Organic Chemistry

Chapter 18: Hydrocarbons and Crude Oil

Hydrocarbons are the simplest organic compounds, made up of only carbon and hydrogen atoms. They are the primary components of fossil fuels, including crude oil and natural gas.

18.1 Hydrocarbon

- **Definition:** Organic compounds consisting solely of carbon and hydrogen atoms.
- **Sources:** Primarily found in fossil fuels (crude oil, natural gas, coal), formed over millions of years from the remains of ancient organisms.
- **Importance:** Serve as major sources of energy (fuels) and raw materials (feedstock) for the petrochemical industry.

18.2 Crude Oil and Natural Gas

- **Crude Oil (Petroleum):** A dark, viscous liquid mixture of various hydrocarbons, ranging from light gases to heavy waxes. It is a fossil fuel formed from ancient marine organisms under intense heat and pressure over geological time.
- **Natural Gas:** Primarily methane (CH_4), often found associated with crude oil deposits. It is a cleaner-burning fossil fuel.
- **Origin of Crude Oil and Natural Gas:** Both formed from the anaerobic decomposition of marine organisms buried under layers of sediment.
- **World Crude Oil Reserves:** Unevenly distributed globally, with major reserves in the Middle East, North America, and Russia.
- **Nigerian Crude Oil Reserves:** Nigeria is a significant oil-producing country, with substantial crude oil and natural gas reserves, primarily in the Niger Delta region.

18.3 Crude Oil Exploring and Drilling

- **Exploration:** Geologists use seismic surveys and other techniques to identify potential oil and gas reservoirs underground or offshore.
- **Drilling:** Once a reservoir is identified, wells are drilled into the Earth's crust to extract the crude oil and natural gas. This involves complex engineering, especially for offshore drilling rigs.

18.4 Fractional Distillation of Crude Oil (Oil Refining)

- **Industrial Fractionation:** Crude oil is a mixture of hydrocarbons with different boiling points. It is separated into its various components (fractions) by a process called **fractional distillation** in an oil refinery.
- **Process:**
    1. Crude oil is heated to a high temperature (around 350-400 {°C}) to vaporize most of its components.
    2. The hot mixture of liquid and vapor is fed into the bottom of a tall **fractionating column**.
    3. The column has a temperature gradient, being hottest at the bottom and coolest at the top.
    4. Vapors rise up the column, cooling as they ascend.
    5. Fractions condense at different levels (trays) according to their boiling points.
        - **Lower boiling point fractions (gases)** rise higher and condense near the top.
        - **Higher boiling point fractions (liquids)** condense lower down the column.
        - **Very high boiling point fractions (residue)** remain at the bottom as a liquid.
- **Fractions of Crude Oil:**
    - **Refinery Gases (Top):** Lowest boiling point (e.g., methane, ethane, propane, butane). Used as LPG fuel, chemical feedstock.
    - **Gasoline (Petrol) / Naphtha:** Used as fuel for cars, feedstock for petrochemicals.
    - **Kerosene (Paraffin):** Used as jet fuel, lamp oil, heating oil.
    - **Diesel Oil (Gas Oil):** Used as fuel for diesel engines, heating oil.
    - **Fuel Oil:** Used as fuel for ships, power stations, industrial furnaces.
    - **Lubricating Oils, Waxes, Bitumen (Bottom Residue):** Highest boiling point. Used as lubricants, candles, road surfacing (asphalt).

18.5 Further Treatment of Crude Oil Fractions

To meet market demands and improve product quality, some fractions undergo further processing:

- **Cracking:** Large, less useful hydrocarbon molecules (e.g., heavy fuel oil) are broken down into smaller, more valuable hydrocarbons (e.g., gasoline, ethene) using heat and/or catalysts.
    - **Thermal cracking:** High temperatures and pressures.
    - **Catalytic cracking:** Lower temperatures and pressures, using a catalyst.
- **Reforming:** Straight-chain alkanes are converted into branched alkanes or cyclic hydrocarbons to improve gasoline octane rating.

18.6 Natural Gas

- As mentioned, primarily methane. Often transported via pipelines or as Liquefied Natural Gas (LNG).
- **Uses:** Fuel for electricity generation, industrial processes, domestic heating, and cooking.

18.7 Petrochemicals

- **Definition:** Chemical products derived from petroleum and natural gas.
- **Importance:** Form the basis for a vast range of products, including plastics, synthetic fibers, detergents, medicines, and fertilizers.
- Many valuable organic compounds (e.g., ethene, propene, benzene) are produced as petrochemical feedstocks.

Chapter 19: Organic Chemistry (1)

Organic chemistry is the study of carbon-containing compounds, which form the basis of all known life. Its vastness stems from carbon's unique ability to form strong bonds with itself and other elements.

19.1 What is Organic Chemistry?

- **Definition:** The branch of chemistry concerned with the structure, properties, composition, reactions, and preparation of carbon-containing compounds.
- **Variety of Organic Compounds:** Carbon's ability to undergo catenation (form long chains, branched chains, and rings) and form single, double, and triple bonds with itself and other elements (H, O, N, S, halogens) leads to an enormous diversity of organic compounds.

19.2 Characteristic Features of Organic Compounds

1. **Bonding:** Primarily form covalent bonds.
2. **Solubility:** Generally insoluble in water (polar solvent) but soluble in organic solvents (non-polar solvents) like benzene, ether, alcohol.
3. **Melting and Boiling Points:** Generally have lower melting and boiling points compared to inorganic compounds due to weaker intermolecular forces (e.g., Van der Waals forces).
4. **Combustibility:** Many organic compounds are flammable and burn readily.
5. **Reactivity:** Reactions are generally slower than inorganic reactions and often require specific conditions (heat, catalyst).
6. **Isomerism:** Many organic compounds can exist as isomers.

19.3 Terms in Organic Chemistry

- **Homologous Series:** A series of organic compounds with the same general formula, similar chemical properties, and whose consecutive members differ by a -{CH}2- group. (e.g., alkanes, alkenes, alkynes).
- **Functional Group:** An atom or a group of atoms within a molecule that largely determines the chemical properties of that molecule. (e.g., -OH for alcohols, -COOH for carboxylic acids).
- **Saturated Hydrocarbons:** Hydrocarbons that contain only single carbon-carbon bonds. (e.g., alkanes).
- **Unsaturated Hydrocarbons:** Hydrocarbons that contain at least one carbon-carbon double or triple bond. (e.g., alkenes, alkynes).

19.4 The IUPAC Nomenclature (Naming) for Aliphatic Compounds

- **International Union of Pure and Applied Chemistry (IUPAC):** Provides a systematic way of naming organic compounds to ensure clarity and consistency.
- **General Rules:**
    1. Identify the longest continuous carbon chain (parent chain).
    2. Number the carbon atoms in the parent chain to give the lowest possible numbers to substituents or functional groups.
    3. Identify and name substituents.
    4. List substituents alphabetically before the parent chain name.
    5. Use prefixes (di-, tri-, tetra-) for multiple identical substituents.
    6. Indicate the position of functional groups and multiple bonds.

19.5 Stereochemistry: Isomerism; Geometric Isomerism

- **Isomerism:** The phenomenon where two or more compounds have the same molecular formula but different structural arrangements of atoms.
- **Structural Isomerism (Constitutional Isomerism):** Isomers that differ in the connectivity of their atoms (different bonding sequence).
    - **Chain Isomerism:** Different arrangement of the carbon skeleton (e.g., n-butane and isobutane).
    - **Positional Isomerism:** Different position of a functional group or multiple bond (e.g., propan-1-ol and propan-2-ol).
    - **Functional Group Isomerism:** Different functional groups (e.g., ethanol and methoxymethane).
- **Stereoisomerism:** Isomers that have the same connectivity but different spatial arrangements of atoms.
    - **Geometric Isomerism (Cis-Trans Isomerism):** Arises due to restricted rotation around a double bond or in a cyclic structure. Requires two different groups attached to each carbon of the double bond.
        - **Cis-isomer:** Identical groups are on the same side of the double bond.
        - **Trans-isomer:** Identical groups are on opposite sides of the double bond.

19.6 Classification of Organic Compounds

- **Based on Hydrocarbon Skeleton:**
    - **Aliphatic Compounds:** Open-chain (straight or branched) or cyclic but non-aromatic compounds.
        - **Alkanes:** Saturated hydrocarbons with single bonds. General formula CnH{2n+2}.
        - **Alkenes:** Unsaturated hydrocarbons with at least one C=C double bond. General formula CnH{2n}.
        - **Alkynes:** Unsaturated hydrocarbons with at least one C≡C triple bond. General formula CnH{2n-2}.
    - **Aromatic Compounds:** Contain a benzene ring or a similar cyclic, conjugated system with special stability. (e.g., benzene).

- **Based on Functional Groups:**
    - **Alkanols (Alcohols):** Contain a hydroxyl (-OH) functional group.
    - **Alkanoic Acids (Carboxylic Acids):** Contain a carboxyl (-COOH) functional group.
    - **Esters:** Derived from carboxylic acids and alcohols, contain an ester (-COO-) linkage.
    - **Amines:** Derivatives of ammonia, containing a nitrogen atom bonded to alkyl/aryl groups.
    - **Amides:** Contain a carbonyl group attached to a nitrogen atom (-CONH-).

19.7 Hydrocarbons: Sources of Hydrocarbons

- As covered in Chapter 18, the primary sources are crude oil and natural gas. Other sources include coal and biomass.

19.8 Petroleum and Its Effect on the Nigerian Economy and Environment

- **Economy:** Petroleum has been the cornerstone of the Nigerian economy, providing the bulk of government revenue and foreign exchange earnings. It has funded infrastructure development, but also led to over-reliance and economic vulnerability to oil price fluctuations.
- **Environment:** Oil exploration, production, and spills have led to significant environmental degradation in the Niger Delta, including pollution of water, soil, and air, affecting livelihoods and ecosystems. Gas flaring contributes to greenhouse gas emissions.

19.9 Conservation of Petroleum

- **Strategies:**
    - **Efficient use:** Improving fuel efficiency in vehicles and industrial processes.
    - **Alternative energy sources:** Shifting to renewable energy (solar, wind, hydro).
    - **Recycling and reuse:** Reducing consumption.
    - **Public transportation:** Reducing reliance on personal vehicles.
    - **Development of biofuels.**

19.10 Alkanes, Alkenes, Alkynes, Benzene, Alkanols, Ethanol

(A brief introduction here, detailed properties and reactions will be in Organic Chemistry (2)).

- **Alkanes:** Saturated hydrocarbons (e.g., Methane (CH4), Ethane (C2H6), Propane (C3H8), Butane (C4H{10})). Relatively unreactive.
- **Alkenes:** Unsaturated hydrocarbons with a C=C double bond (e.g., Ethene (C2H4), Propene (C3H6)). More reactive than alkanes, they undergo additional reactions.
- **Alkynes:** Unsaturated hydrocarbons with a C≡C triple bond (e.g., Ethyne (C2H2)). Highly reactive, undergo additional reactions.
- **Benzene:** The simplest aromatic hydrocarbon (C6H6). A cyclic compound with a delocalized pi-electron system, giving it special stability.
- **Alkanols (Alcohols):** Organic compounds containing the -OH functional group (e.g., Methanol (CH3OH), Ethanol (C2H5OH)).
- **Ethanol (C2H5OH):** A specific alcohol, widely used as a solvent, fuel, and in alcoholic beverages.

Chapter 20: Organic Chemistry (2)

This chapter delves into the specific properties, preparation, and reactions of various organic functional groups.

20.1 Alkanoic Acids and Ethanoic Acid

- **Alkanoic Acids (Carboxylic Acids):** Organic compounds containing the carboxyl functional group (-COOH).
    - They are weak acids.
    - **Nomenclature:** Named by replacing the "-e" of the corresponding alkane with "-oic acid" (e.g., methane \rightarrow methanoic acid).
- **Ethanoic Acid (CH3COOH):** Also known as acetic acid.
    - **Laboratory Preparation:**
        - **Oxidation of Ethanol:** Ethanol can be oxidized to ethanoic acid using oxidizing agents like acidified potassium dichromate(VI) or potassium permanganate(VII).
            - CH3CH2OH(aq) + 2[O] 🔀 {{acidified } K2Cr2O7} CH3COOH(aq) + H2O(l)
        - **From Ethanal (Acetaldehyde):** Further oxidation of ethanal.
    - **Physical Properties:** Colorless liquid, pungent smell (vinegar), sour taste. Miscible with water, higher boiling point than comparable alkanols due to hydrogen bonding.
    - **Chemical Properties:**
        - **Acidity:** Reacts with bases, carbonates, and active metals like inorganic acids.
            - CH3COOH(aq) + NaOH(aq) ➡️ CH3COONa(aq) + H2O(l)
            - 2CH3COOH(aq) + CaCO3(s) ➡️ (CH3COO)2Ca(aq) + H2O(l) + CO2(g)
        - **Esterification:** Reacts with alcohols in the presence of a strong acid catalyst (e.g., conc. H2SO4) to form an ester.
            - CH3COOH(l) + CH3CH2OH(l) \rightleftharpoons CH3COOCH2CH3(l) + H2O(l) (Ethylethanoate)
- **Uses:** Used in vinegar (food preservative), rayon production, plastics, and as a solvent.

20.2 Esters: Ethylethanoate

- **Esters:** Organic compounds formed from the reaction of a carboxylic acid and an alcohol, with the general formula R-COO-R'.
- **Ethylethanoate (CH3COOCH2CH3):** A common ester, formed from ethanoic acid and ethanol.
    - **Physical Properties:** Sweet, fruity smell, generally volatile.
    - **Uses:** Used as artificial flavorings, perfumes, and solvents.

20.3 Fats and Oils

- **Definition:** Esters formed from glycerol (a propan-1,2,3-triol) and long-chain fatty acids.

- **Fats:** Typically solid at room temperature, mostly from animal sources, contain saturated fatty acids.
- **Oils:** Typically liquid at room temperature, mostly from plant sources, contain unsaturated fatty acids.
- **Hydrolysis:** Fats and oils can be hydrolyzed (broken down by water) into glycerol and fatty acids, or saponified (hydrolyzed with a strong alkali) to produce soap and glycerol.
- **Uses:** Energy storage in living organisms, components of cell membranes, used in soap and margarine production.

20.4 Detergents

- **Definition:** Cleaning agents that work by reducing the surface tension of water and emulsifying oils and greases.
- **Types:**
    - **Soap (natural detergent):** Sodium or potassium salts of long-chain fatty acids. Forms scum with hard water.
    - **Soapless Detergents (synthetic detergents):** Manufactured from petroleum products. Do not form scum with hard water, more effective in hard water.
- **Action:** Both have a long non-polar hydrocarbon tail (hydrophobic) that dissolves in grease and a polar head (hydrophilic) that dissolves in water.

20.5 Alkanals and Alkanones (Aldehydes and Ketones)

- **Alkanals (Aldehydes):** Contain the carbonyl functional group (C=O) at the **end** of a carbon chain (-CHO). (e.g., ethanal).
- **Alkanones (Ketones):** Contain the carbonyl functional group (C=O) **within** a carbon chain (not at the end, -CO-). (e.g., propanone).
- **Properties:** Both are polar and undergo nucleophilic addition reactions.

20.6 Carbohydrates

- **Definition:** Organic compounds composed of carbon, hydrogen, and oxygen, with the general formula Cx(H2O)y.
- **Types:**
    - **Monosaccharides:** Simple sugars (e.g., glucose, fructose).
    - **Disaccharides:** Two monosaccharide units joined (e.g., sucrose, lactose).
    - **Polysaccharides:** Many monosaccharide units joined (e.g., starch, cellulose, glycogen).
- **Uses:** Primary source of energy for living organisms, structural components (cellulose in plants).

20.7 Amides

- **Definition:** Organic compounds containing the amide functional group (-CONH-).
- **Formation:** Can be formed from carboxylic acids and amines.
- **Importance:** Peptide bonds in proteins are amide linkages.

20.8 Amino Acids

- **Definition:** Organic compounds that contain both an amino group (-NH2) and a carboxyl group (-COOH).
- **Structure:** All amino acids (except proline) have a central carbon atom (alpha-carbon) bonded to an amino group, a carboxyl group, a hydrogen atom, and a unique side chain (R-group).
- **Building Blocks of Proteins:** There are 20 common amino acids that link together to form proteins.

20.9 Proteins

- **Definition:** Large, complex biological macromolecules made up of long chains of amino acids linked by peptide bonds (amide linkages).
- **Functions:** Diverse roles in living organisms, including enzymes (catalysts), structural components (collagen, keratin), transport (hemoglobin), antibodies, hormones.

20.10 Polymers: Natural Polymers, Synthetic Polymers, Rubber, Polymers in Living Systems

- **Polymers:** Large macromolecules formed by the repetitive bonding of small repeating units called **monomers**.
- **Polymerization:** The chemical process by which monomers are joined together to form polymers.
    - **Addition Polymerization:** Monomers add to one another in a way that all atoms of the monomers are incorporated into the polymer (e.g., ethene ➡️ poly(ethene)).
    - **Condensation Polymerization:** Monomers join together with the elimination of a small molecule (e.g., water) (e.g., formation of nylon, proteins).
- **Natural Polymers:** Polymers that occur naturally in living systems.
    - **Polysaccharides:** Starch, cellulose (monomer: glucose).
    - **Proteins:** (monomer: amino acids).
    - **Natural Rubber:** (monomer: isoprene).
- **Synthetic Polymers:** Man-made polymers produced through industrial processes.
    - **Plastics:** (e.g., poly(ethene), PVC, polystyrene, nylon, polyester). Used in packaging, construction, textiles, etc.
- **Rubber:**
    - **Natural Rubber:** A polymer of isoprene, obtained from rubber trees. Elastic.
    - **Synthetic Rubber:** Man-made rubbers with properties tailored for specific uses.
- **Polymers in Living Systems:** Proteins, nucleic acids (DNA, RNA), carbohydrates (starch, cellulose) are all crucial polymers essential for life.

Chapter 21: Industrial Chemistry

Industrial chemistry applies chemical principles to the production of various substances on a large scale for economic benefit.

21.1 Development of the Chemical Industry

- Has evolved from traditional crafts to highly sophisticated, technology-driven enterprises.
- Driven by demand for materials, energy, and improved quality of life.

21.2 Important Raw Materials

- **From the Earth:** Ores (for metals), crude oil, natural gas, coal, limestone, salt.
- **From the Air:** Nitrogen, oxygen, noble gases.
- **From Water:** Hydrogen, oxygen.
- **Agricultural products:** Grains (for ethanol), vegetable oils (for soap), wood (for paper).

21.3 Division of the Chemical Industry

The chemical industry can be broadly categorized:

- **Heavy Chemicals:** Produced in very large quantities, often raw materials for other industries. (e.g., Sulphuric acid, Ammonia, Chlorine, Sodium hydroxide).
- **Fine Chemicals:** Produced in smaller quantities, high purity, high value. (e.g., Pharmaceuticals, specialty dyes, advanced materials).
- **Fertilizers:** Chemicals added to soil to promote plant growth (e.g., Urea, Ammonium sulphate, Superphosphate).
- **Plastics:** Polymers used to make a vast array of products (e.g., PVC, Polyethylene).
- **Metallurgy:** The science and technology of extracting metals from their ores and preparing them for use. (e.g., extraction of iron, copper, aluminium).
- **Pharmaceuticals:** Drugs and medicines for human and animal health.
- **Glass:** Material made primarily from sand (SiO_2), soda ash (Na_2CO_3), and limestone ($CaCO_3$).
- **Ceramics:** Inorganic, non-metallic solids processed by heat treatment (e.g., bricks, pottery, porcelain).
- **Paints:** Pigments suspended in a liquid vehicle, used for protection and decoration.
- **Cement:** A binding agent made from limestone and clay, essential for concrete production.
- **Soaps and Detergents:** Cleaning agents derived from fats/oils or petroleum.
- **Food and Drinks:** Production involves various chemical processes (e.g., fermentation, preservation).

21.4 Economics of Industrial Process

- **Factors influencing profitability:** Cost of raw materials, energy costs, labor, capital investment, market demand, environmental regulations, efficiency of process, recycling, and waste management.

- **Sustainability:** Modern industrial chemistry emphasizes sustainable practices to minimize environmental impact and resource depletion.

21.5 Importance of Industrial Chemistry in Nigeria

- **Economic Diversification:** Reducing reliance on crude oil.
- **Job Creation:** Provides employment opportunities in manufacturing and related sectors.
- **Local Production:** Meets domestic demand for goods (e.g., plastics, cement, fertilizers, pharmaceuticals).
- **Value Addition:** Processing raw materials into finished goods increases their economic value.
- **Technological Advancement:** Drives innovation and research.

Chapter 22: Chemistry of Earth and Space

This chapter explores the chemical composition and processes occurring on Earth and within the vastness of space.

22.1 Earth: Age of Earth

- **Radiometric Dating:** The age of the Earth (approximately 4.54 billion years) is determined using radiometric dating of rocks and meteorites, which relies on the decay of radioactive isotopes.

22.2 Earth's Structure

- **Composition:** Earth is primarily composed of iron (Fe), oxygen (O), silicon (Si), magnesium (Mg), sulfur (S), nickel (Ni), calcium (Ca), and aluminum (Al).
- **Layers:**
    - **Crust:** Outermost solid layer, composed primarily of silicates.
    - **Mantle:** Thickest layer, mostly solid silicate rock, but capable of flow over geological time.
    - **Outer Core:** Liquid iron and nickel, generates Earth's magnetic field.
    - **Inner Core:** Solid iron and nickel, extremely hot and dense.

22.3 Using Spectroscopy to Study the Planets and Stars

- **Spectroscopy:** The study of the interaction between matter and electromagnetic radiation.
- **Application in Astronomy:**
    - **Composition:** Analyzing the light (spectrum) emitted or absorbed by stars and planets allows scientists to identify the chemical elements and compounds present in their atmospheres and surfaces. Each element has a unique spectral fingerprint.
    - **Temperature:** The intensity and peak wavelength of radiation indicate temperature.
    - **Motion (Doppler Effect):** Shifts in spectral lines (redshift/blueshift) indicate whether objects are moving towards or away from Earth.

22.4 The Solar System: The Sun, The Moon, The Planets, Asteroids, Comets, and Meteoroids

- **The Sun:** Our star, a huge ball of hot plasma primarily composed of hydrogen and helium, undergoing nuclear fusion (Chapter 14) to produce energy.
- **The Moon:** Earth's natural satellite, primarily composed of silicates.
- **The Planets:** Eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune) with diverse compositions and atmospheres.
    - **Terrestrial Planets (Inner):** Rocky, dense (Mercury, Venus, Earth, Mars).
    - **Gas Giants (Outer):** Large, low-density, primarily hydrogen and helium (Jupiter, Saturn, Uranus, Neptune).
- **Asteroids:** Rocky, airless remnants left over from the early formation of our solar system, mostly found in the asteroid belt between Mars and Jupiter.
- **Comets:** Icy, rocky bodies that develop a tail of gas and dust when they approach the Sun.
- **Meteoroids, Meteors, and Meteorites:**
    - **Meteoroid:** A small rocky or metallic body in outer space.
    - **Meteor:** A meteoroid that enters Earth's atmosphere and burns up ("shooting star").
    - **Meteorite:** A meteoroid that survives passage through the atmosphere and hits the Earth's surface.

22.5 Stars: Classification of Stars

- **Stars:** Luminous celestial bodies made of plasma, held together by their own gravity, and powered by nuclear fusion in their cores.
- **Classification:** Stars are classified based on their temperature (color), luminosity, and size.
    - **Color-Temperature Relationship:** Blue (hottest) ➡️ White ➡ Yellow (Sun) ➡ Orange ➡️ Red (coolest).
    - **Hertzsprung-Russell (H-R) Diagram:** Plots stellar luminosity against temperature, revealing patterns in stellar evolution.

22.6 Life History of Stars

- **Nebula:** Stars begin as a cloud of gas and dust.
- **Protostar:** The cloud collapses under gravity, heats up, and begins to glow.
- **Main Sequence Star:** Nuclear fusion of hydrogen to helium begins in the core (e.g., our Sun). This is the longest stage of a star's life.
- **Red Giant/Supergiant:** For average stars, hydrogen runs out, the core contracts, and the outer layers expand and cool to form a red giant. Massive stars become red supergiants.
- **White Dwarf/Neutron Star/Black Hole:**
    - **Average Stars:** After shedding outer layers (planetary nebula), the core becomes a dense **white dwarf**, which slowly cools.
    - **Massive Stars:** Undergo a supernova explosion, leaving behind either an incredibly dense **neutron star** or, for the most massive stars, a **black hole** (a region of spacetime where gravity is so strong that nothing, not even light, can escape).

22.7 Space Travel

- **Chemistry's Role:** Chemistry is vital for space travel in several ways:
    - **Propellants:** Design of rocket fuels (e.g., liquid hydrogen/oxygen, solid propellants).
    - **Life Support Systems:** Oxygen generation, carbon dioxide removal, water purification for astronauts in spacecraft.
    - **Materials Science:** Development of lightweight, strong, heat-resistant materials for spacecraft and suits.
    - **Astrochemistry:** Studying the chemistry of celestial bodies and interstellar space.

Glossary of Terms

- **Hydrocarbon:** Compound of only carbon and hydrogen.
- **Crude Oil:** Mixture of hydrocarbons, fossil fuel.
- **Natural Gas:** Primarily methane, fossil fuel.
- **Fractional Distillation:** Separation of crude oil into fractions by boiling points.
- **Cracking:** Breaking large hydrocarbons into smaller ones.
- **Petrochemicals:** Chemicals derived from petroleum/natural gas.
- **Organic Chemistry:** Study of carbon compounds.
- **Catenation:** Carbon's ability to form bonds with itself.
- **Homologous Series:** Group of compounds with similar formula and properties.
- **Functional Group:** Atom/group determining chemical properties.
- **Saturated Hydrocarbon:** Only single C-C bonds.
- **Unsaturated Hydrocarbon:** Contains C=C or C≡C bonds.
- **IUPAC Nomenclature:** Systematic naming of chemicals.
- **Isomerism:** Compounds with the same formula, different structures.
- **Stereoisomerism:** Same connectivity, different spatial arrangement.
- **Geometric Isomerism (Cis-Trans):** Isomerism due to restricted rotation around double bonds.
- **Alkanes:** Saturated aliphatic hydrocarbons.
- **Alkenes:** Aliphatic hydrocarbons with C=C double bonds.
- **Alkynes:** Aliphatic hydrocarbons with C≡C triple bonds.
- **Aromatic Compounds:** Contain benzene ring structures.
- **Alkanols:** Alcohols, contain -OH group.
- **Alkanoic Acids:** Carboxylic acids contain -COOH group.
- **Esters:** Compounds with -COO- linkage, from acid + alcohol.
- **Fats and Oils:** Esters of glycerol and fatty acids.
- **Detergents:** Cleaning agents.
- **Carbohydrates:** Compounds of C, H, O; sugars, starch, cellulose.
- **Amino Acids:** Building blocks of proteins.
- **Proteins:** Polymers of amino acids.
- **Polymers:** Large molecules from repeating monomers.
- **Industrial Chemistry:** Large-scale chemical production.
- **Spectroscopy:** Study of light-matter interaction to analyze composition.
- **Nuclear Fusion:** Energy process in the Sun.
- **Asteroids:** Rocky bodies in space.

- **Comets:** Icy bodies with tails.
- **Meteoroid:** Small space rock.
- **Meteor:** Meteoroid burning in atmosphere.
- **Meteorite:** Meteoroid hitting Earth's surface.
- **Stars:** Luminous plasma bodies powered by fusion.
- **White Dwarf:** Remnant of average star.
- **Neutron Star:** Remnant of massive star after supernova.
- **Black Hole:** Region of extreme gravity.