SECTION 2 – THE NATURE OF ORGANIC COMPOUNDS: ALKANES AND CYCLOALKANES

2-1 -- Classification of Functional Groups
- Alkanes
- Alkenes
- Alkynes
- Alcohols
- Ketones
- Esters

2-2 -- Hydrocarbons
- Aliphatic Hydrocarbons (alkanes, alkenes, and alkynes)
- Aromatic Hydrocarbons (benzene)

2-2 -- Alkanes (Unbranched, Branched, and Cyclic Alkanes)
- Homologous Series
- Constitutional (“Structural”) Isomers

2-4 -- Types of Carbon Atoms
- Primary Carbons (1°)
- Secondary Carbons (2°)
- Tertiary Carbons (3°)
- Quaternary Carbons (4°)

2-5 -- Various Types of Alkyl Groups (Branches, or Substituents)

2-7 -- Systematic Nomenclature of Alkanes (IUPAC)
- Four Rules for Naming Alkanes (Rules 1-4)
- How to Find the Parent Hydrocarbon (“Parent Chain,” or “Main Chain”)
- How to Number the Atoms in the Parent Chain
- How to Identify and Number the Branches (“Substituents”)
- How to Write the IUPAC Name of the Compound

2-11 -- Naming Complex Branches in Organic Compounds

2-12 -- Common Names (“non-IUPAC”) for Some Simple Alkyl Branches

2-13 -- Examples of Alkane Nomenclature

2-15 -- Nomenclature of Alkyl Halides (R-X)

2-15 -- Disubstituted Cycloalkanes
- Stereoisomerism
- Cis/Trans Isomers

2-16 -- Properties of Alkanes (5 Key Points)
- Nonpolar (“Hydrophobic”) Properties of Alkanes
- Boiling Point Trends
- The Effects of Branching
• Melting Point Trends
• Combustion of Alkanes (Calorimetry and Product Analysis)
Section 2 = The Nature of Organic Compounds: Alkanes and Cycloalkanes.

* Organic compounds are classified according to their functional groups.
  → groups of atoms that determine the properties and reactivity of a compound.
  → see the front or back cover of your textbook (~20 functional groups)
  → note: functional groups with sulfur are "less important."

1. **Alkanes** = contain only C-C and C-H bonds. 
   → unreactive because they contain NO functional groups.
   → also called "hydrocarbons".

2. **Alkenes** = contain \( \text{C} = \text{C} \) functional group.

3. **Alkynes** = contain \( \text{-C} = \text{C} - \) functional group.

4. **Alcohols** = contain \( \text{C} - \text{OH} \) functional group.
   → a "hydroxyl group"

5. **Ketones** = contain \( \text{C} = \text{O} \) functional group.
   → a "carbonyl group"
6. Esters contain \( \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{O}} - \overset{\bullet}{\text{C}} \) functional group.

Hydrocarbons contain only \( \overset{\bullet}{\text{C}} \) and \( \overset{\bullet}{\text{H}} \) and are classified as either:

a) Aliphatic

- **Alkanes** = "saturated" (no double or triple bonds)
- **Alkenes** = "unsaturated" (have fewer than max. # of H's for given C's)
- **Alkynes** = also "unsaturated" (triple bonds)

b) Aromatic = contain *cycles* (rings) of 3 \( \overset{\bullet}{\text{C}} = \overset{\bullet}{\text{C}} \) bonds and have special stability. Also "unsaturated."

\[ \text{ex: } \begin{array}{c}
\text{or } \begin{array}{c}
\overset{\bullet}{\text{H}} - \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{H}} \\
\overset{\bullet}{\text{H}} - \overset{\bullet}{\text{C}} = \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} = \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} = \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{C}} - \overset{\bullet}{\text{H}}
\end{array}
\end{array} \]

Benzene

Alkanes can be either: ① **unbranched** (n-alkanes)

Details on next page...

② **branched**

③ **cyclic**
1. \textit{n-alkanes} = general formula $C_nH_{2n+2}$

\textbf{Ex's:}

- $\text{CH}_4$  \hspace{1cm} \text{methane}
- $\text{CH}_3\text{-CH}_3$ \hspace{1cm} \text{ethane}
- $\text{CH}_3\text{-CH}_2\text{-CH}_3$ \hspace{1cm} \text{propane}
- $\text{C}_4\text{H}_{10}$  \\ \hspace{2cm} \text{butane}
- $\text{C}_5\text{H}_{12}$  \\ \hspace{2cm} \text{pentane}
- $\text{C}_6\text{H}_{14}$  \\ \hspace{2cm} \text{hexane}

\rightarrow \text{a homologous series, where the compounds differ by the \# of} \\
- \text{CH}_2- \text{groups} \\
\downarrow \text{(methylene groups)}

\downarrow \text{heptane, C}_7\text{H}_{16} \\
\text{octane, C}_8\text{H}_{18} \\
\text{nonane, C}_9\text{H}_{20} \\
\text{decane, C}_{10}\text{H}_{22} \\
\text{undecane, C}_{11}\text{H}_{24} \\
\text{dodecane, C}_{12}\text{H}_{26}

2. \textbf{Branched Alkanes} = constitutional ("structural") \textit{isomers} of \textit{n-alkanes} that differ in connectivity of atoms.

- \textit{Note: isomers} = different compounds having the same molecular formula.
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3. Cyclic Alkanes = \[ C_n H_{2n} \] → they are saturated.

- ex: \[ C_3H_6 = \text{CH}_3 \text{CH}_2 \text{CH}_2 \] or \( \Delta \) cyclopropane
- ex: \[ C_4H_8 = \text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CH}_3 \] cyclobutane
- ex: \[ C_5H_{10} = \text{CH}_3 \text{CH}_2 \text{CH}_2 \text{CH}_2 \text{CH}_3 \] cyclopentane

* Carbons are classified as:
  a) primary\((1^o)\) = the carbon is attached to 1 other C; \( C-\text{CH}_3 \)
  b) secondary\((2^o)\) = C attached to 2 other C's; \( C-\text{CH}_2-C \)
c) tertiary ($3^\circ$) = C attached to 3 other C's; 2,5
\[
\begin{align*}
\text{C} & \text{C} \\
\text{C} & \text{C}
\end{align*}
\]

d) quaternary ($4^\circ$) = C attached to 4 other C's;
\[
\begin{align*}
\text{C} & \text{C} \\
\text{C} & \text{C}
\end{align*}
\]

**Note:** for alkanes, [H’s] are also classified as 1°, 2°, 3° according to the type of C they’re attached to.

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**Alkyl groups (branches)** - derived from alkanes by removing an -H atom.

- to name, replace -ane ending with -yl.

- ex: \(-\text{CH}_3\) methyl (Me) \(\rightarrow\) abbreviation
- ex: \(-\text{CH}_2\text{CH}_3\) ethyl (Et)
- ex: \(-\text{CH}_2\text{CH}_2\text{CH}_3\) n-propyl (nPr)
- ex: \(-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\) n-butyl (nBu)

- other common alkyl groups (continued on next pg.)

- ex: \(\text{CH}_3\text{CH} = \text{CH}_3\) isopropyl (iPr) \(\rightarrow\) [H] taken from middle C
ex: \(-\text{CH}_2-\text{CH}^-\text{CH}_3\) \(\equiv\) isobutyl \((\text{iBu})\)

ex: \(-\text{CH}^-\text{CH}_2\text{CH}_3\) \(\equiv\) sec-butyl \((\text{sBu})\)

ex: \(-\text{C}^-\text{CH}_3\) \(\equiv\) tert-butyl \((\text{tBu})\)

\[\text{attaches here}\]

ex: \(-\text{CH}_2-\text{C}^-\text{CH}_3\) \(\equiv\) neopentyl

\[\text{derived from neopentane:}\]
\[\text{CH}_3\]
\[\text{CH}_3-\text{C}^-\text{CH}_3\]
\[\text{CH}_3\]

* To generalize an alkyl group, use "\(\text{R}\)"

\[\text{R} = \text{"Rest" of molecule}\]

ex: \(\text{R} - \text{C} - \text{O} - \text{H}\)

any alkyl group

carboxylic acid functional group.

ex: \(\text{R} - \text{O} - \text{R}'\)

ether with any 2 alkyl groups \(\text{R}\) and \(\text{R}'\)

they are different.
Systematic Nomenclature of Alkanes.

4 Rules for naming, devised by the International Union of Pure and Applied Chemistry (IUPAC).

note: for a very few compounds, a 5th step is needed (examples to follow shortly).

A chemical name has 3 parts:

Prefix — Parent — Suffix

identifies the location of the functional groups and other substituents on the main chain.

tells how many C's are in the main chain.

identifies the functional groups present in the molecule.

4 Rules for Naming Alkanes.

Find the parent hydrocarbon.

find the longest continuous carbon chain and use the name of that chain as the parent name. You may have to "turn corners."

ex: CH₃CH₂CH₂CH = CH — CH₃

named as a substituted hexane

ex: CH₃CH — CHCH = CH₂CH₂CH₃

named as a substituted heptane
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