

Integrated Sciences

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Second term

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Second Term

Energy and Natural Resources



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Chapter 1: Natural Resources



Learning Outcomes:

By the end of this chapter, students will be able to:

1. Explain how energy transfers through different trophic levels.
2. Analyze the impact of energy transfer through food chains and ecological balance.
3. Evaluate strategies for conserving environmental resources and reducing pollution impact.
4. Illustrate the importance of nutrients in maintaining ecosystem health.
5. Describe the cycles of key nutrients (such as carbon and nitrogen) and their significance in the environment.

Included Issues:

1. Natural resources depletion.
2. Environmental pollution and its impacts on nutrient cycles.
3. The importance of sustainability in maintaining ecological balance.
4. Maintaining the ecological balance amidst resource depletion.

(1-1) Energy Transfer Through Ecosystems



Get ready

Imagine being in the midst of a dense forest bathed in bright sunlight. The plants around you are shimmering in vibrant green. How can these plants use the sunlight to become a food source for the animals living here?

In this lesson, we will explore how energy transfers from the sun through ecosystems via food chains and how this process affects ecological balance. We will use concepts from physics and chemistry to understand how this energy transfer occurs and how it impacts the life around us.

Learn:

The Concept of Energy in an Ecosystem:

One approach to studying interactions among organisms in ecosystems is to trace the transfer of energy throughout the system.



A plant obtains its food (energy) through the process of photosynthesis.



A fungus obtains its food (energy) from the trunk of a dead tree.



A snake obtains its food (energy) by mouse predation.

Energy Transfer:

When sunlight reaches plants, they undergo a process called photosynthesis. In this process, solar energy is converted into chemical energy that is stored in glucose sugar molecules and other nutrients within the plants.

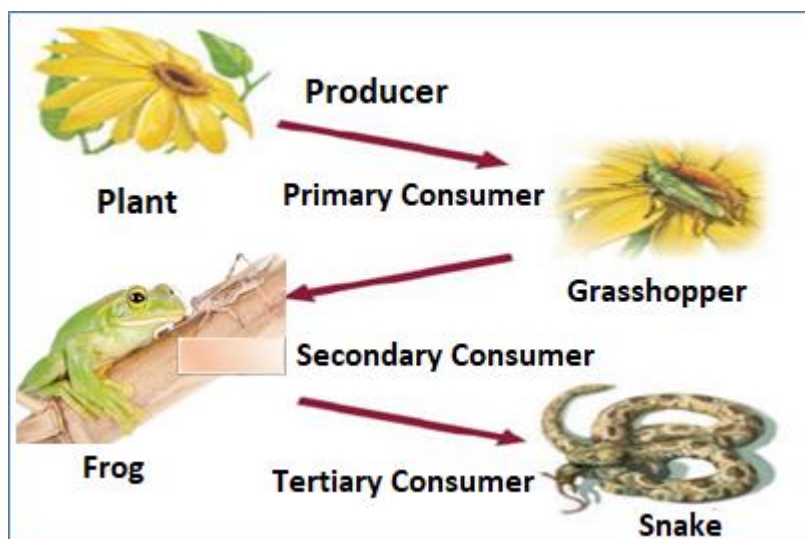
Energy Transfer through Food Chains

When an insect feeds on a plant, it obtains the chemical energy stored in the nutrients within the plant. When another animal eats the insect, the energy transfers from the insect to the animal. However, a significant amount of energy is lost with each transfer from one trophic level to another.

Ecologists use food chains and food webs to model energy transfer in an ecosystem. Each step in a food chain or food web is called a trophic level. Autotrophic organisms, which produce their own food, form the first trophic level in all ecosystems. Heterotrophic organisms, which rely on other organisms for food, form the subsequent levels.

Activity:

Look at the following food chain:

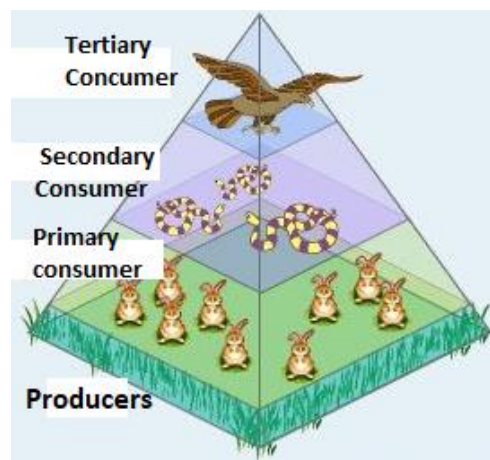


1. How many trophic levels are there?
2. Which organism receives the least amount of energy produced by the plant?

The conservation of Energy:

The **law of conservation of energy** states that **energy is not destroyed, but transformed from one form to another.**

The law of conservation of energy is clearly seen in food chains through the transformation of energy between different forms. The chain begins with light energy from the sun, which is converted within the plant into chemical energy that is stored in the food that is formed during photosynthesis. This energy is transferred to the first consumer when it feeds on the plant, where the chemical energy is transformed during digestion and respiration into thermal and kinetic energy, with some of the energy lost as heat.



As energy is transferred to the second consumer who feeds on the first, additional energy loss occurs during respiration and excretion.

These transformations continue until the energy reaches the decomposers, which return the remaining chemical energy from the dead organisms back to the soil in the form of salts. Throughout the food chain, a portion of energy is lost at each level.

Lost energy

The term lost energy does not contradict the law of conservation of energy, as an animal loses part of its energy mainly as heat during vital processes such as respiration.

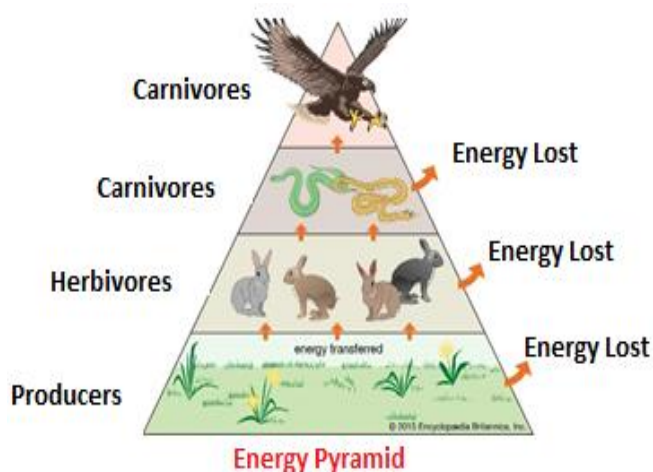
Example:

Assume that the amount of energy a rabbit obtains from plants is 100 J. The majority of this energy is converted during the combustion of sugar in cellular respiration into carbon dioxide gas (chemical energy) that is released back into the environment during exhalation. A portion is converted into kinetic energy that helps the animal move, and some is transformed into thermal energy to warm the body. A part is stored in undigested food (chemical energy) as waste that returns to the soil during excretion as well as chemical energy in the organic matter within its tissues. When all these forms of energy are summed, they equal **100 J**, which aligns with the law of conservation of energy. Therefore, the "lost energy" here, refers to is the energy that is not transferred to the next trophic level.



Calculating Lost Energy:

The energy pyramid as shown is used to show the flow of energy through the different trophic levels in an ecosystem as well as it determines the efficiency of energy transfer between trophic levels in an ecosystem.

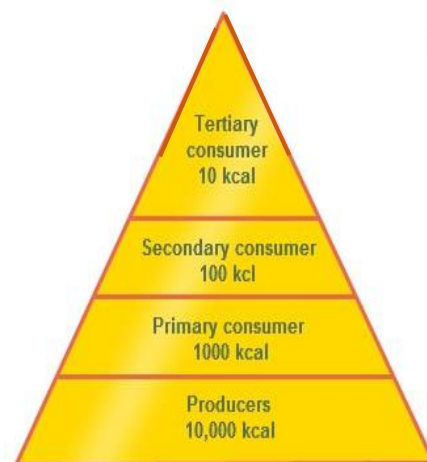


To determine the efficiency of energy transfer between trophic levels, we use the relationship:

$$\text{The efficiency of energy transfer} = \frac{\text{The energy in the upper trophic level}}{\text{The energy in the lower trophic level}} \times 100$$

Typically, the efficiency of energy transfer between two levels in a food chain is about 10%, while about 90% of energy is lost during vital processes such as excretion and respiration.

Because of this loss of energy, an energy pyramid rarely has more than six levels, as the remaining energy is too little to be used as food for another organism. It is therefore more energy efficient for humans to get their food directly from a plant than from an animal that feeds on the plant.



Think:

- How does the loss of energy at each trophic level affect organisms at the end of the food chain?
- What is the role of decomposers in recycling chemical energy back into the soil, and how does this affect the environment?

Pyramid of Energy

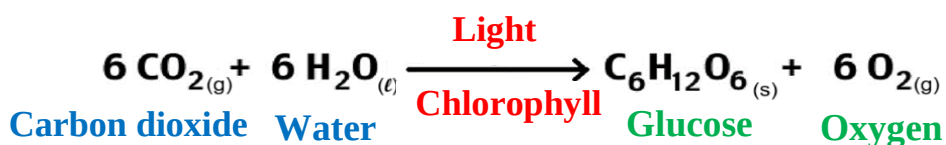
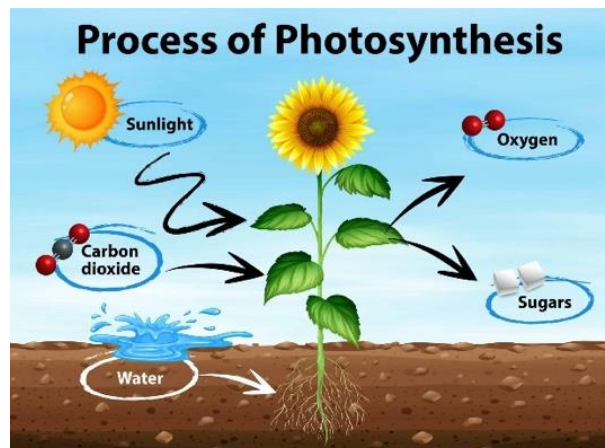
Example:

Let's assume that a plant receives 1000 J of solar energy and uses only 2% of this energy in the process of photosynthesis, while the remainder is lost as heat, reflection, or absorption in other parts. **Calculate:**

- The amount of energy in joule, the plant uses for photosynthesis.
- The amount of energy that was lost (is not used in photosynthesis).

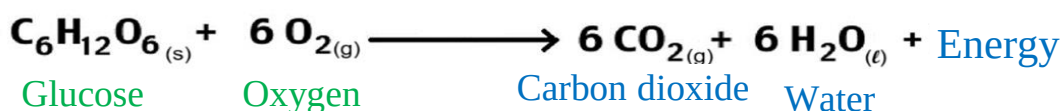
Chemistry in Energy Transfer:

The journey of energy transfer between living organisms begins within green plants. In the process of photosynthesis, which occurs within the chloroplasts (cellular organelles specific to plants), complex chemical reactions take place. The process starts with the absorption of light by chlorophyll, the green pigment in plants. Light then stimulates chemical reactions that convert carbon dioxide and water into glucose and oxygen, as illustrated by the following equation:



Other living organisms in the food chain subsequently utilize the chemical energy stored in glucose when they consume plants directly or indirectly. During the process of cellular respiration, glucose (biofuel) is burned with oxygen inside the tissues of an organism's body; energy is generated that is stored in ATP molecules “ATP: **Adenosine Triphosphate**”. This energy is responsible for sustaining the organism's life.

Thus, energy is converted from light energy into chemical energy stored in the chemical bonds of the glucose molecule, and then into thermal energy, which is essential for the organism's survival.



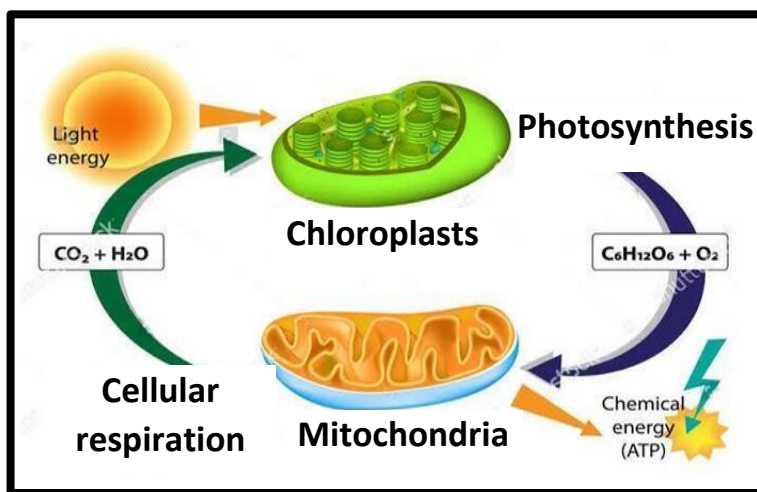
The effect of the photosynthesis and cellular respiration on the ecosystem

1. Ecological Balance:

Photosynthesis and cellular respiration contribute to maintaining the balance of gases in the atmosphere and represent an important link in nature's carbon cycle, where carbon dioxide and water are recycled between the environment and living organisms. Plants absorb carbon dioxide from the atmosphere, release oxygen and store energy in glucose, while organisms (such as plants, animals and humans) consume oxygen in cellular respiration and release carbon dioxide into the atmosphere, maintaining the ecological balance. This integration of photosynthesis and cellular respiration ensures the flow of energy and gas balance in the ecosystem, supporting life on Earth.

2. Energy Flow:

Solar energy stored in glucose molecules through photosynthesis is transferred through the food chain to animals that feed on plants. This energy is utilized in cellular respiration to produce **ATP molecules, the primary energy source for all biological processes in living organisms.**



Energy Stored in Fossil Fuels:

The formation of fossil fuels, such as coal, petroleum, and natural gas, relies on organisms that have stored solar energy either directly or indirectly. Coal, primarily composed of carbon (C), may originate from the remains of trees and plants that have decomposed underground over millions of years. Petroleum, a mixture of various hydrocarbon compounds, may come from marine organisms and sea plants that were buried for millions of years and decomposed under high pressure and temperature. Natural gas, which is found floating on top of petroleum underground or in coal mines and between rocks, is made up of a mixture of consisting of a mixture of several hydrocarbon gases, such as methane (which makes up 70-98%), with smaller amounts of ethane, propane, and butane.

When fossil fuels burn in the presence of oxygen, thermal energy is generated, and this energy is responsible for the motion of machines such as the internal combustion engine.

Research and Investigation

Practical Experiment: Exploring Photosynthesis

Needed Materials:

- Plant with green leaves
- A transparent bottle or glass cup
- Water
- Baking soda (sodium bicarbonate)
- Aluminum foil or opaque paper (to cover certain parts)
- A flashlight or light source (such as sunlight)
- Thermometer (optional)

Steps:

1. Preparing the Plant:

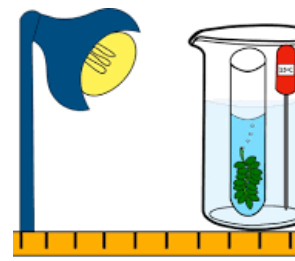
- Fill the bottle or glass cup with water.
- Add a small amount of baking soda (about half a teaspoon) to the water to increase the level of carbon dioxide, which is essential for photosynthesis.
- Place the green-leaved plant in the water and let it acclimate for a few minutes.

2. Setting Up the Light:

- If using a flashlight, direct the light directly onto the plant.
- If using sunlight, place the plant in a sunny location.

3. Covering Parts:

- To identify the areas where photosynthesis occurs, cover some of the plant's leaves with aluminum foil or opaque paper.
- Leave other leaves exposed to sunlight or artificial light.



4. Observing the Reaction:

- Place the plant under the light and let it stay there for several hours.
- After the period has ended, remove the aluminum foil or opaque paper from the leaves.
- Observe any changes in the exposed leaves compared to the covered leaves.

5. Testing for Oxygen:

- You can use a simple test for the presence of oxygen. Fill the glass cup with water, and then place the plant in it. Wait for some time and observe any air bubbles that may form on the water's surface. These bubbles indicate the production of oxygen during photosynthesis.

6. Analysis and Interpretation:

- Compare the results between the exposed and covered leaves. Note where the greatest number of bubbles occurred. The exposed leaves should produce more oxygen compared to the covered leaves, indicating that photosynthesis is occurring in the exposed leaves.
- Record your observations on how light affects the photosynthesis process.

Discussion:

- How does light affect the process of photosynthesis in the plant?
- Why does photosynthesis not occur in the covered leaves?
- How do carbon dioxide and water contribute to the process of photosynthesis?

Check Your Understanding

Multiple-Choice Questions

1. What is the process in which solar energy is converted into chemical energy in plants, and what is the corresponding chemical equation?

(A) Cellular respiration, with the equation:



(B) Photosynthesis, with the equation:



(C) Cellular respiration, with the equation:



(D) Photosynthesis, with the equation:



2. What is the percentage of energy that is transferred from one trophic level to the next in a food chain?

(A) 90%

(B) 50%

(C) 100%

(D) 10%

(1-2) Conservation of environmental resources:



Get ready

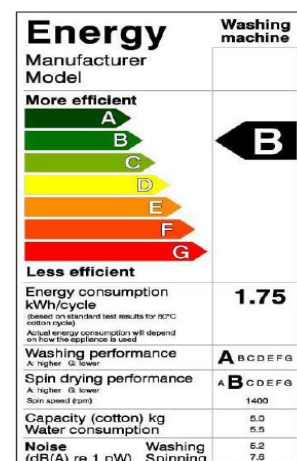
You have studied how energy flows through living organisms as part of ecosystems. In this lesson, we explore the relationship between energy and work in physical systems and how energy is transferred to or from them, and try to explain why some chemical reactions absorb heat while others are exothermic

Learn:

Efficiency of energy conversion systems and their effect on the environment

The efficiency of an energy conversion system refers to its ability to efficiently convert a form of energy into another wanted form of energy.

The most efficient systems are those that minimize the production of unwanted energy through them, thereby reducing energy consumption.



Activity:

Work with a group of your colleagues to find as many electrical devices (systems) with low efficiency and high efficiency in energy conversion processes, identifying the most important indicators to determine these efficiencies.

Basic Concepts in Thermodynamics:

The science of **thermodynamics** is concerned with the study of the concept of energy and its transformations associated with physical processes, chemical reactions, biological processes, etc. One of the key concepts in thermodynamics is the concept of “system”.

The system:

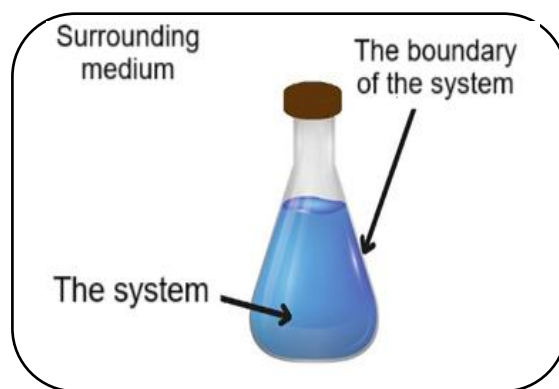
It is the part of the universe in which chemical, physical or biological change occurs, or the specific part of matter to which the study is directed.

Surrounding medium:

It is what surrounds the system.

The boundary of the system:

It is the envelope that surrounds the system and separates it from the surrounding environment; it represents the containment wall of the system and can be real or imaginary.



For example: When a solution of hydrochloric acid is added to a solution of sodium hydroxide (alkali) in a glass flask, the **system** is the acid and alkali solution, the **boundaries of the system** are the walls of the flask, and the **surrounding medium** is the rest of the universe around the flask.

Types of Systems in Thermodynamics

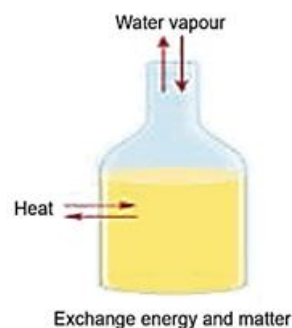
Based on the way system exchanges energy and matter with the surrounding medium, systems are divided into several types:

(a) Open System:

A system that allows the exchange of both matter and energy between the system and the surrounding medium

Example:

In a metal container containing hot water, the system's substance, water, rises as water vapor to the surroundings, and heat energy also escapes from the water to the surround



(b) Closed System:

A system that only allows the exchange of energy between itself and the surrounding medium, either in the form of heat or work

Example:

If the above-mentioned metal container is tightly sealed, heat energy will leak from the water to the surroundings while the amount of water and water vapor (the system material) remains constant.



(c) Isolated System

A system that does not allow the transfer of energy or matter between itself and the surrounding medium

Example:

The thermal preservation of the material (Thermos) as it saves the thermal energy of the system and its material from leaking to the surrounding medium.



Properties of a System:

The physical properties of a system can be divided into two groups:

1- Extensive Properties :

Properties that depend on the amount of matter in the system such as **mass, volume, heat capacity, internal energy, entropy, and surface area**

2- Intensive Properties :

Characteristic properties of the type of substance that do not depend on its quantity in the system such as **temperature, density, surface tension, and specific heat of matter**

The laws of thermodynamics:

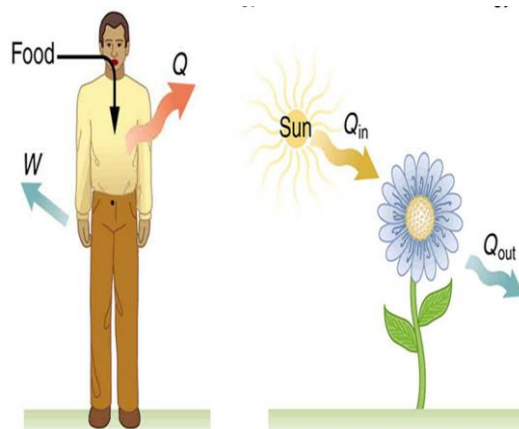
Many physical processes, chemical reactions, biological processes within living organisms, and energy transformations are explained by a wide range of concepts and laws associated with the science of **thermodynamics**.

The first law of thermodynamics :

The first law of thermodynamics, or the law of conservation of energy, states that “**energy is neither destroyed nor created out of nothing, but transformed from one form to another.**”

Examples of the first law of thermodynamics:

- 1- When a light bulb works, the electrical energy from the electrical source is converted into thermal energy and light energy in the bulb's filament.
- 2- In plant photosynthesis, light energy is converted into chemical and thermal energy.
- 3- The chemical energy stored in the food you eat is converted into heat, work, and chemical energy stored as fat.



Thermodynamic processes

Every system with clear boundaries contains a specific amount of internal energy. The internal energy of a system or object is the sum of the kinetic energy of the system's particles and the potential energy associated with the forces of attraction between them, symbolized by (**U**). We can change the internal energy ΔU of a system in one of two ways:

- 1- A quantity of thermal energy ΔQ transferred to or from the system .
- 2- Work (ΔW) is exerted by the system against an external force acting on it, or when work is exerted on the system by an external force.

Example:

If we have a closed system such as a quantity of gas trapped in a cylinder with a movable piston, and the gas gains a quantity of thermal energy (ΔQ) as shown in the diagram, this thermal energy leads to:

- 1- Increasing the kinetic energy of the gas molecules, thus increasing the internal energy of the gas (ΔU), and increasing its temperature.
- 2- Gas expansion, i.e. the gas exerts work (ΔW) on the piston to move it upward.

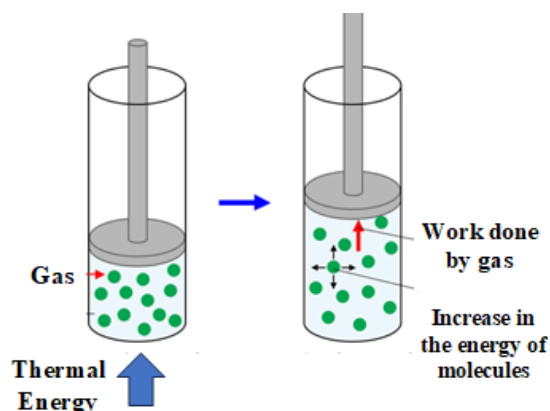
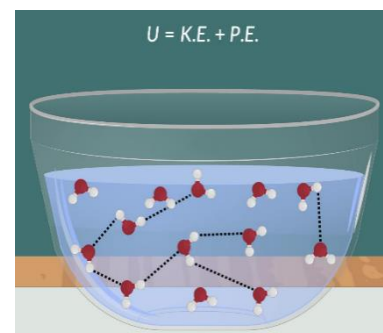
According to the first law of thermodynamics,

$$\Delta Q = \Delta U + \Delta W$$

Therefore, $\Delta U = \Delta Q - \Delta W$

ΔQ is positive (+) for the amount of heat the system gains from the surroundings and negative (-) for the amount of heat the system loses to the surroundings .

ΔW is positive (+) for the work done by the system on the surroundings (gas expansion) and negative (-) for the work done by the surroundings on the system (gas compression)

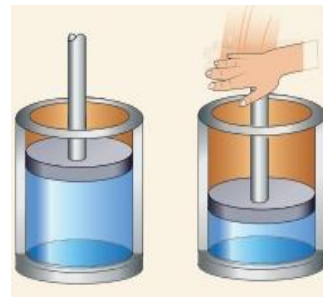


Some processes exist when the first law of thermodynamics is applied to certain systems under certain conditions:

1- Adiabatic Process:

This process occurs in isolated systems where no amount of heat is transferred to or from the system, i.e. ($\Delta Q = 0$), and therefore ($\Delta U = -\Delta W$).

The work the system does on the environment leads to a decrease in its internal energy, and vice versa.



Example:

The rapid expansion of an isolated gas leads to a decrease in its internal energy and therefore a decrease in its temperature, while the rapid compression of a quantity of isolated gas leads to an increase in its internal energy and therefore an increase in its temperature.

2- Isothermal Process:

This process occurs if the temperature of the system does not change, and in the case of an ideal gas the internal energy of the system remains constant.

Then ($\Delta U = 0$), and therefore ($\Delta Q = \Delta W$)

That is, the amount of heat gained by a closed system is converted into work done by the system.

Example: Ice melts at a constant temperature and water boils at a constant temperature.

3- Isochoric Process:

This process occurs if the volume occupied by a closed system does not change, so there is no work done by the system on the surrounding medium, or vice versa.

Then ($\Delta W = 0$), and therefore ($\Delta U = \Delta Q$).

That is, the amount of heat gained by the system is converted into an increase in its internal energy.

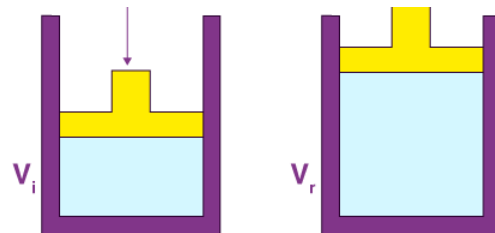
Example: Heating water in a sealed container or pressure cooker.



Solved Example

An ideal gas is compressed slowly in a cylinder to half its original volume. During this process, the temperature remains constant and the work done in the compression is 45 J. Answer the following:

1. What is the type of the process?
2. What is the magnitude of the change in the internal energy of the system ?
3. What is the amount of heat was transferred to the gas?



Answer

- 1- Isothermal process
- 2- System temperature is constant during the change that occurs for the system, so the amount of internal energy also remains constant :

$$\Delta U = 0$$

- 3- From the first law of thermodynamics:

$$\Delta U = \Delta Q - \Delta W \Rightarrow 0 = \Delta Q - \Delta W$$

$$\Delta Q = \Delta W$$

$$\Delta Q = \Delta W = -45J$$

That is, the gas loses a quantity of heat = work done on the gas = -45 J

Chemical reactions and energy conservation:

A chemical reaction can be expressed as a chemical equation:



In chemical reactions, the quantities of reactants or products are expressed in moles (**Mole**).

A mole of a substance: is a mass of the substance in grams equal to its molecular mass.

For example, the molar mass of water (H_2O) is 18 g ($= 1 \times 2 + 16$), and the molar mass of carbon dioxide (CO_2) is 44 g

The heat content (H) of a substance: is the amount of chemical energy stored within a mole of the substance.

The energy is stored in the atoms and molecules of a substance, in chemical bonds, and in the attractive forces between molecules. Since the molecules of substances differ in the types of atoms that make up them, their number, and the types of bonds between them, the heat content varies from substance to another substance.

The change in heat content (ΔH) : is the difference between the sum of the heat content of the products and the sum of the heat content of the reactants.

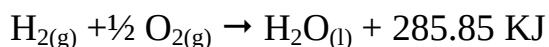
The change in heat content (ΔH) = Heat content of products (H_p) – Heat content of reactants

There are two types of chemical reactions according to the change in heat content (ΔH):

1- Exothermic reactions:

These are reactions in which heat is released as one of the reaction products to the surrounding medium and its temperature rises, where the total heat of the reactants is higher than the total heat of the products, and the amount of heat released is equal to the value of the difference between them. According to the equation for calculating the change in heat content, the sign (ΔH) is **negative**.

Example: Chemical reaction to form a mole of water



The equation can be written as follows:

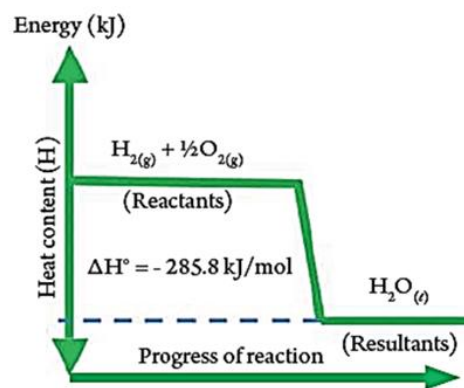
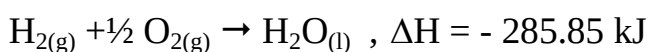
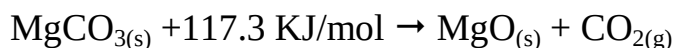


Diagram of exothermic reaction

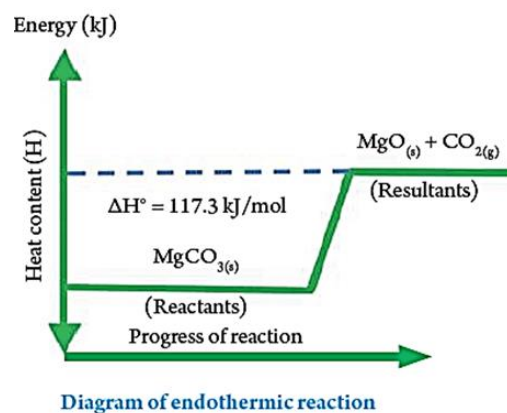
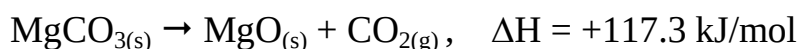
2- Endothermic Reactions :

Reactions in which heat is absorbed from the surrounding medium and its temperature decreases, where the total heat of reactants is less than the total heat of products, and the amount of heat absorbed is equal to the value of the difference between them. According to the equation for calculating the change in heat content, the sign (ΔH) is **positive**.

Example: Decomposition reaction of a mole of magnesium carbonate



The equation can be written as follows:



Research and investigation :

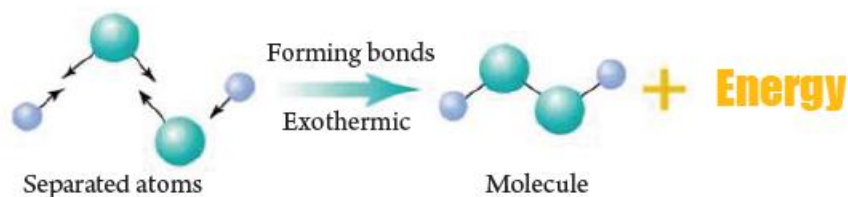
Using trusted research sites, analyze a physical process, a chemical process, or a biological process of an organism concerning, the processes and laws of thermodynamics.

Why is a chemical reaction accompanied by a heat change?

In a chemical reaction, some of the chemical bonds in the molecules of the reactants are broken and new bonds are formed in the molecules of the products. Breaking a bond requires a certain amount of energy from the surroundings.



The formation of bonds is accompanied by the release of energy into the environment.



- If the energy released when forming product bonds is higher than the energy absorbed to break reactant bonds, the reaction will be **exothermic** and (ΔH) is **negative**.
- If the energy absorbed to break reactant bonds is higher than the energy released when product bonds are formed, the reaction will be **endothermic** and (ΔH) is **positive**.
- To determine the type of the heat change in a chemical reaction, we need to know the **bond energy**, which is the energy required to break or form bonds in one mole of a substance.

Bond	Average bond energy kJ/mol
H — H	432
C — O	358
C = O	745
O — H	467
O = O	498

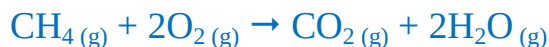
Bond	Average bond energy kJ/mol
C — C	346
C = C	610
C $\equiv$ C	835
C — H	413
Si — H	318

Average energy for some bonds

By using bond energy values, we can determine whether a reaction is exothermic or endothermic and the amount of heat change that occurs during a chemical reaction.

Example:

In the following chemical reaction:

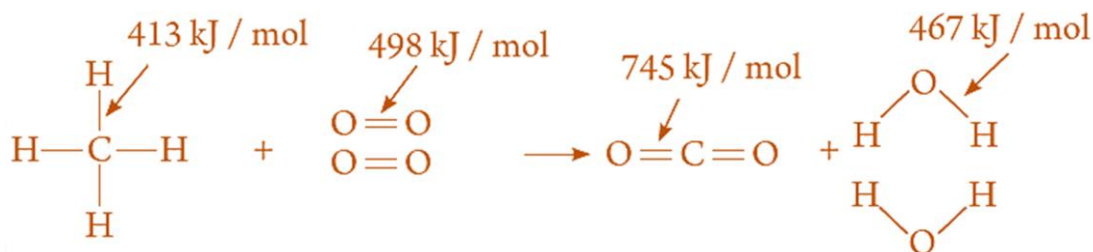


Calculate the value of the heat change and determine whether the reaction is exothermic or endothermic.

Given the bond energies:



Solution:



The energy required to break the bonds of the reactants =

$$4 \times (\text{C-H}) + 2 \times (\text{O=O}) = (4 \times 413) + (2 \times 498) = 2648 \text{ KJ}$$

The energy produced by the formation of bonds in products =

$$2 \times (\text{C=O}) + 2 \times 2 (\text{O-H}) = (2 \times 745) + (2 \times 2 \times 467) = 3358 \text{ KJ}$$

ΔH = sum of absorbed energy to break bonds + (- sum of released energy from forming bonds)

$$\Delta H = (+2648) + (-3358) = -710 \text{ KJ/mol}$$

So, the reaction is exothermic reaction where (ΔH) has a negative value

Research and investigation :

Thermodynamics analysis, energy efficiency and environment's pollutants effect

You are a graduate in the field of environmental sciences and have been assigned to work in an agricultural research laboratory. Your goal is to understand the impact of thermodynamics on the energy efficiency of an ecosystem. You will analyze the results of typical practical experiments.

The task:

Analyze a study on the influence of thermodynamics on the efficiency of energy transformations in an ecosystem.

Available data:

An experiment was performed on two plants of the same species and at the same growth period. One plant was placed under a 2000 lux light source and the other under a 1000 lux light source. The growth of the two plants was measured after two weeks.

	Plant A Under 2000 Lux	Plant B Under 1000 Lux
The final length	30 cm	20 cm
The final mass	100 gram	60 gram
Amount of used water	2 Liter	2 Liter

Discuss:

Based on the data in the table, how can you compare **the efficiency of energy conversions** between Plant A and Plant B?

Use the first law of thermodynamics to explain how light affects growth and stored energy.

Check your understanding

Multiple choice questions:

1- How does the efficiency of energy systems contribute to the conservation of environmental resources?

- a) It reduces energy consumption and minimizes the use of fossil fuels
- b) It increases energy consumption and leads to resource depletion
- c) It does not affect the use of resources
- d) It increases carbon emissions

(1.3) Nutrients and ecosystem health:



Get ready

Have you ever wondered how plants and animals stay healthy in their environments? The health of ecosystems depends on a certain balance of nutrients, which circulate in nature in a complex way.

In this lesson, we will reveal how these cycles work and how human activities affect them. By understanding the role of nutrients in ecosystems, you can learn how human activity can affect the environment and how to keep it in balance.

Learn

In ecosystems, nutrients act as essential elements that support the life of living organisms, they are essential for the growth, development, and health of plants and animals, and play a vital role in biological processes. These elements include carbon, nitrogen, and phosphorus, each of which plays a specific role in supporting ecosystems.

Types of major nutrients:

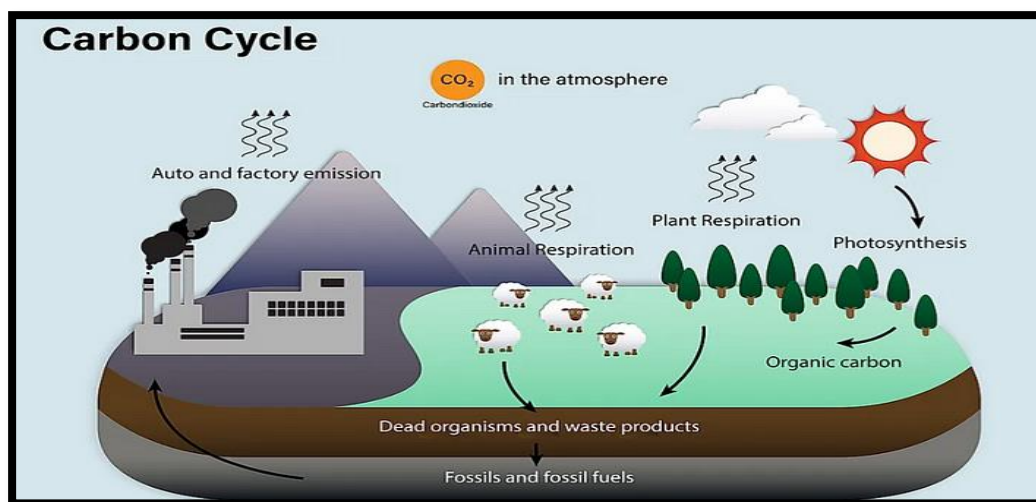
a. Carbon (C)

Carbon is the fundamental element in all organic compounds, such as proteins, carbohydrates, fats, and nucleic acids (DNA and RNA).

Carbon is found in the atmosphere in the form of carbon dioxide (CO_2), also exists in compounds that form the bodies of terrestrial and marine organisms. It is present in organic matter and humus, contributing to soil fertility. Found as dissolved carbonate salts and bicarbonates (e.g., CO_3^{2-} and HCO_3^{-1}) in the aquatic environment, Carbon is present in limestone (CaCO_3) and dolomite ($\text{CaMg}(\text{CO}_3)_2$). Carbon is found in fossil fuels, including coal, oil (petroleum), and natural gas.

Carbon Cycle

It is a continuous biological-geological process in which carbon is exchanged between living organisms, the atmosphere, oceans and rocks. The carbon cycle begins with green plants taking carbon dioxide from the atmosphere in the process of photosynthesis to produce organic compounds.



When herbivores feed on plants, carbon-containing organic matter contributes to the construction of animal tissues, so the carbon atoms in the plant become part of the structure of the cells in the body of the animal that fed on them.

Some of the carbon in the cells and tissues of consuming organisms is returned to the atmosphere through respiration, and organisms lose some of the carbon in their secretions and waste products. After they die, the carbon is a component of organic matter that can be returned to the atmosphere by aerobic decomposition processes carried out by decomposing microorganisms. In plants, respiration also produces CO_2 , which is released back into the atmosphere.

Some of the organic carbon follows a longer pathway. In marine animals, carbon in the form of calcium carbonate is incorporated into the structure of hard parts such as mollusk shells. After long periods of time, the carbon is stabilized in the limestone rocks from the marine deposits of these shells.

Limestone rocks can undergo chemical weathering and some of the carbon is returned to the atmosphere as CO_2 .

Carbon can also become trapped in the organic compounds found in fossil fuels. When these fuels are burned, the carbon is returned to the atmosphere as carbon dioxide to be recycled again.

The carbon cycle is complex and interconnected, linking organisms, the atmosphere, oceans, and rocks. Understanding this cycle is essential to understanding climate change and human impact on the environment.

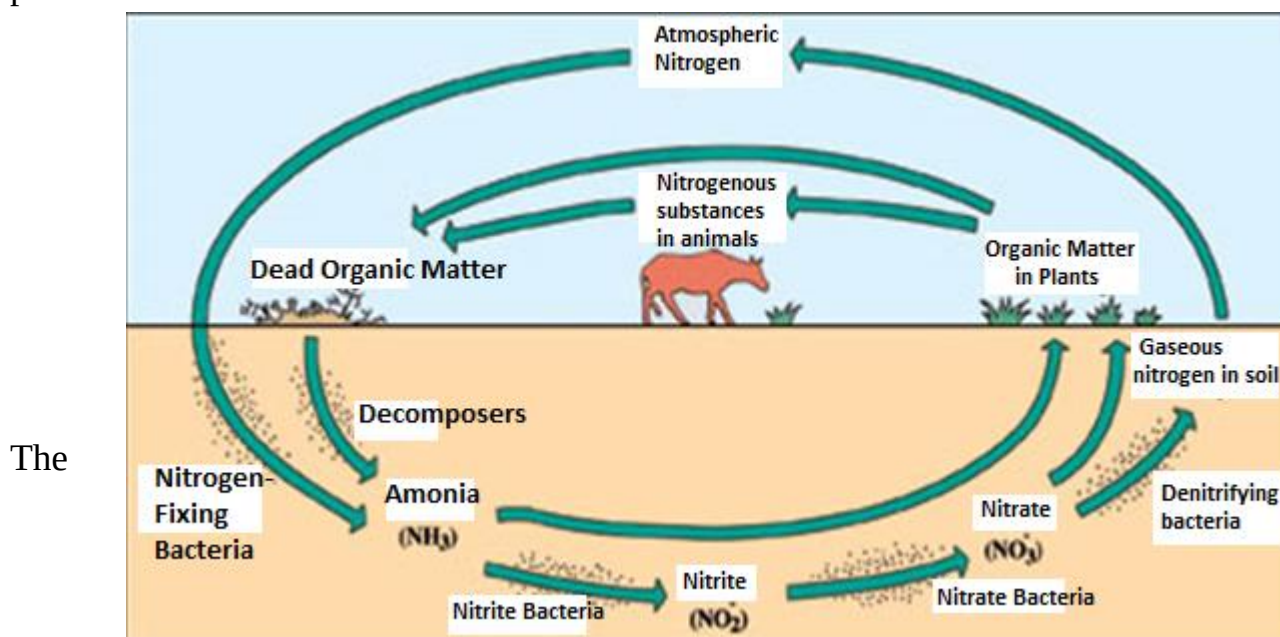
B. Nitrogen (N)

Nitrogen is a major component of amino acids, which make up the essential proteins for growth. Nitrogen enters the ecosystem through nitrogen fixation by bacteria, and then travels up the food chain.

Nitrogen cycle:

After plants and animals die, they are decomposed by certain bacteria and fungi. The decomposition of nitrogen compounds in dead organic matter and animal waste produces ammonia gas NH_3 . Plants absorb some ammonia and use it to make proteins and other substances necessary for life. Ammonia that is not absorbed by plants is converted into nitrate compounds (NO_3^-) by nitrifying bacteria.

There are two types of nitrifying bacteria, nitrite bacteria that convert ammonia into nitrite compounds (NO_2^-) and nitrate bacteria that convert nitrite compounds into nitrate compounds. Plants absorb most of the nitrate and use it, like ammonia, to make proteins. Animals, on the other hand, get nitrogen from eating plants or other animals that feed on plants.



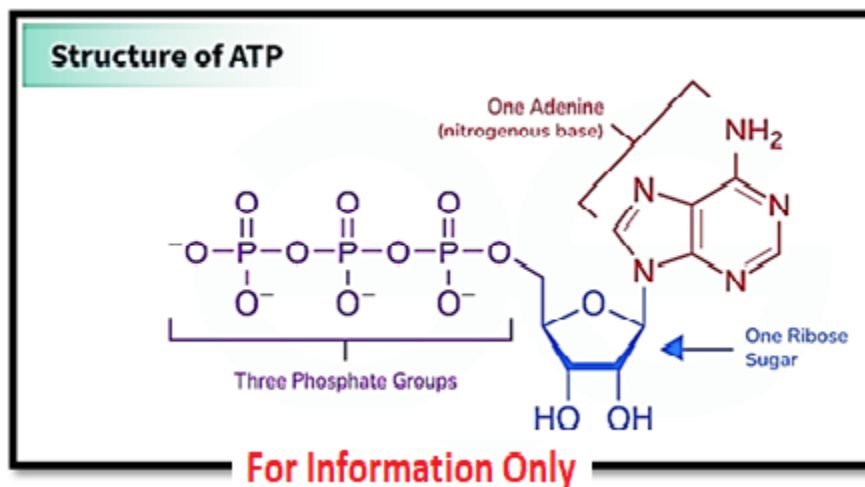
process of nitrogen fixation adds more nitrogen to the biological cycle. Nitrogen-fixing bacteria and algae take nitrogen from the air and turn it into ammonia. Most of the ammonia is absorbed by plants and some is lost to the atmosphere.

Although nitrogen fixation takes nitrogen from the atmosphere, there is an opposite process called **denitrification**. Denitrifying bacteria convert some of the nitrates in the soil into nitrogen gas or nitrous oxide (N_2O). Nitrogen may be cycled between the soil and organisms several times before returning to the atmosphere.

Some human activities may interfere with the nitrogen cycle. For example, industry consumes large amounts of nitrogen to produce fertilizers.

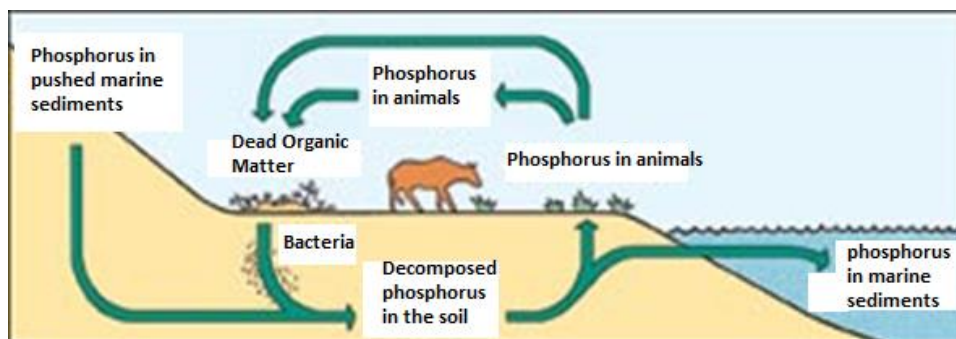
C. Phosphorus (P)

Phosphorus plays an important role in the storage and transportation of energy in cells through ATP (adenosine triphosphate), the synthesis of DNA and RNA molecules, and is involved in the synthesis of cell membranes, bones and teeth.



It also contributes to the growth of roots, flowers, and fruits in the plant, which affects its productivity.

Phosphorus does not exist as gases in the atmosphere like carbon and nitrogen. Instead, most phosphorus is found as compounds in soil, water, sediment, rocks, and volcanic ash.



As rocks are broken up by rain, wind, and temperature, phosphate ions gradually reach the soil and surface water. Plants absorb phosphate ions and incorporate them into organic molecules. Animals obtain phosphate by feeding on plants and other animals. Organic phosphate returns to the soil in plant and animal waste or after they die, where it is broken down by bacteria into inorganic forms that can be used again by plants. Consequently, phosphorus is added to most agricultural fertilizers, and this can cause pollution of aquatic environments when it travels with wastewater to rivers, lakes, and oceans.

Nutrients and Ecosystems

Nutrients keep ecosystems in balance and provide the basis for the food chain. Animals feed on plants, and predators eat other animals. Deficiencies of nutrients such as nitrogen and phosphorus lead to poor plant growth and negatively impact animal health. By understanding the role of these nutrients, we can promote healthier ecosystems and greater sustainability in the environment.

Impact of natural processes and phenomena

The natural processes that contribute to the water cycle also affect nutrient cycles.

When it rains, nutrients dissolved in the water are transported to the soil. On the other hand, evaporation contributes to the transfer of water to the atmosphere, which affects the distribution of nutrients in the ecosystem.

Research has shown that drought has a negative effect on the concentration of organic carbon and nitrogen, and a positive effect on the concentration of inorganic phosphorus. Drought can reduce vegetation cover, which can encourage physical processes - such as rock erosion - at the expense of biological processes.



Search and Inquiry

You are a researcher working at a research center specializing in water quality. You received from an agricultural area indicating an issue with water pollution report with nitrates from the intensive use of fertilizers. Changes in the health of plants and animals have been reported in the health of aquatic plants and animals due to this pollution. Your goal is to analyze how nitrate pollution affects the cycle of nutrients in a freshwater ecosystem and how it affects the health of plants and other organisms.

The task:

You will analyze the impact of nitrate pollution on water quality and plant health. Through previously collected data and experimental results.

Data:

Area	Nitrate concentration (mg/L)	Plant growth ratio (%)	Dissolved oxygen rate (mg/L)	Health of aquatic organisms
Site 1 (Near agriculture land)	50	40	2.5	strongly affected
Site 2 (Mid river)	30	60	4.5	Slightly affected
Site 3 (Clean water source)	10	90	7.0	natural

1. Looking at the table, what is the effect of nitrate pollution on water quality at Site 1 compared to Site 3? How does this reflect the health of the vegetation in these areas?
2. What is the relation between nitrate concentration and the decrease in dissolved oxygen in the water? How does this affect the health of aquatic animals?
3. How might nitrate pollution affect the cycle of nutrients in a freshwater ecosystem? Explain this through the effect of nitrate on plants and aquatic organisms.
4. If nitrate pollution continues at this rate, what are the likely long-term consequences in the long term in this region? What might happen to the biodiversity in the aquatic system?

Based on the data presented and your analysis, what actions could be taken to minimize nitrate pollution and improve water quality at Site 1?

Check your understanding.

1. What is the important of nutrients in maintaining healthy ecosystems?
2. How do physical processes such as precipitation and evaporation affect nutrient cycles?
3. What are the major chemical reactions in the carbon and nitrogen cycles?
4. How does human activity affect nutrient cycles in the environment?

Multiple choice questions:

1. How do physical processes such as precipitation and evaporation affect nutrient cycles?

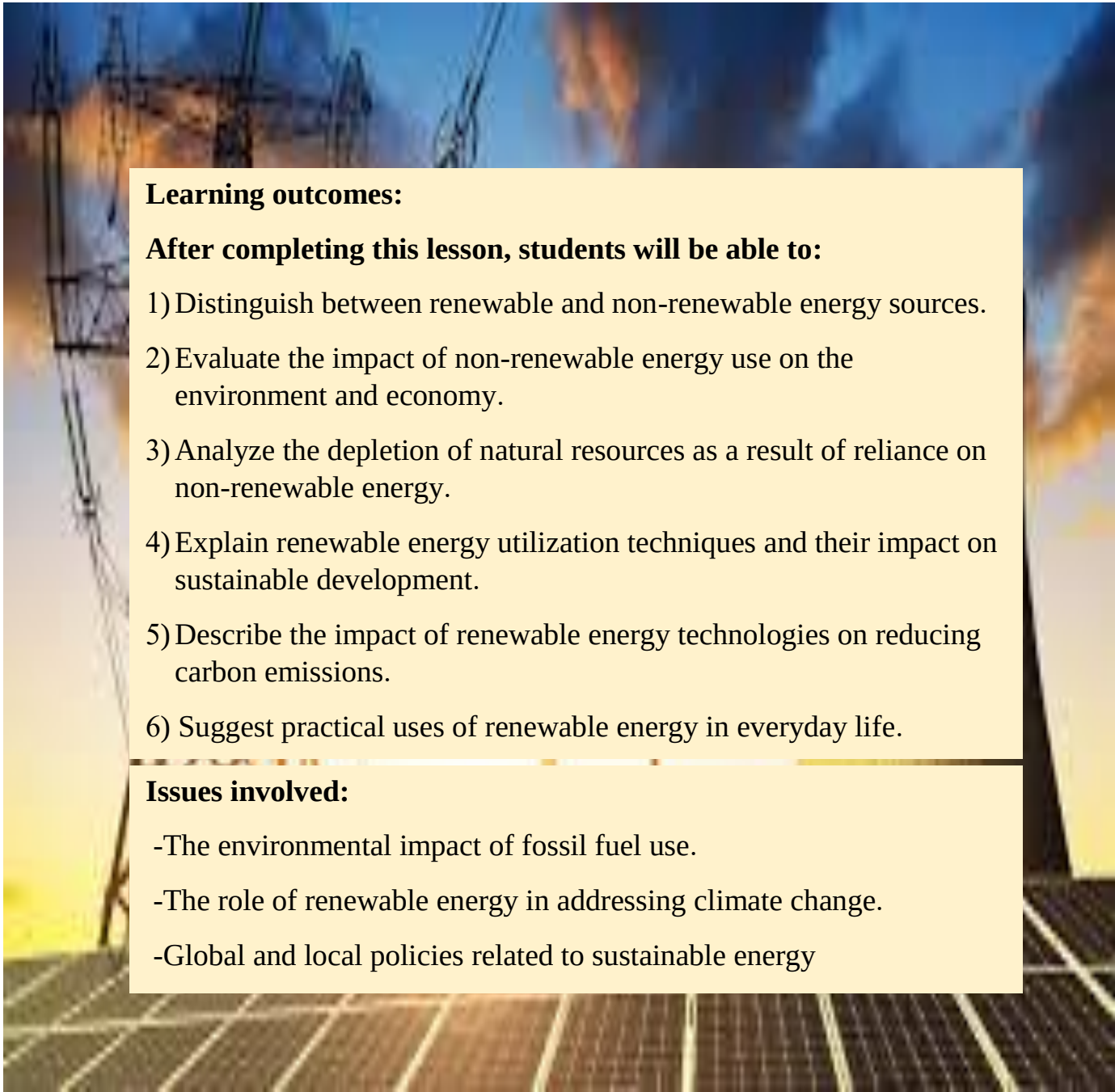
- a) Increase the availability of nutrients in the soil and minimize the loss of nutrients to the air
- b) Lead to the transfer of nutrients from the soil to water bodies
- c) Decrease the concentration of nutrients in the soil and increase their accumulation in the atmosphere
- d) Lead to the accumulation of nutrients in the soil and minimize their transport through water.

2. What are the main chemical reactions in the carbon and nitrogen cycles?

- a) Cellular respiration, photosynthesis, and nitrification
- b) Photolysis, nuclear fusion, and mineralization
- c) Photosynthesis, biodegradation, and filtration
- d) Cellular respiration, nuclear fusion, and precipitation

Chapter 2

Renewable and Non-renewable Energy



Learning outcomes:

After completing this lesson, students will be able to:

- 1) Distinguish between renewable and non-renewable energy sources.
- 2) Evaluate the impact of non-renewable energy use on the environment and economy.
- 3) Analyze the depletion of natural resources as a result of reliance on non-renewable energy.
- 4) Explain renewable energy utilization techniques and their impact on sustainable development.
- 5) Describe the impact of renewable energy technologies on reducing carbon emissions.
- 6) Suggest practical uses of renewable energy in everyday life.

Issues involved:

- The environmental impact of fossil fuel use.
- The role of renewable energy in addressing climate change.
- Global and local policies related to sustainable energy

(2-1) Non-renewable energy sources:



Get ready

Energy runs the wheel of life, and the term energy is used in different contexts in our daily conversations. For example, some commercials display types of foods as sources of energy. Athletes use the word energy when talking about exercise, and companies that provide us with electricity, natural gas, fuel, etc. are called energy companies.

However, scientists and engineers use the word energy more specifically. As you learned earlier, **energy is the ability to do work or make a change**; Energy is neither created nor destroyed, but rather transformed from one form to another.

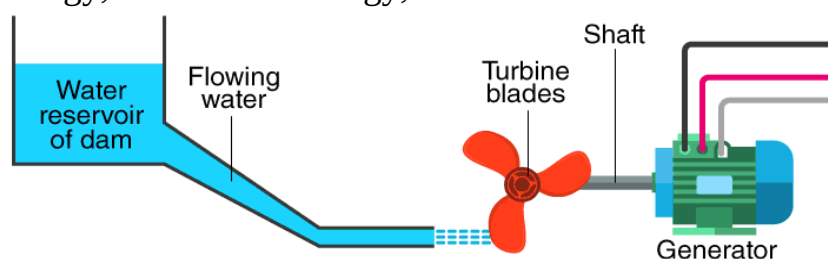
Modern life relies heavily on energy sources to heat our homes, run our cars, and provide us with the electricity. Most of this energy comes from non-renewable sources such as coal, oil, and natural gas. But, what is the result of using these sources irrationally? And what are the expected environmental impacts?

In this lesson, we will explore the different types of fossil fuels, how energy is produced from them, and their environmental impacts on our planet.

Learn

Forms of Energy:

Natural sciences centuries ago, have been interested in studying matter and energy as two basic concepts. Energy exists in several forms. Each form can be transformed into another form. Light, thermal radiation that reaches us from the sun, chemical energy, nuclear energy, electrical energy, mechanical energy, and others are all forms of energy.



Hydroelectric power station

The figure shows a model of a hydroelectric power station.

Explore four forms of energy arranged in order of their transformations. Identify the energy produced by the station.

Energy Resources

Non-renewable energy resources:

Sources of energy those are extracted from the earth and take millions of years to form, meaning they are being used faster than they can be replenished. When these sources are depleted, they cannot be replaced quickly enough to meet human needs. Common examples of these sources include: **Coal, oil, and natural gas.**

Types of Non-Renewable Energy Resources:

1. Oil (Petroleum):

Oil is a mixture of hydrocarbons extracted from deep underground. Its derivatives are used to power cars, airplanes, and factories, as well as to make plastics and chemical products. The combustion of oil releases greenhouse gases such as carbon dioxide (CO_2), which contributes to global warming and climate change.



Example of its effect on environment:

Oil spills from oil tankers pose a threat to marine life and lead to significant pollution in the oceans.

2. Coal:

Coal: is a fossil fuel extracted from mines, it formed from the remains of plants that have been decayed for millions of years. It is mainly used to generate electricity and operate factories. Coal is one of the most polluting energy sources, releasing large amounts of carbon dioxide and sulfur, which contribute to air pollution and climate change.



Example of its effect on environment:

Open-pit coal mines can destroy natural habitats and contribute to the extinction of some plant and animal species.

3. Natural gas:

Natural gas is a mixture of flammable gases extracted from underground. It is mainly used for cooking, heating homes, and generating electricity. Although it is cleaner than oil and coal, its combustion still results in the emission of greenhouse gases such as carbon dioxide and methane .

Example of its effect on environment:

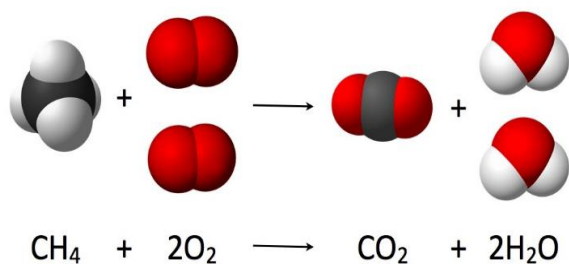
Dangerous leaks from natural gas transportation pipelines can occur, polluting the .environment and increasing the risk of explosions

The most important gases and air pollutants produced by burning fossil fuels

- **Carbon dioxide (CO₂):**

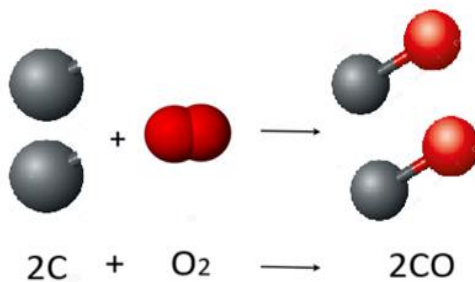
When hydrocarbons (the main component of fossil fuels) are burned, the carbon and hydrogen in the fuel react with oxygen in the air to produce carbon dioxide and water.

Example: Methane combustion



Carbon monoxide (CO):

A colorless, odorless, tasteless, toxic gas produced by the incomplete combustion of carbon-based fuels such as wood, gasoline, coal, natural gas, and kerosene.



Research activity

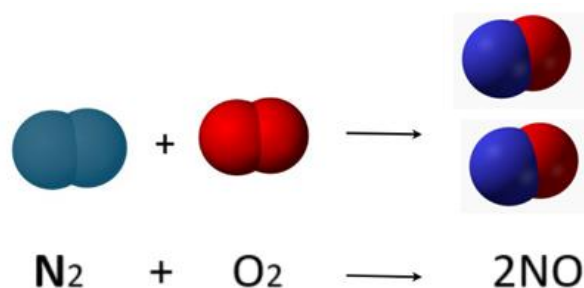
What is the effect of carbon monoxide on the human body?

The gas spreads into the blood as soon as it is inhaled and makes it difficult for the blood to combine with oxygen gas, as the ability of blood hemoglobin to bind with carbon monoxide gas is 210 times greater than its ability to bind with oxygen, which leads to the destruction of many cells. Its symptoms: difficulty breathing, fatigue, dizziness, muscle relaxation and finally leads to death.

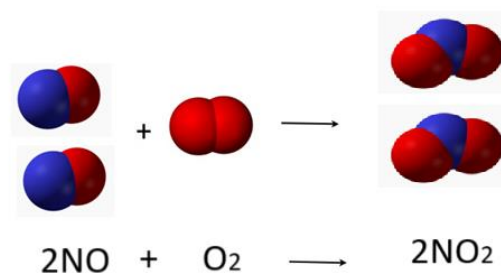
Nitrogen oxides (NO_x):

Nitrogen oxides are formed when fossil fuels are burned at high temperatures, where nitrogenous impurities in the fuel react with atmospheric oxygen to form nitrogen oxides (NO and NO₂).

- **Nitric oxide NO:**



- **Nitrogen dioxide (NO₂):**



- **Example:**

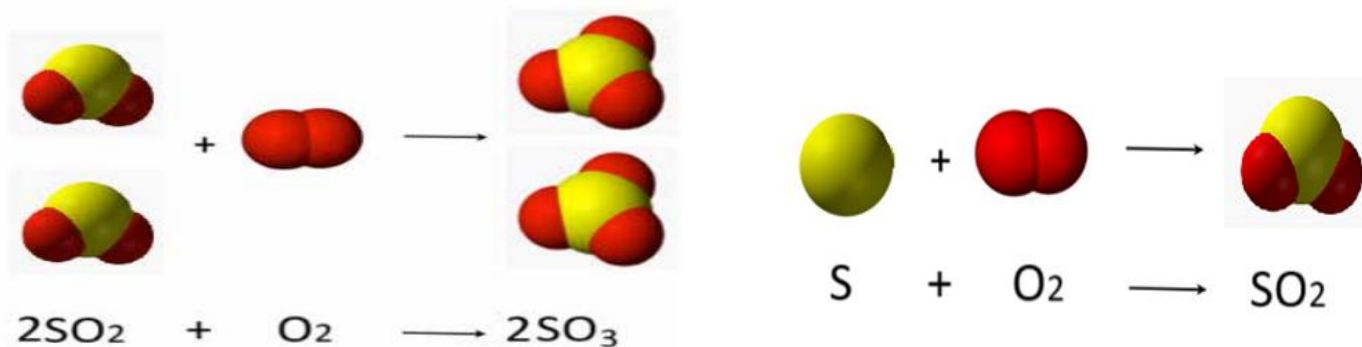
In gasoline-powered car engines, a reaction between nitrogenous impurities and oxygen occurs in the combustion chamber to form nitric oxide (NO), which is then oxidized in the atmosphere to form nitrogen dioxide (NO₂).

Impact of nitrogen oxides on health:

All types of nitrogen oxides are toxic and harmful and can cause eye and respiratory irritation, while long-term exposure can cause cardiovascular or pulmonary diseases. People live in cities are most at risk from inhaling nitrogen oxide gases..

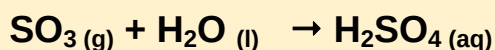
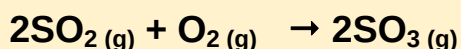
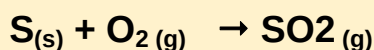
- **Sulfur oxides (SO_x):**

Formed as a result of the combustion of fuel that contains sulfurous impurities, sulfur dioxide gas is formed, which is oxidized by the oxygen in the air due to the impurities that exist in the air, and acts as a catalyst for the completion of this reaction and the formation of sulfur trioxide gas.



The impact of sulfur oxides on the environment:

Sulfur trioxide reacts with water in the atmosphere to form sulfuric acid (H₂SO₄), which is a major component of acid rain that affects the facades of ancient and archaeological buildings as it corrodes building materials such as limestone and marble used in architectural designs and statues that consist of calcium carbonate, forming calcium sulfate salts that dissolve in water to a greater degree than calcium carbonate.



Producing energy from fossil fuels:

The importance of electric power generation is in providing homes and institutions with the energy needed to operate electrical appliances.

Electric power systems support economic growth and job creation in the energy sector, as the manufacture of electrical systems requires the efforts of many workers, engineers and technicians, and contributes to improving the quality of life and enhancing the economic and national security of societies.

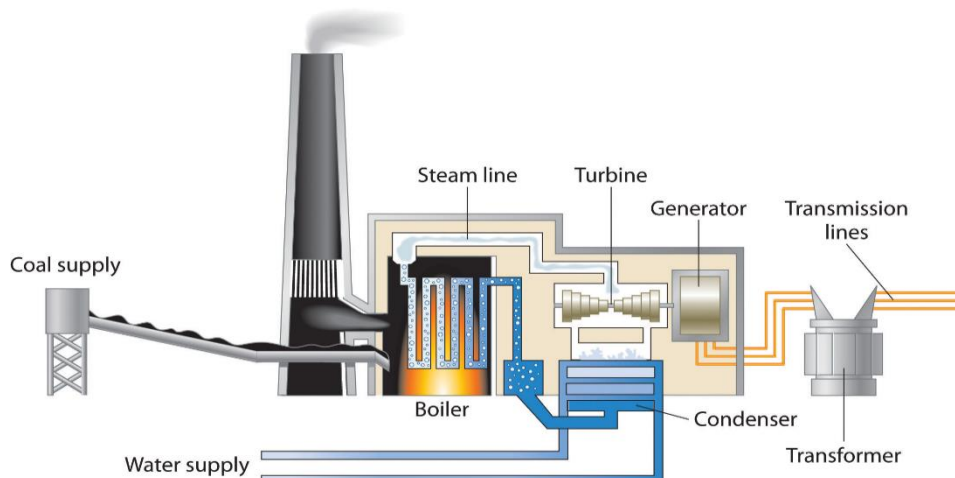


Electric power generation stations:

The process of power generation depends mainly on the first law of thermodynamics. As in a power station, the chemical energy stored in fossil fuels is converted into electrical energy. During this process, a large amount of fossil fuel stocks is consumed, and it also produces a huge amount of gases, like carbon dioxide, which plays an essential role in the continuous rise in the earth's temperature, causing global warming.

How the power station works.

Inside the station, different types of fuel are used, whether coal, petroleum or natural gas, depending on their availability, and the required amount is combusted so that the chemical energy is converted into thermal energy used to heat water and convert it into steam, and the steam moves through pipes that direct it to the turbines. The turbines begin to rotate under the influence of steam pressure and convert kinetic energy into electrical energy



How the power plant works

Research and investigation:

- Conduct a simple experiment to burn different fuels in the school lab's gas chamber, such as candles or small pieces of charcoal. Follow the teacher's safety instructions.

Observe the products of combustion. Record how these products can affect the environment.

Required tools:

Small candles. - Small pieces of charcoal. - Matches - a metal plate or heat-resistant surface. - Small mirror or glass slide (to collect soot). - Test tube or small glass vial (to collect gases)

Check your observations:

If the candles are burning: You notice light smoke and black deposits (soot) on the glass slide or mirror. This soot is carbon that is not completely burnt.

In the case of coal combustion: Note the thicker smoke, with more soot collecting on the glass slide or mirror. You may also notice a strong odor, especially if the charcoal has high sulfur content.

Check your understanding

- 1- Draw a diagram demonstrates the conversion of thermal energy from fossil fuel into electric energy.
- 2- Compare between the impact of use coal, petroleum or natural gas as a source of energy?
- 3- Use the information in this lesson to think how to decrease the impact of using non-renewable sources of energy, and how it can contribute in using sustainable sources of energy in future?

4- Choose the correct answer

1) What is the main gas produced when fossil fuels are burned?

- A) Oxygen O_2 B) Carbon dioxide CO_2
C) Nitrogen N_2 D) Hydrogen H_2

2) Which of the following compounds is produced when fossil fuels are burned and contributes to the formation of acid rain?

- A) CH_4 methane B) carbon monoxide CO
C) sulfur dioxide SO_2 D) Ozone O_3

3) What conditions lead to the formation of nitrogen oxides (NO_x) during the combustion of fossil fuels?

- (A) Combustion at low temperatures
(B) Combustion in the absence of oxygen
(C) Combustion at high temperatures
(D) Combustion in the presence of large amounts of water

4) What are the environmental effects of releasing sulfur oxides (SO_x) into the atmosphere when fossil fuels are burned?

- (A) Increased oxygen content in the atmosphere
(B) Improvement in air quality
(C) Formation of acid rain
(D) Reduction of global warming

2-2 Depletion of natural resources



Get ready

Imagine reviewing the diverse natural resources that the world depends on, such as minerals, oil and coal. These resources are essential to meet our daily needs. But their excessive use causes many environmental issues. In this lesson, we will deal with how the depletion of these resources affects the environment and how to deal with the waste they produce by understanding physical and chemical concepts.

Learn

Natural resource depletion is the process of consuming natural resources at a faster rate than their ability to regenerate. This includes **fossil fuels, minerals, water, soil, and living organisms**. Resource depletion affects ecosystems, public health, and economies significantly, and an example of a process that contributes to resource depletion is mining.

Mining:

It is the process by which important minerals are searched and mined from the earth's surface and resources needed for modern life, and this process is done by digging up the ground to access the important minerals.

Mining can be potentially dangerous to the environment, when natural resources are over-extracted, such as mining or drilling wells, multiple physical impacts occur.

Physical impacts of mining on environment:

- **Change in energy distribution of environment**

When minerals are extracted from the ground, layers of soil are removed, affecting the exchange of heat and moisture in the soil, air and surface and subsurface water pollution, as moist soils have a greater ability to retain heat for longer periods of time compared to dry soils. This leads to changes in the region's **thermal balance**.



Mining effect on the soil



Acid discharge in rivers

- **Pressure and erosion:**

Activities such as mining involve applying significant stresses to rocks and soil. This can lead to soil erosion and land degradation. For example, underground mining creates voids in the rock, which can lead to ground collapse or the formation of deep pits.

When resources such as minerals and oil are extracted, the structure of the land is significantly changed. The processes of mining and drilling remove the top layers of soil and rocks, leading to erosion and the destruction of natural habitats. This erosion can cause landslides and degradation of soil quality.



Mining operations can lead to the release of chemicals into groundwater. This pollution can change the physical properties of water, such as pH and mineral concentrations, affecting the aquatic environment.

Chemistry and mining:

Chemistry related to the extraction, purification, and utilization of minerals in various industries.

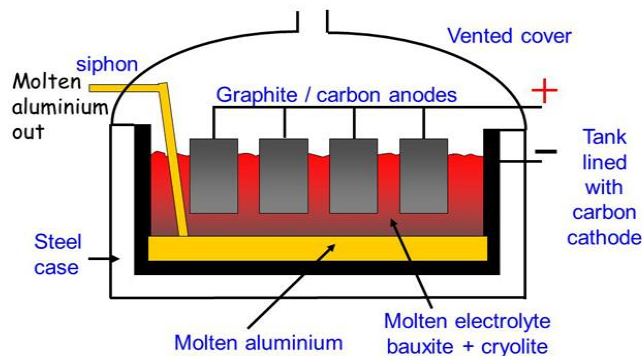
Chemical analysis of ore: Before the mining process begins, mineral ore is analyzed using chemical techniques to determine the type and quantity of minerals in the ore, which helps determine the feasibility of the mining process.

Mineral extraction: Chemical reactions are used to extract minerals from their ores.

For example, electrolysis is used to extract aluminum from bauxite ore. Chemicals such as cyanide are used to extract gold.

(1) Extraction of aluminum from bauxite ore using electrolysis:

Aluminum is extracted from bauxite ore (Al_2O_3) dissolved in cryolite (Na_3AlF_6) by the electrolysis process in an electrolytic cell shown in the figure.



Aluminum extraction equation:



(2) Gold extraction using cyanide:

Cyanide is used to extract gold from its ores by dissolving it in an aqueous solution of sodium cyanide. The gold reacts with cyanide and oxygen to form a soluble compound of gold cyanide.

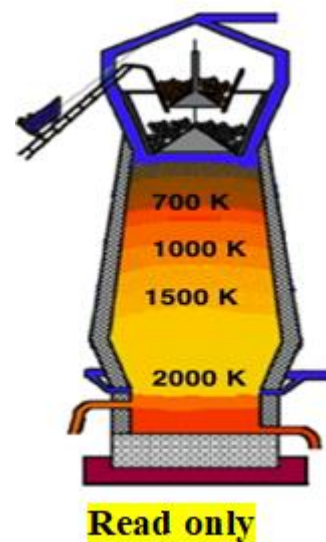
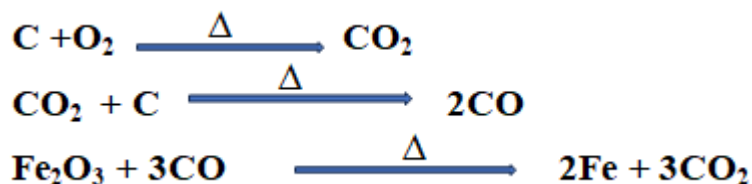


The gold is then separated from the solution using activated carbon or through other processes.

(3) Extraction of iron from hematite:

Iron is extracted from hematite ore in a blast furnace using coke, which reacts with a stream of oxygen forming carbon dioxide gas, which is reduced with more carbon to carbon monoxide gas, which acts as a reducing agent to extract iron in molten form.

The process takes place through several chemical reactions:



Purification of minerals:

After some minerals are extracted from their ores, the minerals need to be refined, through the process of electrolysis to purify copper, or the use of chemical agents to purify metals from impurities.

Environment and mining:

Chemistry plays an important role in minimizing the environmental impact of mining by developing technologies to treat contaminated water and safely dispose of waste.

Chemical wastes disposal:

Chemical waste disposal is the process of the management of waste containing chemicals in a safe and efficient manner to avoid environmental pollution and protect human health. As many of these wastes can be dangerous and toxic, disposing of them requires precise procedures and strict regulatory standards.

Chemical wastes disposal steps:

Categorization and segregation:

Before disposing of chemical wastes, they must be categorized according to their type and depending on their type and severity.

For example, there are flammable wastes, toxic wastes, radioactive wastes, and reactive wastes.

Each type of waste must be segregated separately to ensure safe handling.

Temporary storage:

Chemical wastes are stored in secure, leak-proof and resistance to reaction containers. The containers must have clear warning labels indicating the type of chemicals and their hazardousness. Temporary storage requires a safe environment to avoid unintended leakage or reaction of the waste.

Treatment:

Chemical waste can undergo special treatment to reduce its toxicity or to convert it into less hazardous substances. Chemical treatment methods include using chemicals to neutralize acids or bases, or using processes such as oxidation or reduction to break down toxic compounds.

Example:

Wastes treatment of mining processes include chemical precipitation, using filters to remove heavy metals from waste water



Final disposal:

After treatment, the waste is disposed of in safe ways, such as:

Burial in Special burials:

Waste is buried in specially designed burials to prevent chemicals from Leakage into the soil or groundwater. These burials are equipped with insulation layers and leakage control systems.

Burning in high-temperature furnaces:

Some chemical wastes can be burned in specialized furnaces that reduce the volume of wastes and remove their toxicity. These furnaces operate at high temperatures to ensure that the wastes are completely decomposed.

Recycling:

In some cases, chemical wastes can be recycled for further use. For example, some chemical solvents can be purified and reused in other industrial processes

Monitoring and follow-up:

Even after chemical waste has been disposed of, sites used for final disposal must be monitored over time to ensure that no leakage or pollution occurs. And environmental standards must be followed.

Research and Investigation

Mission:

Explore the impact of natural resource depletion by studying the impact of logging and mining on the ecosystem.

Steps:

1. Choose an area that suffers from logging or mining.
2. Collect data on biodiversity loss, soil and water quality in this region
3. Compare the results with another area that was not affected by human activities

Questions:

- How does the depletion of natural resources affect the living organisms of the region?
- What are the long-term environmental impacts of logging or mining?
- How can environmental damage caused by the depletion of natural resources be minimized?

Check your understanding

1. How do mining operations affect ecological balance? Use the concepts of physics and chemistry to explain the process.
2. What are the main chemical reactions that occur when fossil fuels are combustion?
3. How do these interactions affect the environment?
4. Discuss how resource depletion can affect biodiversity through cumulative and interactive effects between different human activities

Choose the correct answer

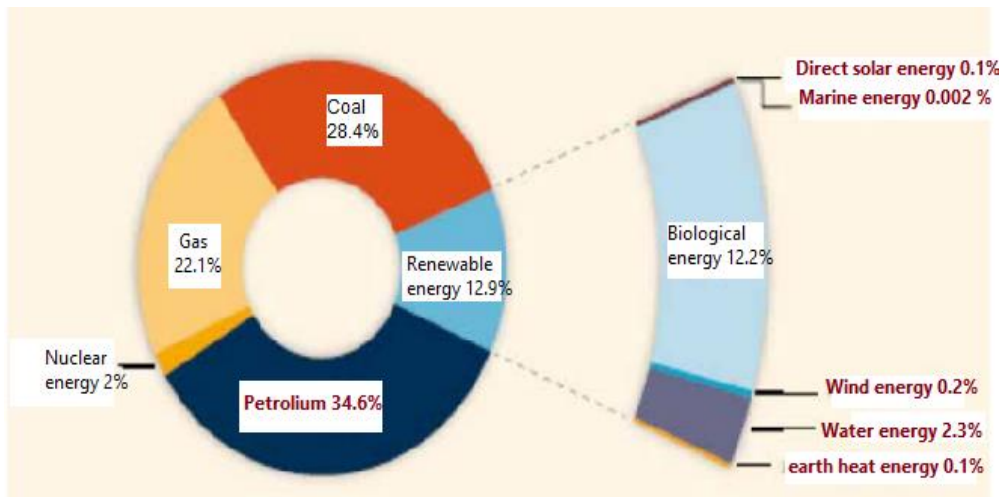
1. **What is the primary goal of proper disposal of chemical waste?**
 - a) Decrease of waste volume
 - b) Protection of the environment and human health
 - c) Increased economic efficiency
 - d) Chemical reuse
2. **What is the first step in the chemical waste disposal process?**
 - A) Burning waste in high temperature furnaces
 - B) Storage of waste in private landfills
 - C) Classification and separation of waste according to type
 - D) Monitoring of sites used for final disposal
3. **Which of the following methods is used to convert toxic chemical waste into less hazardous substances?**
 - A) Burials in private cemeteries
 - B) Chemical treatment
 - C) Recycling
 - D) Burning in high-temperature furnaces
4. **Why should sites used for the final disposal of chemical waste be monitored over time?**
 - A) To ensure that waste is not reused
 - B) To ensure that there is no leakage or pollution
 - C) To increase the volume of landfills used
 - D) To improve the quality of stored waste

2-3: Renewable energy:



Get ready

Imagine walking on a sunny day and wishing you could make better use of this renewable energy, or maybe you notice the strong wind outside, and think about how you can turn it into energy. In this lesson, we will learn about the types of renewable energy, how to harness them, and how to assess their impact on the environment and climate. Let's start exploring these natural energy sources and how to convert them into energy.



Renewable and non-renewable energy sources:

Sources of renewable energy

A) Solar energy

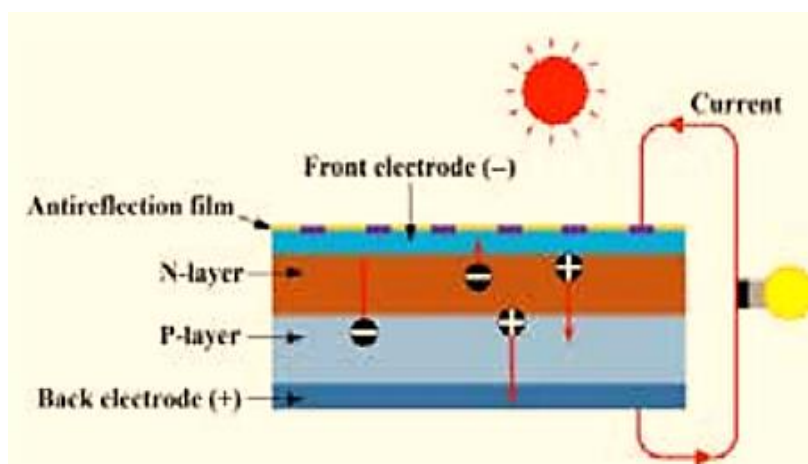
Solar cells:

They are consists of semiconductors that convert solar energy directly into electrical energy. It is considered one of the modern methods that preserve the environment and minimize pollution resulting from the use of fossil fuels to obtain electrical energy.



BENBAN STATION in Aswan considered the capital of solar energy and it is a group of solar stations contain 32 stations its capacity reaches **1465 megawatt**

When light falls on the surface of a semiconductor material such as silicon, photons of light displace electrons to one of its two surfaces, a potential difference arises between the two surfaces that can create an electric current if connected to an external circuit.



To determine the efficiency of a solar cell, we compare the electrical energy produced by the cell to the light energy provided by the sun on its surface. If the cell is able to convert all the light energy that falls on it into electrical energy, then the efficiency of the cell is 100%. In practical applications, no solar cell is perfect.

The efficiency of the solar cell varies from time to time during the day depending on the angle of inclination of the sun's rays, the presence or absence of clouds, and environmental factors such as wind, dust, and humidity.

Recently, scientists have developed techniques to improve the efficiency of solar cells, where nanotechnology has been used in which materials are characterized by new properties on the solar cell that are characterized by a high ability to absorb sunlight to increase its efficiency.

The electrical energy (E) is calculated in joules from the relation

$$E = V.I.t$$

Where I is the current in amperes (A), V is the voltage in volts (V), and t is the time of passing current in seconds (s).

In practical applications, we prefer to deal with power (P) and its unit of measurement is the (Watt)

Watt represents the energy produced or consumed per second, and is calculated from the relationship:

$$P = VI$$



$$\text{Efficiency of solar cell} = \frac{\text{Electric power produced}}{\text{Optical power falling on the cell}} \times 100$$

Example

A photovoltaic panel produces an electric potential difference 10 V and a current of 0.5 A when a circuit connected to it is closed. Calculate the power it produces.

Think:

If you have solar cell panels installed on the roof of your home that are running at 20% efficiency, which means they convert 20% of the solar energy they receive into electricity.

1. If the incident light power on each square meter of the surface of the panels is 1000 W. How much the electric power does a square meter of solar panels produce?
2. If the area of the solar panels is 2 m², what is the total electric power produced by the panels?
3. How can the production of electric energy from solar cells be increased?

You may ask if there are devices that can work by using solar energy in houses. Of course, there are many devices that can work with solar energy and used in daily life such as:

Solar heaters

Solar water heaters are used to heat water at home and use it for multiple purposes, thus reducing the use of electricity significantly, and this type of heater is characterized by high efficiency.



Air conditioners

Residents of hot countries need air conditioners and cooling systems a lot, and solar-powered air conditioners are very convenient for residents, as their use reduces electricity consumption by a large percentage.



Solar lights

To the list of solar-powered devices for the home, we add solar lamps. Solar lamps can be relied upon to illuminate and decorate gardens alike, and are used when there is a power outage, as they are considered a main alternative to lighting and consume less electricity. Solar lamps work by placing them under the sun's rays, and have an automatic operation feature, in addition to being environmentally friendly and not producing any exhausts.



Wind energy:

Wind energy is one of the most important sources of environmentally friendly alternative energy that depends on converting wind energy into clean electrical energy. It relies on the operation of wind turbines by the movement of air. It consists of streamlined and curved blades or fans, turbines, and generators. When the air current passes over the two sides of the blade, two zones of different atmospheric pressure are formed due to the different speed of air movement on both sides of the blade, which causes it to move. The blades are connected by a transmission shaft to a turbine connected to a generator to convert the kinetic energy into electrical energy.



The efficiency of wind turbines depends on the speed of wind movement in the area, so it is preferable to build them in open areas such as deserts and high altitude areas.

Hydroelectric power:

Dams are used to store water in a reservoir. Thus, the water gains potential energy due to its position.

The dam contains gates to control the movement of water. When the gates are opened, water flows from upstream to downstream in front of the dam to fall on turbines that rotate due to the falling water, and then this movement is transmitted to electrical generators that convert the energy into electrical energy.



Research activity

Search for what are the effects of renewable energy on the environment and climate change?

Scientific activity:

Conduct a simple experiment using a small solar cell to measure the amount of electricity that can be produced from sunlight at different times of the day. Record the results and analyze them to determine the best times to utilize solar energy.

Check your understanding

- How do solar cells convert solar energy into electricity?
- What is the difference in carbon emissions between renewable energy and fossil fuels?
- How does renewable energy contribute to minimizing the impact of global warming and climate change?
- What are the potential challenges of each type of renewable energy, and how can these challenges be managed achieve sustainability?

Choose the correct answer:

1. How does solar energy contribute to reducing chemical pollution?
A) By reducing water consumption
B) by reducing dependence on fossil fuels
C) by increasing sulfur dioxide emissions
D) by improving the quality of fuels
2. Which of the following renewable energy sources do not produce carbon dioxide emissions during the power generation process?
A) Coal B) Natural gas C) Wind energy D) Oil
3. How do renewable energy technologies contribute to the fight against climate change?
A) By increasing greenhouse gas emissions
B) By reducing the consumption of natural resources
C) By reducing emissions of greenhouse gases such as carbon dioxide
D) By increasing chemical pollution in the soil

(2-4) Applications of renewable energy sources in everyday life:



Get ready

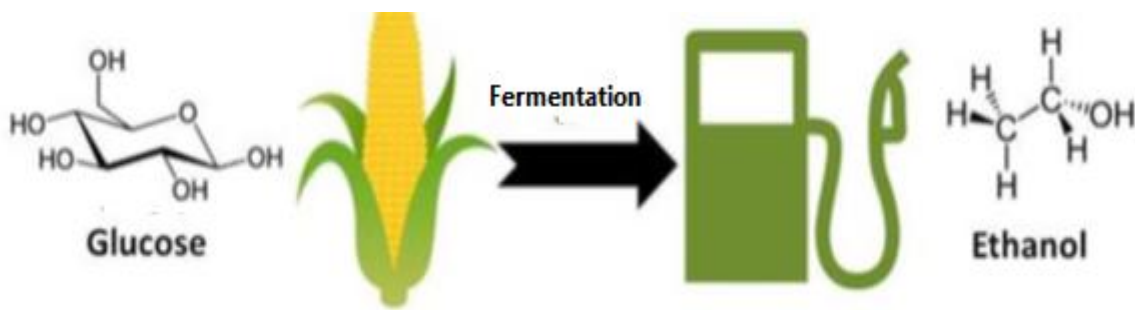
Have you ever asked about other sources rather than wind, solar energy, and water falls as source of renewable energy?

In this lesson, we will explore how biology and technology use living organisms in producing renewable energy as an innovative new field to reach a sustainable sources of energy.

LEARN

Bio- energy produced from living organisms or from organic materials depend on utilizing the natural biological processes that occur in these organisms to convert organic materials into liquid biofuel as ethanol and bio-diesel, or electricity through its burning in energy generating stations. (Renewable energy)

Crops as Maize and Cane sugar to produce ethanol as a fuel instead of benzene.



The biomass of agricultural crops such Cane sugar or residues as rice straw, can be used to produce energy through processes such as fermentation and aerobic decomposition. Meanwhile, microalgae and microbes offer new opportunities to produce biofuels through advanced biological processes.

The use of crops residues and agriculture wastes to convert it to energy through fermentation or burning helps in decrease the carbon emissions if compared by fossil fuel as carbon released from through burning of fossil fuel had been already absorbed from atmosphere by plants.

Methane-producing bacteria: can be used to decompose organic matter in waste treatment plants or animal barns, producing methane as a biofuel.

Enzyme-derived energy is an innovative development in the field of renewable energy, exploiting the ability of enzymes to speed up chemical transformations to efficiently and sustainably convert organic matter into biofuels. Certain enzymes are used to convert **cellulose** found in plants into **sugar**, which can then be converted into **ethanol**, a type of biofuel.

Enzymes can be used to break down fats from biological sources such as vegetable oils or animal fats into biofuels such as **biodiesel**.

Microalgae-derived energy is one of the innovative future solutions in biofuel production, taking advantage of their ability to grow rapidly and convert light and organic matter into efficient and sustainable energy sources. Microalgae can be grown in special environments and produce oils that can be converted into **biodiesel**. This type of biofuel is a promising source because it does not require a large agricultural area and can be grown in non-arable environments.

Plant-derived energy is a vital source of renewable energy. Through fermentation and decomposition, plants are converted into biofuels that can be used sustainably to meet energy needs. Some aquatic plants such as **Nile rose** or **algae** can be grown and used to produce **biodiesel** or **ethanol**.

Plants can be used to produce biomass that is converted into different types of biofuels.

Energy from marine organisms, such as **marine algae**, is an innovative source of renewable energy that can be converted into biofuels due to its ability to grow rapidly and use marine resources sustainably. These algae can grow in seawater and do not require agricultural land. One of the latest innovations in renewable energy is **photosynthetic bacteria**, which utilize light to efficiently and sustainably convert carbon dioxide and water into **biofuels** such as **ethanol** or **hydrogen**.



Check your understanding

Q1: How are biofuels different from fossil fuels?

Q2: What are the main sources of biofuels?

Q3: What are the most common biofuels?

Q4: What role do algae play in the production of biofuels?

Chapter 3

Patterns of Resource Recycling and Utilization

Learning outcomes:

After completing this lesson, students will be able to:

- .1 Explain the importance of resource recycling in achieving sustainable development.
- .2 Evaluate modern technologies in resource recycling and their impact on the environment.
- .3 Explain the process of producing green hydrogen and its use in clean energy technologies.
- .4 Analyzes the role of green hydrogen in reducing carbon emissions
- .5 Evaluates the impact of resource recycling on the environmental economy
- .6 Propose innovative solutions to recycle resources at the local level.

Issues involved:

- The challenges of using green hydrogen as a clean fuel.
- The role of communities in supporting resource recycling initiatives.
- The economic impact of resource recycling on local communities.

3-1: The importance of recycling resources



Get ready

Science

54

First Secondary Grade

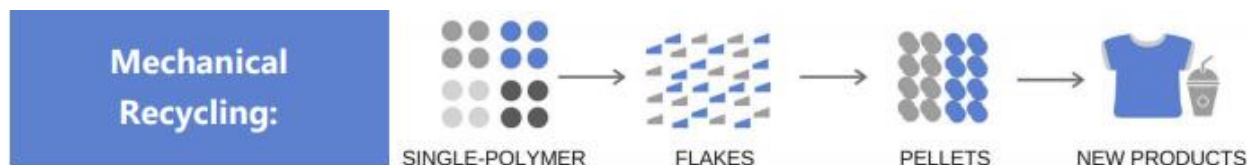
Resource recycling is the process of reusing materials that have already been used, turning them into new products instead of disposing of them as waste. This process plays a vital role in achieving successful sustainable development, reducing pressure on natural resources and minimizing environmental pollution. Let's go

Let's learn about some ways to recycle resources and their benefits to the ecosystem.

Learn:

Mechanical recycling:

It is the most common method globally, in which the non-decomposed remains of materials are collected and reintroduced into the same industry to go through the same manufacturing stages again. And reintroduce them back into the same industry to go through the same manufacturing stages again and make a product of the same type.



For example, to recycle glass, bottles are crushed and melted in special furnace to turn them into reconfigurable glass.

When recycling resources, we reuse energy that was present in raw materials instead of consuming new energy to produce or extract them.

Example:

Recycling aluminum provides about 95% of the energy required to produce aluminum from bauxite in electrolysis cells that require high electrical energy.

In contrast, in the recycling process, spent aluminum is simply remelted and reshaped, requiring much less energy. If a ton of aluminum requires 15,000 kWh, recycling the same amount requires only 750 kWh.

This process takes place in electrolysis cells and requires high electrical power.

From a physical equation:

$$\text{Energy conserved} = \text{Energy used in original production} - \text{Energy used in recycling}$$

Energy recycling:

It is a method used only with plastic waste that is converted into electrical or thermal energy by passing the plastic through an energy burning process that converts it into fuel.

When recycling resources, we reuse the energy that was present in the raw materials instead of consuming new energy. Example: Recycling aluminum saves about 95% of the energy required to produce aluminum from bauxite.

Chemical recycling:

The process of breaking down waste into its basic components to obtain new materials or produce energy

Examples of chemical recycling

A. Chemical Decomposition

- Decomposition of e-waste: Chemical such as acids can be used to separate precious metals such as gold and copper from e-waste.
- Decomposition of Finished Drugs: Using acids or bases to decompose old drugs into non harmful compounds.

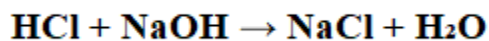
B. Chemical Neutralization

It is a chemical reaction in which acids or bases are neutralized in chemical waste, For example, acids can be neutralized with basic materials such as sodium carbonate or sodium hydroxide.

Examples:

- Neutralization of acids or bases: In chemical waste, acids or bases can be neutralized with antagonists such as sodium carbonate or sodium hydroxide or sodium hydroxide

Example: Hydrochloric acid (HCl) and sodium hydroxide (NaOH)



Hydrochloric acid reacts with sodium hydroxide to form sodium chloride (table salt) and water. This is a complete neutralization reaction that produces a neutral solution.

C. Pyrolysis

Some solid waste, such as waste organic or plastic, can undergo a pyrolysis process. In this process, the waste is heated in the absence of oxygen, decomposing it into simpler components such as combustible gases, low-density liquids such as Bio Oils, and solids that can be used as an energy source or as raw materials in other industries.



D. Biochemical Reactions:

Uses organisms or enzymes to convert organic waste into materials that can be used, such as composting organic waste.

Examples:

- **Bio-decomposition:** Organic waste such as food scraps can be converted into organic fertilizer through chemical reactions that occur with the help of microorganisms.
- **Waste to biofuels:** Certain bacteria can convert organic waste into biofuels such as ethanol.

Chemical processes such as thermal decomposition; chemical decomposition, chemical sterilization, chemical recycling, and chemical bio-reaction are essential tools for converting waste into reusable resources.

These processes help reduce the volume of waste, minimize pollution, and convert unusable materials into useful resources.

The effect of recycling in preserving the environmental balance:

Recycling one ton of paper protects 17 trees and saves 70% of the energy and 85% of the water needed to produce new paper. Imagine the positive environmental impact of recycling all the newsprint in our country!”

By recycling all newspaper, we can reduce carbon dioxide emissions by 20 million tons per year, which is equivalent to removing 5 million cars from the roads.

Research and investigation:

The Sustainable City of the Future

Imagine living in 2050 in a city that depends entirely on renewable energy sources and advanced recycling of resources. In this city, there is no waste sent to garbage dumps, and all materials are recycled using the latest chemical and physical technologies. Factories work with chemical recycling techniques to produce new materials from plastics, metals, and glass, minimizing the depletion of natural resources and reducing pollution.

One of the biggest challenges the city faces is dealing with large amounts of used plastic, which is difficult to break down in nature. Using a new technology to chemically analyze plastic, the city is converting it back to its basic materials to produce new reusable materials.

You are part of a research team that is evaluating the efficiency of using chemical technology to recycle plastics compared to traditional methods. The team is also developing new ways to improve the recycling of aluminum and glass using chemical technologies.

Questions for discussion:

1. With population growth and increasing resource consumption, what are the environmental benefits of using chemical technology to recycle resources in the long term? Can these processes completely replace traditional methods?
2. Which of the following choices is a positive result of the use of chemical recycling technology in Mostakbal City?
 - a) Increased environmental pollution
 - b) Reduce the depletion of natural resources
 - c) Increase waste production
 - d) Decrease in the quality of recycled materials
3. What role can chemical techniques play in reducing the environmental impact of the plastics industry? Are there other ways that can be used to achieve greater sustainability in resource rotation?

Check your understanding

Discuss the relation between resource recycling and biodiversity conservation in ecosystems.

- Recycling resources helps minimize the excessive consumption of natural resources, which conserves the environmental citizens.
- Recycling reduces the need to extract resources from the environment, which reduces the effects of mining and forestry.
- Recycling reduces pollution which can negatively affect wildlife and ecosystems.

Multiple choices

1. What is the effect of recycling organic waste on the waste management system compared to recycling inorganic materials?

- A) Recycling organic waste reduces the volume of waste in landfills and helps improve soil quality.
- B) Recycling organic waste increases the volume of waste in landfills due to decomposition processes.
- C) Recycling organic waste does not affect waste management compared to inorganic materials.
- D) Recycling organic waste leads to increased environmental pollution due to waste treatment issues.

2- Which of the following processes is used to convert plastics such as PET into monomers that can be reused in the manufacture of new plastics?

- (A) Pyrolysis
- (B) Chemical degradation
- (C) Chemical sterilization
- (D) Biological recycling

3- What is the main objective of using chemical decomposition to compost organic waste?

- (A) to improve water quality
- (B) to increase the volume of waste
- (C) to convert waste into harmless and usable materials
- (D) to minimize waste treatment costs

3-2: Resource recycling technologies and their impact on the environment



Get ready

Imagine that you have a box filled with a mixture of different materials, such as steel, plastic, and glass. How can you separate these materials and recover each of them for further use? In this lesson, we will explore modern techniques used to recycle resources and how these techniques affect the environment. We will learn about methods such as magnetic separation and electrostatic separation, and how chemical reactions contribute to the reprocessing of materials. Let's start this journey into the world of technologies that contribute to the preservation of our earth planet.

Learn

Imagine having a box full of a mix of different materials, such as iron, plastic, and glass. How do you separate these materials and restore each of them for further use?

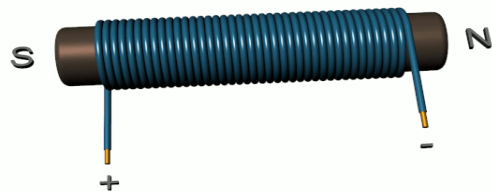
In this lesson, we will explore some of the techniques used in material separation such as magnetic separation and electrostatic separation.

Magnetic separation

The idea of magnetic separation is based on the use of a powerful electromagnet that passes over metal residues in factories, when a large electric current passes over a coil it turns into a temporary magnet that attracts the magnetic materials. Around it and separates them from other materials, this method is considered one of the most effective ways of separating metals.



The opposite figure shows the structure of the electromagnet that It consists of a copper coil with a large number of windings wrapped around a wrought iron bar, when the two ends of the coil are connected to an electric current, and the current begins to pass through the coil, it generating a magnetic flux inside the coil that converts the iron bar into a magnet whose strength depends on the number of turns of the coil, the intensity of the electric current and the type of bar material.



Applications of magnetic separation and its role in energy recycling:

1. Recycling:

The magnetic separator is able to separate metals from residues and waste based on their magnetic ability, which not only promotes the sustainable use of resources but also minimizes the impact of waste and residues on the environment, making it an indispensable tool in global recycling.

2. Environmental cleanup and treatment:

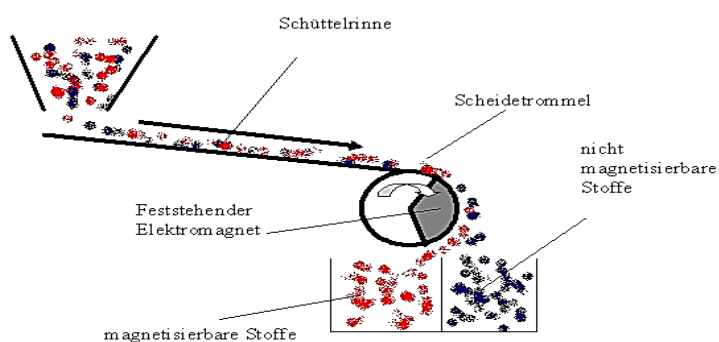
It helps in eliminating magnetic pollutants from water and soil, and contributes to restoring the ecological balance.

3. Food and pharmaceutical processing:

Magnetic separation is used to support purity and safety standards in food and pharmaceuticals; it ensures accurate separation of materials to meet quality and safety standards.

4. Mining and mineral processing industry:

It plays an important role in extracting valuable minerals from ore deposits, where the magnetic separator separates valuable minerals from rocks and sediments, which simplifies the extraction process and increasing products.



5. Chemical and petrochemical industry:

It contributes significantly to the production process, purifying raw materials and removing impurities, to meet quality standards of the industry.

6. Electronic industries

Magnetic separation plays a crucial role in the recovery of precious metals such as copper and gold from, this contributes to minimizing the pollution caused by the unsafe disposal of old electronics and reduces the need to extract more of these metals from nature.

7. Automotive industry:

Magnetic separation is used to separate iron and steel parts from the rest of the components of old cars, this makes it easier to recycle them and turn them into new raw materials for making new cars.

Electrostatic Separation

Introduction

Electrostatic electricity is a physical phenomenon that occurs as a result of an imbalance of electrical charges within a material or on its surface, In other words, when a substance loses electrons (negatively charged particles), it becomes positively charged with a positive charge, and vice versa. This charge remains static and does not move unless an electrical discharge occurs.

How static electricity is is generated?

Static electricity is generated as a result of several factors, including:

- 1- **Friction:** When two objects rub against each other, electrons are transferred from one object to the other, causing them to

Charge each other with an opposite charge. For example, when you rub a balloon against your hair, electrons are transferred from your hair to the balloon, that makes the balloon charged with a negative charge and your hair with a positive charge.



- 2- **Contact:** When a charged object touches a neutral object, some electrons are transferred from the charged object to the neutral object, causing the neutral object to be charged.
- 3- **Induction:** When a charged object approaches a conducting object, the charges in the conducting object are distributed so that Charges opposite to the nearby charge are concentrated on the nearest surface.

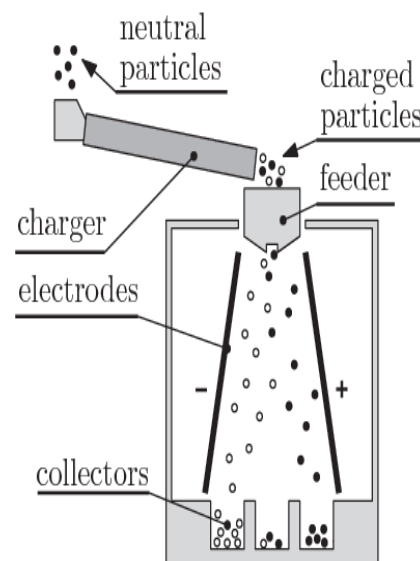
Examples of static electricity in our daily lives:

- A small electric shock when touching a metal doorknob in winter: This is caused by the accumulation of electrical charges in the body as a result of friction with woolen clothing.
- Attracting hair to a plastic comb after combing it: This is caused by the transfer of electrons from the hair to the comb, causing them to charge each other with an opposite charge.
- The balloon sticks to the walls after being rubbed with hair: This occurs due to the electrostatic force that attracts the negatively charged balloon attracts the negatively charged balloon to the positively charged wall.



Electrostatic Separation Process

The idea of electrostatic separation is based on exposing a mixture of particles, such as plastic particles are exposed to an electric field, which causes these particles to acquire positive or negative charges depending on the properties of each material. then a positively and negatively charged rod is dipped into the mixture of charged particles, that leads to repulsion of particles from the rod with the same charge and the attraction of other particles to the rod that carries the opposite charge, thus, separating the mixture of particles on the two rods.



The electrostatic separation method is characterized by a high ability to separate large mixtures of substances that are similar in shape, size and color but different in electrical properties so that they can acquire opposite charges to each other. One of the disadvantages is that it requires a high degree of control of the electric current passing through the mixture and control of surrounding conditions, as any change in humidity, temperature or voltage will affect the separation process.

Some examples of materials that can be separated using this technology include:

1. **Plastics and metals:** Plastics (such as polyethylene or polypropylene) can be separated from metals (such as aluminum or copper) based on the different charges that each type of material acquires in the electric field.
2. **Plastics and glass:** Plastics (such as PVC) can be separated from glass based on their opposite charges when exposed to an electric field.
3. **Wheat and metal impurities:** In agriculture, electrostatic separation can be used to separate grains such as wheat from metallic impurities or other contaminants

Research and Investigation:

Compare material recycling techniques

- Do comprehensive research on magnetic separation, electrostatic separation, and other techniques used in material separation.
- Get information about how each technology works, and what materials can be separated using these technologies.
- Focus on the environmental impact of each technology, such as energy consumption, waste produced, and gas emissions.
- Data analysis: Discuss with colleagues your research findings. Is there a technology that is considered the most environmentally effective? What technology provides the best efficiency in separating different materials?

Check your understanding

1. Explain the following:

- a) Magnetic separation technology plays an important role in extracting magnetic minerals from deposits.
- b) Hair drifts into the plastic comb after combing.
- c) There are disadvantages to electrostatic separation despite its high ability to separate a large mixture of similar materials.

2. Analytical questions:

How does magnetic separation separate metallic materials from non-metallic materials?
Explain using the concept of magnetic force.

(3-2) Green Hydrogen as a Clean Fuel



Get ready

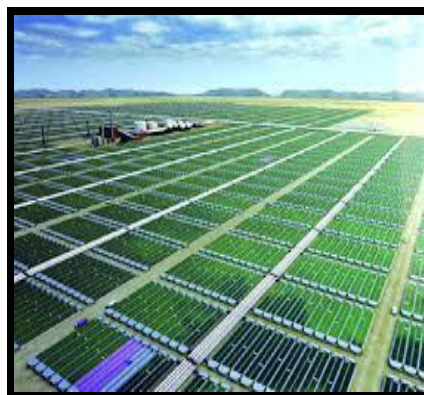
Imagine a future where we use a fuel that does not pollute the environment and reduces the impact of climate change. In this lesson, we will delve into the world of green hydrogen as a clean fuel and explore how it could be an effective alternative to fossil fuels. We will learn how green hydrogen is produced, how it can replace conventional fuels, and how this affects the environment. Can you envision what the world would look like if green hydrogen became the main source of energy?

Learn

In the face of increasing environmental challenges, green hydrogen emerges as a promising clean fuel. However, producing it on a large scale and efficiently poses significant challenges. Living organisms play a crucial role in this field, as certain types of bacteria and algae can produce hydrogen through natural bioprocesses. These biological methods are characterized by high efficiency and lower environmental impacts compared to traditional methods. These organisms utilize light or organic materials to produce hydrogen, making them a promising option for developing sustainable energy technologies. Therefore, investing in research and development in this area will contribute to achieving sustainable development goals and reducing reliance on conventional energy sources.



Algae farming project



Extracting hydrogen from algae

Green hydrogen production process:

Governments are facing several challenges when it comes to green hydrogen production. Foremost among them are the high costs of production, limited renewable energy, and the difficulty of storage. These hurdles must be overcome to transition from gray and blue hydrogen to green hydrogen.

Hydrogen has colors, which is a metaphorical meaning depending on the method by which it is generated. It is a colorless gas. “Green” refers to cleanest technologies as it involves zero carbon emissions. It can be used directly as a fuel for vehicles due to its quality and purity. In contrast “Blue” hydrogen is less pure and includes about 10% carbon emissions making it suitable for industrial activities.

Among the different types of the hydrogen, green hydrogen is the most expensive. Producing one ton of green hydrogen requires 61 megawatts per hour of renewable electricity. Therefore, replacing gray hydrogen, which is currently produced, would require **36,000 megawatts**. Which is more than 60% of Egypt's total electricity generation capacity, according to a study by the Information and Decision Support Center (IDSC)

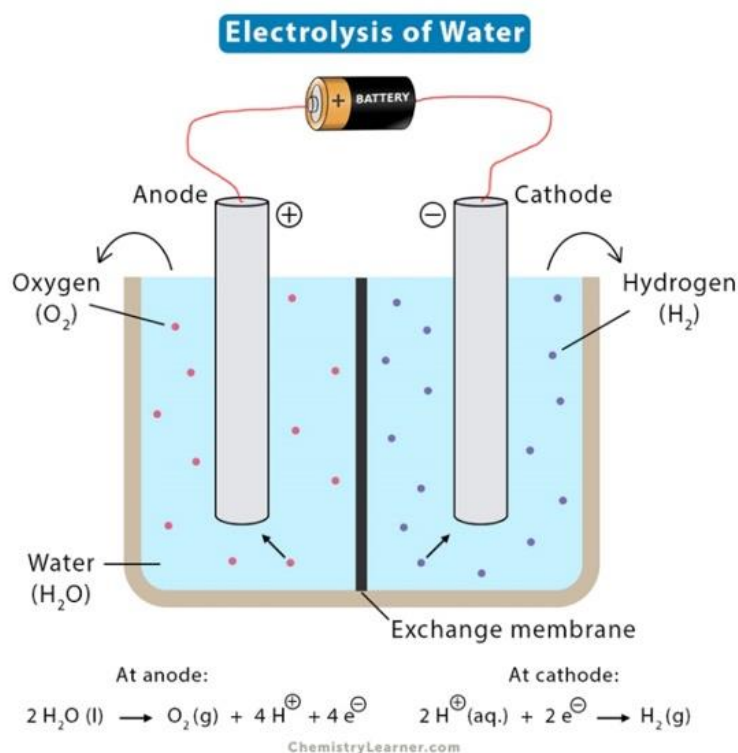
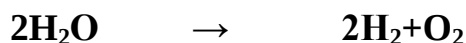


The scale of renewable energy production is not the only challenge to green hydrogen production. There is also the challenge of storage before consumption or transportation. Options for storing green hydrogen include salt caves or depleted gas fields. In Egypt, for example, the first option—using depleted gas fields for hydrogen storage in the Nile Delta and Western Desert—seems feasible. However, there is incomplete information about the number of salt caves, some of which are used for tourism and therapeutic purposes.

However, storage in depleted wells faces the issue that hydrogen can react with the remaining materials in these fields. This can cause the release of hydrogen sulfide gas.

Hydrogen sulfide is a colorless, flammable gas that smells like rotting eggs. It is extracted from petroleum associated gas, separated by heat, processed and condensed to make it easier to transport. It is widely used in chemical analysis.

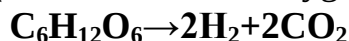
Green hydrogen is produced through the electrolysis of water, which requires passing an electric current through the water. This process splits the water into hydrogen and oxygen. Thus, hydrogen can be extracted from water, while oxygen is released into the air. The chemical equation for this process is:



The essential condition for this process to produce green hydrogen is that the electricity used in electrolysis must be carbon-free, referred to as green electricity. Green electricity is generated from renewable energy sources, the most notable of which are water, wind, and sun.

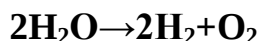
Green hydrogen is also produced by biodegradation using:

- **Bacteria:** species such as *Clostridium* and *Enterobacter* that can produce hydrogen by breaking down organic matter. (in the absence of oxygen)



Clostridium

Algae: Species such as *Chlamydomonas Reinhardtii* can produce hydrogen using solar energy through photosynthesis. Under certain conditions, such as sulfur deprivation (deficiency), these algae can convert water into hydrogen and oxygen. The chemical reaction for this process, in the absence of sulfur, is:

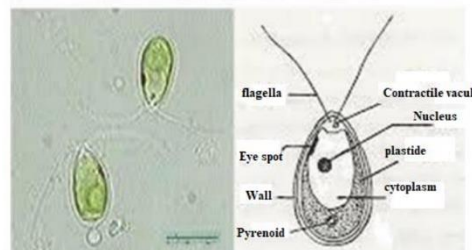


This biological method leverages natural photosynthetic processes to generate green hydrogen sustainably.

Did you know?

Biological production of green hydrogen faces several challenges, including low efficiency and high costs related to research, development, and operation.. The method also requires precise environmental conditions and sustainable food sources for the organisms used. In addition, the technology faces challenges related to the stabilization of the organisms and integration with existing industrial processes. Despite these challenges, investment in this area is essential for a sustainable energy future.

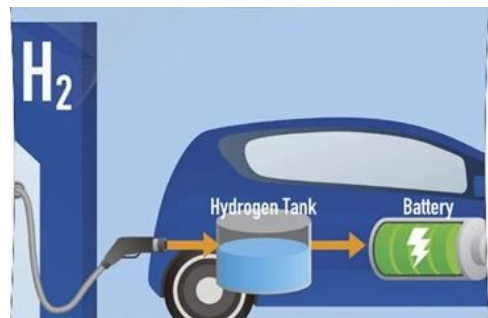
Chlamydomonas



Applications of Green Hydrogen in Clean Energy Technologies:

A. Transportation

- **Hydrogen-Powered Vehicles:** Fuel cells convert hydrogen into electrical energy, reducing the use of fossil fuels and lowering carbon emissions.
- **Public Transit:** Many cities have begun using hydrogen-powered buses to enhance public transportation with cleaner energy.



B. Industry

- **Industrial Processes:** Green hydrogen can serve as a substitute for natural gas in various industrial processes, offering a cleaner alternative.
- **Efficiency Improvement:** Hydrogen helps reduce carbon emissions from heavy industries, contributing to overall emissions reduction.



Research and Investigation:

Using Green Hydrogen vs. Fossil Fuels

Imagine a world where cars drive, airplanes fly, and factories operate using clean energy that does not harm the environment. This world may not be far off, thanks to renewable energy and innovative technologies like green hydrogen. In this lesson, we will explore the differences between green hydrogen and fossil fuels in terms of production, usage, and environmental benefits.

Fossil Fuels: History and Environmental Risks

On the other hand, the world still heavily relies on fossil fuels such as oil, coal, and natural gas. These resources come from underground and require complex extraction processes, such as drilling and mining. However, the major issue is that burning fossil fuels produces massive amounts of carbon dioxide (CO₂) and other pollutants, contributing to climate change and air pollution.

Comparison between Green Hydrogen and Fossil Fuels

Green hydrogen is used in various applications, such as powering electric vehicles, heavy industries, and even airplanes, while fossil fuels are used in nearly everything from cars to electricity generation.

But the crucial question is: which is more sustainable and better for the environment? Now it's your turn to decide!

Your task:

Using the information, you have read in the text, complete the following table:

	Fossil fuels	Green hydrogen
Production process		
Benefits		
Environmental impact		
Applications		

Research and Investigation Questions:

After filling out the table, answer the following questions based on the gathered information:

1. What is the fundamental difference between the production process of green hydrogen and fossil fuels?
2. What are the main environmental benefits of using green hydrogen compared to fossil fuels?
3. Why is green hydrogen a sustainable alternative to fossil fuels?
4. What are the major challenges facing the widespread use of green hydrogen?
5. How can green hydrogen contribute to reducing pollution and climate change?

Check Your Understanding

Choose the correct answer:

1. **What is the primary product of burning green hydrogen, making it an environmentally friendly option?**
 - (A) Carbon dioxide (CO_2)
 - (B) Nitrogen oxide (NO_2)
 - (C) Water vapor (H_2O)
 - (D) Carbon monoxide (CO)
2. **When burning fossil fuels such as coal, which substance is produced and contributes to increase global warming?**
 - (A) Water vapor (H_2O)
 - (B) Nitrogen oxide (NO_2)
 - (C) Ozone (O_3)
 - (D) Carbon dioxide (CO_2)
3. **What is the main environmental benefit of using green hydrogen as a fuel instead of fossil fuels?**
 - (A) Increased energy consumption
 - (B) Reduction in carbon dioxide production
 - (C) Improved combustion efficiency
 - (D) Reduction in energy cost

Analytical Questions:

How is green hydrogen produced, and what technologies are used in this process? Explain using chemical equations and physical concepts.

Chapter 4

Future of Energy

Learning outcomes:

After end this lesson, the student will be able to:

1. Explain modern energy production technologies and evaluate their impact on energy efficiency.
2. Evaluate the role of biotechnology in developing new and sustainable energy sources.
3. Explain the applications of nanotechnology in optimizing energy production and consumption.
4. Analyzes the impact of nanotechnology applications on reducing the environmental impact of energy production.
5. Evaluates the applications of biotechnology and nanotechnology in the conservation of natural resources.
6. Propose innovative ideas for utilizing modern technology in clean energy production.

• Issues involved:

- 1) Challenges and opportunities in nanotechnology applications in the energy sector.
- 2) The role of technological innovation in addressing climate change.
- 3) Economic and social dimensions of biotechnology applications in energy .

(4.1)Biotechnology in energy development



Get ready

Imagine you are part of a team working to develop a new source of energy using biotechnology. In this lesson, you will learn how biotechnology can be used to optimize energy sources such as biomass and energy-generating microbes. How can these technologies contribute to the development of new and sustainable energy sources, and how do they affect energy efficiency and environmental protection?

Learn

Biotechnology

Biotechnology is a scientific field that deals with the use of living organisms or their components to achieve specific goals. This includes applications in medicine, agriculture, and industry. One of the innovative applications is the use of biotechnology to convert living organisms into energy sources.

Bioenergy: Energy derived from living organisms such as plants and animals. It is renewable and environmentally friendly.

Using living organisms to produce energy:

A. Biodegradation

Biodegradation is the process of converting organic matter (such as organic waste) into an energy source using living organisms such as bacteria. This process occurs naturally, or is artificially controlled in warehouses where waste is converted into energy, often producing methane gas that can be used as an energy source. Here are the basic steps of biodegradation:

Step 1: Hydrolysis

In this first stage, bacteria break down complex organic matter into simpler units, such as carbohydrates, proteins, and fats into simple sugars, amino acids, and fatty acids, respectively.

For example, starch (a carbohydrate) is broken down into glucose:



Step 2: Acidogenesis

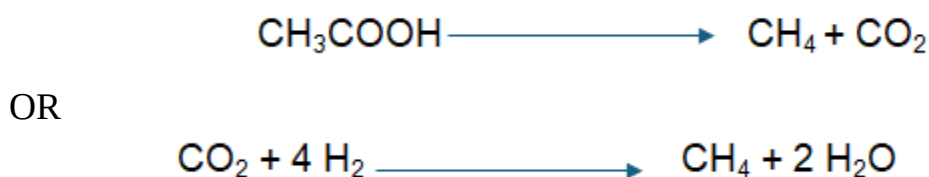
In this step, acidophilic bacteria convert the sugars and amino acids from the initial breakdown into short-chain fatty acids or alcohol, along with producing gases such as carbon dioxide and hydrogen.

Step 3: Acetic acid production (Acetogenesis)

Bacteria perform an additional process to convert the fatty acids and gases produced in the previous stage into acetic acid, hydrogen, and carbon dioxide.

Step 4: Methanogenesis

In this final stage, methanogenic bacteria convert acetic acid or carbon dioxide and hydrogen into methane gas (CH₄) and water.



B. Biofuels

Biofuels are a type of energy source produced from living organisms such as plants or algae. This includes ethanol and biodiesel :

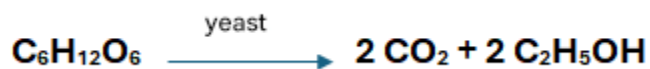


Chemical processes for the formation of biofuels:

A. Production of bioethanol: (Fermentation)

-Bioethanol production begins by converting starchy or sugary substances into simple sugars (such as glucose) through hydrolysis.

-These sugars are then fermented using yeasts to produce ethanol (C₂H₅OH) and carbon dioxide (CO₂).



B. Biodiesel production:

-In this process, vegetable oils or animal fats (containing triglycerides) are reacted with alcohol (usually methanol or ethanol) in the presence of a catalyst, such as sodium hydroxide (NaOH).



Search:

Bioenergy is an important source of renewable and sustainable energy that relies on the utilization of renewable natural resources. What are the environmental benefits of using biofuels, and what are the main challenges in using biofuels as an alternative to fossil fuels?

Check your understanding

Analyzing questions:

-How does biotechnology help improve energy efficiency? Explain how biomass-to-energy conversion can be optimized using biotechnology.

-What are the key chemical reactions in bioenergy production, and how do they contribute to energy sustainability?

Multiple choices:

1- What is the main component of biofuels?

- a) Hydrogen b) Chlorine c) carbon d) Nitrogen

2- Which of the following is an example of a biofuel?

- a) Gasoline b) Diesel c) ethanol d) kerosene

3- What is the main process in the production of ethanol from biomass?

- a) Fermentation b) Distillation c) calcination d) hydrolysis

4- What is the main raw material used in the production of biodiesel?

- a) Sugar b) Starch c) Vegetable oils or animal fats d) Natural gas

5- What is the main chemical reaction in the production of biodiesel?

- a) Combustion b) Esterification c) Oxidation d) Reduction

6- What substance is produced as a by-product in the production of biodiesel?

- a) Water b) Glycerin c) methane d) ethanol

7- What is the main advantage of biofuels over fossil fuels?

- a) Renewable b) Less expensive c) More energy dense
d) Does not produce any pollution

8- What are the challenges facing large-scale production of biofuels?

- a) Lack of raw materials b) High costs c) Competition for agricultural land
d) All of the above

9- Which of the following is an advantage of using biofuels?

- a) Reduced dependence on fossil fuels
b) Reduced greenhouse gas emissions c) Supporting the local economy
d) All of the above

4-2: Nanotechnology applications in energy



Get ready

Imagine working in a modern laboratory where nanotechnology is used to improve energy efficiency and reduce pollution. In this lesson, we will learn how nanotechnology is used in energy production and consumption, such as improving the efficiency of solar cells and batteries. We will also discuss the impact of these technologies on the environment and how they can contribute to energy sustainability.

Learn:

Nanotechnology is a science concerned with the study and manipulation of materials at the nano level, i.e. a particle size between 1 and 100 nanometers. This small size allows materials to have unique properties that are quite different from their normal-sized counterparts, such as electrical conductivity, hardness, chemical reactivity, and even optical properties. In chemistry, nanotechnology is used to improve the performance of materials in many fields such as medicine, energy, environment, and advanced industries.

How the size of a material's particle size affects its properties?

When a given mass of material is ground or atomized, its surface area increases as its volume becomes smaller, thus increasing the ratio between surface area and volume. Scientists have noticed that the properties of a material change when this ratio increases too much .

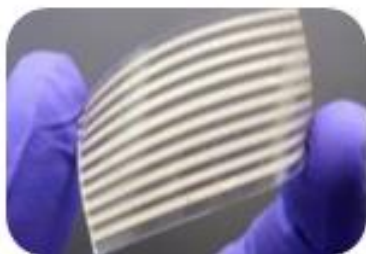
Example:

When comparing the solubility of a block of table salt in water and the solubility of a similar block after grinding it, we find that the ground salt dissolves at a faster rate than the salt blocks. When grinding, the number of grains increases, but the volume of the salt mass remains largely unchanged. The ratio of surface area to volume increases. Thus, when the material reaches the nano size, the solubility property (physical property) changes from the large size

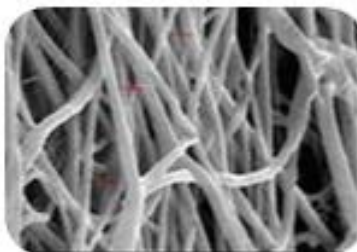
Reaching matter to Nanoscale is done in two basic ways:

1. Top to bottom (Top to down) sculpting, where the material is sculpted from its basic body to obtain ultra-fine particles, similar to the way statues are sculpted or spices are ground.
2. Bottom to up, where the material is built up from small particles and stacked layer by layer until the desired size is reached.

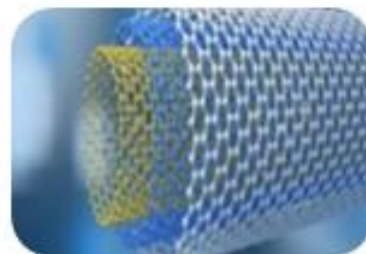
Examples of materials resulting from nanotechnology



Nanowires



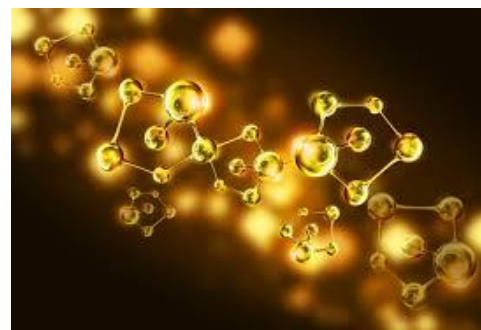
Nanofibers



Carbon nanotubes

Examples of nanotechnology applications:

- 1- **Metal nanoparticles:** They are used to catalyze chemical reactions more efficiently due to their large surface area, such as :
 - a) **Gold Nanoparticles:** Used to catalyze chemical reactions such as carbon or hydrogen oxidation reactions, they play a large role in solar cell reactions and fuel catalysts.
 - b) **Platinum Nanoparticles:** Used in Fuel Cells to catalyze electrochemical reactions in water electrolysis or in catalytic converters to reduce harmful emissions.
 - c) **Silver Nanoparticles:** Widely used in medical dressings and disinfectant products due to their superior ability to kill bacteria. They are found in anti-odor socks, toothpastes, and medical devices such as catheters and surgical equipment.
2. **Carbon nanotubes:** They are characterized by high electrical conductivity and are used in improving battery performance, storing electrical energy, improving electrical and thermal conductivity in electronics, as well as in environmental applications to purify water from pollutants.



Chemical reactions at Nanoscale :

1- Nanotechnology in improving battery efficiency

Nanotechnology plays a crucial role in improving the performance of electric batteries by controlling chemical reactions at Nanoscale, by fabricating the anode (positive electrode) and cathode (negative electrode) using nanomaterials

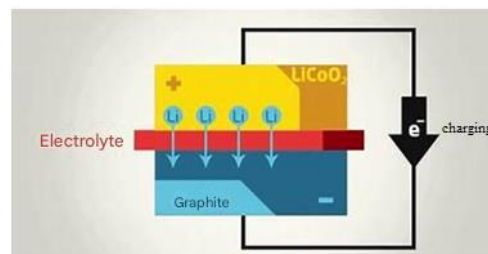
-Increase surface area: Nanomaterials increase the surface area available for charging and discharging reactions, which enhances battery efficiency.

-Improved electrical conductivity: Using nanomaterials in the anode and cathode can improve electrical conductivity and reduce the internal resistance of the battery, improving the overall performance of the battery.

-Minimize losses: The loss of electrical energy through the battery can be significantly reduced by optimizing the nanostructure of the materials, reducing battery degradation and increasing battery life.

Example: Lithium-ion (Li-ion) batteries:

Lithium-ion batteries are a common type of rechargeable battery used in many electronic devices such as smartphones and laptops. These batteries are characterized by their high capacity and efficiency, which can be improved using nanotechnology.



Water purification using Nanofilters:

Nanofilters: Nanofilters use advanced technologies to purify water by removing contaminants that traditional filters may not be able to remove. These filters are characterized by containing nanoparticles that are precisely sized to remove small contaminants such as microbes, bacteria, heavy metals, and chemical pollutants.

Practical application:

Design a model of an energy system that uses nanotechnologies to increase energy efficiency.

Identify how performance can be improved and pollution reduced using these technologies.

Check your understanding

1- Analyzing questions

- How do nanotechnologies** help improve the efficiency of solar cells and batteries?
Explain how Nanoscale sizes affect the physical and chemical properties of materials.
- What are the potential** environmental impacts of nanotechnology applications in energy, and how can these impacts be minimized?
- How can nanotechnologies** improve environmental waste management strategies?
Explain how these technologies can be used to turn waste into useful resources.

Multiple choices:

1- Which of the following best describes how nanotechnology improves the efficiency of solar cells?

- a. Increasing the size of solar cells to capture more light.
- b. Using nanomaterials to increase the thickness of solar cells.
- c. Using nanomaterials to increase the efficiency of absorbing light and converting it into electricity.
- d. Reducing the size of solar cells to facilitate transportation.

2- One of the applications of nanotechnology in the field of energy storage is.....

- a. Using carbon nanotubes to manufacture larger batteries.
- b. Using quantum dots to manufacture batteries with higher energy density.
- c. Using nanoparticles to reduce the lifespan of batteries.
- d. Using nanomaterials to reduce the charging speed of batteries.

4-3: Technological innovation in clean energy



Get ready

Imagine a world where energy is produced in innovative ways, without polluting the environment, and with less reliance on traditional resources. Access to clean energy is one of the most important current challenges due to the negative impacts of non-renewable energy. In this lesson, we discuss how modern technology and nanotechnology can play a crucial role in clean energy production and contribute to addressing the challenges of climate change and achieving energy sustainability .

Learn

Applications of modern technology in clean energy production:

Advanced solar technologies:

Concentrated solar power: CSP

The idea of creating CSP plants was driven by the development of thermal energy storage to obtain electricity during periods when the efficiency of solar cells is significantly reduced, such as cloudy periods or before sunrise and after sunset. This technology has made the use of solar energy as a renewable source of electricity production a continuous and more efficient process compared to solar cells and fossil fuel-based power plants.

How a CSP plant works?

Mirrors (solar reflectors) or lenses are used to focus the sun's rays on receivers that direct them to a network of pipes containing water adjacent to the solar reflectors.

As the water heats up, it turns into steam that passes through turbines connected to electrical generators.

When the turbines rotate due to the pressure of the steam, this motion is transferred to the generators, converting the kinetic energy into electrical energy. The heat may be used directly in factories that rely on thermal energy in their industry, or thermal energy may be stored in giant insulated cylinders containing salt molten that stores thermal energy, and can be reused daily and for long periods of time.

Research and investigation

Analyzing applications of technological innovation:

Data collection: Research the latest technological innovations in clean energy production, such as nanotechnology and biotechnology, and explore how these technologies can be used to address the challenges of climate change

Final project

Designing a sustainable model for energy and natural resources management in a local community

In your local community, you face many challenges related to energy and natural resource management. The region suffers from inefficient energy consumption, shortage of water resources, and increasing environmental pollution. You need a solution to these issues to achieve sustainable development and improve the quality of life for citizens.

Imagine that you live in a community that is experiencing these challenges. The conditions might be as follows:

-Energy: Homes and public buildings use excessive electrical energy, and many are not equipped with energy efficiency systems. Lights stay on even when not needed, and heating and cooling systems don't work efficiently.

-Water: Farms and residential communities are struggling with water availability. Leaking pipes, mismanagement of water resources, and contamination of water sources all contribute to reduced water availability.

-Pollution: Emissions from factories and transportation increase air pollution levels. Industrial waste is improperly disposed of, leading to soil and water pollution.

Final product:

Deliver a sustainable model that can improve the management of energy and natural resources in your community, promoting sustainability, minimizing environmental impact, and improving the quality of life for citizens.



Your mission

As a sustainable designer, your mission is to improve the management of energy and natural resources in your community. You must:

1. **Analyze the current situation:** Gather information about how energy and natural resources are used in your community. Identify key issues and analyze their causes.
2. **Find sustainable solutions:** Look for innovative solutions and best practices that can be implemented to improve the management of energy and natural resources. Choose solutions that can be practically implemented in your community.
3. **Design a model:** Create a model that incorporates these sustainable solutions. Make the model viable and address the identified issues.
4. **Demonstrate and evaluate the model:** Test the model's effectiveness in solving the issues and present it to community members or an evaluation panel. Gather feedback and refine the model based on the results.
5. **Present the report:** Prepare a detailed report outlining how you designed and implemented the model and the results you obtained. Present the report to the teacher or community.

Discussion questions:

-How were you able to integrate green hydrogen, nanotechnology, and biofuel technologies into your sustainable energy and natural resource management model?

-What are possible strategies to balance these different technologies to meet the energy and resource needs of the local community?

-How can you assess the impact of these combined technologies on improving sustainability and minimizing environmental impact in your project?

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