Alkanes

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Definition and Classification

- Alkanes, also known as paraffins, are the simplest class of hydrocarbons, consisting only of carbon (C) and hydrogen (H) atoms with single covalent bonds.
- The general formula for alkanes is CnH2n+2.

Types of Alkanes

- **Straight-chain (Normal) Alkanes**: Carbon atoms connected in a linear sequence without branches. Denoted as "n-" (e.g., n-pentane).
- **Branched chain (Iso) Alkanes**: Carbon atoms form a main chain with one or more branches. Denoted as "iso-" (e.g., isopentane).

Nomenclature of Alkanes

- The naming follows the IUPAC system:
  - Identify the longest chain to determine the base name.
  - Assign a prefix based on the number of carbons in the main chain (meth-, eth-, prop-, etc.).
  - Add the suffix "-ane" to indicate an alkane.
  - Identify and name any branches or substituents (methyl-, ethyl-, etc.).
  - Number the carbon atoms in the main chain from the end nearest a substituent.
  - Assign a number to each substituent and list them alphabetically before the base name.

Physical Properties

1. **Molecular Size and Mass**: Increase with more carbon atoms.
2. **Boiling and Melting Points**: Increase with size; branched alkanes have lower boiling points than their straight-chain counterparts.
3. **Density**: Increases with molecular mass but remains below 1 g/cm^3.
4. **Solubility**: Insoluble in water, soluble in nonpolar solvents (hexane, benzene, chloroform).

Chemical Properties

1. **Reactivity**: Generally low due to stable C-C and C-H bonds.
2. **Combustion**: Burn in oxygen to produce CO2, H2O, and energy.
3. **Halogenation**: Undergo substitution reactions with halogens in UV light or heat.
4. **Cracking**: Broken down into smaller alkanes and alkenes with heat, pressure, or catalysts.
5. **Isomerization**: Can transform into different structural isomers.

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6. **Reforming (Aromatization)**: Converted into aromatic hydrocarbons and H2 gas with a catalyst (e.g., Pt).

Uses of Paraffins (Alkanes)

- Paraffins (alkanes) are widely used across industries due to their stability and non-reactivity:
  - **Fuels**: Key components in gasoline, diesel, and kerosene for transportation, heating, and aviation.
  - **Lubricants**: High molecular weight paraffins serve as lubricants for engines and machinery, reducing wear.
  - **Wax Production**: Used in candles, wax paper, cosmetics, and protective coatings for perishables.
  - **Chemical Industry**: Feedstocks for producing solvents, detergents, and plastics like polyethylene and polypropylene.
  - **Pharmaceuticals**: Used as carriers or excipients in drugs to enhance delivery and effectiveness.

Alkanes: Preparation, Reactions and Applications

- Alkanes, the simplest and most fundamental class of hydrocarbons, are characterized by their single covalent bonds between carbon atoms.
- This section delves into the methods of preparation, key chemical reactions, and the diverse applications of alkanes.

General Methods of Preparation



1. Catalytic Hydrogenation:

Process

- Alkenes or alkynes are converted into alkanes by the addition of hydrogen (H_2) in the presence of a metal catalyst such as **Pt, Pd, or Ni**.

General Reaction

$$Alkene + H_2 \xrightarrow{Ni/Pt/Pd} Alkane$$

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Example

$$CH_2 = CH_2 + H_2 \overset{Ni}{\rightarrow} CH_3 - CH_3$$

- Ethene → Ethane

2. Wurtz Reaction:

Process

- Alkyl halides react with sodium metal in the presence of **dry ether** to produce higher alkanes.

General Reaction

$$2R - X + 2Na \overset{\text{Dry Ether}}{\rightarrow} R - R + 2NaX$$

Example

$$2CH_3CH_2Br + 2Na \overset{\text{Dry Ether}}{\rightarrow} CH_3CH_2 - CH_2CH_3 + 2NaBr$$

- Ethyl bromide → Butane

3. Reduction of Carboxylic Acids:

Process

- Sodium salt of a carboxylic acid is heated with soda lime to produce an alkane with **one carbon less** than the original acid.

General Reaction

$$R - COONa + NaOH \overset{\text{CaO, Heat}}{\rightarrow} R - H + Na_2CO_3$$

Example

$$CH_3COONa + NaOH \overset{\text{CaO}}{\rightarrow} CH_4 + Na_2CO_3$$

- Sodium ethanoate → Methane

4. Decarboxylation:

- Carboxylic acids on reduction with **$LiAlH_4$ or BH_3** give **primary alcohols**, not alkanes. To convert carboxylic acids to alkanes, stronger methods like **reduction to alcohol followed by further reduction**, or special reagents (e.g., HI/red phosphorus), are required.

Reaction ($LiAlH_4$ Reduction)

$$R - COOH \overset{LiAlH_4}{\rightarrow} R - CH_2OH$$

Example

$$CH_3COOH \overset{LiAlH_4}{\rightarrow} CH_3CH_2OH$$

- Ethanoic acid → Ethanol

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