COURSE GUIDE

SED 328
ENERGY AND MATTER II

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UNIT STRUCTURE **PAGE**

Introduction

SED 328: Energy and Matter II is a three-credit and one-semester undergraduate course for chemistry students. The course is made up of eleven units spread across fifteen lectures weeks. This course will expand on SED 224 (Energy and Matter I). It will provide you with a deeper knowledge of the specific uses of the various forms of energy in agriculture, industry and homes. This course guide gives you an insight into introduction to energy in an elementary way and how to study the chemistry in larger dimension. It tells you about the course materials and how you can work your way through these materials. It suggests some general guidelines for the amount of time required of you on each unit in order to achieve the course aims and objectives successfully.

Course Competencies

You will learn about energy and heat, light energy, effects of energy and light in crop production; energy consumption in factories; temperature and human convenience; energy and growth; nuclear energy; splitting of atom. Entropy and experimental applications in physical and chemical processes, radiation and radiation effect on life and weather. The aim of this course is to expand your knowledge of energy and its application for human development. Specific focus is on thermal energy and nuclear energy. It also dwells extensively on the impact of light energy, nuclear energy and radiations on the living world. The impact of these types of energy on man is deeply emphasised.

Course Objectives

At the end of studying the course material, you should be able to:

- explain thermal energy and its applications
- explain light energy and its applications
- describe nuclear energy, how it is generated, its uses, advantages, and disadvantages
- define entropy and its experimental applications in physical and chemical processes
- explain the effects of radiation on life and weather.

Working through this Course

To complete this course, you are expected to read and understand each unit, also use textbooks and other materials which may be provided for you by the National Open University of Nigeria (NOUN). This course is expected to last for a period of one semester after which there will be a final examination. Attempt with all seriousness Self-Assessment

Exercises built into every unit in each module. At the end of the course, there is a final examination. The course should take about 30 weeks to complete.

You are supplied with the components of the course, what you have to do and how to allocate your time to each unit for timely and successful completion of the course. Devote adequate time to thoroughly study the course on your own but do not absent yourself from tutorial class sessions where you will meet and interact with facilitators and your colleagues.

Study Units

The course comprises of the following course units distributed in the two modules that make up the course.

Module 1 Thermal, Light and Nuclear Energy

Unit 1 Thermal (heat) energy, its generation and uses
Unit 2 Light energy, its generation and uses
Unit 3 Solar energy and its uses
Unit 4 Nuclear energy, meaning and production
Unit 5 Uses and advantages of Nuclear Energy
Unit 6 The disadvantages of nuclear energy

Module 2 Entropy and Radiation

Unit 1 Changes of States and Entropy
Unit 2 Application of entropy in physical and chemical processes
Unit 3 Radiation
Unit 4 Effect of radiation on life and weather I
Unit 5 Effect of radiation on life and weather II

References and Further Reading

Anyakoha, M. W. (2008). New school physics for senior secondary schools. Revised edition: AFP Africana First Publishers Limited.

Nelkon, M., & Parkeer, P. (1995). *Advanced Level Physics* (7^{th} ed.). Oxford: Heinemann Publishers.

Ojokuku, G. O. (2018). *Understanding chemistry for schools and colleges*. Press-On Chembooks.

White, B. (2009). Updated assessment of geothermal direct heat use in New Zealand. *New Zealand Association, Inc.* Web page assessed December, 2019.

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Presentation Schedule

Module 1 presents the subject matter content in six units. This module focuses on thermal, light, solar and nuclear energy.

Module 2 also presents the course in five units. It presents the subject matter content in five units focusing on entropy and radiation.

Your course materials have important dates for the early and timely completion and submission of your self-assessment exercise's and attending tutorials. You are expected to submit all your assignments by the stipulated time and date and guard against falling behind in your work.

Course Marking Schedule	
Assignment	**Marks**
Assignments 1 – 4	Four assignments, best three marks of the four counts 10% each of the 30% course marks.
End of course examination	70% of overall course marks
Total	**100% of course materials.**

Assessment

There are eleven (11) assignments in this course, covering all the units studied.

Self-Assessment Exercise

The self-assessment exercise's (SAEs) at the end of each unit are designed to test your understanding and application of the concepts learned. Besides, you would be assessed electronically, as a continuous assessment during the period of studying the course. This would make up 30 % of the total score for the course. The other 70% would be determined by examination of the course at the end of the course.

The TMAs is a continuous component of your course which accounts for 30% of the total score. You will be given three (3) TMAs to answer. These must be answered before you are allowed to sit for the end of course examination. The TMAs would be given to you by your facilitator or online and returned after you have done the assignment. Assignment questions for the units in this course are contained in the assignment file. You will be able to complete your assignment from the information and material contained in your reading, references and study units. However,

it is desirable that you are able to demonstrate that you have read and researched more into your references, which will give you a wider viewpoint of the subject.
Make sure that each assignment reaches your facilitator/submitted online, on or before the deadline given in the presentation schedule and assignment file. If for any reason you cannot complete your work on time, contact your facilitator before the assignment is due to discuss the possibility of an extension. Extension will not be granted after the due date unless there are exceptional circumstances.

Final Examination and Grading
The end of course examination for Energy and Matter II will be for about 3 hours and it has a value of 70% of the total course work. The examination will consist of questions, which will reflect the type of self-testing, practice exercise and Tutor-Marked Assignment problems you have previously encountered. All areas of the course will be assessed. You might find it useful to review your self-test, TMAs and comments on them before the examination. The end of course examination covers information from all parts of the course.

How to get the Most from the Course
In distance learning, the study units replace the lectures in the conventional systems. This is one of the great advantages of distance learning; you can read and work through specially designed study materials at your pace, and at a time and place that suit you best. Think of it as reading the lectures instead of listening to a lecturer. In the same way that a lecturer might set you some reading to do, the study units tell you when to read your set books or other material, and when to undertake computing practical work. Just as a lecturer might give you exercises in a face-to-face classroom situation; your study units also provide exercises for you to do at appropriate points. Each of the study units follows a common format and the first item is an introduction to the subject matter of the unit, detailing how a particular unit is integrated with the other units and the course as a whole.

Next is a set of learning objectives which itemise what you should be able to do by the time you have completed the unit. You should use these objectives to guide your study. When you have finished the unit, you must go back and check whether you have achieved the objectives. If you make a habit of doing this you will significantly improve your chances of passing the course. Exercises are interspersed within the units and answers are given. Working through this exercise will help you to achieve the objectives of the unit and help you to prepare for the assignments and examinations.

The following is a practical strategy for working through the course: Read this course guide thoroughly.

1. Organise a study schedule. Refer to the 'Course Overview' for more details. Note the time you are expected to spend on each unit and how the assignments relate to the units. Important information, e.g. details of your tutorials, and the date of the first day of the semester, is available from the WebCT OLE. You need to gather together all this information in one place, such as your diary or a wall calendar. Whatever method you choose to use, you should decide on and write in your own dates for working on each unit.
2. Once you have created your own study schedule, do everything you can to stick to it. The major reason for students' failure is that they get behind with their course work. If you get into difficulties with your schedule, please let your tutor know before it is too late for help.
3. Turn to Unit I and read the introduction and the objectives for the unit.
4. Assemble the study materials. Information about what you need for a unit is given in the 'Overview' at the beginning of each unit. You will almost always need both the study unit you are working on and one of your set books on your desk at the same time.
5. Work through the unit. The content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit you will be instructed to read sections from your set books or other articles. Use the unit to guide your reading.
6. Keep an eye on the WebCT OLE. Up-to-date course information will be continuously posted here.
7. Well before the relevant due dates (about 4 weeks before due dates), access the Assignment File on the WebCT OLE and download your next required assignment. Keep in mind that you will learn a lot by doing the assignments carefully. They have been designed to help you meet the objectives of the course and, therefore, will help you pass the examination. Submit all assignments not later than the due date.
8. Review the objectives for each study unit to confirm that you have achieved them. If you feel unsure about any of the objectives, review the study material or consult your tutor.
9. When you are confident that you have achieved a unit's objectives, you can then start on the next unit. Proceed unit by unit through the course and try to pace your study so that you keep yourself on schedule.
10. When you have submitted an assignment to the tutor for marking, do not wait for its return before starting on the next unit. Keep to your schedule. When the assignment is returned, pay particular

attention to your tutor's comments, both on the Tutor-Marked Assignment firm and also written on the assignment. Consult your tutor as soon as possible if you have any questions or problems.

11. After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this Course Guide).

Online Facilitation

There are 15 hours of tutorials provided in support of this course. You will be notified of the dates, times and location of the tutorials as well as the name and the phone number of your facilitator, as soon as you are allocated a tutorial group. Your facilitator will mark and comment on your assignments, keep a close watch on your progress and any difficulties you might face and provide assistance to you during the course. You are expected to mail your Tutor-Marked Assignment to your facilitator before the schedule date (at least two working days are required). They will be marked by your tutor and returned to you as soon as possible.

Do not delay to contact your facilitator by telephone or e-mail if you need assistance.
The following might be circumstances in which you would find assistance necessary, hence you would have to contact your facilitator if you:

- do not understand any part of the study or the assigned readings
- have difficulty with self-tests
- have a question or problem with an assignment or with the grading of an assignment.

You should endeavour to attend the tutorials. This is the only chance to have face to face contact with your course facilitator and to ask question which are answered instantly. You can raise any problem encountered in the course of your study. To gain more benefit from course tutorials prepare a question list before attending them. You will learn a lot from participating actively in discussions.

Course Information
Course Code: SED328
Course Title: Energy and Matter II
Credit Unit: Three Credit Unit (3CU)
Course Status:
Course Blub:
Semester:
Course Duration:
Required Hours for Study

Course Team
Course Developer: NOUN
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Date Reviewed: June, 2022
Instructional Designer:
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Ice Breaker

MODULE 1 THERMAL, LIGHT AND NUCLEAR ENERGY

Unit 1 Thermal (Heat) Energy its Generation and Uses

Unit Structure

1.1 Introduction

The terms matter and energy are familiar to all of us but their definitions, at least within chemistry, are not simple. We talk about energy all the time: in your body, energy contained in things, in a battery, in the sun, or in gasoline. Energy is the ability to do work or give off heat. The definition leads to more questions than answers. What is ability? How do we measure it? Have you ever wondered what makes something hot? The answer is not really far-fetched and may be simpler than you think. We make use of heat for so many things in our homes, from cooking to ironing of clothes to preservation of food items. Thermal (heat) energy is generated when the molecules that make up that object move faster. You have learnt earlier in SED224 that energy is the ability to do work and also that there are various forms of energy. Some of the common forms of energy: work, heat (thermal) energy, electrical energy and light energy. One of it forms is thermal energy. In this unit, you will learn about heat energy and how it is generated. You will also learn about the uses of thermal energy.

1.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- Define thermal energy
- List different ways in which thermal energy can be generated
- Mention different ways in which thermal energy can be used.

1.3 The Meaning of Thermal Energy

Thermal energy could be defined as energy possessed by an object, a substance or system due to the movement of atoms, molecules or particles within the object, a substance or the system. Thermal energy is also the portion of the thermodynamics (flow of heat energy) or internal energy of a system that is responsible for the temperature of the system. Thermal energy can also be described as the internal energy present in a system in a state of thermodynamics equilibrium by virtue of its temperature. Thermal energy is the energy a substance or system has related to its temperature. We use thermal energy to cook our food and heat our homes, and we use it to generate electricity.

Thermal energy is not exactly the same as heat but it is often also referred to as heat energy. Heat is the energy transferred between substances or systems due to a temperature difference between them. Hence a system could be said to contain thermal energy, but not that it contains heat because heat means energy transferred from one item to another.

When heat is transferred between objects or systems, the amount of heat transferred by the object depends on the speed and number of atoms or molecules in motion. The faster the atoms or molecules move, the higher the temperature, and the more atoms or molecules that are in motion, the greater the quantity of heat they transfer. Since thermal energy occurs as a result of the movement of particles, it is a form of kinetic energy, which is the energy due to motion. As heat energy is added to a gas, the molecules of the gas increase their velocity. Individual gas molecules have different velocities, though. The average kinetic energy determines the temperature. Temperature is not the same as heat. However, the motion of thermal energy is usually not visible, but we can feel or see its effects. Thermal energy results in something having an internal temperature. Temperature is measured in degrees Celsius or Fahrenheit using thermometer. The faster the particles move within an object or system, the higher the temperature that is recorded.

Fig. 1: Thermal Energy

1.3.1 Generation of Thermal Energy

Thermal energy can be generated through different means. Some of the ways through which thermal energy is generated are listed below:

- It can be generated from electricity using an electric iron.
- It can also be generated by burning of fuels like coal, kerosene, gasoline, diesel, and natural gas.

Petroleum and Coal
Coal has been a useful fuel for generating electricity for many decades because it is relatively cheap and available. Coal is in plentiful supply worldwide which generally makes its price and availability reliable.

Natural gas
Natural gas turbines produce a lot more electricity and less pollution than coal, meaning they put out much less carbon (I V) oxide into the atmosphere for the same output of electrical energy.

Wood
Wood is a major source of energy in developing countries. The rural communities especially rely on dry wood for cooking their food. Wood is considered economical even though it contributes significantly to deforestation.

1.3.2 Uses of Thermal Energy

Thermal energy is very useful to man. It is used in the following ways among others:

- cooking of our food
- heating of our homes
- generating electricity
- driving steam engines
- drying of food as a way of preserving them
- ironing of clothes
- manufacturing of chemicals
- generating steam for drying paper in paper manufacturing
- heating source for evaporators
- pasteurising milk in agriculture
- melting large scale snow

Thermal energy provides continuous, reliable energy that is not dependent on the weather.

Self-Assessment Exercise

1. Explain Thermal Energy.
2. List three means by which thermal energy can be generated.

1.4 Summary

In this unit, we have learnt that:

1. Thermal energy is a portion of the thermodynamics or internal energy of a system that is responsible for the temperature of the system
2. Thermal energy can be generated from coal, natural gas and wood.

Thermal energy can be used in different ways such as in generating electricity, driving engines, cooking etc. Thermal energy is generated due to the movement of particles within an object or a system. It is measured using the thermometer. It is used for many domestic and commercial processes.
3.

1.5 References/Further Readings/Web Resources

White, B. (2009). An assessment of geothermal direct heat use in New Zealand. *New Zealand Association, Inc.* Web page assessed December, 2019.

Zitzewitz, P. W., Haase, D. G. & Harper, K. A. (2017). Principles and problems, Student Edition. Columbus OH: Glencoe/McGraw-Hill

Answers to Self-Assessment Exercise

1. Explain Thermal Energy

Thermal energy is defined as energy possessed by an object or system due to the movement of atoms, molecules or particles within the object or the system. Thermal energy is the portion of the flow of heat energy or internal energy of a system that is responsible for the temperature of the system. Thermal energy is described as the internal energy present in a system in a state of thermodynamics equilibrium by virtue of its temperature. Thermal energy is the energy an object or system has related to its temperature. We use thermal energy to cook our food and heat our homes, and we use it to generate electricity.

2. List three means by which thermal energy can be generated.

a. Petroleum and coal
b. Natural gas
c. Wood

1a. Name four forms of energy

i. Heat energy
ii. Light energy
iii. Electrical energy
iv. Solar energy

b. State five uses of Thermal Energy to man

- cooking of our food
- heating of our homes
- generating electricity
- driving steam engines
- drying of food as a way of preserving them
- ironing of clothes
- manufacturing of chemicals
- generating steam for drying paper in paper manufacturing
- heating source for evaporators
- pasteurising milk in agriculture
- melting large scale snow

(Any five points mentioned from the above are correct)

Unit 2 Light Energy: Its Generation and Uses

Unit Structure

2.1 Introduction

Nature provides us with day and night. Day is characterised by light provided by sunlight while night is characterised by darkness occasionally reduced by moonlight and little light provided by stars. Light energy provided by sunlight is vital to the survival of all living things. Light energy gives us the opportunity to see and move around. In this unit, you will learn the meaning of light energy, how it is generated and its numerous uses.

2.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- describe light energy
- explain how light energy is generated
- give examples of some sources of light energy
- list some properties of light energy
- list the uses of light energy.

2.3 Meaning of Light Energy and its Generation

Light is a form of electromagnetic radiation emitted by hot objects like burning objects, lasers, bulbs, sun and other stars. It has the properties of a wave and can be characterised by its wavelength. The energy of electromagnetic radiation is inversely proportional to its wavelength. Light energy refers to the electromagnetic energy with the ability to make types of light visible to the human eye and is responsible for the sense of sight. It is a type of kinetic energy. It is nature's way of transferring energy through space. It can also be defined as the electromagnetic radiation of visible light. Light energy is the energy carried by photons which are minute packets of energy.

Light energy cannot really be classified into different types; however, they are distinguished by differences in their frequencies and wavelengths. This enables us to utilise them in different ways. They range from very low to extremely high frequency radiations; radio waves, microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays.

Theoretically, light energy has no mass. Light is simultaneously a wave and a particle. The higher the frequency of the energy, the more energy the light or electromagnetic radiation contains. The greater the frequency, the more energy each particle, called the photon. Light is always in motion and cannot be stored, so it is a kinetic type of energy. Light is the only wave that can travel though a vacuum. Light energy is very central among all forms of energy. The energy from the sun which is presented in form of light can be converted into various forms of energy.

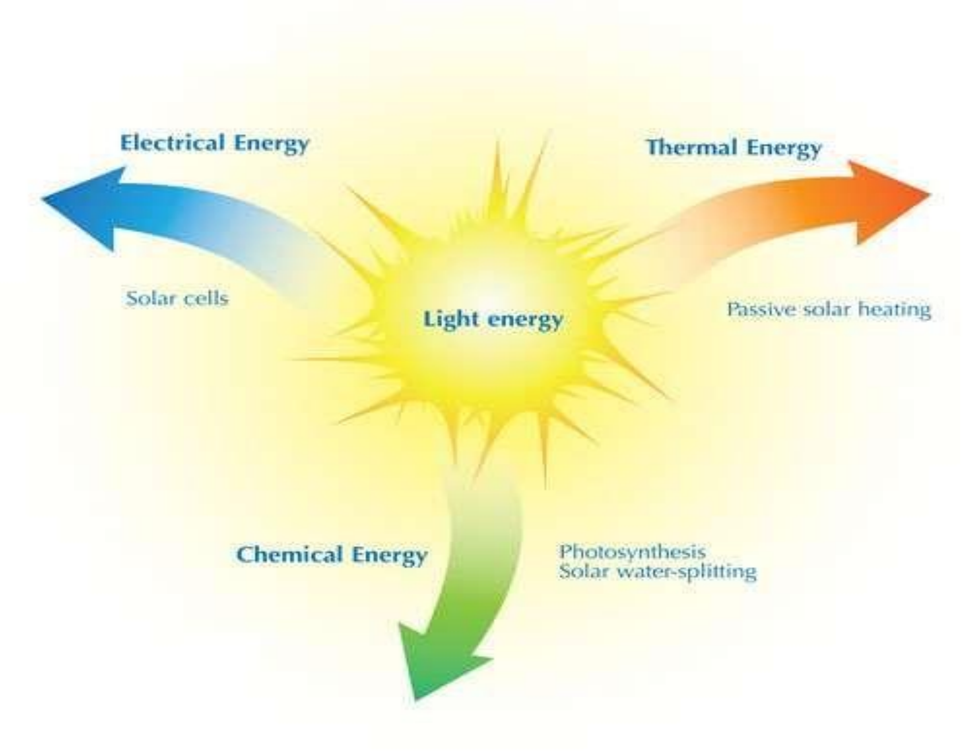


Fig. 1: Light Energy and its Transformations

2.3.1 Sources of Light Energy

The natural source of light energy on our planet is the sun. Sunlight provides the energy that is utilised by green plants to create sugars mostly in the form of starches. The sugars release energy into the living things that digest them. This process of photosynthesis provides all the energy required by living being to survive.

Other sources include:

- Stars
- Meteors
- Lightening
- Bioluminescence e.g. Glowworms, jellyfish, fireflies, foxfire (luminous fungus) generate their own light by themselves
- Earthquakes

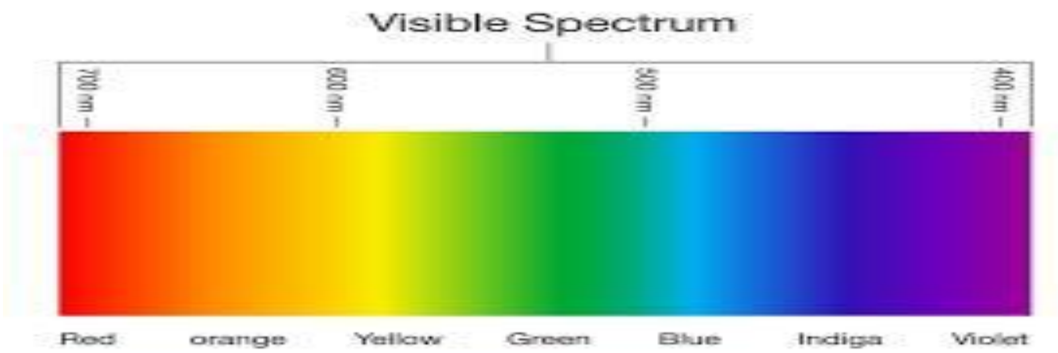
Apart from these natural sources of energy, light energy can be generated from:

a. electrical energy (electric current)
b. fire produced from fuels

2.3.2 Uses of Light Energy

Light energy is useful in the following ways:

- It enables our sense of sight to be activated. Any organism is able to view the objects around them due to the presence of eyes. But this might be useless without light.
- It facilitates photosynthesis thereby providing food and energy to plants and animals except for a few chemotropic bacteria
- It also provides some warmth to the environment
- It can be transformed into electrical energy and used to power machines
- It consists of many spectra and every spectrum has an individual colour which is broadly specified as ROYGBIV/VIBGYOR. The reason we see different colours of light is because each colour has a different wavelength.
-



There are different forms of light energy like Visible light, Infrared light, Ultraviolet/X-ray which have some properties. You will also need to know these properties of light energy when studying light spectrum.

2.4 Properties of Light Energy

- **Intensity**: The intensity of light is the rate at which light energy emitted from the source through unit area.
- **Frequency**: Light rays come in multiple frequencies. The frequency of light is the number of waves that passes through a point.
- **Polarisation**: Polarisation of light is a process in which unpolarised light is converted to polarised light.
- **Phase**: Phase is a point in time period during the cyclic waveform. It is observed that the intensity of light increases when the waves are in phase.

You should also know that *Radiometry* is a unit of light energy which measures light power of all wavelength and *Photometry* measures light with wavelength weighted with reference to human brightness perception.

Self-Assessment Exercise

1. Why does light energy from the sun reach the earth while het energy does not?
2. Explain the uses of light energy
3. Explain the various uses of light energy.
4. List three forms of light energy.
5. The energy from the sun which is presented in form of light can be converted into various forms of energy. List them.
6. Explain five sources of Light energy

Light energy refers to the electromagnetic energy that is visible to the human eye and is responsible for the sense of sight. Apart from giving us the grace to see, light energy contributes to life to a great extent.

2.5 Summary

In this unit, you have learnt that:

i. Light energy is an electromagnetic radiation carried by photons
ii. The sources of light energy include sunlight, meteors, lightning etc.
iii. Light energy can be used for various purposes.
iv. Intensity, frequency, polarisation and phase are properties of light energy
v. Of all the forms of radiation and light on electromagnetic spectrum, humans can only visibly see a very small amount of light.

2.6 References/Further Readings/Web Resources

Davis, G. A. & Keller, J. D. (nd). What is light and how is it produced?

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http://www.fire2fusion.com/light-energy/examples-of-light-energy.html

https://www.dmme.virginia.gov/DE/LinkDocuments/HandbookLighting pdf

2.7 Possible Answers to Self-Assessment Exercise

1. Why does light energy from the sun reach the earth while het energy does not?
   Light energy can penetrate through empty space. Heat radiation cannot.
2. Explain the uses of light energy
   Light energy is useful in the following ways:

- It enables our sense of sight to be activated. Any organism is able to view the objects around them due to the presence of eyes. But this might be useless without light.
- It facilitates photosynthesis thereby providing food and energy to plants and animals except for a few chemotropic bacteria
- It also provides some warmth to the environment
- It can be transformed into electrical energy and used to power machines
- It consists of many spectra and every spectrum has an individual colour which allows us to see different colours of light are because each colour has a different wavelength.

3. Explain the various uses of light energy.
4. List three forms of light energy.
5. The energy from the sun which is presented in form of light can be converted into various forms of energy. List them.

a. Electrical energy
b. Thermal energy
c. Chemical energy
6. Explain five sources of Light energy
a. Sun
b. Stars
c. Meteors
d. Lightening
e. Bioluminescence

UNIT 3 Solar Energy and its Uses

Unit Structure

1.0 Introduction

Do you realize that energy is a very basic natural resource? Man uses energy for his daily activities. From sleeping to walking, eating, jumping, working, cooking, and most strenuous activities of man requires energy. The demand for energy is responsible for the frantic search for alternative sources of energy. Primary energy is obtained from non-renewable sources such as oil, gas, coal and uranium. Only a very small percentage comes from the renewable sources such as hydroelectric source windmill etc. However, the sun still remains the major source of energy (Solar Energy). Sun is the nearest star to us on earth. In fact, the sun is the major supplier of energy to the earth and to all planets within the solar system. Solar energy is inexhaustible source of energy. In this unit you shall learn of the energy from the sun and how this energy has been harnessed for use by all living things.

3.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- meaning of Solar Energy
- explain why the sun is regarded as the chief source of energy
- show that solar energy gives sensation of heat and light to man.
- mention different ways in which solar energy can be used.

3.3 Meaning and Application of Solar Energy

Solar energy is energy from the sun. The sun being a high temperature body emits energy in the form of heat. Solar energy is inexhaustible source of energy. It will remain available as long as the sun lasts.

The sun emits radiation of a wide range of wavelength, from gamma rays (the shortest most energetic) to radio waves (the longest and least energetic). The range between Ultra-Violet short wavelength and Infra-Red long wavelength is received by the earth from the sun as light and heat with maximum intensity in the visible green light. Solar energy is very necessary for the sustenance of life on earth; for example, a reduction of 7% of the solar energy reaching the earth will completely freeze the world earth. Solar energy is used directly in agriculture and forestry at least in the manufacture of plants food known as photosynthesis.

Water is involved in the generation of energy through a number of sources. Vapours are obtained from evaporation of water which replenishes the oceans, rivers, streams and dams in water. Any source of energy that is obtained from water could be said to be indirectly coming from the sun. Such sources like hydroelectric source of energy, windmill power, tidal waves power, geothermal power etc. have been fully discussed in SED224, but let us briefly remind ourselves.

3.3.1 Solar Energy Indirect Applications

Hydroelectric Source of Energy: This is an indirect exploitation source of heat. The oceans may be regarded as the boilers of hydroelectric plants and the sun is the source of heat. The water evaporated by the sun falls as rain on mountains, collects behind dams and drives turbines of the power stations. It is known that hydroelectric power contributes only few percentage of power to the world generation of electricity.

Windmill Power: This is another indirect exploitation of solar energy. Winds obtain their energy from the solar heat absorbed by the surface of the earth thus the atmosphere act as a giant heat engine converting this heat to kinetic energy of motion of the air. Windmills are used mainly for pumping water.

Tidal Waves Power: This is another indirect exploitation of solar energy. The tide rises and falls twice each day. By trapping each high tide and allowing it to flow out through generators, tidal energy can be converted to electrical energy.

Geothermal Power: This is also an indirect exploitation of solar energy as the earth is perpetually heated by the sun. The interior the earth is hot. The temperature of in the earth increases gradually with depth and reaches nearly 450000C at the centre of the earth. The heat obtained from such source operates with steam engines blowing out from wells drilled down to depths as much as 2200m. Geothermal sources near populated areas can be used directly to provide heat and steam for homes and industries.

Name two indirect exploitations of solar energy and give one practical application of each.

Any two of these: hydroelectric, windmill, tidal waves and geothermal

3.3.2 Solar Energy Direct Application

The solar energy technology is just gaining ground in Nigeria. You would recall that sunlight can be used to heat water and other materials on very sunny days. A bucket of water kept outside could become hot and piece of cloth spread outside dries quickly. The solar energy applications could be explained with solar water panel and solar cell.

Solar Water Panel
The panel consists of a blackened surface which absorbs energy directly from solar radiation. As water passes over the panel surface, it is heated up. The larger the panel area the more power it can produce. Solar panels are useful in home heating such as water bath heating.

Solar Cell
A solar cell is made of thing wafers of a semiconductor such as silicon. Solar cells convert the energy of sunlight directly into electric energy. The EMF of a silicon solar cell is about 0.6V. Large panels containing very many solar cells are needed for the generation of appreciable amount of electric power. Electricity can also be generated directly from light by use of photoelectric processes to produce solar cells. Such processes like Voltaic process, the barrier-layer cells, external photoelectric effect which will be discussed in another unit.

3.3.3 The Sun as the Chief Source of Energy

If you use a convex to focus the rays from the sun on a sheet of paper on a sunny day, the point of focus on the paper is either completely burnt or it is charred as a result of the heating up of the spot by the heat from the sun. When you wash your clothes, do you put them in your box directly? No, you need to keep them dry. This can be done by spreading the outside to allow sun to dry them.

Activities such as drying clothes, baking bricks, drying pepper, drying yams with the sun rays show that solar energy has sensation of heat. If you also use a dark cloth to cover your eyes you will notice that you could not see anything. What happens? We need light to see objects because we see light through the light they reflect to our eyes. When the objects cannot reflect light then we will be unable to see it and that is why we were unable to see any object when we covered our eyes with dark cloth. Immediately we removed the cloth the light from the sun enabled the object to reflect light to our eyes. Therefore solar energy has sensation of light.

3.3.4 Uses of Solar Energy

Solar energy is useful to man in the following ways:

- Photography
- Domestic heating
- Drying wet objects like clothes, crops etc.
- Preservation of food
- Earth satellites for operating solar battery
- Photosynthesis for manufacturing plants food
- Solar batteries for calculators
- Solar cells for watches
- Vitamins obtained from directly from the sun

Self-Assessment Exercise

1a. Name four forms of energy
 b. Why is the sun regarded as the chief source of energy?
2. Describe two activities to show that the sun gives sensation of heat and light
3. Name two direct and two indirect exploitation of solar energy and describe one of the indirect exploitation in details
4a. State four uses of solar energy to man
 b. Describe the solar water panel
5. Paint a container black and leave it outside on a sunny day. What happens after about 2 hours when you touch the can?

3.4 Summary

In this unit you have learnt that:

- The sun is the chief source of energy
- All energy is directly or indirectly from the sun
- The sun gives sensation of heat and light
- The indirect exploitation of solar energy include: Hydroelectric power, Windmill power, Tidal waves power and Geothermal power among others
- Solar energy is energy from the sun. solar energy is used directly in agriculture and forestry particularly in photosynthesis and food preservation
- Solar energy is used directly in the construction of solar water panel and solar cell

There are many uses of solar energy to man: as batteries for various purposes, as source of vitamins, photographing, domestic uses. The sun is a mighty ball of glowing solar gases. It is about 300,000 times bigger than the earth. The heat (thermal) and light being emitted by the glowing gases are from the photosphere portion of the sun. Solar energy is inexhaustible source of energy. It is estimated that solar energy will last 5 billion years in inexhaustible source of energy. It is also known to scientists that the total energy intercepted by the earth from the sun is 2.8 x 10^{10}MW but so far we are using only a small portion of this total energy. It is against this background that efforts are geared towards the development of techniques that might lead to the effective use of solar energy

3.5 References/Further Readings/Web Resources

Ojokuku, G. O. (2018). *Understanding chemistry for schools and colleges*. Press-On Chembooks, pp.487.

National Teachers' Institute (2000). Integrated Science Cycle 1, Module 7

3.6 Possible Answers to Self-Assessment Exercise(s)

1a. Name four forms of energy

- Hydroelectric
- Windmill Power
- Tidal Waves Power
- Geothermal Power

b. Why is the sun regarded as the chief source of energy?
Various activities such as drying clothes, baking bricks, drying pepper, drying yams with the sun rays show that solar energy is the chief source of energy.

2. Describe two activities to show that the sun gives sensation of heat and light:

i. Activities such as drying clothes, baking bricks, drying pepper, drying yams with the sun rays show that solar energy has sensation of heat.

ii. If you also use a dark cloth to cover your eyes you will notice that you could not see anything. What happens? We need light to see objects because we see light through the light they reflect to our eyes. When the objects cannot reflect light then we will be unable to see it and that is why we were unable to see any object when we covered our eyes with dark cloth. Immediately we removed the cloth the light from the sun enabled the object to reflect light to our eyes. Therefore solar energy has sensation of light.

3. Name two direct and two indirect exploitation of solar energy and describe one of the indirect exploitations in details.

Direct exploitation of solar energy:

i. Solar Water Panel

ii. Solar Cell

Indirect Exploitation

i. Hydroelectric Source of Energy

ii. Geothermal Power

Hydroelectric Source of Energy: This is an indirect exploitation source of heat. The oceans may be regarded as the boilers of hydroelectric plants and the sun is the source of heat. The water evaporated by the sun falls as rain on mountains, collects behind dams and drives turbines of the power stations. It is known that hydroelectric power contributes only few percentages of power to the world generation of electricity.

4a. State four uses of solar energy to man

Solar energy is useful to man in the following ways

- Photography
- Domestic heating
- Drying wet objects like clothes, crops etc.
- Preservation of food

b. Describe the solar water panel

Solar Water Panel: The panel consists of a blackened surface which absorbs energy directly from solar radiation. As water passes over the panel surface, it is heated up. The larger the panel area the more power it can produce. Solar panels are useful in home heating such as water bath heating.

5. Paint a container black and leave it outside on a sunny day. What happens after about 2 hours when you touch the can?

Solar energy gives the sensation of heat.

Unit 4 Nuclear Energy: Its Meaning and Production

Unit Structure

4.1 Introduction

The terms matter and energy are familiar to all of you. Everything around you are made up of tiny objects called atoms. An atom is made up of three sub-atomic particles: protons, neutrons and electrons. Most of the mass of each atom is concentrated in the centre (nucleus) and the rest of the mass in the cloud of electrons surrounding the nucleus. While the protons and neutrons are located in the nucleus of an atom, the electrons are located in the space outside the nucleus. Because protons and neutrons are located in the nucleus, they are collectively called nucleons. The word 'nuclear' is the derived from the word 'nucleus'. Hence, nuclear energy is the type of energy released when the nuclei of atoms are changed. It therefore involves changes in the protons and the neutrons in the nucleus. Nuclear energy is produced from the nuclei of Hydrogen and Uranium. In a nuclear reaction, the tremendous binding energy inside a hydrogen or uranium nucleus is released. Nuclear reactions occur in the nucleus of the atom of a radioactive element, due to energy changes.

4.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- define nuclear energy
- explain how nuclear energy is produced
- explain nuclear fission
- write a typical nuclear fission reaction.

4.3 The Nucleus and Nuclear Energy

Nuclear energy comes from splitting atoms in a reactor to heat water into steam, turn a turbine and generate electricity. Nuclear Energy is the energy located in the nucleus of an atom. Atoms are the smallest particles that can break a material. At the core of each atom there are two types of particles (neutrons and protons) that are held together. Nuclear energy is the energy that holds neutrons and protons together. The neutron is represented by the symbol $^{1}_{0}n$. This implies that it has a mass number of 1 and a nucleon number of 1. The mass number of an element is the number of protons added to the number of neutrons (nucleon number) possessed by the element or the number of electrons added to the number of neutrons. The number of protons in an atom is therefore the mass number minus the number of neutrons; this gives a value of 0 for protons. Comparing this with the Helium nucleus $^{4}_{2}H$, the Helium nucleus has 2 protons and 2 neutrons. Hence, it has a nucleon number of 4.

Fig. 1: A Nuclear Energy Plant

4.4 Production of Nuclear Energy

Nuclear energy can be produced in two ways: nuclear fusion and nuclear fission. In nuclear fusion, energy is released when atoms are combined or fused together to form a larger atom. This is how the sun produces energy. In nuclear fission, atoms are split into smaller atoms, releasing energy. Nuclear power plants can only use nuclear fission to produce electricity.

When one of these two physical reactions (nuclear fission and nuclear fusion) occurs, there is a slight loss of mass. This mass lost generates a big amount of heat energy, explained by Albert Einstein with his famous equation:

$E = mc^2$

Where M is the smallest amount of mass and C is the speed of light

Nuclear Fission

Nuclear fission occurs when the nucleus of an atom of a heavy element is split into two approximate equal parts with the release of a huge amount of heat energy and neutrons (radiation), which can cause a temperature rise of over one million degrees centigrade. It is usually a chain reaction.

This can be explained by the bombardment of Uranium-235 or Plutonium (Fission Products) with neutrons. This leads to the production of two other elements, Krypton and Barium.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + \text{Energy}$$

Also, when Uranium – 235 captures a fast moving neutron, it leads to the formation of nuclei of strontium and xenon, three new neutrons and a large quantity of heat.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{90}_{38}Sr + ^{144}_{54}Xe + 2^{1}_{0}n + \text{Energy}$$

When this happens, the total mass of the component products is less than the mass of the original Uranium. The nuclear energy released is the difference in mass. The process is used to generate electricity, and to produce new elements, radioisotopes and nuclear bombs.

Nuclear Fusion

Nuclear fusion is a process in the opposite of nuclear fission in which two or more light nuclei such as hydrogen or helium combine or fuse to form a heavier nucleus with the release of a large amount of energy. Such a reaction occurs at extremely high temperature (high activation energy). The reaction can only take place in the sun or where there is nuclear fission.

An example is the fusion of two nuclei of hydrogen atoms in the sun, α-particles together with positrons is emitted; the heat released is responsible for the sunlight we are enjoying on earth.

$$4^{1}_{1}H \rightarrow ^{4}_{2}\alpha + 2^{0}_{1}e + \text{Heat (Energy)}$$

In the man-made (artificial) hydrogen bomb, the nuclei of deuterium and tritium (both are isotopes of hydrogen) undergo nuclear fusion to produce α-particles, neutrons and a large quantity of heat.

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}H + ^{1}_{0}n + \text{Energy}$$

These reactions can release more energy than fission without producing as many radioactive by-products. The process is used to produce new elements, radioisotopes and atomic bombs. Advocates of nuclear energy submit that nuclear energy is a sustainable energy source that reduces carbon emissions and increases energy security leading to a decrease in human dependence on crude oil. Opponents of nuclear energy proliferation believe that it is a potentially dangerous energy source. However, new technologies are being developed to cater for the negative impacts of nuclear energy in the ecosystem. In the next units, the advantages and disadvantages of nuclear energy are enumerated.

Self-Assessment Exercise

1. What is meant by binding energy of the nucleus of an atom?
   The particles in a nucleus are collectively known as nucleons. If the total binding energy of a nucleus is divided by the number of nucleons it contains, we obtain the quality called the binding energy per nucleon. The binding energy is therefore the energy released during the formation of a nucleus from its constituents.
2. Define the following terms using examples:

i. Nuclear fission

ii. Nuclear fission

i. Nuclear fission is the process whereby the nucleus of a heavy element is split into two or more lighter nuclei of nearly equal mass with a release of energy and radiation.

ii. Nuclear fusion is the process whereby two or more light nuclei unit or combines to form a heavier nucleus, with a release of energy and radiation.

b. Balance the following equation and classify it as either nuclear fusion or nuclear fusion:

$$^{1}_{0}n \quad + \quad ^{235}_{92}U \quad \rightarrow \quad ^{141}_{56}Ba \quad + \quad Kr \quad + \quad 3\,^{1}_{0}n$$

$$^{1}_{0}n \quad + \quad ^{235}_{92}U \quad \rightarrow \quad ^{141}_{56}Ba \quad + \quad ^{92}_{36}Kr \quad + \quad 3\,^{1}_{0}n$$

3. In a nuclear fission of uranium-235, there is a mass loss of 0.20g/mol., velocity light 3.0 x $10^{8}ms^{-1}$. Calculate the quantity of heat associated with the mass loss.
4. What do you understand by nuclear energy?
5. Describe how nuclear energy is produced.
6. Write down an equation to illustrate nuclear fission, and another one to illustrate nuclear fusion.
7. State two differences between nuclear fission and nuclear fusion

4.5 Summary

You have learnt the following in this unit:

1. Nuclear Energy is the energy in the nucleus of an atom.
2. Nuclear energy can be produced in two ways: nuclear fusion and nuclear fission.

3. Nuclear fission is the splitting up of the nucleus of a heavy element into two approximate equal parts with the release of a huge amount of energy and neutrons.
4. Nuclear fusion is a process in which two or more light nuclei combine or fuse to form a heavier nucleus with the release of a large amount of energy.

Nuclear energy is beneficial and it can also be dangerous to the environment if not well controlled.

4.6 References/Further Readings/Web Resources

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4.7 Possible Answers to Self-Assessment Exercise

1. What is meant by binding energy of the nucleus of an atom?

The particles in a nucleus are collectively known as nucleons. If the total binding energy of a nucleus is divided by the number of nucleons it contains, we obtain the quality called the binding energy per nucleon. The binding energy is therefore the energy released during the formation of a nucleus from its constituents.

2. Define the following terms using examples:

i. Nuclear fission

ii. Nuclear fission

i. Nuclear fission is the process whereby the nucleus of a heavy element is split into two or more lighter nuclei of nearly equal mass with a release of energy and radiation.

ii. Nuclear fusion is the process whereby two or more light nuclei unit or combines to form a heavier nucleus, with a release of energy and radiation.

b. Balance the following equation and classify it as either nuclear fusion or nuclear fusion:

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + Kr + 3\,^{1}_{0}n$$

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$$

3. In a nuclear fission of uranium-235, there is a mass loss of 0.20g/mol., velocity light 3.0 x 10^8ms^{-1}. Calculate the quantity of heat associated with the mass loss.

E = energy in Joules
M = mass loss in kilogram = 0.20 x 10^{-6}kg
C = velocity of light = 3.0 x 10^8ms^{-1}
Using $E = mc^2$
Substituting:
$E = 0.20 \times 10^{-6} \times (3.0 \times 10^8)^2$
$E = 0.20 \times 10^{-6} \times 3.0 \times 10^8 \times 3.0 \times 10^8$
$E = 0.2 \times 9 \times 10^{10}$
$E = 1.80 \times 10^{10}$ kJ

4. What do you understand by nuclear energy?

Nuclear energy comes from splitting atoms in a reactor to heat water into steam, turn a turbine and generate electricity. Nuclear Energy is the energy located in the nucleus of an atom.

5. Describe how nuclear energy is produced.

Nuclear energy can be produced in two ways: nuclear fusion and nuclear fission. In nuclear fusion, energy is released when atoms are combined or fused together to form a larger atom.
In nuclear fission, atoms are split into smaller atoms, releasing energy. Nuclear power plants can only use nuclear fission to produce electricity.

6. Write down an equation to illustrate nuclear fission, and another one to illustrate nuclear fusion.

Nuclear fission

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{Energy}$$

$$4\,{}^{1}_{1}H \rightarrow {}^{4}_{2}\alpha + 2\,{}^{0}_{1}e + \text{Heat (Energy)}$$

Nuclear fusion

7. State two differences between nuclear fission and nuclear fusion

Nuclear fission is the splitting up of the nucleus of a heavy element into two approximate equal parts with the release of a huge amount of energy and neutrons.

Nuclear fusion is a process in which two or more light nuclei combine or fuse to form a heavier nucleus with the release of a large amount of energy.

Unit 5 Uses and Advantages of Nuclear Energy

Unit Structure

5.1 Introduction

A lot of money is spent on the generation of nuclear energy around the globe. It is the desire of every nation to be a nuclear power not only because of the respect it commands among the comity of nations but because of the huge amount of energy it can supply to the energy needs of the countries. In this unit, you will learn about the economic importance of nuclear energy.

5.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- list the uses of nuclear energy
- list and discuss the advantages of nuclear energy
- explain the problems associated with the use of Nuclear Energy.

5.3 Uses of Nuclear Energy

Before the discovery of nuclear energy, various forms of energy were already in use. However, the discovery of nuclear energy brought a new dimension into the way energy is used. Many nuclear power plants are now being used to generate cheap electricity.

Some of the uses of nuclear energy are listed as follows:

1. Radioisotopes from nuclear energy plants are used in agriculture as radioactive tracers and preservatives
2. Spacecrafts, ships and submarines are powered by nuclear energy because of their in-built reactors.
3. Medically, nuclear fission products obtained in nuclear reactor are used for radiotherapy.

4. Radio-pharmaceuticals are administered to the human body for diagnostic or therapeutic investigation of organ function (e.g. thyroid scintigraphy) is used in obtaining the image of the thyroid gland).

5.3.1 Advantages of Nuclear Energy

There are many advantages of using nuclear energy. Some of these are listed below:

1. Lower greenhouse gas emission: Nuclear energy is clean energy. It has been calculated that the emission of the greenhouse gas has reduced for nearly half due to the popularity in the use of nuclear power. Nuclear energy by far has the lowest impact on the environment since it does not release any gases like carbon (IV) oxide, methane which are largely responsible for greenhouse effect.
2. Powerful and efficient: It is powerful and efficient than other alternative source of energy like solar, wind etc.
3. Reliable: Unlike other source of energy like solar and wind to produce electricity, nuclear energy can be produced from nuclear power plants even in rough weather conditions. They can produce power 24/7 and need to be shut down for maintenance purpose only.
4. Low Fuel Cost: Nuclear energy is cheap. The main reason behind the low fuel cost is that it requires little amount of uranium to produce more energy as compared to traditional sources of energy. It is cheaper; the cost of uranium which is used as fuel in generating electricity is quite low.
5. Nuclear waste generates very little wastes compared to other sources of energy. One gram of uranium yields about as much energy as a ton of coal or oil - it is the famous “factor of a million”. Nuclear waste is correspondingly about a million times smaller than fossil fuel waste, and it is totally confined.
6. Safety: Nuclear power is safe, as proven by the record of half a century of commercial operation.
7. Reliable: Nuclear reactors provide base-load power and are available over 90% of the time; intervals between refuelings have been extended and down time for refueling has been reduced.
8. Competitive: The cost of nuclear power is competitive and stable. The cost of nuclear fuel is a small part of the price of a nuclear kiloWatt-hour, whereas fossil fueled power, especially oil and gas, is at the mercy of the market.
9. Inexhaustible: Uranium from which nuclear energy is generated is found everywhere in the crust of the Earth – it is more abundant than tin, for example.

10. Compact: A nuclear power station is very compact, occupying typically the area of a football stadium and its surrounding parking lots. Other sources of energy like solar cells, wind turbine farms and growing biomass, all require large areas of land.
11. Transportation: Nuclear energy is compact and is hence more easily transported.

5.3.2 Problems of Nuclear Energy

Other Benefits of Nuclear Energy include the following:

- Protects national security by ensuring leaders offers a resilient grid without carbon emissions and supports National defense
- Ensures US Leadership in technology
- Produces electricity reliably for sustainable development by giving a low costsafe and secure electricity
- Generates jobs more than any other type of energy facility
- Protects our air by emitting zero air pollutants and further protecting public health.
- Boost international development
- Powers electric vehicles
- It produces carbon-free electricity than other sources of energy and fight climate change
- It helps the doctors to diagnose and heal the sick
- It helps explore the depths of our oceans without using a single tank of gas
- Nuclear radiation helps to treat food and kill bacteria, insects and parasites that cause illness
- Consumers' products we come across everyday use small amount of radiation or contain some radioactive material, like smoke detectors photocopiers.
- For example manufacturers sterilises cosmetics, medical bandages and some personal hygiene products using radiation
- It helps to pump water locally.

Self-Assessment Exercise

1. Give one advantage and one disadvantage of nuclear energy power generation over the use of fossil fuel.
2. List and explain the uses of nuclear energy

5.4 Summary

In this unit, we have learnt:

1. The uses of nuclear energy.
2. The advantages and problems of using nuclear energy.

There are many uses to which nuclear energy could be put and it has many advantages and little problems.

5.5 References/Further Readings/Web Resources

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5.6 Answers to Self-Assessment Exercise

1. Give one advantage and one disadvantage of nuclear energy power generation over the use of fossil fuel.
   Advantage: A relatively small quantity of uranium is required for nuclear power generation for a very long period of time, while a relatively large quantity of fossil fuel will only last for short period.
   Disadvantage: Nuclear power generation produces toxic wastes, while fossil fuel produces non-toxic wastes.
2. List and explain the uses of nuclear energy
   Some of the uses of nuclear energy are listed as follows:

i. Radioisotopes from nuclear energy plants are used in agriculture as radioactive tracers and preservatives

ii. Spacecrafts, ships and submarines are powered by nuclear energy because of their in-built reactors.

iii. Medically, nuclear fission products obtained in nuclear reactor are used for radiotherapy.

iv. Radio-pharmaceuticals are administered to the human body for diagnostic or therapeutic investigation of organ function (e.g. thyroid scintigraphy) is used in obtaining the image of the thyroid gland).

Unit 6 The Disadvantages of Nuclear Energy

Unit Structure

6.1 Introduction

In spite of the numerous benefits derived from nuclear energy, its use also has some disadvantages. In this unit we shall look at some of the disadvantages and problems associated with the use of nuclear energy.

6.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- List and explain the disadvantages of nuclear energy
- Engage in a rigorous debate on nuclear power and man.

6.3 Disadvantages and Problems of Nuclear Energy

1. Nuclear Wastes are difficult to manage: When atoms split to release energy, the small atoms that are left behind as waste are often in excited states, emitting energetic particles that can cause biological damage. The waste produced by nuclear reactors needs to be disposed of at a safe place since they are extremely hazardous and can leak radiations if not stored properly. The storage of radioactive waste has been major problem for the expansion of nuclear programs.
2. Nuclear Accidents: The effect of nuclear accidents can be very devastating. The risk associated with the use of nuclear energy is very high. Small radiation leaks can cause devastating effect on man and animals and plants. Exposure to nuclear radiations is known to cause cancer in man. Three major accidents have been said to occur in commercial power plants. They are chernobyl (uncontrolled steam explosion), three-mile island (partial-core meltdown, where coolant level dropped) and Fukushima (station blackout caused by tsunami).

3. The production of nuclear energy leads to the production of many radioactive elements which if released to the environment can cause damage to living things.
4. Cost of installation: The complexity of installing nuclear energy causes the up-front cost. Even though nuclear energy is cheap, the initial capital to set up a nuclear plant is enormous and cannot be afforded even by many nations. Nuclear plants have a limited life and they have to be dismantled and reconstructed when they expire. This costs substantial amount of money.
5. Nuclear weapons: Nuclear weapons are among the most dangerous weapons on earth. Nuclear energy is being diverted from useful purposes to harmful purposes by many nations.
6. Nuclear power plants are objectives of terrorist organisations and this poses a great danger to the whole world.
7. It should also be noted that nuclear energy is non-renewable. Non-renewable
8. Nuclear power plants generate external dependence. Not many countries have Uranium mines and not all the countries have nuclear technology. This makes it difficult for them to run nuclear plants.

Self-Assessment Exercise

1. Give one reason why solid radioactive waste is not disposed by composting.
2. Do a research and give some examples of nuclear accidents that have happened in history.

6.4 Summary

In this unit, we have been able to list and explain the disadvantages of nuclear energy. In spite of the numerous benefits of nuclear energy, so many disadvantages also come with its use.

6.5 References/Further Readings/Web Resources

http://nuclear-energy.net/advantages-and-disadvantages-of-nuclear-energy.html

6.6 Answers to Self-Assessment Exercise

1. Give one reason why solid radioactive waste is not disposed by composting.

Solid radioactive waste should not be disposed by composting because it may decay and contaminate the soil or release harmful radiation.

2, Do a research and give some examples of nuclear accidents that have happened in history.

MODULE 2 ENTROPY AND RADIATION

Unit 1 Change of States and Entropy

Unit Structure

1.1 Introduction

In this unit, you will learn the meaning of entropy and discover how it can be applied to everyday situations. You will explore the second law of thermodynamics which is where entropy is introduced, and you will examine the formula for entropy and find out how to use it in a variety of ways.

Entropy, denoted by S, is a natural phenomenon which measures the degree of randomness or disorderliness in a system. All things naturally tend to move towards disorder, unless an effort is applied to put them in order. An increase in the orderliness of a system reduces entropy while a decrease in orderliness increases entropy. In like vein, when heat is released from a system, its entropy decrease and absorption of heat by a system increases its entropy. In chemical reactions, entropy is a function of the changes in enthalpy (ΔH) and free energy (ΔG) of the system.

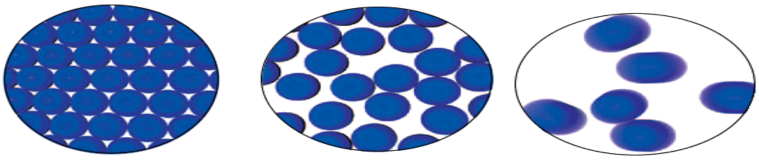
1.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- explain change of states
- define entropy
- explain how entropy of a system is affected by change in temperature.

1.3 Change of States

Let us say you have perfume and you pray it in the corner of a room. What happens? The perfume will not just stay in a corner of the room. The perfume molecules will fill up the room. The perfume went from an ordered state in a container to a state of disorder by spreading throughout the room. This situation explains the term entropy i.e. the number of ways a system can be arranged. Substances can change states, usually when they are heated or cooled. For example, when a solid is heated, the heat absorbed is used in increasing the vibration of the particles, and in breaking the various forces of cohesion between the particles. When enough heat has been absorbed by the particles they become mobile and eventually turn to liquid. The process whereby a solid changes to liquid is called melting. As the liquid is been heated, the heat absorbed is used in breaking up the forces of attraction between the particles. With time the particles become independent and turn to gas. The process whereby a liquid changes to gas is called boiling. See Figure 1.



Solid → Liquid → Gas

Fig. 1: Three States of Matter

The changes described here are reversible, that is can be made to proceed from gas to solid. When a gas is cooled, the particles lose heat to the surrounding, come together to reform the attractive forces, and turn to liquid. The process whereby heat is released to the surrounding from gas to liquid is called condensation. Further cooling of a liquid increases the forces of attraction between the particles, leading to the formation of a solid. The process is called freezing.

Gas → Liquid → Solid

Changes from solid to liquid, and then to gas represent change of states. During these changes, the arrangements of the particles are altered from a complete ordered state in solid (where there is no disorder), to a less ordered state in liquid (where there is a little disorder) and finally, to the least ordered state in a gas (where there is complete disorder). The property that describes the disorderliness of a system is called *entropy*. Solids have the lowest entropy where there is complete order, a liquid where there is less order have higher entropy than solids and in gases where there is complete disorder, and entropy is greatest.

1.3.1 Entropy and Entropy Changes

Entropy as a concept was developed over a long period of time. Human experienced chemical and physical changes that cannot be explained by energy alone. A different concept is required to explain spontaneous changes such as the expansion of a gas into an empty space (vacuum) and heat transfer from a hot body into a cold body. These changes cause an increase in entropy for the system under consideration, but energy is not transferred into or out of the system. Entropy can simply be defined as the measure of the disorder of a system. The concept of entropy is fundamental to understanding the second law of thermodynamics.

The Second Law of Thermodynamics

According to second law of thermodynamics, in any process that involves a cycle, the entropy of the system will either stay the same or increase. When the cyclic process is reversible then the entropy will not change. When the process is reversible, then entropy will increase.

Entropy (or more specifically, increase in entropy) is defined as heat (in calories or British Thermal Units [BTU's]) absorbed by a system, divided by the absolute temperature of the system at the time the heat is absorbed. Absolute temperature is the number of degrees above "absolute zero", the coldest temperature that can exist.

The total entropy in a system is represented by the symbol S. The symbol ΔS is used to represent a given change in the entropy content of a system. If the symbol q is used to represent the amount of heat absorbed by a system, the equation for the resulting entropy increase is:

$\Delta S = \frac{q}{T}$ or $\Delta S = \frac{\Delta q}{T}$

Where T is the absolute temperature

In chemical processes/reactions, entropy change is given as:

$$\Delta S = \frac{\Delta H - \Delta F}{T}$$

Where H is the enthalpy and F is the free energy (also known as the Gibb’s free energy). Likewise, ΔH and ΔF are incremental variations of those quantities. When heat is absorbed, the entropy of a system increases; when heat flows out of a system, its entropy decreases. Generally, an increase in temperature leads to an increase in entropy of a system.

The "surroundings" of a system is everything outside of the system that can interact with it; surroundings can usually be defined as the space that surrounds a system. When heat is evolved by a system, the same heat is absorbed by its surroundings. When heat is absorbed by a system the same heat must necessarily come from its surroundings. Therefore, any entropy increase in a system due to heat flow must be accompanied by an entropy decrease in the surroundings, and vice versa. When heat flows spontaneously from a hotter region to a cooler region, the entropy decrease in the hotter region will always be less than the entropy increase in the cooler region, because the greater the absolute temperature, the smaller the entropy change for any particular heat flow.

As an example, consider the entropy change when a large rock at 500 degrees absolute is dropped into water at 650 degrees absolute. (We are using an absolute temperature scale based on Fahrenheit degrees; on this scale, water freezes at 492 degrees.) For each BTU of heat that flows into the rock at these temperatures the entropy increase in the rock is $\frac{1}{500}$ = 0.0020 and the entropy decrease of the water is $\frac{1}{650}$ = 0.0015. The difference between these values is 0.0020 - 0.0015 = 0.0005. This represents the overall entropy increase of the system (rock) and its surroundings (water).

Of course, the rock will warm up to, and the water cool to, a temperature intermediate between their original temperatures, thus considerably complicating the calculation of total entropy change after equilibrium is achieved. Nevertheless, for every BTU of heat transferred from water to rock there will always be an increase of over-all net entropy. A spontaneous change is an irreversible change. Therefore an increase in the overall net entropy can be used as a measure of the irreversibility of spontaneous heat flow.

Irreversible changes in a system can, and often do, take place even though there may be no interaction, and negligible heat flow, between system and surroundings. In cases like these the entropy "content" of the system is greater after the change than before. Even when heat flow does not occur between system and surroundings, spontaneous changes inside an isolated system are always accompanied by an increase in the system's entropy, and this calculated entropy increase can be used as a measure of irreversibility. The following paragraphs will explain how this entropy increase can, at least in some cases, be calculated.

It is an axiom of thermodynamics that entropy, like temperature, pressure, density, etc., is a property of a system and depends only on the existing condition of the system. Regardless of the procedures followed in achieving a given condition, the entropy content for that condition is always the same. In other words, for any given set of values for pressure, temperature, density, composition, etc., there can be only one value for the entropy content. It is essential to remember this: When a system that has undergone an irreversible change is restored to its original condition (same temperature, pressure, volume, etc.) its entropy content will likewise be the same as it was before.

In cases where an isolated system undergoes an entropy increase as the result of a spontaneous change inside the system, we can calculate that entropy increase by postulating a procedure whereby the system's entropy increase is transferred to the surroundings in a manner such that there is no further increase in net entropy and the system is restored to its original condition.

It bears repeating that when the system is restored to its original condition, its entropy content will be the same as it was before its irreversible change. Therefore the amount of entropy absorbed by the surroundings during restoration must necessarily be the same as the entropy increase accompanying the system's original irreversible change, providing that there is no further increase in net entropy during restoration.

The entropy change in a physical or chemical transformation is written **ΔS**, and defined as $\mathbf{S_{products} - S_{reactants}}$. A positive ΔS denotes an increase in entropy on going from reactants to products, while a negative sign is associated with a decrease in entropy. The relationship between ΔS, ΔG and ΔH is expressed as $\Delta G = \Delta H - T\Delta S$ where T is the temperature of the system.

It should be noted that a given sign for ΔS carries a different interpretation than it does for ΔH. Accordingly, a negative ΔH is associated with an exothermic and energetically favourable transformation; but a negative ΔS indicates an increase in system order (a less random system), and this is entropically unfavourable. Depending on the case to which they apply, these two functions may complement (support) each other or act in opposition. In careful studies of rates and equilibria the consequence of this relationship must be calculated.

Because entropy increases proportionally with the randomness or statistical probability of a state, it is useful to identify and describe some common chemical transformations that result in significant changes in entropy.

1. For a given number of total atoms, a process that converts a few large molecules to many smaller molecules proceeds with a significant increase in entropy (ΔS^o is +).
2. If the total number of molecules remains unchanged, a process that converts a single molecular species to a mixture of different molecules proceeds with a significant increase in entropy (ΔS^o is +).
3. In general, a change from a condensed phase (solid or liquid) to a gaseous state will proceed with a significant increase in entropy (ΔS^o is +).
4. Ionisation reactions in solution are complicated by solvation effects. The expected increase in entropy from the first factor

listed above may be offset by solvent molecule orientation about the ions. This ordering of solvent molecules causes a decrease in ΔS^o.

Self-Assessment Exercise

1 Take a block of ice and drop it in half glass of warm water. After sometime touch the water and compare roughly the coldness or hotness with either the ice or the warm water.

2. Define entropy.
3. $C_{(s)} + H_2O_{(l)} \rightarrow CO_{(g)} + H_{2(g)}$
The reaction above was carried out at 37^0C. If the enthalpy change was +4500J, and the entropy change was $+13JK^{-1}$, calculate the free energy change and comment on the value.

1.4 Summary

In this unit, we have learnt that:

1. Entropy, S, is the measure of the disorder of a system.
2. In chemical processes, entropy is given as $\Delta S = \frac{\Delta H - \Delta F}{T}$.
3. The entropy change in a chemical transformation is $S_{products} - S_{reactants}$
4. A positive ΔS denotes an increase in the entropy after reaction while a negative ΔS denotes a decrease in entropy.

Any entropy increases in a system due to heat flow must be accompanied by an entropy decrease in the surroundings, and vice versa. A positive ΔS denotes an increase in entropy on going from reactants to products, while a negative sign is associated with a decrease in entropy. $\Delta G = \Delta G - T\,\Delta S$.

1.5 References/Further Readings/Web Resources

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1.6 Possible Answers to Self-Assessment Exercise

1. Take a block of ice and drop it in half glass of warm water. After sometime touch the water and compare roughly the coldness or hotness with either the ice or the warm water.

   You would observe that the mixture is hotter than ice and colder than warm water. When two objects at different temperatures are brought together the hotter one gives out heat to the colder one until the two attain a common temperature. When this happens the two bodies are said to be in thermal equilibrium with each other. What this means is that when two bodies are in thermal equilibrium, they have the same temperature.

2. Define entropy.
   Entropy can simply be defined as the measure of the disorder of a system.
3. $C_{(s)} + H_2O_{(l)} \rightarrow CO_{(g)} + H_{2(g)}$
   The reaction above was carried out at 37^0C. If the enthalpy change was +4500J, and the entropy change was $+13JK^{-1}$, calculate the free energy change and comment on the value

Data given:
$\Delta H = 4500J$; $T = 37 + 273 = 310K$; $\Delta S = +13JK^{-1}$
Using $\Delta G = \Delta H - T\Delta S$ for free energy change
$\Delta G = 4500J - (310 \times 13)J$
$\Delta G = (4500 - 4030)J = +470J$
Comment:
Since ΔG has a positive value, the reaction is not feasible at the stated temperature.

Unit 2 Application of Entropy in Physical and Chemical Processes

Unit Structure

2.1 Introduction

Entropy is applicable to both physical and chemical processes. A collection of objects will not arrange itself into a well-ordered pattern unless an effort is put in place to order them. Likewise, when water heated to boiling point is less easy to contain in a container than when water is cooled because entropy increases with increase in heat content and decrease in surrounding temperature. The entropy change, ΔS is the state of orderliness or disorderliness that accompanies physical and chemical processes. According to second law of thermodynamics, any process that occurs in nature is accompanied by an increase in entropy. In fact nature prefers condition of high entropy. In this unit we are going to consider the application of entropy.

2.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- illustrate the application of entropy to physical processes
- illustrate the application of entropy to chemical processes

2.3 Application of Entropy in Physical Processes

As a simple example, if you put a piece stone in a large box, and shook the box around, and you didn't look inside afterwards. Then the stone could be anywhere in the box. Because the box is large, there are many possible places inside the box that the stone could be, so the stone in the box has high entropy. Now suppose you put the stone in a tiny box and shook up the box. Now, even though you shook the box, you pretty much know where the stone is, because the box is small. In this case we say that the stone in the box has low entropy.

It is very interesting to compare the behaviour of entropy compared to energy. Unlike energy, entropy can be created (but not generally destroyed). In fact, your body is creating some right now as it generates heat. One of the reasons that your body temperature has to be higher than the surrounding air, or that you have to sweat off water if it isn't, is that you have to get rid of the extra entropy (otherwise, you would become disorganised and eventually die). The energy that your warm body radiates carries away the extra entropy. It does this because losing this energy decreases the number of microscopic states that the atoms and molecules of your body can be in.

Another practical example of entropy is the following. Suppose we want to use a source of heat, say, from steam generated by heating water, to drive some kind of turbine. Then, it turns out, by considering entropy, that the maximum efficiency of our process will be less than 100%. The reason that this is so is because when heat is brought into the turbine, it carries with it some entropy. We can't keep this entropy in the turbine, because the turbine would become microscopically disordered and eventually break. So, some heat energy has to be released to the outside world to get rid of this entropy to protect the turbine. The heat released for this purpose therefore can't be converted into work (otherwise it wouldn't be available anymore to release as heat). We get rid of the unwanted entropy by rejecting this heat to the outside world at a lower temperature than we brought the heat in at. The reason for the lower temperature is that the heat released into a low temperature environment carries out more entropy from the turbine than the entropy this same amount of heat carries into the turbine at a high temperature. This is because heat disrupts a cold system more than a hot one, because the hot one is already more disordered. Thus, we must only sacrifice some of the heat carried into the turbine to get rid of the entropy imported into the turbine by that heat in the first place. One can see from this discussion, however, why power plants need a cold temperature environment to dump their waste heat.

2.4 Application of Entropy in Chemical Processes

The same idea applicable to putting a piece of stone in a box earlier discussed also applies to the arrangements of atoms of a gas in a jar at room temperature. The smaller the jar, the lower the entropy at room temperature, but keep in mind that we also have to consider the velocities of the gas particles to have full knowledge of their states. The higher the temperature of the gas, the faster the gas particles are moving on average, so the wider the range of possible velocities for the gas particles, and hence, the more uncertainty we have about the velocity of any particular particle. Thus, higher temperature, as well as greater volume, means higher entropy

Knowing the entropy of a system can tell us many things about what can and can't happen. In particular, it’s the basis for the second law of thermodynamics: the Universe evolves such that its total entropy always stays the same or increases (Remember, the first law of thermodynamics is conservation of energy).

Let us examine the principle behind this. In fact, the basic idea of entropy is simple to understand. Suppose you are floating out in space and you have a jar containing a particular gas e.g., argon. When you open the jar for a moment, the argon will almost certainly escape out into space. After the argon has escaped, its entropy is greatly increased (and it continues to increase as the gas expands). The entropy increases because the number of states that the argon gas can be in when it occupies a much larger volume is much greater than when it is confined to the jar. So, the entropy of the gas increases when the argon escapes.

But why must the argon escape? Well, in fact, prior to opening the jar, if you arranged the microscopic states of the argon molecules in just the right way, you could open the jar for a moment and not have the argon escape. The point is that it is highly improbable that the argon is in one of these special non-escaping states when you open the jar - most of the states lead to the gas escaping. This is really the content of the second law - that if you begin not knowing the microscopic state of a system, then the system is more than likely to evolve to state where you are even more ignorant of its exact microscopic state. Just knowing the thermodynamic state variables of a system, such as its temperature and pressure, means you are in fact ignorant about the initial exact microscopic state - all you can know from the state variables is the number of possible microscopic states it can be in, i.e., the entropy. Hence, for most situations we encounter, chances are that entropy will increase with time.

The kinetic energy of the steam molecules is large (because the steam is hot), but the directions of the molecules are disordered. Somehow, to convert all of the energy of the steam into useful work, you'd have to line them all up in the same direction (at least, say, one at a time or in groups). But you're ignorant of the exact configuration at any given instant, right? And even if you weren't, how are you going to get in there and actually do it for each molecule? Clearly, the microscopic disorder is a barrier. This show why being ignorant of those details might seem minor intuitively, but actually has real consequences for real things you would like to do!

This example above demonstrates how heat energy, because it can't be completely converted to mechanical energy in a turbine, is, in a sense, of lesser quality than mechanical energy. People have in fact rated the quality of energy in this sense for many different sources. Solar electric energy captured by photovoltaic cells, in particular, is energy of very high "quality". Virtually all of it can be converted to mechanical energy. Entropy can also be applied to many other situations. For example, it can be used to predict the direction that a chemical reaction will proceed.

Self-Assessment Exercise

1a. Explain why the human body experiences a cooling sensation when methylated spirit touches the skin.
b. What can you say about the entropy change?
2. What is meant by the entropy change in a chemical system?
3. In relation to entropy, explain why the skin produces sweat in hot surrounding and develop goose pimples during cold weather.
4. Explain why steam is not a viable source of energy generation in relation to its entropy.

2.5 Summary

We have learnt that:

1. Entropy is applicable to both physical and chemical processes.
2. Unlike energy, entropy can be created but not destroyed.
3. The higher the heat Unit Structure of a body, the higher the entropy.
4. The entropy of a chemical reaction is a good indicator of the direction of chemical reaction. The entropy of a system is affected by volume and temperature.

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2.7 Answers to Self-Assessment Exercise

1a. Explain why the human body experiences a cooling sensation when methylated spirit touches the skin.

b. What can you say about the entropy change?

a. When methylated spirit, a highly volatile liquid touches the skin, its molecules draw the heat of vapourisation from the body to cause evaporation. Hence, as the molecules evaporate, the body temperature falls, causing the cooling of the body.

b. When a liquid turns to a gas (evaporation or boiling) there is an increase in entropy at any temperature.

2. What is meant by the entropy change in a chemical system?

The entropy change, **ΔS** is the state of orderliness or disorderliness that accompanies a chemical process.

$\Delta S = S_{products} - S_{reactants}$. If the entropy of products, $S_{products}$ is greater than the entropy of the reactants $S_{reactants}$ then, the entropy change, **ΔS** is positive, and vice versa.

3. In relation to entropy, explain why the skin produces sweat in hot surrounding and develop goose pimples during cold weather.

You have to get rid of the extra entropy as the energy that your warm body radiates carries away the extra entropy.

4. Explain why steam is not a viable source of energy generation in relation to its entropy.

Steam generated by heating water, to drive some kind of turbine. Then, it turns out, by considering entropy, that the maximum efficiency of our process will be less than 100%. The reason that this is so is because when heat is brought into the turbine, it carries with it some entropy. We can't keep this entropy in the turbine, because the turbine would become microscopically disordered and eventually break.

Unit 3 Radiations

Unit Structure

3.1 Introduction

Radiation or energy/particle transmission is one of the most important invisible things happening around us. Light from sunlight, a type of radiation, is a basic necessity of life. Infrared, ultraviolet rays, radio waves and x-rays are of vital applications in technology and medicine. Electromagnetic radiation occurs when charged light particles or photons are created, released and absorbed. Particles are either primary or secondary in nature, depending on their source and composition.

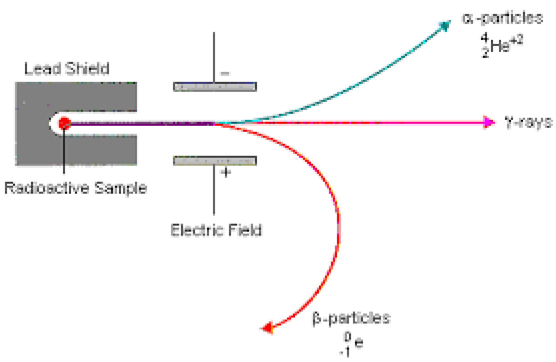
3.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- define radiation
- explain electromagnetic radiation and electromagnetic spectrum
- differentiate between primary and secondary particles.

3.3 Types of Radiation

Ernest Rutherford (1904), a physicist, studied the nature of radiations emitted during radioactivity; by subjecting the radiations from a small piece of uranium salt to a strong electromagnetic field. Three types of radiations were identified as *alpha* (α) rays are positively charged, *beta* (β) rays are negatively charged and *gamma* (γ) rays are neutral. He discovered that the alpha and beta rays were deflected in opposite directions by the magnetic field while the gamma rays were not deflected at all.



Radiation is the energy radiated or transmitted in the form of rays, waves or particles. Some examples include:

- Visible light that can be seen by naked eye;
- Infrared radiation;
- Ultraviolet radiation (UV) that cannot be seen with the naked eye;
- Long wave radiation, such as TV waves and radio waves;
- Very short waves, such as x-rays and gamma rays.

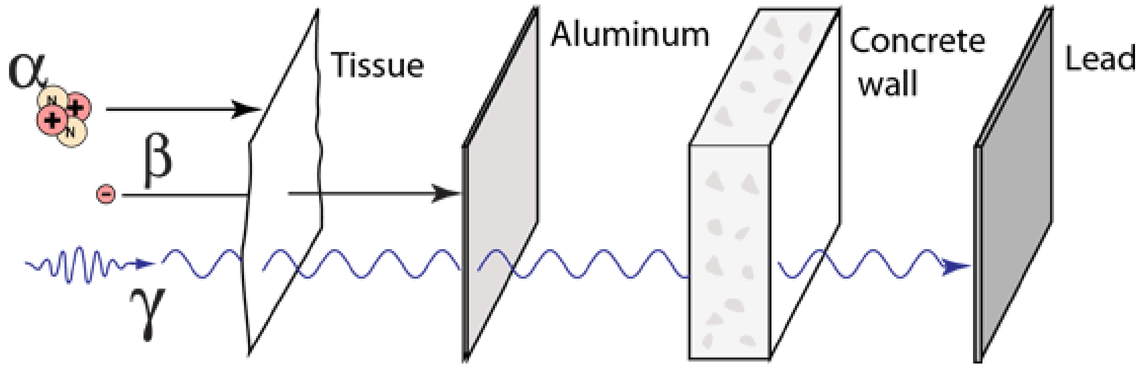
Properties of the Radioactive Radiations

Alpha (α) rays

- Alpha (α) rays consist of positively charged particles; hence, they are deflected towards the negative pole of the electromagnetic field.
- Alpha (α) rays are massive; hence, only slightly deflected and cause ionization on collision with particles on their path.
- Alpha (α) rays have the longest wavelength; hence, the least energetic and have the least penetrating power: a sheet of tissue paper or thin aluminum foil can stop them

  Beta (β) rays
- Beta (β) rays consist of negatively charged particles; hence, they deflected towards the positive pole of the electromagnetic field.
- Beta (β) rays are less massive than α-particles; hence, more deflected towards the positive pole
- Beta (β) rays have less ionizing effect than α-particles
- Beta (β) rays have a shorter wavelength than α-particles; hence, more energetic, move fast and have a high penetrating power. They will pass through a sheet of tissue paper or an aluminum foil. Only a 5 mm thick foil or a sheet of aluminum can stop
- Gamma (γ) rays have no mass or charge, (γ) rays are neutral; hence, they are not deflected at all by the magnetic field.
- Gamma (γ) rays have the least ionizing power
- Gamma (γ) rays have shortest wavelength; hence, the most energetic.

- Gamma (γ) move at the velocity of light and have the highest penetrating power. They can only be stopped by 15 cm thick steel or lead block Penetrating power of different types of radiation.



3.4 Electromagnetic Radiation and Spectrum

Electromagnetic Radiation

Energy from the sun comes to the earth in the form of electromagnetic radiation, which is a type of energy that oscillates (side to side) and is coupled with electric and magnetic fields that travel freely through space. Electromagnetic radiation is composed of photons or particles of light, which are sometimes referred to as packets of energy. Photons, like all particles, have properties of waves. Photons are created when electrons jump to lower energy levels in atoms, and absorbed when electrons jump to higher levels. Photons are also created when a charged particle, such as an electron or proton, is accelerated. An example of this phenomenon is a radio transmitter antenna that generates radio waves.

Electromagnetic Spectrum

The electromagnetic spectrum is a representation of the wide range of wavelengths of electromagnetic radiation. Photons are associated with visible light, which accounts for only a very limited part of the electromagnetic spectrum. A great discovery of the nineteenth century was that radio waves, x-rays, and gamma-rays are just forms of light, and that light is electromagnetic waves.

The reason why sunlight can hurt your skin or your eyes is because it contains ultraviolet light, which consists of high energy photons. These photons have short wavelength and high frequency, and pack enough energy in each photon to cause physical damage to your skin if they get past the outer layer of skin or the lens in your eye.

Radio waves, and the radiant heat you feel at a distance from a campfire, for example, are also forms of electromagnetic radiation, or light, except that they consist of low energy photons (long wavelength and high frequencies - in the infrared band and lower) that your eyes can't perceive. This was a great discovery of the nineteenth century - that radio waves, x-rays, and gamma-rays are just forms of light, and that light is electromagnetic waves.

Sources of Particles

Different Sources of Particles include:

Primary particles are formed from combustion sources and are emitted directly into the atmosphere. Examples of primary particles are dust from roads or black carbon (soot).

Secondary particles are formed in the atmosphere from primary gaseous emissions. Examples of secondary particles are sulfates formed from SO_2 emissions from power plants and industrial facilities; nitrates formed from NO_X emissions from power plants, automobiles, and other combustion sources; and carbon formed from organic gas emissions from automobiles and industrial facilities.

The chemical composition of particulate matter (PM) depends on location, time of year, and weather. Generally, primary particles make up coarse PM and secondary particles make up most of fine PM.

Detection of Radioactive Radiations

Radioactive radiations are not only harmful; they are dangerous being invisible. You can detect the radiations by the following instruments:

- Geiger-Muller counters
- Wilson diffusion cloud chamber
- Scintillation counter
- Photographic plate
- Fluorescent screen coated with zinc sulphide (ZnS)

Self-Assessment Exercise

1a. What are the three main types of radiations that are usually emitted by radioactive substances?
b. Give three properties of each
2. Give examples of waves/particles of radiation.
3. What is a photon?
4. Differentiate between primary particles and secondary particles.

3.5 Summary

We have learnt that:

1. Energy can be transmitted as rays, waves or particles in a process known as radiation.

2. Energy can be obtained from sunlight through the process of electromagnetic radiation (by the creation and absorption of photons).
3. Radio waves, x-rays and gamma-rays are also form of light waves or electromagnetic radiation.
4. Primary particles are product of combustion and released directly into the atmosphere.
5. Secondary particles are products of primary particles.

Radiation can either be visible or invisible to the human eye. It is available everywhere in the atmosphere and can be beneficial or harmful to life.

3.6 References/Further Readings/Web Resources

A Consumer's Guide to Energy Efficiency and Renewable Energy
Ojokuku, G. O. (2018). *Understanding chemistry for schools and colleges*. Press-On Chembooks, pp.279.

3.7 Possible Answers to Self-Assessment Exercise

1a. What are the three main types of radiations that are usually emitted by radioactive substances?
alpha (α), beta (β) and gamma (γ)

b. Give three properties of each
Properties of the Radioactive Radiations (Any three of the following)

Alpha (α) ray

- It consists of positively charged particles; hence, they are deflected towards the negative pole of the electromagnetic field.
- It massive; hence, only slightly deflected and cause ionization on collision with particles on their path.
- It has the longest wavelength; hence, the least energetic and has the least penetrating power: a sheet of tissue paper or thin aluminum foil can stop it.

Beta (β) ray

- It consists of negatively charged particles; hence, it deflected towards the positive pole of the electromagnetic field.
- It is less massive than α-particles; hence, more deflected towards the positive pole
- It has less ionizing effect than α-particles
- It has a shorter wavelength than α-particles; hence, more energetic, move fast and has a high penetrating power. It will pass through a sheet of tissue paper or an aluminum foil. Only a 5 mm thick foil or a sheet of aluminum can stop

Gamma (γ) ray

- It has no mass or charge, (γ) ray is neutral; hence, it is not deflected at all by the magnetic field.
- It has the least ionizing power
- It has shortest wavelength; hence, the most energetic.
- It moves at the velocity of light and has the highest penetrating power. It can only be stopped by 15 cm thick steel or lead block

b. Which of the nuclear particles has the following characteristics?

- Low penetrating
- Powerful ionizing power on gases
- Particulate

2. Give examples of waves/particles of radiation.

- Visible light that can be seen by naked eye;
- Infrared radiation;
- Ultraviolet radiation (UV) that cannot be seen with the naked eye;
- Long wave radiation, such as TV waves and radio waves;
- Very short waves, such as x-rays and gamma rays

3. What is a photon?

Photons are created when electrons jump to lower energy levels in atoms, and absorbed when electrons jump to higher levels. Photons are also created when a charged particle, such as an electron or proton, is accelerated. An example of this phenomenon is a radio transmitter antenna that generates radio waves.

4. Differentiate between primary particles and secondary particles.

Primary particles make up coarse PM and secondary particles make up most of fine PM.

Unit 4 Effects of Radiation on Life and Weather I

Unit Structure

4.1 Introduction

Radiation has already been described as a basic necessity of life. From photosynthesis and Vitamin D absorption to photography and telecommunication, the human gains from radiation are endless. However, scientists around the world are suggesting that radiation can turn out to be the biggest environmental challenge in the future. Many health hazards are already associated with exposure to radiation. The concept of global warming is more becoming a reality than a myth.

4.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- differentiate between primary and secondary pollutants.
- enumerate the health and environmental effects of primary and secondary pollutants
- explain how particulate matter affects human health.
- explain global warming
- explain the likely and uncertain effects of global warming

4.3 Effects of Radiation on Life and Weather I

Health and Environmental Effects of Primary Pollutants
The pollutants that are emitted directly from a combustion process – or the products of combustion - are called “primary pollutants.”

Carbon (IV) Oxide (CO_2)
Carbon (IV) oxide (CO_2) is not a pollutant that would harm our health but it is a proven greenhouse gas. It has an ability to absorb infrared radiation that is escaping from the surface of the earth causing the atmosphere to warm up. Excessive emission of CO_2 along with other greenhouse gases is thought to contribute to the undesirable climate change.

Carbon (II) Oxide (CO)

Carbon (II) oxide, or CO, is a colourless, odourless and tasteless gas that is formed when carbon in fuel is not burned completely.

At much higher levels of exposure not commonly found in ambient air, CO can be poisonous, and even healthy individuals can be affected. Exposure to elevated levels of CO may result in:

- visual impairment;
- reduced work capacity;
- reduced manual dexterity;
- poor learning ability;
- difficulty in performing complex tasks.

The health threat from levels of CO sometimes found in the ambient air is most serious for those who suffer from cardiovascular disease such as angina pectoris.

In the human body, Hemoglobin (an iron compound) in the blood carries the oxygen (O_2) from the lungs to various tissues and transports back carbon (IV) oxide (CO_2) to the lungs. Researchers have established that Hemoglobin has 240 times more affinity toward CO than it does for oxygen. Therefore, when the hemoglobin reacts with CO, it reduces the hemoglobin that is available for the transport of O_2. This in turn reduces oxygen supply to the body's organs and tissues.

Sulphur (IV) Oxide (SO_2)

High concentrations of SO_2 can result in the following health problems:

Short-term exposure

- Adults and children with asthma who are active outdoors will experience temporary breathing impairment.
- Individuals with asthma may experience breathing difficulties with moderate activity and may exhibit symptoms such as wheezing, chest tightness, or shortness of breath.

Long-term exposure (along with high levels of PM)

- Aggravation of existing cardiovascular disease
- Respiratory illness
- Alterations in the lungs' defenses

The subgroups of the population that may be affected under these conditions include individuals with heart or lung disease, as well as the elderly and children.

Nitrogen Oxides (NO_X)

Nitric oxide (NO) and nitrogen (IV) oxide (NO_2) together are represented by NO_X. It is estimated that about 90% of the emissions from combustion devices are in the form of NO.

NO_X reacts in the air to form ground-level ozone and fine particulates, which are associated with adverse health effects.

1. Short-term exposures (e.g., less than 3 hours) to low levels of NO_2 may lead to changes in airway responsiveness and lung function in individuals with pre-existing respiratory illnesses. These exposures may also increase respiratory illnesses in children.

2. Long-term exposures to NO_2 may lead to increased susceptibility to respiratory infection and may cause irreversible alterations in lung structure.

NO_X contributes to a wide range of environmental effects directly and when combined with other precursors in acid rain and ozone.

1. Increased nitrogen inputs to terrestrial and wetland systems can lead to changes in plant species composition and diversity.
2. Direct nitrogen inputs to aquatic ecosystems such as those found in estuarine and coastal waters e.g. the Lagos Bar Beach can lead to eutrophication (a condition that promotes excessive algae growth, which can lead to a severe depletion of dissolved oxygen and increased levels of toxins harmful to aquatic life).
3. Nitrogen, alone or in acid rain, also can acidify soils and surface waters.

Acidification of soils causes the loss of essential plant nutrients and increased levels of soluble aluminum that are toxic to plants. Acidification of surface waters creates conditions of low pH and levels of aluminum that are toxic to fish and other aquatic organisms. NOx also contributes to visibility impairment. **Particulate Matter (PM)**

Particles smaller than or equal to 10 µm (micro meter or millionth of a meter) in diameter can get into the lungs and can cause numerous health problems. Inhalation of these tiny particles has been linked with illness and death from heart and lung disease. Various health problems have been associated with long-term (e.g., multi-year) exposures to these particles. Shorter-term daily and potentially even shorter term peak (e.g., 1-hour) exposures to these particles can also be associated with health problems.

Particles can aggravate respiratory conditions, such as asthma and bronchitis, and have been associated with cardiac arrhythmias (heartbeat irregularities) and heart attacks. People with heart or lung disease, the elderly, and children are at highest risk from exposure to particles.

Particles of concern can include both fine and coarse-fraction particles, although fine particles have been more clearly linked to the most serious health effects.

- Particles larger than 2 micro meters (µm) do not penetrate beyond the nasal cavity or trachea.
- Particles smaller than 0.1 µm tend to deposit in tracheobronchia tree and are removed when exhaling.
- Particles between 0.1 and 2.0 µm penetrate deep into the lungs and settle in respiratory bronchioles or alveolar sacs

In addition to health problems, PM is the major cause of reduced visibility in many parts of the world by scattering and absorbing some of the light emitted or reflected by the body reducing the contrast. Airborne particles can also impact vegetation and ecosystems, and can cause damage to paints and building materials.

Lead

Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues and can adversely affect the kidneys, liver, nervous system, and other organs.

Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation, and behavioral disorders.
Even at low doses, lead exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ.

Recent studies indicated that lead may be a factor in high blood pressure and subsequent heart disease.
Lead can also be deposited on the leaves of plants, presenting a hazard to grazing animals and to humans through ingestion.

Secondary Pollutants

The pollutants that are emitted directly from a combustion process are called “primary pollutants.” When emitted into the atmosphere, these primary pollutants combine with other reactants and form “secondary” pollutants.

An example of a secondary pollutant would be ozone. When hydrocarbons are emitted and they react with NO_X in presence of sunlight, they form ozone. Ozone is a form of oxygen and also a poisonous gas. However, when in the earth's atmosphere, ozone acts as a protective shield against ultraviolet radiation in space.

Global and Regional Effects of Secondary Pollutants

The Earth is continuously receiving energy from the sun. Energy also leaves the Earth in the night time in the form of invisible infrared energy. Otherwise, the Earth would be continuously warming up. This delicate balance between the energy coming in and leaving due to natural greenhouse effect is what keeps the planet warm enough for us to live on.

It is very obvious that if more energy comes in than the energy that leaves, the planet will become warm. Similarly, if the energy that leaves is more than the energy that comes in, the planet will become cool. The atmospheric temperature fluctuates over centuries due to certain natural causes.

Greenhouse Gases

The concentration of greenhouse gases in the atmosphere has been changing over the past 150 years. Since pre-industrial times, atmospheric concentrations of the gases have increased. These greenhouse gases are by-products of many industrial processes. Overview of the greenhouse gases emissions in 2018 have been estimated to be:

- CO_2 has climbed over 81 percent.
- CH_4 has climbed over 10 percent.
- N_2O has climbed 7 percent.
- Fluorinated gases 3 percent.

They claim that this is primarily due to human activities, which include burning coal, oil, and gas, and cutting down forests.

The increase in the greenhouse gases between 1950 and 2010 is believed to have caused an increase in the global temperature. The mean increase in the global temperature over the past one century is about 1 degree Fahrenheit.

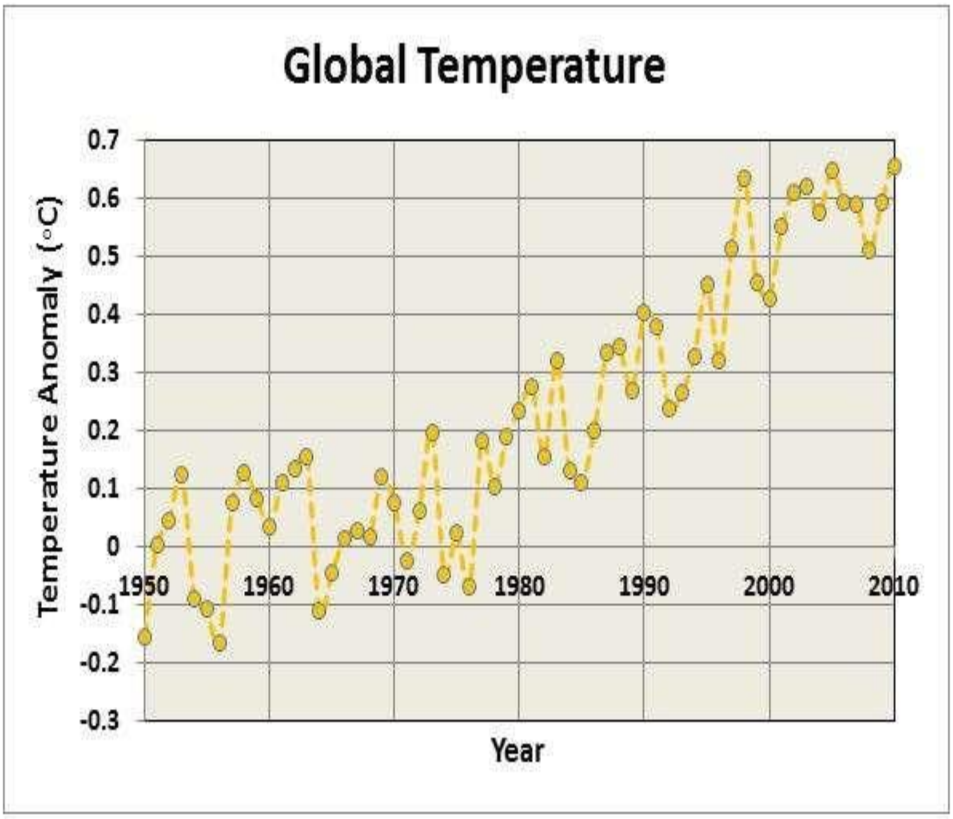


Fig. 1: Global Annual Surface Temperature Increase over the Past 60 Years

Source:
http://www.giss.nasa.gov/research/observe/surftemp/2002fig1.gif

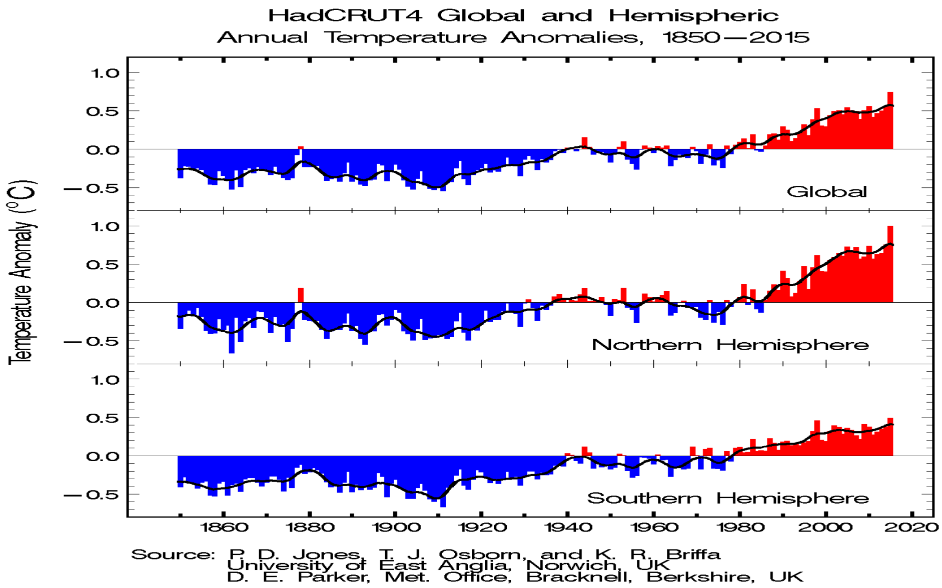


Fig. 2: Global, Northern and Southern Hemisphere Annual Surface Temperature Increase over the Past 160 Years

Not only has there been an increase in temperatures with the increase of greenhouse gases, there has also been an increase in CO_2 emissions from fossil fuels – this has been apparent over the last 150 years (since about 1850).

Global Warming

Global warming is a gradual increase in the average temperature of the earth's atmosphere due to greenhouse effect caused by high level of greenhouse gases like oxides of carbon, particularly carbon (IV) oxide, oxides of Nitrogen and Chlorofluorocarbons (CFCs). Global warming has become an issue of concern for world leaders and there is continuous effort at stemming the tide of global warming.

Let us have a little examination of the impact of global warming on three important areas: health, water resources, and forests.

Health

The most direct effect of climate change would be the impacts of the hotter temperatures, themselves. Extremely hot temperatures increase the number of people who die on a given day for many reasons:

- People with heart problems are vulnerable, because one's cardiovascular system must work harder to keep the body cool during hot weather.
- Heat exhaustion and some respiratory problems increase.
- Higher air temperatures also increase the concentration of ozone at ground level.
- Diseases that are spread by mosquitoes and other insects could become more prevalent if warmer temperatures enabled those insects to become established farther north; such "vector-borne" diseases include malaria, dengue fever, yellow fever, and encephalitis. These diseases could spread to other areas where they are not originally endemic

Water Resources

Changing climate has the propensity to increase evaporation and precipitation in many areas. When evaporation increases more than precipitation, soil will become drier, lake levels will drop, and rivers will carry less water. Lower river flows and lower lake levels could impair navigation, hydroelectric power generation, and water quality, and reduce the supplies of water available for agricultural, residential, and industrial uses. Some areas may experience increased flooding during the raining season and lower supplies during summer.

Forests

There could be significant shift in the global forest zones of the world. If the climate changes slowly enough, warmer temperatures may enable the trees to colonise areas that are originally too cold for plant survival. At the same time, an increase in temperature could affect the growth of plants in warmer areas and become too high for them to survive. If this persists, it could lead to desertification. Projections for the effect of global warming for large area could be more accurate; however, this is difficult for smaller areas. **Solutions for Global Warming**

Since global warming has been attributed to the effect of greenhouse gases, the one sure solution to it is to reduce the release of greenhouse gases to the environment. Such measures to be taken include:

1. Proper legislation on industrial practices that release gases to the atmosphere
2. Fixing of filters and absorbers on the exhaust pipes of engines
3. Planting of trees to absorb carbon (IV) oxide from the atmosphere
4. Using alternative procedure to those industrial practices that generate greenhouse gases

At the individual level, we can take the following actions:

These are the things you can do in your home – from top to bottom - to protect from the environment:

1. Purchase "Green Power" - electricity that is generated from renewable sources such as solar, wind, geothermal, or biomass - for your home's electricity, if available from your utility company. Although the cost may be slightly higher, you'll know that you are buying power from an environmentally friendly energy source.
2. Insulate your home – you’ll learn more about this in Home Activity Three.
3. Use low-flow faucets in your showers and sinks.
4. Replace toilets with water-saving lavatories.
5. Purchase home products—appliances, new home computers, copiers, fax machines, that display the ENERGY STAR® label - You can reduce your energy consumption by up to 30 percent and lower your utility bills! Remember, the average house is responsible for more air pollution and carbon (IV) oxide emissions than is the average car.
6. When your lights burn out, replace them with energy-efficient compact fluorescent lights.
7. Lower the temperature on your hot water tank to 120 degrees.
8. Tune up your furnace.

9. Insulate your water heater and all water pipes to reduce heat loss.

When faced with this question, individuals should recognise that, collectively, they can make a difference. In some cases, it only takes a little change in lifestyle and behaviour to make some big changes in greenhouse gas reductions. For other types of actions, the changes are more significant. When that action is multiplied by the 170 million people in the Nigeria or the 6 billion people worldwide, the savings are significant. The actions include being energy efficient in the house, in the yard, in the car, and in the store. Everyone's contribution counts, so why not do your share?

Apart from green house effect and global warming, other health and environmental effects of secondary pollutants include acid rain and ozone depletion (read up).

Self-Assessment Exercise

1a. What is ozone and what is ozone layer?
b. Why is ozone content in the atmosphere in a layer rather than being distributed uniformly at all levels?
2. What is the difference between primary and secondary pollutants?
3. What is the greenhouse effect?
4. Explain the difference between greenhouse effect and global warming?
5. Which gases contribute to the greenhouse effect?

4.5 Summary

In this unit, we have learnt that:

1. Primary and secondary pollutants are generated from primary and secondary particles respectively.
2. Primary pollutants usually have negative effects on the health and individual lives, secondary pollutants pose great environmental threat to global population.
3. The human respiratory system is adversely affected by the inhalation of invisible particulate matter.
4. The temperature and CO_2 concentration is the air has increased in the last half century due to global warming.
5. Individual effort, spread across global population, can help reduce or prevent the future effect of global warming.

Radiation has both positive and negative effects, thus it is imperative that we understand how to harness the values of radiation and avoid the adverse effects.

4.6 References/Further Readings/Web Resources

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http://www.epa.gov/ghgemissions/overview-greenhouse-gases

4.7 Possible Answers to Self-Assessment Exercise

1a. What is ozone and what is ozone layer?
Ozone, O_3, is an unstable allotrope of oxygen, O_2. Ozone has three oxygen atoms; it is very reactive and less stable than oxygen. The ozone layer in the atmosphere acts as a protective shield by preventing too much ultra-violet radiation from falling on earth and harming living organisms.

b. Why is ozone content in the atmosphere in a layer rather than being distributed uniformly at all levels?
Ozone is not distributed uniformly because the energy required for the formation of ozone is provided by the ultra-violet photons which come from the sun. The second step in the ozone formation is the joining up of oxygen atom O, to molecular oxygen O_2 to form ozone, O_3. The rate of production of ozone depends upon both the O_2 concentration and the intensity of ultra-violet radiation. At very high altitudes, O_2 molecules are not very abundant. Between 15 and 35km above the ground there are enough oxygen molecules, O_2 to permit a reasonable rate of formation of ozone in the presence of ultra-violet ration. At lower altitudes the ultra-

violet radiations have already been absorbed so no ozone can be formed. Thus, the ozone concentration cannot be uniform in places, but in layers of fluctuating thickness.

2. What is the difference between primary and secondary pollutants?

Primary and secondary pollutants are generated from primary and secondary particles respectively

Primary pollutants usually have negative effects on the health and individual lives, secondary pollutants pose great environmental threat to global population

3. What is the greenhouse effect?
4. Explain the difference between greenhouse effect and global warming?
5. Which gases contribute to the greenhouse effect?

UNIT 5 Effects of Radiation on Life and Weather II

Unit Structure

5.1 Introduction

As stated in unit Apart from greenhouse effect and global warming, other health and environmental effects of secondary pollutants include acid rain and ozone depletion. Acid rain occurs when sulphur (IV) oxide or nitrogen oxides, released as a product of combustion, combines with atmospheric oxygen and then absorbed by cloud water to form sulphate and nitrate. The resultant precipitate affects life and matter either as wet or dry deposition. Ozone, produce in natural cycle, can be harmful or beneficial depending on its closeness to the earth's surface. Ozone depletion exposes the earth surface to high ultraviolet rays causing harm to terrestrial and aquatic life as well as damage to matter.

5.2 Intended Learning Outcomes (ILOs)

By the end of this unit, you will be able to:

- explain the formation of acid rain
- describe the process of acid deposition
- explain the beneficial and harmful effect of ozone
- list the steps that could be taken to protect the environment from acid rain
- list the effects of ozone depletion on man.

5.3 Formation of Acid Rain and Acid Deposition

Acid Rain

Acid rain is a serious environmental problem around the world, particularly affecting Asia, Europe, and large parts of the U.S. and

Canada. The acidic pollutants such as SO_2 and NO_x are emitted into the environment by combustion of fossil fuels.

Most of the sulphur in any fuel combines with oxygen and forms SO_2 in the combustion chamber. This SO_2 when emitted into the atmosphere slowly oxidises to SO_3. SO_3 is readily soluble in water in the clouds and forms H_2SO_4 (tetraoxosulphate (VI) acid).

$$S + O_2 \rightarrow SO_2 + 12O_2 \rightarrow SO_3 + H_2O + H_2SO_4$$

Most of the NO_x that is emitted is in the form of NO. This NO is oxidised in the atmosphere to NO_2. NO_2 is soluble in water and forms HNO_3 (nitric acid).

$NO + 12O_2$ (in the atmoshpere) $\rightarrow NO_2 + H_2O \rightarrow HNO_3$ (nitric acid)

Acid Deposition

Sunlight increases the rate of most of the SO_2 and NO reactions. The result is a mild solution of tetraoxosulphate (VI) acid and nitric acid. "**Acid rain**" is a broad term used to describe several ways that acids fall out of the atmosphere. A more precise term is **acid deposition**, which has two parts: wet and dry.

Wet deposition - refers to acidic rain, fog, and snow. As this acidic water flows over and through the ground, it affects a variety of plants and animals. The strength of the effects depend on many factors, including:

- the acidity of the water;
- the chemistry and buffering capacity of the soils involved;
- the types of fish, trees, and other living things that rely on the water.

Dry deposition - refers to acidic gases and particles. About half of the acidity in the atmosphere falls back to earth through dry deposition.

Acidic particles and gases are blown by the wind onto buildings, cars, homes, and trees.

Dry deposited gases and particles can also be washed from trees and other surfaces by rainstorms. When that happens, the runoff water adds those acids to the acid rain, making the combination more acidic than the falling rain alone.

Process of Acid Deposition

Prevailing winds blow the compounds that cause both wet and dry acid deposition across state and national borders, and sometimes over hundreds of miles. The figure below shows the process of acid deposition.

Effects of Acid Rain on Forests

Acid rain does not usually kill trees directly. Instead, it is more likely to weaken trees by:

- damaging their leaves;
- limiting the nutrients available to them;
- exposing them to toxic substances slowly released from the soil.

Quite often, injury or death of trees is a result of these effects of acid rain in combination with one or more additional threats.

Effects of Acid Rain on Aquatic Life

Acid rain causes acidification of lakes and streams and contributes to damage of trees at high elevations and many sensitive forest soils. Some types of plants and animals can handle acidic waters. Others, however, are acid-sensitive and will be lost as the pH declines.

Effects of Acid Rain on Materials

Acid rain and the dry deposition of acidic particles contribute to the corrosion of metals (such as bronze) and the deterioration of paint and stone (such as marble and limestone). These effects seriously reduce the value to society of buildings, bridges, cultural objects (such as statues, monuments, and tombstones), and cars.

Effects of Acid Rain on Visibility

Sulphates and nitrates that form in the atmosphere from sulphur (IV) oxide (SO_2) and nitrogen oxides (NO_x) emissions contribute to visibility impairment, meaning we can't see as far or as clearly through the air.

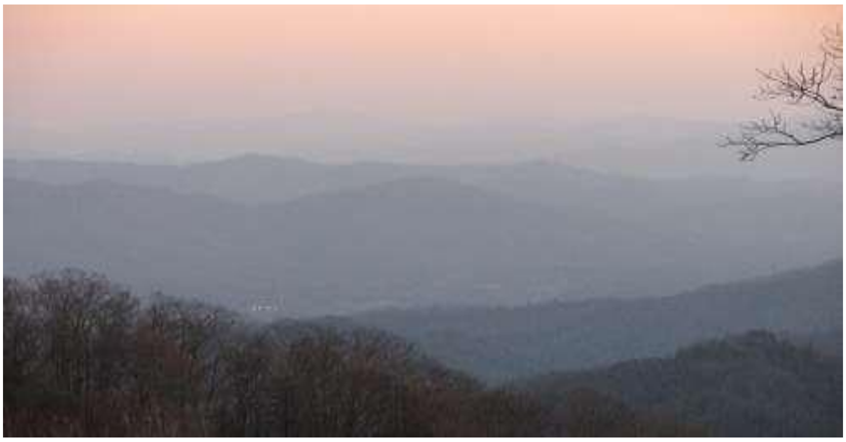

Fig. 1: Great Smoky Mountains, US

Fig. 2: The Grand Canyon, US

Effects of Acid Rain on Human Health

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Walking in acid rain, or even swimming in an acid lake, is no more dangerous than walking or swimming in clean water. However, the pollutants that cause acid rain also damage human health.

Effects of Sulfur Dioxide (SO_2): These gases interact in the atmosphere to form fine sulfate and nitrate particles that can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors. Many scientific studies have identified a relationship between elevated levels of fine particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.

Effects of Nitrogen Oxide (NO_X): Decrease in nitrogen oxide emissions are also expected to have a beneficial impact on human health by reducing the nitrogen oxides available to react with volatile organic compounds and form ozone. Ozone impacts on human health include a number of morbidity and mortality risks associated with lung inflammation, including asthma and emphysema.

Protecting the Environment from Acid Rain

The following steps could be taken to protect the environment from acid rain:

1. Turning off lights, computers, and other appliances when they are not in use.
2. Using energy efficient appliances: lighting, air conditioners, heaters, refrigerators, washing machines, etc.
3. Using electric appliances only when you need them.
4. Insulating the home as best you can.
5. Using public transportation, walking or riding bicycle whenever possible.
6. Buying vehicles with low NO_X emissions, and maintaining all vehicles well.

5.3.1 Beneficial and Harmful Effect of Ozone

Ozone

Ozone (O_3) is a triatomic oxygen molecule gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone can be good or bad, depending on where it is found: It is a bluish gas that is harmful to breathe. Therefore, it is bad at the ground level.

Production and Destruction of Ozone

Ozone is constantly produced and destroyed in a natural cycle. However, the overall amount of ozone is essentially stable. This balance can be thought of as a stream's depth at a particular location. Although individual water molecules are moving past the observer, the total depth remains constant. Similarly, while ozone production and destruction are balanced, ozone levels remain stable. This was the situation until the past several decades.

Large increases in stratospheric chlorine and bromine, however, have upset the balance of the Ozone. In effect, they have added a siphon downstream, removing ozone faster than natural ozone creation reactions can keep up. Therefore, ozone levels fall.

Since ozone filters out harmful UVB radiation, less ozone means higher UVB levels at the surface. The more the ozone is depleted, the larger will be the increase in incoming UVB radiation. UVB has been linked to:

- skin cancer;
- cataracts;
- damage to materials like plastics;
- harm to certain crops and marine organisms.

Although some UVB reaches the surface even without ozone depletion, its harmful effects will increase as a result of this problem.

Effects of Ozone Depletion on man

Effects of ozone depletion can result in:

1) increased cases of skin cancer
2) skin damage
3) cataracts and other eye damage, and
4) immune suppression.

Effects of ozone depletion on eyes and immune system

Cataracts are a form of eye damage in which a loss of transparency in the lens of the eye clouds vision. If left untreated, cataracts can lead to blindness. Research has shown that UV radiation increases the likelihood of certain cataracts. Although curable with modern eye surgery, cataracts diminish the eyesight of millions of Americans and cost billions of dollars in medical care each year.

Other kinds of eye damage include **pterygium** (i.e., tissue growth that can block vision), skin cancer around the eyes, and degeneration of the macula (i.e., the part of the retina where visual perception is most acute). All of these problems can be lessened with proper eye protection from UV radiation.

Immune Suppression

Scientists have found that overexposure to UV radiation may suppress proper functioning of the body's immune system and the skin's natural defenses. All people, regardless of skin colour, might be vulnerable to effects including impaired response to immunizations, increased sensitivity to sunlight, and reactions to certain medications

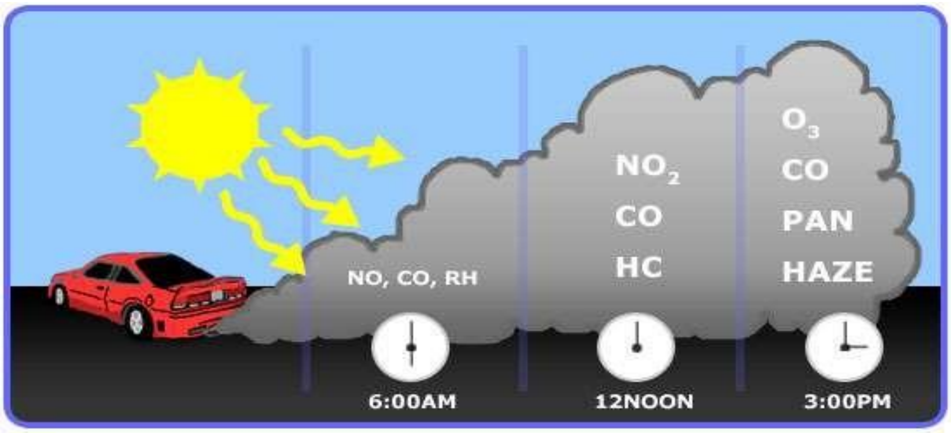

Fig. 3: Pollution from Exhaust Pipe of Engines

Health and Environmental Impact

Several groups of people are particularly sensitive to ozone especially when they are active outdoors because physical activity causes people to breathe faster and more deeply. In general, as concentrations of ground-level ozone increase, more and more people experience health effects, the effects become more serious, and more people are admitted to the hospital for respiratory problems. When ozone levels are very high, everyone should be concerned about ozone exposure.

Ozone can inflame the lung's lining. These photos show a healthy lung air way (left) and an inflamed lung air way (right).

Health Effects of Ground Level Ozone

1. **Ozone can irritate the respiratory system**, causing you to start coughing, feel an irritation in your throat and/or experience an uncomfortable sensation in your chest.
2. **Ozone can reduce lung function** and make it more difficult for you to breathe as deeply and vigorously as you normally would. When this happens, you may notice that breathing starts to feel uncomfortable. If you are exercising or working outdoors, you may notice that you are taking more rapid and shallow breaths than normal.
3. **Ozone can aggravate asthma**. When ozone levels are high, more people with asthma have attacks that require a doctor's attention or the use of additional medication. One reason this happens is that ozone makes people more sensitive to allergens, which are the most common triggers for asthma attacks. Also, asthmatics are more severely affected by the reduced lung function and irritation that ozone causes in the respiratory system.
4. **Ozone can inflame and damage cells that line your lungs**.

Within a few days, the damaged cells are replaced and the old cells are shed much in the way your skin peels after a sun burn.

5. **Ozone may aggravate chronic lung diseases** such as emphysema and bronchitis and reduce the immune system's ability to fight off bacterial infections in the respiratory system.
6. **Ozone may cause permanent lung damage**. Repeated short-term ozone damage to children's developing lungs may lead to reduced lung function in adulthood. In adults, ozone exposure may accelerate the natural decline in lung function that occurs as part of the normal aging process.

Self-Assessment Exercise

1. What steps can you take to prevent you environment from acid rain?
2. You are aware that ozone (hole) is developing around your atmosphere: Suggest the INDICATIONS that ozone hole is developing

ii. You realize that it is impossible to stop atmospheric pollution completely. What is your ADVICE to your community on how to control rate of creating hole in the atmosphere.

3. What is acid rain?
4. Explain how acid rain is formed?
5. What are the health effects of ground level ozone on human health
6. List five steps that you, as an individual, can take to reduce potential global warming, and explain how each of these steps will reduce the emissions.
7. List 5 ways in which you, as an individual, can reduce gaseous emissions that contribute to acid rain.
8. State the arguments that scientists who say that global warming is not due to burning of fossil fuels are making.
9. What are the effects of ground level ozone
10. Briefly describe the methods by which information is gathered and used to show that the planet is warming up.

5.4 Summary

In this unit, we have learnt that:

1. Acid rain is formed when acidic pollutants (secondary pollutants) such as Sulphur (IV) oxide and oxides of Nitrogen are emitted into the environment by combustion of fossil fuels.
2. Acid deposition can be in the form of wet deposition (acid rain, fog, snow) or dry deposition (acidic gases and particles).

3. Both acid rain and ozone affect aquatic life, plants, human health, topography and visibility.

Acid rain is harmful to life and environment, negatively affecting aquatic life, vegetation, humans, visibility and soil. Ozone may be beneficial or harmful depending on its closeness to the earth's surface because of its ability to absorb ultraviolet rays.

5.5 References/Further Readings/Web Resources

http://www.epa.gov/globalwarming/climate/index.html
http://www.giss.nasa.gov/edu/gwdebate/
http://www.epa.gov/air/acidrain/

5.6 Possible Answers to Self-Assessment Exercises

1. What steps can you take to prevent you environment from acid rain?
   The following steps could be taken to protect the environment from acid rain:

a. Turning off lights, computers, and other appliances when they are not in use.
b. Using energy efficient appliances: lighting, air conditioners, heaters, refrigerators, washing machines, etc.
c. Using electric appliances only when you need them.
d. Insulating the home as best you can.
e. Using public transportation, walking or riding bicycle whenever possible.
f. Buying vehicles with low NO_X emissions, and maintaining all vehicles well.

2. You are aware that ozone (hole) is developing around your atmosphere: Suggest the INDICATIONS that ozone hole is developing

ii. You realize that it is impossible to stop atmospheric pollution completely. What is your ADVICE to your community on how to control rate of creating hole in the atmosphere.

i. INDICATIONS
a. Increase in the incidence of cancer and possible deaths
b. Withering of plants and dark pigmentation on leaves
c. Damage to aquatic life and marine ecosystem
d. Cataract and other eye damages
e. Immune system suppression
f. Skin damage (sun burns)

ii. ADVICE
a. Reduce burning of hydrocarbons in the atmosphere
b. Reduce the use of chlorofluorocarbons; find better alternatives

c. Avoid open door activities in hot afternoons
d. Regulate bush burning
e. Use of improved automobile fuels, but at very high costs.
3. What is acid rain?
4. Explain how acid rain is formed?
5. What are the health effects of ground level ozone on human health
6. List five steps that you, as an individual, can take to reduce potential global warming, and explain how each of these steps will reduce the emissions.
7. List 5 ways in which you, as an individual, can reduce gaseous emissions that contribute to acid rain.
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