Chemistry 110
Bettelheim, Brown, Campbell & Farrell
Ninth Edition
Introduction to General, Organic and Biochemistry
Chapter 11
Alkanes & Cycloalkanes
Carbon Can Have *Only* Four Bonds

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{CH}_{\text{CH}}\text{CH}_2\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{CCH}_2\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{CHCHCHCH}_3
\end{align*}
\]
Constitutional Isomerism in Alkanes

Constitutional or Structural isomers are compounds that have the same molecular formulas, but different structural formulas. Example the *hexanes, $C_6H_{14}$.*

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 & \equiv \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} \\
\text{C} - \text{C} - \text{C} & \equiv \text{C} - \text{C} - \text{C} - \text{C} \\
\text{C} & \equiv \text{C} - \text{C} - \text{C} - \text{C} \\
\text{C} & \equiv \text{C} - \text{C} - \text{C}
\end{align*}
\]
IUPAC Systematic Naming of Alkanes

- Longest *continuous* carbon chain = Parent Alkane (PA)
- Locate any chain branching off PA, name as alkyl group.
- Assign smallest set of numbers to branch points counting from one end of PA.
- For multiple branching – Locate *identical* alkyl groups, indicate their number using bi, di (2); tri (3); tetra (4) … Locate different alkyl groups.
- Construct the name by placing the alkyl groups in alphabetical order (ignoring Greek prefixes, dimethyl = m) preceded by *locator number* separated by hyphens from words and commas from numbers. There should be a locator number for each alkyl group, i.e. 2,2-dimethyl.

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3-ethyl-2,2-dimethylpentane
A *nonane* isomer!
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Alkane to Substituent Group

methane \( \text{CH}_4 \) methyl \( \text{CH}_3 \)

ethane \( \text{CH}_3\text{CH}_3 \) ethyl \( \text{CH}_3\text{CH}_2 \)

propyl \( \text{CH}_3\text{CH}_2\text{CH}_2 \)

isopropyl \( (\text{CH}_3)_2\text{CH} \) or \( \text{CH}_3\text{CHCH}_3 \)

butyl \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2 \)

sec-butyl \( \text{CH}_3\text{CH}_2\text{CHCH}_3 \)
Alkane to Substituent Group

iso\textit{butane} $\xrightarrow{\text{isobutyl}}$ \[\text{CH}_3\text{CHCHCH}_3\] $\xrightarrow{\text{tert-butyl}}$ \[\begin{aligned}
\text{CH}_3 \\
\text{CH}_3\text{CHCH}_2 \\
\text{CH}_3
\end{aligned}\]

or

\[\begin{aligned}
\text{CH}_3 \\
\text{CH}_3
\end{aligned}\]

\{(CH_3)_3C\}
Free Rotation about Single Bonds

n-hexane
Different Views of 2-Methylpentane
Distinguishing Isomers

A
\[\text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C}\]

B
\[\text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \]

C
\[\text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C}\]

D
\[\text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C}\]

E
\[\text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C}\]
Cycloalkanes
IUPAC Systematic Naming of cycloAlkanes

- Largest carbon ring = Parent cycloalkane (PCA) – use cyclo+ (name of straight chain having same number of carbon atoms as the ring)
- Locate any chain branching off PCA, name as alkyl group.
- For multiple branching assign consecutive numbers to ring positions that give lowest set – Locate identical alkyl groups and indicate their number using bi, di (2); tri (3); tetra (4) … Locate different alkyl groups.
- Construct the name by placing the alkyl groups in alphabetical order (ignoring Greek prefixes, dimethyl = m) preceded by locator number separated by hyphens from words and commas from numbers. There should be a locator number for each alkyl group.

\[
\text{CH}_3 - \text{CH}_3 \quad \text{H}_3\text{C} - \text{CH}_3
\]

Methylecyclopentane
1,3-dimethylecyclopentane
The Shapes of Cycloalkanes

Cis / trans isomerism

methyls on same side of ring!
cis-1,2-dimethylcyclobutane

methyls on opposite sides of ring!
trans-1,2-dimethylcyclobutane
Physical Properties of (Cyclo)Alkanes

- Alkanes are non-polar compounds because the difference in electronegativity between C & H is small.

- Alkanes have lower boiling points than most organic compounds of the same molecular weight, because London attractive forces are very weak.

- Constitutional isomers are different compounds and have different physical properties.

- Alkanes serve as the framework on which functional groups are chemically attached. Much like a bare mannequin they support what is attached to them.

- Alkanes are isolated mostly from petroleum by fractional distillation.