
Basic Essentials Of
CHEMISTRY
CBC
SENIOR 3
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How to Use This Book

Welcome to your Chemistry Journey! This textbook is designed to make your learning experience engaging and informative. Here are some tips on how to make the most of it:

Read Actively:

Skim: Quickly go through the chapter headings, subheadings, and visuals to get an overview.

Read Carefully: Pay attention to key concepts, definitions, and examples.

Highlight and Annotate: Mark important points, ask questions, and write down your thoughts.

Engage with the Text:

Solve Problems: Practice the exercises and problems to solidify your understanding.

Conduct Experiments: Perform the suggested experiments to observe chemical phenomena firsthand.

Discuss with Peers: Share your ideas and ask questions to deepen your knowledge.

Use the Visuals: Diagrams and Graphs: Analyze the visual aids to understand complex concepts.

Tables and Charts: Use these to organize information and identify patterns.

Photographs: Observe real-world applications of chemistry.

Review Regularly:

Summarize: Write brief summaries of each chapter to reinforce key points.

Create Mind Maps: Visualize the connections between concepts.

Quiz Yourself: Test your knowledge with practice questions and quizzes.

Seek Help When Needed:

Consult Your Teacher: Ask questions and seek clarification.

Study Groups: Collaborate with classmates to discuss and solve problems.

Online Resources: Explore additional resources like educational websites and videos. By following these tips, you can enhance your learning experience and achieve academic success.

Introduction to Chemistry

Chemistry: The Science of Change
Chemistry is the science that explores the composition, structure, properties, and interactions of matter. It is the study of substances, atoms, molecules, and how they combine to form everything around us. From the air we breathe to the food we eat, chemistry plays a vital role in our daily lives.

Why Study Chemistry?

Understanding chemistry helps us:
Make Informed Decisions: By understanding the properties and effects of chemicals, we can make informed choices about the products we use.
Solve Real-World Problems: Chemists develop new materials, medicines, and technologies to address global challenges.
Appreciate the Natural World: Chemistry explains the beauty and complexity of the natural world, from the smallest atom to the largest galaxy.

Key Concepts in Chemistry

Matter and Its Properties: Learn about the different states of matter, their properties, and how they change.
Atoms and Elements: Explore the building blocks of matter, atoms, and how they combine to form elements.
Chemical Reactions: Discover the fascinating world of chemical reactions, how substances change, and the energy involved.
The Periodic Table: Understand the organization of elements and their periodic trends.
Acids and Bases: Learn about the properties of acids and bases and their applications.
Organic Chemistry: Explore the chemistry of carbon compounds, the basis of life.
As you delve into the world of chemistry, you will develop essential skills such as critical thinking, problem-solving, and experimental design. You will also gain a deeper appreciation for the interconnectedness of science and society.

Preface

Welcome to the World of Chemistry! This textbook is designed to introduce you to the fascinating world of chemistry, a science that explores the composition, structure, properties, and interactions of matter. As you journey through these pages, you will discover how chemistry is essential to our daily lives, from the food we eat to the technology we use. This book is aligned with the New Lower Secondary Curriculum, providing you with a solid foundation in key chemical concepts. Through engaging explanations, practical examples, and stimulating activities, you will develop a deep understanding of chemistry and its applications.

Key Features of This Book

Clear and Concise Explanations: Complex topics are broken down into simple, easy-to-understand concepts.
Real-World Applications: Numerous examples illustrate how chemistry is relevant to everyday life.
Engaging Activities: Hands-on experiments and projects encourage active learning and critical thinking.
Stunning Visuals: Colorful diagrams and photographs enhance understanding and make learning enjoyable.
Review Questions and Practice Problems: Reinforce learning and prepare for assessments.
We hope that this book inspires you to explore the wonders of chemistry and fosters a lifelong love of learning.

Happy exploring

1. CARBON IN LIFE

Competency: The learner appreciates the diversity of organic carbon Compounds including the alkanes, alkenes, alcohols, and fatty acids.

Key keywords

Organic compounds, Hydrocarbons, Functional groups, Polymerization, Surfactants, Hydrophilic head, hydrophobic tail, Biogas, Crude oil, Alcohols, Carboxylic acids, Homologous series, Soapless detergents, Soapy detergents

By the end of this topic, the learner should be able to;

- Recognize the diverse range of carbon compounds found in living things and materials derived from them and Classify carbon compounds into different groups based on their properties and uses (u,s)
- Understand that crude oil is a mixture of different alkanes and that these can be separated by fractional distillation and that these products can be useful in fuels and other products synthesis (k,u)
- Appreciatethe role of biogas as a renewable carbon-based fuel in cooking and lighting (u,s)
- Understandhow organic compounds can be grouped into homologous series, each of which has similarities in structure and properties (k,u)
- Recognize the properties and uses of common synthetic and natural polymers (u,s)
- Understands the properties and uses of alcohols, particularly ethanol (u,s)
- Know the process of ethanol production through fermentation and its various uses (u,s)
- Understand the process of soap and detergent production from natural fats and oils, and appreciate their cleaning properties, also know that soapless detergents are better cleaning agents in hard water than soapy detergents but impact negatively on the environment (k,u,s)

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Carbon is a versatile element that forms the backbone of organic molecules, which are essential for life. It is found in a wide variety of compounds, from simple sugars to complex proteins.

1.1. Carbon, the Building Block of Life

Carbon is a remarkable element that forms the basis of all known life on Earth. Its unique properties make it the perfect building block for the complex molecules that make up living organisms.

Why is Carbon So Special?

- Versatile Bonding: Carbon can form strong bonds with itself and other elements, such as hydrogen, oxygen, nitrogen, and Sulphur. This ability allows it to create a vast array of molecules with diverse structures and functions.
- Stability: Carbon-based molecules are relatively stable, making them suitable for the complex structures and processes of life.
- Diversity of Structures: Carbon can form chains, rings, and branched structures, leading to the formation of countless organic compounds.

Carbon in Living Organisms

Carbon is the backbone of four major classes of organic compounds.

Organic compounds are compounds containing carbon, often with hydrogen and other elements.

Carbohydrates: These provide energy for living organisms. Examples include sugars, starches, and cellulose.

Lipids: These store energy and form cell membranes. Examples include fats, oils, and waxes.

Proteins: These are essential for building and repairing tissues, as well as for various cellular functions.

Nucleic Acids: These carry genetic information. Examples include DNA and RNA.

The Carbon Cycle

Carbon is constantly cycling through the environment. It moves from the atmosphere to plants, animals, and back to the atmosphere. This cycle ensures the continuous availability of carbon for life on Earth.

Chemical Reactions Involving Carbon

Combustion: Burning of organic compounds in oxygen to produce carbon dioxide and water.

Equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Photosynthesis; Plants use sunlight to convert carbon dioxide and water into glucose and oxygen.

Equation: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Cellular respiration: Organisms break down glucose to release energy.

Equation: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Additional Notes:

Carbon is a versatile element that can form single, double, or triple bonds with other atoms.

Organic compounds can be classified based on their functional groups (e.g., alcohols, carboxylic acids, ketones).

Carbon is also found in inorganic compounds, such as carbonates and carbon dioxide.

1.2. Crude Oil (Petroleum)

What is Crude Oil?

Crude oil, often referred to as petroleum, is a naturally occurring liquid mixture of hydrocarbons, primarily consisting of carbon and hydrogen atoms. It is a fossil fuel formed over millions of years from the remains of marine organisms subjected to intense heat and pressure.

Formation of Crude Oil:

Organic Matter:

The **remains** of **tiny marine** organisms, such as plankton and algae, settle at the bottom of oceans.

Sedimentation:

Over time, layers of **sediment** such as Sand, silt and clay **accumulate** on top of the organic matter. The weight of these sediments **compress the organic matter** (plant materials) causing it to **heat up.**

Heat and Pressure:

As the plant material is subjected to increasing heat and pressure, it undergoes a process called **diagenesis**. During this process, the plant material is **transformed** into a **waxy**, organic substance called **kerogen**.

Over millions of years, the **kerogen** continues to undergo heat and pressure, **transformations eventually** forming a complex mixture of **hydrocarbons**. This mixture is what we know as **crude oil.**

Migration and Accumulation:

As the **crude oil** is **formed**, it begins to **migrate** through the rock layers, eventually **accumulating** in porous rock formations such as sandstone and limestone. These formations are known as **oil reservoirs.**

Trapping and Preservation:

The **crude oilistrapped** in the oil reservoirs by **impermeable rock layers**, such as shale or salt. This **trapping allows** the crude oil to be **preserved** for millions of years, waiting to be discovered and extracted.

Composition:

Crude oil is a complex mixture of hydrocarbons, including:

Alkanes: Straight-chain hydrocarbons (e.g., methane, ethane, propane, butane)

Cycloalkanes: Cyclic hydrocarbons (e.g., cyclohexane, cyclopentane)

Aromatic Hydrocarbons: Ring-shaped hydrocarbons (e.g., benzene, toluene, xylene)

Extraction and Refining:

Drilling: Crude oil is extracted from underground reservoirs by drilling wells.

Fractional Distillation: Crude oil is separated into various products based on their boiling points through a process called fractional distillationin a fractional distillation column/tower. This process yields products like gasoline, diesel, kerosene, and other petrochemicals.

Fractional Distillation of Crude Oil

Fractional distillation is a process used to separate crude oil into its various components based on their boiling points. Crude oil is a complex mixture of hydrocarbons, which are compounds made up of hydrogen and carbon atoms.

Process

Crude oil is pre-treated to remove impurities such as water, salts, and sediments. This is done through a series of physical and chemical processes.

The pre-treated crude oil is then heated in a furnace to a temperature of around 350-400°C. This heat energy breaks the crude oil into its various components.

The heated crude oil is then fed into a fractional distillation column, also known as a fractionating column. The column is divided into several sections, each with a specific temperature range.

As the heated crude oil rises through the column, it separates into different fractions based on their boiling points. As the vapor rises and cools, the lighter components with low boiling points condense at the upper trays of the tower and heavier components with higher boiling points condense at lower levels of the column and are collected in trays

The separated fractions are collected and further refined to produce various petroleum products.

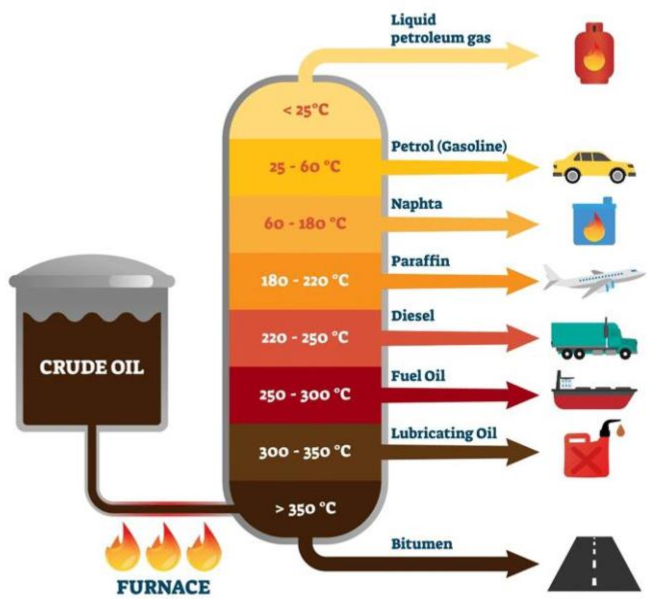

Fig.1.1. fractionating tower

Fractions from Fractional Distillation of Crude Oil

Fractional distillation separates crude oil into various fractions based on their boiling points. Here are the main fractions, their properties, and use.

Gasoline/Petrol (A mixture of hydrocarbons with 4-12 carbon atoms)
Properties: Volatile liquid, highly flammable
Uses: Fuel for cars, motorcycles, and other vehicles.

Kerosene/paraffin
Properties: Liquid, flammable.
Uses: Jet fuel, heating fuel, and as a solvent.

Petroleum/Refinery Gases: The lightest fraction, consisting of gases like methane, ethane, and propane.
Properties: Low boiling point, gaseous state at room temperature
Uses: Domestic heating, cooking, and as a raw material for petrochemical industries, fuel for power generation.

Diesel
Properties: Liquid, less volatile than gasoline
Uses: Fuel for diesel engines in trucks, buses, and some cars.

Fuel Oil
Properties: Viscous liquid
Uses: Fuel for large ships, heating homes, power stations, and industrial heating.

Lubricating Oil
Properties: Viscous liquid
Uses: Lubrication of machinery and engines.

Bitumen
Properties: Viscous thick black liquid or solid
Uses: Road surfacing, roofing materials, and waterproofing, fuel for power generation.

Naphtha
Flammable, volatile liquid hydrocarbon mixture
Uses: solvent in the chemical industry for cleaning applications. Naphtha is also used in laundry soaps, varnishes, and paint, Fuel for camp stoves and lighter fluid.

Uses of Crude Oil:

- Transportation Fuel: Gasoline, diesel, and jet fuel power vehicles and aircraft.
- Heating and Electricity: Fuel oil is used for heating homes and generating electricity.
- Petrochemicals: Crude oil is a source of raw materials for plastics, synthetic fibers, drugs such as paracetamol, aspirin.
- Lubricants: Lubricating oils are used to reduce friction in machinery.

Environmental Concerns:

Pollution: Oil spills and leaks can contaminate water bodies and soil.
Greenhouse Gas Emissions: Burning fossil fuels contributes to climate change.
Depletion of Resources: Crude oil is a finite resource, and its extraction and use have long-term environmental consequences.

Sustainable Alternatives:

To reduce reliance on fossil fuels and mitigate environmental impacts, it's crucial to explore and invest in renewable energy sources like solar, wind, and hydro power. Additionally, improving energy efficiency and developing sustainable transportation alternatives are essential steps towards a greener future.

Key Points:

- The boiling point of a hydrocarbon depends on the number of carbon atoms in its molecule. Longer chains have higher boiling points.Hydrocarbons with fewer carbon atoms have lower boiling points and condense higher up the fractionating column.
- The temperature decreases as you move up the column, ensuring that different fractions condense at their respective levels.
- Fractional distillation is a crucial process for obtaining various fuels and other products from crude oil, meeting the world's energy demands.
- The properties of each fraction, such as volatility, viscosity, and flammability, determine their specific uses.

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1.3. Biogas, a carbon based fuel

Biogas is a renewable energy source produced from the anaerobic digestion of organic matter, such as food waste, animal manure, and plant material. It is a mixture of gases, primarily methane (CH_4) and carbon dioxide (CO_2).

Biogas as a renewable fuel

Biogas is considered a renewable fuel because it is produced from organic matter, such as food waste, animal manure, and plant material. This organic matter is constantly being replenished through natural processes like agriculture and food production.

The raw materials used to produce biogas are constantly being replenished, making it a sustainable energy source.Biogas production helps reduce the amount of organic waste that ends up in landfills, where it would decompose and release methane, a potent greenhouse gas.

When biogas is produced and used responsibly, it can be considered carbon neutral. This means that the carbon dioxide released during its combustion is offset by the carbon dioxide absorbed by the plants used to produce the organic matter.

Composition of biogas

Component	**Percentage (%)**
Methane (CH_4)	50-75
Carbon Dioxide (CO_2)	25-50
Nitrogen (N_2)	2-8
Hydrogen sulphide (H_2S)	0.1-3.0
Hydrogen (H_2)	1
Water Vapor (H_2O)	2.5-7
Ammonia (NH_3)	0.1-3.0

Physical Properties of Biogas

- Density: Biogas is lighter than air, with a density of approximately 0.7-1.0 kg/m^3.

- Calorific Value: Biogas has a calorific value of approximately 20-25 MJ per cubic meter (MJ/m^3).
- Flammability: Biogas is highly flammable, with a flammability range of 5-15%.

Chemical Properties of Biogas

- Combustion: Biogas can be combusted in the presence of oxygen to produce heat and light.
- Corrosion: Biogas can be corrosive due to the presence of hydrogen sulfide.
- Toxicity: Biogas can be toxic due to the presence of hydrogen sulfide and methane.

Production process

Feedstock Preparation:

Collection: Organic waste materials are collected from various sources, such as farms, industries, and households.

Pre-treatment: The collected waste is pre-treated to remove impurities and improve the efficiency of the digestion process. This may involve grinding, shredding, or mixing with water to form slurry.

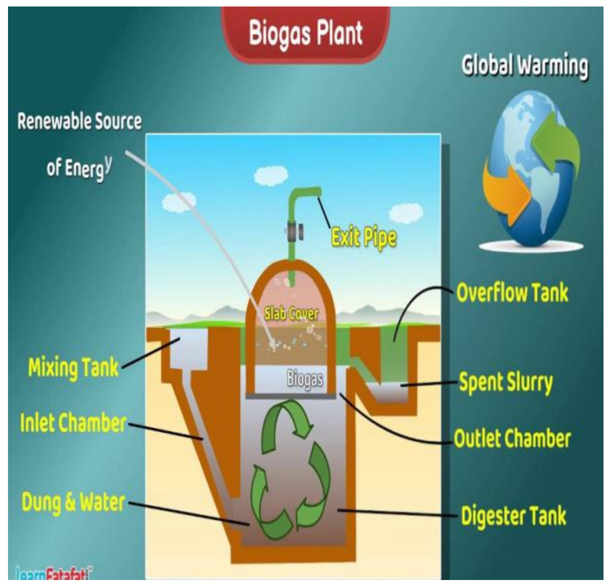

Fig.1.2. Biogas plant

Anaerobic Digestion:

Digester: The pre-treated organic matter is fed into a sealed anaerobic digester, where it undergoes a series of biological processes in the absence of oxygen.

Hydrolysis: Complex organic molecules are broken down into simpler sugars, amino acids, and fatty acids by bacteria.

Acidogenesis: Acid-forming bacteria convert the simple sugars into organic acids, such as acetic acid, propionic acid, and butyric acid.

Acetogenesis: Acetogenic bacteria convert the organic acids into acetic acid, hydrogen, and carbon dioxide.

Methanogenesis: Methanogenic bacteria convert the acetic acid, hydrogen, and carbon dioxide into methane (CH_4) and carbon dioxide (CO_2), which form biogas.

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Biogas Storage and Purification:

Purification: The biogas may be purified to remove impurities like hydrogen sulphide (H_2S) and carbon dioxide (CO_2). This can be done through techniques like water scrubbing or chemical absorption.

Gas Holder: The biogas produced in the digester is stored in a gas holder, which can be a simple gas bag or a more complex system.

Gas utilization: The cleaned biogas can be used for various purposes, including:

- Electricity Generation: Biogas can be used to generate electricity using internal combustion engines or gas turbines.
- Heat Production: Biogas can be used to produce heat for cooking, space heating, and industrial processes.
- Transportation Fuel: Biogas can be compressed or liquefied and upgraded to biomethane, used as a transportation fuel.
- Industrial Applications: Biogas can be used as a feedstock for the production of chemicals, such as methanol and ammonia.
- Fertilizer: The digestate, a nutrient-rich byproduct of the process, can be used as a fertilizer to improve soil fertility.

By harnessing the power of microbial activity, biogas production offers a sustainable and environmentally friendly way to generate energy and manage organic waste.

Industrial biogas production has several advantages:

- Renewable energy; Biogas is a renewable energy source, reducing dependence on fossil fuels.
- Waste reduction; Biogas production can help to reduce waste and pollution.
- Energy efficiency; Biogas can be used to generate electricity and heat efficiently.
- Reduced greenhouse gas emissions; Biogas production can help to reduce greenhouse gas emissions by replacing fossil fuels.

Environmental impact of biogas production

- **Greenhouse Gas Emissions**

Biogas production can lead to greenhouse gas emissions, primarily methane released during the anaerobic digestion process and carbon dioxide released during the combustion of biogas, which contribute to climate change, global warming, and associated impacts such as sea-level rise, more frequent natural disasters, and changes in precipitation patterns.

Mitigation

- Implement efficient biogas production systems with proper gas capture and utilization.
- Use biogas as a substitute for fossil fuels, reducing overall greenhouse gas emissions.
- Implement carbon capture and storage (CCS) technologies.

- **Water Pollution**

Biogas production can lead to water pollution through the release of nutrients, pathogens, and other contaminants from the digestate. This can occur through improper storage or handling of digestate, or through the use of contaminated feedstocks. Water pollution can lead to the degradation of aquatic ecosystems, harm to human health, and economic impacts on industries that rely on clean water.

Mitigation

- Implement proper digestate management practices, such as storage in covered tanks and application to land as fertilizer.
- Use treatment technologies, such as anaerobic treatment or constructed wetlands, to remove contaminants from the digestate.
- Monitor water quality regularly and implement corrective actions as needed.

- **Soil Degradation**

Biogas production can lead to soil degradation through the excessive application of digestate, leading to nutrient imbalances and soil erosion. This can occur through improper management of digestate, or through the use of low-quality digestate. Soil degradation can lead to reduced fertility, decreased crop yields, and increased soil erosion.

Mitigation

- Implement sustainable digestate management practices, such as application rates based on soil type and crop requirements.
- Use conservation tillage practices to reduce soil erosion.
- Monitor soil health regularly and implement corrective actions as needed.

- **Odor and Noise Pollution**

Biogas production can lead to odor and noise pollution, affecting nearby communities. Odor pollution can occur through the release of volatile organic compounds (VOCs) from the digestate, while noise pollution can occur through the operation of biogas production equipment. Odor and noise pollution can lead to decreased quality of life, health impacts, and economic impacts on nearby communities.

Mitigation

- Implement odor control measures, such as bio-filters or chemical scrubbers.
- Use noise reduction technologies, such as soundproofing or noise barriers.
- Implement community engagement and education programs to raise awareness about biogas production.

- **Land Use and Habitat Disruption**

Biogas production can lead to land use changes and habitat disruption, particularly if feedstocks are grown specifically for biogas production. This can occur through the conversion of natural habitats, such as forests or grasslands, into feedstock crops. Land use changes and habitat disruption can lead to biodiversity loss, ecosystem degradation, and decreased ecosystem services.

Mitigation

- Implement sustainable feedstock production practices, such as crop rotation and agroforestry.
- Use waste biomass as feedstocks, reducing the need for dedicated land use.
- Conduct environmental impact assessments to identify potential habitat disruption and implement mitigation measures.

- **Pathogen and Microplastic Pollution**

Biogas production can lead to pathogen and microplastic pollution, particularly if digestate is not properly treated. Pathogens can be present in the digestate, while microplastics can be introduced through the use of contaminated feedstocks.Pathogen and microplastic pollution can lead to human health impacts, ecosystem degradation, and decreased water quality.

Mitigation

- Implement proper digestate treatment technologies, such as pasteurization or anaerobic treatment.
- Use microplastic-reducing technologies, such as microfiltration or ultraviolet (UV) treatment.
- Monitor digestate quality regularly and implement corrective actions as needed.

1.4. Homologous Series and Functional Groups

Homologous series is a group of organic compounds that have the same functional group and differ in their carbon chain length by a single methylene unit (CH_3). Each member in the group is called a **homologue**. Homologous series help classify organic compounds based on their structure and properties.

Understanding homologous series and functional groups is essential for the synthesis of organic compounds.

Properties of Homologous Series

- All members of a homologous series possess the same functional group. This functional group is responsible for the characteristic chemical properties of the series.
- Due to the presence of the same functional group, members of a homologous series exhibit similar chemical properties. They undergo similar chemical reactions.
- There is a gradual change in physical properties like melting point, boiling point, and density as you move up the series. Generally, these properties increase with increasing molecular mass.

- All members of a homologous series can be represented by a single general formula. This formula shows the general arrangement of atoms in the molecules of the series.
- Successive members of a homologous series differ by a $-CH_2$ group.

Functional Groups: The Reactive Parts of Organic Molecules

Functional group is a specific group of atoms or bonds within a molecule that is responsible for its characteristic chemical properties. They determine how a molecule will react with other substances.

Examples of Homologous Series and Functional Groups

Homologous Series	**Functional Group**	**General Formula**	**Examples**
Alkanes	Single bond (C-C)	C_nH_{2n+2}	Methane, ethane, propane
Alkenes	Double bond (C=C)	C_nH2n	Ethene, propene, butene
Alkynes	Triple bond (C≡C)	C_nH_{2n-2}	Ethyne, propyne, butyne
Alcohols	Hydroxyl group (-OH) Alcohols can form hydrogen bonds, influencing their solubility and boiling points.	R-OH	Methanol, ethanol, propanol
Carboxylic acids	Carboxyl group (-COOH) Carboxylic acids are acidic and can react with bases to form salts.	R-COOH	Methanoic acid, ethanoic acid, propanoic acid
Esters	Ester group (-COO-)	RCOOR'	Methyl ethanoate, ethyl ethanoate, methyl propanoate

Conclusion

Homologous series and functional groups are fundamental concepts in organic chemistry. They provide a framework for understanding the structure, properties, and reactions of organic compounds.

Alkanes

Alkanes are a group of hydrocarbons (compounds containing only carbon and hydrogen) that have single bonds between all their carbon atoms. They are also known as saturated hydrocarbons.

Hydrocarbons are compounds that contain elements carbon and hydrogen only in them.

The first four Alkanes are gases at room temperature, the next twelve are liquids, and the rest are waxy solids.

General Formula

The general formula for alkanes is C_nH_{2n+2}, where ***n*** is the number of carbon atoms, and ***n***=1, 2, 3…

Examples of Alkanes

Name	Formula	State of matter
Methane	CH_4	Gas
Ethane	C_2H_6	Gas
Propane	C_3H_8	Gas
Butane	C_4H_{10}	Gas
Pentane	C_5H_{12}	Liquid

Naming of alkanes

The naming of alkanes follows the **I.U.P.A.C** system of naming organic compounds. The system follows the following rules.

I. The name of an alkane consist of two parts I.e the **prefix** and the **suffix.**

II. The name of straight chain alkanes always ends with the suffix ***and.***

III. The prefix (first part of the name) is determined by the number of carbon atoms as shown below.

Number of carbon atoms	Prefix
1	Meth
2	Eth
3	Prop
4	But

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From carbon atom number five, the prefix can be derived from the names of polygons i.e

A five sided polygon is called Pentagon, so the prefix for an alkane with 5 carbon atoms is ***pent.***

An alkane with 6 carbon atoms has the prefix hex from hexagon.

Activity

Use the general molecular formula for alkanes to derive the Formulae and the names of the alkanes with the following number of carbon atoms.

I. 3
II. 7
III. 5
IV. 2

Methane as a Building Block for Organic Compounds

Methane (CH_4) is a simple hydrocarbon that serves as a building block for the production of various organic compounds. These compounds can be further transformed into a wide range of useful natural or synthetic polymers.

- Production of Methanol (CH_3OH)

Methane can be converted into methanol through the following reaction:

$CH_4 + H_2O + \text{energy} \rightarrow CH_3OH + H_2$

Methanol is an important organic compound used as a solvent, fuel, and feedstock for the production of other chemicals.

- Production of Ethylene (C_2H_4) and Propylene (C_3H_6)

Methane can be converted into ethylene and propylene through steam cracking:

$CH_4 + \text{energy} \rightarrow C_2H_4 + H_2$

$CH_4 + \text{energy} \rightarrow C_3H_6 + H_2$

Ethylene and propylene are important building blocks for the production of various plastics, such as polyethylene and polypropylene.

- Production of Acetylene (C_2H_2)

Methane can be converted into acetylene through the following reaction:

$2CH_4 + \text{energy} \rightarrow C_2H_2 + 3H_2$

Acetylene is an important organic compound used as a fuel and feedstock for the production of other chemicals.

- Production of Formaldehyde (CH_2O)

Methanol can be converted into formaldehyde through the following reaction:

$CH_3OH + O_2 \rightarrow CH_2O + H_2O$

Formaldehyde is an important organic compound used as a feedstock for the production of various plastics, such as polyformaldehyde.

- Production of Polymers from Methane-Derived Compounds

The organic compounds produced from methane can be further transformed into a wide range of useful natural or synthetic polymers.

Polyethylene (PE): Ethylene can be polymerized to produce polyethylene:

$nC_2H_4 \rightarrow (-C_2H_4-)n$

Polyethylene is a versatile plastic used in packaging, plastic bags, and other applications.

Polypropylene (PP): Propylene can be polymerized to produce polypropylene:

$nC_3H_6 \rightarrow (-C_3H_6-)n$

Polypropylene is a versatile plastic used in packaging, automotive parts, and other applications.

Polyvinyl Chloride (PVC): Acetylene can be converted into vinyl chloride, which can be polymerized to produce polyvinyl chloride:

$nC_2H_3Cl \rightarrow (-C_2H_3Cl-)n$

PVC is a versatile plastic used in pipes, vinyl records, and other applications.

Polyformaldehyde (POM)

Formaldehyde can be polymerized to produce polyformaldehyde:

$nCH_2O \rightarrow (-CH_2O-)n$

POM is a versatile plastic used in gears, bearings, and other applications.

Conclusion

Methane is a simple hydrocarbon that serves as a building block for the production of various organic compounds. These compounds can be further transformed into a wide range of useful natural or synthetic polymers, such as polyethylene, polypropylene, polyvinyl chloride, and polyformaldehyde.

Physical properties of Alkanes

- Colorless, odorless, and tasteless gases or liquids at room temperature.
- Low density.
- Non-polar.
- Insoluble in water but soluble in non-polar solvents.

Chemical properties:

- Relatively unreactive due to the strong C-H bonds.
- Undergo combustion reactions with oxygen to produce carbon dioxide and water.
- Can undergo substitution reactions with halogens (e.g., chlorine, bromine).

Combustion of Alkanes

What is Combustion?

Combustion is a chemical reaction where a substance reacts with oxygen to produce heat and light.

Alkanes are a group of hydrocarbons that only contain single bonds between carbon atoms. When alkanes burn in the presence of oxygen, they undergo combustion.

Complete Combustion

When there is plenty of oxygen, complete combustion occurs. This produces carbon dioxide and water.

Example:

Methane + Oxygen → Carbon Dioxide + Water

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Incomplete Combustion

When there is limited oxygen, incomplete combustion occurs. This can produce carbon monoxide, carbon, or a mixture of both, along with water.

Incomplete combustion of methane:

$$2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$$

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Why is Incomplete Combustion Dangerous?

Carbon Monoxide Poisoning: Carbon monoxide is a poisonous gas that can cause headaches, dizziness, and even death.

Soot Formation: Carbon particles can cause air pollution and respiratory problems.

Importance of Combustion of alkanes

Energy Source: Combustion of alkanes is a major source of energy for heating, cooking, and transportation.

Industrial Processes: Combustion is used in various industrial processes, such as power generation and manufacturing.

Remember:

Complete combustion produces carbon dioxide and water.

Incomplete combustion produces carbon monoxide, carbon, or a mixture of both, along with water.

Complete combustion is preferred as it is more efficient and less harmful to the environment.

Uses of Alkanes

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