Organic Chemistry

• **Organic chemistry** is the branch of chemistry that deals with the study of carbon based compounds. Bonds between carbon atoms are covalent; each carbon is capable of forming four bonds:
  – Four single bonds = tetrahedral geometry
  – Two single, one double = trigonal planar geometry
  – Two double = linear geometry
  – One single, one triple = linear geometry

• There are over 18 million known structures ranging from one C to over a million carbons, and containing other elements such as N, O, and S.

• Hydrocarbons are the simplest organic compounds and are made up of carbon and hydrogen atoms only.
  – Saturated: contain the maximum number of hydrogen atoms possible on every carbon atom. Saturated hydrocarbons are known as alkanes.
  – Unsaturated: contain less than the maximum number of hydrogen atoms. Unsaturated hydrocarbons are either alkenes or alkynes.
Nomenclature of Straight Chained Hydrocarbons

- Composed of a prefix that tells how many carbons there are.

  - Meth-
  - Eth-
  - Prop-
  - But-
  - Pent-
  - Hex-
  - Hept-
  - Oct-
  - Non-
  - Dec-

- Composed of a suffix that tells whether the molecule is an alkane, alkene or alkyne.

  - -ane
  - -ene
  - -yne
Cyclic Hydrocarbons

Cyclic Alkanes

- cyclopropane
- cyclobutane
- cyclopentane
- cyclohexane
- cycloheptane
- cyclooctane

Cyclic Alkenes and Alkynes

- cyclopropene
- cyclooctyne
Isomers

- Iso- means same and –mers means parts; Isomers are compounds with the same molecular formulas, but different chemical structures. There are different types of isomers.
  - Structural (constitutional)

  ![Structural Isomers](image)

- Geometric (cis-trans)

  ![Geometric Isomers](image)
Naming Branched Alkanes, Alkenes and Alkynes

Branched Alkanes
1. Name the longest chain.
2. Number that chain so as to give the lowest number priority to any branched groups.
3. Name the branched groups.
4. Write the full name as one word:
   a. Use hyphens to separate numbers from prefixes
   b. Use commas to separate numbers from other numbers
   c. Use alphabetical order to list branched groups

Branched Alkenes and Alkynes
1. Name the longest continuous chain containing the double or triple bond.
2. Number the chain giving the lowest priority to the double or triple bond.
3. Name and number branched groups.
4. Write the full name as one word:
   a. Use hyphens to separate numbers from prefixes
   b. Use commas to separate numbers from other numbers
   c. Use alphabetical order to list branched groups
   d. If it is an alkene, do cis-trans isomers apply?

*The red bond shows the connection to the rest of the molecule.*

TABLE 12.4  Some Common Alkyl Groups*

<table>
<thead>
<tr>
<th>Chain</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃</td>
<td>Methyl</td>
</tr>
<tr>
<td>CH₃CH₂</td>
<td>Ethyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₃</td>
<td>n-propyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₂CH₃</td>
<td>iso-propyl</td>
</tr>
<tr>
<td>CH₃CHCH₂CH₃</td>
<td>sec-butyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₂</td>
<td>isobutyl</td>
</tr>
<tr>
<td>CH₃CH₂CH₃</td>
<td>tert-butyl</td>
</tr>
</tbody>
</table>

*The red bond shows the connection to the rest of the molecule.*

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Problems

1. Draw the following in structural formulas:
   a. Butane
   b. Propene
   c. 2-methyldecane

2. Draw the following in line structures:
   a. Trans-3-methyl-3-heptene
   b. Cyclopentane
   c. 4-methyl-2-pentyne

3. Name:
   a. \( \text{CH}_4 \)
   b. \( \text{CH}_3(\text{CH}_2)_3\text{CH(CH}_3)_2 \)

4. Why do we not specify the location of the double bond in propene?

5. Why is there no such compound known as methyne?
Basic Reactions of Hydrocarbons

• Alkanes: Not very reactive. Takes energy from a spark or heat to get over the activation energy barrier.
  – Combustion:
  – Halogenation:

• Alkenes and Alkynes: more reactive than alkanes.
  – Combustion:
  – Halogenation:
  – Hydrogenation:
  – Hydrohalogenation:
  – Hydration (alkenes only, alkynes do something different when hydrated):

• Mechanisms: A mechanism shows the theoretical details of a reaction including bond breakage and formation, and the direction of electron movement.
Problems

1. Write out the following reactions using structural formulas. Show only the MAJOR product formed.
   a. Methyl propene reacts with HBr

   b. methylcyclopentene reacts with HCl

   c. 2-methyl-2-butene reacts with water in the presence of an acid catalyst

2. Fill in the product(s) for the reaction shown below:

   \[
   \text{\text{\begin{align*}
   \text{CH}_2=\text{CH}_2 + \text{Cl}_2 & \rightarrow \\
   & \text{Product(s)}
   \end{align*}}}
   \]
Functional Groups

When a small portion of a molecule is responsible for the reactivity of that molecule, we call that small portion a functional group.
IUPAC Nomenclature

- **Alcohol**: Name as usual, -e ending, +ol ending; use number to specify alcohol location if there are 3 or more carbons in the chain
  - Example: ethanol
  - NOTE: There are two methods of naming alcohols that are accepted by IUPAC; ethyl alcohol is also acceptable.

- **Halide**: Name the halide as a side group using:
  - Chloro-, Bromo-, Fluoro-, Iodo-
  - Example: chloromethane
  - NOTE: There are two methods of naming alkyl halides that are accepted by IUPAC; methyl chloride is also acceptable.

- **Ether**: List alkyl groups alphabetically with the –yl ending and add the word ether
  - Example: diethyl ether
  - NOTE: There are two methods of naming ethers that are accepted by IUPAC; ethoxyethane is also acceptable.

- **Amine**: Name the alkyl groups alphabetically with the –yl ending and the suffix –amine
  - Example: propylamine, N-methylethylamine, N,N-dimethylproplamine
  - NOTE: There are two methods of naming amines that are accepted by IUPAC; propanamine is also acceptable.

- **Aldehyde**: Name as usual, -e ending, +al ending
  - Example: methanal and ethanal
  - NOTE: common names formaldehyde and acetaldehyde

- **Ketone**: Name as usual, -e ending, +one ending
  - Example: 4-octanone
  - NOTE: common name acetone for IUPAC propanone

- **Carboxylic Acid**: Name as usual, -e ending, +oic acid ending
  - Example: methanoic acid and ethanoic acid
  - NOTE: common names formic acid and acetic acid

- **Amide**: Name as usual, -e ending, +amide suffix
  - Example: ethanamide, N-methylethanamide, N,N-dimethylethanamide

- **Ester**: Name the alkyl group off of the oxygen, name the alkyl group that includes the carbonyl carbon –e ending, +oate ending
  - Example: ethyl butanoate
  - NOTE: formate is commonly used in place of methanoate and acetate is commonly used in place of ethanoate
Problems

1. Circle and name each functional group:

   ![Chemical Structures]
   - acetylsalicylic acid; aspirin
   - testosterone; a steroid/sex hormone
   - phenylalanine; an essential amino acid

2. Draw structural formulas and line structures for:
   a. 2-pentanol
   b. Hexanoic acid
   c. 2-butanone
   d. Ethyl propyl ether