DEPARTMENT OF EDUCATION

GRADE 11

CHEMISTRY

MODULE 6

OTHER NON-METALS AND THEIR COMPOUNDS

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GRADE 11

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MODULE 6

OTHER NON-METALS AND THEIR COMPOUNDS

IN THIS MODULE YOU WILL LEARN ABOUT:

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Acknowledgement

We acknowledge the contributions of all secondary teachers who in one way or another have helped to develop this Course.

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DIANA TEIT AKIS
PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution, Government Policies and Reports. It is developed in line with the National Education Plan (2005 -2014) and addresses an increase in the number of school leavers affected by the lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual
- To develop and encourage an education system that satisfies the requirements of Papua New Guinea and its people
- To establish, preserve and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced through this course to provide alternative and comparable pathways for students and adults to complete their education through a one system, two pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all the teachers, curriculum writers and instructional designers who have contributed towards the development of this course.

UKE KOMBRA, PhD
Secretary for Education

MODULE 6: OTHER NON-METALS AND THEIR COMPOUNDS

Introduction

Non-metals are elements that display proprieties that are different to metals. They are poor conductors of electricity and heat. They are not ductile and cannot be easily reshaped. Generally included in this grouping are the six noble gases, the five halogens and eight orphan elements.

During the course of studying this module, important elements such as hydrogen, carbon, chlorine and oxygen that are so essential to human life are studied**.** Hydrogen, a non-metal and helium, the noble gas family**,** together account for about 99% of the mass of the universe. The human body and the earth are composed primarily of oxygen, together with other important components of carbon, nitrogen and hydrogen.

Among other non-metals are the elements phosphorus, sulphur, boron and selenium. In reality, human, animal, and plant life are made with these four elements making the earth as unique as it is from other known planets.

A chemical element contains only one type of atom. If a substance contains more than one type of atom, it is a compound. In simple terms they are described as substances that have two or more atoms bonded together.

There are millions of different chemical compounds. Different types of compounds are often expressed as chemical formulas or equations.

Learning Outcomes

After going through this module, you are expected to:

- demonstrate an understanding of fundamental scientific principles and models.
- apply scientific thinking, motor, and process skills to investigate and find solutions to problems.
- communicate findings of scientific investigations in different ways.
- analyze and evaluate past and present scientific developments and their impacts on human beings and the environment and on the ethical decisions made.
- justify the importance of oxygen and oxides and enumerate their uses
- trace the carbon cycle.
- differentiate oxides, hydroxide, carbonates and bicarbonates

- justify the importance of chlorine and its compounds
- explain the importance of carbon and its compounds
- trace how fossil fuels were formed and explored
- explain carbon dating
- enumerate the advantages and disadvantages of exploiting non-renewable energy sources and options available to shift sources of energy

Time Frame

Suggested allotment time: 8 weeks

If you set an average of 3 hours per day, you should complete the module comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor.

DO NOT LEAVE ANY QUESTION UN-ANSWERED.

Terminologies

Before you get into the thick of things, let us make sure you know some of the terminologies that are used throughout this module.

Compound A chemical combination of atoms of different elements to form a substance in which the ratio of combining atoms remains fixed and is specific to that substance. The constituent atoms cannot be separated by physical means; a chemical reaction is required for the compounds to be formed or to be changed. The existence of a compound does not necessarily imply that it is stable. Many compounds have lifetimes less than a second.

Conductor Allows heat or electrical charge to pass through material.

Decomposition The breakdown of complex molecules of dead organisms composed into simple nutrients and re-used by living organisms.

Empirical Formula The formula of a compound showing the simplest ratio of the atoms present. The empirical formula is the formula obtained by experimental analysis of a compound. It can be related to a molecular

	formula only if the molecular weight is known. For example, P_2O_5 is the empirical formula of phosphorus (V) oxide even though its molecular formula is P_4O_{10}.
Fossil fuel	A fuel such as coal, oil, or natural gas that is formed over millions of years from the remains of plants and animals.
Greenhouse effect	The warming of Earth's atmosphere due to water vapour, carbon dioxide, and other gases in the atmosphere that trap heat radiated from Earth's surface.
Hydrocarbons	Molecules composed solely of hydrogen and carbon atoms.
Inert	Lacking the power to move, very slow to move or act or deficient in active properties especially lacking a usual or anticipated chemical or biological action inactive.
Insulator	Does not allow electricity to pass through easily.
Ionization	The process of producing ions; in certain chemical reactions ionization occurs by transfer of electrons. For example, sodium atoms and chlorine atoms react to form sodium chloride, which consists of sodium ions (Na^{+1}) and chloride ions (Cl^{-1}).
Metals	are those elements (with the exception of hydrogen) that are found to the left of a group of elements referred to as the metalloids.
Non-metals	are those elements found to the right of metalloids, including the element, hydrogen.
Metalloids	are a group of elements with properties similar to both the metals and non-metals and they are Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, and Polonium.
Oxidation	An atom, ion, or a molecule is said to undergo oxidation or to be oxidized when it loses electrons.
Oxidation State	The number of electrons lost or effectively lost by the neutral atom, that is the oxidation number.
Photosynthesis	Chemical process by which plants containing chlorophyll use sunlight to manufacture their own food by converting carbon dioxide and water to carbohydrates, and releasing oxygen as a by-product.
Redox	Relating to the process of oxidation and reduction, which are intimately connected in that during oxidation by chemical agents the oxidizing agent itself becomes reduced, and vice versa. Thus an oxidation process is always accompanied by a reduction process.
Reduction	The gain of electrons by such species as atoms, molecules, or ions; it often involves the loss of oxygen from a compound or addition of hydrogen.
Respiration	The process in which oxygen is used to break down organic compounds into carbon dioxide and water.

11.6.1 Oxygen

Oxygen is an important part of the atmosphere and is necessary to sustain terrestrial life. Because it comprises most of the mass in water, it also comprises most of the mass of living organisms.
All major classes of structural molecules in living organisms, such as proteins, carbohydrates, and fats, contain oxygen, as do the major inorganic compounds that comprise animal shells, teeth, and bone.
Elemental oxygen (O_2) is produced by cyanobacteria, algae, and plants through the process of photosynthesis, and is used in cellular respiration by most living organisms on earth.

You are breathing right now and your body is taking in oxygen (O_2) molecules. You need oxygen to survive, as do almost all other living organisms. It is a good thing that oxygen makes up over twenty percent (20%) of the Earth's atmosphere. We are the only planet in the solar system with enough oxygen gas available to let us survive.Did you know that if you breathe too much oxygen you could die?

What about this? If you have a room filled with oxygen (O_2) and hydrogen (H_2) and someone lights a match it will explode! That is because oxygen is very reactive.

Oxygen is the eighth element of the Periodic Table and can be found in the second row (period). It is a colourless and odourless gas at room temperature.

When living things need energy they take in oxygen for respiration. The oxygen returns to the atmosphere in the form of carbon dioxide.

Oxygen gas is fairly soluble in water, which makes aerobic life in rivers, lakes and oceans possible.

Oxygen molecules are not the only form of oxygen in the atmosphere; you will also find oxygen as ozone (O_3) and carbon dioxide (CO_2). A chemist named Priestly isolated oxygen in 1774.

Uses of Oxygen

1. Plants and animals rely on oxygen for respiration. Oxygen is frequently used to help breathing in patients with respiratory ailments.

2. Ozone layer
   It is a compound that floats in the atmosphere around the Earth. Three oxygen atoms can combine and make ozone. Naturally occurring ozone in the upper atmosphere shields the earth from ultraviolet radiation.

3. Plastics
   Oxygen is inside things made out of plastic. Every time you get a 2-liter bottle or a yoghurt, look at the plastic. Now you know there is oxygen inside all plastics.

4. Breathable air
   Oxygen is very important. Life on Earth could not exist without it. Animals need to breathe oxygen to survive. There is enough oxygen in the air for everyone to breathe.

5. Rocks and soils
   You just learned that there is oxygen in the air. Here is something else. 50% of the Earth's crust is made up of oxygen. It means that no matter what you pick up or dig up from the ground, there is a good chance that one half of it is made out of oxygen.

6. Water
   Over half of the Earth is covered with water which is made of hydrogen and oxygen. In the same way we breathe the oxygen in air and fish breathe the oxygen in water.

7. The greatest commercial use of oxygen gas is in the steel industry. Large quantities are also used in the manufacture of a wide range of chemicals including nitric acid and hydrogen peroxide. It is also used to make epoxy ethane (ethylene oxide), used as anti-freeze and to make polyester, and chloroethene, the precursor to PVC.

8. Oxygen gas is used for oxy-acetylene welding and cutting of metals. A growing use is in the treatment of sewage and of effluent from industry.

Compounds of Oxygen

1. Water (H_2O)
   Water is a compound because it is made up of more than one element: hydrogen and oxygen. Even though you find complex names on other molecules, everyone calls H_2O "water". It is made up of two hydrogen (H) atoms and one oxygen (O) atom.
   The hydrogen atoms have filled orbitals with two electrons and the oxygen atom is filled with eight electrons.

2. Hydrogen peroxide (H_2O_2)
   The chemical formula for the compound water is H_2O indicating that 2 atoms of hydrogen combine with 1 atom of oxygen. But if another oxygen atom is added, a new compound called hydrogen peroxide will be created (H_2O_2) which indicates that 2 atoms of hydrogen combine with 2 atoms of oxygen create the compound hydrogen peroxide.

Combustion of fuels

Combustion takes place when fuel, most commonly a fossil fuel, reacts with the oxygen in air to produce heat. The heat created by the burning of a fossil fuel is used in the operation of equipment such as boilers, furnaces, kilns, and engines.

Along with heat, CO_2 (carbon dioxide) and H_2O (water) are created as by-products of the exothermic reaction. The term exothermic ("outside heating") describes a process or reaction that releases energy from the system, usually in the form of heat and light. The release of heat can result in the production of light in the form of either a glow or a flame.

The objective of combustion is to retrieve energy from the burning of fuels in the most efficient way possible. To maximize combustion efficiency, it is necessary to burn all fuel material with the least amount of losses. The more efficiently fuels are burned and energy is gathered, the cheaper the combustion process becomes.

Disadvantages of fuel combustion

The burning of fossil fuels has a number of very unpleasant side effects, ranging from health problems caused by air pollution to climate change caused by excess carbon dioxide in the global atmosphere.

Some effects of fuel **combustion are:**

- Air pollution — Hazardous substances such as carbon monoxide, sulphur dioxide, nitrogen oxides and volatile organic compounds are released into the atmosphere when fossil fuels are burned. Fuel combustion is the largest man-made source of air pollution.
- Acid rain — Sulphur dioxide and other pollutants contribute to acid rain. Acid rain can damage forest and aquatic ecosystems by increasing the pH level to above what native plants and animals can tolerate. pH is the measure of acidity or alkalinity.
- Smog — Various air pollutants combine to form smog, which can damage crops and cause respiratory problems in humans.
- Global warming — Fuel combustion produces carbon dioxide which forces heat to remain near the surface of Earth. The long-term effects of this excess carbon dioxide range from stronger storms to rising ocean levels, and many fear that the environmental damage may be irreversible.

Alternative energy sources

Due to threatening side-effects of fuel combustion on global warming, many are attempting to do what they can to encourage energy conservation and to live in a way that is far cleaner and less demanding of energy and fuel. Alternative energy sources such as wind, solar, and geothermal energy are growing in reputation as more and more people become aware of the ecological hazards associated with fossil fuels.

Test of oxygen

There are two key methods used to obtain oxygen gas. The first is by the distillation of liquid air. The second is to pass clean, dry air through a zeolite that absorbs nitrogen and leaves oxygen. A newer method, which gives oxygen of a higher purity, is to pass air over a partially permeable ceramic membrane.

In the laboratory it can be prepared by the electrolysis of water or by adding a manganese (IV) oxide catalyst to aqueous hydrogen peroxide.

Glowing splint test

The glowing splint test is a test for an oxidising gas, such as oxygen. A splint is a simple piece of equipment used in scientific laboratories. Splints are typically long, thin strips of wood, about 6 inches (150 mm) long and ¼ inch (6 mm) wide, and are consumable but inexpensive.

In this test, a splint is lit, allowed to burn for a few seconds, then blown out by mouth or by shaking. Whilst the ember at the tip is still glowing hot, the splint is introduced to the gas sample that has been trapped in a vessel.

Upon exposure to concentrated oxygen gas, the glowing ember flares, and re-ignites to produce a sustained flame. The more concentrated the oxygen, the faster the splint burns, and the more intense the flame. This test is not specific for oxygen, but will react similarly for any oxidising gas (such as nitrous oxide) that supports the combustion of the splint.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 1 **20 minutes**

Answer all the following questions:

1. What and how can you prove that oxygen is found almost anywhere.

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2. What kind of compound of oxygen is hydrogen peroxide? Search on its uses.

Thank you for completing your learning activity 1. Check your work. Answers are at the end of this module.

11.6.2 Oxides

An oxide is a compound of oxygen and another element found through the process of combustion.

Oxides are complex chemical substances that represent simple chemical compounds of the elements with oxygen.

There are three types of salt-forming oxides: basic oxides, acidic oxides and gas formed by electrical storms in the atmosphere; Carbon monoxide (CO), an odourless gas which is formed by the combustion of coal. It is usually called carbon monoxide. There are other oxides that do not form salts. Oxides of the elements across the periodic table from left to right change from basic to neutral to acidic.

Basic Oxides

Basic oxide is a complex chemical substance which forms a salt with a chemical reaction with acids or acidic oxides and does not react with bases or basic oxides. Basic oxides include the following Potassium oxide (K_2O), Calcium oxide (CaO), and Iron (II) oxide (FeO).

Properties
1. Do not react with bases.
2. React with acids to form salt and water.
3. Basic Oxides are usually insoluble in water. Those that do dissolve in water form alkaline solutions.

Examples:
1. Reaction with water
   React with water and form a base (or alkali); example, Calcium oxide (CaO) + Water (H_2O) = Calcium hydroxide ($Ca(OH)_2$); (reaction is known as liming, it releases a large amount of heat)

2. Reaction with acids
   React with acid and forms of salt and water (a solution of salt in water)
   $CaO+H_2SO_4 = CaSO_4+ H_2O$ (Crystals of this substance $CaSO_4$ known as "plaster of Paris").

3. React with acidic oxides to form salts
   $CaO+CO_2=CaCO_3$ (This substance is known as chalk!)

Acidic Oxides

An acid oxide is a complex chemical substance which forms a salt with a chemical reaction with bases or basic oxides.

Properties
1. Do not react with acids.
2. React with bases and alkalis to form salt and water.
3. Dissolve in water to form acidic solutions.
4. Usually gases at room temperature

Examples:
Carbon dioxide (CO_2), - Oxide of phosphorus (P_2O_5) formed in air if white phosphorus is burnt. Oxide of sulphur (VI) (SO_3) is a substance used for sulphuric acid.

Chemical reaction with water
Carbon Dioxide (CO_2) + Water (H_2O) =Carbonic acid (H_2CO_3) is a substance - carbonic acid is one of the weak acids, it is added to carbonated water for "bubbles" of gas. With increasing temperature the solubility of gas in water decreases, and the excess comes out in the form of bubbles.

Reaction with alkalis (bases)
Carbon dioxide (CO_2) +Sodium hydroxide (NaOH) = Sodium carbonate (Na_2CO_3) is widely used in agriculture. It is called soda ash or washing soda, a great cleanser for burnt pans, fat, burn-on. Carbon dioxide (CO_2) +Magnesium oxide (MgO) = Magnesium carbonate ($MgCO_3$) is also called **bitter salt.**

Amphoteric oxides
Amphoteric oxide is a complex chemical substance which forms a salt with chemical reactions with acids (or acid oxides) and with bases (or basic oxides). "Amphoteric" is used for the oxides of metals.

Property
React with both acids and bases to form salt and water

Example:
Zinc oxide (ZnO) (white powder, often used in medicine to produce masks and creams), Aluminum oxide (Al_2O_3) also called "alumina".

Chemical properties of amphoteric oxides are unique in that they can enter into a chemical reaction, appropriate as bases and acids.

Examples
Reaction with acidic oxide
(i) Zinc oxide (ZnO) +Carbonic acid (H_2CO_3) = Zinc carbonate ($ZnCO_3$)+ Water (H_2O)
(ii) Zinc oxide (ZnO) +Sodium hydroxide (2NaOH)=Sodium zincate (Na_2ZnO_2) + Water (H_2O)

Neutral Oxides

Neutral oxide is oxide which shows neither basic nor acidic properties when it reacts with water.

Property
Neutral pH

Examples
Carbon monoxide (CO) and Nitrous oxide (N_2O) which are only slightly soluble in water, and Nitric oxide (NO) which is appreciably soluble in cold water and Oxygen difluoride (O_2F_2).

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 2 **5 minutes**

1. Differentiate the different oxides and give examples of each.

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Thank you for completing your learning activity 2. Check your work. Answers are at the end of this module.

11.6.3 Chlorine

Chlorine is the second member of the halogen family. It is in the Periodic Table with other elements like bromine (Br) and iodine (I). Being a halogen, chlorine is found in many salts that are formed with both alkaline metals and alkaline earth metals (Groups I and II).

Always think about table salt that combines sodium with chlorine to form sodium chloride (NaCl). Scientists use the letter **Cl** to represent chlorine in chemical equations. Chlorine is in Group VII. It has seven electrons in its highest energy level. It gains an electron from another atom in reactions, forming a chloride ion, Cl^-.

It was not until 1774 that a chemist named Sir Humphrey Davy isolated chlorine gas. It is not clear like other gases. It actually has a greenish hue to it. Once Davy purified the element, science was able to prove that chlorine existed in thousands of compounds that we use every day. It makes all of those compounds, because it is super reactive. It is the main component in bleaches.

Uses of Chlorine

Chlorine combines directly with nearly every element**.** It is never found free in nature. Chlorine was first produced by Carl Wilhelm Scheele, a Swedish chemist, when he combined the mineral pyrolusite (MnO_2) with hydrochloric acid (HCl) in 1774.

Although Scheele thought the gas produced in his experiment contained oxygen, Sir Humphrey Davy proved in 1810 that it was actually a distinct element. Today, most chlorine is produced through the electrolysis of aqueous sodium chloride (NaCl).

Listed below are some of the most useful uses of chlorine.

(i) Swimming Pools
Have you ever gone swimming? When you go into the pool you are swimming with chlorine. People put chlorine in the pool to kill bacteria and disease. That addition makes the pool clean for you so you will not get sick.

(ii) Making Paper
When you write on white paper, that white paper is made from chlorine. Scientists use chlorine to make paper white. It bleaches the paper of all colours.

(iii) Bleach
Whenever you go to wash your clothes and you use bleach, that is chlorine you are using. Chlorine in bleach makes your white clothes really white. It also takes the colour out of your darker clothes.

(iv) Water purification
The next time you drink a glass of water you should thank chlorine. Chlorine is used to clean the water that comes to your house

(v) Table salt
The salt on your table is made with chlorine. Scientists discovered that salt is made of one chlorine atom combined with one sodium atom.

(vi) Plastics
PVC (poly-vinyl chloride) pipes are made up of plastic which contains chlorine.

11.6.4 Chlorides

Two of the most familiar chlorine compounds **are sodium chloride** (NaCl) and **hydrogen chloride** (HCl). Sodium chloride, commonly known as table salt, is used to season food and also in some industrial processes.

Hydrogen chloride, when mixed with water (H_2O), forms hydrochloric acid, a strong and commercially important acid. Hydrogen chloride and its aqueous solution, hydrochloric acid, are produced on megaton scale annually both as valued intermediates but sometimes as undesirable pollutants.

Other chlorine compounds include: chloroform ($CHCl_3$), carbon tetrachloride (CCl_4), potassium chloride (KCl), lithium chloride (LiCl), magnesium chloride ($MgCl_2$) and chlorine dioxide (ClO_2).

Chlorine combines with almost all elements to give chlorides. Compounds with oxygen, nitrogen, xenon, and krypton are known, but do not form by direct reaction of the elements. Chloride is one of the most common anions in nature.

Hydrochloric Acid

Hydrochloric acid has many uses. It is used in the production of chlorides, fertilizers, and dyes, in electroplating, and in the photographic, textile, and rubber industries. Hydrochloric acid is corrosive to the eyes, skin, and mucous membranes.

Acute (short-term) inhalation exposure may cause eye, nose, and respiratory tract irritation and inflammation and pulmonary edema in humans. Acute oral exposure may cause corrosion of the mucous membranes, esophagus, and stomach and dermal contact may produce severe burns, ulceration, and scarring in humans.

Chronic (long-term) occupational exposure to hydrochloric acid has been reported to cause gastritis, chronic bronchitis, dermatitis, and photosensitization in workers. Prolonged exposure to low concentrations may also cause dental discoloration and erosion.

Uses of hydrochloric acid

- in the production of chlorides,
- for refining ore in the production of tin and tantalum,
- for pickling and cleaning of metal products,
- in electroplating and removing scale from boilers,
- for the neutralization of basic systems,
- as a laboratory reagent,
- as a catalyst and solvent in organic syntheses,
- in the manufacture of fertilizers and dyes,
- for hydrolysing starch and proteins in the preparation of various food products, and
- in the photographic, textile, and rubber industries.

Acute Effects

- Hydrochloric acid is corrosive to the eyes, skin, and mucous membranes. Acute inhalation exposure may cause coughing, hoarseness, inflammation and ulceration of the respiratory tract, chest pain, and pulmonary edema in humans.

- Acute oral exposure may cause corrosion of the mucous membranes, esophagus, and stomach, with nausea, vomiting, and diarrhoea reported in humans. Dermal contact may produce severe burns, ulceration, and scarring.

- Pulmonary irritation, lesions of the upper respiratory tract, and laryngeal and pulmonary edema have been reported in rodents acutely exposed by inhalation.
- Acute animal tests in rats, mice, and rabbits, have demonstrated hydrochloric acid to have moderate to high acute toxicity from inhalation and moderate acute toxicity from oral exposure.

Chronic effects (non-cancer)

- Chronic occupational exposure to hydrochloric acid has been reported to cause gastritis, chronic bronchitis, dermatitis, and photosensitization in workers. Prolonged exposure to low concentrations may also cause dental discoloration and erosion.
- Chronic inhalation exposure caused hyperplasia of the nasal mucosa, larynx, and trachea and lesions in the nasal cavity in rats.

Reproductive/Developmental effects

- No information is available on the reproductive or developmental effects of hydrochloric acid in humans.
- In rats exposed to hydrochloric acid by inhalation, severe dyspnea, cyanosis, and altered estrus cycles have been reported in dams, and increased fetal mortality and decreased fetal weight have been reported in the offspring.

Cancer Risk

- No information is available on the carcinogenic effects of hydrochloric acid in humans.
- In one study, no carcinogenic response was observed in rats exposed via inhalation.

Potassium Chloride

Potassium is a mineral that is found in many foods and is needed for several functions of our body, especially the beating of our heart.
Potassium chloride is used to prevent or to treat low blood levels of potassium (hypokalemia). Potassium levels can be low as a result of a disease or from taking certain medicines, or after a prolonged illness with diarrhoea or vomiting.

Potassium chloride side effects

These are some signs of an allergic reaction to potassium chloride: hives; difficulty breathing; swelling of your face, lips and tongue.

Stop using potassium chloride once any of these serious side effects become evident:

- confusion, anxiety, feeling like you might pass out;
- uneven heartbeat;
- extreme thirst, increased urination;
- leg discomfort;
- muscle weakness or limp feeling;
- numbness or tingly feeling in your hands or feet, or around your mouth;
- severe stomach pain, ongoing diarrhoea or vomiting;
- black, bloody, or tarry stools; or
- coughing up blood or vomit that looks like coffee grounds.

Less serious potassium chloride side effects may include:

- mild nausea or upset stomach;
- mild or occasional diarrhoea;
- slight tingling in your hands or feet; or
- appearance of a potassium chloride tablet in your stool.

Sodium Chloride

Sodium chloride-commonly known as salt-is used in medical treatments such as IV infusions and catheter flushes.

Uses
Sodium chloride is an ionic compound found in various foods and medical treatments. More commonly referred to as “salt” or “table salt,” sodium chloride is used as a seasoning in many foods.

Medically, sodium chloride solutions are used in catheter flush injections or intravenous infusions, and for cleaning objects such as contact lenses in the form of saline. Sodium chloride inhalation can remove certain bacteria in body secretions.
Excessive sodium chloride intake has been linked to:

- heart disease
- diabetes
- gastric cancer

Side Effects
Sodium chloride consumption can induce bloating. Injections of sodium chloride can induce irritation at the injection site

Vinyl chloride
Vinyl chloride is an organochloride with the formula $H_2C=CHCl$ that is also called vinyl chloride monomer (VCM) or chloroethene. This colourless compound is an important industrial chemical chiefly used to produce the polymerpolyvinyl chloride (PVC). VCM is among the top twenty largest petrochemicals (petroleum-derived chemicals) in world production.

Vinyl chloride is a gas with a sweet odour. It is highly toxic, flammable, and carcinogenic. It can be formed in the environment when soil organisms break down "chlorinated" solvents. Vinyl chloride that is released by industries or formed by the breakdown of other chlorinated chemicals can enter the air and drinking water supplies. Vinyl chloride is a common contaminant found near landfills.

Most vinyl chloride is used to make polyvinyl chloride (PVC) plastic and vinyl products. Acute (short-term) exposure to high levels of vinyl chloride in air has resulted in central nervous system (CNS) effects, such as dizziness, drowsiness, and headaches in humans.

Chronic (long-term) exposure to vinyl chloride through inhalation and oral exposure in humans has resulted in liver damage. Cancer is a major concern from exposure to vinyl chloride via inhalation, as vinyl chloride exposure has been shown to increase the risk of a rare form of liver cancer in humans.

Uses

- Most of the vinyl chloride produced is used to make polyvinyl chloride (PVC), a material used to manufacture a variety of plastic and vinyl products including pipes, wire and cable coatings, and packaging materials.
- Smaller amounts of vinyl chloride are used in furniture and automobile upholstery, wall coverings, housewares, and automotive parts.
- Vinyl chloride has been used in the past as a refrigerant.

Sources and Potential Exposure

- Ambient air concentrations of vinyl chloride are generally quite low, with exposure occurring from the discharge of exhaust gases from factories that manufacture or process vinyl chloride, or evapouration from areas where chemical wastes are stored.
- Air inside new cars may contain vinyl chloride at higher levels than detected in ambient air because vinyl chloride may outgas into the air from the new plastic parts.
- Drinking water may contain vinyl chloride released from contact with polyvinyl pipes.
- Vinyl chloride is a microbial degradation product of trichloroethylene in groundwater, and thus can be found in groundwater affected by trichloroethylene contamination.
- Occupational exposure to vinyl chloride may occur in those workers concerned with the production, use, transport, storage, and disposal of the chemical.

Acute Effects

- Acute exposure of humans to high levels of vinyl chloride via inhalation in humans has resulted in effects on the CNS, such as dizziness, drowsiness, headaches, and giddiness.
- Vinyl chloride is reported to be slightly irritating to the eyes and respiratory tract in humans.
- Acute exposure to extremely high levels of vinyl chloride has caused loss of consciousness, lung and kidney irritation, and inhibition of blood clotting in humans and cardiac arrhythmias in animals.
- Tests involving acute exposure of mice have shown vinyl chloride to have high acute toxicity from inhalation exposure.

Chronic Effects (Non-cancer)

- Liver damage may result in humans from chronic exposure to vinyl chloride, through both inhalation and oral exposure.
- CNS effects (including dizziness, drowsiness, fatigue, headache, visual and/or hearing disturbances, memory loss, and sleep disturbances) as well as peripheral nervous system symptoms (peripheral neuropathy, tingling, numbness, weakness, and pain in fingers) have also been reported in workers exposed to vinyl chloride.
- Animal studies have reported effects on the liver, kidney, and CNS from chronic exposure to vinyl chloride.

Reproductive/Developmental Effects

- Several case reports suggest that male sexual performance may be affected by vinyl chloride. However, these studies are limited by lack of quantitative exposure information and possible co-occurring exposure to other chemicals.
- Several epidemiological studies have reported an association between vinyl chloride exposure in pregnant women and an increased incidence of birth defects, while other studies have not reported similar findings.
- Epidemiological studies have suggested an association between men occupationally exposed to vinyl chloride and miscarriages in their wives' pregnancies although other studies have not supported these findings.
- Testicular damage and decreased male fertility have been reported in rats exposed to low levels for up to 12 months.
- Animal studies have reported decreased fetal weight and birth defects at levels that are also toxic to maternal animals in the offspring of rats exposed to vinyl chloride through inhalation.

Cancer Risk

- Inhaled vinyl chloride has been shown to increase the risk of a rare form of liver cancer (angiosarcoma of the liver) in humans.
- Animal studies have shown that vinyl chloride, via inhalation, increases the incidence of angiosarcoma of the liver and cancer of the liver.

Physical Properties

- Vinyl chloride is a colourless gas with a mild, sweet odour.
- The odour threshold for vinyl chloride is 3,000ppm.
- Vinyl chloride is slightly soluble in water and is quite flammable.
- The chemical formula for vinyl chloride is C_2H_3Cl and the molecular weight is 62.5 g/mol.
- The vapour pressure for vinyl chloride is 2,600mmHg at 25°C, and it has a log octanol/water partition coefficient (log K_{ow}) of 1.36.
- The half-life of vinyl chloride in air is a few hours.

Chlorofluorocarbon (CFC)

Chlorofluorocarbon (CFC) is an organic compound that contains carbon, chlorine, and fluorine, produced as a volatile derivative of methane and ethane. A common subclass is the hydrochlorofluorocarbons (HCFCs), which contain hydrogen, as well.

Chlorofluorocarbons (CFCs) are a family of chemical compounds developed back in the 1930's as safe, non-toxic, non-flammable alternative to dangerous substances like ammonia for purposes of refrigeration and spray can propellants. One of the elements that make up CFCs is chlorine. Very little chlorine exists naturally in the atmosphere. But it turns out that CFCs are an excellent way of introducing chlorine into the ozone layer. The ultraviolet radiation at this altitude breaks down CFCs, freeing the chlorine.

Under the proper conditions, this chlorine has the potential to destroy large amounts of ozone. This has indeed been observed, especially over Antarctica. As a consequence, levels of genetically harmful ultraviolet radiation have increased. **Development of alternatives for CFCs.**

Work on alternatives for chlorofluorocarbons in refrigerants began in the late 1970s after the first warnings of damage to stratospheric ozone were published. The hydrochlorofluorocarbons (HCFCs) are less stable in the lower atmosphere, enabling them to break down before reaching the ozone layer.

Nevertheless, a significant fraction of the HCFCs do break down in the stratosphere and they have contributed to more chlorine build up there than originally predicted. Later alternatives lacking the chlorine, the hydrofluorocarbons (HFCs) have an even shorter lifetime in the lower atmosphere. One of these compounds, HFC-134a, is now used in place of CFC-12 in automobile air conditioners.

Hydrocarbon refrigerants (a propane/isobutane blend) are also used extensively in mobile air conditioning systems as they have excellent thermodynamic properties and perform particularly well in high ambient temperatures. One of the natural refrigerants (along with Ammonia and Carbon Dioxide), hydrocarbons have negligible environmental impacts and are also used worldwide in domestic and commercial refrigeration applications, and are becoming available in new split system air conditioners.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 3 **20 minutes**

Answer the following questions:

1. List the uses of chlorine.
   (i) ____________________
   (ii) ____________________
   (iii) ____________________
   (iv) ____________________
   (v) ____________________
   (vi) ____________________

2. Give three examples of chlorine compounds and their uses.
   (i) ____________________
   (ii) ____________________
   (iii) ____________________

Thank you for completing your learning activity 3. Check your work. Answers are at the end of this module.

11.6.5 Carbon

1. Carbon is the 4th most common element in the Universe (after hydrogen, helium, and oxygen). It is the 15th most common element in the Earth's crust while it is the second most common element in the human body (behind oxygen). Carbon has the highest melting point of all elements, around 3500 °C (3773 K, 6332 °F).

2. It is found in the Earth's atmosphere in the form of carbon dioxide (CO_2). Although it only makes up a small percentage of the atmosphere it plays an important role, including being used by plants during photosynthesis.

3. Carbon plays a huge role in the world we live in, from the carbon dioxide in the air to the graphite in your pencil. You will find its imprint everywhere. The word carbon comes from the Latin word **carbon,** meaning coal.

4. Carbon is a chemical element with the symbol C and atomic number 6. Carbon forms a large number of compounds, more than any other element. Because of its willingness to bond to other non-metallic elements it is often referred to as the building block of life.

Uses of Carbon

- Carbon, commonly obtained from coal deposits, is usually processed into a form suitable for commercial use. Three naturally occurring allotropes of carbon are known to exist: amorphous, graphite and diamond.
- Amorphous carbon, also known as lampblack, gas black, channel black or carbon black, is used to make inks, paints and rubber products. It can also be pressed into shapes and is used to form the cores of most dry cell batteries, among other things.
- Graphite, one of the softest materials known is primarily used as a lubricant. In addition to its use as a lubricant, graphite, in a form known as coke, is used in large amounts in the production of steel.
- Although commonly called lead, the black material used in pencils is actually graphite.
- Diamond, one of the hardest substances known is typically used for jewellery.
- Commercial diamonds, made by squeezing graphite under high temperatures and pressures for several days or weeks, are primarily used to make things like diamond tipped saw blades.
- Carbon-14, a radioactive isotope of carbon with a half-life of 5,730 years, is used to find the age of formerly living things through a process known as radiocarbon dating.
- The theory behind carbon dating is fairly simple. Scientists know that a small amount of naturally occurring carbon is carbon-14. Although carbon-14 decays into nitrogen-14 through beta decay, the amount of carbon-14 in the environment remains constant because new carbon-14 is always being created in the upper atmosphere by cosmic rays. Living things tend to ingest materials that contain carbon.

The percentage of carbon-14 within living things is the same as the percentage of carbon-14 in the environment. Once an organism dies, it no longer ingests much of anything. The carbon-14 within that organism is no longer replaced and the percentage of carbon-14 begins to decrease as it decays. By measuring the percentage of carbon-14 in the remains of an organism, and by assuming that the natural abundance of carbon-14 has remained constant over time, scientists can estimate when that organism died.

For example, if the concentration of carbon-14 in the remains of an organism is half of the natural concentration of carbon-14, a scientist would estimate that the organism died about 5,730 years ago, the half-life of carbon-14.

Carbon Compounds

You might have seen the bubbling effect when lime juice is dropped on the floor, leaving a white mark. You might have observed the use of baking soda as a leavening agent to raise cookies and cakes. You may have wondered about the fizz when club soda or coke bottles are opened. It is a known fact that our favourite bakery items are rendered tasty by adding baking powder. The use of washing soda in laundries, in softening bore water, and the use of lime stone and lime water in making construction materials like cement and lime mortar - all of these involve carbonates or bicarbonates.

Carbonates and bicarbonates find their way from household things to metallurgical processes and even biological reactions. They are present in tooth pastes, black board and chalks**.**

It is observed that lime water, $Ca(OH)_2$ turns milky initially when carbon dioxide passes through it and becomes clear after passing an excess of carbon dioxide. Initially an insoluble white solid, $CaCO_3$ is formed. Hence, lime water turns milky. It is then converted to water soluble bicarbonate, $Ca(HCO_3)_2$ upon passing excess of carbon dioxide by making the solution clear again.

The reactions are summarized below.

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3\downarrow + H_2O$$

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

Note: The formation of calcium carbonate is one of the reactions that occurs during setting of lime mortar, which was used in the construction of old buildings.

It has been observed that a white precipitate is formed when aqueous solution of sodium hydroxide is preserved for a longer time in a container which is not closed properly. When sodium hydroxide (NaOH) reacts with excess carbon dioxide in air, it forms sodium carbonate ($NaHCO_3$).

$$NaOH + CO_2 \longleftrightarrow NaHCO_3$$

Test for Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is colourless and odourless. It can't be detected through direct observation. You will need to collect an air sample (or a CO_2 sample), then run one of several simple tests to identify the presence of the gas. You can bubble the gas through limewater, or you can hold a lit splint into the sample to see if it is extinguished by the presence of CO_2.

Collect a CO_2 sample.

To begin your test, you will need a sealed test tube filled with collected gas. You can collect carbon dioxide in a gas jar, a boiling tube, or another airtight container. Collection is usually performed over water in a beaker. CO_2 gas is denser than air, so you can collect it using "downward delivery" or a gas syringe.

- Mix calcium carbonate with Hydrochloric acid (HCl).The simplest way to collect carbon dioxide is to react calcium carbonate (or limestone chips) with Hydrochloric acid. First, pour 20ml of HCl into a conical flask. Add a spoonful of calcium carbonate (or limestone chips) to the HCL. When the reaction starts, cover the conical flask with a bung and delivery tube: you will collect the gas through the delivery tube and into an upturned test tube (which is immersed in bowl of water). If the water in the test tube is displaced, then gas is being collected.

You can continue to collect the gas for as long as the reaction occurs.
The equation is:

$$CaCO_3(s) + 2HCl(aq) ==> CaCl_2(aq) + H_2O(l) + CO_2(g).$$

Be very careful when working with Hydrochloric acid – wear gloves, a lab coat, and protective goggles, and do not let the acid touch your skin!

Cover the test tube with a bung**.** Put the tube on a rack to keep it safe until you perform the test. The "bung" is essentially a small cork or cap that allows you to pipe the contents of the test tube elsewhere through a connected delivery tube.
It is important to seal the CO_2 gas into the container. If you leave it open, the gas will mix with the air, and your test will be much less effective.

Lime water Test

The most effective way to test for CO_2 is to bubble the gas through "lime water", a diluted solution of calcium hydroxide (slaked lime). When you bubble carbon dioxide through the solution, it forms a solid precipitate of calcium carbonate – chalk or limestone. Calcium carbonate is insoluble in water. Thus, if there is CO_2 present in the sample, the limewater will turn milky, cloudy white.
Bubble the gas through the limewater. Half-fill a test tube with limewater – then boil it. Use a delivery tube to pipe the contents of the CO_2 sample test tube directly into the boiling limewater. You can use a flexible pipe or a (metal) straw as a delivery tube, if nothing better is around. Let the captured gas "bubble" through the liquid, and wait for the reaction to take place.

- If you don't want to boil anything, you can use a gas syringe to discharge the CO2gas directly into the half-filled limewater test tube. Stopper the test tube, then shake vigorously for 1-2 minutes. If there is carbon dioxide in the sample, then the solution should grow cloudy.
- Look for cloudy water. If CO_2 is present, the lime water will turn milky white with calcium carbonate particulates. If the limewater is boiling, and the gas is piped directly into the limewater, then the reaction should begin immediately. If nothing happens after a minute or so, you can safely assume that there is no carbon dioxide in your sample.
- Know the chemical reaction. Understand what exactly is taking place to indicate the presence of CO_2. The equation for the test is: $Ca(OH)_2$ (aq) + CO_2 (g) -> $CaCO_3$ (s) + H_2O.
- In non-chemistry language: liquid limewater + gas (which contain CO_2) reacts to solid lime (the particles) and liquid water.

Testing with a Lit Splint

Carbon dioxide extinguishes for fires, in high concentrations. You'll simply need to hold a small lit flame inside a test tube that you suspect contains CO_2. If the gas is present, the flame should go out immediately. Combustion (creation of a flame) is the reaction of oxygen with another substance; it is a rapid oxidation of the organic compound and a reduction of oxygen. The fire goes out because the oxygen is replaced by the CO_2, which is not a combustible gas.

- Bear in mind that any oxygen-free gas will also extinguish a flame in this manner. Thus, this is an unreliable test for carbon dioxide, and it may lead you to misidentify **the gas.**
- Make sure that the sample has been properly stored and stoppered before you try to test for CO_2. Be reasonably certain that the test tube does not contain any flammable or explosive gases; in this case, the introduction of fire could be dangerous, or at least very frightening.

Place a small flame inside the test tube. Use a splint or any long, thin strip of wood. In a pinch, a match or a lighter will do – but the further your hands are from the opening of the test tube, the safer your experiment will be. If the flame immediately goes out, there's likely a high concentration of CO_2 in the test tube.

Alternately, try using a gas syringe to put out a candle. Fill a syringe with carbon dioxide. Then, use a drop of molten wax to affix a short candle to the surface of a coin. Next, place the candle and coin into a wide-mouthed cup – and light the candle. Equip the syringe with the tubing, and push the syringe to transfer the CO_2 to the bottom of the cup. If you push out the entire contents of the syringe within a second or two, the flame should go out.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 4 **20 minutes**

Answer the following questions:

1. Give three uses of carbon to show its importance.
   (i) ____
   (ii) ____
   (iii) ____

2. What are the two carbon dioxide tests?
   (i) ____
   (ii) ____

Thank you for completing your learning activity 4. Check your work. Answers are at the end of this module.

11.6.6 Carbon in Living Things

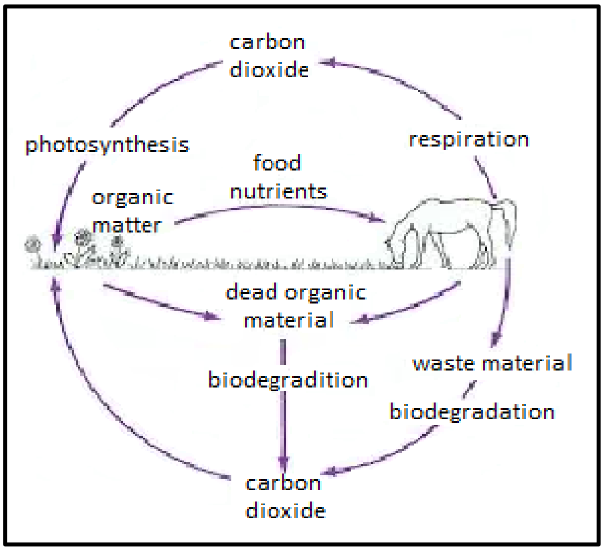
The Carbon Cycle

Carbon is the backbone of life on Earth. All living things are made of carbon. We are made of carbon, we eat carbon, and our civilizations, economies, homes, means of transport. We need carbon, but that need is also leading to global climate change.

Carbon is also a part of the ocean, air, and even rocks. Because the Earth is a dynamic place, carbon does not stay still. It is on the move! In the atmosphere, carbon combines with oxygen to form **carbon dioxide**.

Plants use carbon dioxide and sunlight to make their own food and grow. The carbon becomes part of the plant. Plants that die and are buried may turn into fossil fuels made of carbon like coal and oil over millions of years. When humans burn fossil fuels, most of the carbon quickly enters the atmosphere as carbon dioxide.

Carbon Cycle



Carbon dioxide is a greenhouse gas and traps heat in the atmosphere. Without it and other greenhouse gases, Earth would be a frozen world. But humans have burned so much fuel that there is about 30% more carbon dioxide in the air today than there was about 150 years ago, and Earth is becoming a warmer place.

The carbon cycle is the process in which carbon is exchanged between all parts of Earth and its living organisms. It is of vital importance to life on Earth, allowing carbon to be continually reused and recycled. The carbon cycle shows the movement of carbon between land, atmosphere, and oceans.

Instead of seeing the different stages of the carbon cycle, we shall try to answer this question: "Why is carbon important to life?" for a better understanding.

The question is simple and straight forward because most living things on Earth are made of carbon. Living things need carbon in order to live, grow, and reproduce. Carbon is a finite resource that circles through the Earth in many forms. This makes carbon available to living organisms and remains in balance with other chemical reactions in the atmosphere and in bodies of water like ponds, rivers and oceans.

We know that carbon is the basic building block for all forms of life on Earth. Fortunately, carbon is also one of the most abundant elements on our planet. Like all matter, carbon can neither be created nor destroyed, and so all living organisms must find a way to continually reuse the finite carbon supply that is available. By reading through you will find the ways of reusing that finite supply of carbon in the atmosphere and elsewhere.

Importance

Living things or creatures (living organisms) are, to a large extent, a series of chemical reactions occurring in a particular context. Therefore, the simplest explanation for the importance of carbon to living organisms/things is a chemical one. Carbon is the chemical basis for most of the molecules that are important to maintaining life. These molecules include carbohydrates, lipids (the category that includes fats), proteins and nucleic acids.

Photosynthesis

The radiation from the sun is the only source of outside energy available to our planet. However, some living organisms (such as animals) cannot use the sun directly to produce food and to keep themselves alive. We are all dependent on plants that have special ability to use the sun's radiation. Plants turn sunlight into food by combining the sun's energy with carbon, which plants absorb from the atmosphere in the form of carbon dioxide. Carbon is the key element for photosynthesis, which ultimately provides food for all living things on Earth, making it the primary producer.

Respiration

While photosynthesis is the way the sun's energy is combined with carbon to produce food, respiration is the way that food is turned into energy for use by a living organism. All of the food animals eat is based on carbon atoms (humans can eat carbohydrates, proteins and lipids). Animals use oxygen to convert this food into energy they can use, and to maintain a steady supply of carbon atoms that are necessary for building animal cells.

Respiration also returns carbon dioxide back to the atmosphere as a waste product, where plants can reabsorb it in the process of photosynthesis.

Decomposition

While an organism is alive, it acts as a **carbon sink**, or as a storage room for carbon atoms, because so many carbon atoms are being used to build the organism's skin, bark, toenails or leaves. However, as soon as an organism dies, these valuable carbon atoms begin to be returned to the environment, where they can be used by other organisms.

Decomposers are tiny microorganisms that live in soil and water and consume organic waste matter and dead organisms, returning the carbon back into the atmosphere in the form of carbon dioxide.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 5 **20 minutes**

Answer the following question:

1. Name the three important processes in the carbon cycle.
   (i) ____
   (ii) ____
   (iii) ____

2. Define the following:
   (i) Decomposers
   ____
   (ii) Decomposition
   ____

Thank you for completing your learning activity 5. Check your work. Answers are at the end of this module.

11.6.7 Fossil Fuels

Fossil fuels are essentially the remains of dead plants or animals that have been buried deep in the earth's crust. Fossil fuels power our life. They provide us with a source of non-renewable energy that took millions of years to develop and provide us light and heat to develop our modern lifestyles. Fossil fuels come in the form of **coal, oil or natural gas.** They are the cheapest and easiest of all fuels to acquire and use. These fossil fuels are extracted pumped from underground and used in a variety of ways.

Coal can form a synthetic fuel similar to natural gas. It can also be liquefied to make a synthetic crude oil. To date, it has not been economical to make synthetic fuels from coal on a large scale. As processes become more efficient, the use of synthetic fuels may become more economical.

Types of Fossil Fuels

(i) **Coal**
Coal is an abundant fossil resource that consists mostly of carbon. Coal reserves are located all over the world. Energy content (Btu/pound) ranges from 5,000 to 15,000 depending on the type of coal. Electric utilities consume about 87% of the total coal produced.
It is used to generate electricity and is found closer to the Earth's surface. It is also used to power machines such as cars and planes.

(ii) Oil
Oil comes from crude oil, which is a mix of hydrocarbons with some oxygen, nitrogen, and sulphur impurities. Crude oil reserves are found all over the world, but the Middle East alone has about 63% t of the known reserves. Crude oil is used to produce not only a range of fuels, but also petrochemical ingredients for plastics, inks, tires, pharmaceuticals, and a host of other products.

(iii) Natural gas
It is the gas component of coal and oil formation. It is used in industrial and commercial purpose and to fuel electricity generation. Natural gas can also be used as a transportation fuel. It is either found mixed in oil or is released from coal. World

reserves of natural gas are greatest in Russia, Iran, Qatar, Saudi Arabia, Arab Emirates, and the U.S. and most recently Papua New Guinea.

Wells for natural gas are from underground reservoirs of porous rock. When it is removed from a reservoir, natural gas can either be pumped to the processing station for removal of liquid hydrocarbons, sulphur, carbon dioxide, and other components, or stored in large caverns underground until it is needed. **Pipelines** are the main method of transporting natural gas. Natural gas can also be liquefied and shipped overseas, but this process is complex and expensive.

The main component of natural gas is methane, which is highly flammable. Natural gas has no smell. A chemical called **mercaptan** is added so that it can easily be detected. Natural gas is pumped to houses by way of underground pipelines that connect directly to the natural gas source.

Global warming is primarily driven by the burning of fossil fuels (coal, oil and natural gas) for energy. In addition to reducing the amount of energy we use in our personal lives, another avenue for individual impact is to pull our investments out of the fossil fuel industry

In November 2006, a giant gas field estimated to contain reserves of more than 113 billion m^3 was discovered on the upper reaches of the Purari River in Papua New Guinea (PNG). It is estimated that the giant reserve is capable of supplying a record 2.8 million $m^3$of gas and gas liquids a day.

InterOil, a Canadian oil and gas company, has been given the rights to extract the gas which is thought to be the biggest discovery of its kind in the history of PNG. It is believed that this new discovery could also be underpinned by a major oil basin.

One of the regions containing the highest levels of oil and gas deposits until now is also one of the most important biodiversity hotspots in PNG, the Kikori River Basin.

Oil refinery and oil search facility in Papua New Guinea

Formation of fossil fuels

Crude oil, coal and gas are fossil fuels.

They were formed over millions of years, from the remains of dead organisms,

- coal was formed from dead plant material
- crude oil and gas were formed from dead marine organisms.

Crude oil is a mixture of hydrocarbons. These are separated into useful products, such as fuels, using a process called fractional distillation.

The demand for short hydrocarbon molecules is greater than their supply in crude oil, so a reaction called cracking is used. **Cracking** converts long alkane molecules into shorter alkanes and alkenes, which are more useful. The exploitation of oil can damage the environment - for example, through oil spills.

How Fossil Fuel Formed?

- Fossil oil is trapped in some of the sedimentary rocks of the Earth's crust.
- Millions of years ago, huge numbers of microscopic animals and plants - plankton - died and fell to the bottom of the sea. Their remains were covered by mud.
- As the mud sediment was buried by more sediment, it started to change into rock as the temperature and pressure increased.
- As the trees and plants died, they sank to the bottom of the oceans. They formed layers of a spongy material called **peat**.
- Over many hundreds of years, the peat was covered by sand and clay and other minerals, which turned into a type of rock called sedimentary.
- The plant and animal remains were 'cooked' by this process, and slowly changed into fossil oil.

Oil is less dense than the water in the rocks. It will rise as a result of pressure from below. Often the oil will escape altogether if the rocks are permeable (liquids can pass through them).If some of the rocks above the oil are impermeable, the oil cannot rise through them, so it gets trapped underneath.

More rock piled on top of more rocks weighing more and more and it began to press down on the peat. The peat was squeezed and squeezed until all the water came out of it and it eventually, over millions of years; turned into coal, oil, petroleum and natural gas.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 6 **20 minutes**

Answer the following:

1. Explain the different types of fossil fuels?

____
____
____
____
____
____

2. Trace the steps in the formation of fossil fuels.

____
____
____
____
____
____
____
____
____

Thank you for completing your learning activity 6. Check your work. Answers are at the end of this module.

11.6.8 Fossil Fuels and the Environment

Environmental problems the world faces today include climate change, air pollution, oil spills, and acid rain which all result from our dependence on fossil fuels. The burning of fossil fuels produces heat-trapping gases that are the main cause of the ongoing rise in global atmospheric temperatures.

Despite a growing list of global warming indicators, underscored by the alarmingly rapid receding of the Arctic sea ice, opportunistic oil companies continue to exploit the ever-increasing human need for energy consumption and are constantly on the lookout for untapped oil and gas sources.

In addition to ecological disturbances from fossil fuel extraction, there are certain cultural consequences for commodities around the Pacific Rim. These commodities, many

indigenous, are threatened by the depletion of specific resources they depend upon for their livelihoods and culture.

Environmental problems
Oil is carried from oil fields to refineries using ocean-going tankers. If it is spilled, it causes considerable damage to the environment:

- oil slicks travel across the sea, far from the original spill
- beaches and wildlife are harmed when they are coated with oil.

Detergents are often used to help clean up oil slicks, but these in turn may harm wildlife.

Consequence of oil spills

The continuing expansion of drilling for oil and gas around the world is placing increasing pressure upon the global environment. More and more, the industry is seeking resources in remote and previously untouched areas of Papua New Guinea.

Pumping out resources, money and potential problems
Oil and gas exploitation are sources of significant income in Papua New Guinea. The problem is that these industries do not just generate cash. They can also potentially cause a range of environmental and social issues.

The continuing expansion of drilling for oil and gas around the world is placing increasing pressure upon the global environment. More and more, industry is seeking resources in remote and previously untouched areas, including the island of New Guinea.

What are the impacts?
The exploration of oil and gas deposits brings with it huge amounts of infrastructure, with pipelines and shipping routes stretching thousands of kilometres.

As a result, the potential for land clearance, pollution, oil spills and waste, can threaten marine, freshwater and forest habitats, and in turn the globally significant species and unique cultures that rely on them. One of the fundamental impacts of the industry is the contribution that the use of fossil fuels makes to climate change.

Possible solutions

(i) Manage and reduce emissions

Leading businesses are taking steps to understand and manage their greenhouse gas emissions by preparing annual greenhouse gas inventories and setting long-term targets to reduce emissions.

(ii) Increase energy efficiency

Improving energy efficiency not only reduces greenhouse gas emissions into the atmosphere, it is good for a corporation's bottom line. Developing and implementing an effective corporate energy management program allows companies to manage energy with the same expertise used to manage other aspects of their business.

(iii) Buy renewable energy

An organization's purchased electricity use can be a significant source of air pollution and greenhouse gas emissions. Buying renewable energy can help reduce an organization's environmental impact while also providing a number of other valuable benefits.

(iv) Conserve Energy

Air pollution from energy production leads to acid rain, excess greenhouse gases, and health risks. One important step you can take to minimize airborne nutrient pollution is to conserve energy. You can do this by:

- Turning off lights, computers, televisions, video games, and other electrical equipment when you're not using them.
- Buying equipment that uses less electricity, including lights, air conditioners, heaters, refrigerators, and washing machines. Energy Star-certified products and buildings use at least 10% less energy than standard models.
- Limiting the use of air conditioning.
- Installing a programmable thermostat.

Despite current dependence on fossil fuels, several options exist to begin the necessary transition away from a harmful fossil fuel economy. Improving the energy efficiency of buildings, vehicles, industrial processes, appliances, and equipment is the most immediate and cost effective way to reduce energy use.

Planning commodities where people can safely and conveniently use public transit, walk, or bike, instead of using private vehicles, also reduces energy demand. Finally, there are several alternative resources that can supply clean, renewable energy to replace fossil fuels, including water, biomass, wind, geothermal, and solar energy.

Energy from the sun, wind and the ocean's waves can help us reduce our use of fossil fuels. These energy sources will never run out, and they do not release carbon dioxide into the atmosphere. Switching to clean, renewable energy is a big step in helping our planet.

Now, check what you have just learnt by trying out the learning activity below!

Learning Activity 7 **20 minutes**

Answer the following questions:

1. List the environmental consequences brought about by the use of fossil fuels.
   (i) ____
   (ii) ____

---

2. What are the possible solutions that can be adopted to address the problem of pollution?
   (i) ____
   (ii) ____
   (iii) ____
   (iv) ____

Thank you for completing your learning activity 7. Check your work. Answers are at the end of this module.

REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE.

SUMMARY

You will now revise this module before doing Assessment 6. Here are the main points to help you revise. Refer to the module topic if you need more information.

- Non-metals total 17 and make up less than 25% of the known elements. Although they are few, they nonetheless constitute a large portion of the Earth's crust and are essential for the growth and existence of living things.
- Chlorine, nitrogen, oxygen, fluorine and helium make up the non-metal family.
- Oxygen makes up over twenty percent of the Earth's atmosphere. An oxide is a compound of oxygen and another element and includes water (H_2O), lithium oxide (Li_2O) and hydrogen peroxide (H_2O_2).
- Chlorine combines directly with nearly every element but is never found free in nature. It is produced through electrolysis of aqueous sodium chloride (NaCl). Its oxides include chlorides, chlorine oxides and chlorine fluorides.
- Carbon is often called the building block of life. There are several forms or allotropes of carbon but the most well - known are amorphous carbon (coal, soot and others), diamond and graphite. Its compounds include carbonates and bicarbonates.
- The use of carbon cannot be ignored. It is the backbone of human existence. However, its overuse has contributed to a serious problem to humanity – global climate change.
- Carbon cycle means exchange of carbon in all parts of the earth and its living organisms.
- Fossil fuels come in the form of coal, oil and natural gas which are engines of economic development. Derived from the decomposition of dead plants and animals and buried millions of years deep in the Earth's crust, their exploration and mining have brought about large scale environmental pollution due to unacceptable carbon emissions by developed countries like the USA, China, Russia and Australia. International efforts to cap carbon emissions to prevent a world-wide disaster which will seal the fate of nations are on-going.
- Papua New Guinea is the latest participant in oil and gas exploration. It has proven oil reserves of 170 million as of 2004 and its proven reserves of natural gas totalled 385.5 billion cu m in 2004. Production of LNG started in 2014 and initial export was sent to Japan in 2015.

NOW YOU MUST COMPLETE ASSESSMENT 6 AND RETURN IT TO THE PROVINCIAL CENTRE CO-ORDINATOR.

ANSWERS TO LEARNING ACTIVITIES 1 - 7

Learning Activity 1

1. It is found in water, rocks and soils, breathable air and plastics. Without oxygen, there will be no life on earth.
2. Hydrogen peroxide is adding another oxygen atom to water (H_2O) to form the chemical formula H_2O_2.
   Hydrogen peroxide is used as a common household disinfectant. It is used to bleach or dye hair, disinfects small cuts and wounds, as an antiseptic mouth rinse, helps heal boils, soften corns and calluses and relieves ear infections.

Learning Activity 2

1. (i) Acidic oxides are oxides of non-metals that react with water to form an acid; or react with a base to form a salt.

   Example: Carbon dioxide and sulphur dioxide

   (ii) Basic oxides are oxides that react with water to form a base; or react with an acid to form a salt and water.

   Example: Magnesium oxide and sodium oxide

   (iii) Neutral oxides are oxides which show neither basic nor acidic properties when they react with water.

   Example: Carbon monoxide (CO)and Water (H_2O)

   (iv) Amphoteric oxides are oxides that can act as either antacid or base in a reaction.

   Example: Zinc oxide and Aluminium trioxide

Learning Activity 3

1. (i) As table salt
   (ii) Bleaching agent
   (iii) Making paper
   (v) Plastic pipes
   (vi) In swimming pools to kill bacteria

2. (i) Sodium chloride – table salt for seasoning food and as an industrial preservative
   (ii) Hydrochloric acid – as commercial cleaning agent
   (iii) Potassium chloride – as fertilizer and as a cure to low blood levels of potassium in the body system.

Learning Activity 4

1. (i) Carbon is the building block of life since one of its compounds is carbon dioxide needed for photosynthesis.
   (ii) Graphite, an allotrope of carbon, is used as a lubricant.
   (iii) Plastics are made from carbon polymers.

2. (i) You can bubble the gas through limewater
   (II) you can hold a lit splint into the sample to see if it is extinguished by the presence of CO_2.

Learning Activity 5

1. (i) Photosynthesis
   (ii) Respiration
   (iii) Decomposition

2. Decomposition refers to the time an organism dies, its valuable carbon atoms begin to be returned to the environment, where they can be used by other organisms.

   Decomposers are tiny microorganisms that live in soil and water and consume organic waste matter and dead organisms, returning the carbon back into the atmosphere in the form of carbon dioxide.

Learning Activity 6

1. (i) Coal is an abundant fossil resource that consists mostly of carbon. It is used to generate electricity and to power machines such as cars and planes.
   (ii) Oil, from crude oil, is a mix of hydrocarbons with some oxygen, nitrogen, and sulphur impurities. It is used to produce not only a range of fuels, but also petrochemical ingredients for plastics, inks, tires, pharmaceuticals, and a host of other products.
   (iii) Natural gas is the gas component of coal and oil formation. It is used in industrial and commercial purpose and to fuel electricity generation.

2. (i) Fossil oil is trapped in some of the sedimentary rocks of the Earth's crust.
   (ii) Millions of years ago, huge numbers of microscopic animals and plants - plankton - died and fell to the bottom of the sea. Their remains were covered by mud.
   (iii) As the mud sediment was buried by more sediment, it started to change into rock as the temperature and pressure increased.
   (iv) As the trees and plants died, they sank to the bottom of the swamps of oceans. They formed layers of a spongy material called peat.
   (v) Over many hundreds of years, the peat was covered by sand and clay and other minerals, which turned into a type of rock called sedimentary rock.
   (vi) The plant and animal remains were 'cooked' by this process, and slowly changed into fossil oil.

Learning Activity 7

1. (i) Oil is carried from oil fields to refineries using ocean-going tankers. If it is spilled, it causes considerable damage to the environment.
   (ii) The potential for land clearance, pollution, oil spills and waste can threaten marine, freshwater and forest habitats, and in turn the globally significant species and unique cultures that rely on them. Detergents are often used to help clean up oil slicks, but these in turn may harm wildlife.

   (iii) One of the fundamental impacts of fossil fuel use is climate change.

2. (i) Manage and reduce emissions
   Leading businesses are taking steps to understand and manage their greenhouse gas emissions by preparing annual greenhouse gas inventories and setting long-term targets to reduce emissions.

(ii) Increase energy efficiency
Improving energy efficiency not only reduces greenhouse gas emissions into the atmosphere, it is good for a corporation's bottom line. Developing and implementing an effective corporate energy management program allows companies to manage energy with the same expertise used to manage other aspects of their business.

(iii) Buy renewable energy
An organization's purchased electricity use can be a significant source of air pollution and greenhouse gas emissions. Buying renewable energy can help reduce an organization's environmental impact while also providing a number of other valuable benefits.

(iv) Conserve Energy such as Daylight Saving Time, four passengers in every car travelling.

(v) Alternative energy like solar, wind and water.

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FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONE (COORDINATOR)	CUG PHONE (SENIOR CLERK)
1	ALOTAU	P. O. Box 822, Alotau	6411343/6419195	72228130	72229051
2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
11	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	72229056
12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
13	MADANG	P. O. Box 2071, Madang	4222418	72228126	72229063
14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics – General / Advance
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

GRADES 11 & 12 COURSE PROGRAMMES			
No	**Science**	**Humanities**	**Business**
1	Applied English	Language & Literature	Language & Literature/Applied English
2	General / Advance Mathematics	General / Advance Mathematics	General / Advance Mathematics
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry and Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:

You must successfully complete 8 courses: 5 compulsory and 3 optional.