

# The Trigonal Bipyramid Geometry (SN = 5) (VSEPR Part 4)

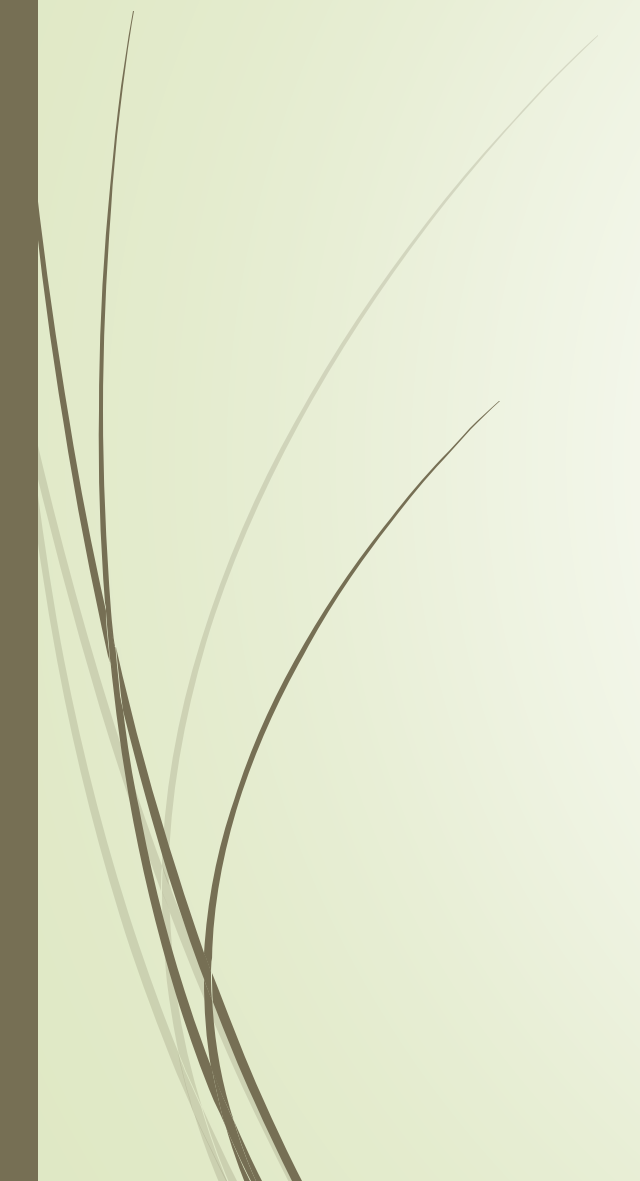
By Shawn P. Shields, Ph.D.



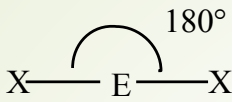
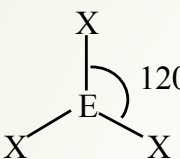
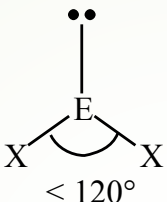
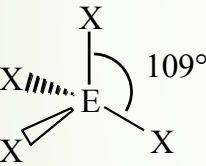
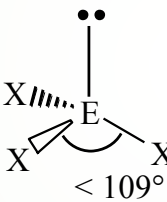
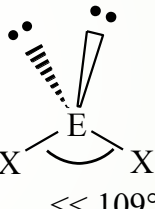
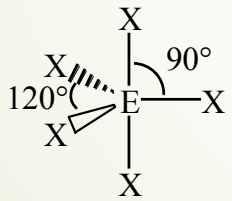
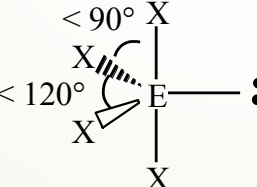
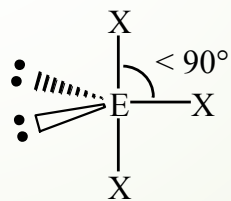
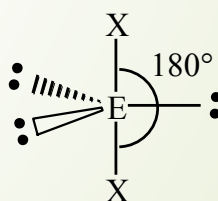
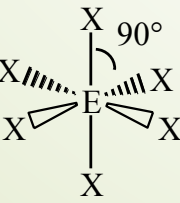
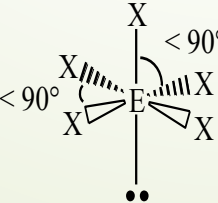
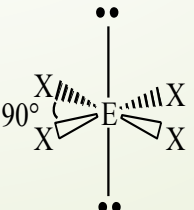
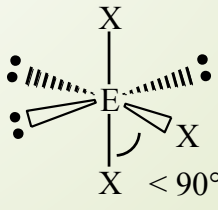
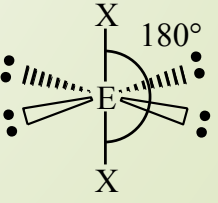
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# Recall: The Basic Molecular Geometries (Shapes)


- ➡ Linear (SN = 2)
  - ➡ Trigonal planar (SN = 3)
  - ➡ Tetrahedral (SN = 4)
  - ➡ **Trigonal bipyramid (SN = 5)**
  - ➡ Octahedral (SN = 6)
- 

# VSEPR Geometries


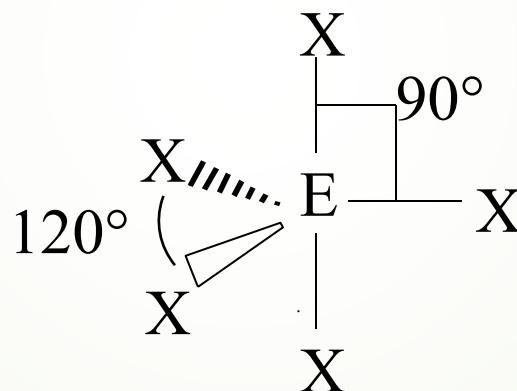
Steric No.	Basic Geometry 0 lone pair	1 lone pair	2 lone pairs	3 lone pairs	4 lone pairs
2	 <b>Linear</b>				
3	 <b>Trigonal Planar</b>	 <b>Bent or Angular</b>			
4	 <b>Tetrahedral</b>	 <b>Trigonal Pyramid</b>	 <b>Bent or Angular</b>		
5	 <b>Trigonal Bipyramid</b>	 <b>Sawhorse or Seesaw</b>	 <b>T-shape</b>	 <b>Linear</b>	
6	 <b>Octahedral</b>	 <b>Square Pyramid</b>	 <b>Square Planar</b>	 <b>T-shape</b>	 <b>Linear</b>

# Basic Geometry for SN = 5

**SN = 5: Five electron “domains”**  
(Notice the apparent expansion of octet)



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of the page

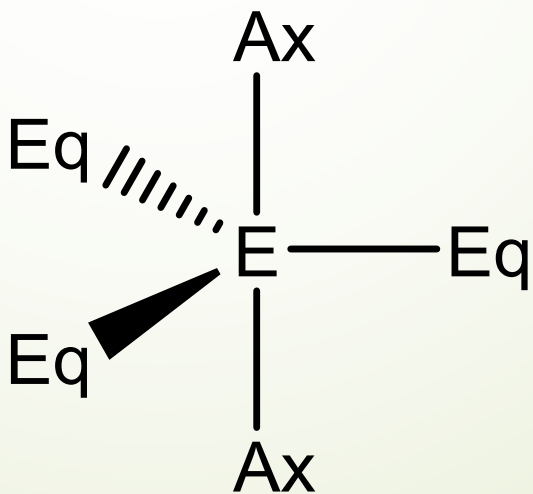


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the page

**(Basic) Molecular Shape: Trigonal Bipyramid**

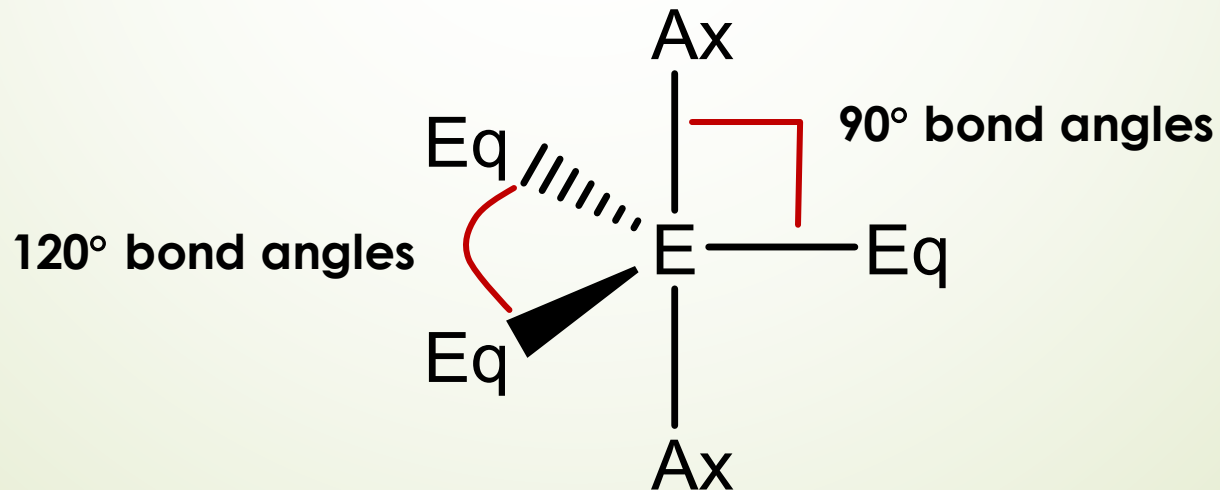
# The Trigonal Bipyramidal Molecular Geometry

- ▶ Trigonal bipyramidal structures have **two types of atom positions**
- ▶ **Equatorial positions (Eq)** (in the horizontal plane intersecting the central atom)
- ▶ **Axial positions (Ax)** vertical to the central atom



# Bond Angles in the Trigonal Bipyramidal Molecular Geometry

- ▶ Trigonal bipyramidal structures ALSO have **two different bond angles**
- ▶ **Bond angles for equatorial positions (Eq)** are  $120^\circ$  apart
- ▶ **Bond angles for axial positions (Ax)** are  $90^\circ$  apart



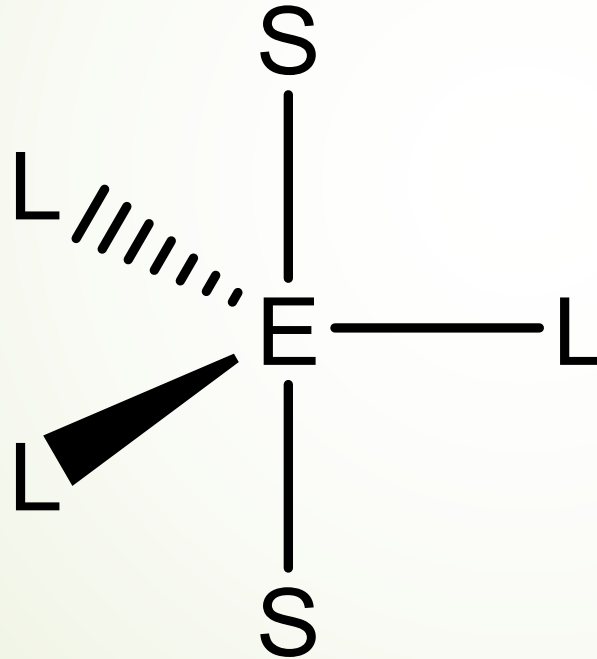


# Application of Bent's Rule in $SN = 5$ Structures

- More electronegative atoms prefer axial positions.
- Less electronegative atoms prefer equatorial positions.
- Equatorial positions are “roomier”
- Lone pairs **MUST** be placed in equatorial positions.



# Bent's Rule and the Trigonal Bipyramidal Geometry



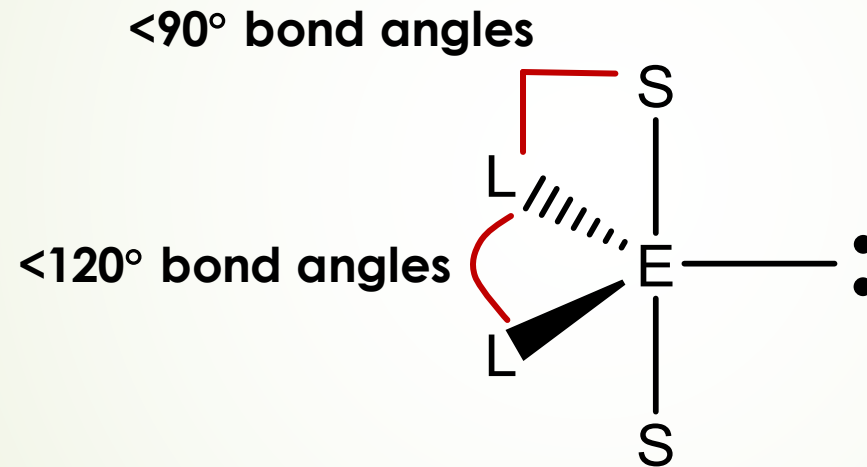
Lone pairs take up a lot of room, so they must be placed in equatorial positions

(labeled L for “large”)



# SN = 5 with One Lone Pair

Four bonded atoms, with the one lone pair placed in one of the equatorial positions.

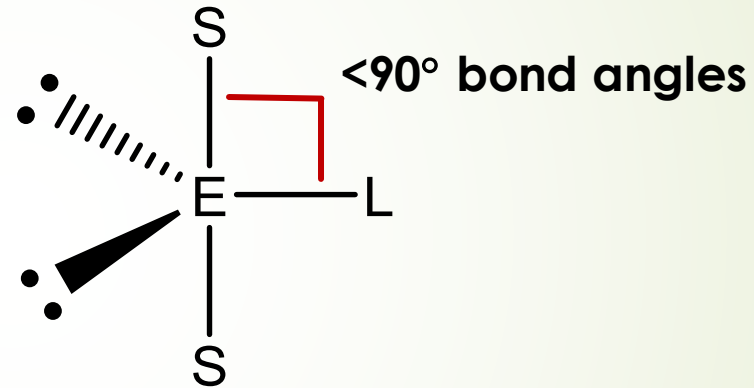


The bond angles distorted to less than 90° and 120° due to repulsions from lone pairs.

**Molecular Shape: Sawhorse or Seesaw**

# SN = 5 with Two Lone Pairs

Three bonded atoms, with the two lone pairs placed in equatorial positions.

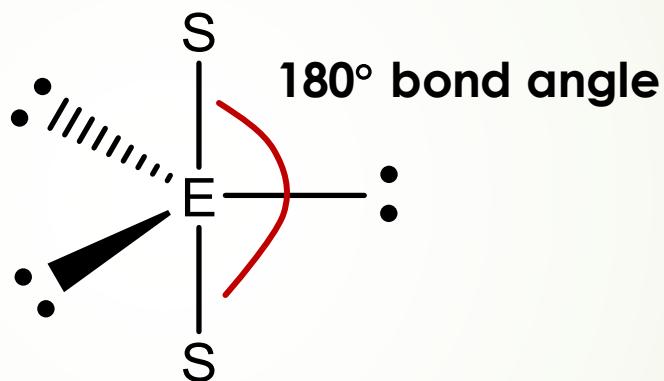


The bond angles between the equatorial atom and the axial atoms are distorted to  $<90^\circ$  due to repulsions from lone pairs.

**Molecular Shape: T-Shape**

# SN = 5 with Three Lone Pairs

Three bonded atoms, with the two lone pairs placed in equatorial positions.

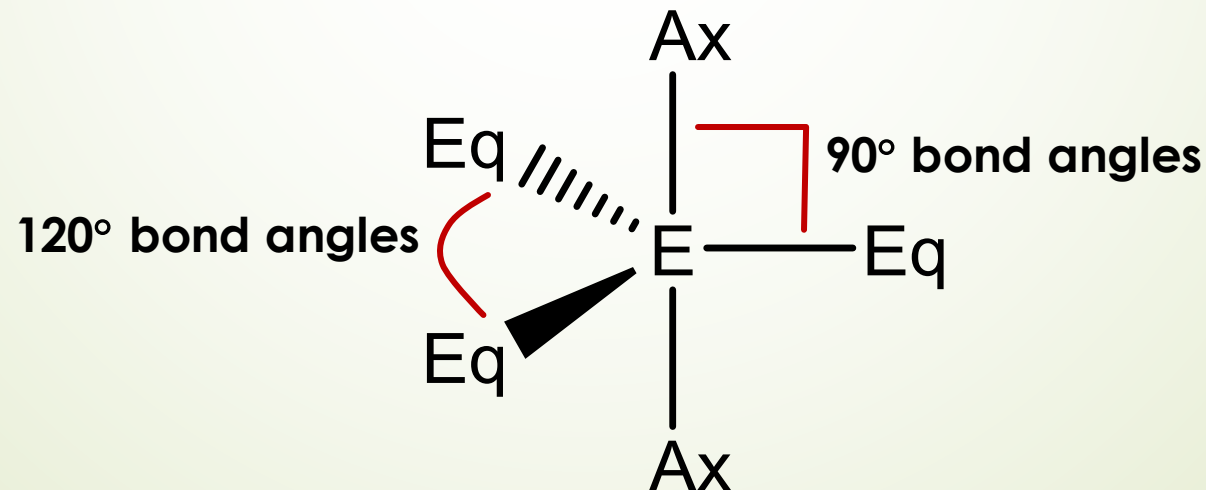


The repulsions from lone pairs cancel out to leave the X—E—X bond angle undistorted (180°).

**Molecular Shape: Linear**

# Summary: Trigonal Bipyramidal Geometry

- Less electronegative atoms and lone pairs go into equatorial positions.
- More electronegative atoms are placed in axial positions.
- Both types of bond angles are distorted due to the presence of lone pairs (in specific situations).



## Example: Determining the SN and Naming the Geometry

- ➡ Draw the Lewis structure for  $\text{ClF}_4^+$ . Determine the steric number and name the molecular geometry. Identify the bond angle(s), including distortions, if present.

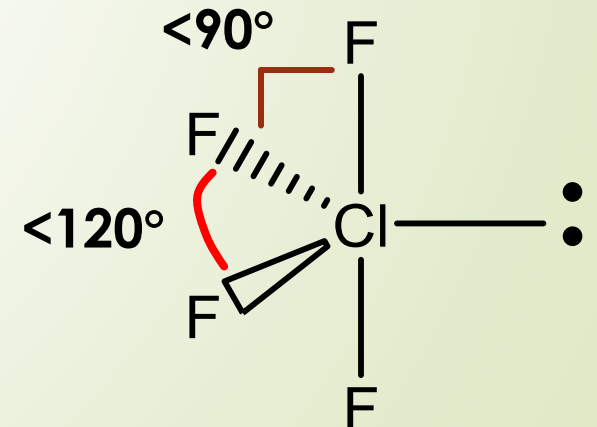
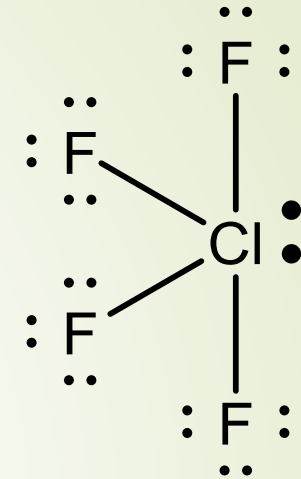
## Example Solution:

The Lewis structure for  $\text{ClF}_4^+$  is


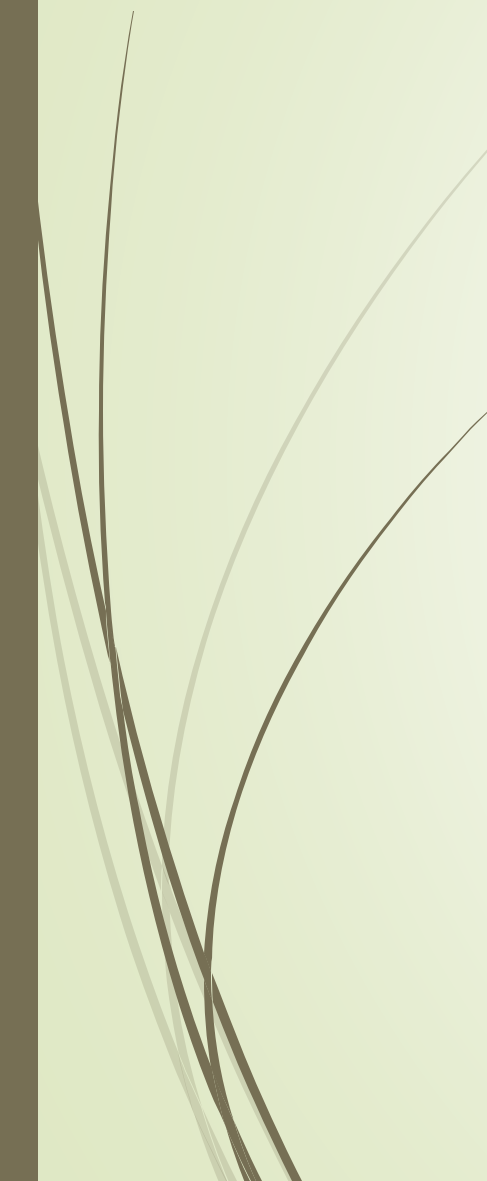
There are 4 F atoms bonded to Cl plus a lone pair, so **SN = 5** and the **basic geometry is trigonal bipyramid**.

The bond angles are distorted to less than  $120^\circ$  and  $90^\circ$ .

The geometry is **Seesaw (or Sawhorse)**.



# What You Should Be Able to Do

- 
- 
- **Draw a Lewis structure** and use it to **determine the steric number** for the central atom.
  - Determine the basic geometry around the central atom.
  - **Substitute lone pairs** as appropriate and **identify distortions** in the bond angles.
  - **Apply Bent's Rule** for  $SN=5$  molecules.
  - **Draw the molecule showing geometry and name it** based on the positions of the atoms.