4.4 Nomenclature of Cycloalkanes
4.4A Monocyclic Compounds

- Cycloalkanes with only one ring are named by attaching the prefix \textit{cyclo-} to the names of the alkanes possessing the same number of carbon atoms.
4-Bromo-2-ethyl-1-methylcyclohexane

1-Bromo-3-ethyl-5-methylcyclohexane

2-Chlorocyclohexanol
When a single ring system is attached to a single chain with a greater number of carbon atoms, or when more than one ring system is attached to a single chain, then it is appropriate to name the compounds as \textit{cycloalkylalkanes}.
4.4B Bridged Hydrocarbons (橋環烃)
(a) Bicyclic Compounds

Compounds containing two fused or bridged rings — bicycloalkanes

Bicyclo[2.2.1]heptane

Parent name: the total number of carbon atoms in the rings
2-Ethyl-7,7-dimethylbicyclo[2.2.1]heptane

Bicyclo[5.2.0]nonane
(b) Polycyclic Compounds

Compounds consisting of three or more rings may be named by adding the appropriate prefix "tricyclo-", "tetracyclo-", etc. before the name of the open-chain hydrocarbon.

A polycyclic system is regarded as containing a number of rings equal to the number of scissions required to convert the system into an open-chain compound.

\[
\begin{align*}
\text{三环[3.2.1.0}^{2,4}\text{]} \text{辛烷} \\
\text{Tricyclo[3.2.1.0}^{2,4}\text{]} \text{octane}
\end{align*}
\]
4.4C Spiro Hydrocarbons (螺环烃)

A spiro atom

A "spiro union" is one formed by a single atom which is the only common member of two rings.

The common atom is designated as the "spiro atom".

According to the number of spiro atoms present, the compounds are distinguished as monospiro-, dispiro-, trispirocompounds, etc.
Monospiro compounds consisting of only two alicyclic rings as components are named by placing "spiro" before the name of the normal acyclic hydrocarbon of the same total number of carbon atoms.

The number of carbon atoms linked to the spiro atom in each ring is indicated in ascending order in brackets placed between the spiro prefix and the hydrocarbon name.

The carbon atoms in monospiro hydrocarbons are numbered consecutively starting with a ring atom next to the spiro atom, first through the smaller ring (if such be present) and then through the spiro atom and around the second ring.

 Spiro[3.4]octane  
6-Chlorospiro[4.5]decane
4.5 Nomenclature of Alkenes and Cycloalkenes
Select the longest chain that contains the double bond.

Number the chain so as to include both carbon atoms of the double bond, and begin numbering at the end of the chain nearer the double bond.

Alkane $\rightarrow$ alkene

CH$_3$CH=CHCH$_2$CH$_2$CH$_3$  
2-Hexene

CH$_3$CH$_2$CH$_2$CH=CH$_2$  
2-Ethyl-1-pentene

CH$_3$CH$_2$CH$_2$CH$_2$CH$_2$CH$_3$  
2,3-Dimethyl-2-pentene
<table>
<thead>
<tr>
<th>Compound</th>
<th>Structural Formula</th>
<th>IUPAC Name</th>
<th>Chinese Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Methyl-1,3-butadiene</td>
<td>( \text{CH}_3\text{CH}=\text{C}−\text{CH}≡\text{CH}_2 )</td>
<td>2-甲基-1,3-丁二烯</td>
<td>2- ( \text{甲基}−1,3−\text{丁二烯} )</td>
</tr>
<tr>
<td>4-Methyl-3-penten-2-ol</td>
<td>( \text{CH}_3\text{CH}=\text{C}−\text{CHCHCH}_3 )</td>
<td>4-甲基-3-戊烯-2-醇</td>
<td>4- ( \text{甲基}−3−\text{戊烯}−2-\text{醇} )</td>
</tr>
<tr>
<td>1,6-Dimethylcyclohexene</td>
<td><img src="image" alt="1,6-Dimethylcyclohexene" /></td>
<td>1,6-二甲基环己烯</td>
<td>1,6- ( \text{二甲基环己烯} )</td>
</tr>
<tr>
<td>1,4-Cyclohexadiene</td>
<td><img src="image" alt="1,4-Cyclohexadiene" /></td>
<td>1,4-环己二烯</td>
<td>1,4- ( \text{环己二烯} )</td>
</tr>
</tbody>
</table>

- **The vinyl group**
- **The allyl group**
4.6 Nomenclature of Alkynes
Alkane $\rightarrow$ alkyne

$\text{CH}_2\text{CH}_3\text{C}≡\text{CCH}_3$

2-Pentyne

$\text{CH}_3\text{C}≡\text{CCH}_2\text{C}≡\text{CCH}_2\text{CH}_3$

2,5-Octadiyne

$\text{CH}_3\text{CH}=\text{CHCH}=\text{CHC}≡\text{CCH}_3$

2,4-Octadiene-6-yne

$\text{CH}_3\text{CH}=\text{CHCHCH}=\text{CHC}≡\text{CCH}_2\text{CH}_3$

6-Methyl-3-octyne

6-Isopropylcyclooctyne
3,4-Dimethyl-3-penten-1-yne

1-Octadecyne
When there is a choice in numbering, though, double bonds receive lower numbers than do triple bonds.

\[
\text{HC} \equiv \text{CCH}_2\text{CH}_2\text{CH}_2\text{CH} = \text{CH}_2
\]

1-Hepten-6-yne

\[
\text{CH}_3
\]

\[
\text{HC} \equiv \text{CCH}_2\text{CHCH}_2\text{CH}_2\text{CH} = \text{CHCH}_3
\]

4-Methyl-7-nonen-1-yne
An –OH group has priority over the triple bond when numbering the chain of an alkynol.
1-Alkynes are called **terminal alkynes**.

The anion obtained when the acetylenic hydrogen is removed is known as an **alkynide ion** or an **acetylide ion**.

- **R−C≡C−H**
  - A terminal alkyne
  - Acetylenic hydrogen

- **R−C≡C−**
  - An alkynide ion
  - (An acetylide ion)

- **CH₃−C≡C−**
  - The propynide ion
4.7 Physical Properties of Alkanes and Cycloalkanes
Boiling Points

- The boiling points of the unbranched alkanes show a regular increase with increasing molecular weight.
- Branching of the alkane chain, however, lowers the boiling point.

<table>
<thead>
<tr>
<th>CH₃CH₂CH₂CH₂CH₃</th>
<th>CH₃CHCH₂CH₃</th>
<th>CH₃−C−CH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>b.p.(°C)</td>
<td>36.1</td>
<td>27.85</td>
</tr>
</tbody>
</table>
Melting Points

- There is an alternation as one progresses from an unbranched alkane with an even number of carbon atoms to the next one with an odd number of carbon atoms.

- The effect of chain branching on the melting points of alkanes is more difficult to predict. Generally, branching that produces highly symmetrical structures results in abnormally high melting points.

<table>
<thead>
<tr>
<th></th>
<th>Methane</th>
<th>ethane</th>
<th>propane</th>
<th>butane</th>
<th>pentane</th>
<th>hexane</th>
<th>heptane</th>
</tr>
</thead>
<tbody>
<tr>
<td>m.p. (°C)</td>
<td>-182</td>
<td>-183</td>
<td>-188</td>
<td>-138</td>
<td>-130</td>
<td>-95</td>
<td>-91</td>
</tr>
</tbody>
</table>
Density

- As a class, the alkanes and cycloalkanes are the least dense of all groups of organic compounds.
- All alkanes have densities considerably less than 1.00 g/mL (the density of water at 4°C).

Solubility

- Alkanes and cycloalkanes are almost totally insoluble in water because of their very low polarity and their inability to form hydrogen bonds.