Organic Chemistry

- What is organic chemistry?
- What do you think makes it different from inorganic chemistry?

- Why is organic chemistry a separate discipline within chemistry?
  - historical: scientists at one time believed that a “vital force” present in living organisms was necessary to produce an organic compound
  - Then, are organic compounds only found in living organisms? (NO!)
Organic Chemistry

- **Organic chemistry**: the study of the compounds of carbon
  - organic compounds are made up of carbon and only a few other elements
  - chief among these are hydrogen, oxygen, and nitrogen
  - also present are sulfur, phosphorus, and halogens (fluorine, chlorine, bromine, or iodine)

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Elements of Organic Chemistry

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Organic Chemistry

- **The sheer number of organic compounds**
  - chemists have discovered or made over 10 million organic compounds and an estimated 100,000 new ones are discovered or made each year
  - by comparison, chemists have discovered or made an estimated 1.7 million inorganic compounds
  - thus, approximately 85% of all known compounds are organic
What then is different from inorganic chemistry?
- What elements are involved?
  - Salt vs. sugar
  - Chemical formulas:

### Organic Chemistry

<table>
<thead>
<tr>
<th>Organic Compounds</th>
<th>Inorganic Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding is almost entirely covalent</td>
<td>Most have ionic bonds</td>
</tr>
<tr>
<td>May be gases, liquids, or solids with low melting points (less than 360°C)</td>
<td>Most are solids with high melting points</td>
</tr>
<tr>
<td>Most are insoluble in water</td>
<td>Many are soluble in water</td>
</tr>
<tr>
<td>Most are soluble in organic solvents such as diethyl ether, toluene, and dichloromethane</td>
<td>Almost all are insoluble in organic solvents</td>
</tr>
<tr>
<td>Aqueous solutions do not conduct electricity</td>
<td>Aqueous solutions conduct electricity</td>
</tr>
<tr>
<td>Almost all burn</td>
<td>Very few burn</td>
</tr>
<tr>
<td>Reactions are usually slow</td>
<td>Reactions are often very fast</td>
</tr>
</tbody>
</table>

### A Look at carbon
- Forms four bonds
  - What is carbon’s electron configuration?
    - 1s²2s²2p²
  - How many valence electrons?
  - How many does it need to be “happy”?
  - How does it get more electrons?
- Covalent – what does this mean?
Carbon: Bonding

- Bonds arrange as far apart as possible.
  - Why?
    - If molecules with 4 single bonds were flat, what would be the bond angles?
    - Tetrahedron – 109.5°
  - What about double or triple bonds?
    - 1 double + 2 single = 4 bonds
    - 2 double bonds = 4 bonds
    - 1 triple + 1 single = 4 bonds
  - How many electrons are involved in all the bonds?

Bonding of other elements of organic compounds

- Hydrogen
  - # valence electrons
  - # additional electrons needed:
    - # bonds:
- Nitrogen
  - # valence electrons:
  - # additional electrons needed:
    - # bonds:
- Oxygen
  - # valence electrons
  - # additional electrons needed:
    - # bonds:
- Halogens
  - # valence electrons
  - # additional electrons needed:
    - # bonds

Draw some Lewis structures

- Methane
  - CH₄
- Ammonia
  - NH₃
- Methyl alcohol
  - CH₃OH
- Carbon tetrachloride
  - CCl₄
Practice

- Insert the correct number of hydrogens to complete the structures.
  a. C−C−C
  b. C−O−C
  c. C=C−C−N

Practice

- What is wrong with the structures shown?

```
H3C
\(\text{C=O} \quad \text{C=O}\)
H3C
```

Formulas

- Molecular
  - Tell numbers of each atom
    - CH₃
    - C₂H₆
- Structural
  - Shows how atoms bonded
    - Expanded
    - Condensed
Formulas: Example 1

- Draw the molecular formula and the condensed structural formula for the following expanded structural formula:

\[ \text{H}_3\text{C}-\text{CH}_2\text{CH}_3 \]

- Write its condensed structural formula?
  - Find the longest chain of carbon
  - List each C in the chain
  - After the C list all groups attached to it except the next carbon
  - Use parentheses if an attached group contains carbon

Formulas: Example 2

- Draw the molecular formula and the condensed structural formula for the following expanded structural formula:

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

Structural Isomers

- Constitutional isomers
- Compounds with the same molecular formula but different structural formulas.
- Isomers have the same atoms but they are bonded in different orders.
- Isomers have different names.
- Isomers have different physical and chemical properties.
**Structural Isomers: Examples**

What is the difference between these molecules?

- **Ethyl Alcohol**
  - Molecular formula: \( \text{C}_2\text{H}_5\text{OH} \)
  - Molecular weight: 46.1 g/mol
  - Mp: -117 °C
  - Bp: 78 °C

- **Diethyl ether**
  - Molecular formula: \( \text{C}_4\text{H}_8\text{O} \)
  - Molecular weight: 74.1 g/mol
  - Mp: -138 °C
  - Bp: -25 °C

Write the condensed molecular formula for each isomer. (next slide)

**Structural Isomers**

- It doesn’t matter how the bonds are drawn on the page for single bonds. (up or down)
  - These are all butane:
  - Are they constitutional isomers?
  - No! They are the same compound!

\[ \text{H}_3\text{C}—\text{CH}_2—\text{CH}_2—\text{CH}_3 \]

\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \]
Structural Isomers

- What about?
  - \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \)

Are these isomers or the same compound?

What is the molecular formula for butane?

Draw the condensed formula for each of the above isomers of butane.

Practice

- Draw the expanded structural formula for \( \text{CH}_3(\text{CH}_2)_2\text{CH}_3 \)

- Draw the expanded structural formula for \( \text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3 \)

Practice

- Draw the expanded structural formula for \( \text{CH}_3(\text{CH}_2)_3\text{CH}_3 \)

Write the molecular formula for the above compound.

Draw a structural isomer of the above compound.
Practice: Homework

1. Draw the expanded structural formula for \( \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \)
2. Write the molecular formula for the above compound.
3. Draw a structural isomer of the above compound.
   [Make sure you have the same atoms and the correct number of bonds!]