

Name two natural carbon compounds that are Malaysia's exports which contribute significantly to the economy.

What makes oil palm special compared to other products, such as soya bean, as a source of cooking oil?



Let's study

- Introduction to carbon compounds
- Hydrocarbons
- Alcohol
- Fats
- Palm oil



According to sources from the ESRL's Global Monitoring Laboratory (GML) of the National Oceanic and Atmospheric Administration (NOAA), the composition of greenhouse gases including carbon dioxide in the atmosphere continues to rise. To date, efforts ranging from global bodies like the United Nations (UN) down to individuals have yet to successfully address the carbon dioxide issue.



Keywords

- Organic carbon compound
- Inorganic carbon compound
- Carbon cycle
- Saturated hydrocarbon
- Unsaturated hydrocarbon
- Alkane
- Alkene
- Alternative energy source
- Renewable energy source
- Alcohol
- Esterification
- Saturated fat
- Unsaturated fat
- Palm oil
- Palm kernel oil
- Fatty acid
- Glycerol
- Hydrolysis
- Emulsification
- Saponification
- Cleansing action of soap
- Sustainable management

Carbon dioxide is released into the atmosphere through **three** main processes:

(a) **Respiration**

Carbon dioxide is a carbon compound which is released into the atmosphere through the respiration of all living things including animals, plants and microorganisms.

(b) **Combustion**

Burning of fossil fuels releases carbon dioxide into the atmosphere. Natural phenomena such as volcanic eruptions and forest fires also release carbon dioxide into the atmosphere.



Photograph 5.1 Smoke from petrol combustion



Photograph 5.2 Smoke from forest fire

(c) **Decomposition**

During the process of decomposition by decomposers such as bacteria and fungi, carbon dioxide is released into the atmosphere.

Carbon dioxide is absorbed by green plants from the atmosphere to carry out photosynthesis (Figure 5.3).

The importance of photosynthesis includes:

- enabling green plants to make their own food
- providing food to animals
- increasing the oxygen content in the air
- removing excess carbon dioxide from the air to maintain the carbon dioxide content in the air

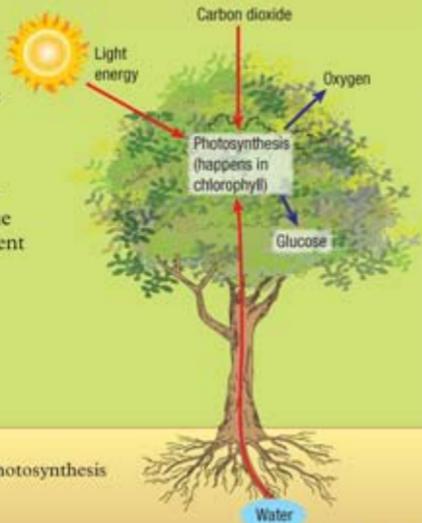


Figure 5.3 Photosynthesis

5.1

Introduction to Carbon Compounds

Carbon Compounds in Nature

Carbon compounds are compounds which contain the element carbon, C. Carbon compounds can be divided into **two** groups, namely **organic carbon compounds** and **inorganic carbon compounds** (Figure 5.1).

BRAIN TEASER

If compound X contains the carbon element, is compound X an organic carbon compound or an inorganic carbon compound?

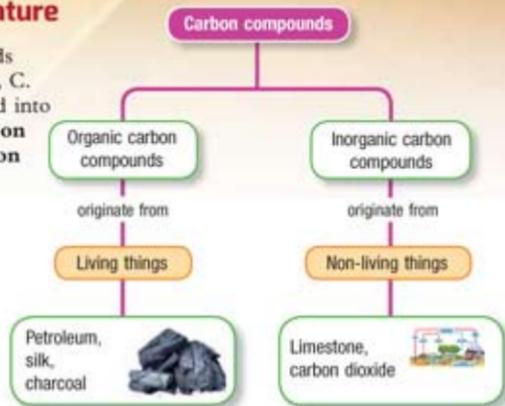


Figure 5.1 Organic carbon compounds and inorganic carbon compounds

Carbon Cycle

The **carbon cycle** shows how carbon elements are recycled through the formation or decomposition of carbon compounds in living things and organic substances in the environment through processes such as respiration, combustion, decomposition and photosynthesis (Figure 5.2).

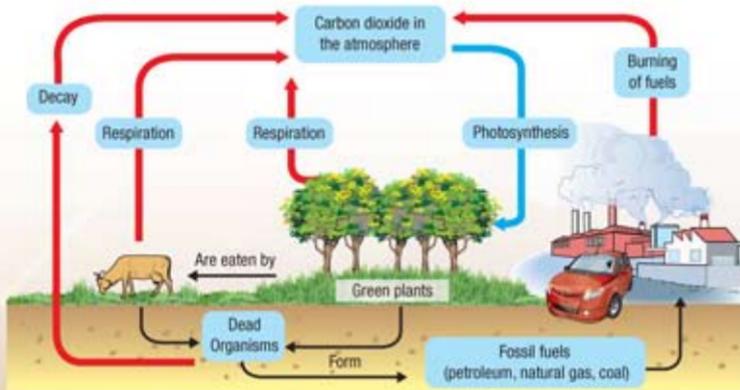


Figure 5.2 Carbon cycle

Activity 5.1

21st Century Skills

- ICS
- Project-based activity

To illustrate the carbon cycle in the form of a diagram

Instructions

1. Complete the carbon cycle diagram in Figure 5.4.

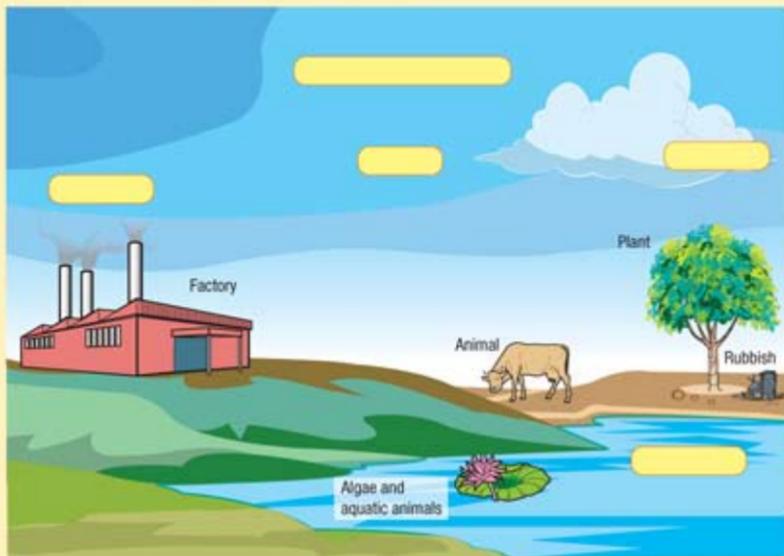


Figure 5.4

2. Present and display your illustration of the carbon cycle to the class.
3. Justify the enhancements or changes made to your group's illustration of the carbon cycle.

Formative Practice 5.1

1. What is organic carbon compound?
2. What is inorganic carbon compound?
3. Give **two** examples of inorganic carbon compounds.
4. What is carbon cycle?
5. State the importance of carbon cycle.

5.2 Hydrocarbons

Hydrocarbon compounds are organic carbon compounds made up of only **carbon** and **hydrogen** elements.

Hydrocarbon Compounds from Natural Sources

The formation of hydrocarbon compounds from natural resources are shown in Figures 5.5 and 5.6.

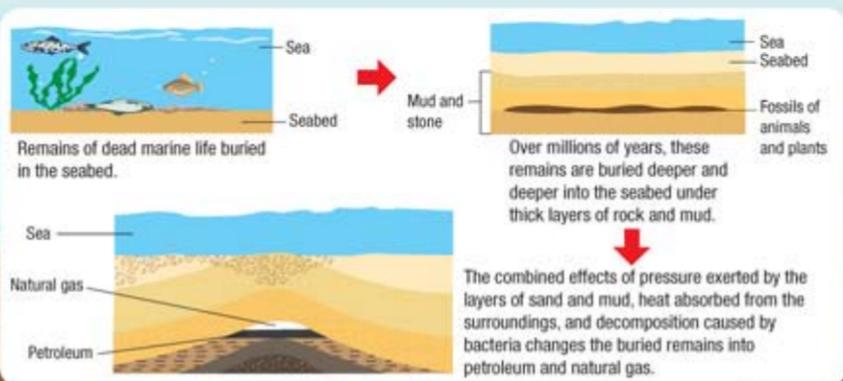


Figure 5.5 Formation of petroleum and natural gas

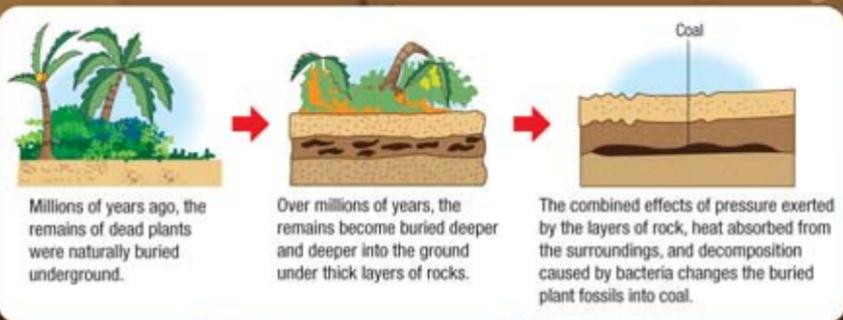


Figure 5.6 Formation of coal

Fractional Distillation of Petroleum

Petroleum is a mixture of hydrocarbons. This mixture of hydrocarbons needs to be separated through the fractional distillation process before the petroleum fractions can be used. Fractional distillation is used because the petroleum fractions have different boiling points.

Fractional distillation in a distillation tower at an oil refinery and uses of different petroleum fractions.
<http://buku-teks.com/sc5146>



Activity 5.2

To separate crude oil into four different petroleum fractions using fractional distillation

Materials

Crude oil, wooden splinter, ice, water and glass wool

Apparatus

Measuring cylinder, boiling tube, retort stand, test tubes, test tube rack, beaker, rubber stopper with delivery tube, thermometer ($0^{\circ}\text{C} - 360^{\circ}\text{C}$), Bunsen burner and evaporating dishes

Instructions

1. Fill a boiling tube with 10 cm^3 of crude oil.
2. Prepare the apparatus set-up (Figure 5.7).

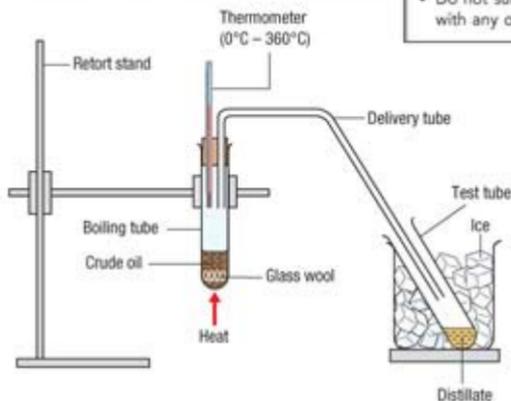


Figure 5.7 Fractional distillation of petroleum

21st Century Skills

- TPS
- ISS

Safety Precautions

- Wash your hands with soap and water if you get crude oil on your hands.
- Heating crude oil releases petroleum vapour which is highly flammable.

CAUTION!

- Use crude oil only.
- Do not substitute crude oil with any other fuel.

- Heat the crude oil in the boiling tube gently from room temperature to 80°C .
- Stop heating the crude oil when its temperature reaches 80°C . Continue the heating process when its temperature drops below 80°C .
- When there is about 1 cm^3 of distillate collected in the test tube, replace the test tube with another empty test tube.
- Label the distillate collected from room temperature to 80°C as Fraction 1.
- Repeat step 3 to collect three more fractions of petroleum at the following ranges of temperatures:
 - $80^{\circ}\text{C} - 150^{\circ}\text{C}$ with the collected distillate labelled as Fraction 2
 - $150^{\circ}\text{C} - 230^{\circ}\text{C}$ with the collected distillate labelled as Fraction 3
 - $230^{\circ}\text{C} - 250^{\circ}\text{C}$ with the collected distillate labelled as Fraction 4
- Observe and record the colour of each of the fractions labelled 1, 2, 3 and 4.
- Pour each petroleum fraction into separate evaporating dishes.
- Observe and compare the rate of flow or viscosity of each petroleum fraction.
- Record the viscosity of each petroleum fraction obtained.
- Ignite each petroleum fraction with a burning splinter. Compare and record how flammable each fraction is.

Observation

Fraction	1	2	3	4
Range of boiling points	$30^{\circ}\text{C} - 80^{\circ}\text{C}$	$80^{\circ}\text{C} - 150^{\circ}\text{C}$	$150^{\circ}\text{C} - 230^{\circ}\text{C}$	$230^{\circ}\text{C} - 250^{\circ}\text{C}$
Colour				
Viscosity				
Flammability				

Questions

- Name the method of separation used in this activity.
- Is petroleum a compound or a mixture? Give your reasons.
- Based on the information from Science Info on page 146, name the distillate obtained from the fractions labelled as follows:
 - Fraction 1:
 - Fraction 2:
 - Fraction 3:
 - Fraction 4:
- What characteristic of the petroleum fractions is applied in the fractional distillation of petroleum?

Saturated and Unsaturated Hydrocarbons

Figure 5.8 shows two types of hydrocarbon compounds, namely **saturated hydrocarbons** and **unsaturated hydrocarbons**.

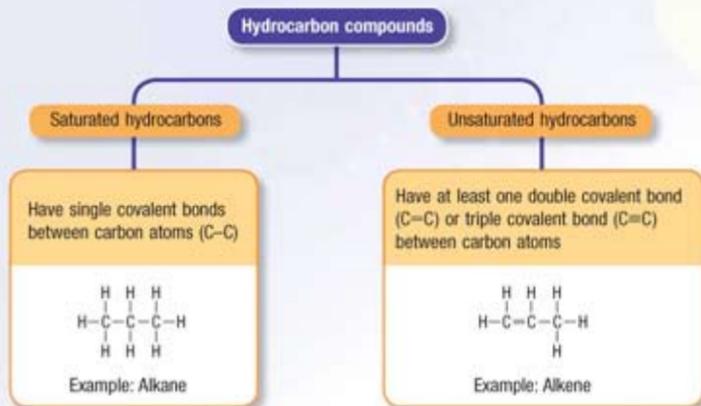


Figure 5.8 Hydrocarbon compounds

Homologous Series

In organic chemistry, a homologous series is made up of a specific group of organic compounds which have similar chemical properties. Examples of homologous series are the **alkane** and the **alkene**.

Alkane

Alkanes are saturated hydrocarbon compounds. Each carbon atom in an alkane molecule forms single covalent bonds with other carbon atoms (Figure 5.9).

As alkane is a homologous series, each member of the alkane homologous series can be represented by the general formula $C_n H_{2n+2}$ where $n = 1, 2, 3, \dots$

Alkene

Alkenes are unsaturated hydrocarbon compounds. Each alkene molecule has at least one double covalent bond between two carbon atoms (Figure 5.10).

As alkene is a homologous series, each member of the alkene homologous series can be represented by the general formula $C_n H_{2n}$ where $n = 2, 3, \dots$

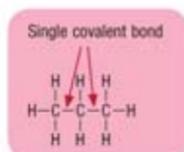


Figure 5.9 Alkane

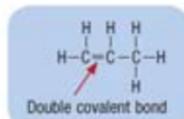


Figure 5.10 Alkene

The names of the first six members of alkane and first five members of alkene are given in Table 5.1.

Table 5.1 Names of alkanes and alkenes

Number of carbons, n	Alkane	Alkene
1	Methane	–
2	Ethane	Ethene
3	Propane	Propene
4	Butane	Butene
5	Pentane	Pentene
6	Hexane	Hexene

Activity 5.3

To build and name molecular models of alkane and alkene

Materials

Environmental-friendly materials for building model such as waste paper and wooden splinters

Instructions

- Carry out this activity in groups.
- Build and name models of the following alkane and alkene molecules using used materials:
 - first 6 members of the alkane homologous series
 - first 5 members of the alkene homologous series
- Present your built models to the class.

21st Century Skills

- ICS, ISS
- Project-based activity

Alternative Energy and Renewable Energy Sources in Daily Life

Fossil fuels such as petroleum, coal and natural gas are non-renewable energy sources which are fast depleting. As such, alternative energy sources are becoming increasingly important in supplying the energy for daily life.

Alternative energy sources are sources of energy that will not deplete easily such as nuclear energy or other renewable energy sources. Examples of renewable energy sources are as follows:

- solar energy
- wind energy
- hydroelectric energy
- biomass energy
- geothermal energy
- tidal energy
- wave energy

Many countries, including Malaysia, have the potential to build nuclear power stations to obtain energy. The advantages and disadvantages of building nuclear power stations should be taken into consideration before any decision is made.

Activity 5.4

21st Century Skills

- ICS, ISS, TPS, STEM
- STEM project-based activity

To produce methane gas from school canteen food waste

Instructions

1. Carry out this activity in groups.
2. Gather information related to alternative energy and renewable energy sources in daily life.
3. Read and understand the following information:

Rubbish disposal sites release carbon dioxide and methane gases as a result of organic waste decay. There are some countries which use methane gas to generate electrical energy.

4. Gather and analyse ways to produce methane gas from food waste from the Internet.
5. Plan and carry out a project using the STEM approach to produce methane gas from the decay of food waste in your school canteen.
6. Present your group project to the class.



Safety Precautions

Be careful when collecting the methane gas.

CAUTION!

Methane gas is highly flammable.

Formative Practice 5.2

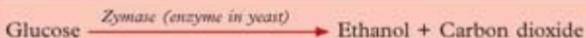
1. What is hydrocarbon?
2. State **one** similarity and **one** difference between saturated and unsaturated hydrocarbons.
3. Name **one** gas which is produced from food waste decay to generate electrical energy.

5.3 Alcohol

Alcohol is an organic carbon compound which contains carbon, hydrogen and oxygen elements. Alcohol is prepared through the **fermentation** process by using the action of yeast on food containing glucose or starch such as sugar, grapes, apples, sugarcane, rice, wheat, potato and barley.

Alcohol Preparation Process

In the fermentation process, the zymase in yeast converts glucose into ethanol and carbon dioxide as in the following equation:



Activity 5.5

To prepare ethanol through fermentation

Materials

Distilled water, yeast, sugar, starchy substances such as bread and rice, fruits such as banana and apple, porcelain chips and limewater

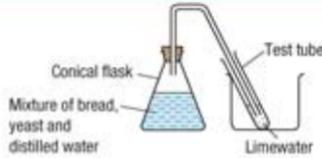
Apparatus

Beaker, glass rod, conical flask, measuring cylinder, delivery tube with stopper, test tube, distillation flask, Liebig condenser, thermometer, Bunsen burner, tripod stand and wire gauze

Instructions

1. Carry out this activity in groups.
2. Your teacher will instruct each group to prepare either apparatus set-up A, B or C as follows:

Apparatus set-up A	Procedure
 <p>Figure 5.11</p>	<ol style="list-style-type: none"> (a) Put 100 g of sugar and 50 cm³ of distilled water into a beaker. Stir the mixture with a glass rod until it forms a sugar solution. (b) Add 10 g of yeast into the sugar solution and pour the mixture into a conical flask. (c) Prepare the apparatus set-up (Figure 5.11).

Apparatus set-up B	Procedure
 <p>Figure 5.12</p>	<ol style="list-style-type: none"> (a) Place 100 g of starchy substance like bread and 50 cm³ of distilled water in a beaker. Stir the mixture with a glass rod. (b) Add 10 g of yeast into the mixture and pour the mixture into a conical flask. (c) Prepare the apparatus set-up (Figure 5.12).

21st Century Skills

- TPS
- Inquiry-based activity

Apparatus set-up C

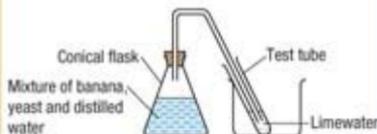


Figure 5.13

Procedure

- Place 100 g of fruits such as mashed bananas and 50 cm³ of distilled water in a beaker. Stir the mixture with a glass rod.
- Add 10 g of yeast into the mixture and pour the mixture into a conical flask.
- Prepare the apparatus set-up (Figure 5.13).

- Keep apparatus set-ups A, B and C in the laboratory for a week. Observe and record changes in the conical flask mixture and the limewater in the test tube.
- After one week, filter the mixture into a conical flask and pour the filtrate into a distillation flask.
- Distill the contents in the distillation flask using the apparatus set-up shown in Figure 5.14.
- Collect the distillate at a temperature of 78°C.
- Observe and record the colour and smell of the collected distillate in the table.

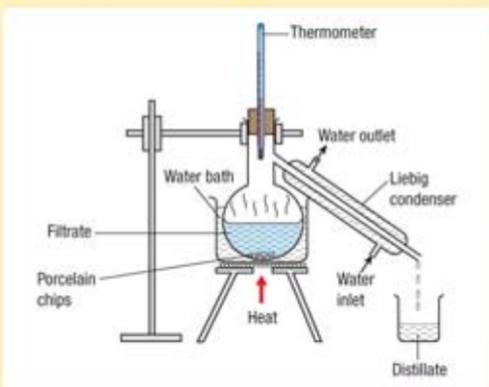


Figure 5.14

Observation

Substance	Observation	
	Beginning of activity	End of activity
Mixture in apparatus set-up A, B or C		
Limewater		
Distillate	-	Colour: Smell:

Questions

- What product turns the limewater cloudy?
- What is the purpose of the distillation process in this activity?
- What is the principle used to separate ethanol from the products of fermentation through distillation?

The Physical and Chemical Properties of Alcohol

The physical properties of alcohol are as follows:

- colourless
- liquid at room temperature
- has a distinctive smell
- the boiling point increases when its number of carbon atoms increases
- the solubility in water decreases when its number of carbon atoms increases

Apart from these physical properties, carry out Activity 5.6 to study the physical and chemical properties of alcohol.



Photograph 5.3 Use of alcohol as an antiseptic which is applied before an injection

Activity 5.6

To study the physical and chemical properties of ethanol

Materials

Ethanol, ethanoic acid, concentrated sulphuric acid, limewater, dry cobalt chloride paper, matches and water

Apparatus

Boiling tube, measuring cylinder, delivery tube, dropper, evaporating dish, test tube holder, filter funnel, beaker, test tube, retort stand, connecting tube and Bunsen burner

Instructions

A. Physical properties of ethanol

Observe and record the following physical properties of ethanol:

- colour
- state of matter at room temperature
- smell
- solubility in water

B. Combustion

1. Measure 2 cm^3 of ethanol using a measuring cylinder and pour into an evaporating dish.
2. Ignite the ethanol in the evaporating dish (Figure 5.15).
3. Observe and record the colour of the flame.
4. Test the gas released with limewater.
5. Test the droplets of liquid formed on the filter funnel with dry cobalt chloride paper.

C. Esterification

1. Measure 2 cm^3 of ethanol and 2 cm^3 of ethanoic acid using a measuring cylinder and pour both liquids into a boiling tube (Figure 5.16(a)). Shake the boiling tube.

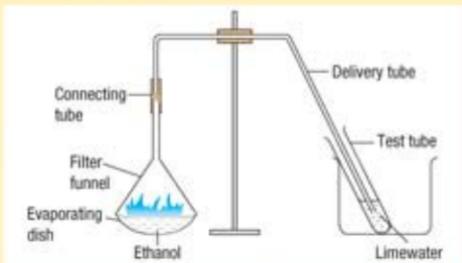


Figure 5.15

21st Century Skills

- CPS, ISS
- Inquiry-based activity

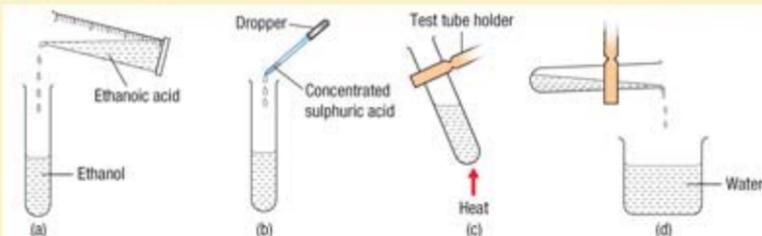


Figure 5.16

- Add five drops of concentrated sulphuric acid into the boiling tube mixture (Figure 5.16(b)) in a fume chamber. Shake the boiling tube.
- Heat the mixture for several minutes (Figure 5.16(c)).
- Pour the mixture into a beaker filled with water (Figure 5.16(d)). Observe and record the characteristics of the product.

CAUTION!

Concentrated sulphuric acid is very corrosive. Its use is limited within the fume chamber.

Observation

A. Physical properties of ethanol

Physical property of ethanol	Observation
Colour	
State of matter at room temperature	
Smell	
Solubility in water	

B. Combustion

Characteristic	Observation
Colour of flame	
Change(s) to limewater	
Change(s) to dry cobalt chloride paper	

C. Esterification

Characteristic	Observation
Smell of product	
Solubility of product in water	

Questions

- What is produced from the combustion of alcohol?
- (a) What is produced from the reaction between ethanol and ethanoic acid?
(b) What are the physical properties of the product of the reaction between ethanol and ethanoic acid?
- What is the function of sulphuric acid in the process of esterification?

Uses of Alcohol in Daily Life

Alcohol is widely used in various fields in daily life as follows:

Fuel

Alcohol is a good fuel because this organic carbon compound is highly flammable, burns with a blue flame and produces a complete and clean combustion without soot. For example, alcohol is used as a biofuel for motorised vehicles in the Philippines.

Medicine

Alcohol is used as an antiseptic and disinfectant to kill microorganisms and it is also used as a solvent for various types of medicine.

Cosmetics

Alcohol is also used as a solvent for various cosmetics such as perfume, lotion and lipstick.

Industry

Alcohol is normally used as a solvent in industry because it can dissolve organic substances that are used to prepare various types of industrial substances such as liquid cleaners and food. Alcohol is also a reactant in the formation of ester which is used in food processing, cosmetics, paint and other industries. Ethanediol, on the other hand, is a type of alcohol used as an antifreeze in industries.



Photograph 5.4 Uses of industrial substances which contain alcohol and ester in daily life

Effects of Excessive Alcohol Consumption

Alcohol consumption, especially in excess, causes **addiction**. Alcohol addiction normally causes social problems in families and social crimes that disrupt societal peace.

A person who is drunk as a result of excessive alcohol consumption normally causes various problems such as dangerous driving and altercations. Expectant mothers who consume excessive alcohol can cause defects in their baby known as **foetal alcohol syndrome**. Babies with foetal alcohol syndrome have small-sized head and brain, abnormal face and stunted growth.



Click@Web

Scientific studies on effects of alcohol consumption
<http://buku-teks.com/sc5156>



Table 5.2 Adverse effects of excessive alcohol consumption on health

Part of the body	Adverse effects of excessive alcohol consumption
Brain	Damage to brain cells as well as compromised coordination and nervous system cause disruptions to body balance and difficulty in estimating distance
Eyes	Blurred vision
Lungs	Increased rate of breathing
Heart	<ul style="list-style-type: none">• Increased rate of heartbeat• High blood pressure
Stomach	Irritation to stomach wall causes bleeding and ulcers
Liver	<ul style="list-style-type: none">• Damage to liver cells• Liver cells die and harden• Cirrhosis• Liver cancer
Kidney	Kidney damage due to overactive elimination of waste substances
Urinary bladder	Frequent urination

Activity 5.7

To produce posters or pamphlets or a scrap book on the effects of excessive alcohol consumption on health

21st Century Skills

- ICS
- Project-based activity

Instructions

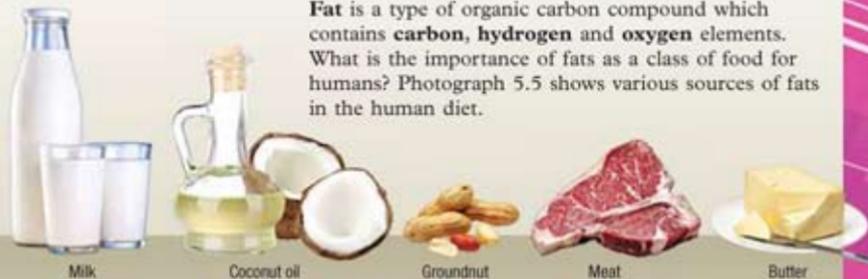
1. Carry out this activity in groups.
2. Gather information from various sources about the effects of excessive alcohol consumption on health.
3. Discuss the information gathered.
4. Prepare posters or pamphlets or a scrap book based on the outcome of your group discussion.
5. Present and display the posters or pamphlets or a scrap book on the science notice board in your class or science laboratory.

Formative Practice 5.3

1. What is alcohol?
2. How is alcohol prepared?
3. What is the purpose of distillation in the process of alcohol preparation through glucose fermentation?
4. State **two** uses of alcohol in daily life.
5. Why is drunk driving caused by the excessive intake of alcohol a serious traffic offence?

5.4 Fats

Fat is a type of organic carbon compound which contains **carbon, hydrogen and oxygen** elements. What is the importance of fats as a class of food for humans? Photograph 5.5 shows various sources of fats in the human diet.



Photograph 5.5 Sources of fats

Fats exist in two states, solid and liquid. Solid fats at room temperature usually originate from sources of animal fats. For example, chicken, cow, goat and fish. Fat in the form of liquid is known as **oil**. Oil normally originates from plants. For example, palm oil, coconut oil and soya bean oil.

As in hydrocarbons, fats can be divided into **saturated fats** and **unsaturated fats**. The similarities and differences between saturated fats and unsaturated fats are shown in Figure 5.17.

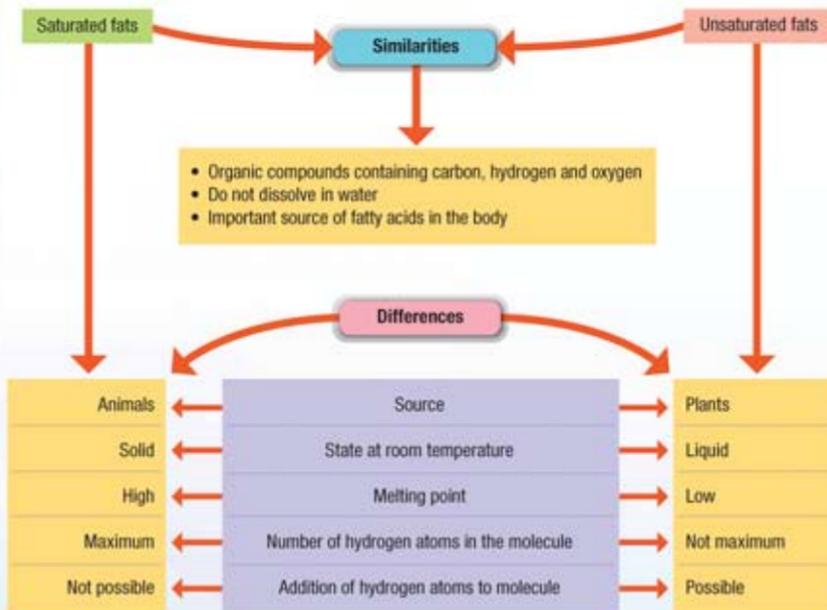


Figure 5.17 Similarities and differences between saturated fats and unsaturated fats

Effects of Eating Food Containing Excessive Fats on Health

Fats represent an important component of a balanced diet in human nutrition. Eating of food containing excess fats especially saturated fats will increase the level of cholesterol in the blood and affect our health.

Saturated fats from animal sources such as cheese, eggs, butter and meat contain high levels of cholesterol. The importance of cholesterol in the human body includes building of cell membranes, synthesising bile and sex hormones, and producing vitamin D in skin that is exposed to sunlight.

However, excessive cholesterol in the blood can affect human health as follows:

- (a) **Gallstones and jaundice**
Excessive cholesterol in the blood can form gallstones which block the bile duct. Blocked bile duct can cause **jaundice**.
- (b) **Cholesterol deposited in the inner wall of arteries and atherosclerosis**
Cholesterol that accumulates and deposits on the inner artery walls causes the artery lumen to become narrow. This narrowed artery can disrupt or block flow of blood in a condition known as **atherosclerosis** (Figure 5.18).



Information on cholesterol
<http://buku-teks.com/sc5159>

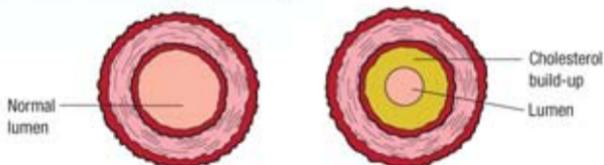


Figure 5.18 Cross section of healthy artery and effect of atherosclerosis on artery

Atherosclerosis can cause hypertension or high blood pressure, stroke (burst or blocked artery leading to the brain) and fatal heart attack.

Steps to avoid health problems caused by excessive cholesterol in blood include:

- reducing the intake of saturated fats in nutrition
- consuming unsaturated fats which can lower the cholesterol level in blood

Activity 5.8

To gather information on fats

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media on the following:
 - (a) fat content of various sources in daily life
 - (b) saturated and unsaturated fats
 - (c) effects of excessive fat intake on health
3. Discuss the information gathered.
4. Present the outcome of your group discussion to the class using a multimedia presentation.

21st Century Skills

- ICS
- Discussion

Formative Practice 5.4

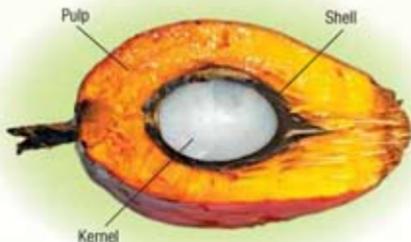
1. What are fats?
2. Give **one** example of fats and the source.
3. State **one** similarity and **one** difference between saturated fats and unsaturated fats.
4. State **three** health problems caused by food intake which contains excess fats.

5.5 Palm Oil

Structure of Oil Palm Fruit

Observe the structure of the oil palm fruit in Photograph 5.6. The oil palm fruit is made up of **three** parts, namely:

- **pulp** (mesocarp) which contains the most palm oil
- **kernel** which contains the best quality palm kernel oil
- **shell** (endocarp) which does not contain oil



Photograph 5.6 Structure of oil palm fruit

Activity 5.9

To observe the structure of the oil palm fruit and identify the quantity aspect of oil from pulp and kernel

Materials

10 oil palm fruits

Apparatus

Forceps, knife, magnifying glass, press, Bunsen burner, tripod stand, wire gauze and white tile

Instructions

1. Place an oil palm fruit on a white tile. Hold the oil palm fruit using forceps and make a cross-sectional cut on the oil palm fruit using a knife (Figure 5.19).

21st Century Skills

- TPS
- Inquiry-based activity

- Observe and sketch the structure of the oil palm fruit and label the parts in the structure of the oil palm fruit.
- Wash all the oil palm fruits with water.
- Put the oil palm fruits into a beaker filled with water and boil the water and the oil palm fruits for 20 minutes (Figure 5.20).
- Remove the oil palm fruits from the beaker using forceps.
- Separate the pulp from the shell of the oil palm fruit (Figure 5.21).
- Put the pulp into a press to be squeezed. Collect the palm oil extracted from the pulp in a beaker (Figure 5.22).
- Cut open the shell and remove the kernel.
- Repeat step 7 by replacing the pulp with the kernel.
- Compare and contrast the quantity of oil extracted from the pulp and kernel. Record the quantity of oil collected in the beaker.

Observation

Sketch and label a cross section of the oil palm fruit.

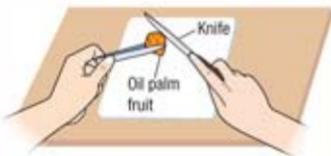


Figure 5.19

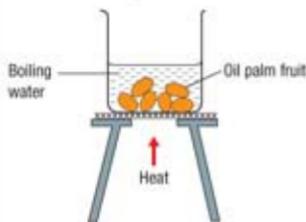


Figure 5.20



Figure 5.21



Figure 5.22

Oil extracted from	Quantity of oil collected
Pulp	
Kernel	

Questions

- What is the aim of boiling the oil palm fruits?
- What is the difference in the quantity of oil extracted from the pulp and the kernel?
- State the difference in colour of the oil extracted from the pulp with the oil extracted from the kernel.

Sequence in the Industrial Extraction Process of Palm Oil

The sequence in the industrial extraction process of palm oil is shown in Figure 5.23.

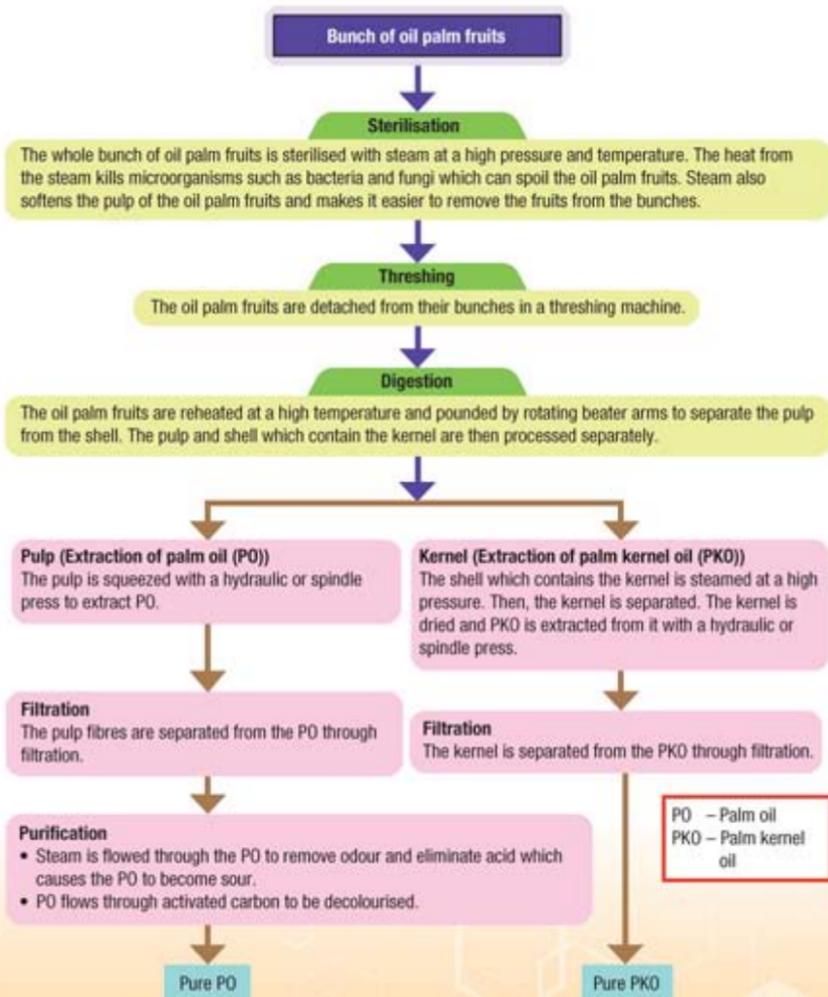


Figure 5.23 Sequence of the industrial extraction process of palm oil

Activity 5.10

To prepare a review about a visit to a palm oil processing factory or to the Malaysian Palm Oil Board (MPOB)

21st Century Skills

- TPS, ISS, ICS
- Inquiry-based activity

Instructions

1. Pay a visit to a palm oil processing factory or to the Malaysian Palm Oil Board (MPOB).
2. Gather and record information on the sequence of the industrial extraction process of palm oil in your notebook.
3. Based on the information gathered, review the industrial extraction process of palm oil.

Components of Palm Oil

Palm oil is made up of two parts, namely glycerol and various types of fatty acids (Figure 5.24).



Figure 5.24 Components of palm oil

Palm oil is made up of saturated fatty acids such as palmitic acid and stearic acid, as well as unsaturated fatty acids such as oleic acid and linoleic acid.

Composition of Palm Oil and Other Vegetable Oils

The composition of palm oil and other vegetable oils is shown in Table 5.3.

Activity 5.11

To study the differences in composition such as glycerol and fatty acid in palm oil and other vegetable oils

21st Century Skills

ICS

Instructions

1. Carry out this activity in groups.
2. Conduct online searches through the Internet to gather information on the differences in composition such as the glycerol and fatty acid content in palm oil and other vegetable oils.
3. Discuss the information gathered.
4. Present your findings using a graphic organiser.

Table 5.3 Comparing and contrasting the composition of palm oil with other vegetable oils

Weight percentage of fatty acids (%)									
Oil or fat	Ratio of unsaturated fats/saturated fats	Saturated					Mono unsaturated	Poly unsaturated	
		Capric acid	Lauric acid	Myristic acid	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Alpha linoleic acid
Coconut oil	0.1	6	47	18	9	3	6	2	-
Corn oil	6.7	-	-	-	11	2	28	58	1
Olive oil	4.6	-	-	-	13	3	71	10	1
Palm oil	1.0	-	-	1	45	4	40	10	-
Palm kernel oil	0.2	4	48	16	8	3	15	2	-
Peanut oil	4.0	-	-	-	11	2	48	32	-
Sesame oil	6.6	-	-	-	9	4	41	45	-
Soya bean oil	5.7	-	-	-	11	4	24	54	7

Source: MPOB, UCCS, NCBI and Oil Palm Knowledge Base

The Chemical Properties of Palm Oil

The chemical properties of palm oil are explained in the following aspects:

(a) **Oxidation**

Oxidation of palm oil occurs when its oil molecules combine with oxygen in the air or from other reactants. The oxidation of palm oil produces free radicals and compounds which are harmful to human health.

(b) **Hydrolysis**

Hydrolysis occurs in palm oil when palm oil molecules react with water. In the hydrolysis process, the reaction between palm oil and water produces glycerol and fatty acids.

(c) **Esterification**

Esterification of palm oil occurs when its fatty acid molecules react with alcohol to produce ester (methyl ester), that is palm oil biodiesel.

Emulsification Process of Palm Oil

The emulsification of palm oil is a process where palm oil is broken into smaller droplets. This increases the total surface area of the palm oil. How does the increase in total surface area of palm oil influence the rate of digestion of palm oil? The emulsification of palm oil by bile juice is shown in the video on the right.

 **Video**

Emulsification process of oil such as palm oil
<http://buku-teks.com/sc5165a>



Nutritional Content of Palm Oil

The nutritional content of palm oil are as follows:

(a) **Fats**

Palm oil is a balanced oil with the same amount of saturated fats and unsaturated fats (Table 5.3).

(b) **Vitamins**

Palm oil is a rich source of vitamin E and vitamin A.

 **My Malaysia**

Scientists from the Malaysian Palm Oil Board have conducted various research on the nutritional content of palm oil.
<http://buku-teks.com/sc5165b>



(c) **Antioxidants**

Palm oil contains antioxidants such as carotene and vitamin E which slow down or stop the oxidation process.

(d) **Substances in palm oil which constitute less than 1%**

Among the substances contained in palm oil include sterol, phosphatides, triterpene and aliphatic alcohols. These substances add nutritional value, stability and facilitate the filtration of oil.

Use of Palm Oil in Healthcare and Food

Besides a balanced content of saturated fats and unsaturated fats, palm oil contains many nutrients suitable for use in various types of food such as cooking oil, vegetable oil, margarine and chocolate.

Palm oil is also used to make non-food substances (Photograph 5.7).



Photograph 5.7 Examples of palm oil-based products

Activity 5.12

To study the use of palm oil-based products as well as their effects on human health

21st Century Skills

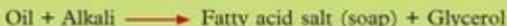
- ICS
- Discussion

Instructions

1. Carry out this activity in groups.
2. Conduct online searches through the Internet to gather information on the uses of palm oil-based products in:
(a) medicine (b) plastic surgery (c) cosmetics (d) prosthetics
3. Discuss the information gathered. Give reasons why the use of palm oil-based products and their effects on human health need to be justified.
4. Present your findings using a graphic organiser or multimedia presentation.

Soap Production

Soap is a fatty acid salt normally produced through the reaction between palm oil and concentrated alkali (concentrated sodium hydroxide or concentrated potassium hydroxide) as in the following word equation:



Entrepreneurship

A soap business can be carried out from home. The substances used are natural substances, natural fruit extracts and fragrances from approved aromatic resources for making organic soap.



Experiment 5.1

Aim: To produce soap through saponification

Problem statement: How is soap produced?

Materials: Palm oil, 5 mol dm^{-3} concentrated sodium hydroxide solution, distilled water, sodium chloride, filter paper, red litmus paper and blue litmus paper

Apparatus: Beaker, measuring cylinder, glass rod, Bunsen burner, tripod stand, wire gauze, filter funnel, retort stand, spatula, test tube and conical flask

Procedure:

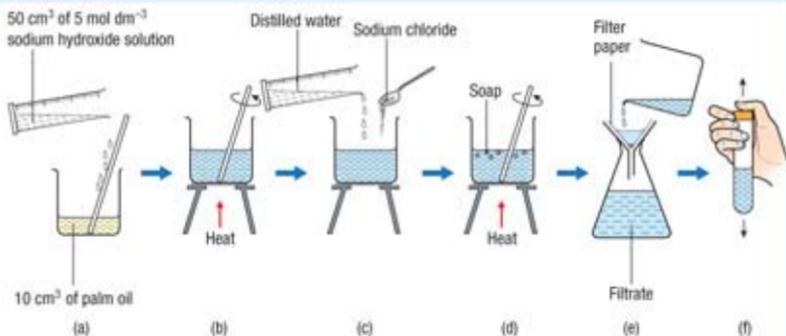


Figure 5.25 Process of soap production

1. Measure and pour 10 cm^3 of palm oil into a clean beaker using a measuring cylinder.
2. Measure and pour 50 cm^3 of 5 mol dm^{-3} concentrated sodium hydroxide solution into the beaker (Figure 5.25(a)). Observe and record the changes of the mixture in the beaker.
3. Stir and boil the mixture in the beaker for 5 minutes (Figure 5.25(b)). Observe and record the changes to the mixture in the beaker after heating.

- Stop heating the mixture. Measure and pour 50 cm^3 of distilled water as well as three spatula full of sodium chloride into the solution in the beaker (Figure 5.25(c)). Observe and record changes to the mixture in the beaker.
- Stir and boil the mixture in the beaker again for 5 minutes (Figure 5.25(d)).
- Filter the mixture in the beaker (Figure 5.25(e)).
- Rinse the residue with distilled water and dry it.
- Add a little water to the dried residue in a test tube and shake it. Observe and record the changes when the residue is mixed with water and shaken, and when you touch it with your fingers (Figure 5.25 (f)).
- Test the mixture of the residue and water with red and blue litmus papers. Observe and record the change in colour, if any, to the red and blue litmus papers.

Observations:

Record your observations for procedures 2, 3, 4, 8 and 9.

Conclusion:

What is the conclusion for this experiment?

Molecular Components of Soap and Cleansing Action of Soap

Molecular Components of Soap

Soap molecules are made up of **two** parts (Figure 5.26), namely:

- the '**head**' or '**hydrophilic**' part which can dissolve in water and is made up of an ionic group.
- the '**tail**' or '**hydrophobic**' part which cannot dissolve in water but can dissolve in oil or grease. This part is made up of a hydrocarbon chain.

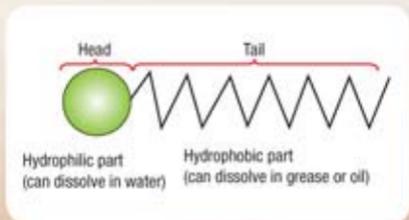


Figure 5.26 Molecular structure of soap

Why is soap able to dissolve in water as well as in oil or grease?

Cleansing Action of Soap

The cleansing action of soap is as follows:

- when soap dissolves in water, the surface tension of the water is reduced. Therefore, the surface of cloth becomes completely wet with soap water.
- the hydrophobic part of the soap molecules will dissolve and attach to the greasy dirt on the cloth surface while the hydrophilic part will dissolve in water (Figures 5.27(a) and (b)).
- scrubbing and brushing the cloth will dislodge the greasy dirt from the cloth surface to form greasy droplets that are surrounded by soap molecules and suspended in soapy water (Figure 5.27(c)).
- soap bubbles produced by soapy water trap greasy droplets in the soapy water. When the soapy water and bubbles are removed during rinsing, the greasy dirt will also be removed as well. In this way, soap removes greasy dirt and cleans the cloth.

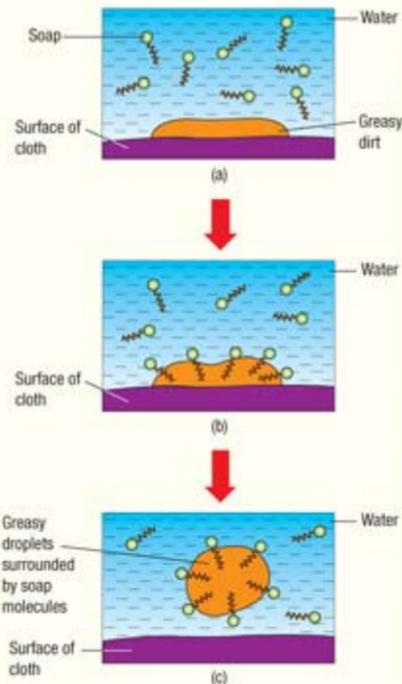


Figure 5.27 Cleansing action of soap

Sustainable Management and its Importance in the Palm Oil Industry

The scope of sustainable management and its importance in the palm oil industry include:

- Land use**
Replanting is carried out to optimise land use.
- Wastewater**
Palm oil mill effluent (POME) (Photograph 5.8) produced from sterilisation processes are made into organic fertilisers and biogas energy substances.

(c) **Air quality**

The quality of air improves when carbon dioxide is absorbed and oxygen is released by oil palm trees during photosynthesis.

(d) **Oil palm waste**

Sustainable management of oil palm industry normally practises zero waste concept by converting oil palm waste into various types of useful products (Figure 5.28).



Photograph 5.8 POME from palm oil mill



Fronds made into fertilisers



Tree trunks as wood replacement



Empty fruit bunches turned into compost

Types of biomass (Oil palm waste)



Shells are burnt to boil water



Pulp fibre is made into carpets and textile



POME turned into biogas and fertilisers

Figure 5.28 Applications of the zero waste concept in the oil palm industry

Activity 5.13

To conduct a debate or forum on the efficient management of the palm oil industry to counter the negative perceptions of Western countries on local palm oil

21st Century Skills

- ICS, ISS, TPS
- Debate

Instructions

1. Carry out this activity in groups.
2. Gather information from the Internet, print media and other electronic media on the negative perceptions of Western countries on local palm oil.

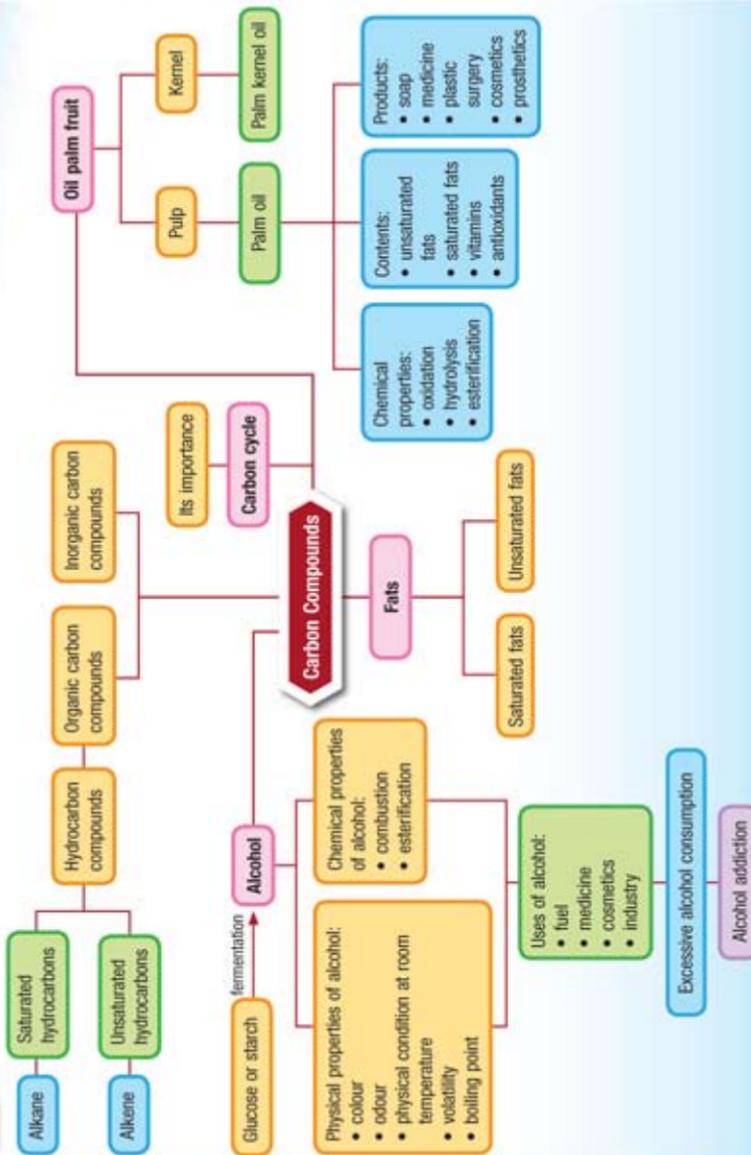
Example of negative perception

The oil palm industry has been linked to worldwide deforestation. This happens when forests are burnt to provide agricultural land for planting oil palm trees.

3. Discuss and generate ideas on sustainable management to counter the negative perceptions of Western countries on local palm oil. The scope of discussion should include:
 - (a) land use
 - (b) wastewater
 - (c) air quality
 - (d) oil palm waste
4. Conduct a debate or forum to discuss this topic.

Formative Practice 5.5

1. Name the oil extracted from the following parts of the oil palm fruit:
 - (a) pulp
 - (b) kernel
2. Why are the oil palm fruits steamed before oil is extracted?
3. What are the reactants that react with palm oil in the following processes?
 - (a) Hydrolysis
 - (b) Esterification
4. Name **two** antioxidants found in palm oil.





Self-Reflection

After studying this chapter, you are able to:

5.1 Introduction to Carbon Compounds

- Identify carbon compounds in nature.
- Explain the importance of carbon cycle.

5.2 Hydrocarbons

- Describe hydrocarbon compounds and explain how carbon compounds are obtained from natural sources.
- Name members of the homologous series of alkanes and alkenes from carbon 1 to carbon 6.
- Communicate about alternative energy sources and renewable energy in daily life.

5.3 Alcohol

- Describe the preparation of alcohol.
- Identify the physical properties and chemical properties of alcohol.
- Communicate about the uses of alcohol in daily life.
- Communicate about the effects of excessive alcohol consumption.

5.4 Fats

- State the content of fats and its sources.
- Compare and contrast between saturated and unsaturated fats.
- Explain with examples, the effects of eating food containing excess fat on health.

5.5 Palm Oil

- Describe the structure of oil palm fruit.
- Identify the quantity of oil from pulp and kernel.
- Explain in order the process of palm oil extraction in industry.
- Describe components of palm oil.
- Compare and contrast the composition of palm oil with other vegetable oils.
- State the chemical properties of palm oil.
- Explain the emulsification process of palm oil.
- List the nutritional content of palm oil.
- Justify the use of palm oil in healthcare and food.
- Carry out an experiment to produce soap through saponification.
- Communicate about the cleansing action of soap.
- Generate ideas on sustainable management and their importance in the palm oil industry.



Summative Practice 5

Quiz
<http://bukuteks.com/sc5174>



Answer the following questions:

1. Figure 1 shows an experiment to study the preparation of a type of carbon compound.

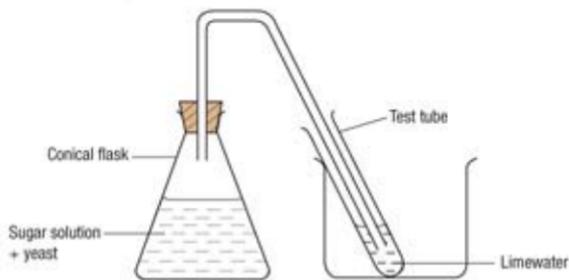


Figure 1

- (a) Name the process in Figure 1.
(b) What type of carbon compound is prepared?
(c) State your observation of the limewater.
(d) State the inference for your answer in 1(c).
2. Figure 2 shows a cross section of an artery blocked by substance P which causes the lumen of the artery to become narrow and disrupts or blocks blood flow.

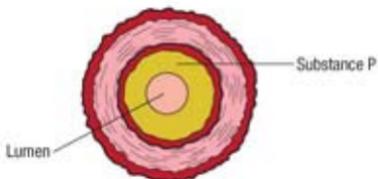


Figure 2

- (a) Name the condition.
(b) Name substance P.
(c) What class of food causes blocked arteries?
(d) Suggest **two** ways to avoid blocked arteries.

3. Figure 3 shows a cross section of an oil palm fruit.

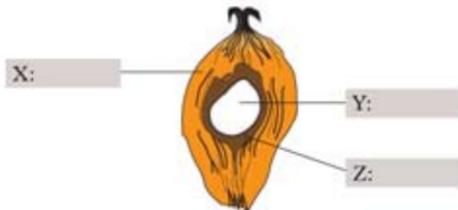


Figure 3

- (a) Name the parts labelled X, Y and Z.
 (b) Name the type of oil extracted from parts X and Y.
 (c) Complete the flow chart for the extraction process of palm oil.



- (d) Give **three** reasons why palm oil is suitable as cooking oil.



Enrichment Practice

4. Assume that you are tasked to build a new palm oil mill which operates based on zero waste concept.



Figure 4

Build a graphic organiser to show how zero waste concept is applied in the oil palm industry such as the conversion of oil palm waste into oil palm biomass. 🧠