College of science

Department of Biochemistry

Second class

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Lecture2: Alkanes

Alkanes are a fundamental group of organic compounds, consisting entirely of hydrogen and carbon atoms arranged in a structure of single bonds. They are also known as saturated hydrocarbons because each carbon atom is fully "saturated" with hydrogen atoms through single covalent bonds. Alkanes are a key topic in organic chemistry due to their simplicity and presence in everyday life, from fuels to natural gases.

1. General Formula and Structure

The general molecular formula for alkanes is C_nH_{2n+2}, where "n" represents the number of carbon atoms. Each carbon atom in an alkane forms four sigma (σ) bonds, either with hydrogen atoms or other carbon atoms.

Alkanes can be:

Linear (straight-chain): Carbon atoms are connected in a continuous line, such as in methane (CH_4), ethane (C_2H_6), and propane (C_3H_8).

Branched: One or more carbon atoms are attached to a carbon in the main chain, leading to compounds like isobutane (C_4H_{10}).

2. Nomenclature of Alkanes

The naming of alkanes follows the International Union of Pure and Applied Chemistry (IUPAC) system. The root name is determined by the number of carbon atoms in the longest chain:

Methane (1 carbon, CH_4)

Ethane (2 carbons, C_2H_6)

Propane (3 carbons, C_3H_8)

Butane (4 carbons, C_4H_{10})

Pentane (5 carbons, C_5H_{12}) The rest follow a similar pattern with prefixes derived from Greek or Latin numbers (hexane, heptane, octane, etc.)

3. Physical Properties

Alkanes are non-polar molecules, meaning they do not dissolve in water (which is polar) but are soluble in organic solvents. Their physical properties depend on their molecular weight:

State: The first four alkanes (methane to butane) are gases at room temperature, while those with 5 to 16 carbon atoms are liquids, and higher alkanes are solids.

Boiling and Melting Points: Both increase with the molecular weight. Branched alkanes tend to have lower boiling points compared to their straight-chain counterparts due to less efficient packing of molecules.

Density: Alkanes are less dense than water, which is why oils and hydrocarbons float on water.

4. Chemical Properties

Alkanes are relatively unreactive compared to other organic compounds. This is because they only contain strong carbon-carbon and carbon-hydrogen single bonds, which require a significant amount of energy to break. However, they undergo a few key reactions:

Combustion: Alkanes readily burn in the presence of oxygen to produce carbon dioxide, water, and energy (heat). This reaction is the basis for their use as fuels:

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

Halogenation: In the presence of ultraviolet light, alkanes react with halogens like chlorine or bromine in a substitution reaction. For example, methane reacts with chlorine to form chloromethane:

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$

5. Sources and Uses of Alkanes

Alkanes are found primarily in natural gas and petroleum. Methane is the main component of natural gas, while longer-chain alkanes are present in crude oil. Through refining processes like fractional distillation, alkanes are separated based on their boiling points and used in various industries:

Fuels: Methane (natural gas), propane, butane, gasoline (a mixture of alkanes), and kerosene are used as energy sources.

Lubricants and Waxes: Higher alkanes like paraffin are used in candles, lubricants, and coatings.

Feedstock for Chemical Synthesis: Alkanes are precursors to many chemicals and plastics.

6. Isomerism in Alkanes

Alkanes exhibit a type of structural isomerism known as chain isomerism. This occurs when the same molecular formula corresponds to different structures due to branching. For example, butane (C_4H_{10}) exists as:

n-Butane (a straight chain).

Isobutane (a branched chain).