO_2 = \frac{1}{1} \times 0.025$
$= 0.025$ mol

**Step 5**

Convert the mole of $CO_2$ to volume

Volume of $CO_2$
= number of moles × molar volume
$= 0.025 \times 22.4$
$=$ **0.56 $dm^3$**

2.1.5

**Example 4**

What is the volume of 2.0 mol $dm^{-3}$ hydrochloric acid needed to dissolve 8.4 g of magnesium carbonate powder?

[Relative atomic mass: C = 12, O = 16, Mg = 24]

**Solution:**

**Step 1**

Write a balanced chemical equation.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

**Step 2**

Convert the mass of $MgCO_3$ to mole.

Relative molecular mass of $MgCO_3$

$= 24 + 12 + (16 \times 3)$

$= 84$

Number of moles of $MgCO_3 = \frac{8.4}{84}$

$= 0.1$ mol

**Step 3**

Find the mol ratio of HCl to $MgCO_3$ from the chemical equation.

$$\frac{\text{Number of moles of HCl}}{\text{Number of moles of } MgCO_3} = \frac{2}{1}$$

**Step 4**

Use the mole ratio to find the mole of HCl used in the reaction.

Number of moles of HCl

$= \frac{2}{1} \times$ number of moles of $MgCO_3$

$= \frac{2}{1} \times 0.1$

$= 0.2$ mol

**Step 5**

Use the mole of HCl to find the volume of HCl.

Number of moles of HCl

= concentration × volume of HCl in $dm^3$

$$\text{Volume} = \frac{\text{Number of moles of HCl}}{\text{Molarity of HCl}}$$

$$= \frac{0.2}{2}$$

∴ Volume of HCl = **0.1 $dm^3$**

## Formative Exercise 2.1

1. Suggest **three** ways to prepare soluble salts other than sodium, potassium and ammonium.
2. Give physical properties of salt crystals.
3. What is the preliminary step in preparing insoluble salts?
4. Reaction between magnesium with 20 $cm^3$ of 2 mol $dm^{-3}$ hydrochloric acid produces 120 $cm^3$ of hydrogen gas at room temperature. What is the mass of magnesium needed for this reaction?
5. Calculate the mass of iron that reacts with hydrochloric acid to produce 60 $cm^3$ of hydrogen gas at room temperature.
6. 4.0 g of magnesium oxide is added to 30 $cm^3$ of 2.0 mol $dm^{-3}$ hydrochloric acid. What is the mass of magnesium oxide that is insoluble in the reaction?
7. Calculate the volume of oxygen gas evolved at room temperature when 4.7 g of copper(II) nitrate is heated strongly.

[Relative atomic mass: H = 1, N = 14, O = 16, Mg = 24, Fe = 56, Cu = 64;
1 mol gas occupies 24 $dm^3$ at room temperature]





# 2.2 Qualitative Analysis of Salt

## Meaning of Qualitative Analysis

There are many compounds that have the same colour in a laboratory. For compound such as, sodium chloride, magnesium carbonate and zinc sulphate are white in colour. How do you distinguish these compounds?

**Qualitative analysis** is a technique to identify the cations and anions present in salts by analysing their physical and chemical properties. Steps in qualitative analysis are as follows:


**Figure 2.7** Steps in qualitative analysis

## Inference Based on Colour and Solubility of Salt in Water

Early observations on the physical properties such as colour and solubility of salt in water can provide basic information on cations and anions that may be present.

Most of the solid salts are **white** and produce **colourless solution** when dissolved in water. However, cations of **transition elements** produce **certain colours**. Table 2.3 shows colour of salts in solid forms and aqueous solution. For the solubility of salt in water, you can refer to Table 2.2 on page 38.

**Table 2.3** Colour of salts in solid forms and aqueous solution

| Salt | Colour | |
|---|---|---|
| | Solid | Aqueous solution |
| Salts of $Na^+$, $K^+$, $NH_4^+$, $Mg^{2+}$, $Ca^{2+}$, $Ba^{2+}$, $Al^{3+}$, $Pb^{2+}$, $Zn^{2+}$ (if anions are colourless) | White | Colourless |
| Salts of $Fe^{2+}$ | Green | Green or light green |
| Salts of $Fe^{3+}$ | Brown | Brown or yellowish brown |
| Copper(II) sulphate, $CuSO_4$<br>Copper(II) nitrate, $Cu(NO_3)_2$ | Blue | Blue |
| Copper(II) chloride, $CuCl_2$ | Green | Blue |
| Copper(II) carbonate, $CuCO_3$ | Green | Insoluble in water |

You need to do a preliminary test on salt such as observing colour and solubility in water to determine its identity. This preliminary test cannot confirm the identity of the ions present but can provide information of ions that may be present.

### Activity 2.7

**Aim:** To make an inference on the presence of cation.

**Instruction:**

1. Based on Experiment 2.1 that you have done before, make an inference on the presence of cation based on colour and salt solubility.
2. Scan the QR code to download and print Table 2.4. Complete the table.

**Observation:**

**Table 2.4** Observation and deduction

| Salts | Solution colour | Solubility | Cation present |
|---|---|---|---|
| Ammonium chloride | | | |

(Scan the QR code for full table)

ATTACHMENT

Table

**Discussion:**

1. Which metal ions produce coloured salt?
2. Would all salts containing the same cation have the same colour?
3. Which salts are insoluble in water? Does solubility test show the presence of a particular cation or anion? Explain your answer.

## Test for Gases

Apart from colour and solubility of salt in water, gas may be released when a salt compound is heated and reacts to an acid or alkali. Based on the type of gas released, information about anions and cations can be identified.

**Table 2.5** Types of ions that may present from the gas released

| Types of gas released | Types of ions that may present |
|---|---|
| Carbon dioxide gas, $CO_2$ | Carbonate ion $CO_3^{2-}$ except $Na_2CO_3$ and $K_2CO_3$ |
| Oxygen gas, $O_2$ | Nitrate ion, $NO_3^-$ |
| Oxygen gas, $O_2$ and nitrogen dioxide gas, $NO_2$ | Nitrate ion, $NO_3^-$ except $NaNO_3$ and $KNO_3$ |
| Sulphur dioxide gas, $SO_2$ | Sulphate ion, $SO_4^{2-}$ ($ZnSO_4$, $CuSO_4$, $FeSO_4$ only) |
| Ammonia gas, $NH_3$ | Ammonium ion, $NH_4^+$ |

Gas released should be tested to confirm its presence. Confirmatory gas test can start with the observation of the colour, the smell and then confirmatory gas test as shown in Table 2.6.





**Table 2.6** Confirmatory gas test

| Types of gas | Gas colour | Gas odour | Confirmatory gas test |
|---|---|---|---|
| Oxygen, $O_2$ | Colourless | Odourless | • Ignite the glowing wooden splint |
| Hydrogen, $H_2$ | Colourless | Odourless | • Produce "pop" sound when tested with lighted wooden splint |
| Carbon dioxide, $CO_2$ | Colourless | Odourless | • Limewater turns milky<br>• Moist blue litmus paper turns red |
| Ammonia, $NH_3$ | Colourless | Pungent | • Produce white fume with HCl vapour<br>• Moist red litmus paper turns blue |
| Chlorine, $Cl_2$ | Yellow-greenish | Pungent | • Decolourise moist red or blue litmus paper |
| Hydrogen chloride, HCl | Colourless | Pungent | • Produce white fume with $NH_3$ vapour<br>• Moist blue litmus paper turns red |
| Sulphur dioxide, $SO_2$ | Colourless | Pungent | • Purple colour of acidified potassium manganate(VII) solution decolourised<br>• The orange colour of acidified potassium dichromate(VI) turns green<br>• Moist blue litmus paper turns red |
| Nitrogen dioxide, $NO_2$ | Brown | Pungent | • Moist blue litmus paper turns red |

Let's do Activity 2.8 to identify the gas released from heating the salt or the reaction with an acid or alkali.

### Activity 2.8

**Aim:** To identify the gas released.

**Materials:** Potassium chlorate(V), 1.0 mol $dm^{-3}$ sulphuric acid, zinc powder, zinc carbonate powder, limewater, 1.0 mol $dm^{-3}$ sodium hydroxide solution, ammonium chloride, manganese(IV) oxide, concentrated hydrochloric acid, sodium chloride, concentrated aqueous ammonia solution, sodium sulphite, lead(II) nitrate, acidified potassium manganate(VII) solution, concentrated sulphuric acid, 1.0 mol $dm^{-3}$ hydrocloric acid, wooden splint, blue and red litmus paper.

**Apparatus:** Test tube, boiling tube, Bunsen burner, tongs, delivery tube, rubber stopper, spatula and glass rod.

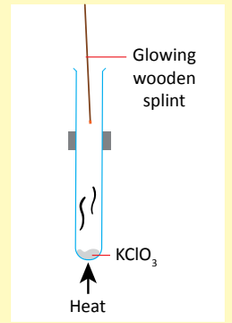



**Figure 2.8**

**A. Test for oxygen gas**

**Instruction:**

1. Put two spatulas of potassium chlorate(V) into a boiling tube.
2. Strongly heat the pottasium chlorate(V).
3. Place a glowing wooden splint into the boiling tube.
4. Record your observation.

**B. Test for hydrogen gas**

**Instruction:**

1. Put 5 $cm^3$ of 1.0 mol $dm^{-3}$ sulphuric acid into a test tube.
2. Add one spatula of zinc powder into the test tube.
3. Place the lighted wooden splint into the mouth of the test tube.
4. Record your observation.

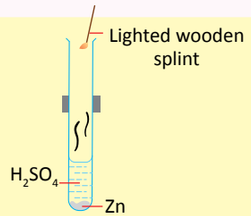



**Figure 2.9**

**C. Test for carbon dioxide gas**

**Instruction:**

1. Put one spatula of zinc carbonate powder into a boiling tube.
2. Strongly heat the powder.
3. Channel the gas released into the limewater.
4. Record your observation.

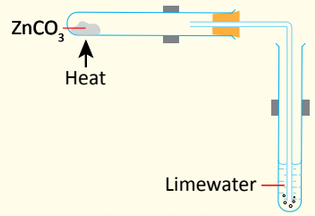



**Figure 2.10**

**D. Test for ammonia gas**

**Instruction:**

1. Measure 5 $cm^3$ of 1.0 mol $dm^{-3}$ sodium hydroxide solution and put it into a boiling tube.
2. Add one spatula of ammonium chloride.
3. Heat the mixture.
4. Place a moist red litmus paper into the mouth of the boiling tube.
5. Record your observation.

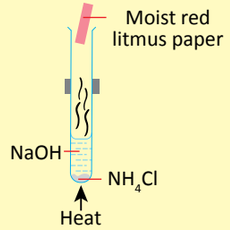



**Figure 2.11**

**E. Test for chlorine gas**

**Instruction:**

1. Put half spatula of manganese(IV) oxide into a test tube.
2. Add a small amount of concentrated hydrochloric acid.
3. Heat the mixture.
4. Observe the colour of the gas released.
5. Place a moist blue litmus paper into the mouth of the test tube.
6. Record your observation.

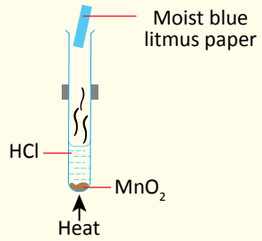



**Figure 2.12**

**Be Careful!**

Carry out this activity in a fume chamber.

**F. Test for hydrogen chloride gas**

**Instruction:**

1. Put half spatula of sodium chloride into a boiling tube.
2. Add 2 $cm^3$ of concentrated sulphuric acid.
3. Heat the mixture.
4. Place a moist blue litmus paper into the mouth of the boiling tube.
5. Place a glass rod dipped in concentrated ammonia into the mouth of the test tube.
6. Record your observation.

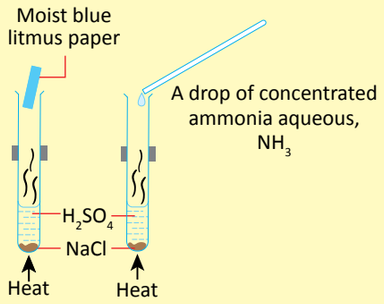



**Figure 2.13**





**G. Test for sulphur dioxide gas**

**Instruction:**

1. Put half spatula of sodium sulphite, $Na_2SO_3$ into a boiling tube.
2. Add 3 $cm^3$ of 1.0 mol $dm^{-3}$ of hydrochloric acid.
3. Heat the mixture.
4. Channel the gas released into the acidified potassium manganate(VII) solution.
5. Record your observation.

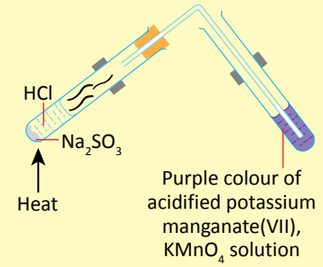



**Figure 2.14**

**H. Test for nitrogen dioxide gas**

**Instruction:**

1. Put two spatulas of lead(II) nitrate into a boiling tube.
2. Strongly heat the lead(II) nitrate.
3. Observe the colour of gas released.
4. Place a moist blue litmus paper into the mouth of the boiling tube.
5. Record your observation.

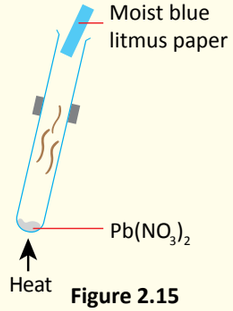



**Figure 2.15**

**Discussion:**

1. List the properties of each gas.
2. Summarise the method to test the gas released in the table provided. Scan QR code to download and print the table. Complete the table.

ATTACHMENT
Table

## Effect of Heat on Salts

**All ammonium**, **carbonate**, **nitrate** and **some sulphate salts decompose** when heated strongly. **All chloride salts are stable** against heating except ammonium chloride. Most salts that decompose when heated will produce metal **oxide** as residue. Changes of colour during heating give information about the type of metal oxide and the cation present in the salt.

**Table 2.7** Changes in salts colour after heating

| Original salt colour | Residue colour | Metal oxide formed | Cation present in salt |
|---|---|---|---|
| White | Yellow (when heated)<br>White (when cooled down) | ZnO | $Zn^{2+}$ |
| White | Brown (when heated)<br>White (when cooled down) | PbO | $Pb^{2+}$ |
| Blue or green | Black | CuO | $Cu^{2+}$ |
| Green or yellow | Brown | $Fe_2O_3$ | $Fe^{2+}$ or $Fe^{3+}$ |

## Activity 2.9

**Aim:** To study the effect of heat on carbonate salt and nitrate salt.

**A. Effect of heat on carbonate salt**

**Materials:** Limewater, copper(II) carbonate, zinc carbonate, lead(II) carbonate, sodium carbonate, calcium carbonate, potassium carbonate and magnesium carbonate.

**Apparatus:** Boiling tube, test tube, clamp, spatula, Bunsen burner, delivery tube and rubber stopper.

**Instruction:**

1. Put two spatulas of copper(II) carbonate, $CuCO_3$ into a boiling tube. Observe and record the colour of the carbonate salt.
2. Attach the delivery tube and rubber stopper to the mouth of the boiling tube. Make sure the other end of the delivery tube is in the limewater as shown in Figure 2.16.
3. Strongly heat the carbonate salt.
4. Note the changes that occur in the limewater and the colour of the residue left in the boiling tube when heated and cooled down. Record your observation.
5. Repeat steps 1 to 4 using zinc carbonate, lead(II) carbonate, sodium carbonate, calcium carbonate, potassium carbonate and magnesium carbonate to replace copper(II) carbonate.

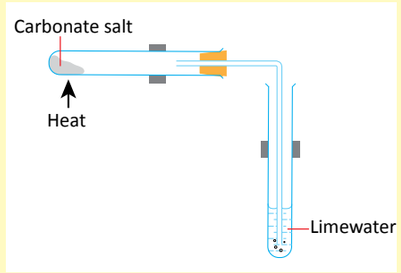



**Figure 2.16**

**Observation:**

**Table 2.8**

| Carbonate salts | Colour of salt before heating | Colour of solid residue | | Effect on the limewater |
|---|---|---|---|---|
| | | When heated | When cooled down | |
| Copper(II) carbonate | | | | |
| Zinc carbonate | | | | |
| Lead(II) carbonate | | | | |
| Sodium carbonate | | | | |
| Calcium carbonate | | | | |
| Potassium carbonate | | | | |
| Magnesium carbonate | | | | |

**Discussion:**

1. What is the role of the limewater in this activity?
2. Name the gas released in this activity.
3. List the carbonate salts that are decomposed by heat and write equation for each carbonate salt decomposition.
4. List the carbonate salts that are not decomposed by heat.
5. What can you deduce from the colour change that occurs on carbonate salts during heating?





**B. Effect of heat on nitrate salt**

**Materials:** Limewater, sodium nitrate, magnesium nitrate, lead(II) nitrate, zinc nitrate, iron(II) nitrate, iron(III) nitrate, calcium nitrate, copper(II) nitrate, potassium nitrate and wooden splint.

**Apparatus:** Boiling tube, test tube, tongs, spatula, Bunsen burner, delivery tube, dropper and rubber stopper.

**Instruction:**

1. Conduct this activity in groups. Discuss with your group members to plan a procedure to carry out this activity.
2. In your plan, include the following aspects:
   - the correct technique during heating of salt
   - test for the released gas
   - safety measures
   - observations
   - tabulation of data
3. Use the following salts for this activity:
   - sodium nitrate
   - calcium nitrate
   - magnesium nitrate
   - zinc nitrate
   - iron(II) nitrate
   - iron(III) nitrate
   - lead(II) nitrate
   - copper(II) nitrate
   - potassium nitrate
4. Make necessary observations and record in your report book.

**Observation:**

Record the data in a table.

**Discussion:**

1. Do all nitrate salts decompose to form the same results? Use observation to support your answer.
2. Write the equation for decomposition of nitrate salts when heated.

# Test for Anions and Cations

## Tests for Anions

You have learned that anion can be identified through gas released when salt is heated. The identity of anion in salt can also be determined through tests on the aqueous solution. Let's do Activity 2.10 to identify anions in aqueous solution.

### Activity 2.10

**Aim:** To test the presence of anions in aqueous solution.

**Materials:** 1.0 mol $dm^{-3}$ sodium carbonate solution, 1.0 mol $dm^{-3}$ sodium chloride solution, 1.0 mol $dm^{-3}$ sodium sulphate solution, 1.0 mol $dm^{-3}$ sodium nitrate solution, 1.0 mol $dm^{-3}$ iron(II) sulphate solution, 0.1 mol $dm^{-3}$ silver nitrate solution, 1.0 mol $dm^{-3}$ barium chloride solution, diluted sulphuric acid, diluted hydrochloric acid, 2.0 mol $dm^{-3}$ nitric acid, concentrated sulphuric acid, limewater and red litmus paper.

**Apparatus:** Test tube, spatula, glass rod, delivery tube, rubber stopper, Bunsen burner, dropper and tongs.

**A. Test to identify the carbonate ion, $CO_3^{2-}$**

**Instruction:**

1. Pour about 3 $cm^3$ of 1.0 mol $dm^{-3}$ sodium carbonate solution into a test tube.
2. Add diluted hydrochloric acid.
3. Channel the resulting gas into the limewater.
4. Make observations and record in Table 2.9.

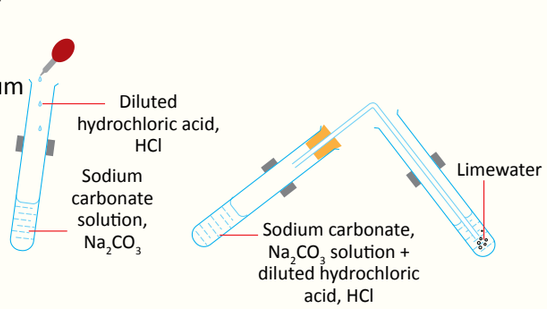



**Figure 2.17**

**B. Test to identify chloride ion, $Cl^-$**

**Instruction:**

1. Put 2 $cm^3$ of 1.0 mol $dm^{-3}$ sodium chloride into a test tube.
2. Add 2 $cm^3$ of 2.0 mol $dm^{-3}$ nitric acid.
3. Add 2 $cm^3$ of 0.1 mol $dm^{-3}$ silver nitrate solution.
4. Make observations and record in Table 2.9.

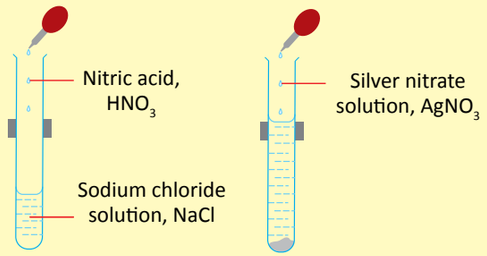



**Figure 2.18**





**C. Test to identify sulphate ion, $SO_4^{2-}$**

**Instruction:**

1. Put 2 $cm^3$ of 1.0 mol $dm^{-3}$ sodium sulphate into a test tube.
2. Add 2 $cm^3$ of diluted hydrochloric acid.
3. Add 2 $cm^3$ of 1.0 mol $dm^{-3}$barium chloride solution.
4. Make observations and record in Table 2.9.

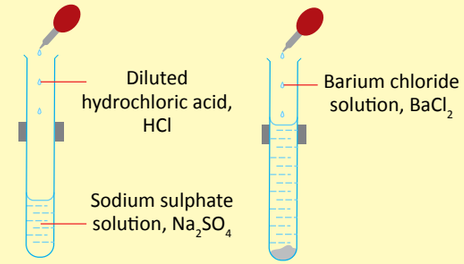



**Figure 2.19**

**D. Test to identify nitrate ion, $NO_3^-$**

**Instruction:**

1. Pour about 2 $cm^3$ of 1.0 mol $dm^{-3}$sodium nitrate solution into a test tube.
2. Add about 2 $cm^3$ of diluted sulphuric acid into the solution.
3. Add about 2 $cm^3$ of 1.0 mol $dm^{-3}$iron(II) sulphate solution. Shake the mixture.
4. Tilt the test tube and add concentrated sulphuric acid cautiously.
5. Make observations and record in Table 2.9.

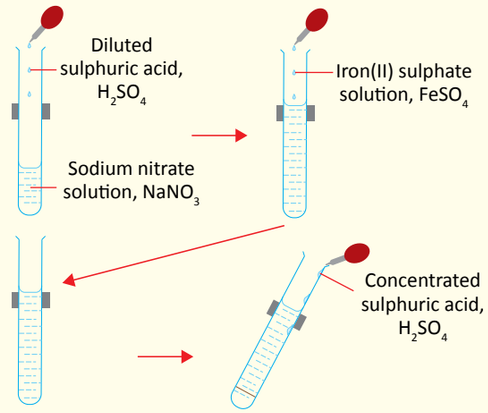



**Figure 2.20**

**Observation:**

**Table 2.9**

| Anion test | Observation | Inference |
|---|---|---|
| Carbonate ion test, $CO_3^{2-}$ | | |
| Chloride ion test, $Cl^-$ | | |
| Sulphate ion test, $SO_4^{2-}$ | | |
| Nitrate ion test, $NO_3^-$ | | |

**Discussion:**

1. Write the ionic equation for the reaction between acid and carbonate ions.
2. (a) Name a white precipitate formed for the chloride ion test.
   (b) Write the ionic equation for the formation of the precipitate.
3. (a) Name a white precipitate formed for the sulphate ion test.
   (b) Write the ionic equation for the formation of the precipitate.

## Tests for cations

The presence of cations can be detected by using two alkaline solutions, namely sodium hydroxide solution, NaOH and aqueous ammonia solution, $NH_3$. Alkaline solution used to produce metal hydroxide as in the following chemical formula:

Metal ion + hydroxide ion → metal hydroxide

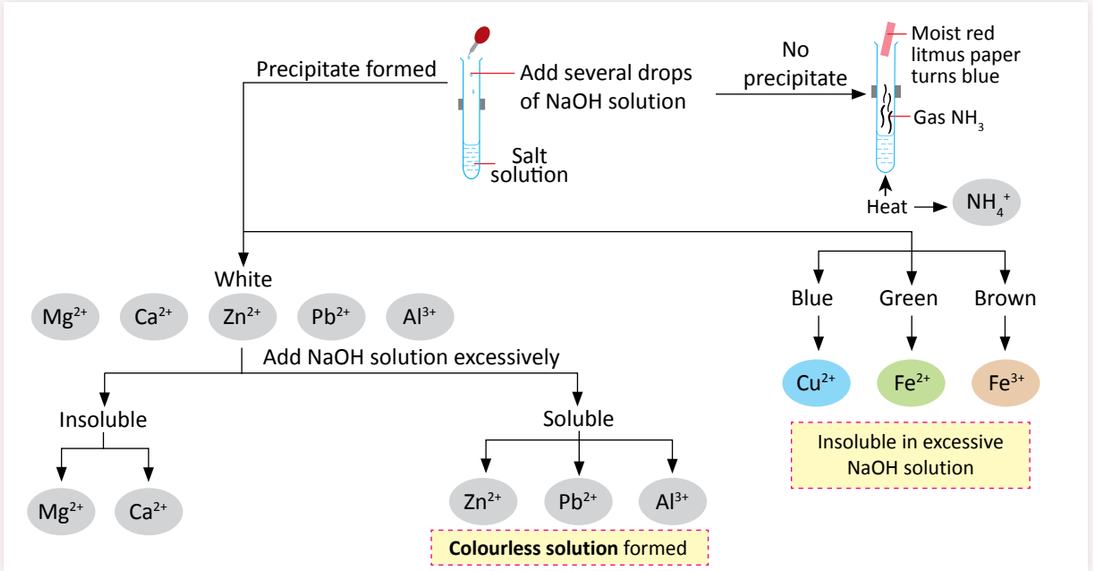



**Figure 2.21** Test for cations using sodium hydroxide solution, NaOH

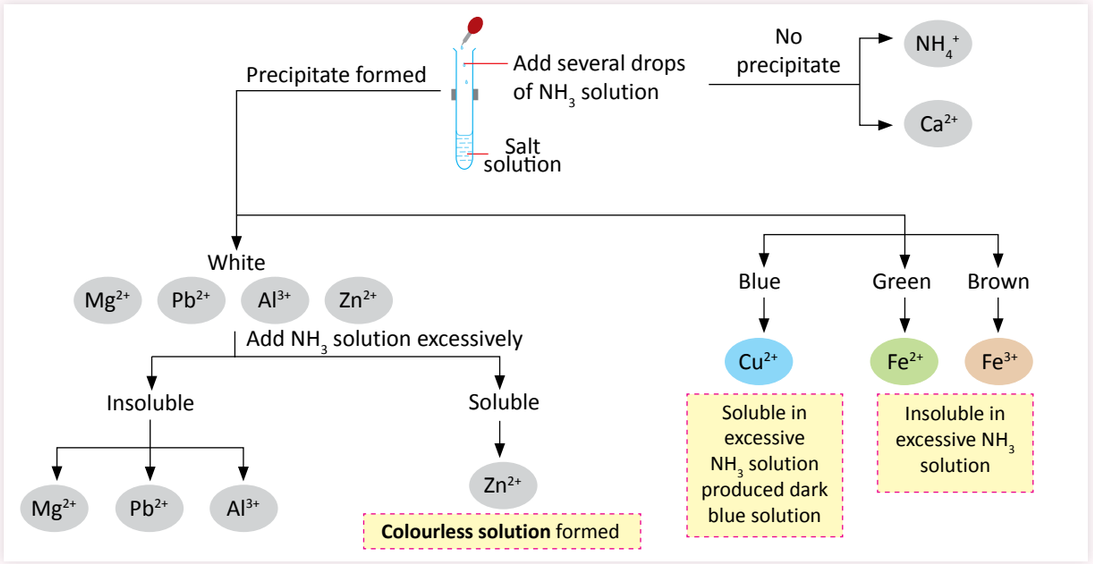



**Figure 2.22** Test for cations using ammonia solution, $NH_3$





Table 2.10 shows confimatory test for several types of cation.

**Table 2.10** Confirmatory test for $NH_4^+$, $Pb^{2+}$, $Fe^{2+}$ and $Fe^{3+}$

| Cation | Reagent | Observation |
|---|---|---|
| $NH_4^+$ | Nessler's Reagent | Brown precipitation |
| $Pb^{2+}$ | Potassium iodide solution | Yellow precipitation |
| $Fe^{2+}$ | Potassium hexacyanoferrate(II) solution, $K_4Fe(CN)_6$ | Light blue precipitation |
| | Potassium hexacyanoferrate(III) solution, $K_3Fe(CN)_6$ | Dark blue precipitation |
| | Potassium thiocyanate solution, KSCN | Red colour fades |
| $Fe^{3+}$ | Potassium hexacyanoferrate(II) solution, $K_4Fe(CN)_6$ | Dark blue precipitation |
| | Potassium hexacyanoferrate(III) solution, $K_3Fe(CN)_6$ | Brown-greenish precipitation |
| | Potassium thiocyanate solution, KSCN | Red-blood colour |

## Identification of Anions and Cations in an Unknown Salt

Do you remember the steps to identify anions and cations in salt? Figure 2.23 shows a qualitative analysis of an unknown salt.

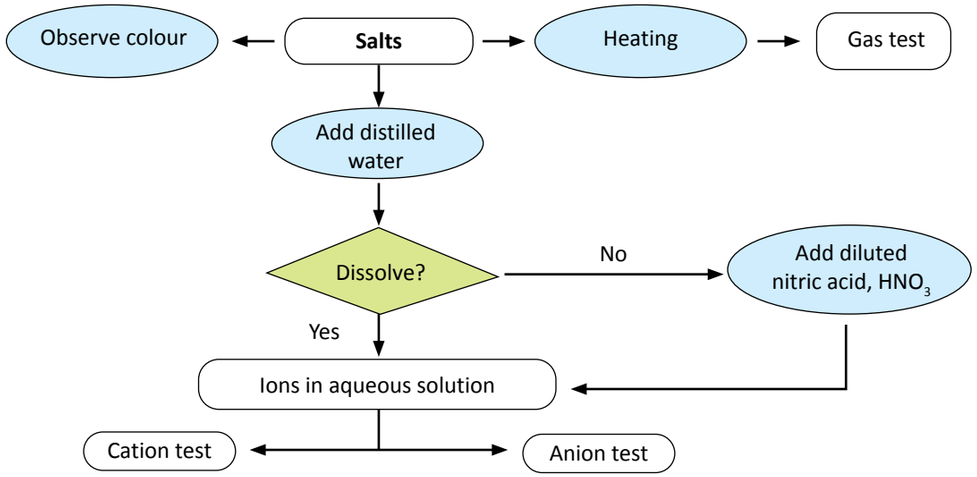



**Figure 2.23** Qualitative analysis for an unknown salt

### Activity 2.11

**Aim:** To identify unknown salt.

**Materials:** Two types of unknown salts, G1 and G2, diluted nitric acid solution, 2.0 mol $dm^{-3}$ sodium hydroxide solution, 2.0 mol $dm^{-3}$ ammonia solution, distilled water, 0.1 mol $dm^{-3}$ silver nitrate solution, diluted sulphuric acid, concentrated sulphuric acid, 1.0 mol $dm^{-3}$ iron(II) sulphate solution and 0.5 mol $dm^{-3}$ potassium iodide solution.

**Apparatus:** Test tube, boiling tube, tongs, Bunsen burner and wash bottle.

**Instruction:**

1. Perform a test as in Table 2.11 to identify salt G1 and test in Table 2.12 to identify salt G2.
2. Record observations and inferences for each test.

**Table 2.11** Test to identify salt G1

| Tests | Observation | Inference |
|---|---|---|
| Pour about 2 $cm^3$ of G1 into a test tube. Add ammonia solution until it is in excess. | | |
| Pour about 2 $cm^3$ of G1 into a test tube. Add sodium hydroxide solution until it is in excess. | | |
| Pour about 2 $cm^3$ of G1 into a test tube. Add diluted nitric acid followed by silver nitrate solution. | | |

**Table 2.12** Test to identify salt G2

| Tests | Observation | Inference |
|---|---|---|
| Add one spatula of solid G2 in a boiling tube and heat strongly. | | |
| Add 10 $cm^3$ of dilute nitric acid to dissolve the solid G2. Divide the resulting solution into four different test tubes labelled A, B, C and D. | | |
| **Test tube A**<br>Add diluted sulphuric acid and iron(II) sulphate solution, followed by concentrated sulphuric acid slowly through the wall of the test tube. | | |
| **Test tube B**<br>Add sodium hydroxide solution gradually until it is in excess. | | |
| **Test tube C**<br>Add ammonia solution gradually until it is in excess. | | |
| **Test tube D**<br>Add potassium iodide solution. | | |





## Formative Exercise 2.2

1. The following table shows the observations of tests conducted on salt Q.

| Tests | Observation |
|---|---|
| Test 1: Heating on solid salt Q | A gas is released and turns limewater milky. Residue turns brown when heated and yellow when it is cooled down. |
| Test 2: Salt Q is dissolved in a diluted nitric acid. Filtrate is mixed with excess sodium hydroxide solution | A white precipitate that dissolves in excess sodium hydroxide solution is formed. |

   (a) Identify an anion present in Test 1 and describe a chemical test to confirm this anion.

   (b) Identify three cations present in Test 2. Describe a chemical test to confirm the cations in salt Q based on the residue colour in Test 1.

2. List the steps in qualitative analysis to identify cations and anions present in a salt.

3. Heating calcium carbonate powder produces gas X which turns limewater milky.

   Name gas X.

4. Heating a blue colour salt produces black powder. What cation that may be present in the salt?

## Summary

**Uses in daily life**

- Food preparation
- Food preservation
- Agriculture
- Medical

Quick Quiz 2

**SALTS**

**Quantitative solution**

Calculations involving quantities of materials that are used or products that are formed in the reaction

**Salt preparation**

**Soluble salts**

Reaction of acid with:

- alkali
- metal oxide
- metal carbonate
- metal

**Insoluble salts**

Double decomposition through precipitation method

**Qualititative analysis**

**Anion**

- Action on heat and tests for gas released
- Particular reagents

**Cation**

- Sodium hydroxide
- Ammonia solution
- Particular reagents

## Self-reflection

After studying this chapter, students will be able to:

**2.1 Salts**

- Explain with examples the meaning of salt and its uses in daily life.
- Describe the preparation process of soluble salts and insoluble salts.
- Conduct an experiment to distinguish the solubility of nitrate, sulphates, carbonate and chloride salts in water.
- Explain the importance of purification process of soluble salts.
- Solve quantitative problems in stoichiometric reaction.

**2.2 Qualitative Analysis of Salt**

- Describe the meaning of qualitative analysis.
- Make inferences on salts based on colour and solubility in water.
- Determine tests to identify gases.
- Describe the action of heat on salts.
- Identify chemical tests for anions and cations.
- Plan qualitative analysis to identify salts.





## Summative Practice 2

1. State the **two** materials to produce copper(II) nitrate. Explain how the preparation process of such salt is done.
2. Hydrochloric acid reacts with sodium hydroxide solution to produce sodium chloride and water.
   (a) Write a balanced chemical equation.
   (b) What is the volume of 2.0 mol $dm^{-3}$ sodium hydroxide solution required to neutralise 25 $cm^3$ of 1.0 mol $dm^{-3}$ hydrochloric acid?
3. Figure 1 shows a flow chart of a series of reactions of copper(II) carbonate.

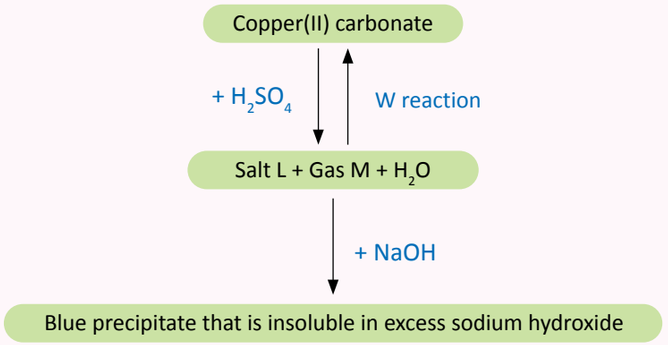



**Figure 1**

Copper(II) carbonate reacts with sulphuric acid to produce salt L, gas M and water. Gas M turns limewater milky.

(a) Based on Figure 1, identify salt L and gas M.
(b) Write the chemical equation for the reaction.
(c) When salt L solution is added to sodium hydroxide solution, insoluble blue precipitate is produced in excess sodium hydroxide. Write the formula for the blue precipitate.
(d) Salt L can be converted back to copper(II) carbonate by reaction W. Suggest a suitable chemical used in reaction W.
(e) Specify the name of reaction W.

Check answers

CHAPTER 3

# Carbon Compounds in Daily Life

In this chapter, students will learn about:

- Green technology and management of used palm oil

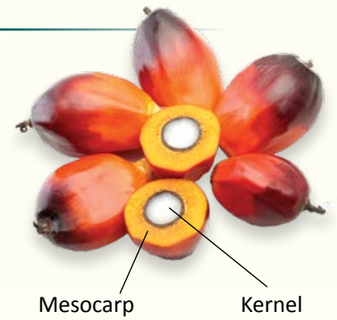
Soap is a chemical used as a cleaning agent to remove stains. In order to preserve a clean environment, soap can be produced using used palm oil. What are the advantages of green technology in the management of used palm oil?

**KEYWORDS**

- Used cooking oil
- Oxidation
- Hydrolysis
- Polymerisation
- Green technology
- Transesterification
- Biodiesel
- Glycerol

# 3.1 Green Technology and Management of Used Palm Oil

Malaysia is amongst the world's largest producer in palm oil industry thus contributes to the main economic growth in Malaysia.




**Photograph 3.1**
Cross section of palm fruit

## Palm Oil and Used Palm Oil

Apart from palm oil, used palm oil such as used cooking oil can also be processed into new products such as biodiesel, soap and detergent.

**Palm oil characteristics**

- Ratio; saturated fat : unsaturated fat, 50 : 50
- Resist heat and oxidation
- Lowering Low Density Lipoprotein (LDL) cholesterol level and raising High Density Lipoprotein (HDL) cholesterol level
- Competitive price (cheaper than other vegetable oils)
- Rich in vitamin A and vitamin E (antioxidant)

**Figure 3.1** Palm oil characteristics

***Science Info***

Saturated fatty acids contain only single bond, -C-C- between carbon atoms.

Unsaturated fatty acids contain at least one double bond, C=C between carbon atoms.

Used palm oil has darker colour and the amount of free fatty acids and oxidised compounds are higher than refined palm oil. Used palm oil cannot be refined to be used as source of food.

***Activity 3.1***

**Aim:** To compare the differences in characteristics of palm oil and used palm oil.

**Instruction:**

1. Carry out this activity in groups.
2. Scan the QR code to read an article on repeated use of cooking oil.
3. Gather information on the similarities and differences of palm oil and used palm oil.

INFORMATION

Articles on the use of cooking oil repeatedly

Medium: Bahasa Melayu



3.1.1



4. Record the results of your group in Table 3.1.
5. Present the discussion of each group using multimedia presentation.

**Table 3.1**

| | Palm oil | Used palm oil |
|---|---|---|
| **Differences** | | |
| **Similarities** | | |

## Factors Affecting the Spoilage of Palm Oil

Palm oil has a ratio of saturated fatty acid and unsaturated fatty acid similar to 1 : 1. This causes the palm oil to be stable at higher temperature compared to olive oil. Stability at high temperature allows palm oil to be used for frying for a long period.

However, the quality of palm oil will reduce when it is exposed to high temperature or stored for a very long time. Factors affecting the spoilage of palm oil are oxidation, hydrolysis and polymerisation.

INFORMATION

Life cycle of an oil palm tree

**Oxidation**

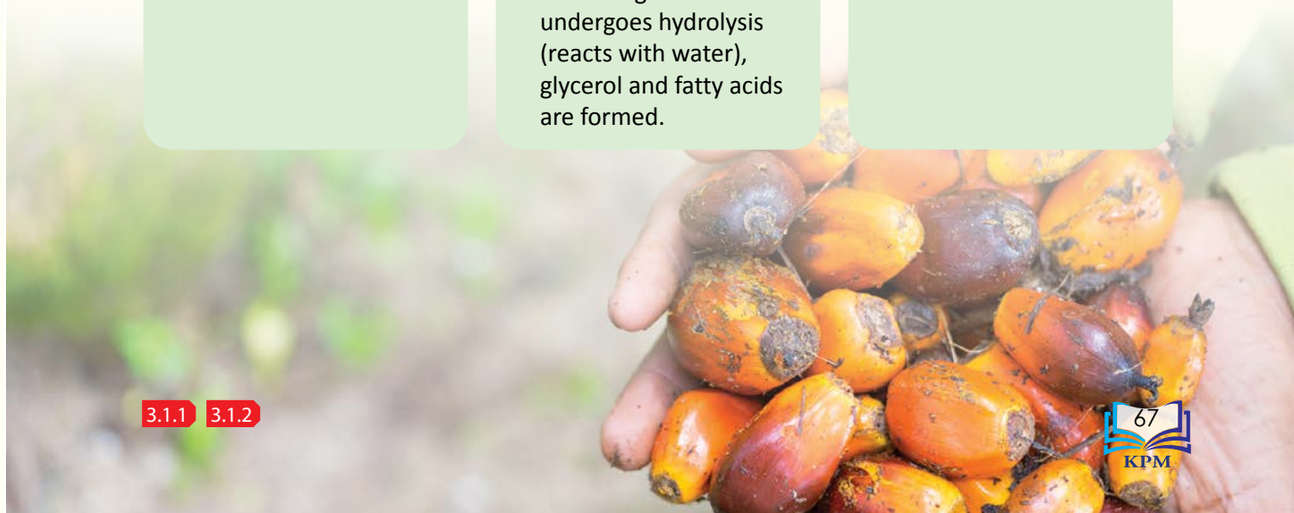
- The process of oxidation can occur in palm oil due to heating of oil at a very high temperature and for repeated frying used.

**Hydrolysis**

- During the heating process of a palm oil, the water vapour presence will cause hydrolysis process to take place.
- When vegetable oil undergoes hydrolysis (reacts with water), glycerol and fatty acids are formed.

**Polymerisation**

- The polymerisation process only occurs when there is suitable catalyst such as a metal or mineral, a suitable reaction temperature and a sufficient time.



3.1.1 3.1.2

## The Needs to Process Used Palm Oil

Used palm oil can be processed for non-food use. Reprocessing of used palm oil can reduce dependency on natural resources that are not renewable. Some of the needs to process used palm oil are as follows:

**Needs to process used palm oil**

- The lower price makes palm oil becomes consumer's main preference
- The bonds ratio of C=C: -C-C- of palm oil can produce many non-food products

**Figure 3.2** The needs to process used palm oil

### Wonderful Malaysia

Malaysian Palm Oil Board (MPOB) has developed biodiesel production technology from palm oil. Since 2006, MPOB has commercialised biodiesel production technology in Malaysia, Thailand, South Korea and Colombia.

## Biodiesel and Glycerol

Energy source that is widely used by many countries nowadays is based on non-renewable energy, namely fossil fuels. However, the use of this energy source is a concern because:

1. Fossil fuels are almost extinct and inadequate as a fuel source.
2. Fuel energy demand is increasing for continuous development, especially in developed countries.
3. The uses of fossil fuels have negative effects on the environment such as acid rain.

### Science Info

Transesterification is a transformation process of big triglyceride molecule to become smaller molecules. The molecular structure will look similar or almost as the molecules contained in diesel fuel.

**Photograph 3.2** Palm biodiesel pilot plant of Malaysia Palm Oil Board (MPOB)

Therefore, biodiesel source from used palm oil is in high demand to replace fossil fuels. Biodiesel is increasingly popular for use as a source of renewable energy.

In theory, biodiesel emits carbon footprint lower than diesel.

Biodiesel is produced from palm oil through transesterification process is produced using methanol, while potassium hydroxide (KOH) or sodium hydroxide (NaOH) is used as a catalyst. The by-products of this process are water and glycerol. The resulting glycerol can be treated and processed into soap.



3.1.3 3.1.4



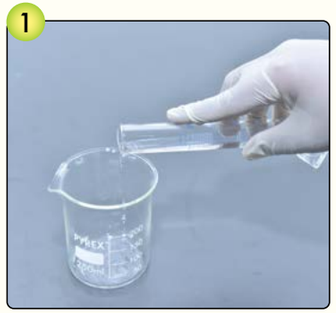
**Production of Biodiesel and Glycerol Using Used Palm Oil**

Biodiesel and glycerol can be produced using palm oil and used palm oil. Figure 3.3 shows steps in the production of biodiesel and its by-product, glycerol using used palm oil.

Animation of biodiesel production

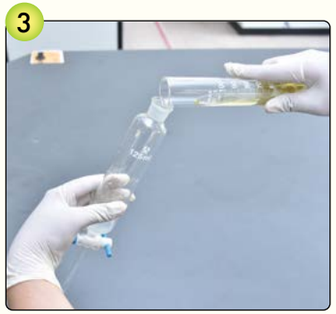
Medium: Bahasa Melayu

VIDEO



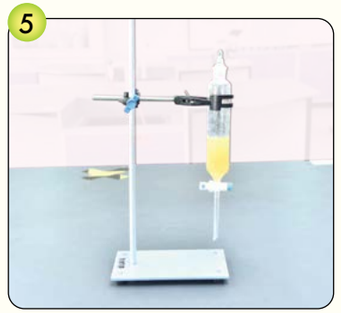
1 Pour ethanol into a beaker.

2 Dissolve NaOH in ethanol.



3 Heat used cooking oil and pour into the mixture (NaOH and ethanol).

4 Shake the mixture.



5 Let the mixture sit.

6 Biodiesel and glycerol.

**Figure 3.3** Steps in the production of biodiesel and glycerol

ATTACHMENT

*Modul Teknologi Hijau Kimia*, CETREE USM
Title: *Minyak Masak Terpakai ke Arah Kelestarian*
Pages: 61 – 65
Medium: Bahasa Melayu

The advantages of biodiesel production through the recycling process of cooking oil are as follow:

- avoid drainage system disruption.
- alternative fuel sources.
- reduce air pollution.

### Science Info

In Malaysia, MPOB regulates the country's palm oil industry. In the production of biodiesel, MPOB uses palm oil to ensure the quality of biodiesel.

3.1.4

Green Technology

## Activity 3.2

**Aim:** To make soap from used cooking oil.

**Materials:** 60 $cm^3$ of used cooking oil, 10 g of sodium hydroxide powder (NaOH), 50 $cm^3$ of distilled water, 2 tablespoons of salt, molds of various shapes (if necessary), pH indicator, ice and screwpine leaves (pandan leaves).

**Apparatus:** Beaker, measuring cylinder, glass rod, Bunsen burner, filter funnel, filter paper, wire gauze, spatula, tripod stand and thermometer.

**Instruction:**

1. Discuss in groups and plan an activity to produce soap using the materials provided.
2. You need to give a brief report on soap making activities. For example, in terms of texture, pH value and others.
3. You also need to present the results of your group discussion on the pH value of the soap mixture and ways to increase the commercial value of the soap produced by giving its rationale.

ATTACHMENT

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Title: *Minyak Masak Terpakai ke Arah Kelestarian*
Pages: 57 – 60
Medium: Bahasa Melayu

## Uses of Glycerol

Production of biodiesel requires high cost. In order to accommodate this, its by-product, glycerol can be fully utilised as it has wide range of uses in the field of cosmetics, pharmaceuticals and polymers. There are as many as 10% – 12% of glycerol produced as a by-product of biodiesel per tonne.

The glycerol produced has 15% of impurities and will be purified before consumption. In addition, glycerol is also processed into polyglycerol using microwave reactor. It is used as an emulsifier in cosmetics and food.

The uses of glycerol are:

| | | |
|---|---|---|
| 1 | Cosmetics | Foundation, facial cleanser, lipstick |
| 2 | Food | Emulsifier agent for pastry, chocolate |
| 3 | Pharmaceuticals | Baby cream, sunscreen, lotion |
| 4 | Hair care | Shampoo, conditioner, hair gel |
| 5 | Cleaning agent | Soap, detergent |
| 6 | Agriculture | Pesticide |



3.1.4 3.1.5



## Usage Of Green Technology In Managing Used Palm Oil

Green technology is defined as the development and application of products, equipment and systems to preserve the environment and nature as well as minimise or reduce the negative impacts of human activities.

Used palm oil is one of the wastes managed by green technology under the Waste Management and Wastewater Sector. It is used in the production of biodiesel by applying the isolation and recycling methods. Biodiesel is increasingly being used as a renewable energy source to replace other fossil fuels. Biodiesel is a more effective source of energy because it does not harm the environment, even though the energy produced is the same as diesel. Therefore, the use of green technology is becoming the choice of the society because of its effectiveness in maintaining a good environment.

### Science Info

There are seven sectors in green technology, namely:

- Energy Supply Sector
- Waste Management and Wastewater Sector
- Building Sector
- Industrial Sector
- Agriculture and Forestry Sector
- Transport Sector
- ICT Sector

Green Technology

## Activity 3.3

**Aim:** To compare the carbon content released by diesel and biodiesel.

**Materials:** Biodiesel, diesel, matches, wooden splint and filter paper.

**Apparatus:** Dropper and crucible.

**Instruction:**

1. Put 10 drops of biodiesel and diesel into different crucibles.
2. Light up wooden splints and place on biodiesel and diesel simultaneously.
3. Compare the soot released using filter paper.

**Discussion:**

1. What is the effect of carbon on the environment?
2. Why biodiesel produced less soot than diesel?

ATTACHMENT

*Modul Teknologi Hijau Kimia*, CETREE USM
Title: *Minyak Masak Terpakai ke Arah Kelestarian*
Pages: 66 – 68
Medium: Bahasa Melayu

From Activity 3.3, biomass fuel produces smoke that may be hazardous to the environment. Thus, Malaysia has introduced green technology in order to manage used palm oil. The examples are the production of soap, biodiesel and glycerol.

**Photograph 3.3** Example of used palm oil products

3.1.6

Green Technology

## Activity 3.4

**Aim:** To design a plan for management of used palm oil.

Most Malaysians love to fry food using palm oil. If used palm oil is not properly managed, it will have a detrimental impact on the environment, especially aquatic life.

**Instruction:**

1. Conduct this activity in groups.
2. Collect and make further analysis on the information of the followings:
   (a) Impact of the palm oil on the environment.
   (b) Ways to minimise the impact of the palm oil on the environment.
3. Analyse the information.
4. Present your findings using multimedia presentation.

The use of green technology in managing used palm oil gives a lot of positive effects such as:

1. Avoid clogged drainage system.
2. Reduce water pollution.
3. Reduce the use of chemicals in soap production.
4. Create awareness that cooking oil can be recycled.

## Formative Exercise 3.1

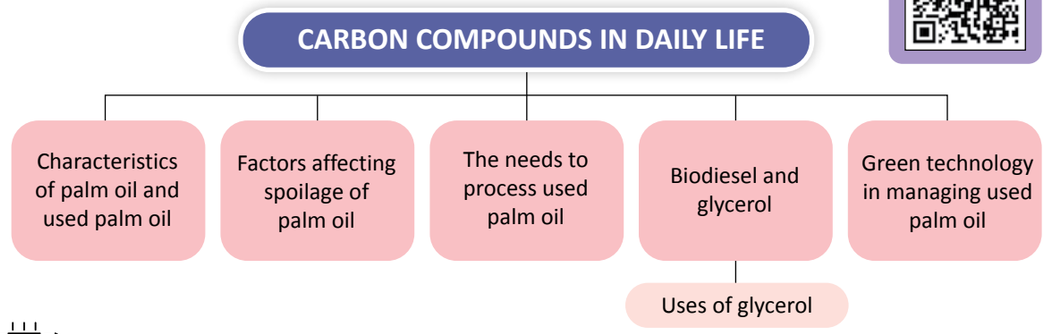
1. What physical changes can be observed when oil spoilt?
2. State **three** factors that cause the spoilage of palm oil.
3. State **three** products that can be produced from used palm oil.
4. Give **two** reasons why palm oil is preferable.





Quick Quiz 3

## Summary




## Self-reflection

After studying this chapter, students will be able to:

**3.1 Green Technology and Management of Used Palm Oil**

- Compare and contrast the characteristics of palm oil and used palm oil.
- Identify the factors that cause the spoilage of palm oil.
- Justify the needs to process used palm oil.
- Break down of used palm oil to produce biodiesel and glycerol.
- Elaborate the uses of by-product that is glycerol.
- Justify the usage of green technology in managing used palm oil.

## Summative Practice 3

1. Describe briefly the advantages of using palm oil in the frying process compared to olive oil.
2. State **two** products related to glycerol in the food industry.
3. Explain the process of producing biodiesel using used palm oil.
4. You are an entrepreneur who makes soap from used oil and wants to sell it to the foreign market and competes with other entrepreneurs. How can you produce higher economic value of soap from used cooking oil?
5. What can be done to avoid producing soap that is too alkaline?

Check answers

CHAPTER 4

# Energy and Chemical Change

In this chapter, students will learn about:

- Light energy in chemical reactions
- Heat energy in chemical reactions
- Electrical energy in chemical reactions

Have you ever wondered why most medicines are stored in a dark coloured bottle or in an opaque bottle?

**KEYWORDS**

- Photosensitive
- Photochromic
- Exothermic
- Endothermic
- Displacement
- Electrolysis
- Extraction
- Plating
- Purification

# 4.1 Light Energy in Chemical Reactions

## Examples of Chemical Reactions that Require Light

Light energy can be used to perform chemical reactions. Examples of chemical reaction caused by light are the process of photosynthesis and the change of newspaper's colour when exposed to sunlight. What other chemical reactions that can be observed around us?


**Figure 4.1** Chemical reactions that require light

### Photolysis of Water in Photosynthesis

Green plants need sunlight to produce glucose. Chlorophyll is a green-coloured pigment in a green leaf that absorbs sunlight.

The absorbed light energy is then used to split water molecules into hydrogen ion and oxygen. This process is called photolysis of water.

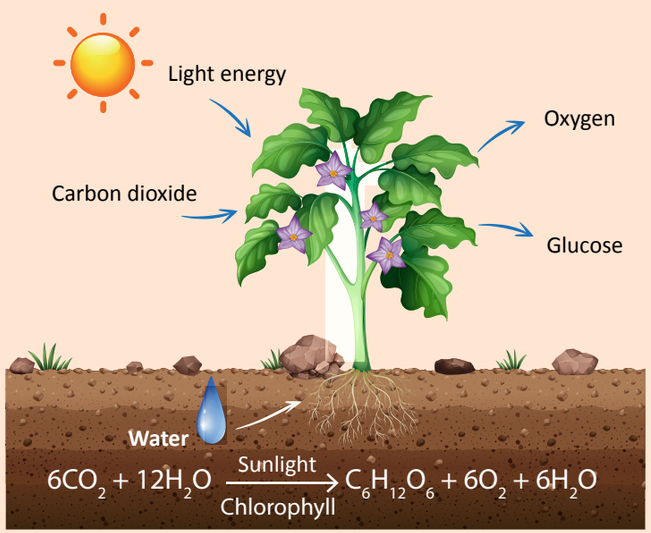



**Figure 4.2** Chemical equation of photosynthesis process

VIDEO

Process of photosynthesis

The products of photosynthesis are **glucose** and **oxygen gas**. Plants and animals use synthesised glucose as a **food source**. Excess glucose is **stored** in the form of starch in fruit, roots or other parts of plant. Energy change that occurs during the process of photosynthesis is **light energy → chemical energy**.





### Photographic Film

Did you know the surface of **photographic film** is coated with a thin layer of **silver bromide** or **silver chloride**, which is sensitive to light? When photographing, the photographic film is exposed to light and causing decomposition of silver bromide into black silver granules and bromine gas. Photographic film should be stored in a sealed dark coloured bottle.

VIDEO

How film camera works

Light

Silver bromide → silver + bromine

### Storage of Light-Sensitive Chemicals

Light-sensitive chemical is known as photosensitive chemical (sensitive to light). For example, silver salt, chlorine water and hydrogen peroxide are very sensitive to light and will decompose to other forms of material when exposed to light. Therefore, all **photosensitive chemicals** must be stored in a sealed **dark coloured bottle** as in Photograph 4.1.


**Photograph 4.1** Chemicals stored in dark coloured bottles

### Activity 4.1

**Aim:** To study the reaction that occurs rapidly and slowly due to sunlight.

**Instruction:**

1. Carry out this activity in groups.
2. Each group is assigned to prepare a multimedia presentation on the following topics:
   (a) Chemical reactions that occur rapidly due to sunlight, with examples.
   (b) Chemical reactions that occur slowly due to sunlight, with examples.

## Effect of Light to Produce Chemical Reactions

**Photochromic glass** is a glass with silver chloride or silver bromide trapped in it. Due to silver salt that is sensitive to light, it will decompose and form black silver granules when exposed to light. The uses of photochromic glass are:

Spectacles

Camera lens

Information panel

Light intensity meter

### Activity 4.2

**Aim:** To study the effect of light on photochromic glass.

**Materials:** Normal glass spectacles and photochromic glass spectacles.

**Instruction:**

1. Carry out this activity in groups.
2. Each group is supplied with normal glass spectacles and photochromic glass spectacles.
3. Two students will wear different glass spectacles.
4. Students are asked to be in a dark room. Other team members need to observe the glass spectacles of both students.
5. Repeat steps 2 and 3 in a bright area.

**Discussion:**

1. What are the changes to the normal glass spectacles and photochromic glass spectacles?
2. What are the advantages of photochromic glass spectacles compared to normal glass spectacles?

### Formative Exercise 4.1

1. Give **two** examples of chemical reactions that require light.
2. Photochromic glass spectacles have become the choice of society today because of its ability to change colour according to the quantity of light present.
   (a) Explain the mechanism that applies to photochromic glass spectacles when exposed to sunlight.
   (b) What is the relationship between the sensitivity of photochromic glass spectacles with the duration of its use?





# 4.2 Heat Energy in Chemical Reactions

## Heat Changes in Chemical Reactions

All materials have energy. Different materials have different **energy content**. The absolute energy content of a substance is given by symbol **H** with unit of joules (J) or kilojoules (kJ).

### Energy Level Diagram

Energy level diagram is a diagram that shows the total energy content of the reactants compared to the total energy content of the products.

The difference between the energy level of the reactant ($H_1$) and the energy level of the product ($H_2$) gives the value of heat energy released ($\Delta H$) during the reaction, $\Delta H = H_2 - H_1$.

For **exothermic** reaction, the total energy content of the products is **lower** than the total energy content of the reactants. Therefore, the value of $\Delta H$ for the exothermic reaction is negative.

**Science Info**

Exothermic reaction is a reaction that releases heat energy to surrounding.

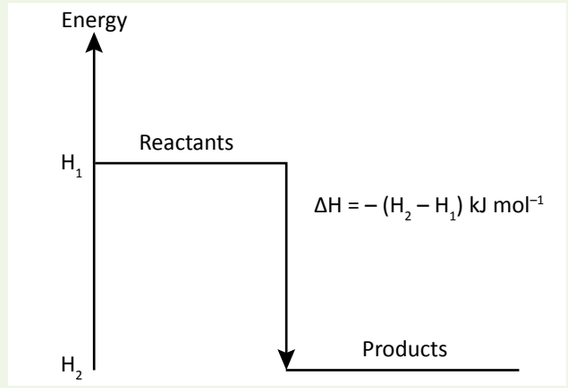



**Figure 4.3** Energy level diagram for **exothermic** reaction

For **endothermic** reaction, the total energy content of the products is **higher** than the total energy content of the reactants. Therefore, the value of $\Delta H$ for the endothermic reaction is positive.

**Science Info**

Endothermic reaction is a reaction that absorbs heat energy from surrounding.

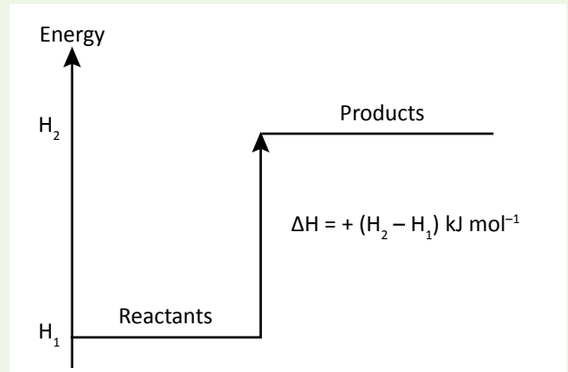



**Figure 4.4** Energy level diagram for **endothermic** reaction

**Example 1**

Draw an energy level diagram when magnesium reacts with oxygen and heat is released.

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

$$\Delta H = -1\ 204\ kJ\ mol^{-1}$$

**Solution:**

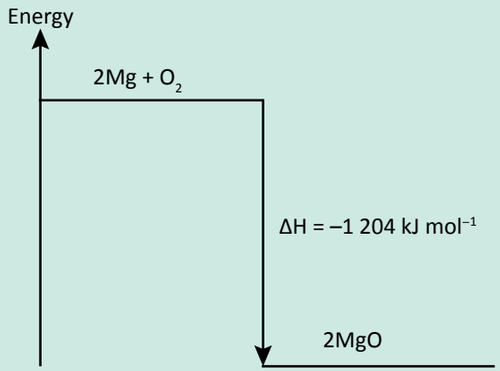



**Figure 4.5** Energy level diagram for the reaction between magnesium and oxygen

In the reaction between magnesium and oxygen, the total energy content of magnesium oxide is lower than the total energy content of magnesium and oxygen. The excess energy is released as heat. Thus, this reaction is exothermic reaction.

## Heat of Displacement

**Heat of displacement** is heat released when 1 mol of metal is displaced from its salt solution by a more electropositive metal. Let's do Activity 4.3.

### Activity 4.3

**Aim:** To determine heat of displacement of copper by zinc and magnesium.

**Apparatus:** Thermometer, plastic cup and measuring cylinder.

**Materials:** 0.2 mol $dm^{-3}$ copper(II) sulphate solution, zinc powder and magnesium powder.

**Instruction:**

1. Measure 25.0 $cm^3$ of 0.2 mol $dm^{-3}$ copper(II) sulphate solution and pour into a plastic cup. Record the initial temperature reading.
2. Pour the zinc powder into the plastic cup containing copper(II) sulphate solution until it is in excess.
3. Stir the mixture using a thermometer and record the highest temperature reached.
4. Repeat steps 1 to 3 using magnesium powder.





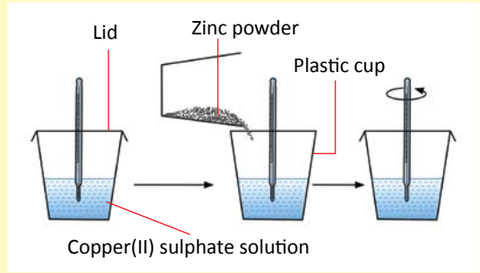



**Figure 4.6**

**Observation:**

**Table 4.1**

| Temperature / Type of metals | Zinc powder | Magnesium powder |
|---|---|---|
| Initial temperature of copper(II) sulphate (°C), $T_1$ | | |
| Highest temperature reached (°C), $T_2$ | | |
| Changes in temperature (°C), $(T_2 - T_1)$ | | |

**Discussion:**

1. Determine the heat of displacement of copper by zinc. Then, draw the energy level diagram for the reaction.
2. Determine the heat of displacement of copper by magnesium. Then, draw the energy level diagram for the reaction.
3. Why plastic cup is used in this activity?
4. Why zinc powder is added until it is in excess?

**Calculation Involving Heat of Displacement**

We can calculate the heat of displacement of a chemical reaction by using the following formula:

(a) Calculate the number of moles of metal displaced = *x* mol

(b) Calculate the changes in temperature, θ = highest temperature – initial temperature

(c) Find the heat released = mcθ

mcθ = *y* J

Where, m = mass
c = specific heat capacity of water
θ = changes in temperature

(d) Determine the heat of displacement

From (a) and (c):

Heat of displacement of *x* mol of metal produces *y* J of heat.

Heat of displacement is

$= -\frac{y}{x}$ J $mol^{-1}$

(e) Convert J $mol^{-1}$ to kJ $mol^{-1}$ for final answer.

**Example 2**

When excess zinc powder is added to 100 $cm^3$ of copper(II) sulphate, 0.64 g of copper is produced and temperature of the solution changes from 28.0°C to 33.5°C. Calculate the heat of displacement of copper by zinc.

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

[Relative atomic mass: Cu = 64; density of water = 1.0 g $cm^{-3}$;
Specific heat capacity of water = 4.2 J $g^{-1}$ $^oC^{-1}$]

**Solution:**

**Step 1**

Find the number of moles of copper,

$$\text{Number of moles} = \frac{\text{mass of copper}}{\text{molar mass of copper}}$$

$$= \frac{0.64}{64}$$

$$= 0.01 \text{ mol}$$

**Step 2**

Calculate the changes in temperature, θ

θ = Highest temperature – initial temperature

= 33.5 – 28.0,

= 5.5°C

**Step 3**

Find the heat released,

Using the formula, heat released = mc θ

= (100 × 1.0) × 4.2 × 5.5

= 2 310 J

**Step 4**

Calculate the heat of displacement of copper by zinc.

Displacement of 0.01 mol Cu releases energy of 2.31 kJ. Heat of displacement released by 1 mol Cu

$$= \frac{-2.31}{0.01}$$

$= -231 \text{ kJ mol}^{-1}$

## Formative Exercise 4.2

1. Draw energy level diagram for each of the following reactions:
   (a) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$ $\Delta H = -152 \text{ kJ mol}^{-1}$
   (b) $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ $\Delta H = -1270 \text{ kJ mol}^{-1}$
   (c) $C + 2S \rightarrow CS_2$ $\Delta H = +320 \text{ kJ mol}^{-1}$
   (d) $N_2 + 2O_2 \rightarrow 2NO_2$ $\Delta H = +300 \text{ kJ mol}^{-1}$
2. When excess magnesium powder is added to 20 $cm^3$ of 0.5 mol $dm^{-3}$ zinc(II) nitrate solution, the temperature increases from 30.0°C to 40.5°C. What is the heat of displacement of zinc?
3. 2.4 g of magnesium is added to 100 $cm^3$ of 2.0 mol $dm^{-3}$ copper(II) chloride solution at a temperature of 30.0°C. The heat of reaction is –13.86 kJ $mol^{-1}$. What is the highest temperature for this experiment?
   [Relative atomic mass: Mg = 24; Specific heat capacity of water = 4.2 J $g^{-1}$ $^oC^{-1}$]





# 4.3 Electrical Energy in Chemical Reactions

## Energy Changes in Electrolytic Cell and Chemical Cell

**Electrolysis** is a **decomposition** process of a chemical compound (electrolyte) in a molten or aqueous state when an **electric current** flows through it. Meanwhile, **electrolytic cell** is an arrangement of a circuit consisting **electrodes** (known as anode and cathode) dipped in an electrolyte and connected to a battery.

### Electrolytic Cell

**Electrolysis of Molten Compounds**

In molten electrolytes, the ions move freely. During electrolysis, the negative ions or anions move to the anode, while the positive ions or cations move to the cathode. Let's do Activity 4.4 to study the electrolysis process of lead(II) bromide, $PbBr_2$.

### Activity 4.4

**Aim:** To study the electrolysis of molten lead(II) bromide, $PbBr_2$.

**Material:** Lead(II) bromide.

**Apparatus:** Batteries, carbon electrodes, connecting wires, light bulb, ammeter, crocodile clips, spatula, crucible, clay triangle, tripod stand and Bunsen burner.

**Instruction:**

1. Put one spatula of lead(II) bromide powder into a crucible.
2. Connect two bars of carbon electrodes to batteries, ammeter and light bulb.
3. Dip the electrodes in lead(II) bromide powder.
4. Heat the lead(II) bromide until it becomes molten.
5. Record the observations in Table 4.2.

**Be Careful!**

Do not inhale the brown gas released because it is poisonous. Carry out this activity in a fume chamber.

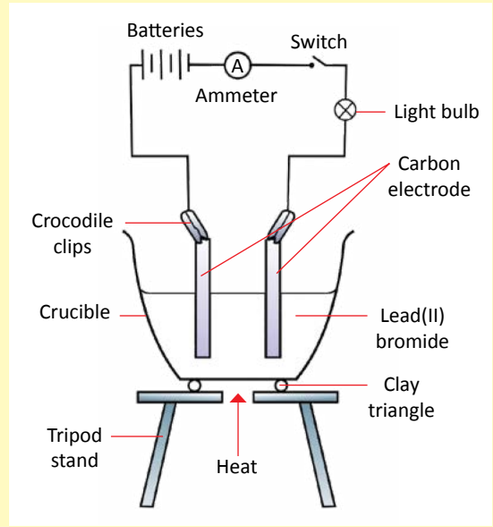



**Figure 4.7**

**Observation:**

**Table 4.2**

| State of lead(II) bromide | Observations | | | |
|---|---|---|---|---|
| | Light bulb | Ammeter | Anode | Cathode |
| Solid | | | | |
| Molten | | | | |

**Discussion:**

1. Name the ions that move to cathode and anode during electrolysis.
2. Write the half equations to represent the reaction at the anode and cathode.

During the electrolysis of molten lead(II) bromide, bromide ion, $Br^-$ is attracted to anode while lead(II) ion, $Pb^{2+}$ is attracted to cathode. At cathode, the lead(II) ions, $Pb^{2+}$ will be discharged and each of its ions will receive two electrons to form lead atom, Pb. Thus, lead metal forms at cathode. The half equation for this process is:

$$Pb^{2+} + 2e^- \rightarrow Pb$$

Meanwhile, at anode, the bromide ions, $Br^-$ will be discharged by removing one electron to form a neutral bromine atom. Two bromine atoms will combine to form one bromine molecule, $Br_2$. Bromine gas will be released at anode. The half equation for this process is:

$$2Br^- \rightarrow Br_2 + 2e^-$$

## Electrolysis of Aqueous Solution

Electrolysis also occurs when an electric current flows through an aqueous solution. Let's do Activity 4.5 to study the electrolysis of **aqueous solution** of copper(II) sulphate, $CuSO_4$ and sodium chloride solution, NaCl.

### Activity 4.5

**Aim:** To study the electrolysis of aqueous copper(II) sulphate solution, $CuSO_4$ and sodium chloride solution, NaCl.

**Materials:** 0.5 mol $dm^{-3}$ copper(II) sulphate solution, 0.5 mol $dm^{-3}$ sodium chloride solution and wooden splint.

**Apparatus:** Batteries, electrolysis cell, carbon electrodes, ammeter, switch, connecting wires with crocodile clips and test tubes.

QUIZ

Test Your Understanding!





**Instruction:**

1. Put copper(II) sulphate solution into an electrolysis cell until it is half full.
2. Invert two test tubes filled with copper(II) sulphate solution onto the anode and cathode electrodes.
3. Turn on the switch and leave for 15 minutes. Observe the changes on the anode and cathode.
4. Test any emitted gases by inserting a lighted wooden splint and a glowing wooden splint into the test tube.
5. Record the observations in Table 4.3.
6. Repeat steps 1 until 5 using sodium chloride solution.

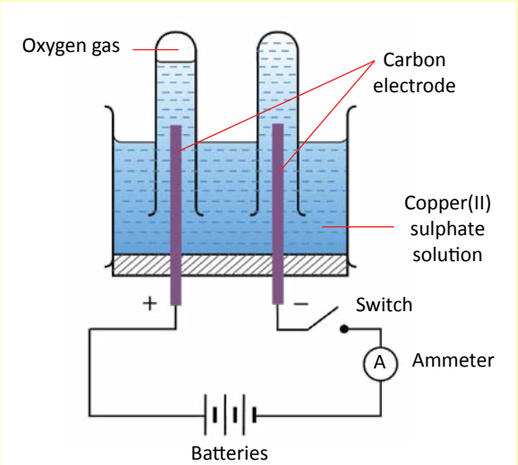



**Figure 4.8**

**Observation:**

**Table 4.3**

| Electrolytes | Observations | Inferences |
|---|---|---|
| Copper(II) sulphate solution | Cathode: | |
| | Anode: | |
| Sodium chloride solution | Cathode: | |
| | Anode: | |

**Discussion:**

Based on the results during the electrolysis of copper(II) sulphate, $CuSO_4$ and sodium chloride solution, NaCl,

1. Identify all anions and cations present in both solutions.
2. Name the ions that move to the anode and cathode.
3. State the ions to be discharged at anode and cathode.
4. Write the half equations to represent the reaction occurs at anode and cathode.

An **aqueous solution** of salt contains **two types of cations** (salt cation and hydrogen ion, $H^+$) and **two types of anions** (salt anion and hydroxide ion, $OH^-$). For example, there are four types of ions present in copper(II) sulphate salt solution, $CuSO_4$, namely $Cu^{2+}$, $SO_4^{2-}$, $H^+$ and $OH^-$. Let's look at the changes that occur on each electrode in Table 4.4.

**Table 4.4** Process that occurs during electrolysis of copper(II) sulphate

| Description \ Electrode | Cathode | Anode |
|---|---|---|
| **Ions at the electrode** | $Cu^{2+}$, $H^+$ | $SO_4^{2-}$, $OH^-$ |
| **Ions to be discharged** | Copper ion, $Cu^{2+}$ | Hydroxide ion, $OH^-$ |
| **Reason** | $Cu^{2+}$ ion will be discharged because the position of $Cu^{2+}$ ion is lower than $H^+$ ion in the electrochemical series | $OH^-$ ion will be discharged because the position of $OH^-$ ion is lower than $SO_4^{2-}$ ion in the electrochemical series |
| **Half Equation** | $Cu^{2+} + 2e^- \rightarrow Cu$ | $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ |
| **Observation** | Brown deposit is formed | Colourless gas is produced and ignites the glowing wooden splint |
| **Conclusion** | Copper metal is formed | Oxygen gas is formed |

## Simple Chemical Cell

Simple chemical cell is a cell that produces electricity through chemical reactions that occur in it.

### Activity 4.6

**Aim:** To show the production of electric current from chemical reaction of copper and magnesium in simple chemical cell.

**Materials:** Magnesium ribbon, copper strips and 1.0 mol $dm^{-3}$ copper(II) sulphate solution.

**Apparatus:** Beaker, voltmeter, connecting wires with crocodile clips and sandpaper.

**Instruction:**

1. Clean copper strip and magnesium ribbon using sandpaper.
2. Measure 50 $cm^3$ of 1.0 mol $dm^{-3}$ copper(II) sulphate solution and pour it into a beaker.
3. Dip the copper and magnesium metals into the solution.
4. Connect both metals using a connecting wire to voltmeter.
5. Record the observations in Table 4.5.
6. Repeat steps 1 to 5 using two copper metals as electrodes.

**Table 4.5**

| Metal pairs | Observation | Inference |
|---|---|---|
| Magnesium ribbon and copper strip | | |
| Copper strip and copper strip | | |



4.3.1 4.3.2



**Discussion:**

1. Which metal pair will show the deflection of the needle on the voltmeter? Explain.
2. Write the half equation for the reaction occurs.

Based on the cell made up of magnesium and copper electrodes, magnesium that is more electropositive than copper will act as negative terminal. Thus, magnesium donates electrons and causes it to become thinner.

Half equation at the negative terminal:

$$Mg \rightarrow Mg^{2+} + 2e^-$$

Free electrons flow through the external circuit to copper electrode, which acts as the positive terminal of the cell.

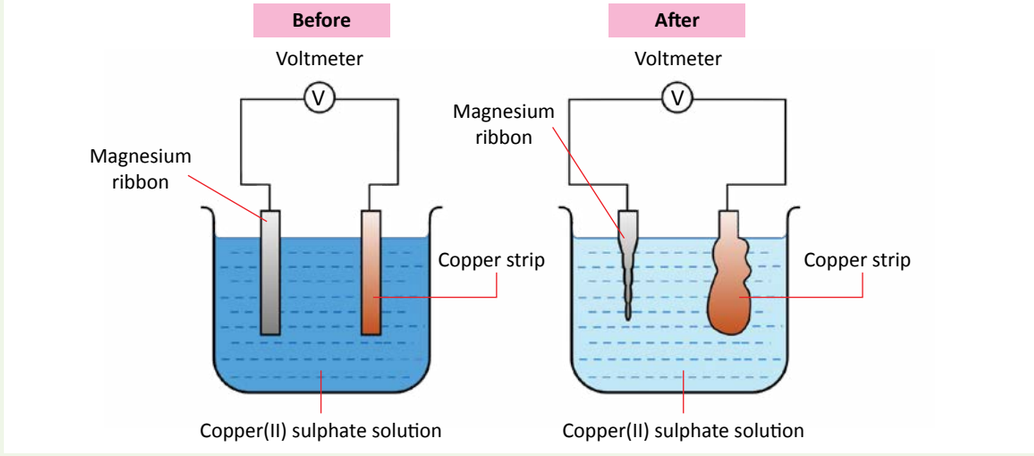



**Figure 4.9** Flow of electrons in a simple chemical cell

At the copper electrode, the electrons received by copper(II) ions that exist in copper(II) sulphate solution discharged to form copper atom, Cu. Therefore, copper strip becomes thicker. Half equation at the positive terminal:

$$Cu^{2+} + 2e^- \rightarrow Cu$$

4.3.2

## Applications of Electrolytic Cell in Industry

The process of electrolysis is widely used in the industry. The industries involved are:

### Extraction of metals

Reactive metals located at higher position in electrochemical series can be extracted from the ore through electrolysis. Electrolysis is carried out using molten metal compound, concentrated aqueous solutions of salt, or hydroxide solution. Metal is obtained at cathode during electrolysis.

The extraction process of aluminium from its ore, that is aluminium oxide, $Al_2O_3$ or bauxite done through electrolysis. Cryolite, $Na_3AlF_6$ is mixed with aluminium oxide to lower its melting point. The molten is electrolysed with carbon as an electrode as shown in Figure 4.10.

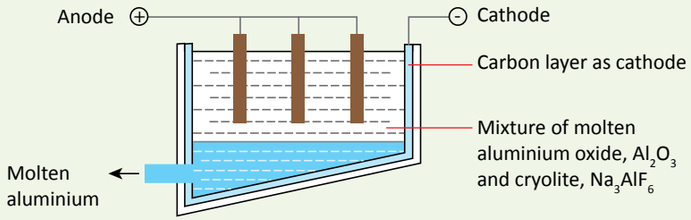



**Figure 4.10** Extraction of aluminium by electrolysis of molten aluminium oxide

**Science Info**

Almost 50% of aluminium is recycled. The recycling of aluminium consumes only 9% of the energy required for electrolysis of bauxite.

### Purification of metals

Impure metal containing impurities can be purified through the process of electrolysis in the following manner:

1. **Impure** metal is used as **anode**.
2. **Pure** metal is used as **cathode**.

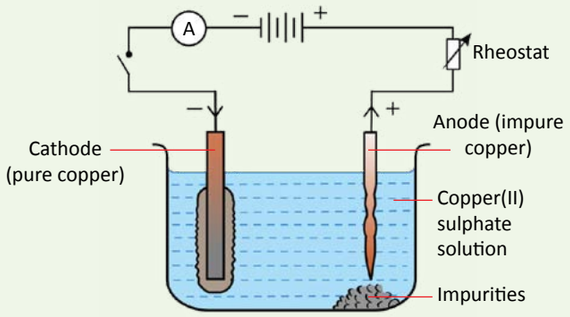



**Figure 4.11** Purification of copper metal

For example, in **purification of copper metal**, impure copper is used as anode while thin pure copper is used as cathode. During electrolysis, copper anode will be ionised into copper ion, $Cu^{2+}$. These ions will move to cathode and deposited as pure copper metal. Through electrolysis, pure copper is produced at cathode, while the impurities will accumulate at the bottom of the beaker.





### Electroplating of metal

Electroplating is a process of coating the surface of a metal device with a layer of thin and uniform metal surface. The main purposes of plating are to:

1. Prevent corrosion. For example, iron tools are coated with chromium metal to protect iron from rust.
2. Esthetic value. For example, gold plating makes the objects shiny and look attractive.

During electroplating, the object to be plated is used as cathode whilst plating metal as anode. The electrolyte used is a solution containing plating metal ions. Let's look at Figure 4.12 to study copper electroplating on a steel spoon.

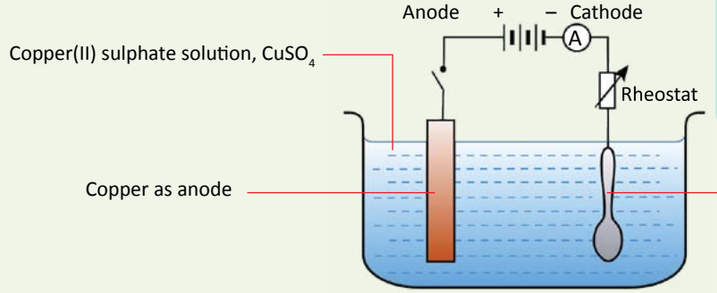



**Figure 4.12** Copper electroplating

**Science Info**

The waste of the electrolysis industry emits hazardous substances such as acids and heavy metals. The acids used need to be diluted and neutralised before being drained as industrial waste, while metal ions such as chromium ions and cyanide ions should be removed from the waste.

**Green Technology**

### Activity 4.7

**Aim:** To process various household wastewater in order to produce treated wastewater using the principle of electrolysis.

Almost 50% to 80% of household wastewater contains a little bit of oil, food waste, detergent and bacteria residues but still safe to be reused.

**Instruction:**

1. Carry out this activity in groups.
2. Based on the above statement, each group will need to provide a scientific report on wastewater treatment to produce treated wastewater.
3. Present the findings to the class.

ATTACHMENT

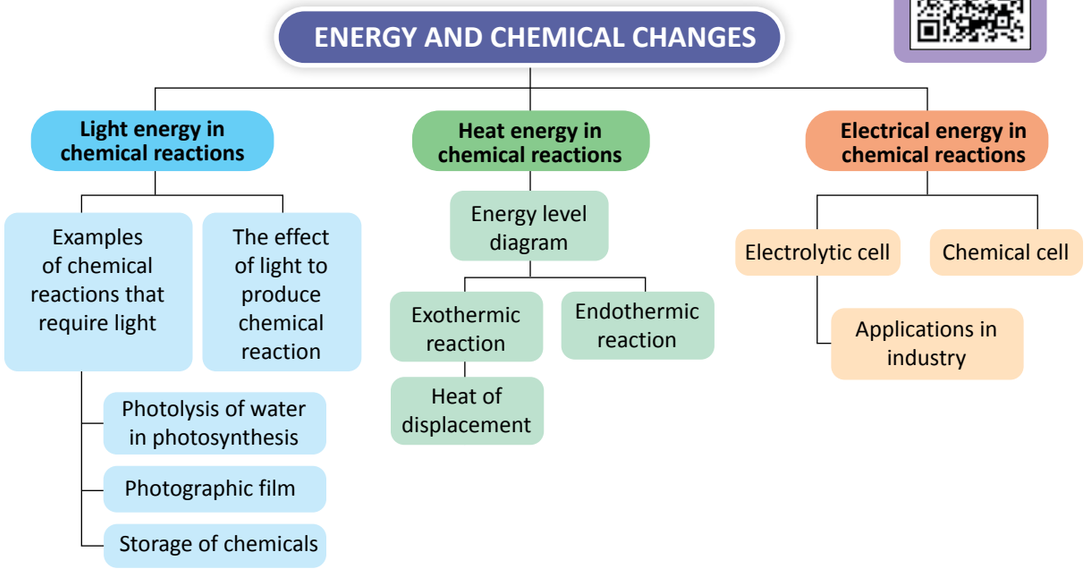
*Modul Teknologi Hijau Kimia*, CETREE USM
Title: *Mewajarkan Teknologi Hijau dalam Elektrokimia*
Pages: 33 – 37
Medium: Bahasa Melayu

### Formative Exercise 4.3

1. What are the energy changes occur in electrolytic cell and chemical cell?
2. State the application of electrolytic cell in industry.

## Summary

Quick Quiz 4




## Self-reflection

After studying this chapter, students will be able to:

### 4.1 Light energy in chemical reactions

- Explain with examples the chemical reactions that require light.
- Communicate about the effect of light to produce chemical reactions.

### 4.2 Heat energy in chemical reactions

- Describe the heat changes in chemical reactions.
- Determine heat of displacement in chemical reactions.

### 4.3 Electrical energy in chemical reactions

- Describe the energy changes in electrolytic cell and chemical cell.
- Explain with examples the half equation for reactions occurring in electrolytic cells and chemical cells.
- Communicate about the application of electrolytic cell in industry.





## Summative Practice 4

1. Figure 1 shows the apparatus arrangement of electrolysis of sodium chloride solution using carbon electrode.

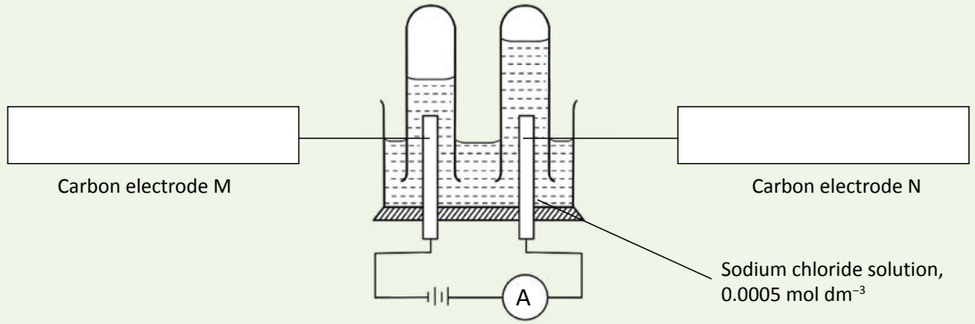



**Figure 1**

(a) Label the anode and cathode in Figure 1.

(b) Write the formula for all ions present in the electrolyte.

(c) (i) Name the ion discharged on electrode M.

(ii) Name the gas collected in the test tube on electrode M.

(iii) Write the half equation for the reaction on electrode M.

(vi) Briefly describe the chemical test to confirm the results on electrode M.

2. An experiment was performed to determine the heat of displacement for the reaction between 100 cm$^3$ of 0.2 mol dm$^{-3}$ copper(II) sulphate solution with magnesium powder. Excess magnesium powder is added to the copper(II) sulphate solution in a polystyrene cup. Table 1 shows the results obtained.

**Table 1**

| | |
|---|---|
| Initial temperature of the solution | 28.6°C |
| Highest temperature of the mixture | 31.2°C |

[Relative atomic mass: Mg = 24; density of water = 1.0 g cm$^{-3}$; specific heat capacity of water = 4.2 J g$^{-1}$ °C$^{-1}$]

(a) Write down the ion equation for the reaction.

(b) State two other observations besides temperature change.

(c) Calculate:

(i) The heat released in the experiment.

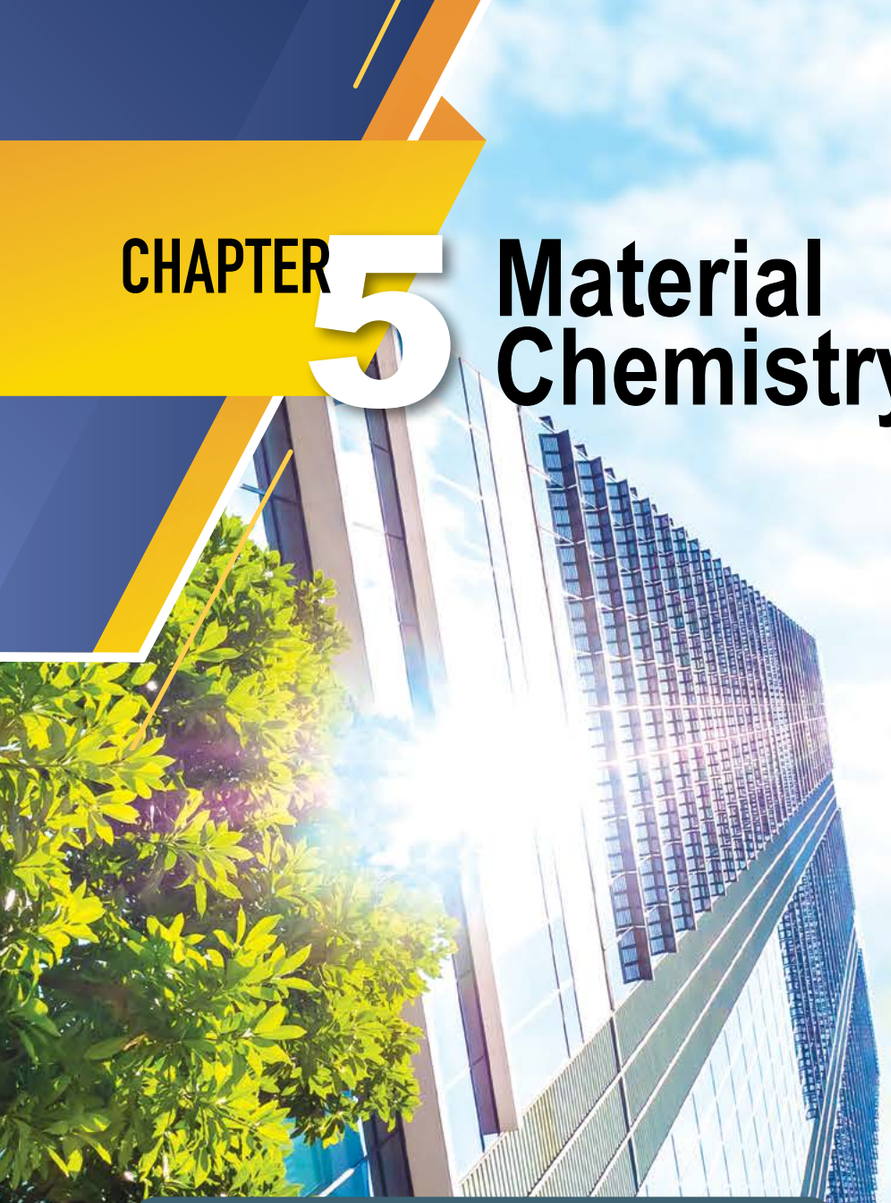
(ii) The number of moles of copper(II) sulphate which reacts with magnesium.

(iii) Heat of displacement.

Check answers

CHAPTER 5

# Material Chemistry



In this chapter, students will learn about:

- Advanced material

Clean water supply is very important for human health. Water filters have been used at homes and workplaces for a long time. Various forms and brands of water filters have been produced with their respective advantages. What are the advanced material technologies behind various water filters?

**KEYWORDS**

- Composite material
- Teflon
- Vulcanised rubber
- Polymer
- Copolymer
- Superconductor
- Carbon nanotubes
- Fibre optic

# 5.1 Advanced Material

## Examples of Advanced Material

Advanced materials are materials which have been used in high technology since 1980s, at present and in the future. Advanced materials are produced through research to meet specific needs.

Advanced materials are needed in making artificial organs to replace human organs due to organ shortage for organ transplant. As an example, organ such as kidney can be replaced with artificial kidney made from plastic composite.

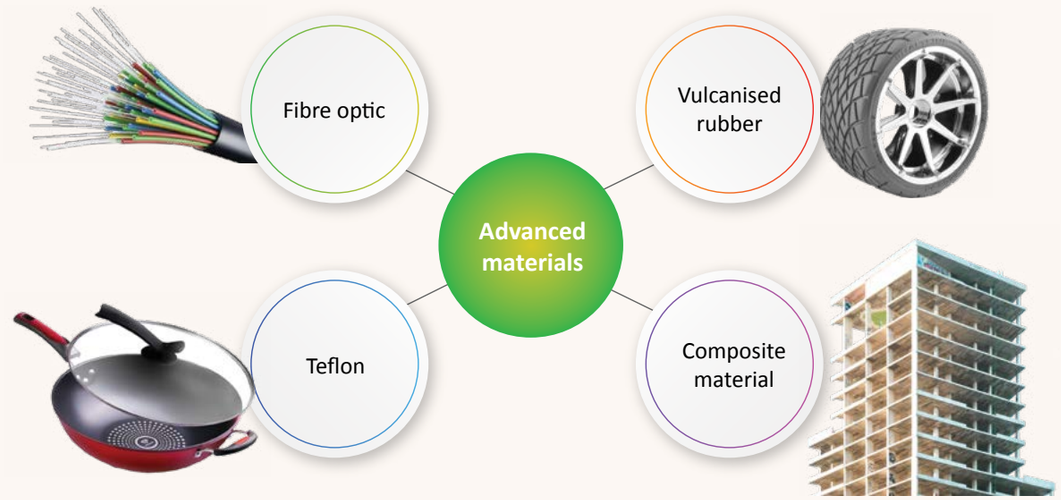



**Figure 5.1** Example of advanced materials

Figure 5.1 shows the example of various advanced materials produced to meet current demands. Can you name the most advanced material around you?

### Activity 5.1

**Aim:** To gather information about advanced materials.

**Instruction:**

1. Gather information on the uses of advanced materials from Figure 5.1 that can be obtained from the Internet, magazines, books, newspapers and other sources.
2. Discuss the information that has been collected.
3. Present outcome of the discussion. You may use a variety of presentation mediums.



5.1.1



## Polymer and Copolymer

**Polymer** is a long molecule chain consists of a **combination** of several repetitive **monomers**. On the other hand, **copolymer** is a polymer that contains more than one type of monomer.

Polymer is produced through a process of combining monomers known as **polymerisation**.

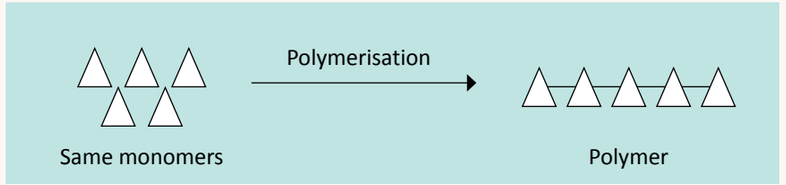



**Figure 5.2** Polymer formations

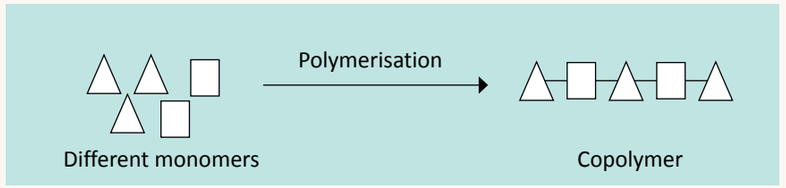



**Figure 5.3** Copolymer formations

### Polymer

Polymers are divided into two types, namely natural polymer and synthetic polymer.

#### Natural polymer

Natural polymer presents in plants and animals. For example, protein, carbohydrate and natural rubber.

Protein is produced from a combination of monomers known as amino acid.

Amino acid $\xrightarrow{\text{Polymerisation}}$ Protein

Carbohydrates such as starch and cellulose are combination of monomers known as glucose.

Glucose $\xrightarrow{\text{Polymerisation}}$ Carbohydrate

The natural rubber in latex is comprised of monomers known as isoprene or 2-methylbut-1,3-diene.

Isoprene $\xrightarrow{\text{Polymerisation}}$ Natural rubber

5.1.2

## Synthetic polymer

Synthetic polymers are produced by copying natural polymer structure such as plastics.

Plastic is a polymer that can be changed into various shapes due to its characteristics such as light, strong, resistant to chemical and also acts as electrical and thermal insulator.

**Table 5.1** Uses of synthetic polymers and copolymers in daily life

| Synthetic polymer or copolymer | Monomer | Uses |
|---|---|---|
| Polyethene | Ethene | Plastic wraps, plastic containers, plastic cups |
| Polyvinyl chloride (PVC) | Chloroethene | Pipes, shoes, bags |
| Polypropylene | Propene | Plastic bottles |
| Polystyrene | Styrene | Wrapping materials |
| Perspex | Methyl-2-methylpropenoate | Aeroplane's windows, car headlights |
| Nylon | Hexanedioic acid and hexamethylene diamine | Ropes, socks, rugs, clothes |
| Terylene | Benzenedicarboxylic acid and ethanediol | Clothes, fish nets |
| Styrene-butadiene rubber | Styrene and butadiene | Vehicle tyres |

Green Technology

### Activity 5.2

**Aim:** To produce bioplastics using natural polymer materials.

Harmful effects from the uses and disposal of synthetic polymer materials have become an integral challenge in preserving our environment.

**Instruction:**

1. You are a member of the Wastewater and Waste Management Sector in the category of prevention and reduction through Alternative Practices Program for Plastics and Polystrene.
2. With reference to the *Modul Teknologi Hijau Kimia*, CETREE USM, produce bioplastics using natural polymer materials.
3. Carry out this activity in a group of five students.

*Source*: *Modul Teknologi Hijau Kimia*, CETREE USM
Title: *Melestarikan Polimer Mesra Alam*
Pages: 48 – 51

ATTACHMENT

*Modul Teknologi Hijau Kimia*, CETREE USM
Medium: Bahasa Melayu





## Composite Material

A composite material is a combination of two or more materials forming a new material with an enhanced physical properties compared to the original composition. The followings are the example of composite materials:

**Original material**
- Plastic is lightweight, elastic, not heat resistant but not brittle.
- Glass is hard but brittle.

**Fibreglass**

**Content**
- Made of molten glass and mixed with polyester resin fibres (a type of plastic).

**Characteristics**
- Lightweight, stronger than steel, corrosion resistant, easy to forge into various shapes, not brittle, water impermeable, electrical insulator and non-flammable.

**Application**
- Used to make vehicle frames, boat frames, electrical appliances and helmet.

**Original material**
- Glass is an insulator and unable to send electronic data in electron form.

**Content**
- Made of very fine translucent glass and a molten glass. It consists of core glass, which has a high refractive index and is surrounded by glass that has a lower refractive index.

**Fibre optic**

**Characteristics**
- Transmits data in the form of light so that the data can be transmitted faster using less space and not affected by electromagnet.

**Application**
- Used in telecommunications and medicine.

**Original material**
- Glass is transparent and insensitive to light.

**Content**
- Produced by mixing silver chloride or silver bromide and a small amount of copper(II) chloride to ordinary glass.

**Photochromic glass**

**Characteristics**
- A type of glass that is photosensitive, it becomes dark when exposed to bright ultraviolet light and the glass turns dark.

**Application**
- Used in the production of spectacle lenses and building glass panels.

**Original material**
- Concrete from a mixture of cement, sand and pebbles is strong but cannot withstand vibration and cannot support massive weights.
- Steel is strong but can be rusty.

**Reinforced concrete**

**Content**
- Contains steel bars in concrete columns.

**Characteristics**
- It makes the pillars of the building stronger, sturdier and able to hold heavy loads.

**Application**
- Used in the framework of bridges, tall buildings and dams.

5.1.3





## Activity 5.3 PAK 21

**Aim:** To create composite materials.

**Instruction:**

1. Carry out the activity in groups.
2. Your group has to design a composite material using materials available around you. Your custom composite material should contain at least two main ingredients for use in daily life.
3. Present your design to the class.

## Superconductor

A **conductor** is one of the materials that can conduct electric current, such as copper metal. However, the presence of **resistance** in the conductor causes the electrical energy to be converted to heat energy. The greater the heat energy, the higher the resistance produced.

A **superconductor** is a material that does not have any resistance when the temperature drops to a certain point known as the **critical temperature**. At this temperature, the superconductor is able to conduct electric current without losing much energy.

Examples of frequently used superconductors are yttrium barium copper oxide (YBCO) resulting from a mixture of copper(II) oxide, yttrium oxide and heated barium carbonate.

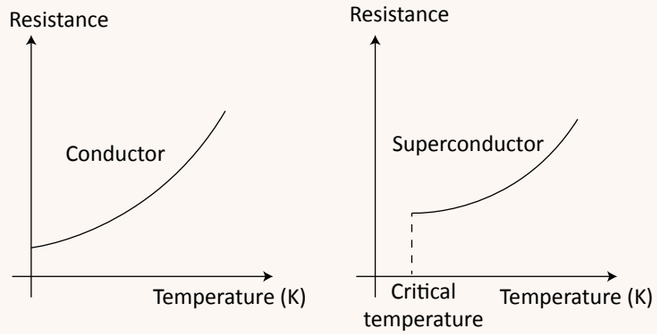



**Figure 5.4** A comparison on resistance between conductor and superconductor

Apart from being able to save electricity, superconductors are also used in the manufacturing of magnets. The magnets produced from superconductor materials are very strong and light and are able to float trains on their rails.

### Science Info

Advantages of superconductors:
- maintain electric current flow without additional voltage.
- able to hold huge current.
- reduce energy loss.
- heat energy is not generated.
- smaller size of motor and generator can be used.

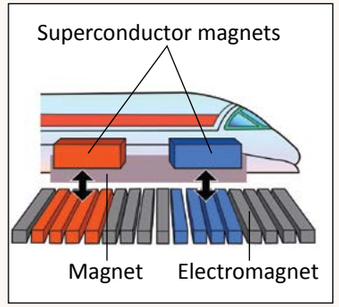



**Figure 5.5** Superconductor

5.1.3 5.1.4

### Activity 5.4

**Aim:** To gather information about superconductor in different situations.

**Instruction:**

1. Carry out this activity in groups.
2. Gather information about superconductors that include:
   (a) Magnetic Levitation (Maglev) in transportation system.
   (b) Magnetic Resonance Imaging (MRI) in image scanning.
3. Present the findings using a multimedia presentation.

## Carbon Nanotubes

Nano comes from the Greek word which means very small. The field of nanoscience and nanotechnology is a study conducted on a scale of 1 – 100 nanometers (nm). The extremely small size of the nano particles causes it to have a larger surface area to volume ratio. In addition, the product produced can provide a more effective and stronger impact than larger particles.

Carbon nanotubes were discovered in 1991 by Sumio Ijima, a physicist from Japan. Carbon nanotubes have high strength and durability, can conduct electricity and heat well and are often used in nanotechnology products because they are lightweight.

To date, nanotechnology has been applied in various fields because it can benefit human beings such as in medicine and manufacturing. Figure 5.6 shows the application of carbon nanotubes produced to meet the needs of today's society.

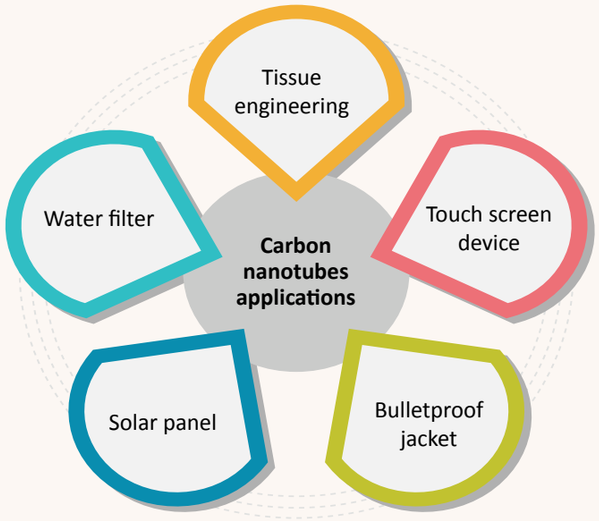
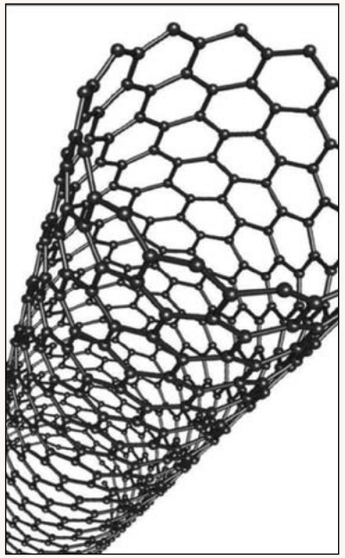



**Figure 5.6** Examples of carbon nanotubes applications



**Photograph 5.1** Carbon nanotubes



5.1.4 5.1.5



### Example of carbon nanotubes applications

**Water filter**

Carbon nanotubes are used in water filters as membranes to filter out microorganisms, heavy metals and water-soluble organic pollutants. The use of carbon nanotubes is a choice nowadays because of its efficiency and consumes lower energy.

**Bulletproof jacket**

The characteristics of carbon nanotubes that are lightweight, heat-resistant and strong make it suitable for the manufacturing of bulletproof jacket. Carbon nanotubes are used as reinforcement materials to prevent bullet penetration or high-speed impact.

**Touch screen device**

The use of carbon nanotubes in touch screen devices is due to their better mechanical properties than stannum oxide that has been used in most touch screen devices. The use of carbon nanotubes gives better screen display and is more sensitive to touch at a lower cost.

**Solar panels**

Carbon nanotubes are inserted in solar panels as receivers and carriers of electrons in the device. The presence of carbon nanotubes gives better and more stable electrical conductivity compared to the original material.

**Tissue engineering**

The use of carbon nanotubes in the manufacturing of artificial tissues and organs is one of the efforts of tissue engineering. This usage is becoming popular due to the excellent physical properties of carbon nanotubes in resembling the original structure of tissues.

5.1.5

## Activity 5.5

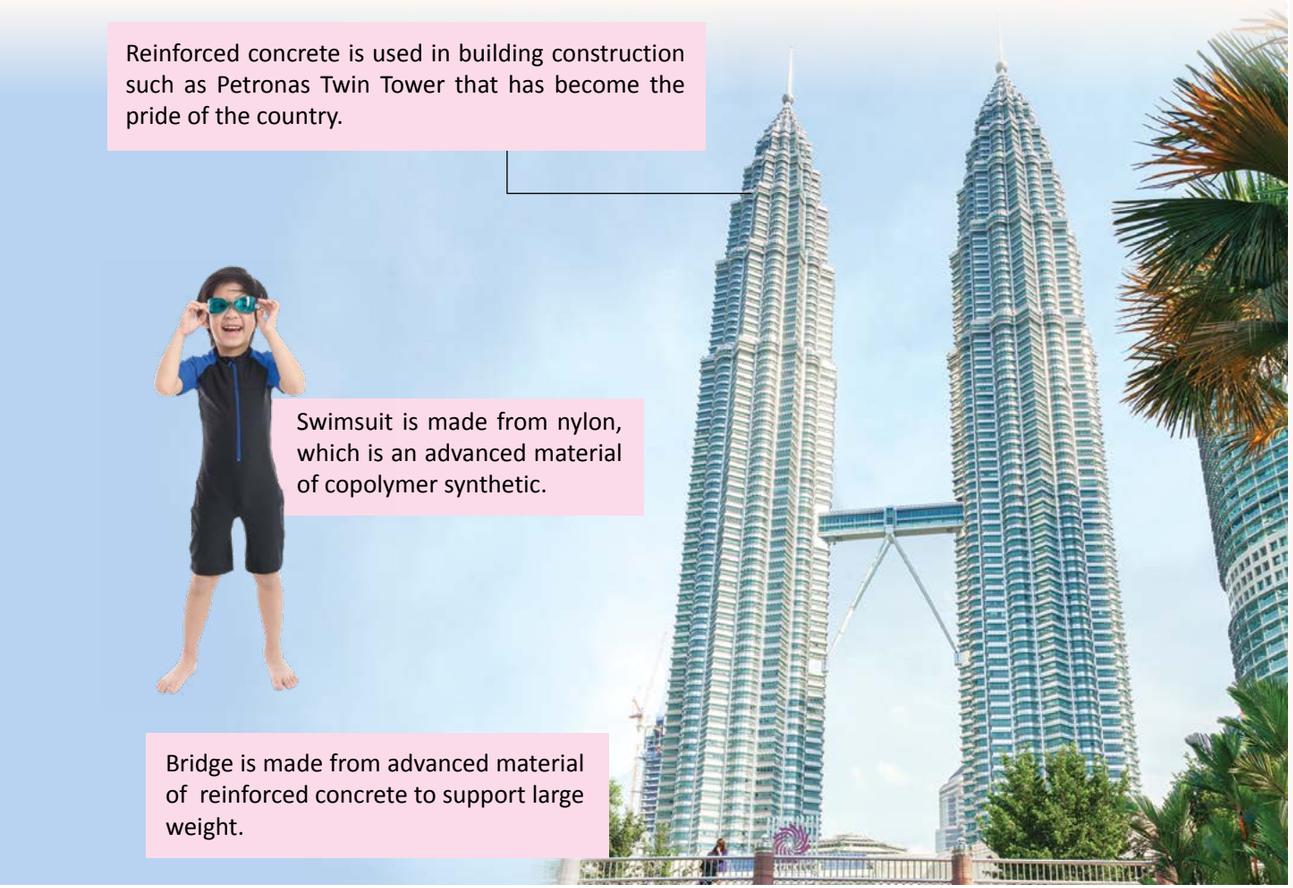
**Aim:** To gather information on the application of nanotechnology.

**Instruction:**

1. Gather information about nanotechnology applications from the Internet, magazines, books, newspapers and other sources.
2. Discuss the information that has been collected.
3. Report your findings using a variety of presentation methods.

## Use of Advanced Materials in Daily Life

Some of the uses of advanced materials in daily life are as follows:



Reinforced concrete is used in building construction such as Petronas Twin Tower that has become the pride of the country.

Swimsuit is made from nylon, which is an advanced material of copolymer synthetic.

Bridge is made from advanced material of reinforced concrete to support large weight.

List the examples of superconductors and carbon nanotubes in daily life.



5.1.5 5.1.6



## Activity 5.6

PAK 21

**Aim:** To organise a forum on the use of advanced materials.

**Instruction:**

1. Divide into three groups of experts, namely:

| Expert | Topic discussed |
|---|---|
| Engineer | The importance of synthetic materials in daily life. |
| Scientist | The importance of conducting ongoing research and development for human well-being. |
| Environmentalist | Pollution caused by the disposal of advanced materials. |

2. Each group of experts needs to gather information from the Internet, magazines, newspapers and related books.
3. Discuss the information gathered.
4. Send a group representative as a member of a forum to discuss the topic entitled "Uses of Advanced Materials".

## Electronic Waste

Electronic waste means electronic products that are damaged and no longer be used.

Advanced technology in telecommunication systems has resulted in electronic devices such as mobile phones and laptops becoming electronic waste in no time. Most electronic products become electronic waste even though they can still be used due to the lifestyle of the society that pursues more advanced technology.

**Figure 5.7** Electronic waste

5.1.6 5.1.7

This escalation of electronic waste has negative impact on the environment. This is because:

(a) electronic waste is not a biodegradable material

(b) disposal by open burning releases:
- toxic gases that cause air pollution
- carbon dioxide contributes to the greenhouse effect
- hazardous carbon monoxide gas

Sustainable waste management practices can reduce the greenhouse effects. Most countries around the world also have taken initiatives to tackle the carbon footprint due to electronic waste disposal activities.

### Activity 5.7 PAK 21

**Aim:** To create a campaign to raise public awareness on the negative impacts of electronic waste on all living things.

Electronic waste is an electronic product that is damaged and no longer be used. Rapid improvement in advanced technology has caused most electronic devices to become waste in a short period of time. This will have a negative impact on the environment.

**Instruction:**

1. Form a group of five students.
2. Browse the Internet to gather information on electronic waste.
3. Create a poster or video of an awareness campaign on the negative impacts of electronic waste against living things.
4. Conduct the campaign on social media.

## Formative Exercise 5.1

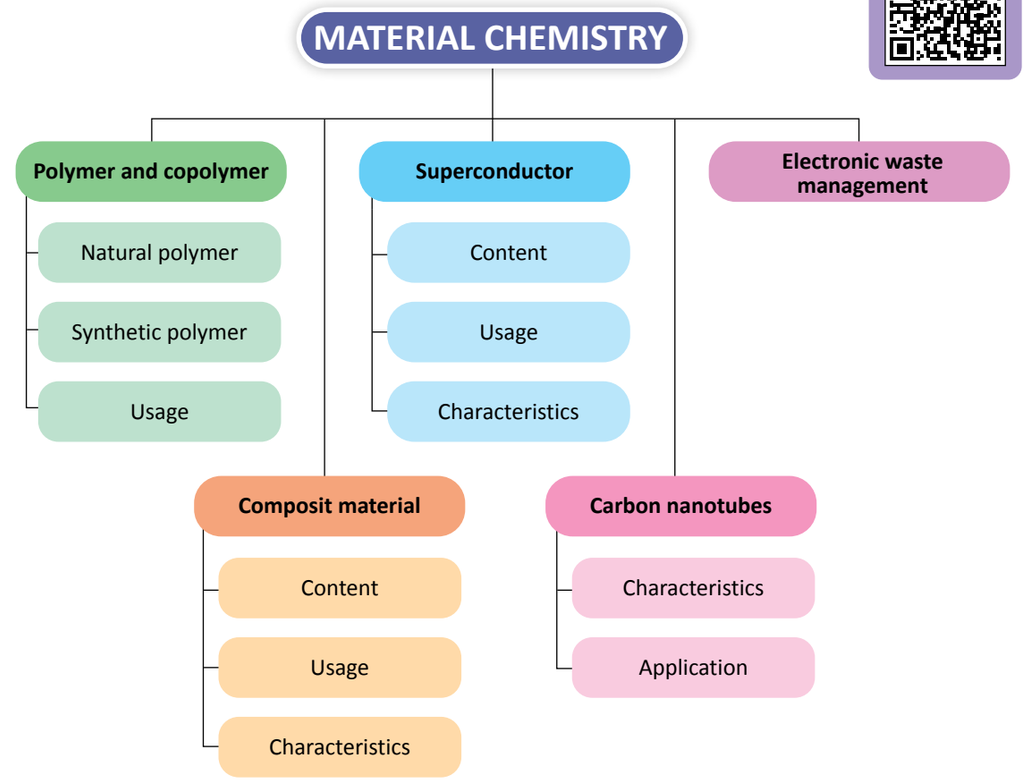
1. What is the meaning of advanced materials?
2. Give **two** examples of natural composite materials.
3. Fibreglass is a composite material made from glass. What are the advantages of fibreglass?
4. Why advanced materials are important in our lives today?
5. The creation of advanced materials has an impact on human life. Justify your answer.





## Summary

Quick Quiz 5




## Self-reflection

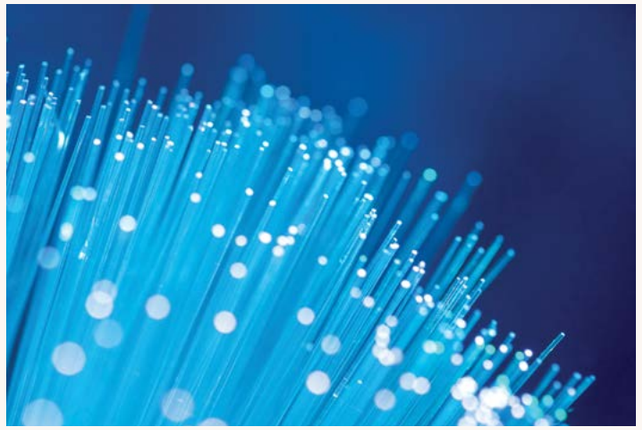
After studying this chapter, students will be able to:

**5.1 Advanced material**

- Describe with examples of advanced material.
- Communicate about polymer and copolymers.
- Justify the needs of composite material.
- Explain with examples the uses of superconductors.
- Describe the application of carbon nanotubes.
- Justify the use of advanced materials in daily life.
- Communicate about electronic waste.

## Summative Practice 5

1. Photograph 1 shows fibre optics used in the field of telecommunications to transmit data.



**Photograph 1**

   (a) What is the material used to produce fibre optics?
   (b) State **three** advantages of fibre optics as compared to copper wire.
   (c) Apart from telecommunications, fibre optics are also widely used in medicine. What are some examples of its usage in medicine?

2. Polymer is a type of advanced material.
   (a) What is polymer?
   (b) List **four** examples of synthetic polymers and their usage.

3. (a) In your opinion, why should not advanced materials be disposed by open burning?
   (b) State **two** ways to reduce pollution caused by advanced materials.

Check answers



# THEME 3

# ENERGY AND SUSTAINABILITY OF LIFE

There are two chapters covering this theme, which are waves and electricity. The chapter on waves explains the properties of waves and its characteristics. Therefore, students will get better understandings on two types of waves, namely mechanical waves and electromagnetic waves and thus apply the concept of waves in daily life.

Next, the chapter on electricity discussed on the concepts of current, potential difference and resistance. Students will also be exposed to the use of formulae in problem solving and will be encouraged to develop thinking skills to solve problems.

CHAPTER 6

# Waves

In this chapter, students will learn about:

- Production of waves
- Resonance
- Properties of waves
- Mechanical wave and electromagnetic wave

Seismic waves caused by the earthquake are reflected by the Earth's crust. This helps seismologists understand the structure of the Earth to determine the phenomenon of earthquake. Do you know how earthquake causes tsunami?

**KEYWORDS**

- Oscillation
- Frequency
- Longitudinal waves
- Transverse waves
- Vibration
- Interference
- Reflection
- Diffraction
- Refraction
- Resonance

# 6.1 Production of Waves

## Production of Waves

Did you know that on 26th December 2004, states in northern Malaysia were hit by tsunami that killed about 67 lives. The tsunami occured due to earthquake at the west coast of Sumatera. Tsunami is a series of waves generated by energy that is transmitted in the form of waves and moving at high speed. What is a wave and how is it produced? Take a look at Photograph 6.1 to understand the production of wave.

**Mind Challenge**

Give examples of electromagnetic waves.

(a) Oscillating system

(b) Vibrating system

**Photograph 6.1** The production of waves through oscillating and vibrating systems

The movement of oscillating or vibrating objects produces waves. Waves are the process of **transferring energy** from one location to another caused by an **oscillation** or **vibration** due to external forces. Waves transfer energy **without transferring matter** while energy is transferred in the direction of wave propagation. Here are the types of waves:

**Water waves**
Waves resulting from the vibration of water particles. For example, sea waves are water waves that transfer energy and propagate from sea to shore and erode the shore.

**Light waves**
Waves resulting from the vibration of electrons in an atom. For example, sunlight is a light wave that transmits light energy to Earth.

**Electromagnetic waves**
Waves resulting from the vibration of particles between electric field and magnetic field. For example, a microwave produces electromagnetic waves that transfer energy to heat food.

**Sound waves**
Waves resulting from the vibration of air particles. For example, a musical instrument such as a guitar produces sound waves that transmit sound energy to the ear.





**Activity 6.1**

**Aim:** To conduct observations and describe production of waves.

**Instruction:**

Carry out this activity at each station.

**Station A:** Using oscillation of slinky spring.

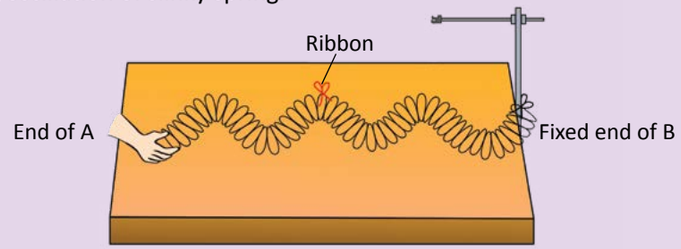



**Figure 6.1** Waves generated by oscillating slinky spring

1. Tie the end of the slinky spring to the end of B and pull it straight to the end of A.
2. Tie the red ribbon to the slinky spring as shown in Figure 6.1.
3. Move the end of the slinky spring A to the left and to the right while the end of B is fixed.
4. Observe the resulting wave motion.
5. Describe the position of the ribbon and the direction of energy transfer on the slinky spring.

**Station B:** Use a tuning fork.

**Figure 6.2** Sound waves generated by tuning fork

1. Hit the tuning fork at different sound tuning positions on the table and listen to the resulting sound wave.

**Station C:** Using computer simulation.

1. Scan the QR code.
2. Tune at different frequencies.
3. Make observations based on computer simulation.

SIMULATION

Waves simulation

## Types of Waves

There are two types of waves, namely **transverse** and **longitudinal waves**. The transverse and longitudinal wave propagations can be identified using slinky springs as shown in Figure 6.3 and Figure 6.4.

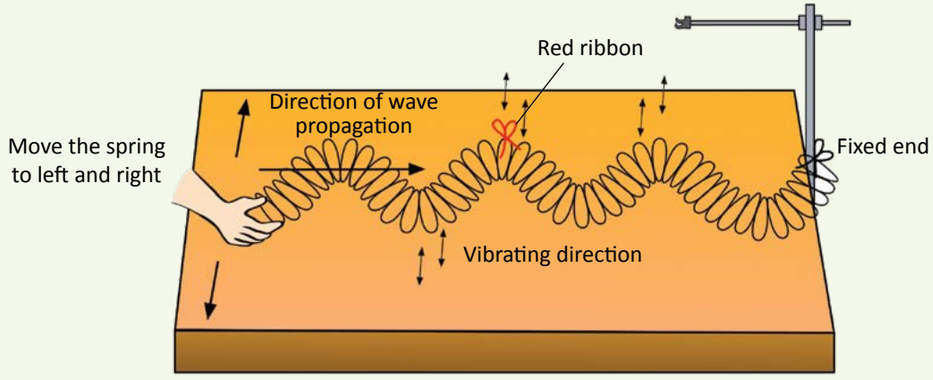



**Figure 6.3** Direction of the transverse wave propagation

Red ribbon tied to slinky spring represents particles in the medium (spring). When the slinky spring is moved to the left and right, the red ribbon (particle) moves in the direction perpendicular to the wave propagation.

**Transverse waves** are generated when the particles of the medium vibrate in a direction **perpendicular** to the wave propagation. Examples of transverse waves are water waves, light waves and electromagnetic waves.

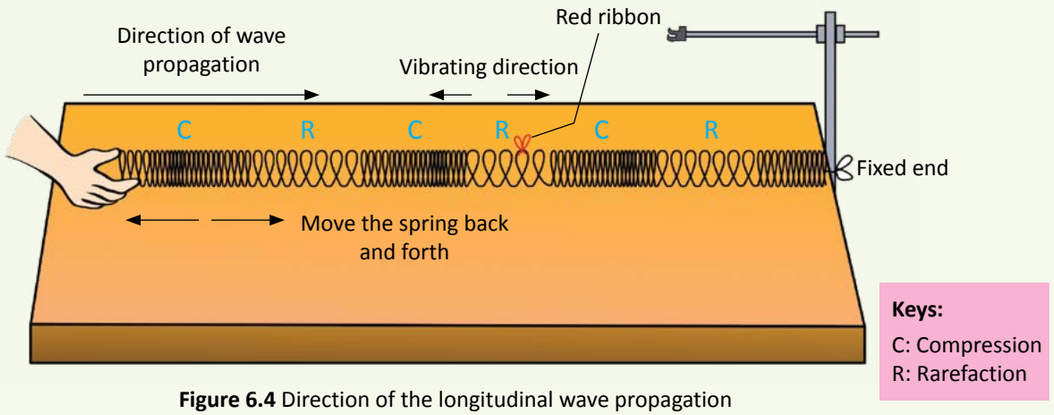



**Figure 6.4** Direction of the longitudinal wave propagation

When the slinky spring is moved back and forth, the red ribbon (particle) moves in a direction parallel to the wave propagation.

**Longitudinal waves** are generated when the particles of the medium vibrate in a direction **parallel** to the wave propagation. An example of longitudinal waves is sound waves.





## Oscillating System

Waves are generated by repeated vibrating or oscillating system. The oscillating system is an interval of back and forth movement in a single trajectory at a fixed point. Look at Figure 6.5 and Figure 6.6 to understand the production of wave clearly.

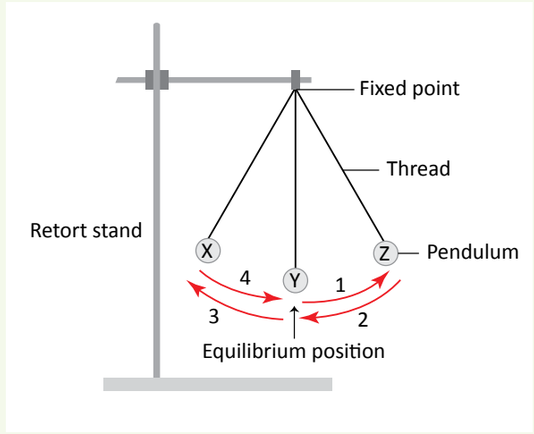



**Figure 6.5** Simple pendulum

**A complete oscillation** is when the pendulum swings from stationary position Y to Z, returns to Y and then to X and finally to its original position, Y (Y → Z → Y → X → Y). The motion of the pendulum is as in Figure 6.5.

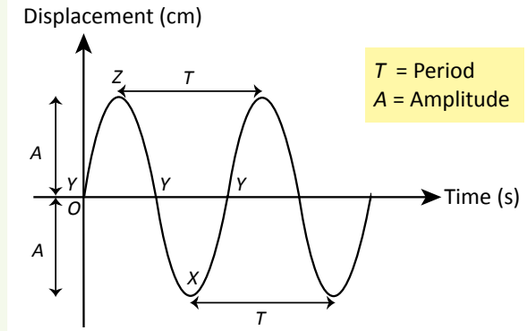
### Displacement-time graph

Displacement at different times of the swinging pendulum from its equilibrium position can be seen in the displacement-time graph as in Figure 6.6. This graph provides information on characteristics of wave such as amplitude and period.

**Frequency**, $f$ of a wave is a **number of complete oscillation** in **one second**. The S.I. unit for frequency is hertz, Hz or $s^{-1}$. The relationship of frequency and period of oscillation is given as,

$f = \frac{1}{T}$, where $f$ = frequency
$T$ = period

**Period**, ***T*** of a wave is the time taken to complete an oscillation.

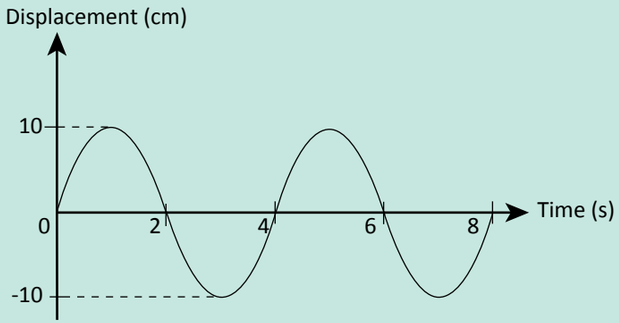



**Amplitude**, ***A*** is the maximum displacement from its equilibrium position.

**Figure 6.6** Displacement-time graph of a simple pendulum

**Example 1**

The diagram below shows the displacement-time graph of a wave motion. Determine the amplitude, period and frequency of the wave.




**Solution:**

Amplitude, $A$ = 10.0 cm

Period, $T$ = 4.0 s

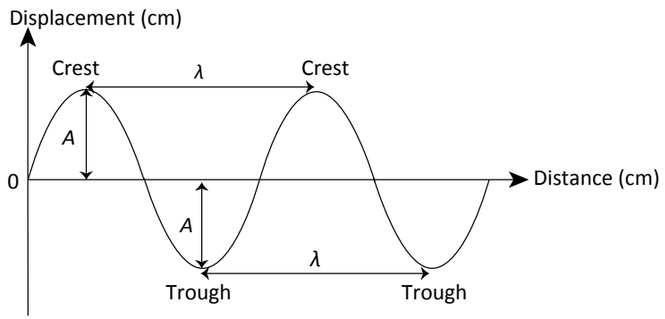
Frequency, $f = \frac{1}{T}$

$= \frac{1}{4.0}$

$= 0.25$ Hz

## Displacement-distance graph

The propagation of waves causes the particles to vibrate in an equilibrium position due to the energy transfer process. The displacement for each vibrating particle at different distances can be seen in Figure 6.7.




**Wavelength**, $\lambda$ is the distance between two crests or two troughs (two consecutive points in the same phase)

**Figure 6.7** Displacement-distance graph

Recall,

Speed, $v = \frac{\text{Distance, } d}{\text{Time, } t}$

The velocity of the wave can be determined by the same formula, $v = \frac{\lambda}{T}$.

Since the wave frequency is $f = \frac{1}{T}$,

substitute $T = \frac{1}{f}$

thus speed, $v = \lambda \times \frac{f}{1}$

Wave speed, $v = \lambda f$

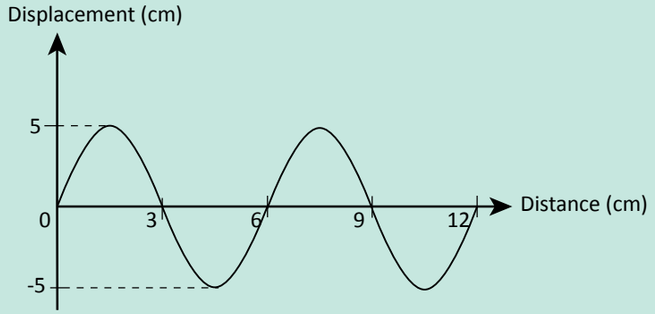
6.1.3





**Example 2**

The diagram below shows the displacement-distance graph of a wave motion resulting from a slinky spring vibrating at a frequency of 6 Hz. Determine the amplitude, wavelength and speed of the wave.




**Solution:**

Amplitude, $A$ = 5.0 cm

Wavelength, $\lambda$ = 6.0 cm

Velocity, $v = \lambda f$

$= 6.0 \times 6$

$= 36$ cm s$^{-1}$

## Experiment 6.1

**Problem statement:** What is the relationship between frequency and wavelength?

**Aim:** To study the relationship between frequency and wavelength.

**Hypothesis:** The larger the frequency, the shorter the wavelength.

**Manipulated variable:** Wave frequency, $f$

**Responding variable:** Wavelength, $\lambda$

**Constant variable:** Depth of water

**Materials**: White paper as a screen, rubber band and water.

**Apparatus**: Ripple tank, mechanical stroboscope, metre rule, vibrating motor, power supply, motor frequency controller, lamp and vibrating bar.

**Procedure**:

1. Set up the ripple tank and other apparatus as shown in Figure 6.8 and place a white paper under the ripple tank.

**Science Info**

The depth of water influences the speed of waves.

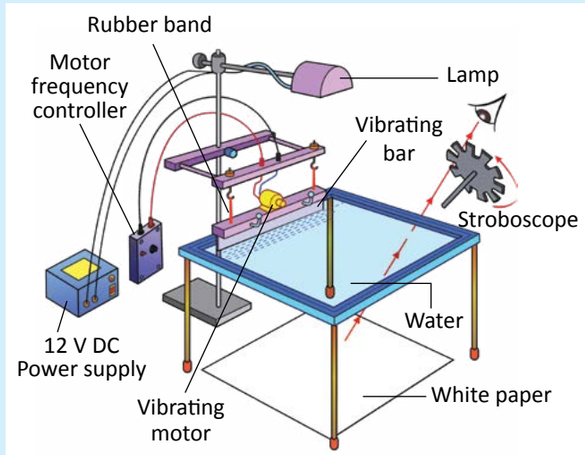



**Figure 6.8**

6.1.3 6.1.4

2. Fill in the water and adjust the ripple tank legs until the depth of the water is uniformed.
3. Switch on the light and vibrating motor at the frequency of 10 Hz.
4. Observe the wave motion formed on white paper using a stroboscope.
5. Measure and record the wavelength readings using the metre rule.
6. Repeat steps 3 to 5 by changing the vibrating motor frequency to 20 Hz, 30 Hz, 40 Hz and 50 Hz.

**Observation:**

**Table 6.1**

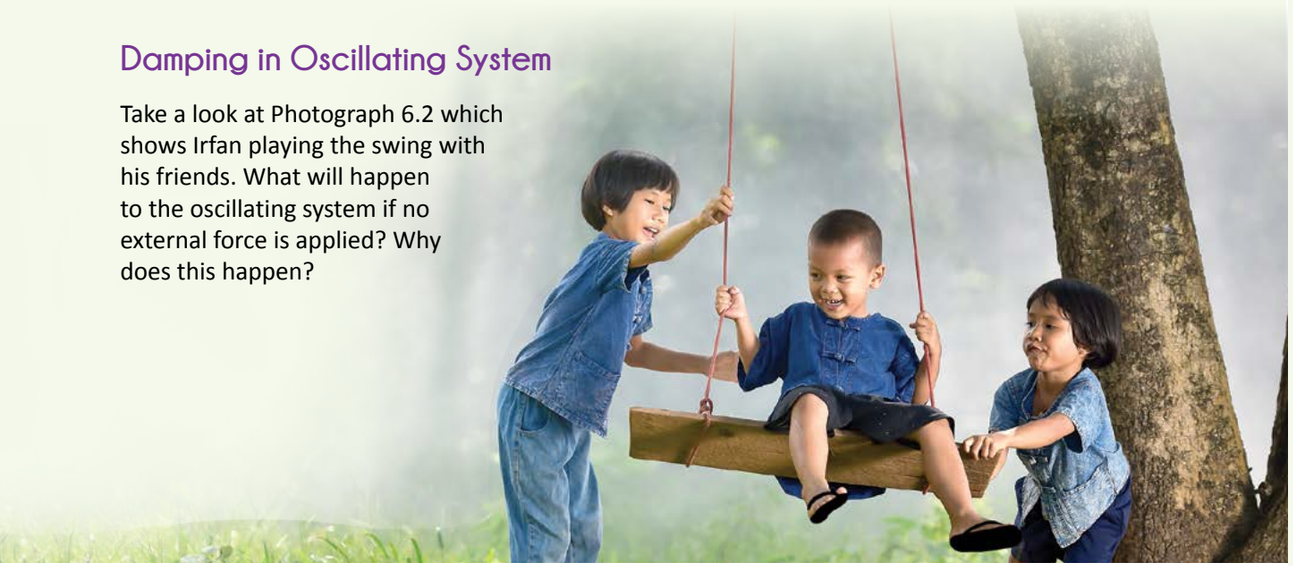
| Frequency, $f$ (Hz) | Wavelength, $\lambda$ (cm) | $\frac{1}{f}$ ($Hz^{-1}$) |
|---|---|---|
| 10 | | |
| 20 | | |
| 30 | | |
| 40 | | |
| 50 | | |

**Data interpretation:**
Plot the graph $\lambda$ against $\frac{1}{f}$. Calculate the speed of the wave, $v$ from the gradient of the graph.

**Conclusion:**
Is the hypothesis accepted? State the conclusion of this experiment.

## Damping in Oscillating System

Take a look at Photograph 6.2 which shows Irfan playing the swing with his friends. What will happen to the oscillating system if no external force is applied? Why does this happen?



**Photograph 6.2** Swing oscillates when external force is applied





### Activity 6.2

1. Displace the jigsaw blade to position X and release it as shown in Figure 6.9.
2. Observe the amplitude of the oscillation of the jigsaw blade in 20 seconds.

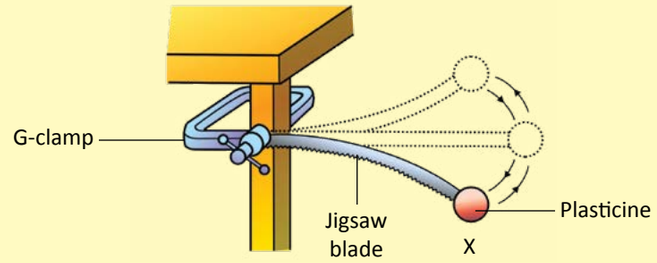



**Figure 6.9** Jigsaw blade oscillating system

From Activity 6.2, the amplitude of the oscillating system decreases and becomes zero when the oscillation stops. This is because no external force is applied to the system. This process is called damping.

**Damping** is the **decreasing of amplitude** in an oscillating system. Damping is caused by dissipation of energy by the external and internal damping. The displacement-time graph for damping is shown in Figure 6.10.

Example of external damping is **air resistance** while internal damping is **friction** between molecules in an oscillating system.

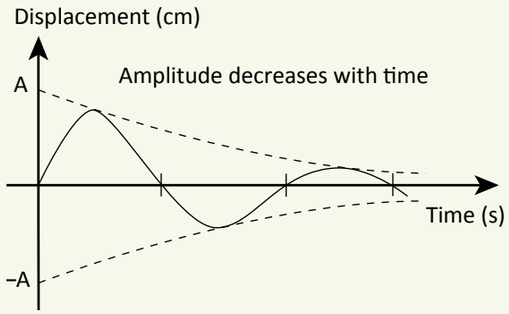



**Figure 6.10** Displacement-time graph of the jigsaw blade oscillating system

### Science Info

The frequency of oscillation is constant.

### Activity 6.3

**Aim:** To sketch a displacement-time graph for a system experiencing damping.

**Instruction:**
1. Pick a situation where the oscillating system is experiencing damping.
2. Record displacement against time for a complete oscillating system.
3. Sketch a displacement-time graph of the system.

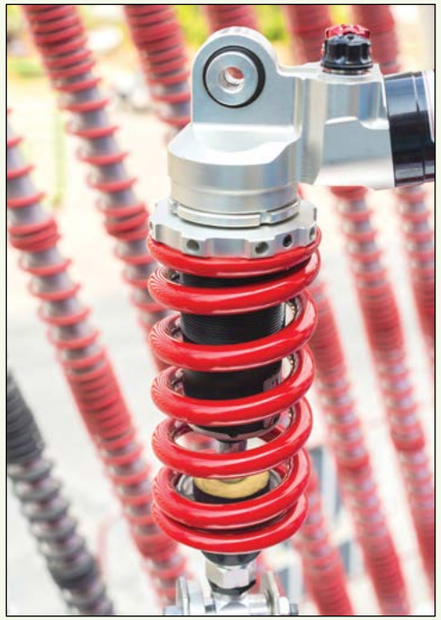
## Examples of Damping in Oscillating Systems

There are many examples of damping in oscillating systems in daily life. Among them are, the swing at the playground and shock absorber in vehicles.

**Photograph 6.3** Example of external damping in the oscillation of swing

**Swing at the playground**

The motion of the swing at the playground slows down due to external damping, which is air resistance.



**Photograph 6.4** Example of internal damping in shock absorber in vehicles

**Shock absorber in vehicles**

Vibration of the shock absorber in vehicles decreases due to internal damping, which is the friction between molecules in spring when the shock absorber vibrates.

### Mind Challenge

What can be done to overcome damping in oscillation?

### Activity 6.4 PAK 21

**Aim:** To discuss examples of damping in oscillating system in daily life.

**Method:** Think-Pair-Share

**Instruction:**

1. State other examples of damping in oscillating system in daily life.
2. Discuss with friends and share your findings.





### Formative Exercise 6.1

1. What is the difference between the transverse waves and longitudinal waves?
2. Diagram 1 (a) and (b) shows the displacement-time graph and the displacement-distance graph of an oscillation.

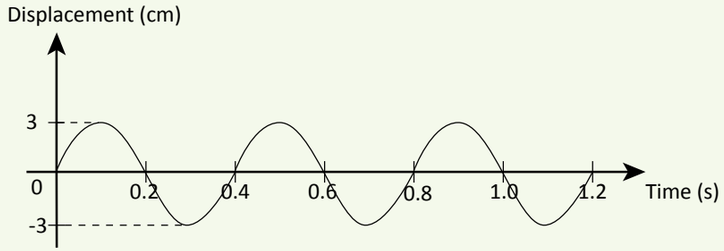



**Figure 1 (a)**

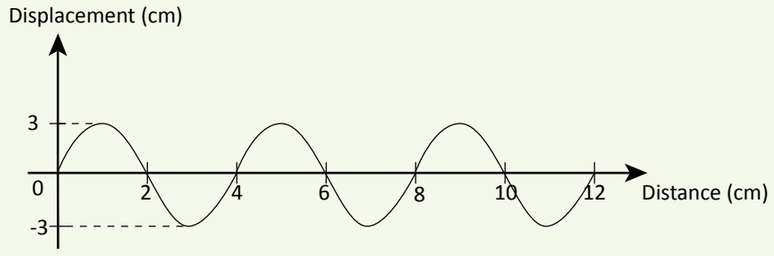



**Figure 1 (b)**

Based on the graph above, determine:

(a) oscillation period

(b) frequency

(c) wavelength

(d) wave speed

3. Figure 2 shows the end of the slinky spring moving back and forth at a frequency of 5 Hz. Given the distance between two consecutive compressions is 0.5 m, calculate the wave speed.

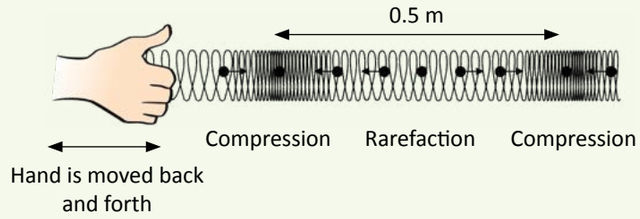



**Figure 2**

# 6.2 Resonance

## Resonance in Oscillating System

From the last topic, we have learned that oscillating system without external force will undergo damping. External force must be applied to ensure the system continuously oscillates.

External force supplies energy to the system to keep oscillating. The oscillation caused by an external force is called **forced oscillation**. The frequency of a system oscillates freely without any external force is called **natural frequency**.

**Resonance** occurs when the system is forced to oscillate at the same frequency as the natural frequency due to external forces. System experiencing resonance will oscillate at **maximum amplitude**. Predict what will happen if the system reaches maximum amplitude.

Let's carry out Activity 6.5 to understand the concept of resonance clearly.

### Activity 6.5

**Aim:** To study the resonance in oscillating system.

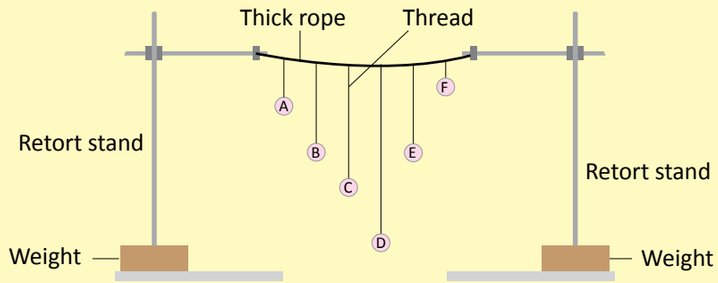



**Figure 6.11**

**Instruction:**

1. Prepare a Barton pendulum consists of series of pendulums mounted on a thick rope as shown in Figure 6.11. Make sure the length of the threads on pendulums B and E are the same.
2. Displace pendulum B and release it. Observe what happens to the other pendulums.
3. Observe the amplitude of the oscillation for each pendulum.

**Discussion:**

1. What happens to other pendulums when pendulum B is displaced and released?
2. Which pendulum oscillates at its maximum amplitude?
3. By comparing the length of each pendulum, state the inference that can be made based on your observation.





## Application of Resonance in Daily Life

Observe the following situations:

Guitar is a musical instrument used by musicians to produce rhythm in a song. When the frequency of the string plucked is equal to the natural frequency of the guitar, resonance occurs and produces sound.

Radio broadcasts and television channels have specific frequencies. In order to obtain the frequency of radio broadcasts and television channels, an electrical component is set to resonate with the selected broadcast or channel frequency.

Can you state another situation that involves resonance?

### Science Info

A suspension bridge that is blown by wind at a frequency equal to the natural frequency of the bridge may cause the bridge to collapse. The incident has occurred at the Tacoma Narrows Bridge in the United States, which collapsed in November 7, 1940 due to the effect of resonance.

VIDEO

Video of the Tacoma Bridge collapse

### Activity 6.6

PAK 21

**Aim:** To study the effect of resonance in daily life.

**Method:** Gallery Walk

**Instruction:**

1. Carry out this activity in groups.
2. Study the positive and negative effects of resonance in daily life.
3. Write the findings of the discussion on a display sheet.
4. Paste it in front of the class.
5. Place a pen or paper for other groups to visit and comment.
6. Take turns to visit other groups.
7. Report what you have learned from your visit.

### Formative Exercise 6.2

1. Underline the correct answer.
   (a) (Amplitude / Frequency) will be maximum when the vibrating system is resonant.
   (b) When a system oscillates at natural frequency in the vacuum space, the amount of energy after three hours will be (decreasing / increasing / unchanged).

2. "The voice of a soprano singer could break a glass."

   Do you agree with this statement? Explain your reason.

3. Explain how resonance occurs.
4. Describe **two** examples of resonance applications that are useful in daily life.

6.2.2





# 6.3 Properties of Waves

There are four phenomena of wave that can be observed and each phenomenon has its own characteristics. These four phenomena are reflection, refraction, diffraction and interference.

## Reflection of Waves

While on vacation with your family on the beach, you will find seawalls built along the coast. Do you know why these seawalls were built?

Seawalls were built on the coast to prevent erosion caused by waves as shown in Photograph 6.5. How can seawalls help reduce the coastal erosion?

**Reflection of waves** occurs when the wave propagates and hits a barrier (reflector). The waves will experience change in the **direction of propagation** when reflected.

**Photography 6.5** Seawalls along the coast in Tanjung Piandang, Perak

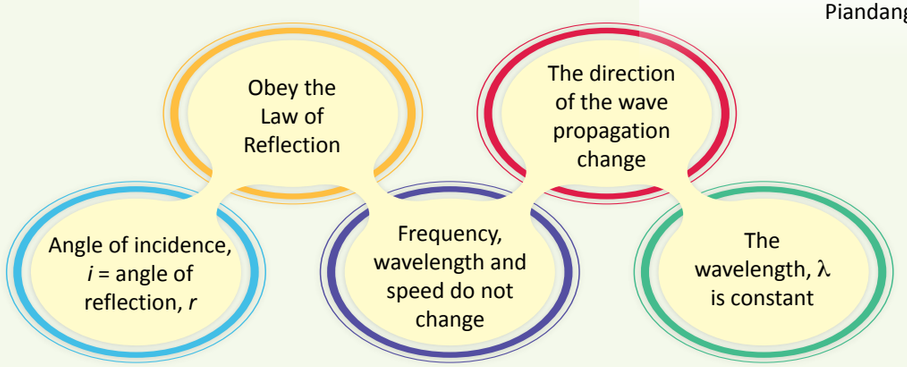



**Figure 6.12** Characteristics of wave reflection

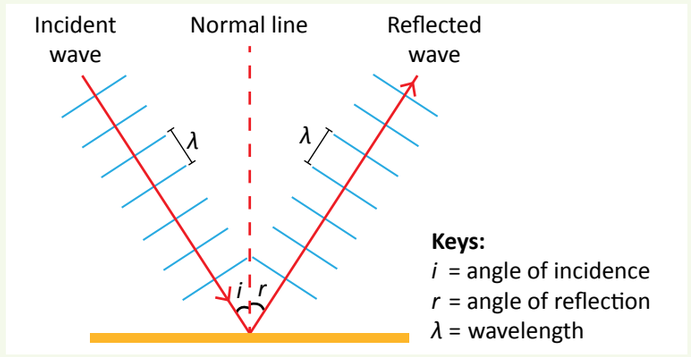



**Figure 6.13** Law of Reflection

### Science is Easy!

Law of Reflection:

- Angle of incidence, $i$ = angle of reflection, $r$
- Incident wave, reflection wave and normal line are in the same plane.

6.3.1

## Activity 6.1

**Aim:** To study the reflection of waves.

**Materials:** White paper as a screen, rubber band and water.

**Apparatus:** Ripple tank, mechanical stroboscope, vibrating motor, power supply, lamp, vibrating bar, plane reflector, protractor, metre rule and motor frequency controller.

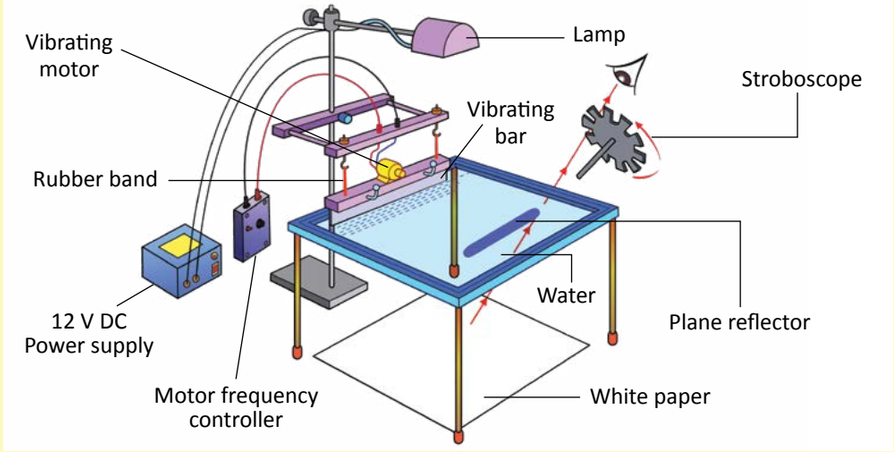



**Figure 6.14**

**Instruction:**

1. Set up ripple tank and other apparatus as shown in Figure 6.14 and place a white paper under the ripple tank.
2. Fill in the water and adjust the ripple tank legs until the depth of the water is uniformed.
3. Switch on the light and vibrating motor. Adjust the frequency of the vibrating motor so that the patterns of the wave front produced on the white paper can be clearly seen using a stroboscope.
4. Place the plane reflector so that the incidence angle of the wave, $i = 30°$.
5. Measure and record the angle of reflection generated using a protractor.
6. Observe and measure the resulting wavelengths and the resulting waves reflection.
7. Repeat step 3 until 6 for $i = 40°$, 50°, 60° and 70°.

**Observation:**

**Table 6.2**

| $i$ (°) | 30 | 40 | 50 | 60 | 70 |
|---|---|---|---|---|---|
| $r$ (°) | | | | | |

**Discussion:**

1. Compare the resulting wavelengths and waves reflection.
2. Draw the wave front of reflection in Figure 6.15.





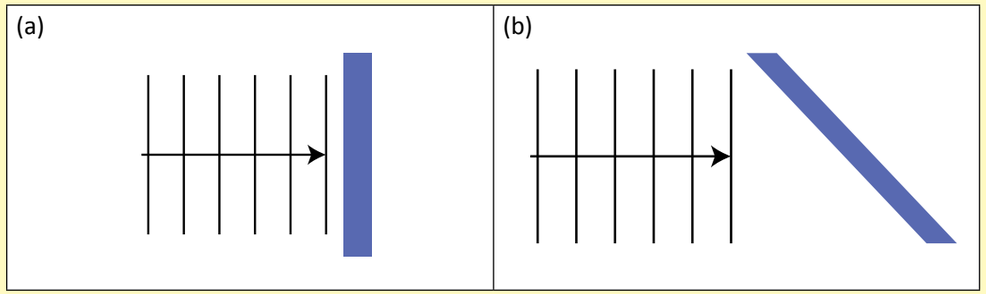



**Figure 6.15**

**Conclusion:**

What conclusion can you draw from your findings?

## Refraction of Waves

As the water waves propagate from the deep sea to the coast, the direction of the waves propagation changes and the wave fronts follow the shape of the beach as shown in Photograph 6.6. What caused the direction of waves propagation to change? What change did the wave fronts produce at the capes and bays?

**Refraction of waves** is a change in waves direction due to the change in speed when waves propagate from one medium to another medium with different depth.

As the wave propagates from the deep region to the shallow region, the wave speed decreases, causing the direction of wave propagation moves towards the normal and the wavelength decreases as shown in Figure 6.16.

### Mind Challenge

Why is the frequency of refracted waves and incident waves that propagate in an area of different depth are constant?

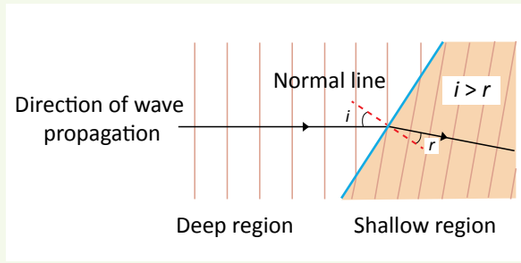



**Figure 6.16** Waves propagate from deep region to shallow region


**Photograph 6.6** Coastal area with bay and cape

The direction of waves propagation will be more away from the normal line when the waves propagate from shallow to deep region. This is because of the increase in wave speed and wavelength as shown in Figure 6.17.

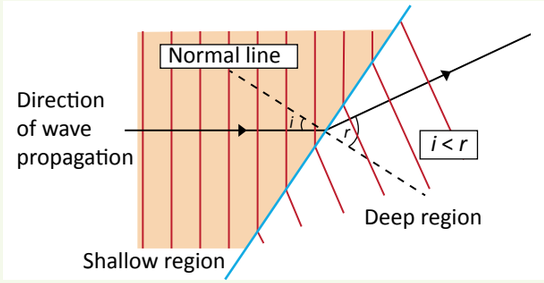



**Figure 6.17** Waves propagate from shallow region to deep region

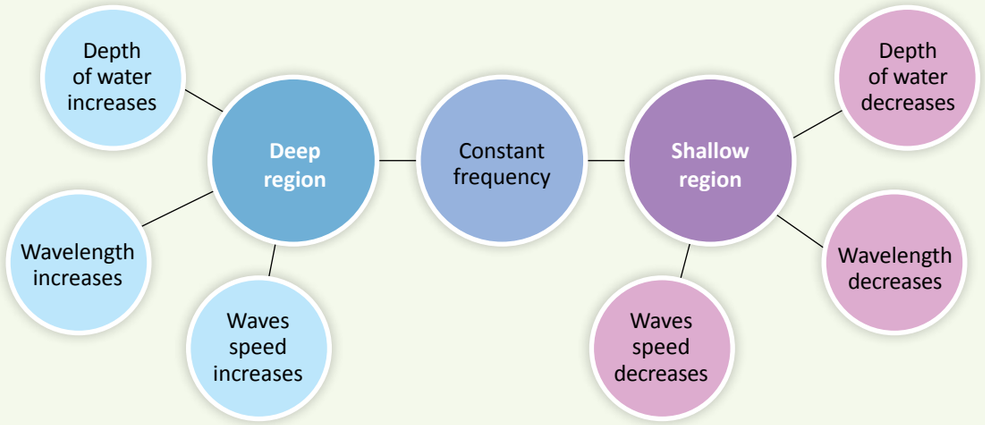



**Figure 6.18** Characteristics of refraction of waves

## Activity 6.8

**Aim:** To study the refraction of waves.

**Materials:** White paper as a screen, rubber band and water.

**Apparatus:**

Ripple tank, mechanical stroboscope, vibrating motor, power supply, lamp, vibrating bar, trapezium-shaped perspex plate, convex-shaped perspex plate, concave-shaped perspex plate and motor frequency controller.

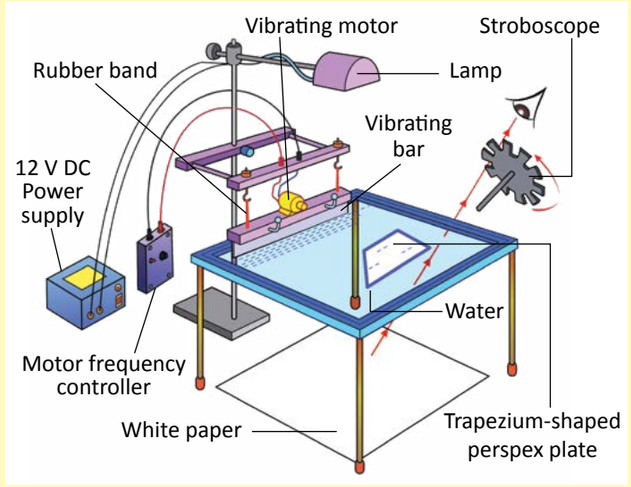



**Figure 6.19**





**Instruction:**

1. Set up the ripple tank and other apparatus as shown in Figure 6.19 and place a white paper under the ripple tank.
2. Place a trapezium-shaped perspex plate to create a shallow water region.
3. Fill in the water and adjust the ripple tank legs until the depth of the water is uniformed.
4. Switch on the lamp and vibrating motor. Adjust the frequency of the vibrating motor so that the patterns of the wave fronts produced on the white paper can be clearly seen using a stroboscope.
5. Change the position of the trapezium-shaped perspex plate so that the sides are parallel and in an angle with the vibrating bar.
6. Observe the wave fronts produced on shallow and deep regions.
7. Repeat steps 2 to 6 using convex-shaped and concave-shaped perspex plates.

**Observation:**

Draw observable wave fronts to show the refraction of water waves produced in shallow and deep regions as in Figure 6.20.

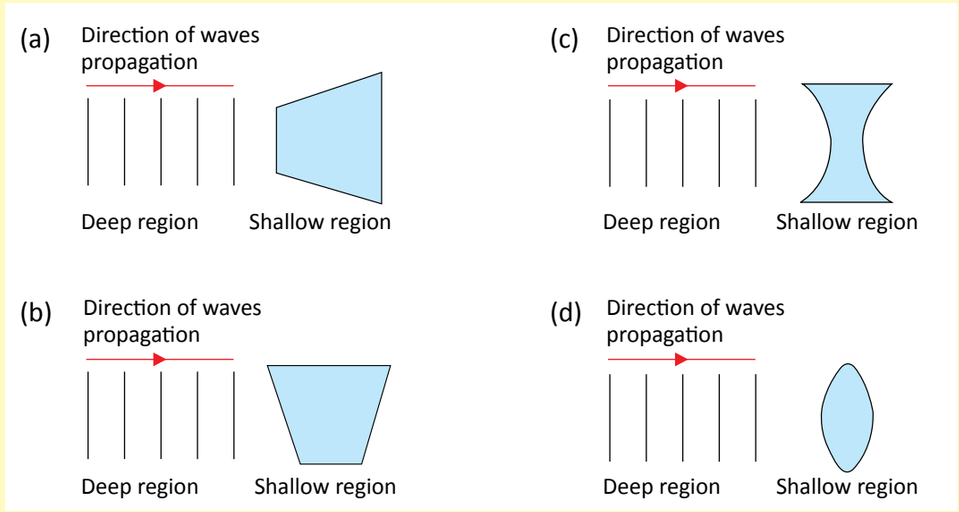



**Figure 6.20**

**Discussion:**

Compare the wavelengths of the incident waves and refracted waves propagated in shallow and deep regions.

**Conclusion:**

What conclusion can be drawn based on the direction of waves propagation?

## Diffraction of Waves

The gap between two breakwaters was built in the harbour area to reduce waves energy approaching the shore and thus reducing the damage to the harbour. Why does the waves energy decrease after passing through the gap between the two breakwaters as shown in Photograph 6.7?

**Diffraction of waves** is the effect of waves dispersion that occurs when waves propagate through a gap or barrier. The effect of diffraction becomes more apparent when waves pass through small gaps or obstacles.

**Photograph 6.7** The gap between two breakwaters in the sea

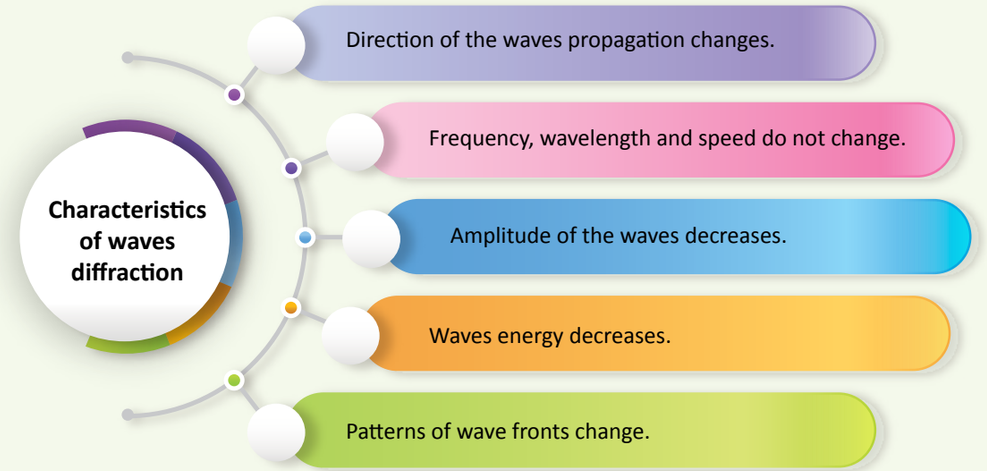



**Figure 6.21** Characteristics of waves diffraction

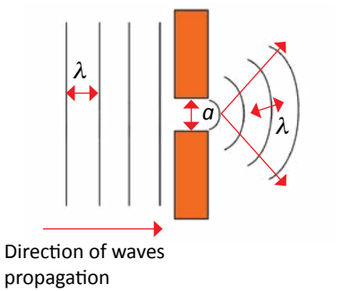



**Figure 6.22** Waves passing through small gap

- Wavelength, $\lambda \geq$ gap size, $a$.
- The effect of diffraction is more significant.

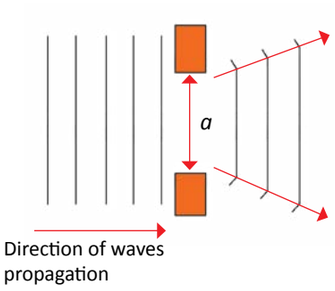



**Figure 6.23** Waves passing through large gap

- Wavelength, $\lambda <$ gap size, $a$.
- The effect of diffraction is less significant.





After diffraction, the wavelength, $\lambda$ does not change, while the direction of waves propagation changes and causes energy to diverge. The diverged energy decreases causing the amplitude of wave to decrease as well.

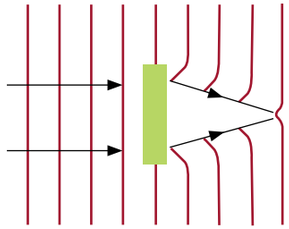


**Figure 6.24** Waves through small obstacle

- The effect of diffraction is more significant.

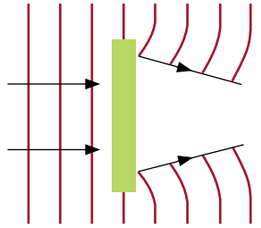


**Figure 6.25** Waves through large obstacle

- The effect of diffraction is less significant.

### Activity 6.9

**Aim:** To study the diffraction of waves.

**Materials**: White paper as a screen, rubber band and water.

**Apparatus:** Ripple tank, mechanical stroboscope, vibrating motor, power supply, lamp, vibrating bar, two pieces of metal bar and motor frequency controller.

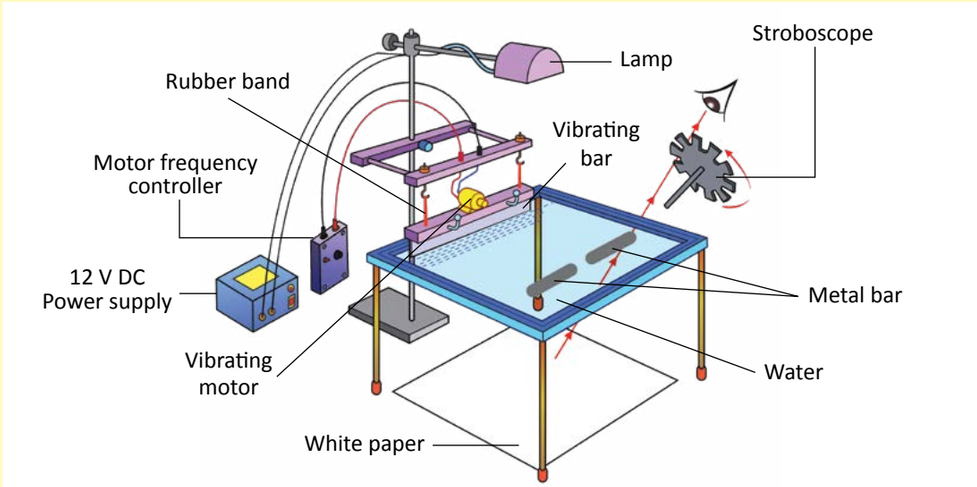



**Figure 6.26**

**Instruction:**

1. Set up the ripple tank and other apparatus as shown in Figure 6.26 and place a white paper under the ripple tank.
2. Fill in the water and adjust the ripple tank legs until the depth of the water is uniformed.
3. Switch on the lamp and vibrating motor. Adjust the frequency of the vibrating motor so that the patterns of the wave fronts produced on the white paper can be clearly seen using a stroboscope.
4. Place the metal bars so that they form a gap with different sizes.
5. Draw the patterns of the wave front and measure the wavelength before and after the diffraction of waves produced.
6. Repeat steps 4 and 5 using metal bars of different sizes as obstacles.

**Observation:**

Draw the resulting patterns of the wave front after passing through small and large gaps as well as after going through small obstacles and large obstacles.

**Discussion:**

Compare wavelengths before and after diffraction.

**Conclusion:**

What conclusion can be drawn based on your findings?

## Interference of Waves

Figure 6.27 shows two men fishing. Both fishing rods produce circular waves and propagate from inside to outside. What happens when the resulting waves from the two fishing rods meet?

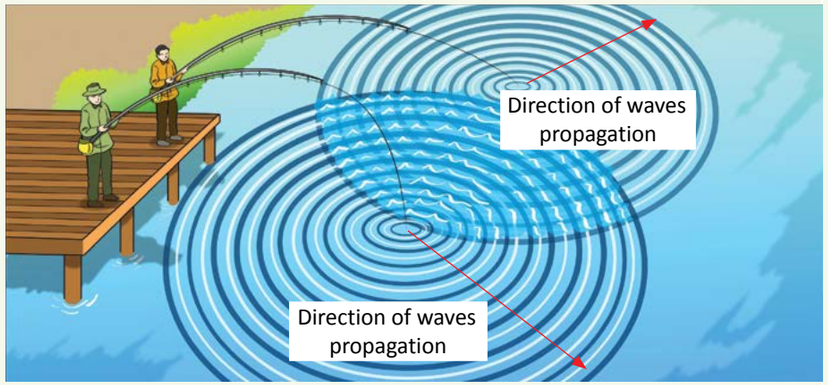


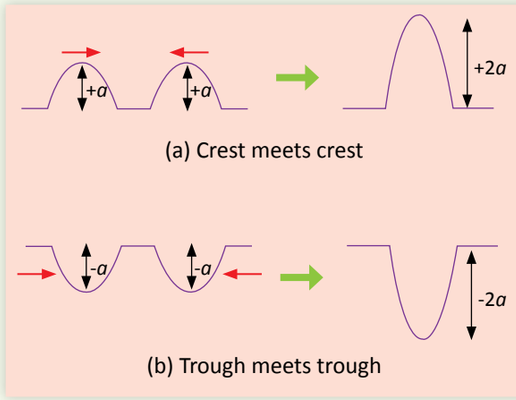

**Figure 6.27** Interference from two coherent sources

**Interference** is the effect of the superposition of two or more coherent waves. Two coherent waves have the same frequency and the phase difference is constant. Interference occurs when two waves propagating in the same medium meet and overlap. There are two types of interference, namely constructive interference and destructive interference.

**The principle of superposition** is when two waves propagate and meet at one point, the resulting displacement at that point is the sum of the displacements of the individual waves.








**Constructive interference**

Occurs when crest meets crest or trough meets trough and produce maximum amplitude

**Destructive interference**

Occurs when crest meets trough and produce zero amplitude

**Figure 6.28** Constructive and destructive interference

## Activity 6.10

**Aim:** To study the interference of waves.

**Materials**: White paper as a screen, rubber band and water.

**Apparatus:** Ripple tank, mechanical stroboscope, vibrating motor, power supply, lamp, spherical dippers and motor frequency controller.

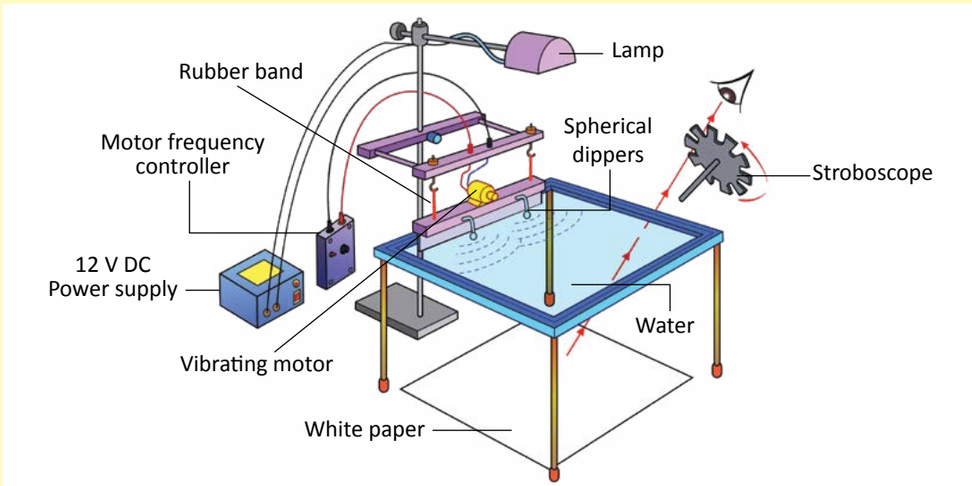



**Figure 6.29**

**Instruction:**

1. Set up the ripple tank and other apparatus as shown in Figure 6.29 and place a white paper under the ripple tank.
2. Install two spherical dippers on the vibrating motor but make sure the dippers do not touch the base of the ripple tank.
3. Fill in the water and adjust the ripple tank legs until the depth of the water is uniformed.
4. Switch on the lamp and vibrating motor to produce two circular waves. Adjust the frequency of the vibrating motor so that the patterns of the wave front produced on the white paper can be clearly seen using a stroboscope.
5. Observe the patterns of the wave front resulting from the superposition of the two waves.

**Observation:**

Draw the patterns of the wave front resulting from superposition of two waves and identify constructive and destructive interference.

**Conclusion:**

What conclusion can be drawn based on your findings?

## Application of Wave Properties

You have learned about the properties of waves. Now, let us examine situations involving properties of waves in daily life.

### Sound Navigation and Ranging (SONAR)

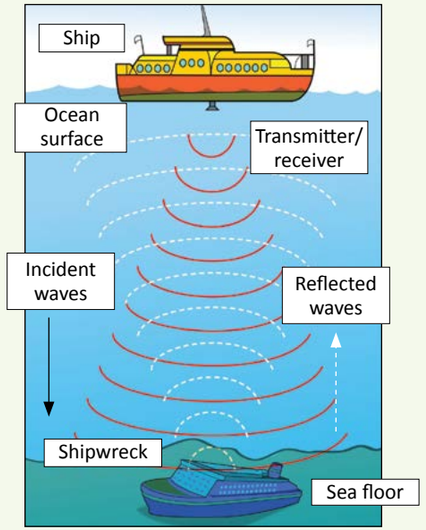



**Figure 6.30** Application of waves reflection in SONAR

The depth of the sea or the location of a shipwreck can be determined using the concept of sound wave reflection known as SONAR. Transmitter will send signals in the form of ultrasound and produce a wave reflection when it hits the sea floor. Receiver will detect the reflected sound wave and measure the time interval, $t$ between transmission time and the signal reception. The depth of the sea can be measured using the formula:

$$d = v\left(\frac{t}{2}\right)$$ where, $d$ = depth

$v$ = speed of sound waves in water

$t$ = time interval



6.3.1 6.3.2



### Interference of Sound Waves

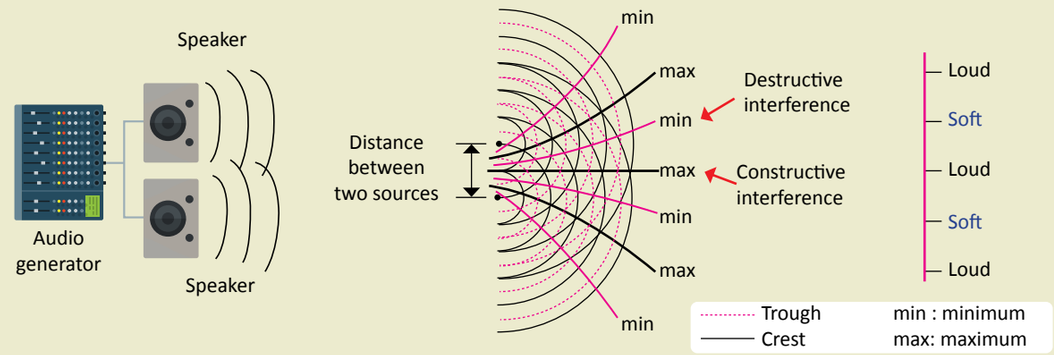



**Figure 6.31** Interference of sound waves

A series of loud and soft sounds will be produced alternately as constructive and destructive interference are formed. Therefore, the concept of sound wave interference shall be taken into account in the arrangement of cinema seats. Seats shall be arranged along the lines forming constructive interference only so that the sound produced by the speakers is maximum.

### Activity 6.11

**Aim:** To discuss the application of wave properties in daily life.

**Instruction:**

1. Find other information related to the application of wave properties in daily life.
2. Report the results of your findings. You can use a variety of presentation mediums.

### Formative Exercise 6.3

1. State **four** phenomena of waves.
2. List **two** characteristics for:
   (a) reflection of waves
   (b) refraction of waves
   (c) diffraction of waves
   (d) interference of waves
3. Ultrasound waves are used to determine the depth of the sea. Time taken by the ultrasonic wave to travel from the transmitter to the sea floor and back to the receiver is 0.36 s. If the speed of sound waves in water is 1 500 m $s^{-1}$, calculate the depth of the sea.

6.3.2

# 6.4 Mechanical Waves and Electromagnetic Waves

## Examples of Mechanical Waves and Electromagnetic Waves

We have learned about mechanical waves in the last topic. **Mechanical waves** are waves that require a medium to propagate. Examples of mechanical waves are sound waves, water waves and slinky spring waves.

**Electromagnetic waves** are waves that can propagate without a medium. Examples of electromagnetic waves are the electromagnetic spectrum consisting of radio waves, microwaves, infrared rays, visible light, ultraviolet rays, X-rays and gamma rays.

Electromagnetic waves are produced when electric fields and magnetic fields vibrate perpendicularly to each other. The direction of wave propagation is perpendicular with both magnetic field and electric field as shown in Figure 6.32.

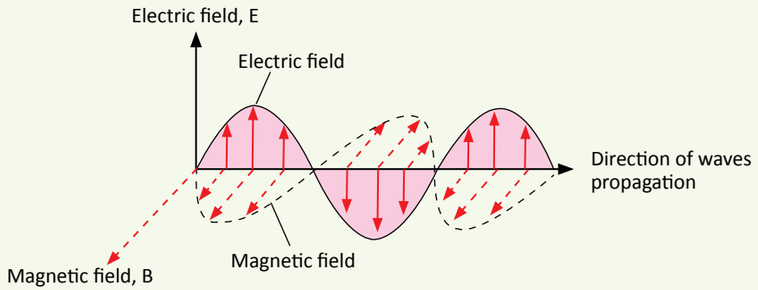



**Figure 6.32** Direction of waves propagation perpendicular to the magnetic field and electric field





## Difference Between Mechanical Waves and Electromagnetic Waves

Table 6.3 shows the differences of mechanical waves and electromagnetic waves.Can you observe the differences between mechanical waves and electromagnetic waves?

**Table 6.3** Differences of mechanical waves and electromagnetic waves

| Mechanical waves | Characteristics | Electromagnetic waves |
|---|---|---|
| Transverse waves: Water waves<br>Longitudinal waves: Sound waves | Type of waves | Transverse waves |
| Depends on the type of wave and medium<br>Example:<br>Speed of sound waves in the air = 330 m $s^{-1}$<br>Speed of sound waves in water = 1 500 m $s^{-1}$ | Speed | The speed of light in a vacuum,<br>$c = 3.0 \times 10^8$ m $s^{-1}$ |
| Unable to propagate in vacuum<br>Requires mediums such as solid, liquid and gas to propagate | Propagation in vacuum | Able to propagate in vacuum |
| Sound waves, water waves and slinky spring waves | Examples of waves | Radio waves, microwaves, infrared rays, visible light, ultraviolet rays, X-rays and gamma rays |

### Activity 6.12 PAK 21

**Aim:** To discuss the differences between mechanical and electromagnetic waves.

**Method:** Think-Pair-Share

**Instruction:**

1. Carry out this activity in groups.
2. Do an active reading to get more information on the differences between mechanical waves and electromagnetic waves.
3. Share the findings with group members in pairs.

## Spectrum of Electromagnetic Waves

Electromagnetic spectrum is a series of electromagnetic waves arranged in sequence of wavelength or frequency. The frequency of electromagnetic waves increases as the wavelength decreases.

| Type of radiation | Radio | Microwave | Infrared | Visible light | Ultraviolet | X-Ray | Gamma ray |
|---|---|---|---|---|---|---|---|
| Wavelength (m) | $10^{3}$ | $10^{-2}$ | $10^{-5}$ | $0.5 \times 10^{-6}$ | $10^{-8}$ | $10^{-10}$ | $10^{-12}$ |

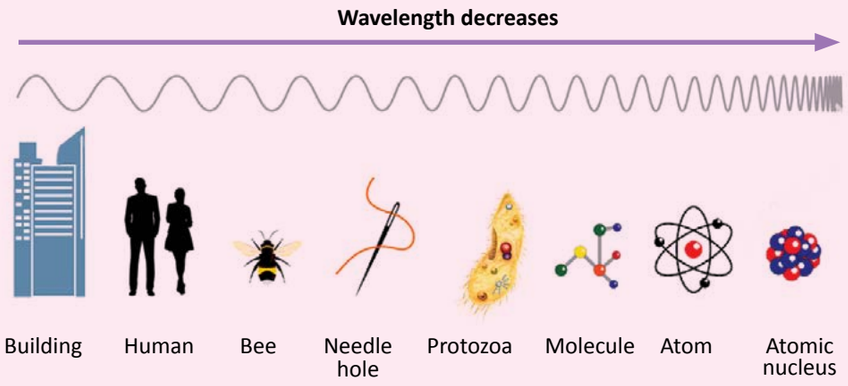



**Figure 6.33** Electromagnetic spectrum

### Activity 6.13

**Aim:** To determine types of signals in electromagnetic spectrum.

**Instruction:**

1. Gather information to identify the types of wave signals such as Bluetooth, LTE 4G, 3G, 2G, GPRS, GPS and WIFI used in smartphone technology.
2. Determine its position in the spectrum of electromagnetic waves.

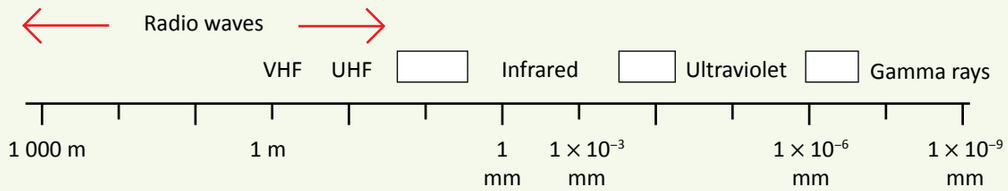


6.4.3



### Formative Exercise 6.4

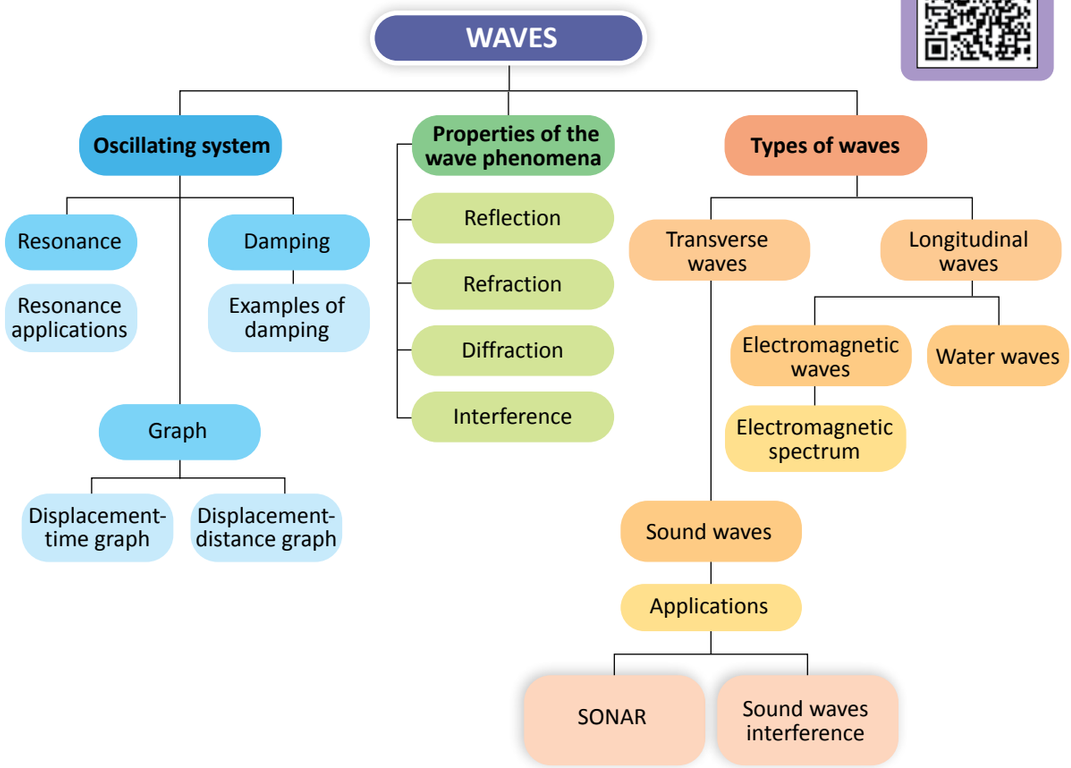
1. The diagram below shows the electromagnetic spectrum. Fill in the blanks with the correct electromagnetic waves name.




2. Compare the frequency of infrared with gamma ray. State the relationship between frequency and wavelength.
3. State the differences between electromagnetic waves and sound waves.

### Summary

Quick Quiz 6



## Self-reflection

After studying this chapter, students will be able to:

### 6.1 Production of waves

- Explain how waves are produced.
- Define and give examples of transverse and longitudinal waves.
- Communicate about characteristics of waves.
- Conduct an experiment to determine the relationship between frequency and wavelength.
- Explain damping in oscillating system.
- Communicate about examples of damping in oscillating systems in daily life.

### 6.2 Resonance

- Explain resonance in oscillating system.
- Communicate about the uses of resonance in daily life.

### 6.3 Properties of waves

- Explain the properties of waves.
- Communicate about the application of wave properties in daily life.

### 6.4 Mechanical and electromagnetic waves

- Explain with examples mechanical and electromagnetic waves.
- Differentiate mechanical and electromagnetic waves.
- Determine the position of different types of signals in the spectrum of electromagnetic wave.





## Summative Practice 6

Check answers

1. State **two** damping situations in the oscillating system.
2. Figures 1 and 2 show the displacement-distance graph and the displacement-time graph for oscillating system

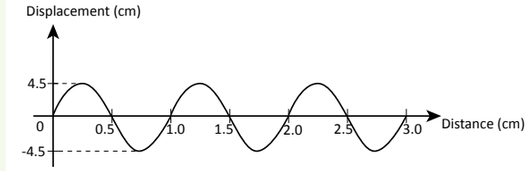



**Figure 1**

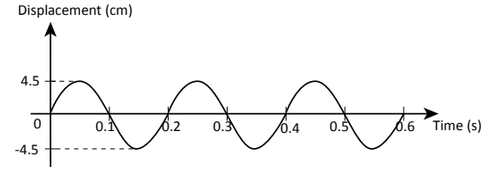



**Figure 2**

Based on Figures 1 and 2, determine:

(a) oscillating period
(b) frequency
(c) wavelength
(d) wave speed
(e) oscillating amplitude

3. Figure 3 shows water waves propagating from X to Y at different depths.

If the speed of water waves in Y is 10 cm $s^{-1}$, what is the speed of wave in X?

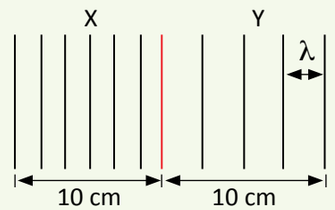



**Figure 3**

4. Figure 4 shows a wave phenomenon occurring on the coast.

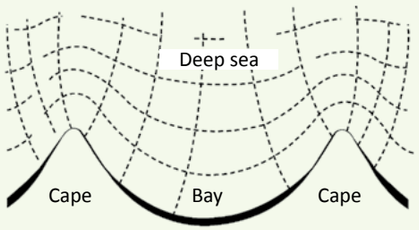



**Figure 4**

(a) State the waves phenomenon that occurs.
(b) Why the speed and wavelength in the deep sea are almost the same?
(c) Why does the distance of the wave fronts decrease when the wave approaches the shore?
(d) Why are the water waves in the bay calmer compared to the waves in the cape?

CHAPTER 7

# Electric

In this chapter, students will learn about:

- Electric current and potential difference
- Electrical resistance
- Electrical energy and power

Malaysia is one of the countries that is mostly hit by lightning every year. Lightning can cause injury to humans. What safety measures can be taken to avoid us from lightning strikes?

**KEYWORDS**

- Current
- Potential difference
- Electric charge
- Heating element
- Fuse
- Conductor
- Resistance
- Electrical energy
- Ohm
- Power

**Photograph 7.1** Lightning around Kuala Lumpur

# 7.1 Electric Current and Potential Difference

Did you know, a lightning has an energy that can ignite a 100 watt bulb for three months? According to studies, there are about 16 million thunderstorms every year and areas that are struck by lightning can reach a temperature up to 30 000°C, which is three times hotter than the surface of the Sun. Do you know how lightning works?

## Definition of Electric Current

**Electric current** is the rate of flow of electric charge in a conductor. Current is calculated using the following formula:

$$I = \frac{Q}{t}$$ where $I$ = electric current, $Q$ = electric charge, $t$ = time

The unit for current is Ampere, A and the unit for electric charge is Coulomb, C.

### Activity 7.1

**Aim:** To study the relationship between charge flow and electric current.

**Apparatus:** Van de Graaff generator, connecting wire, crocodile clip and microammeter (0 – 100 μA).

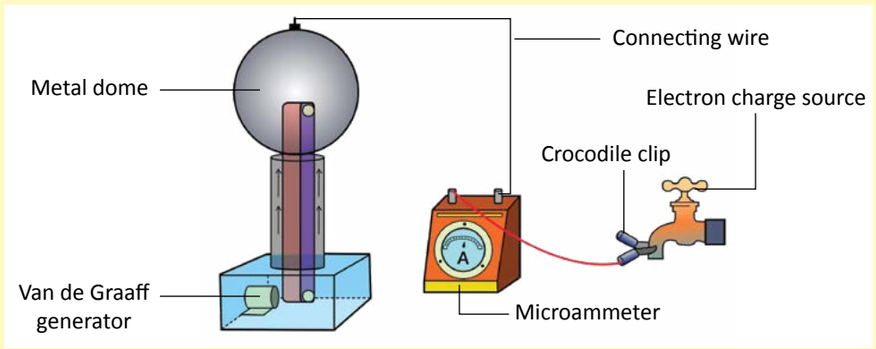



**Figure 7.1**

**Instruction:**

1. Set up the apparatus as shown in Figure 7.1.
2. Turn on the motor switch of the Van de Graaff generator for a few minutes to produce positive charges on the metal dome.
3. Bring your fingers closer to the metal dome. Observe what happens.
4. Touch the metal dome using the end of the connecting wire that connects to the microammeter. Note the pointer on the microammeter.

**Observation:**

1. What will happen when the finger is brought closer to the metal dome?
2. What will happen to the microammeter pointer when the connecting wire is connected to a metal dome?

**Conclusion:**

What conclusion can be drawn based on your findings?

## Potential Difference

When the battery in Figure 7.2 is connected to the bulb, the bulb will light up. Terminal X that is closer to the positive battery terminal produces high potential while terminal Y that is closer to the negative terminal produces low potential.

**Science is Easy!**

The S.I. unit for potential difference is volt, V.

The potential difference between point X and point Y causes the flow of electrons through the bulb. The charge flow produces an electric current that lights a bulb. Work is done when the charge flows through the bulb and converts electrical energy into thermal energy and light energy.

**Potential difference** is the work done when 1 coulomb of charge moves between two points in an electric field.

$$\text{Potential difference, } V = \frac{\text{Work, } W}{\text{Electric charge, } Q} = \frac{\text{Energy, } E}{\text{Electric charge, } Q}$$

$$1\text{ V} = \frac{1\text{ J}}{1\text{ C}} = 1\text{ J C}^{-1}$$

The measurement unit for potential difference is volt. 1 volt means 1 joule of work done to move 1 coulomb of charge from one point to another.

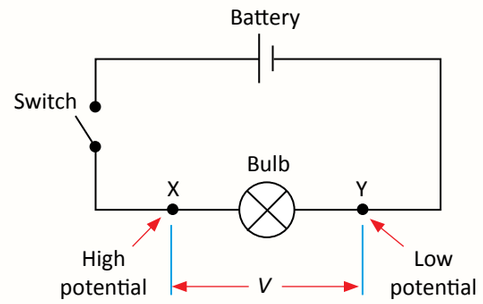



**Figure 7.2** Simple electric circuit

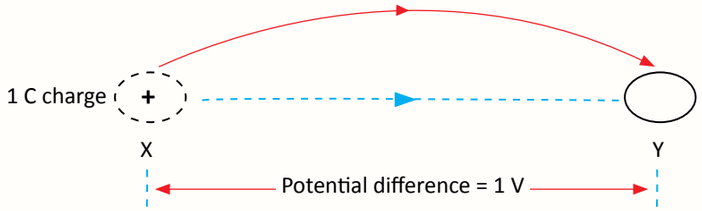



**Figure 7.3** 1 joule of work done for charge to move from point X to point Y

## Problem Solving Involving Electric Current and Potential Difference

Did you know that the defibrillator machines function by using medium to high potential difference which is 200 V to 1 000 V to conduct electricity and produce high electrical energy to the heart. High-energy electric shock is called defibrillation. The purpose of this shock is to return the heart to normal condition when a person has a heart attack. During the defibrillation process, the patient's heart receives about 300 J of electrical energy.

**Photograph 7.2**
Defibrillator machine

**Electric charge** is the product of electrons and the charge for an electron. The amount of electrical charge flowing through a conductor can be calculated using:

$Q = ne$, where $Q$ = electric charge
$n$ = number of charge
$e$ = electron charge = $1.6 \times 10^{-19}$ C

**Example 1**

The striking lightning generates an electric current of 500 A within 0.08 s. Calculate the quantity of charge transferred.

**Solution:**

Using the formula, $Q = It$
$= 500 \times 0.08$
$=$ **40 C**

**Example 2**

A battery with a potential difference of 4.5 V is used to transfer 35 C of electrical charge through a bulb. Calculate the work done to transfer the electric charge through the bulb.

**Solution:**

Using the formula, $W = VQ$
$= 4.5 \times 35$
$=$ **157.5 J**

**Example 3**

Given that the current flowing in the bulb is 0.4 A.

(a) Calculate the total electric charge flowing through the bulb in five hours.

(b) What are the number of electrons flowing in that five hours?

**Solution:**

(a) Given time, $t$ = 5 hours
$= 5 \times 60 \times 60$
$= 18\,000$ s

Using the formula $Q = It$
$= 0.4 \times 18\,000$
$=$ **7 200 C**

(b) Using the formula,

$$n = \frac{Q}{e}$$

$$= \frac{7\,200}{1.6 \times 10^{-19}}$$

$=$ **$4.5 \times 10^{22}$ electrons**





### Formative Exercise 7.1

1. An electric charge of 50 C flows through a motor within two minutes. Calculate the current flowing through the motor.
2. The battery in a lorry supplies a current of 5 A for a period of 6 s. Calculate the amount of charge stored in the battery.
3. A current of 3 A flows through a lamp. How long will it take for 1 500 C of electric charge to flow through the lamp?
4. The current flowing through a fan is 25 A. Calculate:
   (a) the amount of electrical charge flowing through the fan for two days.
   (b) the number of electrons flowing through the fan if the charge per electron is $1.6 \times 10^{-19}$ C.

# 7.2 Electrical Resistance

The atoms present in a conductor cause resistance and disrupt the flow of electrons as shown in Figure 7.4.

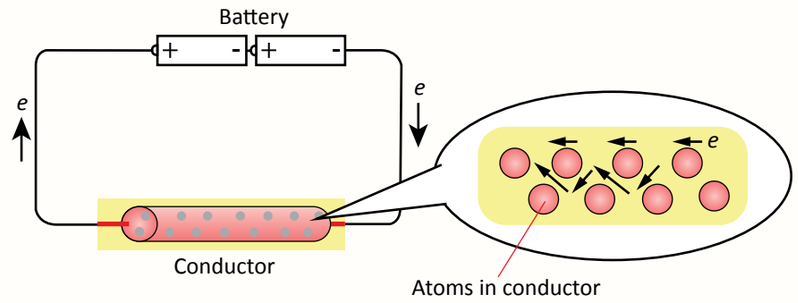



**Figure 7.4** Atoms in conductor disrupt the flow of electrons

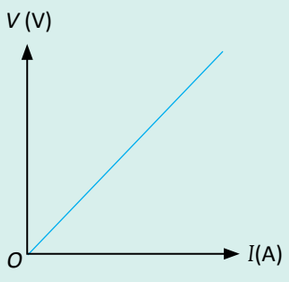



**Figure 7.5** Graph of $V$ against $I$

The graph of potential difference, $V$ against current, $I$ in Figure 7.5 is a straight line passing through the origin. Thus, the relationship between potential difference and current is directly proportional.

Ohm's Law states that the current, $I$ flowing through a conductor is directly proportional to the potential difference, $V$ if the temperature and physical conditions are constant.

From Ohm's Law, $V \propto I$, then

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

= gradient of graph $V$ against $I$.

For ohmic conductors, the constant is the resistance,

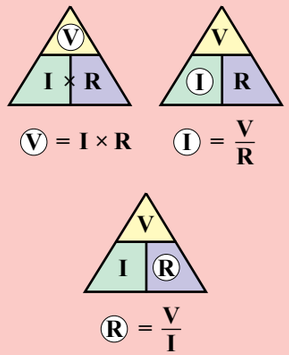
$R = \frac{V}{I}$, where $V$ = potential difference

$I$ = current

Thus, the **resistance *R*** is the ratio of the potential difference, $V$ across the conductor to the current, $I$ which flows through it.

The S.I. unit for resistance is volts per ampere, $VA^{-1}$ or Ohm, Ω.

**Science is Easy!**




This diagram can be used to calculate $V$, $I$ and $R$.

## Relationship Between Current and Potential Difference of Conductor

What differences can you observe in Figure 7.6? Why does this happen?

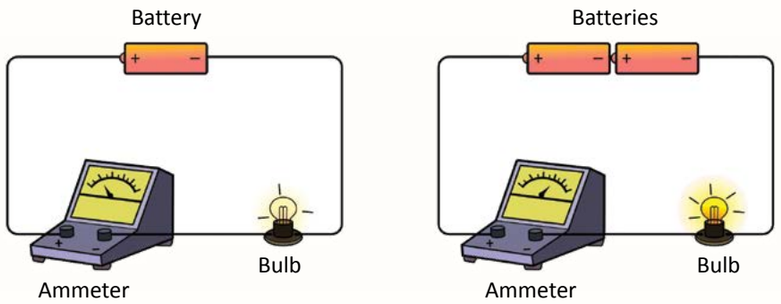



**Figure 7.6** Electric circuits with different potential differences

Ammeter shows different readings because the value of current flowing in the circuit is different. The brightness of the bulb is influenced by the value of the current flowing in the circuit.

Let's conduct Experiment 7.1 to study the relationship between current and potential difference of an ohmic conductor.

**Science Info**

Standard wire gauge (s.w.g.) is a measure of wire thickness. The smaller the value of s.w.g., the larger the diameter of the wire.





### Experiment 7.1

**Problem statement:** What is the relationship between current and potential difference of ohmic conductor?

**Aim:** To study the relationship between current and potential difference of ohmic conductor.

**Hypothesis:** The larger the current flowing through the ohmic conductor, the greater the potential difference.

**Manipulated variable:** Current, $I$

**Responding variable:** Potential difference, $V$

**Constant variable:** Length of constantan wire and temperature

**Material:** 30 cm of constantan wire (s.w.g. 28).

**Apparatus:** Two 1.5 V batteries, battery holder, ammeter (0 – 1 A), voltmeter (0 – 3 V), rheostat (0 - 15 Ω), connecting wires, crocodile clips and switch.

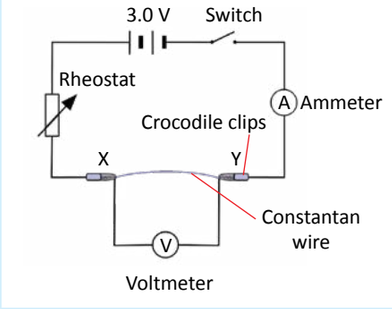



**Figure 7.7**

**Procedure:**

1. Connect the circuit as shown in Figure 7.7.
2. Turn on the switch and adjust the rheostat until the ammeter reading, $I$ = 0.2 A
3. Read and record voltmeter readings.
4. Repeat steps 2 and 3 for $I$ = 0.3 A, 0.4 A, 0.5 A and 0.6 A.
5. Plot graph $V$ against $I$.

**Observation:**

**Table 7.1**

| Current, $I$ (A) | Potential difference, $V$ (V) |
|---|---|
| 0.2 | |
| 0.3 | |
| 0.4 | |
| 0.5 | |
| 0.6 | |

**Data Interpretation:**

1. Plot graph $V$ against $I$.
2. Calculate the resistance of the ohmic conductor, $R$ from the gradient of the graph.

**Discussion:**

State the precautions that need to be taken throughout the experiment.

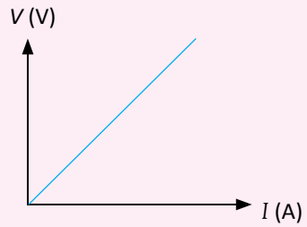
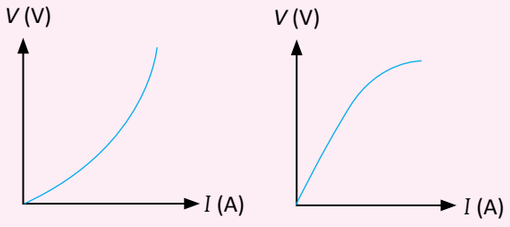
**Conclusion:**

Is the hypothesis acceptable? State the conclusion of this experiment.

## Characteristics of Ohmic Conductor and Non-Ohmic Conductor

Ohmic conductor is an electrical conductor that obeys Ohm's Law, while a non-ohmic conductor is a conductor that does not obey Ohm's Law. Table 7.2 shows the differences between ohmic conductors and non-ohmic conductors.

**Table 7.2** Differences between ohmic conductor and non-ohmic conductor

| Ohmic conductor | Non-ohmic conductor |
|---|---|
|  |  |
| The potential difference is directly proportional to the current. | The potential difference is not directly proportional to the current. |
| The gradient of the graph of $V$ against $I$ is constant. | The gradient of the graph of $V$ against $I$ is not constant. |
| Examples of ohmic conductors: constantan, copper, silver and nichrome | Examples of non-ohmic conductors: diode, thermistor and bulb |

### Activity 7.2

**Aim:** To study the relationship between current and potential difference of non-ohmic conductor.

**Instruction:**

1. Study the method used in Experiment 7.1.
2. Plan and carry out an experiment to study the relationship between current and potential difference of non-ohmic conductor. Seek advice from your teacher before carrying out this activity.
3. Prepare a complete report for this activity.

## Factors that Affect Resistance of a Conductor

Figure 7.8 shows bulbs connected to batteries using different conductor lengths. Why is the brightness of the bulb different?

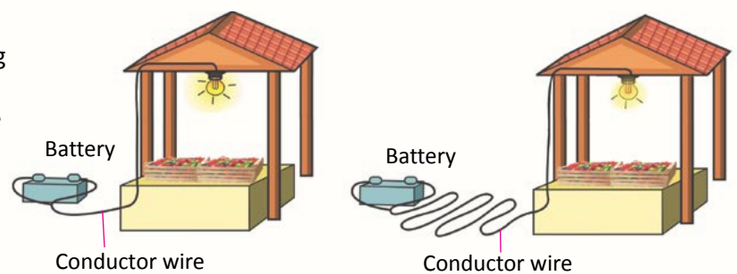



**Figure 7.8** Stalls with different brightness of bulbs

7.2.2 7.2.3

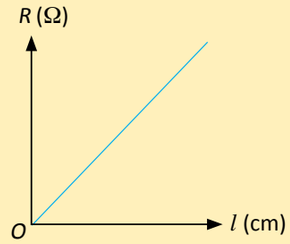




There are four factors that affect the resistance of a conductor, that are length of a conductor, diameter, temperature and type of conductor material.

### Length of a conductor

Resistance, $R$ is directly proportional to the length of a conductor, $l$ of the same material and diameter.



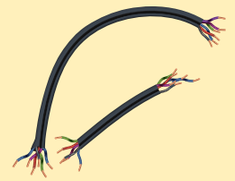
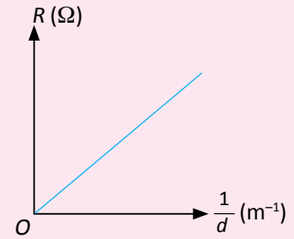



**Figure 7.9** Conductors of different lengths

### Diameter of a conductor



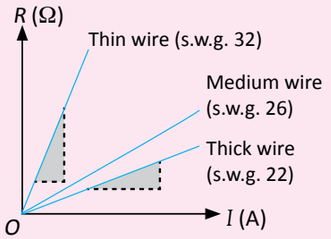
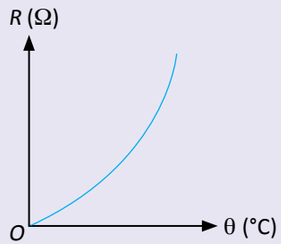




**Figure 7.10** Conductors with different diameter

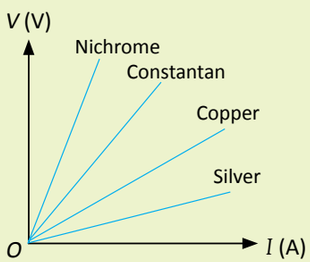
Resistance, $R$ is inversely proportional to the diameter of a conductor, $d$ for conductors of the same material and length.

### Temperature of a conductor

Resistance, $R$ increases as the temperature, $\theta$ increases for conductors of the same material, length and its diameter.




### Type of conductor material




Resistance, $R$ depends on the type of a conductor material used for the conductor of the same length and diameter.

Resistance decreasing

Nichrome Constantan Copper Silver

7.2.2

## Experiment 7.2

### A. Relationship between the length and the resistance of a conductor

**Problem statement:** Does the length of a conductor influence the resistance of a conductor?

**Aim:** To study the length of a conductor as a factor affecting the resistance of a conductor.

**Hypothesis:** The longer the conductor, the greater the resistance.

**Manipulated variable:** Length of a conductor, $l$

**Responding variable:** Resistance, $R$

**Constant variable:** Temperature, diameter and type of conductor material

**Material:** Constant wire (s.w.g. 28).

**Apparatus:** Two 1.5 V batteries, battery holder, ammeter (0 – 1 A), voltmeter (0 – 3 V), rheostat (0 – 15 Ω), metre rule, connecting wires, crocodile clips and switch.

**Procedure:**

1. Connect the circuit as shown in Figure 7.11.
2. Measure the length of the constantan wire between X and Y, $l$ = 20 cm.
3. Turn on the switch and adjust the rheostat until the ammeter reading, $I$ = 0.5 A
4. Record voltmeter reading.
5. Repeat steps 2 to 4 for $l$ = 40 cm, 60 cm, 80 cm and 100 cm.
6. Calculate the value of resistance, $R = \frac{V}{I}$ for the five lengths of constantan wire used.

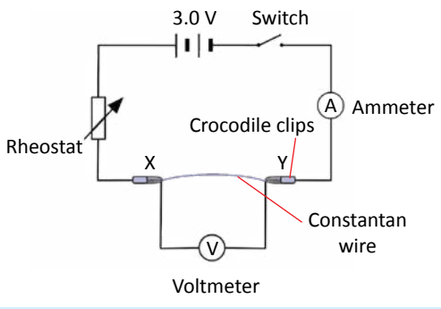



**Figure 7.11**

**Observation:**

**Table 7.3**

| Length of Constantan Wire, $l$ (cm) | Current, $I$ (A) | Potential difference, $V$ (V) | Resistance, $R$ (Ω) |
|---|---|---|---|
| 20.0 | 0.5 | | |
| 40.0 | 0.5 | | |
| 60.0 | 0.5 | | |
| 80.0 | 0.5 | | |
| 100.0 | 0.5 | | |

**Data Interpretation:**

Plot graph $R$ against $l$.

**Discussion:**

1. State the precautions that need to be taken throughout this experiment.
2. What is the relationship between the length and the resistance of a conductor?

**Conclusion:** Is the hypothesis accepted? State the conclusion of this experiment.





### B. Relationship between the diameter and the resistance of a conductor

**Problem statement:** Does the diameter of a conductor influence the resistance of a conductor?

**Aim:** To study the diameter of a conductor as a factor affecting the resistance of a conductor.

**Hypothesis:** The larger the diameter of the conductor, the smaller the resistance.

**Manipulated variable:** Diameter of conductor, $d$

**Responding variable:** Resistance, $R$

**Constant variable:** Temperature, length and type of conductor material

**Materials:** 50 cm constantan wire (s.w.g. 24, s.w.g. 26, s.w.g. 28, s.w.g. 30 and s.w.g. 32)

**Apparatus:** Two 1.5 V batteries, battery holder, ammeter (0 – 1 A), voltmeter (0 – 3 V), rheostat (0 – 15 Ω), metre rule, connecting wires, crocodile clips and switch.

**Procedure:**

1. Connect the circuit as shown in Figure 7.12.
2. Connect 50 cm of constantan wire s.w.g. 24 between point X and Y.
3. Turn on the switch and adjust the rheostat until the ammeter reading, $I$ = 0.5 A.
4. Read and record voltmeter readings.
5. Repeat steps 2 to 4 using constantan wire s.w.g. 26, s.w.g. 28, s.w.g. 30 and s.w.g. 32.
6. Calculate the resistance value, $R = \frac{V}{I}$ for the five constantan wires used.

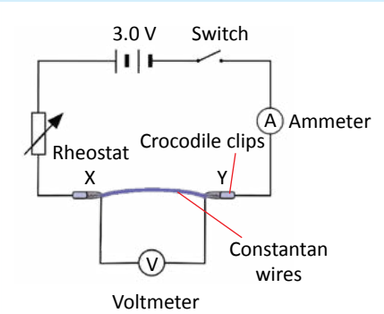



**Figure 7.12**

**Observation:**

Prepare a table to record the results of the experiment.

**Data Interpretation:**

Based on the experiment results, how does the diameter of a wire affect the resistance of a conductor?

**Discussion:**

1. State the precautions that need to be taken throughout this experiment.
2. What is the relationship between the diameter and the resistance of a conductor?

**Conclusion:** Is the hypothesis accepted? State the conclusion of this experiment.

### C. Relationship between the temperature and the resistance of a conductor

**Problem statement:** Does the temperature of a conductor influence the resistance of a conductor?

**Aim:** To study the temperature of a conductor as a factor affecting the resistance of a conductor.

**Hypothesis:** The higher the temperature of a conductor, the greater the resistance.

**Manipulated variable:** Temperature, $\theta$

**Responding variable:** Resistance, $R$

**Constant variable:** Diameter, length and type of conductor material

**Materials:** 50 cm nichrome wire (s.w.g. 30), ice and hot water.

**Apparatus:** Two 1.5 V batteries, battery holder, ammeter (0 – 1 A), voltmeter (0 – 3 V), rheostat (0 – 15 Ω), metre rule, connecting wire, crocodile clips, switch and two 250 ml beakers.

**Procedure:**

1. Connect the circuit as shown in Figure 7.13.
2. Connect 50 cm of nichrome wire s.w.g. 30 cm between point X and Y and immerse in an ice-filled beaker.
3. Turn on the switch and adjust the rheostat until the ammeter reading, $I$ = 0.2 A.
4. Read and record voltmeter readings.
5. Repeat steps 2 to 4 using a beaker containing hot water.
6. Calculate the resistance value, $R = \frac{V}{I}$ for both beakers used.

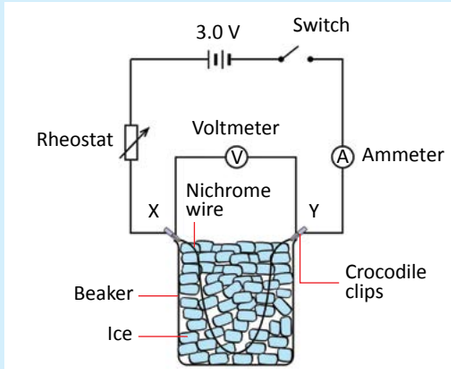



**Figure 7.13**

**Observation:**

Prepare a table to record the results of the experiment.

**Data Interpretation:**

Based on the experiment results, how does the temperature of a conductor affect the resistance of a conductor?

**Discussion:**

1. State the precautions that need to be taken throughout this experiment.
2. What is the relationship between the temperature and the resistance of a conductor?

**Conclusion:** Is the hypothesis accepted? State the conclusion of this experiment.





### D. Comparison between the type of material and the resistance of a conductor

**Problem statement:** Does the type of material conductor influence the resistance of a conductor?

**Aim:** To study the type of material conductor as a factor affecting the resistance of a conductor.

**Hypothesis:** Nichrome wire has higher resistance than constantan wire.

**Manipulated variable:** Type of conductor material

**Responding variable:** Resistance, $R$

**Constant variable:** Diameter, length and temperature

**Materials:** 50 cm nichrome wire (s.w.g. 28) and 50 cm constantan wire (s.w.g. 28).

**Apparatus:** Two 1.5 V batteries, battery holder, ammeter (0 – 1 A), voltmeter (0 – 3 V), rheostat (0 – 15 Ω), metre rule, connecting wire, crocodile clips and switch.

**Procedure:**

1. Connect the circuit as shown in Figure 7.14.
2. Connect 50 cm of constantan wire s.w.g. 28 between point X and Y.
3. Turn on the switch and adjust the rheostat until the ammeter reading, $I$ = 0.5 A.
4. Read and record voltmeter readings.
5. Repeat steps 2 to 4 using 50 cm of nichrome wire s.w.g. 28.
6. Calculate the resistance value, $R = \frac{V}{I}$ for both wires used.

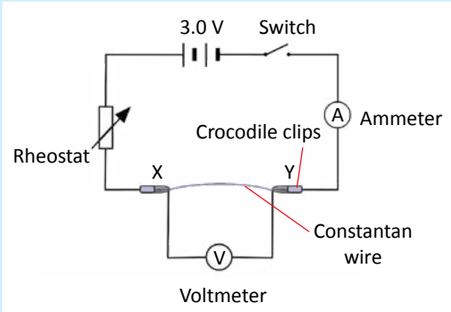



**Figure 7.14**

**Observation:**

Prepare a table to record the results of the experiment.

**Data Interpretation:**

Based on the experiment results, state the type of conductor material that has higher resistance.

**Discussion:**

State the precautions that need to be taken throughout the experiment.

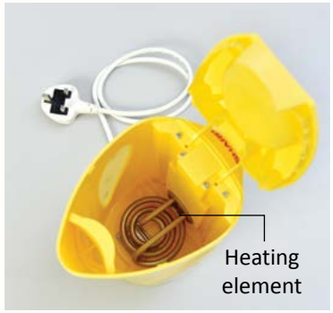
**Conclusion:**

Is the hypothesis accepted? State the conclusion of this experiment.

## Choosing Materials With High Resistance as a Heating Elements

Electrical appliances such as toasters, electric kettles, ovens and bulbs require high resistance materials to be used as heating elements.

Material like nichrome is used as heating elements because it has high resistance to convert electrical energy into heat energy. The resulting heat is used to cook food and heat water. The heating element in a bulb will convert electrical energy into light energy.




**Photograph 7.3** Electric kettle with heating element

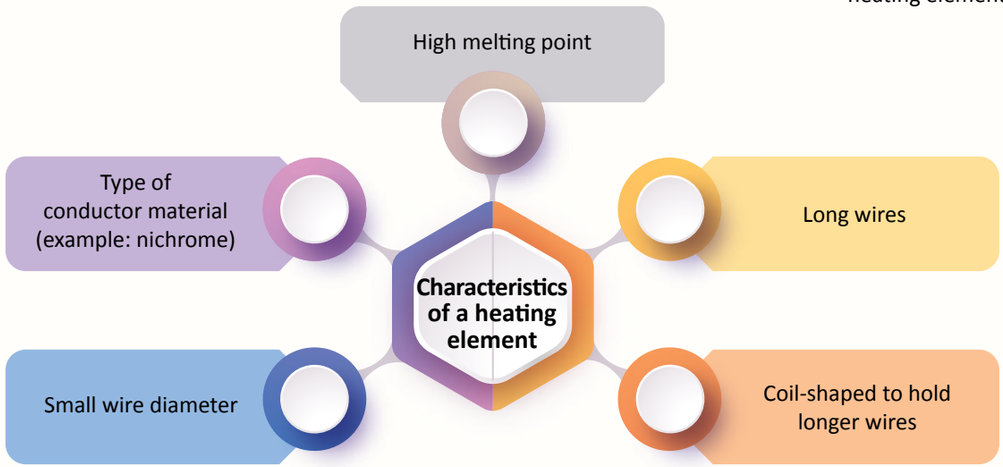



**Figure 7.15** Characteristics of a heating element

### Activity 7.3

**Aim:** To study about high resistance material as a heating element.

**Instruction:**
1. Gather information about high resistance materials that are suitable to use as a heating element.
2. Report the results of your findings. You may use a variety of presentation mediums.

### Formative Exercise 7.2

1. Differentiate ohmic conductor and non-ohmic conductor.
2. State **four** factors affecting the resistance of a conductor.



7.2.4



# 7.3 Electrical Energy and Power

**Electrical energy**, ***E*** means the ability of an electric current to do work. Electrical energy is supplied by energy sources such as dry cells or batteries when current flows in a closed circuit.

Electrical energy can be converted to other forms of energy according to the type of electrical equipment used such as heat energy, light energy or mechanical energy when current flows in it. The S.I. unit for electrical energy is joules, J.

## Relationship between Electrical Energy ($E$), Potential Difference ($V$), Electric Current ($I$) and Time ($t$)

We have learned about potential difference in the previous topic. Let's revisit the definition of potential difference, which is the work done when 1 coulomb of charge moves between two points in an electric field.

Given
Potential difference, $V = \frac{\text{Work, } W}{\text{Charge, } Q}$

Energy change, $E$ is equivalent to the work done, $W$.

$$V = \frac{\text{Energy change, } E}{\text{Charge, } Q}$$

Therefore, $E = VQ$
From formula of charge, $Q = It$ and $E = VQ$,

Thus, $E = VIt$

### Science Info

Watt is the S.I. unit for power and was named after Scottish engineer, James Watt who successfully improved the steam engine to be more efficient.

## Relationship between Power ($P$), Potential Difference ($V$) and Current ($I$)

**Power, *P*** is the rate of change of electrical energy. The S.I. unit for power is joules per second, J $s^{-1}$ or watts, W.

$$\text{Power, } P = \frac{\text{Energy change, } E}{\text{Time, } t}$$

From formula $P = \frac{E}{t}$ and $E = VIt$,

$P = \frac{VIt}{t}$

Thus, $P = VI$

**Keys**
- $E$ = Energy
- $P$ = Power
- $V$ = Potential difference
- $R$ = Resistance
- $I$ = Current
- $t$ = Time

7.3.1 7.3.2

From Ohm's Law, $V = IR$

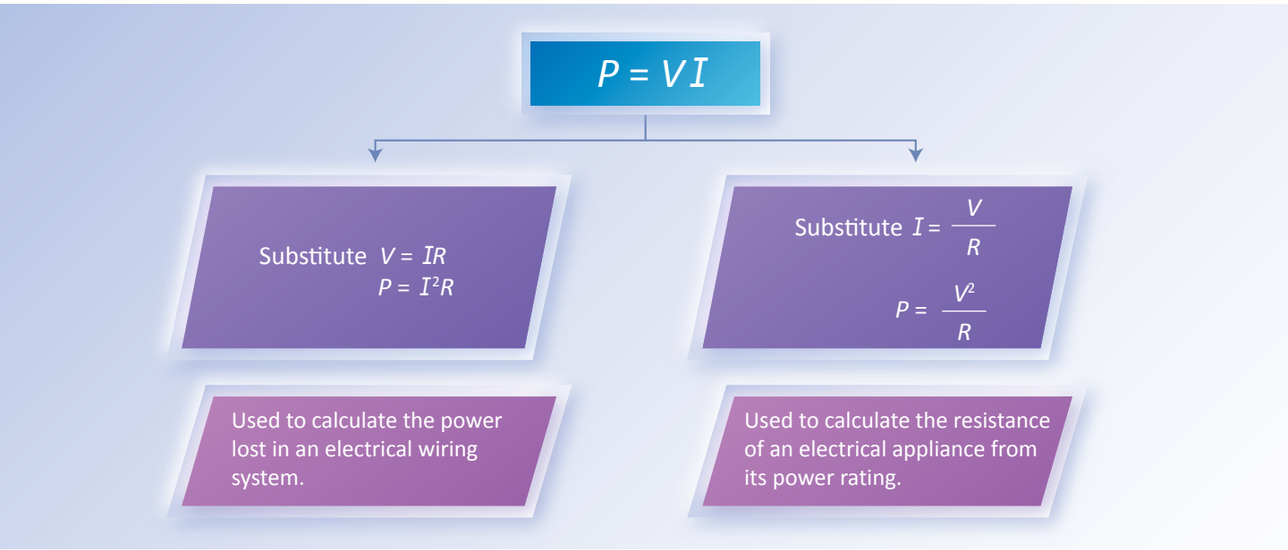



**Figure 7.16** Relationship between electrical energy ($E$), power ($P$), potential difference ($V$) and current ($I$)

**Example 1**

A toaster is connected to a power supply of 240 V. If the resistance of the heating element is 35 Ω, calculate:

(a) current flowing through the heating element.

(b) the quantity of heat produced in eight minutes.

**Solution:**

(a) Using formula $I = \frac{V}{R}$

$= \frac{240}{35}$

$= \mathbf{6.86\ A}$

(b) Convert minutes to seconds, $t = 8 \times 60$

$= 480$ s

Using formula,

$E = VIt$

$= 240 \times 6.86 \times 480$

$= \mathbf{790\ 272\ J}$

**Photograph 7.4** Toaster



7.3.2



**Example 2**

An electric kettle with a power of 750 W is connected to a power supply of 240 V. Calculate:

(a) resistance for the kettle.

(b) electrical energy consumed in 15 minutes.

**Solution:**

(a) Using formula

$P = \frac{V^2}{R}$

$750 = \frac{(240)^2}{R}$

$R = \frac{(240)^2}{750}$

$= \mathbf{76.8\ \Omega}$

(b) Convert minutes to seconds

$t = 15 \times 60$

$= 900$ s

Using formula

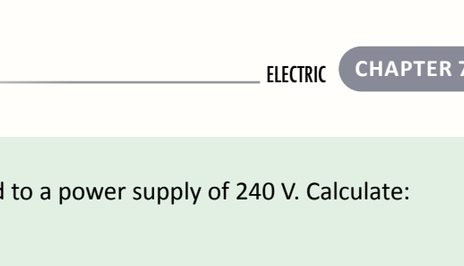
$E = Pt$

$= 750 \times 900$

$= \mathbf{675\ 000\ J}$

## Determine the Appropriate Fuse Value for Electrical Equipment

**Fuse** is a fine, short conductor wire that will melt when the current flowing through it is greater than the value of the fuse. When a short circuit occurs in an electrical appliance, excessive current flow will cause the fuse to melt and break the circuit.




**Photograph 7.5** Fuse structure

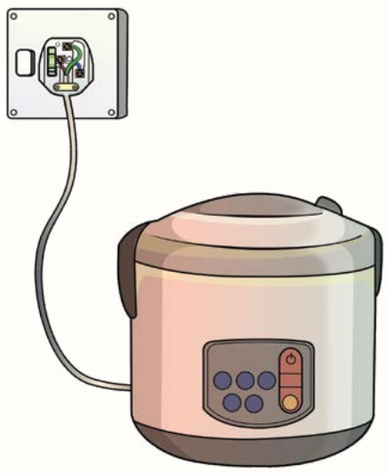


**Figure 7.17** Electric pot

Fuse is a safety component found in every electrical appliance. The function of the fuse is to protect electrical equipment from excessive current thus preventing the occurrence of fire. Examples of some commonly used fuse values are 1 A, 5 A, 13 A and 15 A.

If an electrical appliance has a power of 960 W and is connected to a 240 V power supply, then the current flowing in the electrical appliance is 4 A. The fuse value suitable for use should be slightly higher than the maximum amount of current flowing in the electrical appliance. An example of a suitable fuse value is 5 A.

7.3.2 7.3.3

## Activity 7.4

**Aim:** To identify appropriate fuse value for electrical appliances at home.

**Instruction:**

1. Identify the power and potential differences of some electrical appliances at home.
2. Determine the value of current flowing in the electrical appliances.
3. Determine the appropriate fuse value.
4. Complete Table 7.4.

**Table 7.4** Appropriate fuse values for home electrical appliances

| Electrical appliances | Power, $P$ (W) | Potential difference, $V$ (V) | Current, $I$ (A) | Fuse value (A) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
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| | | | | |

## Formative Exercise 7.3

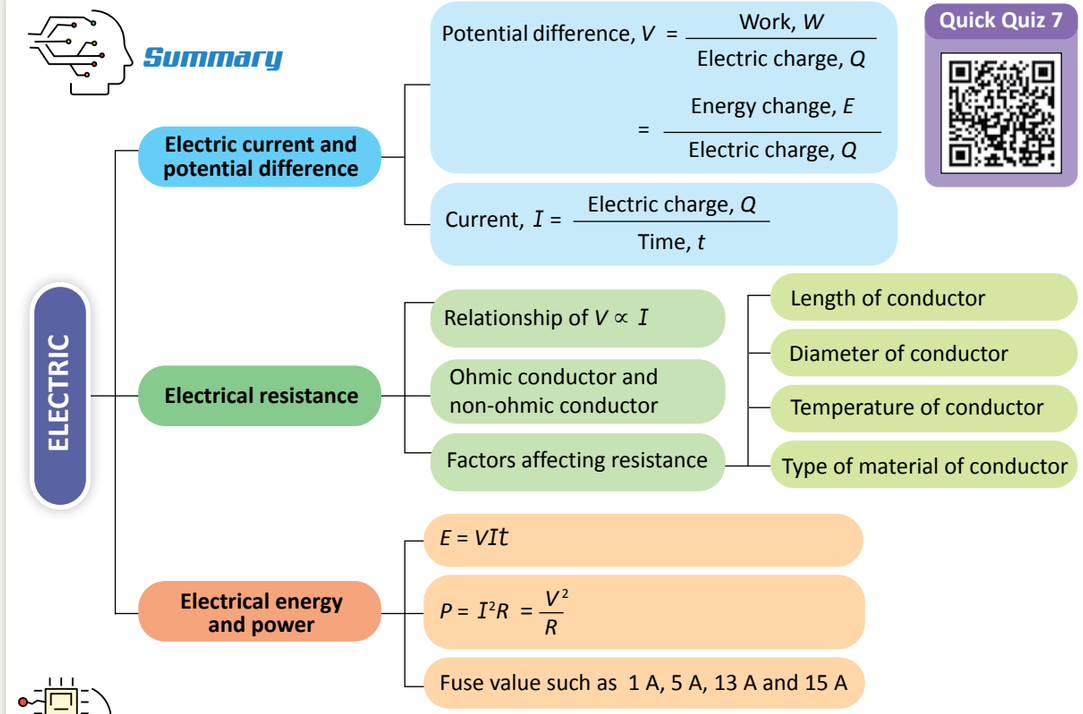
1. Resistance of a heating coil in an electric kettle is 9 Ω and the current flowing in the kettle is 10 A. Calculate the power generated by the kettle.
2. A washing machine supplies 1 800 W of power when connected to a 240 V power supply.
   (a) Calculate the current flowing in the washing machine.
   (b) Calculate the resistance of the washing machine.
3. Motorcycle's lights are labelled with "12 V, 15 W".
   (a) Calculate the value of current flowing through a lamp when it is connected to a 12 V supply.
   (b) What is the resistance of the lamp's filament?
4. What is the function of a fuse?
5. State **two** causes of short circuit.







## Summary




Quick Quiz 7

## Self-reflection

After studying this chapter, students will be able to:

**7.1 Electric current and potential difference**

- Define electric current.
- Explain potential difference.
- Solve numerical problems involving electric current and potential differences.

**7.2 Electrical resistance**

- Conduct an experiment to determine the relationship between current and potential difference of conductor.
- Differentiate between characteristics of an ohmic conductor and a non-ohmic conductor.
- Carry out an experiment to study factors affecting the resistance of a conductor.
- Justify choosing materials with high resistance as heating elements.

**7.3 Electrical energy and power**

- Relate electrical energy ($E$), potential difference ($V$), electrical current ($I$) and time ($t$).
- Relate power ($P$), potential difference ($V$) and current ($I$).
- Determine the appropriate fuse value for electrical equipment in daily life.

## Summative Practice 7

1. Given the specification of an iron is 900 W, 240 V. The iron is connected to a 240 V power supply and used for 45 minutes. Calculate the current flowing through the heating coil of the iron.

2. Sarimah conducts an experiment to compare the heating effects of toaster X, Y and Z. The toaster is connected to a power supply of 240 V. The table below shows the findings.

**Table 1**

| Toasters | Current, $I$ (A) | Time, $t$ (s) |
|---|---|---|
| X | 4.0 | 120 |
| Y | 6.0 | 90 |
| Z | 8.0 | 60 |

   (a) Calculate the energy consumption of each toaster X, Y and Z.

   (b) Based on your answer in question (a), which toaster is the most suitable to be used? Explain your answer.

3. Five hairdryers A, B, C, D and E with specifications of 1 500 W, 240 V are made of materials with different characteristics. The table below shows the characteristics of the materials used.

**Table 2**

| Hairdryer | Melting point (°C) | Resistance (Ω) | Shape of the heating element | Fuse value (A) |
|---|---|---|---|---|
| A | High | 40 | Straight | 5 |
| B | Low | 30 | Coil | 7 |
| C | High | 40 | Coil | 7 |
| D | Low | 30 | Straight | 5 |
| E | Low | 40 | Coil | 5 |

   (a) Based on the specifications of the hairdryer, state the appropriate fuse value for the hairdryer. Explain your options.

   (b) Based on the above characteristics,
   (i) select the most suitable hairdryer to be used.
   (ii) explain your answer.

Check answers



# THEME 4

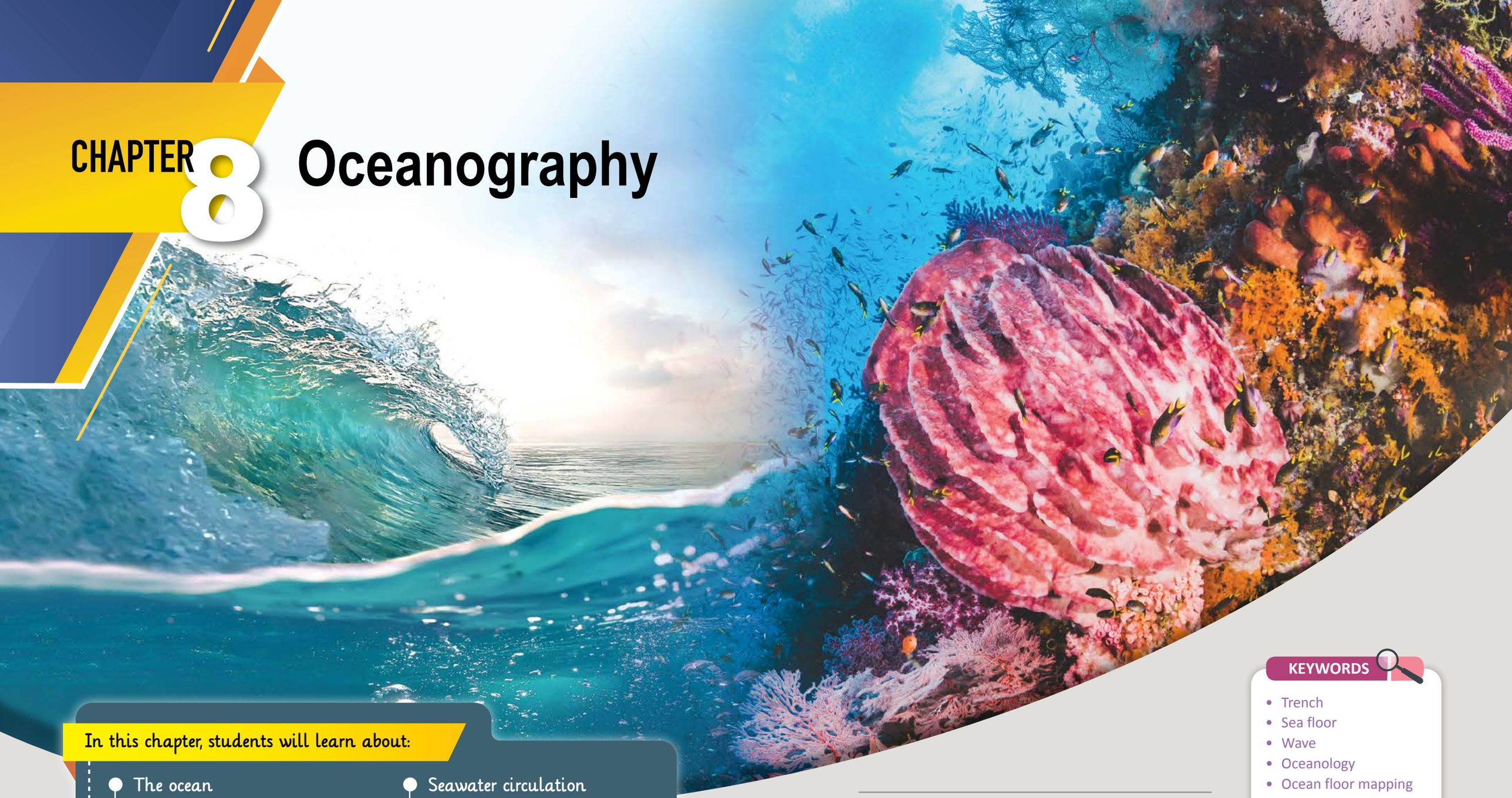
# EXPLORATION OF EARTH AND SPACE

This theme emphasises on marine science which includes marine life and ecosystems, as well as chemical and physical characteristics. This chapter covers four major areas of science in the aspects of biology, chemistry, physics and geology.

From the biological aspect, this chapter emphasises on the distribution of aquatic life and its environment. The chemical aspect focuses on the composition of seawater and the effects of pollution on marine life. On the other hand, the physical aspect explains the movement of seawater and how the pressure and density differences affect aquatic organisms. The geological aspect explains the formation of mountains, trenches and ocean valleys as a result of tectonic plate movement millions of years ago.

CHAPTER 8

# Oceanography



In this chapter, students will learn about:

- The ocean
- Ocean floor mapping
- Physical properties of seawater
- Ocean biology
- Seawater circulation
- Ocean resources
- Issues and challenges related to ocean

Aquaman film, released in 2018, depicts human life in the ocean. In your opinion, can humans adapt and live in the sea?

**KEYWORDS**

- Trench
- Sea floor
- Wave
- Oceanology
- Ocean floor mapping
- Salinity
- Coral reef
- Transparency

# 8.1 The Ocean

## The Early History and Reason for Ocean Exploration

In the 15th century, maritime society emerged shortly after the European Trade Revolution. Portugal was the earliest European country to embark on exploration and navigation abroad. The goals of the exploration and navigation were:

**The purpose of the exploration and navigation**

**Economic aspect**
- To trade merchandise such as spices, black pepper, silk and gemstones.

**Social aspect**
- To spread religion.

**Political aspect**
- To expand colonies and conquer regions.

**Figure 8.1** Purpose of exploration and navigation

Some of the earliest figures of sea exploration are as follow:

### Ibn Battuta

**Full name:** Abu Abdullah Muhammad Ibn Abdullah Ibn Muhammad al-Lawati Al-Tanji Ibn Battuta

**Pen name:** Ibn Battuta

**Year of birth:** 1304

**Exploration purpose:** To gain knowledge and to share the experience because he started his exploration when he was 21 years old.

**Contribution:**

- Recorded geographical conditions of each and every country visited.
- Contributed to the body of knowledge in the areas of sociology and anthropology focusing on community culture especially clothing and food.
- Contributed to medieval history of people's lives in West Africa and India.

Ibn Battuta's courage in travelling led many scholars to call him The Prince of Muslim Travellers.





### Christopher Columbus

**Name:** Christopher Columbus

**Year of birth:** 1451

**Exploration purpose:**

To gain wealth and fame. His first voyage in 1492 was to search for the Asian continent, but landed on an island in the Bahamas. He also wanted to test his theory, which is world is round.

**Contribution:**

- Discovered and opened new territories such as:
  - The Bahamas Islands in the Caribbean Sea
  - Dominica Island, Puerto Rico and Jamaica
  - Trinidad
  - The American continent
- Discovered the links between Europe and America via the Atlantic Ocean.
- Pioneer in Spanish exploration and navigation activities.

### Vasco da Gama

**Name:** Vasco da Gama

**Year of birth:** 1460

**Exploration purpose:**

He was commissioned by King Manuel I of the Portuguese to search for countries in the Eastern continent for the Portuguese to commercialise in this part of the world.

**Contribution:**

- Discovered the sea route to India from Europe by sailing around Africa.


**Figure 8.2** The voyage of Vasco da Gama

### Activity 8.1

**Aim:** To identify the earliest figures of ocean exploration.

**Instruction:**

1. In groups, find information about the earliest figures in ocean exploration.
2. The figures are as follow:
   (a) Ibn Battuta
   (b) Christopher Columbus
   (c) Vasco da Gama
3. Gather information about the history, successes and contributions of these figures.
4. Discuss the purpose of exploration from economical, social and political point of view.
5. Create a brochure from the information gathered.
6. Share the findings with teachers and friends.

## Major Oceans on the World Map

The surface of the earth is made up of four main components, namely hydrosphere, geosphere, biosphere and atmosphere. The hydrosphere component comprises about 70% and the rest of it is geosphere component. Hydrosphere is the total amount of Earth water, either in the ocean, on the land, on the surface or in the air. Over 97% of the water is salt water, which is seawater. There are five major oceans in the world map; The Arctic Ocean, The Pacific Ocean, The Atlantic Ocean, The Indian Ocean and The Southern Ocean.


**Figure 8.3** Major oceans on the world map

*Source:* Worldatlas.com



8.1.1 8.1.2



**Characteristics of the main oceans on the world map**

The following are the characteristics of the main oceans on the world map:

**The Pacific Ocean**

- The world's largest and deepest ocean.
- Branching out from north of The Arctic Ocean to The Southern Ocean.
- It covers all the seas of Asia, western Australia, eastern America, southern Antarctica and north Arctic.

**The Atlantic Ocean**

- Second largest ocean.
- It starts from The Southern Ocean between South America, Africa, North America and Europe to The Arctic Ocean.
- Meets the southern Indian Ocean at Cape Agulhas, Africa.

**The Indian Ocean**

- It stretches from the north of The Southern Ocean to India, between Africa and Australia.

**The Southern Ocean**

- Located around Antarctica.
- It is partly covered with ice and the boundaries of the ice also vary according to the seasons.

**The Arctic Ocean**

- The Arctic Ocean is the smallest among the five major oceans.
- It meets The Atlantic Ocean near Greenland and Iceland.
- It is located at the North Pole and partly covered by ice.

8.1.2

## Major Seas in Southeast Asia

Southeast Asia is made up of eleven countries, namely Brunei, The Philippines, Indonesia, Cambodia, Laos, Malaysia, Myanmar, Singapore, Thailand, Timor-Leste and Vietnam. Southeast Asia countries are surrounded by five seas, which are Andaman Sea, South China Sea, Sulu Sea, Java Sea and Sulawesi Sea.

### Activity 8.2

**Aim:** To identify the major oceans on the world map and major seas in Southeast Asia.

**Instruction:**

1. Find information about the major oceans on the world map and major seas in Southeast Asia.
2. Identify the name of the oceans and their locations.
3. Create an exciting game such as jigsaw puzzle to help you to learn it better.

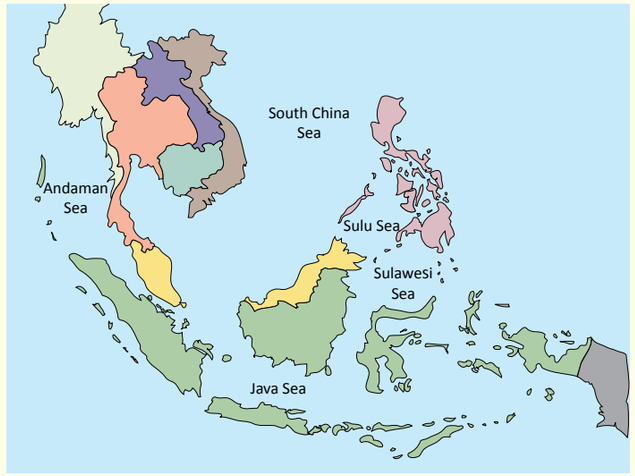



**Figure 8.4** Major seas in Southeast Asia

## Structure of Sea Floor

Have you ever wondered how the sea floor looks like? Is it flat or otherwise? Sea floor structures also have high mountains, wide plains and deep valleys.

Some of the structures of the sea floor include mid-ocean ridges, seamounts, subduction zones, abyssal plains and trenches.

### Science Info

Only 19% of the sea floor is mapped. The Seabed 2030 Project aims to map the entire sea floor.

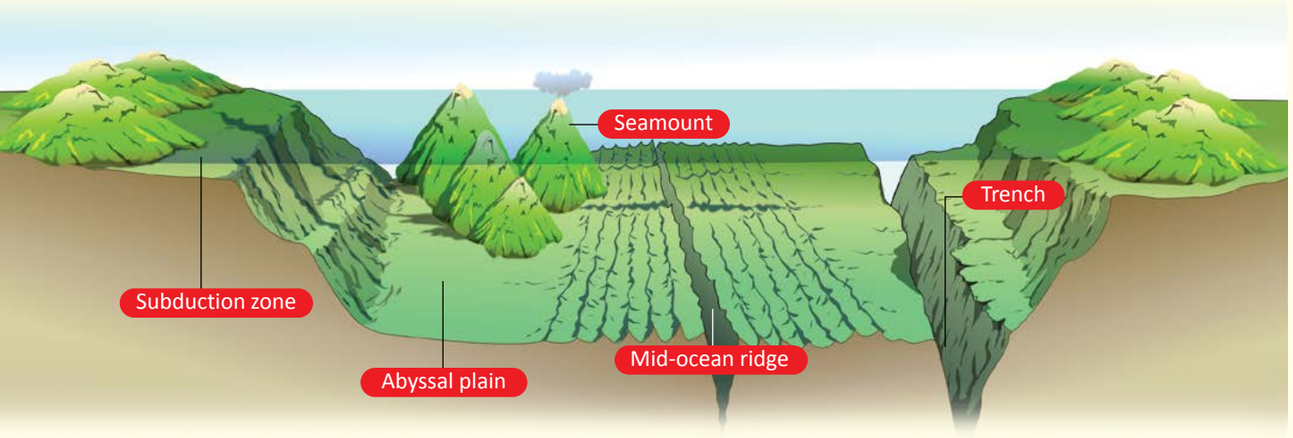


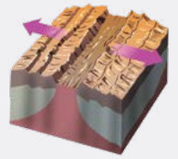
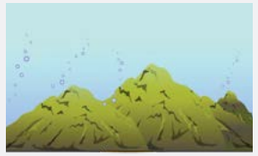
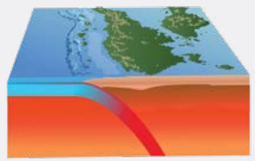

**Figure 8.5** Sea floor structure



8.1.3 8.1.4



**Table 8.1** Sea floor structure and its descriptions

| Sea floor structures | Description |
|---|---|
| **Mid-ocean ridge**  | • The mid-ocean ridge is formed when magma from the Earth's crust separates two oceanic plates.<br>• This area is said to be unstable because magma from the Earth's crust will push the ocean's crust layer gently outward and cause new ocean's crust to form after magma cooling process. |
| **Seamount**  | • Seamount is an underwater mountain formed by volcanic activity.<br>• The height of seamount is 1 000 – 4 000 m. |
| **Abyssal plain**  | • Abyssal plain is an underwater plain on the deep ocean floor.<br>• It is usually located at the depths of 3 000 – 6 000 m.<br>• Abyssal plain is composed of thick sediments. |
| **Subduction zone**  | • The subduction zone indicates a collision between two tectonic plates.<br>• These two tectonic plates meet in the subduction zone forming a bend into the mantle. |
| **Trench**  | • Trenches are topographic depressions of the sea floor, relatively narrow in width, but very long.<br>• It is also the deepest part of the sea.<br>• Mariana Trench at the base of The Pacific Ocean to the east and south of the Mindanao, The Philippines is the deepest trench in the world. |

### Activity 8.3

**Aim:** To sketch sea floor structure.

**Instruction:**

1. Gather information on the sea floor structure.
2. Sketch the sea floor structure on a display sheet.
3. Share the sketches with teachers and friends.

8.1.4

## Relationship between the Theory of Continental Drift and Tectonic Plates to the Evolution of the Ocean Floor

The continental drift is a theory explaining how parts of continents can shift position on the Earth's surface due to the movement in the tectonic plate (Earth's crust). In 1912, one of the German scientists, Alfred Wegener discovered and introduced the theory of continental drift.

Since Earth was formed around 4.6 billions years ago, it had only one huge continent, known as Pangea that was surrounded by an ancient ocean of Panthalassa. Around 335 millions years ago, Pangea began to split or drift due to the movement at the tectonic plate boundaries on the Earth's surface.

There are three types of tectonic plate boundaries, which are convergent boundary, divergent boundary and transform boundary. The formation of islands, ocean trenches and ocean floors are related to the movement of tectonic plate boundaries.

### Convergent Plate Boundary

- Happens when two tectonic plates shift and collide between each other.
- The converged tectonic plates form deep ocean trench.
- Example: The collision of the Pacific and The Philippines Plates forming Mariana Trench, which is the deepest trench in the world.

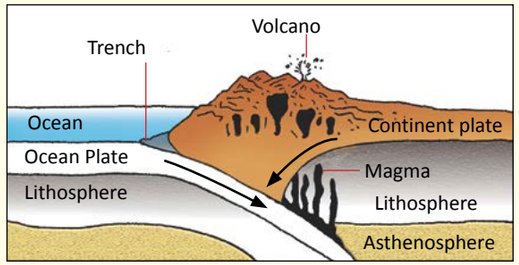



**Figure 8.6** Convergent plate boundary

### Divergent Plate Boundary

- Happens when two tectonic plates move in the opposite directions.
- Divergent tectonic plate forming mid-ocean ridges leads to the discovery of various minerals, sediments and different organisms.
- Example: The Mid-Atlantic Ridge.

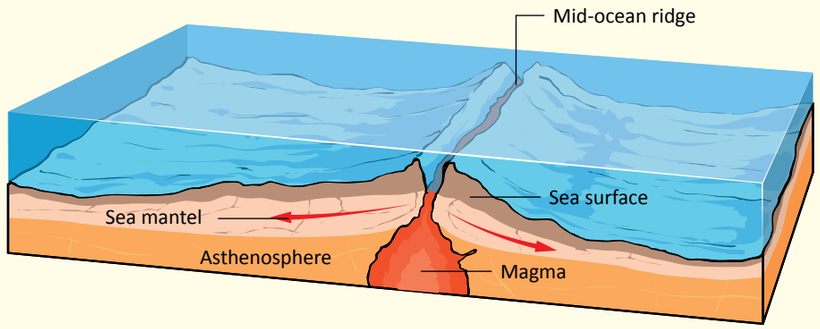



**Figure 8.7** Divergent plate boundary





### Transform Boundary

- Happens when two tectonic plates collide horizontally between each other.
- Movements of transform boundary can cause earthquake formation.

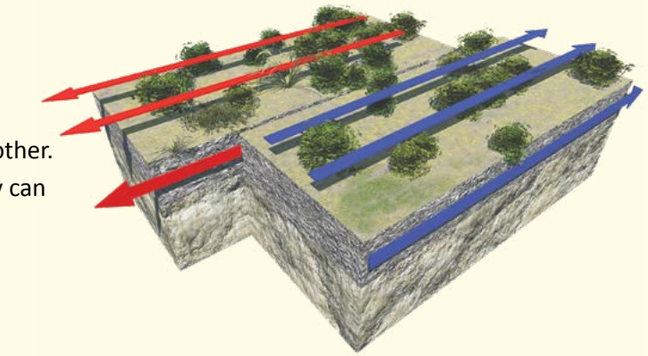


**Figure 8.8** Transform boundary

### Activity 8.4

**Aim:** To relate the theory of continental drift and tectonic plates to the evolution of ocean floor.

**Instruction:**

1. Carry out this activity in groups.
2. Gather information about the relationship between theory of continental drift and tectonic plates to the evolution of the ocean floor.
3. Build a 3D model of the ocean floor based on the information obtained.
4. Present your model to the class.

### Formative Exercise 8.1

1. State the purpose of sea exploration and navigation from economic, social and political aspects.
2. List **five** major oceans that can be found on the world map.
3. 
   - This ocean has an ice sheet that changes with the seasons
   - Located around Antarctica

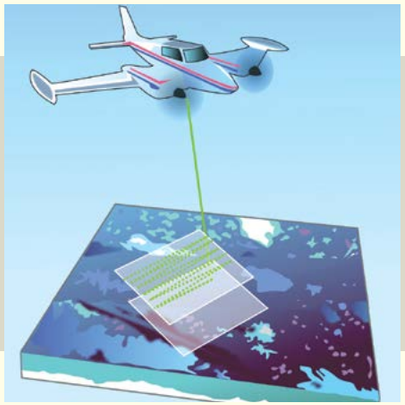
   State the name of the ocean based on the statement above.
4. State the largest sea in Southeast Asia.
5. What are the **two** theories involved in the evolution of the ocean floor?
6. State the changes that occur in the geological features as a result of convergent plate boundary.
7. In your opinion, is it possible for a new island to emerge in the future? Why?

# 8.2 Sea Floor Mapping

## Methods of Sea Floor Mapping

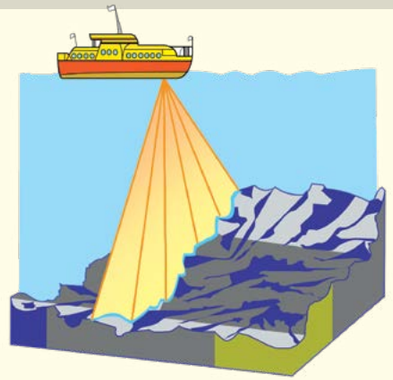
By now, you should have known that the sea floor is similar to the Earth's land surface. We are unable to see it because it is covered by the seawater. Scientists gather information about the sea floor and map it by using a few methods.

These methods apply the physics principles such as reflection of sound and light waves. Some of the methods used to map the sea floor are:



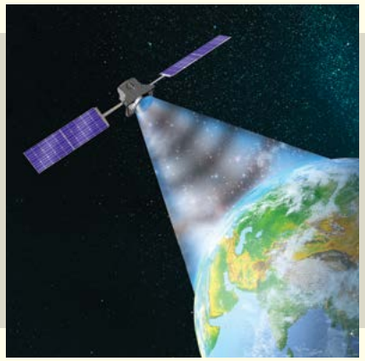
**LiDAR (Light Detection and Ranging)**

- A remote sensing method used for examining the Earth's surface.
- It uses light in the form of a pulsed laser to measure variable distances on the Earth's surface.



**SONAR (Sound Navigation and Ranging)**

- Sonar uses sound waves to detect what is in the water.
- This method is used to explore and map the ocean because sound waves travel farther in the water than radar and light waves.



**Satellite**

- Man-made satellites have various functions. One of them is to monitor the Earth.
- By remotely sensing from their orbit, satellite can monitor and provide information about the Earth's surface, including the sea floor.





## The Importance of Sea Floor Mapping

Why sea floor mapping is important that scientists research about it? A lot of information can be obtained from sea floor mapping. Let's look at the importance of mapping the sea floor.

**The importance of the sea floor mapping**

- Obtain information about the state of the oceans such as sea surface temperature, ocean colour, coral reefs and condition of the sea surface.
- Find out about the condition of the sea and the changes in sea floor that contribute to natural phenomena such as earthquakes.
- Identify the condition of the sea floor such as seamounts and trenches. This information can help the submarine to navigate safely on the sea floor.
- Increase global effort to overcome pollution and predict natural disasters such as tsunami.
- Help the search and rescue operation if there is a shipwreck or aeroplane crash on the sea floor.

**Figure 8.9** The importance of sea floor mapping

### Activity 8.5 PAK 21

**Aim:** To share the importance of sea floor mapping and issues related to it.

**Method:** Rotating Review

**Instruction:**

1. Divide the class into two groups.
2. The first group seeks information on the importance of the sea floor mapping. The second group looks for information on issues related to the sea floor mapping.
3. Write down the information obtained on a display sheet and share it in class.
4. The first group will evaluate the work of the second group and vice versa. Any comments, additional ideas or questions can be written on the paper with a different coloured pen.

### Formative Exercise 8.2

1. State the methods used to map the sea floor.
2. What is the importance of sea floor mapping?

# 8.3 Physical Properties of Seawater

## The Physical Properties of Seawater

Imagine you are in the ocean and running out of drinking resources, can you drink seawater? You will find that it is salty. Why does this happen?

Seawater is a complex mixture. It consists of 96.5% of water and 3.5% of other elements such as salt, dissolved gases, organic substances and insoluble particles. The salty element in the sea water comes from dissolved salts due to volcanic eruptions in the oceans as well as on the land.

The physical properties of seawater affect the state of the ocean and the distribution of aquatic organisms. What are the physical properties of seawater? Among the physical properties of seawater are shown in Figure 8.10.

**Mind Challenge**

Are the physical properties of seawater the same as water?

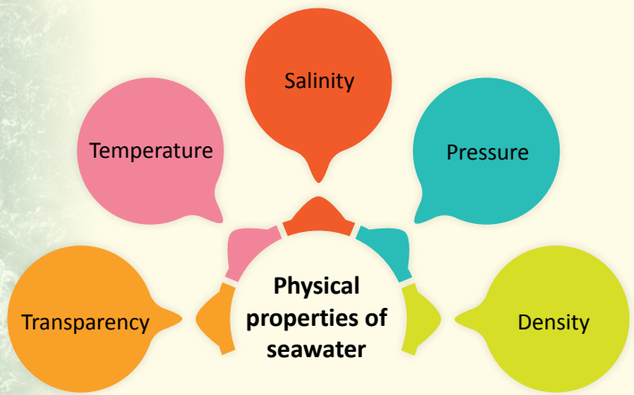



**Figure 8.10** Physical properties of seawater

## Temperature Profile of Seawater

Seawater temperature is inconsistent and depends on various factors such as location, which is according to latitude and the depth of the ocean. Seawater temperature is influenced by space and the ability of light to penetrate deep into the ocean floor.

The ocean surface is exposed to sunlight and wind movement. Therefore, the ocean surface temperature varies according to the environment. For example, seawater in the polar region has a surface temperature of –2.0°C, while seawater temperature in hot areas like the Persian Gulf near West Asia is around 36.0°C. On average, the ocean surface temperature is about 17.0°C. The average temperature of the deep ocean layer is between 0.0°C to 3.0°C.

**Science Info**

The term thermocline is derived from two words. Thermo means heat whereas cline means slope. Therefore, the thermocline means a layer of thermal slope that separates the surface of the ocean layer and the deep ocean layer.

8.3.1 8.3.2





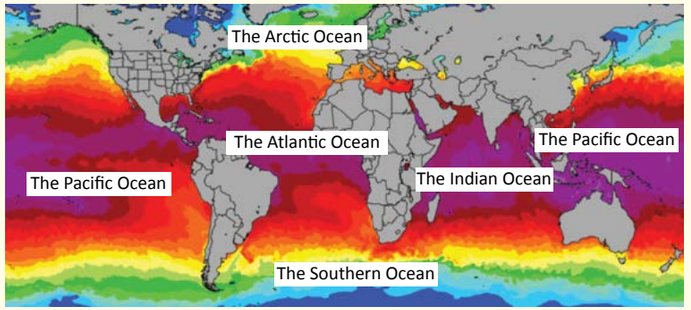



**Figure 8.11** Temperature of ocean around the world

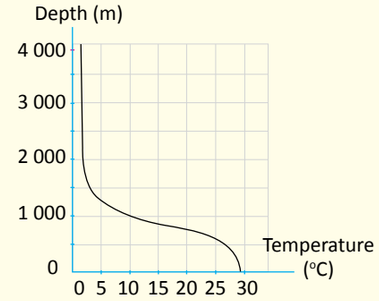



**Figure 8.12** Graph of ocean depth compared to seawater temperature

**Activity 8.6**

**Aim:** To identify the ocean surface temperature.

**Instruction:**

1. In groups, gather information to determine the ocean surface temperature in the world for the following:
   (a) The Pacific Ocean (b) The Atlantic Ocean (c) The Southern Ocean
2. Record the ocean surface temperature using an i-Think map.
3. Share your findings with the class.

## Factors Affecting Salinity of Seawater

Salinity is defined as the amount of salt (in grams) dissolved in one kilogram of seawater. The content of salt in each volume of seawater varies according to location and depends on the addition or reduction of salt.

**Factors affecting the saltiness of the ocean (salinity)**

| Factors that increase salinity | Factors that reduce salinity |
|---|---|
| • **Evaporation** When evaporation occurs, salt and mineral contents are left on the sea floor to precipitate. The more water evaporates, salt precipitation increases and ocean becomes saltier. | • **Rain or precipitation** The content of salt decreases in the water with more rainfalls. |
| • **Ice formation** Ice is formed only from the water without salt, leaving the salt to precipitate. Therefore, ocean becomes saltier. | • **Ice melting** The melting of ice increases the volume of water which causes the concentration of salt to decrease. |

**Figure 8.13** Factors affecting the saltiness of the ocean (salinity)

8.3.2 8.3.3

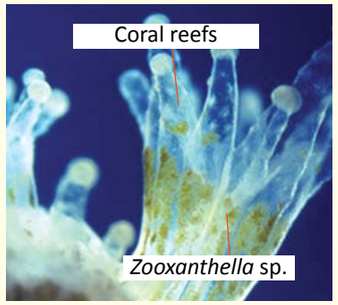
## The Effect of Seawater Transparency with Distribution of Aquatic Organisms

Seawater transparency affects the distribution of aquatic organisms such as coral reefs and marine algae growth.

Sunlight is needed to ensure the growth of coral reefs through symbiosis with microscopic algae. Therefore, coral reefs can be found at the depth of sunlight penetration, which is at the depth of 18 – 27 metres and can be reached up to 90 metres.

Sunlight is needed for the growth of microscopic algae to carry out the photosynthesis process to provide nutrient for coral reefs growth. Marine algae also needs sunlight for food production through photosynthesis process.

The ocean in the tropical areas has a warm water temperature. The water is also clear. This condition is particularly suitable for coral reefs habitat and promotes coral reefs growth. Coral reefs thrive at water temperature between 23.0°C to 29.0°C.




**Photograph 8.1** Symbiosis between coral reefs and microscopic *Zooxanthella* sp.

**Photograph 8.2** Coral reefs

**Photograph 8.3** Sea algae

### Activity 8.7

**Aim:** To find information about the coral reefs habitat and marine algae from various sources.

**Instruction:**

1. Make a short video of 3 – 5 minutes from various sources.
2. Show your video to the class.

### Wonderful Malaysia

Department of Marine Park Malaysia gazetted 42 islands across Malaysia as coral reef locations.





## Effect of Different Pressure and Density of Seawater on Aquatic Organisms

When the depth of sea increases, pressure and density of seawater also increase. These affect aquatic organisms living in different depth zones of the sea.

Distribution of aquatic organisms is more at the surface zone because of food sources from photosynthesis process by primary organisms. Primary organisms become nutrient for secondary organisms and so on. At the surface zone, sunlight can still penetrate and this encourages the growth of phytoplankton, which becomes the main food for secondary organisms.

Aquatic organisms that live in the dark zone have to adapt to their surrounding because of increasing density and pressure. Sunlight is unable to penetrate this zone.

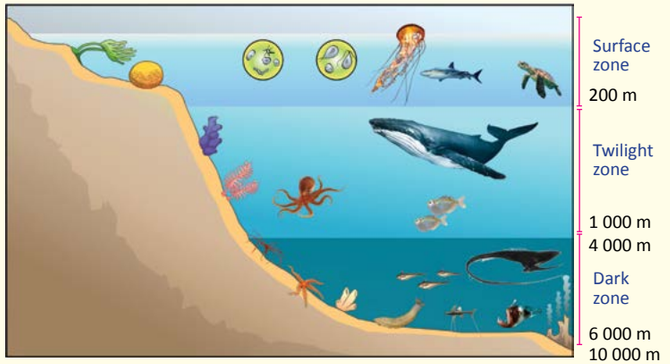



**Figure 8.14** Marine life distribution based on sea depth

### Activity 8.8

**Aim:** To understand the adaptation of aquatic organisms in the dark zone of the ocean.

**Instruction:**

1. Search articles from the web on the adaptation of aquatic organisms in the dark zone of the ocean.
2. Conduct an active reading with your group members.
3. Gather the characteristics adapted by these aquatic organisms in the deep sea environment such as high pressure, low light intensity and also ways of obtaining food.
4. Present your findings to your classmates.

### Formative Exercise 8.3

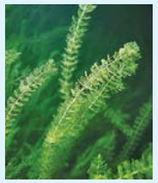
1. State the factors that influence sea water temperature.
2. What is the relationship between seawater depths and seawater temperature?
3. List the factors that contribute to the increase and decrease of seawater salinity.

# 8.4 Ocean Biology

## Classification of Marine Organisms

Previously, you have learned that organisms are classified into five kingdoms. Marine organisms are also divided into the same five classes as shown in Table 8.2.

**Table 8.2** Classification of marine organisms

| Kingdoms | Characteristics | Examples |
|---|---|---|
| Monera | • Consists of one cell or unicellular.<br>• Has various shapes.<br>• Has cell wall.<br>• Its habitat is at the extreme areas such as in the seas with high salinity and temperature. |  Silicibacter |
| Fungi | • Consists of non-flagellated spores.<br>• Has the ability to produce enzymes.<br>• The life of fungi depends on the decomposition of dead animals and plants.<br>• Its habitat is at the sea area with high salinity. |  *Aigialus parvus* |
| Protista | • Consists of unicellular and multicellular (forming colony).<br>• Has the ability to produce its own food using sunlight through the process of photosynthesis.<br>• In the ocean, protista is phytoplankton that becomes part of food source to marine animals. |  Algae |
| Plantae | • Multicellular organism that has the ability to produce its own food using sunlight.<br>• Does not have the ability to move on its own. |  Seaweed |
| Animalia | • Multicellular organism that can move on its own and depends on other lives and plants to live as food.<br>• Marine animals are divided into invertebrates and vertebrates. |  *Aurelia aurita* |



8.4.1



### Activity 8.9

**Aim:** To explain the distribution of life in the ocean.

**Instruction:**

1. Browse the web and create multimedia presentations on the distribution of marine life based on size, mobility, location and life.
2. Look for the following marine organisms to find information for this activity.
   (a) Pleuston
   (b) Neuston
   (c) Plankton
   (d) Necton
   (e) Benthos
3. Share your findings with your friends and teachers.

## Dynamic Interactions in Reef Ecosystems

The ocean is one of the most precious and unique gifts human can ever have. The sea floor has panaromic views like coral reefs. Coral reefs are a chain of coral structures with many types of marine plants and animals inside them. Coral reefs are formed from small animals such as polyps and algas calcareas. The formation of coral reefs takes a very long time, but it is easily destroyed. The factors affecting the formation of coral reefs are:

- sunlight.
- sea temperatures ranging from 23.0°C to 29.0°C.
- the depth of seawater ranges from 18 to 27 metres and can reach up to 90 metres.
- clear seawater.
- seawater salinity which ranges from 30% to 40%.
- waves, tidal currents and high and low tides.

**Photograph 8.4** Coral reefs


**Figure 8.15** The Coral Triangle area declared by World Wildlife Fund (WWF)

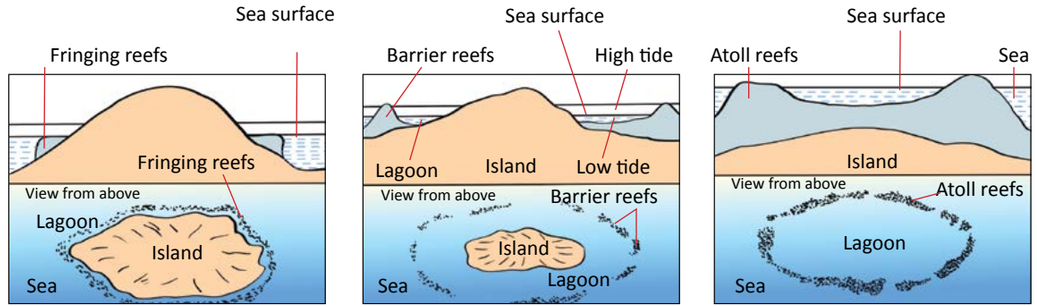
Almost one third of fishes in the ocean make coral reefs a place for food, breeding grounds and shelter.

The following are animals that inhabit coral reefs:

- fishes such as Butterflyfish, Angelfish
- lobsters
- sea horses
- turtles

8.4.1 8.4.2

The distribution of the World's coral reefs is mainly found at the Asia Pacific region, Southeast Asia, Pacific and Australia.




(a) Fringing reefs (b) Barrier reefs (c) Atoll reefs

**Figure 8.16** Types of coral reefs

Among human activities that can destroy coral reefs are:

- use of trawls.
- use of explosives to catch fish.
- ships anchored at the shore.
- pollution of seawater due to disposal of industrial waste.
- oil spills caused by oil tanker accidents.
- disposal of domestic waste into the sea environment.

**Wonderful Malaysia**

Popular coral reef islands in Malaysia:

- Redang Island
- Perhentian Island
- Tioman Island
- Sipadan Island
- Layang-layang Island

Therefore, steps should be taken to address the problem of coral reefs' destruction which include:

- establish marine parks such as Tunku Abdul Rahman Marine Park in Kota Kinabalu, Sabah and Pulau Payar Marine Park in Langkawi, Kedah.
- enforcement of law (Fisheries Act, 1987).
- conduct research.
- provide environmental education.
- create artificial reef projects for fish and coral reefs to breed.

## Formative Exercise 8.4

1. List the kingdoms of marine organisms and state one example for each kingdom.
2. Provide **three** suitable conditions for coral reefs growth.
3. Why are coral reefs important to other marine organisms?



8.4.2

# 8.5 Seawater Circulation

## Circulation of Seawater

Seawater circulation is the movement of seawater that is affected by the wind blow and water movement. If we are on the beach, we can see a common phenomena, where seawater movement that forms wave and directions of current. Have you ever wondered what causes waves?

### Direction of Current and Waves

**Waves** occur due to the blowing of wind on the ocean surface and other factors such as earthquakes. This causes swirling and known as waves. When the swirlings crashes to the shore, it breaks and produces waves. The condition of the waves is influenced by the depth of the ocean.

The height of wave does not increase in deep water. However, when it flows in the shallow water, the waves get taller and the current flow will become slower. Figure 8.17 shows changes of the waves from deep to shallow water.

Waves have two energies, potential energy (height of the wave) and kinetic energy (speed of the wave). These two energies are constantly interchanging.

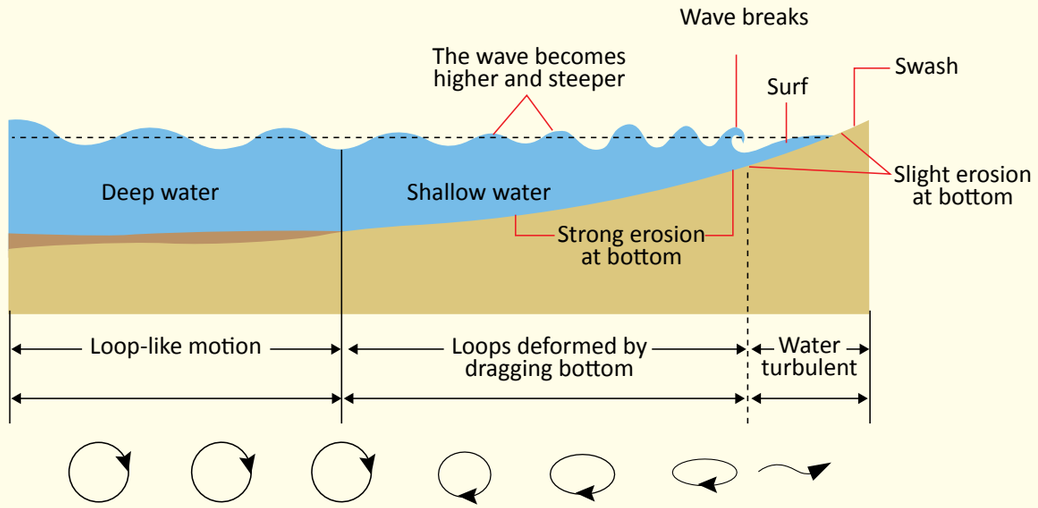


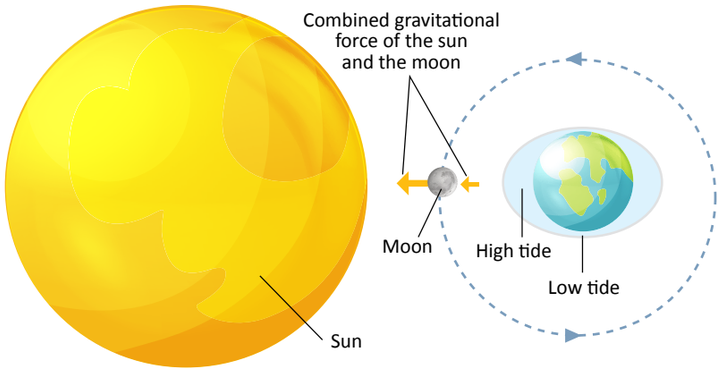

**Figure 8.17** Change of waves from deep to shallow areas

8.5.1

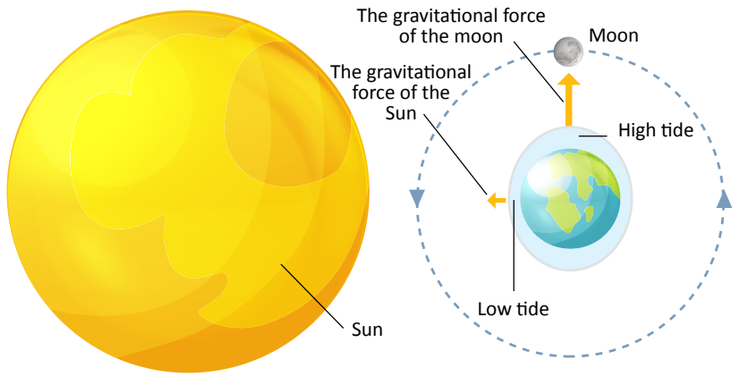
### Tides Process

Do you know how tides occur? Tides occur due to the combined effects of the Earth's rotation and the gravitational force of the sun and moon causing the sea level to rise and fall.

However, the moon has the biggest impact on tidal currents. Although the moon is much smaller than the sun, it is closer to the Earth. Thus, it has twice the force of attraction to the oceans, compared to the sun as shown in Figure 8.18.




(a) High tides occur due to gravitational force of the sun and the moon




(b) High tides occur due to gravitational force of the moon

**Figure 8.18** The influence of gravitational force of the moon and sun on tides



8.5.1



### Activity 8.10

**Aim:** To communicate about the circulation of seawater.

**Instruction:**

1. Study the circulation of seawater and the contributing factors to:
   (a) Current flows and waves
   (b) Tsunami
   (c) Tides
2. Present the findings of your research using multimedia presentations.
3. Share with your friends and teachers.

## Upwelling Phenomena and the Distribution of Aquatic Organisms

Have you heard of fertiled surface water? Water is said to be fertile if there are many fishes in the area and provide a great benefit to the fishermen. Why do you think fishes gather in this area? Fishes live in fertile areas due to favourable environmental conditions, such as:

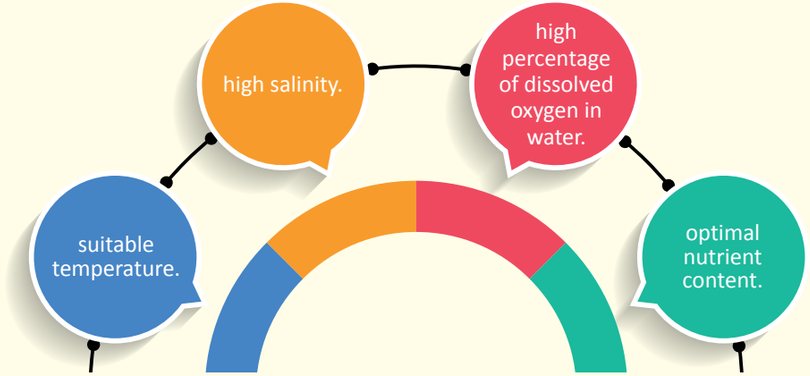



**Figure 8.19** Factors affecting fishes living in fertile area

What is the phenomena that makes seawater fertile? The water is fertile due to the upwelling phenomena occurring in the sea.

Upwelling phenomena refers to seawater from the deep rises to the ocean surface, while the seawater from the surface falls to the deep. This process causes water high with nutrient from the deep rises to the ocean surface as in Figure 8.20.

Upwelling phenomena is suitable for the growth of primary organism through the photosynthesis process. Ocean surface will also be rich with nutrient and plankton. The presence of plankton is a factor in the increased number of fish gathered in this area. This upwelling phenomena affects the distribution of aquatic organisms.

8.5.1 8.5.2

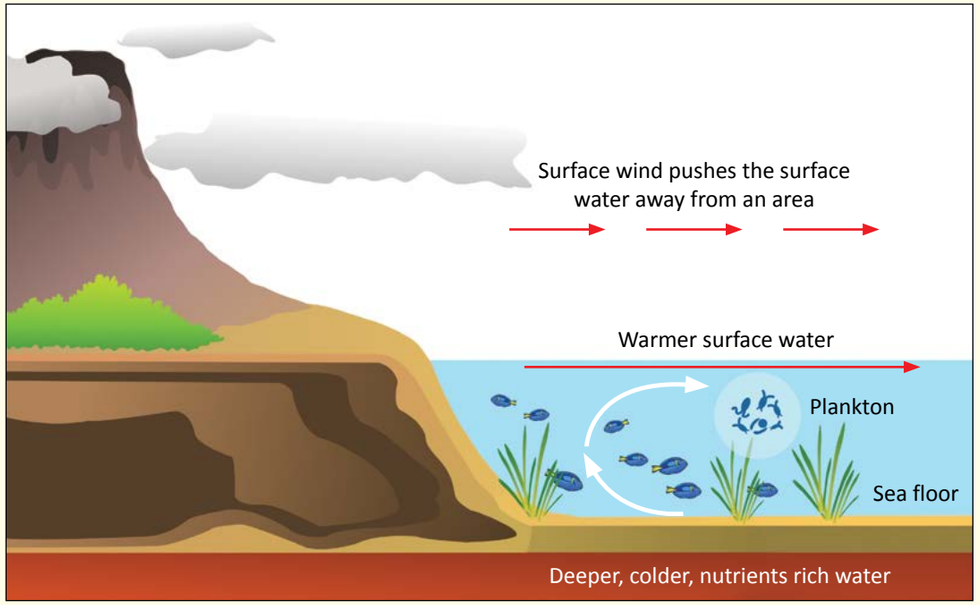



**Figure 8.20** Upwelling phenomena occurs when seawater from the deep rises to the ocean surface

### Activity 8.11

**Aim:** To present the relationship between the upwelling phenomena and the average distribution of aquatic organisms.

**Instruction:**

1. Conduct this activity in groups.
2. Gather information on the relationship between the percentage of dissolved oxygen in seawater and the distribution of aquatic organisms.
3. Relate your information with the situation at the Peruvian Coast.
4. Present your findings to friends and teacher.

### Formative Exercise 8.5

1. What is upwelling phenomenon?
2. What does the seawater bring to the surface of the sea during the upwelling phenomena?
3. What are the causes of seawater circulation?
4. What causes tide?



8.5.2



# 8.6 Ocean Resources

## Types of Food from the Marine Environment

In our country, there are various types of marine food. Among them are fishes, shellfish and sea plants. Examples of shellfish are molluscs, crustaceans and echinoderms. Sea plants that can be eaten are seaweed and microalgae.

Table 8.3 shows the seafood group classified by the International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) used by the Food and Agriculture Organization (FAO) for the purpose of collecting and compiling fishery statistics.

**Table 8.3** Seafood groups

| Types of seafood group | | Descriptions |
|---|---|---|
| Fish | Pelagic fish  | • Live and eat near the ocean surface.<br>• Divided into predatory fish such as shark and tuna (bigger sized fish) and forage fish such as sardine and anchovies (smaller sized fish). |
| | Deep sea fish  | • Live and eat at the bottom of the sea.<br>• Examples: grouper and stingray. |
| | Diadromous fish  | • Migrate between seawater and freshwater.<br>• Example: salmon. |
| | Freshwater fish  | • Live in rivers, lakes and ponds.<br>• Examples: catfish, murrel and tilapia. |
| Molluscs | Shellfish  | • Has a protective shell in two hinged sections.<br>• Examples: oysters and clams. |
| | Cephalopod  | • The name means head-feet because parts of the body attached to the head.<br>• No shell.<br>• Examples: squid and octopus. |

8.6.1

| Types of seafood group | | Descriptions |
|---|---|---|
| Crustaceans | Shrimp  | • Shrimp is a small crustacean, has compound eyes and has 10 thorny feet. |
| | Crab  | • Crabs are crustaceans with compound eyes, small feet, claws, small abdomen and short antennas. |
| | Lobster  | • Has a long antenna covered by tiny hairs.<br>• The size is larger than the normal shrimp. |
| Other aquatic animals | Echinoderms  | • A headless invertebrate.<br>• Found on the sea floor.<br>• Example: sea cucumbers. |
| Aquatic plants and microphytes | Seaweed  | • Examples: red algae and brown algae. |
| | Microphytes  | • Microscopic organisms such as algae, bacteria or fungi.<br>• Microalgae such as spirulina. |

## A Country's Dependence on the Sea for Food Sources

The importance of seafood in the human diet varies worldwide. In the United States, seafood is consumed at about 7 kg per person per year. The number is small compared to other countries.

Japan for instance, relies entirely on seafood as a source of protein. This is because meat from terrestrial animals such as beef are more expensive than seafood in Japan. Therefore, Japan emphasises on the aquaculture industry. The consumption of seafood in Japan is five times higher than that of the United States.



8.6.1 8.6.2



The following are the factors that influence a country's dependency on the sea for food.

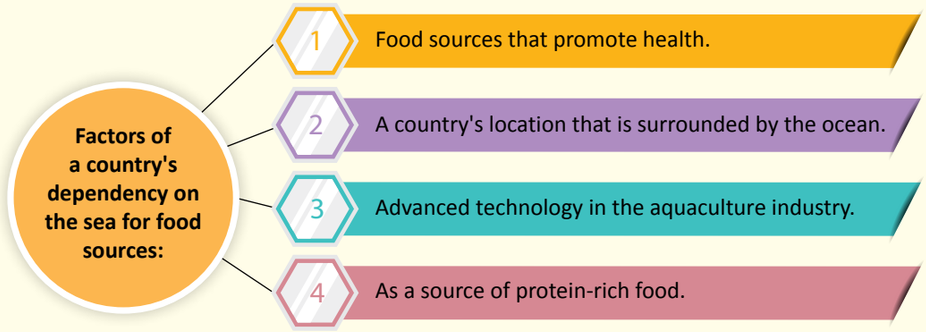



**Figure 8.21** Factors of a country's dependency on the sea for food source

### Activity 8.12 PAK 21

**Aim:** To study the source of marine food.
**Method:** Gallery Walk
**Instruction:**

1. Conduct this activity in groups.
2. Gather information about:
   (a) Food sources from the sea.
   (b) Factors that determine the dependency of a country on the sea for food.
3. Present your information on a display sheet.
4. Paste it on the classroom wall when you are done.
5. Each groups move to the nearest group in a clockwise direction.
6. Discuss with the teacher about your findings of the Gallery Walk.

## The Economic Importance of Marine Products and Related Issues

Marine products such as sea algae, plants and fish contribute to economic growth and a source of a country's income.

What will happen if over fishing is practised?

Over fishing is a practice of excessive fishing. Over fishing practices cause:

- the number of marine products to decrease.
- the imbalance of the ecosystem in the ocean.
- the loss of income for coastal communities that depend on marine products.

8.6.2 8.6.3

The ban on trawling was implemented as trawling contributed to the reduction of fish supply and caused fish extinction. This is because the trawling method catches anything in its path regardless of the size of the fish and can destroy the sea floor.

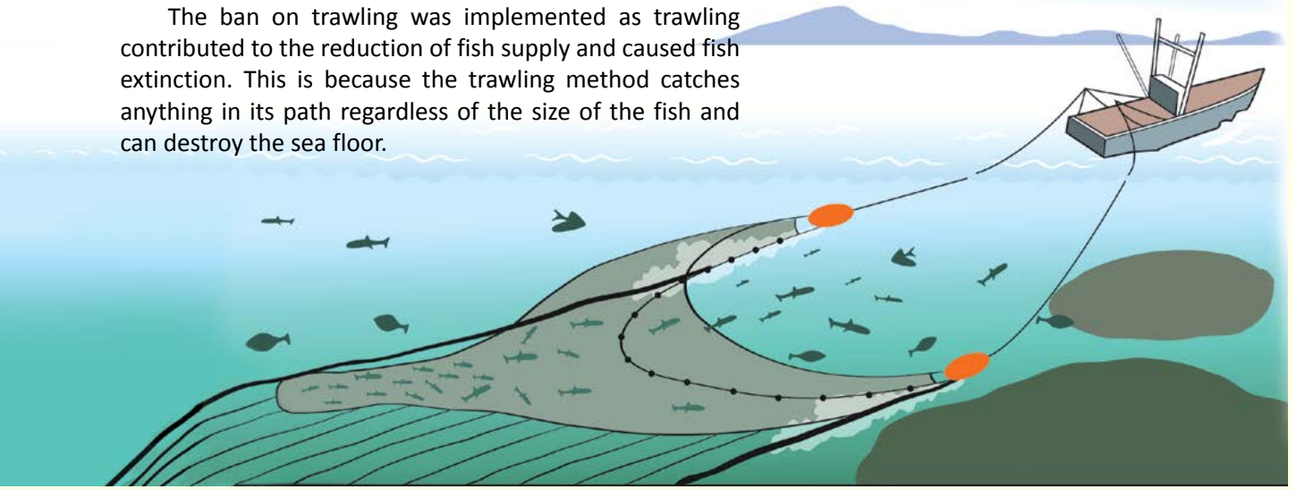


**Figure 8.22** The trawling captures everything in its path

### Activity 8.13 PAK 21

**Aim:** To raise awareness on the effects of over fishing.

**Method:** Fan-n-Pick

**Instruction:**

1. Conduct this activity in groups.
2. Each group have to choose one card arranged like a fan.
3. Each card contains the following questions:
   (a) the effect of over fishing to the marine ecosystem.
   (b) the importance of the implementation of trawling ban.
   (c) the effects if trawling ban is not implemented.
   (d) efforts that can be taken to ensure that over fishing is under control.
4. Present the answer to the class.

## The Role of Aquaculture in Meeting the Demand for Global Seafood Needs

Aquaculture is one of the major economic sources of most countries and it is an important component of food security. **Aquaculture** is a process of farming aquatic species that includes freshwater, brackish and saltwater.

The aim of aquaculture is to improve the quality and quantity of fish farming and meet the demand for food. Figure 8.23 shows animal that are bred through aquaculture.



8.6.3 8.6.4



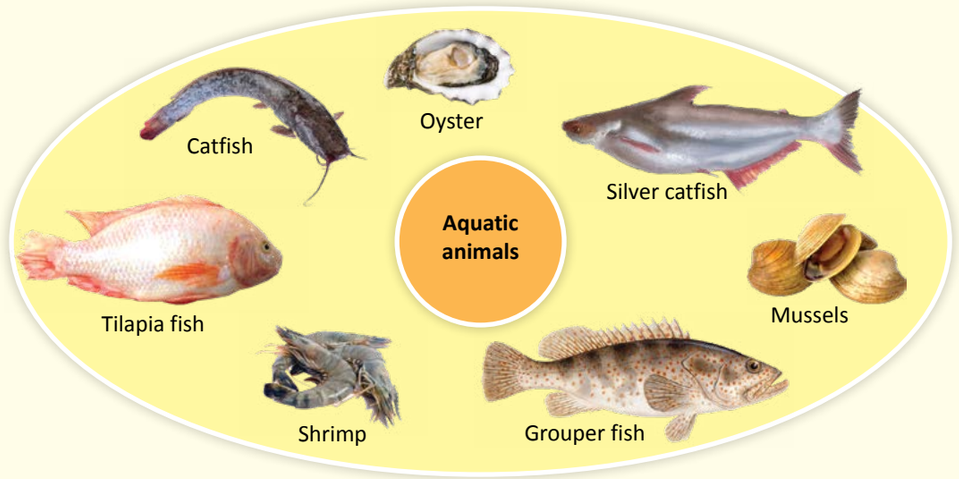



**Figure 8.23** Aquaculture animals

STEM

### Activity 8.14

**Aim:** To create an aquaculture project.

The human population is expected to increase to 9.6 billion by 2050. Therefore, food security will be a major issue. Thus, we need to produce more food even though there are limited resources in aquaculture.

**Instruction:**

1. Based on the above statement, plan a project on how to solve the problem of insufficient marine sources through aquaculture.
2. Produce a folio of how your aquaculture project will be developed.
3. Your folio content suggestions are as follows:
   (a) problem statement
   (b) suggestion of solution to the problem or project
   (c) estimation cost
   (d) project sketch
   (e) project description

### Formative Exercise 8.6

1. List **two** major sources of seafood.
2. Other than marine animals, state seafood-based sea plants.
3. State **two** factors that influence a country's dependency on the sea for food.

8.6.4

# 8.7 Issues and Challenges Related to Ocean

## Issues Related to Marine Ecosystem

Ocean is a balanced and sensitive ecosystem that is constantly threatened by human activities. Natural disasters also affect the marine ecosystem.

Marine ecosystem is defined as interaction of plants and animals with the marine environment. There are three zones for marine ecosystem; coastline zone, coral reefs zone and deep ocean zone.

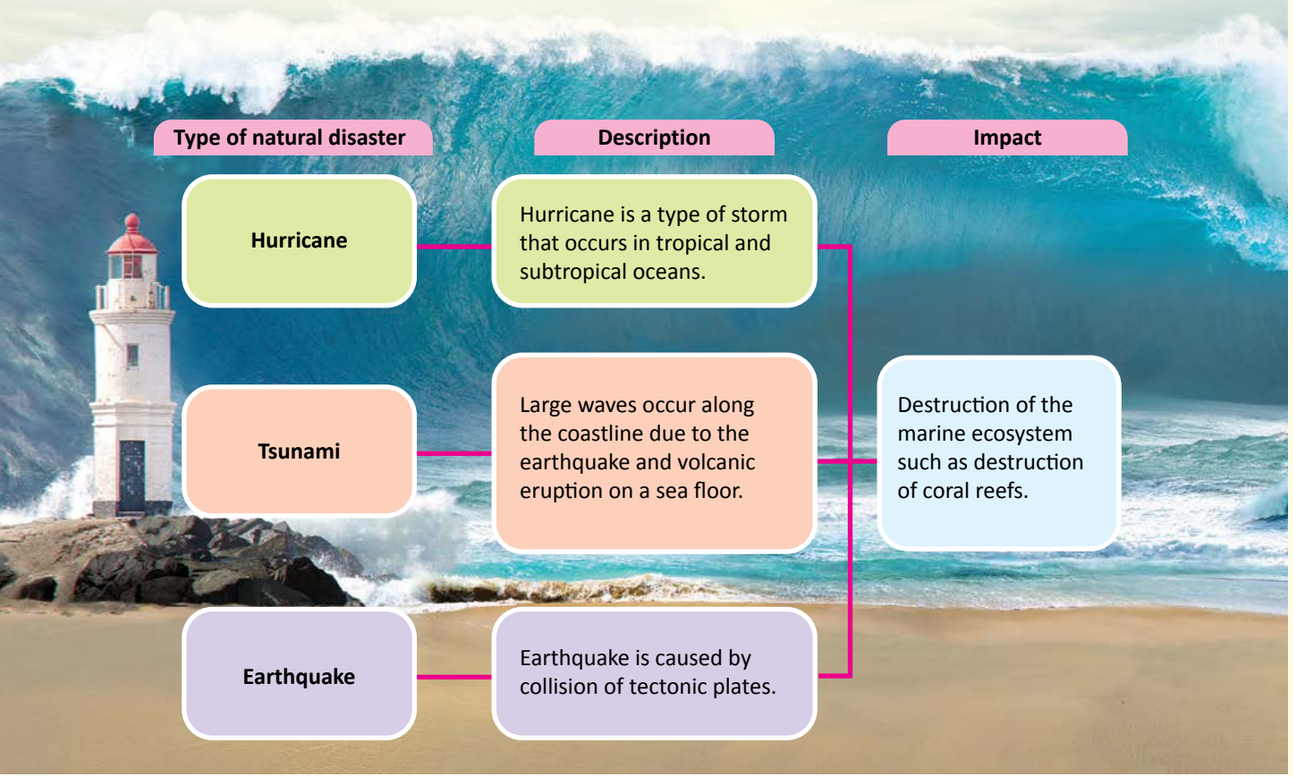



**Figure 8.24** Natural disaster

**Table 8.4** Effects of marine pollution caused by human activities on the marine ecosystem

| Causes of Marine Pollution by Human Activity | Effects of Marine Pollution |
|---|---|
| • Oil drilling and exploration activities.<br>• Oil spillage.<br>• Pollution from land.<br>• Land reclamation.<br>• Untreated sewage. | • The death of various aquatic species.<br>• Destruction of coral reefs which is an aquatic habitat.<br>• Impact tourism activities. |





### Efforts in Addressing Issues Related to Marine Ecosystems

#### Carbon Sink

Carbon sink is a natural reservoir that absorbs and stores more carbon than it releases as carbon dioxide. Sea is a carbon sink that absorbs carbon dioxide from the atmosphere biologically and physically. Carbon sink can reduce high concentration of carbon dioxide in the atmosphere. However, the excessive carbon dioxide that is not absorbed can cause harm to the Earth and animals.

Biologically, the absorption of carbon from the atmosphere to the bottom of the ocean is through the food chain. Plankton and seaweed ecosystems are important in ensuring that carbon is absorbed and stored at sea floor as shown in Figure 8.25.

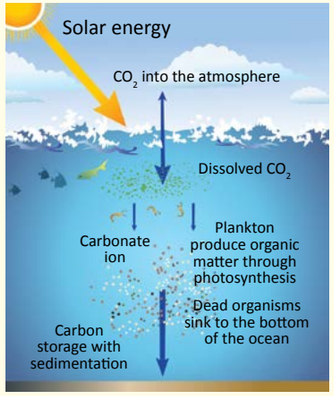



**Figure 8.25** Biological carbon sink process

The efforts made through biological processes include adding iron particles such as sulphuric iron and iron oxides to stimulate plankton growth. High amount of plankton increases the removal of most of the carbon dioxide from the air through photosynthesis.

Physical processes occur when carbon is transferred to the seabed by movement of seawater. Carbon dioxide from the atmosphere is absorbed into the ocean and dissolved. Carbon dioxide is transported to the seabed through the movement of seawater as shown in Figure 8.26.

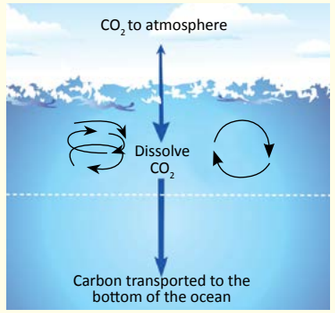



**Figure 8.26** Physical carbon sink process

#### Gazetted National Marine Park

Marine Park is an area of marine waters zoned up to two nautical miles from the lowest tide. The Department of Marine Park Malaysia has gazetted the National Marine Park to protect and conserve various marine aquatic habitats and wildlife.

The functions of the Department of Marine Park Malaysia include:

- manage, conserve and protect marine biodiversity.
- repair damaged marine habitat.
- preserve and conserve endangered marine life.
- conduct and encourage marine biodiversity research.
- enforce laws and regulations relating to marine parks.
- regulate recreational activities and other activities in the marine park waters.
- increase public awareness of the marine ecosystem.
- provide advisory services and expertise on the marine ecosystem.

**Science Info**

Even 1% growth of plankton is equivalent to 2 billion mature trees in absorbing carbon dioxide from the atmosphere.

INFORMATION

Islands that are gazetted as marine parks in Malaysia

**Marine Pollution Control Act**

Marine law enforcement is implemented to preserve and conserve the marine ecosystem. The acts involved are:

- Environmental Quality Act, 1974
- Exclusive Economic Zone Act, 1984
- Continental Shelf Act, 1966
- Petroleum Mining Act, 1966

## Design and Create Products to Solve Ocean Problems or Issues

A group of teenagers are trapped on an uninhabited island. They have to use their survival skills to survive. They have source of food from the sea such as fish, squid and shrimp. However, they have difficulties to get water supply. If they drink seawater, their bodies will be dehydrated. Can you help that group of teenagers to get drinking water from the seawater?

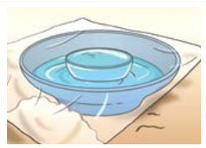
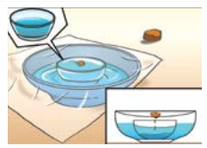
As previously mentioned, seawater has high salinity or high saltiness. Seawater needs to go through several processes before it becomes drinking water. Let's carry out Activity 8.15 to help this group of teenagers.

### Activity 8.15

**Aim:** To get drinking water from seawater.

**Material:** Large bowl, small bowl, small stone and plastic.

**Instruction:**

| | | | |
|---|---|---|---|
|  |  |  |  |
| 1. Fill seawater in a large bowl. | 2. Place a small bowl in the centre of the large bowl. | 3. Cover the bowl with plastic wrap. | 4. Place a small rock in the centre of the plastic and leave the bowl under the sun for condensation to take place. |

The water collected in a small bowl is drinking water from the condensation process. It does not have salt content like seawater and can be used as drinking water.



8.7.1 8.7.2



Green Technology

### Activity 8.16

**Aim:** To create products to solve ocean-related problems.

**Instruction:**

1. Perform this activity in groups.
2. Some of the issues that you need to resolve are:
   (a) oil spillage on the surface of the ocean.
   (b) littering in the ocean.
3. Suggest a solution to the problem identified.
4. You can also use the *Modul Teknologi Hijau Sains* CETREE USM, entitled; "*Tulenkah Aku*" by CETREE USM for reference.
5. Share the information obtained at your school science carnival.

ATTACHMENT

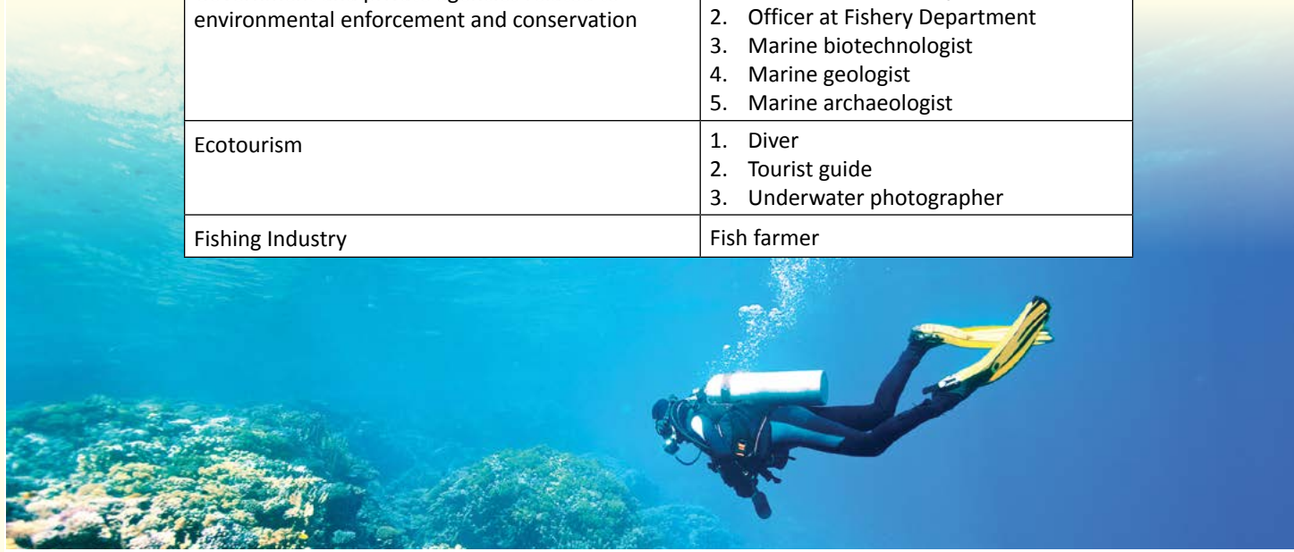
*Modul Teknologi Hijau Sains*, CETREE USM
Title: *Tulenkah Aku*
Pages: 67 – 78
Medium: Bahasa Melayu

## Careers in Oceanology

There are many job opportunities in oceanology, shown in Table 8.5.

**Table 8.5** Careers in oceanology

| Area work | Career |
|---|---|
| Government and private agencies related to environmental enforcement and conservation | 1. Officer at Marine Department<br>2. Officer at Fishery Department<br>3. Marine biotechnologist<br>4. Marine geologist<br>5. Marine archaeologist |
| Ecotourism | 1. Diver<br>2. Tourist guide<br>3. Underwater photographer |
| Fishing Industry | Fish farmer |



**Photograph 8.5** Careers in oceanology

8.7.2 8.7.3

## Hypothetical Situation

In your opinion, can humans live in the ocean? Let's revisit the physiological system of human body.

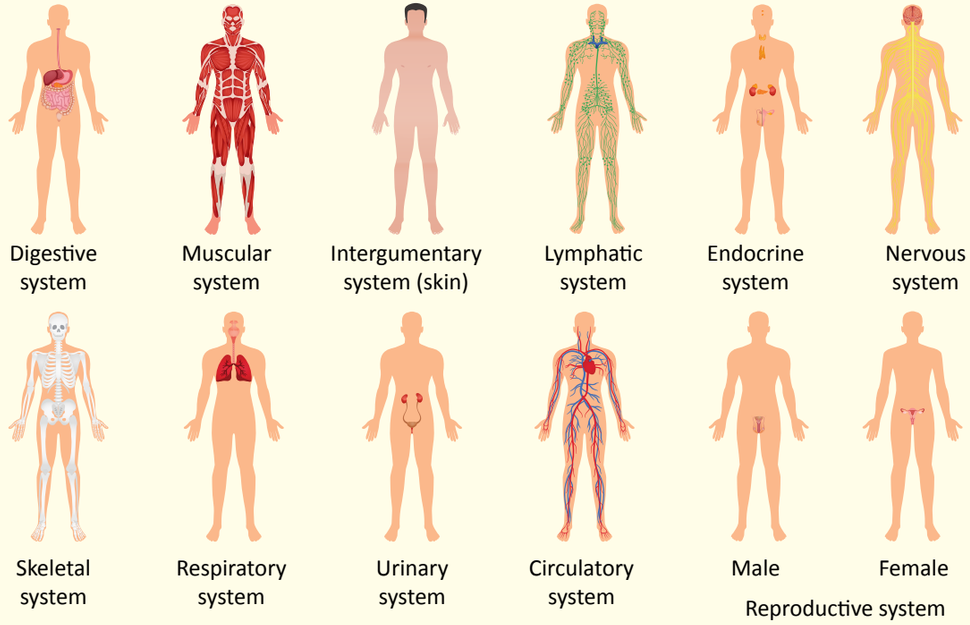



**Figure 8.26** Physiological system of human body

What about the basic needs of human life? Humans need sunlight, water, air, food, life partner and shelter.

### Activity 8.17

1. Can humans live underwater? Discuss.
2. Based on your understanding of the physiology and basic needs of human life, predict necessary changes and adaptations to enable humans to live underwater.

### Formative Exercise 8.7

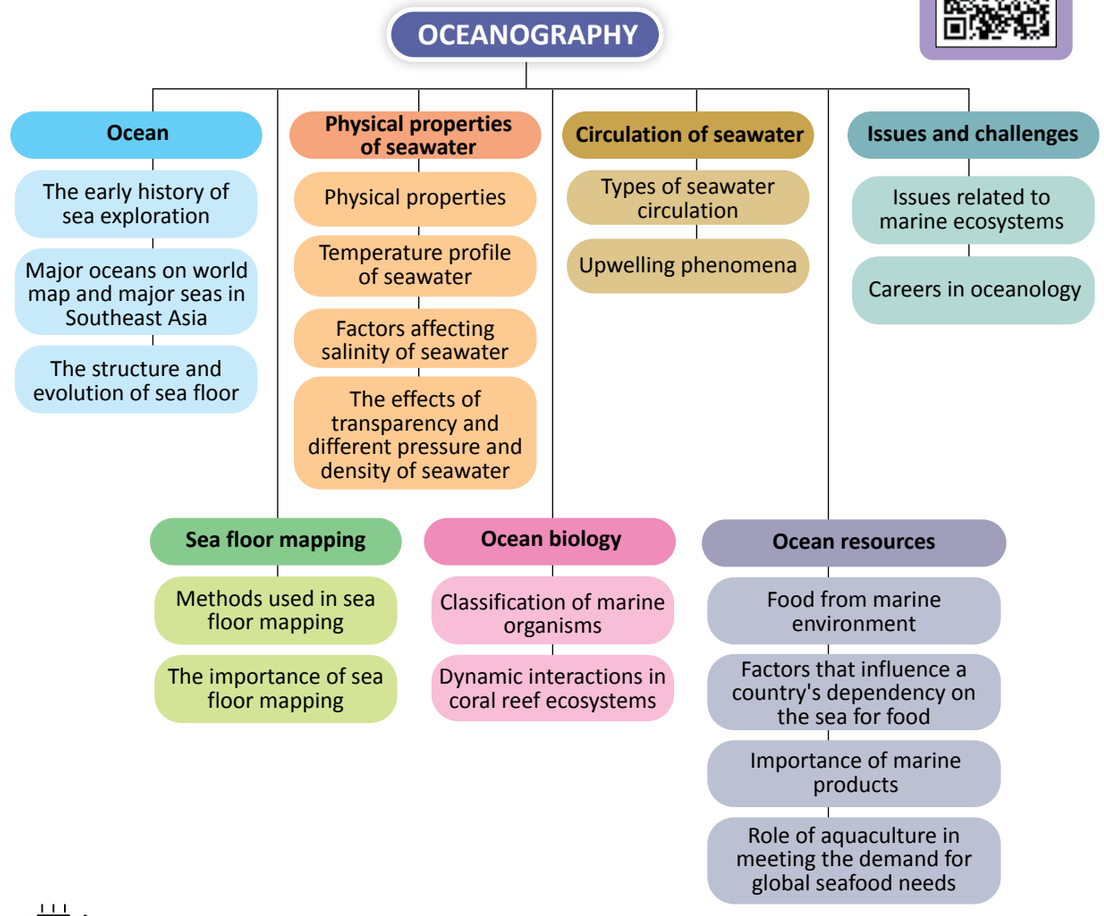
1. How can carbon sink help the marine ecosystem to overcome issues related to biological and physical aspect?
2. State **five** careers that can be pursued in oceanology.
3. What are the challenges you have to face in the career of oceanology?





### Summary

Quick Quiz 8




### Self-reflection

After studying this chapter, students will be able to:

**8.1 Ocean**

- Explain the early history and reasons for ocean exploration.
- Identify major oceans on the world map.
- Identify major seas in Southeast Asia.
- Explain by a visual drawing the structure of sea floor.
- Relate continental drift theory and tectonic plates to the evolution of the ocean floor.

### 8.2 Sea floor mapping

- Explain how sea floor mapping is done.
- Communicate about the importance of ocean floor mapping.

### 8.3 Physical properties of seawater

- Determine physical properties of seawater.
- Describe the temperature profile of seawater.
- Describe the factors affecting the salinity of seawater.
- Relate the effects of transparency on seawater to distribution of aquatic organisms.
- Explain the effect of different seawater pressure and densities on aquatic organisms.

### 8.4 Ocean biology

- Explain with examples how marine organisms are classified.
- Communicate about the dynamic interactions in coral reef ecosystem.

### 8.5 Seawater circulation

- Communicate about the circulation of seawater
- Justify how upwelling affects the distribution of marine life.

### 8.6 Ocean resources

- Identify types of food obtained from a marine environment.
- Identify factors that influence a country's dependence on the sea for food sources.
- Explain with examples the economic importance of marine products and related issues.
- Justify the role of aquaculture in meeting the demand for global seafood needs.

### 8.7 Issues and challenges related to ocean

- Communicate about issues related to the marine ecosystem.
- Design and create a product to solve problems or issues related to the ocean.
- Describe careers in oceanology.
- Reasoning and making analogies on a hypothetical situations when humans can live in the ocean.





## Summative Practice 8

1. One of the purposes of exploring the ocean exploration is to spread religion.
   (a) State another purpose of ocean exploration.
   (b) List **two** earliest figures in the exploration of the oceans.
   (c) State **two** contributions of the figures specified in 1 (b).

2. Coral reefs are a chain of coral structures with many types of plants and small animals.
   (a) What are the factors that influence the formation of coral reefs?
   (b) Why coral reefs can only be found at depths of less than 90 meters?
   (c) List **three** human activities that can destroy coral reefs.
   (d) What can be done to overcome the problem of coral reef destruction?

3. Malaysia is a country rich in marine resources.
   (a) Give **two** types of seafood that people can eat.
   (b) Carbon sink is said to manage issues related to the marine ecosystem. How can carbon sinks reduce high concentration of carbon dioxide in the atmosphere biologically?

4. Look at the Figure 1 below, is it possible fish would extinct in the future? Discuss.

**Figure 1**

Check answers

# GLOSSARY

*Anatomy* branch of biology that studies the internal structure of plants and animals.

*Aquaculture* breeding or rearing of marine life (both animal and plant) for human consumption; focusing on aquaculture development such as scallops, cage fish, pond shrimp and clams.

*Barton's pendulum* a set of pendulum apparatus consisting of several simple pendulums of different lengths but two of them are of the same length.

*Biomass* the mass of all organisms that form a population or the level of the trophic occupying an area.

*Crystal* molecular shapes (such as snow forms) that is fixed and natural to an object.

*Electric charge* charges of positive and negative fundamental particles that can attract or repel each other through electromagnetic reactions. Two particles with similar charges repel against each other, while two particles with different charges attract each other.

*Electromagnet* temporary magnet whose magnetic field can be lost in the absence of electric current.

*Fibrin* an insoluble protein formed from fibrinogen during the clotting of blood.

*Haemodialysis* process of using a dialysis machine to get rid of metabolic waste such as urea, water and excess mineral salt from the blood.

*Hydrolysis* chemical reactions when a compound reacts with water to produce another compound.

*Kernel* a softer, usually edible part of a nut, seed, or coconut contained within its shell.

*Ligament* flexible fibrous connective tissues that connect parts of the body (connecting bone to bone and others).

*Mesocarp* a fibrous layer of skin in the middle, like a coating in a coconut.

*Neuron* nerve cells.

*Physiology* processes and functions of the whole or part of an organism.

*Plate* crust layer that has been slowly moving to the surface for millions of years.

*Platelet* a small cell without nucleus in the blood that helps with blood clotting.

*Polymerisation* a process of combining two or more monomers to form polymers.

*Precipitation* is any product of the condensation of atmospheric water vapor that falls under gravity from clouds. The main forms of precipitation include drizzle, rain, sleet, snow and ice pellets.

*Propagation* wave energy movements that occur on electromagnetic, water or sound waves in a direction perpendicular to the wave surface.

*Ripple tank* tank used to study the characteristics of water waves.

*Salinity* salts (in grams) dissolve in one kilogram of seawater.

*Stroboscope* a tool that emits a bright light that flashes quickly, used to determine the speed of rotation or vibration or to adjust the motion of an object.

*Tendon* fibrous connective tissue which attaches muscle to bone.



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