Chapter 10
Shapes of Molecules
Lewis Dot Structures Review

Draw Lewis Dot Structures of:

$\text{SiO}_2$
$\text{SO}_3^{2-}$
$\text{HNO}_2$

Place your answer(s) on the board.
Exceptions to the Octet Rule

Examples:

Deficient Octet
  BF$_3$

Expanded Octet
  H$_2$SO$_4$

Radicals
  NO
Resonance Structures

Consider the following molecules:

\[ \text{CO}_3^{2-} \]

\[ \text{C}_6\text{H}_6 \]

\[ \text{CH}_3\text{COO}^- \]

Note: Atoms do not change position! Only pi and lone pair electrons.
Formal Charge

Determination of formal charge for each atom within a molecule:

\[ \text{V.E.} - (\text{NB.E.} + \frac{1}{2} \text{ B.E.}) = \text{formal charge} \]

What are the formal charges of each atom in HCN?

What are the formal charges of each atom in NO$_3^-$?

What are the formal charges of each atom in SO$_4^{2-}$?
Selecting the Preferred Lewis Dot Structure

Use the concept of formal charge to select the preferred structure of the CON$^-$ ion.
Valence Shell Electron Pair Repulsion Theory (VSEPR)

Each group of valence electrons around a central atom is located as far away from the other atoms as possible.

Strength of electron pair repulsions:
L.P.-L.P. > L.P.-B.P. > B.P.-B.P.

A “group” of electrons is defined as any number of electrons that occupies a space around an atom and may consist of a single, double, triple bond or lone pair of electrons.

The 3-dimensional arrangement of these groups determines the molecular arrangement (shape).
Molecular Shape

The arrangement of the atoms around a **central atom** determines the shape of the molecule or portion of the molecule.
Possible Shapes of Molecules
- Linear
- Bent
- Trigonal Planar
- Trigonal Pyramidal
- Square Planar
- Square Pyramidal
- Octahedral
- T-Shaped
- Seesaw
- Trigonal Bipyramidal
Different Shapes of Molecules (or portions of molecules)

Two electron groups around the central atom:

- Linear shape
- Bond angle = 180°
**Class**: Linear

**Shape**: Linear

**Examples**: CS₂, HCN, BeF₂

**Key**:

- A
- X
- E

**Diagram**:

- A is linearly bonded with two X atoms at 180°.
- CS₂, HCN, and BeF₂ are examples of linear molecules.
Three electron groups

Trigonal planar arrangement

Bond angles = 120°
<table>
<thead>
<tr>
<th>Class</th>
<th>Shape</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>AX₃</td>
<td>Trigonal planar</td>
<td>SO₃, BF₃, NO₃⁻, CO₃²⁻</td>
</tr>
<tr>
<td>AX₂E</td>
<td>Bent (V shaped)</td>
<td>SO₂, O₃, PbCl₂, SnBr₂</td>
</tr>
</tbody>
</table>
Four electron groups

- Tetrahedral arrangement
- Bond angles = 109.5°
Five electron groups

Bipyramidal arrangement

Consists of three equatorial groups

And two axial groups
Class | Shape | Examples
--- | --- | ---
\(AX_6\) | Trigonal bipyramidal | \(PF_5, AsF_5, SOF_3\)
\(AX_4E\) | Seesaw | \(SF_4, XeO_2F_2, IF_4^+, IO_2F_2^-\)
\(AX_3E_2\) | T shaped | \(ClF_3, BrF_3\)
\(AX_2E_3\) | Linear | \(XeF_2, I_3^-, IF_2^-\)
Six electron groups

- Octahedral arrangement

- Bond angles = 90°
<table>
<thead>
<tr>
<th>Class</th>
<th>Shape</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>$AX_6$</td>
<td>Octahedral</td>
<td>$SF_6$, $IOF_5$</td>
</tr>
<tr>
<td>$AX_5E$</td>
<td>Square pyramidal</td>
<td>$BrF_5$, $TeF_5^-$, $XeOF_4$</td>
</tr>
<tr>
<td>$AX_4E_2$</td>
<td>Square planar</td>
<td>$XeF_6$, $ICl_4^-$</td>
</tr>
</tbody>
</table>
Polar vs. Nonpolar Molecules

Generally speaking, a molecule will be nonpolar if …

(1) All of the bonded atoms (or groups of atoms) to the central atom are the same and equidistant from each other.
   i.e. $\text{BH}_3$ vs. $\text{BF}_3$

(2) There are no lone pairs of electrons on the central atom(s).

(3) It is a hydrocarbon.