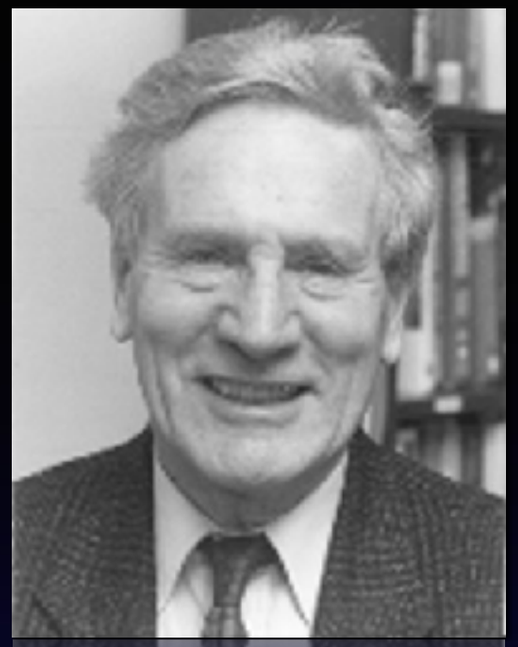
Previously in Molecularity…

Valence-shell electron-pair repulsion theory (VSEPR)

- Assign a geometric shape around an atom based on a **steric number, SN**
- **SN** = # bonded atoms + # lone pairs
- SN 2–8 correspond to specific geometric shapes.
- Lone pairs occupy positions just like bonded atoms.



Ronald Gillespie

archive.cnx.org
graphics1.jpg

Ronald Nyholm

images.npg.org.uk
mw86253.jpg

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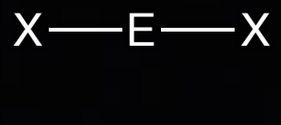
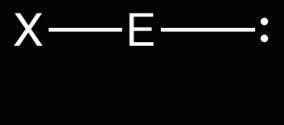
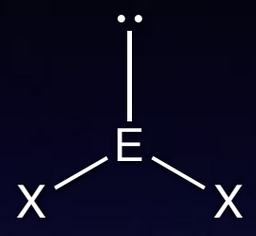
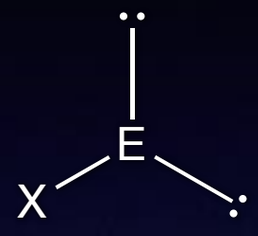
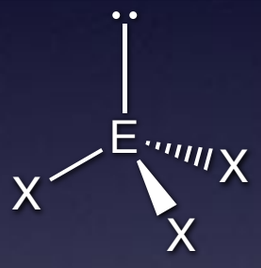
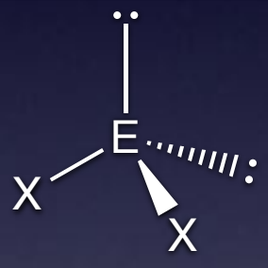
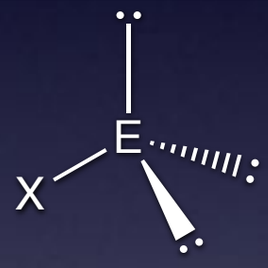
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
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Where are we going today?

Ch1010-A17-A03 Lecture 16

- §5.7 VSEPR: Fundamental Structures
- §5.8 VSEPR: Effect of Lone Pairs
- §5.9 VSEPR: Predicting Geometries

http://stevedeace.com/wp-content/uploads/2012/11/

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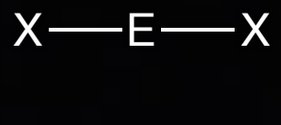
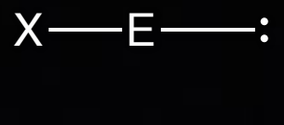
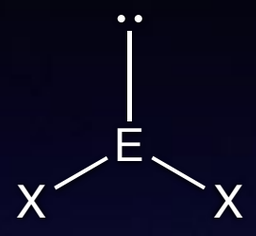
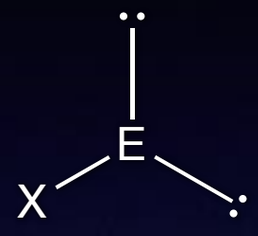
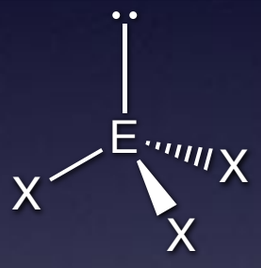
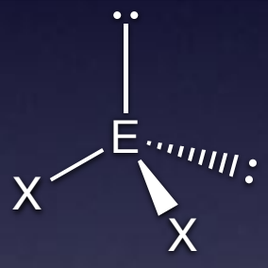
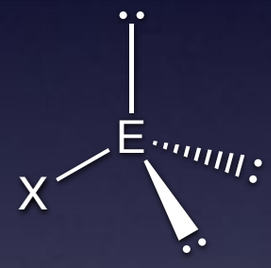
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal					
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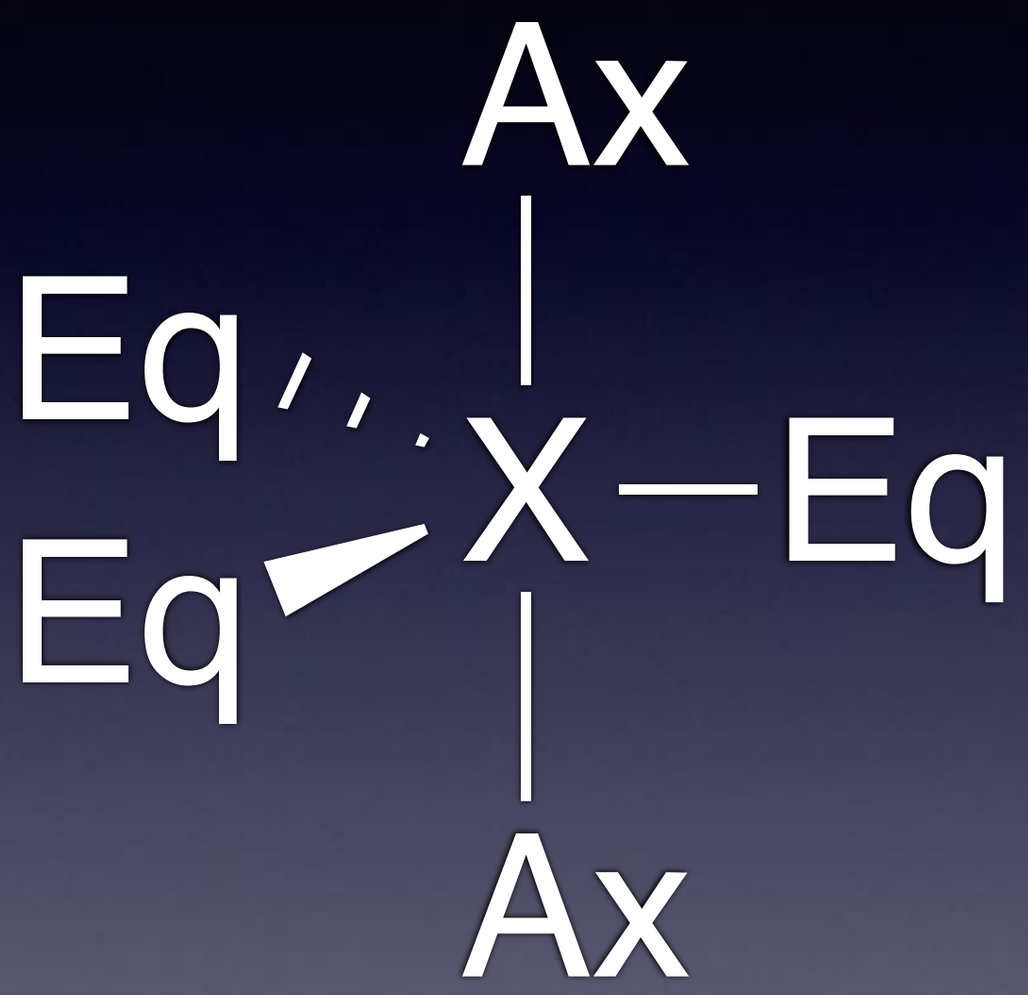
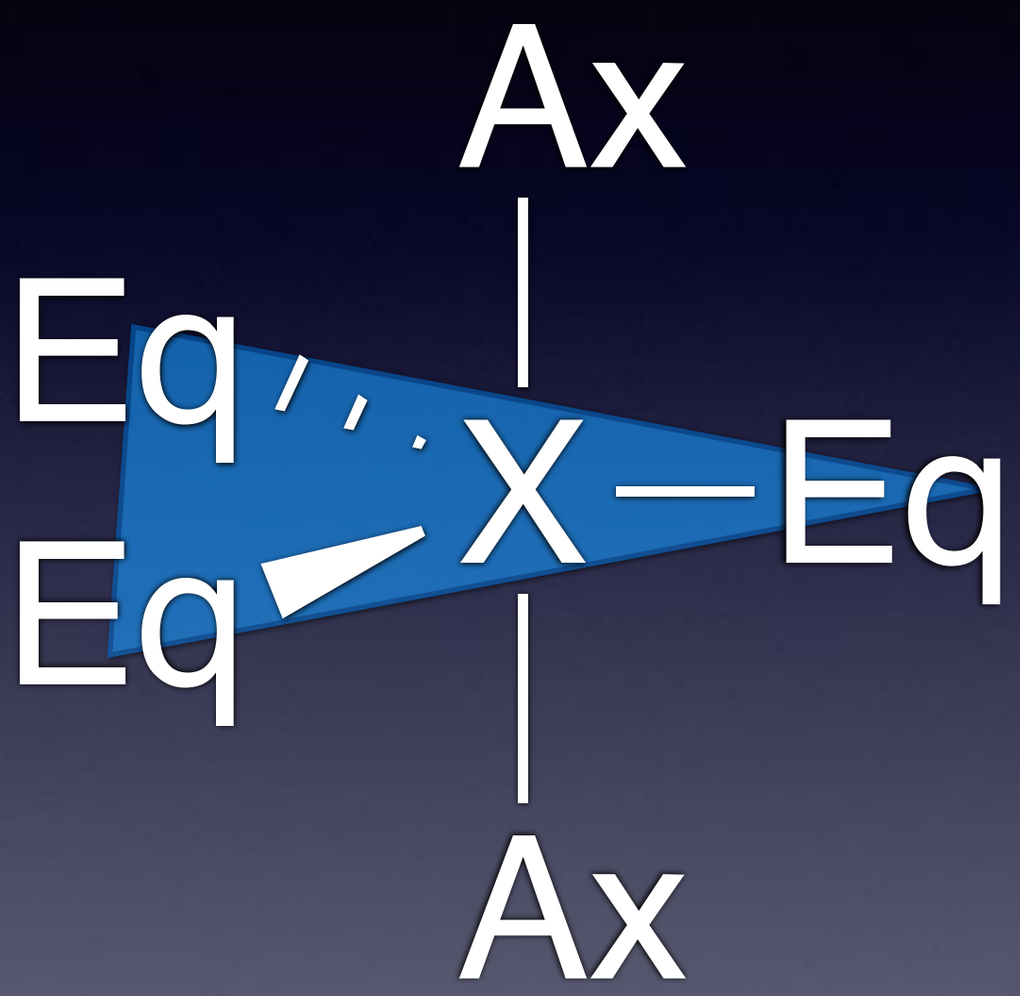
SN 5: Trigonal bipyrimidal

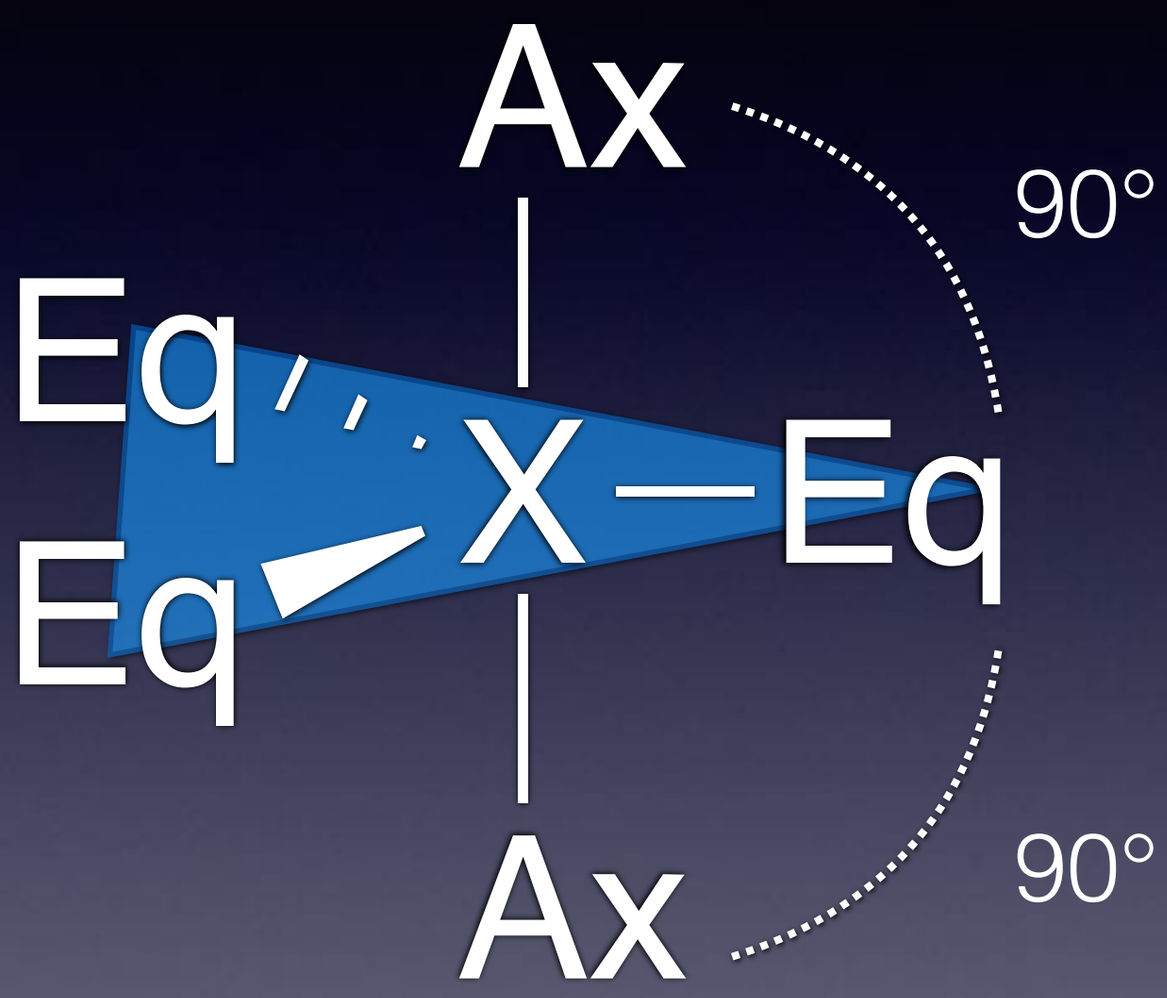


Ax: Axial position
Eq: equatorial position

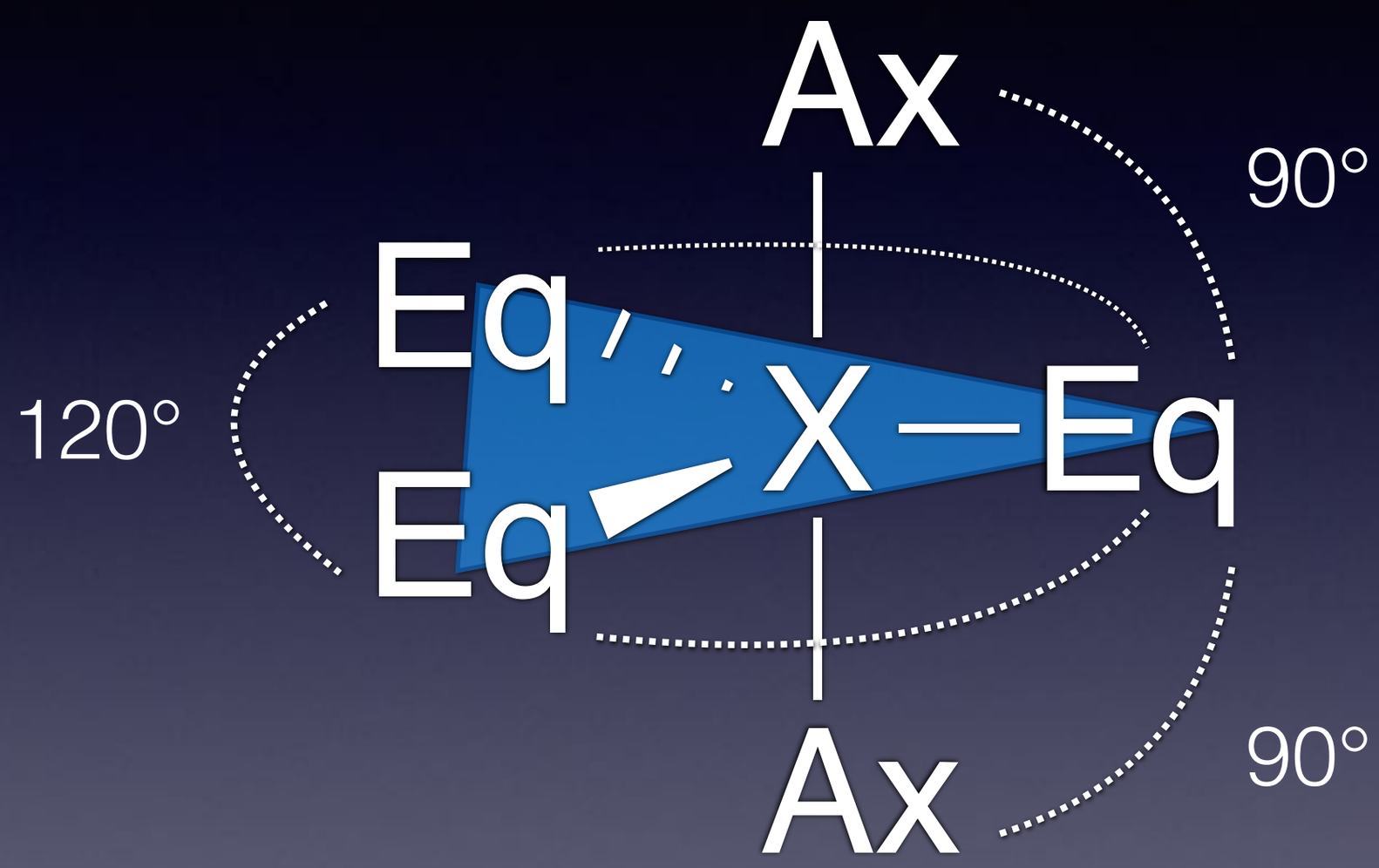
SN 5: Trigonal bipyrimidal



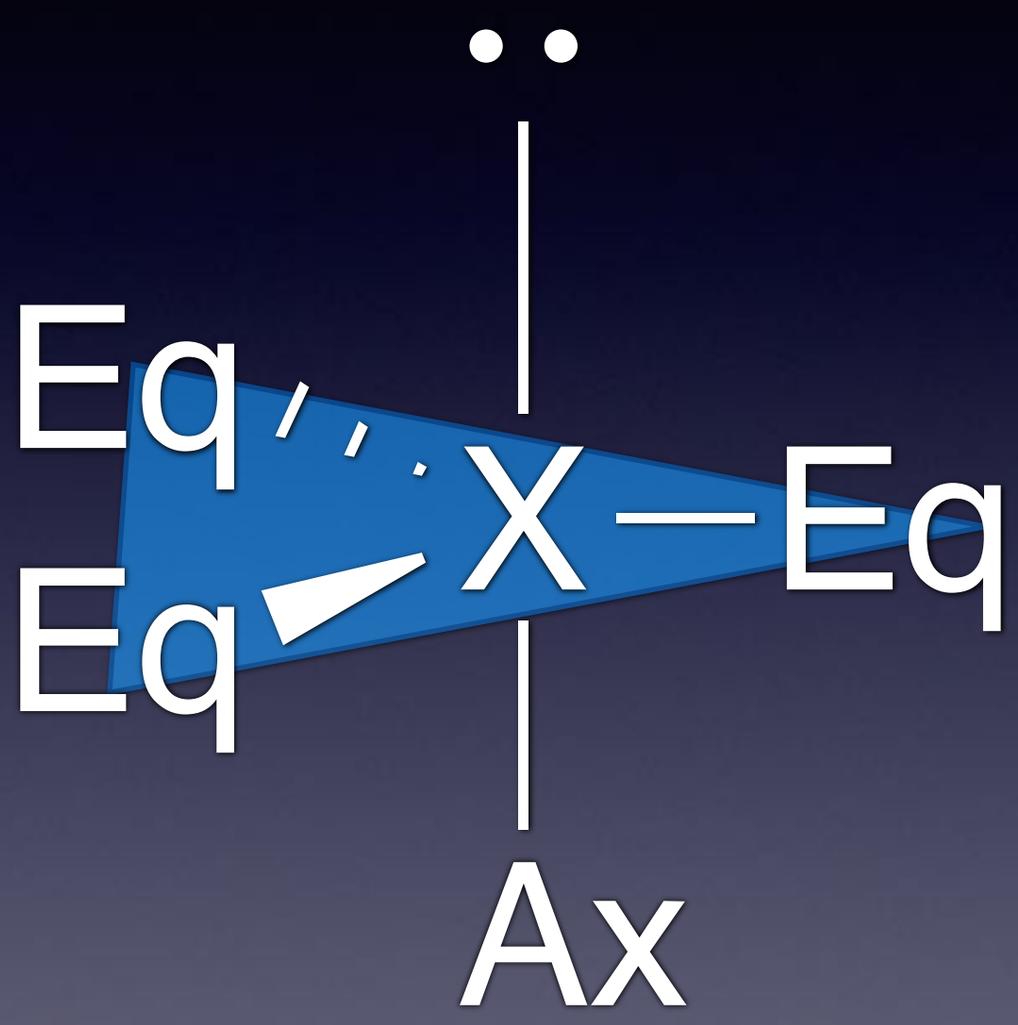
SN 5: Trigonal bipyrimidal

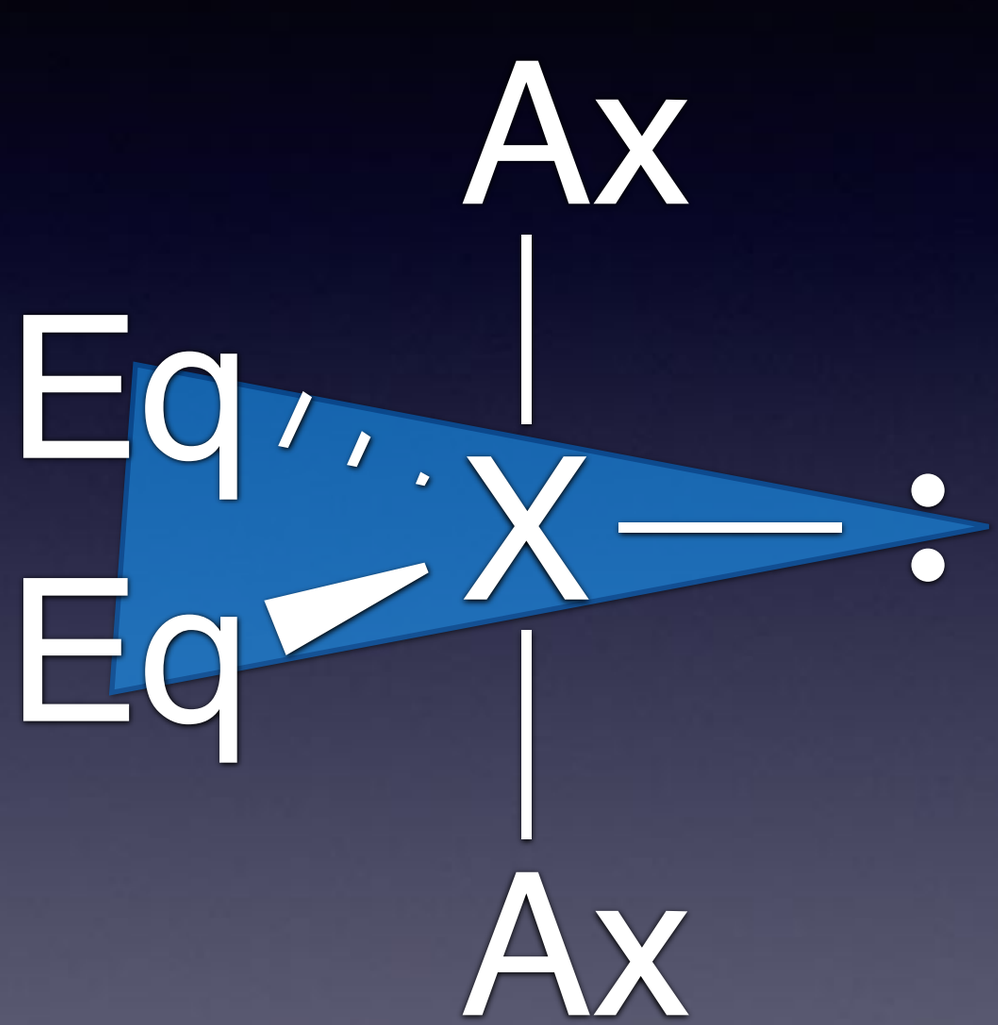


SN 5: Trigonal bipyrimidal



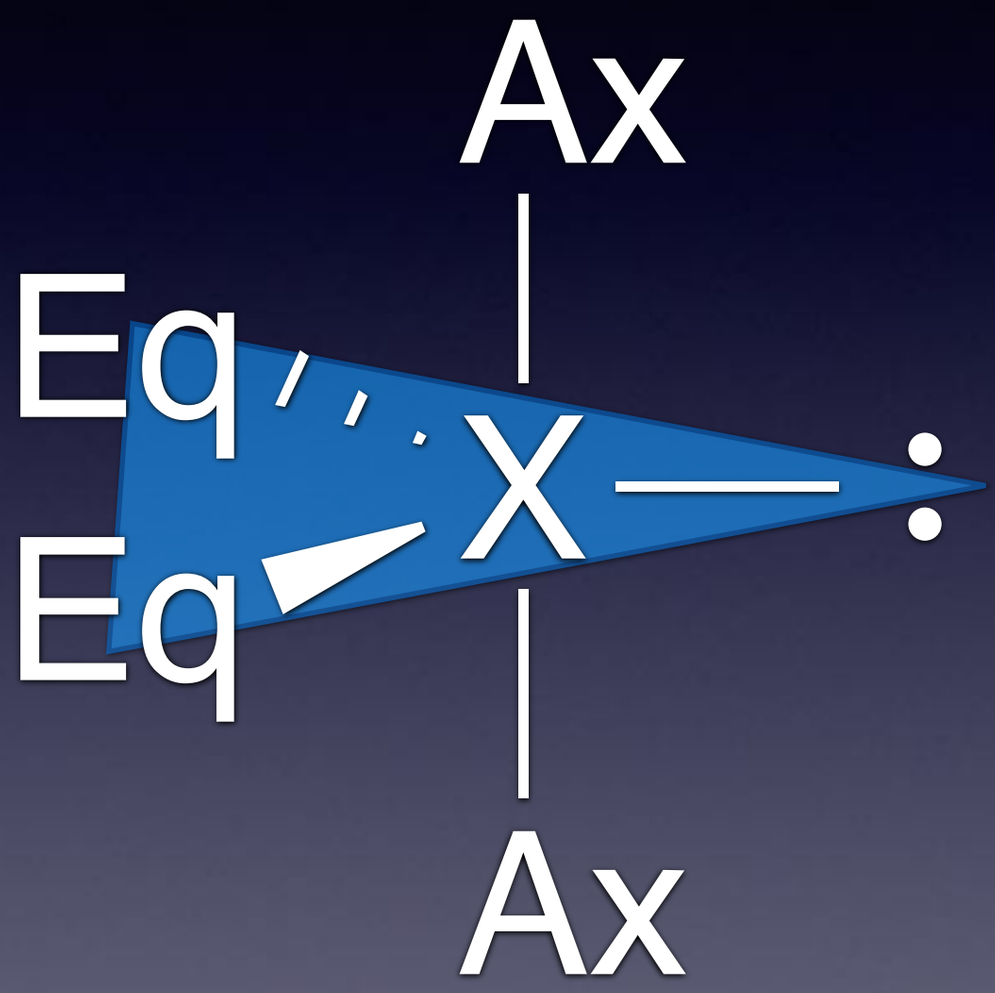
SN 5: where would a lone pair go?





SN 5: where would a lone pair go?

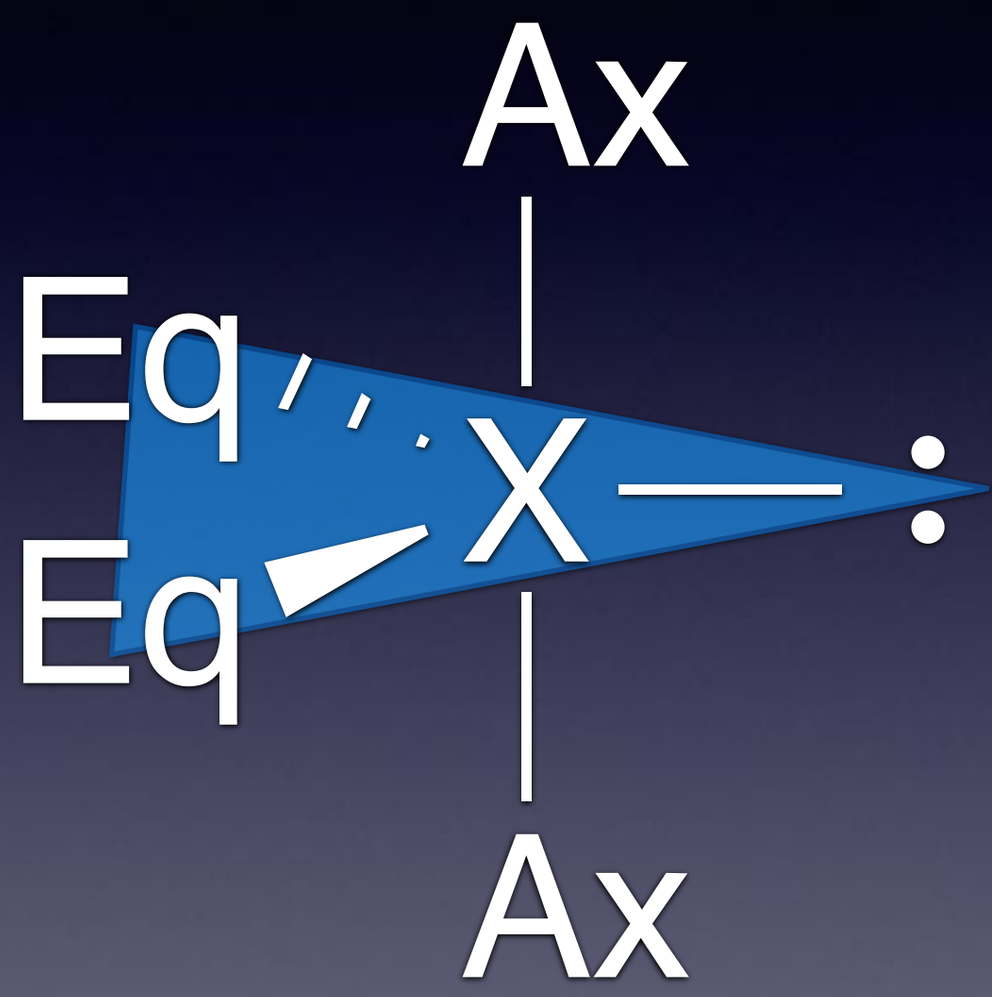
- Lesson: Lone pairs occupy more space than atoms. In other words, lone pairs are fat!



Lone pairs are fat #1

- Lone pairs occupy more space than atoms.

- Lone pairs will occupy the least sterically crowded location around the central atom.



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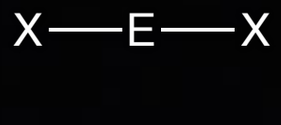
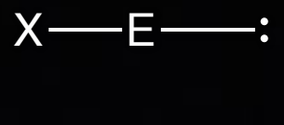
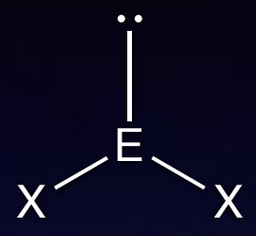
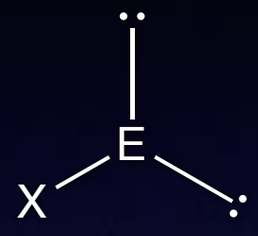
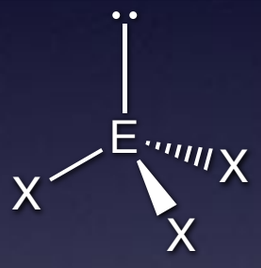
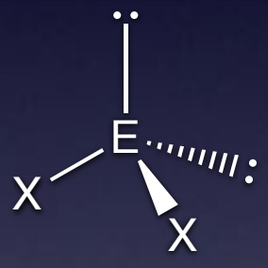
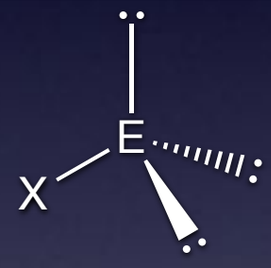
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal					
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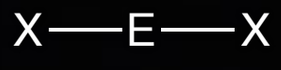
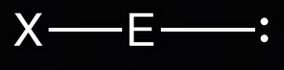
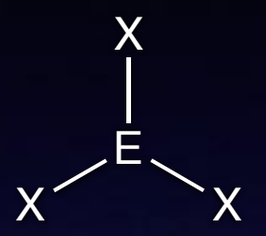
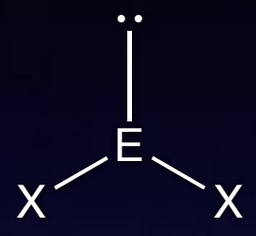
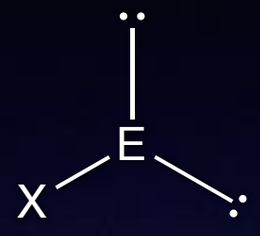
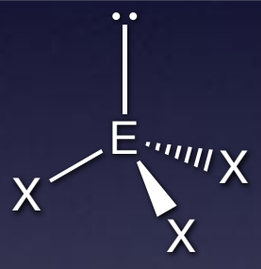
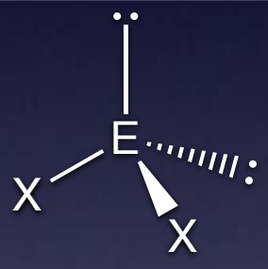
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw				
6						

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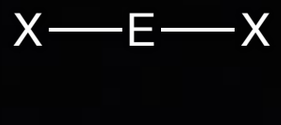
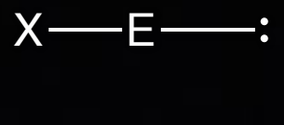
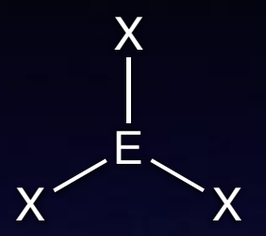
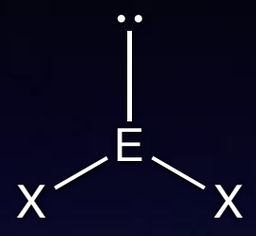
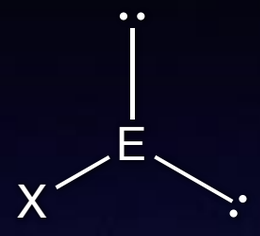
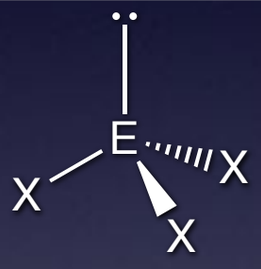
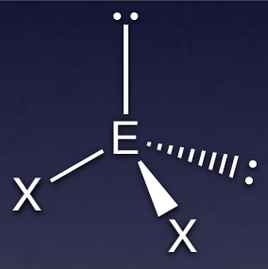
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped			
6						

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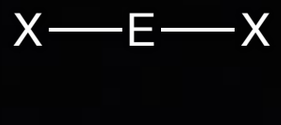
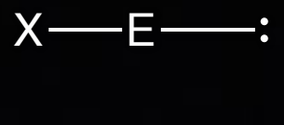
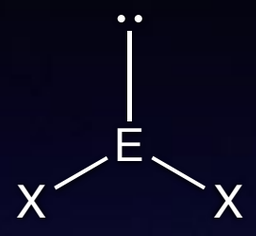
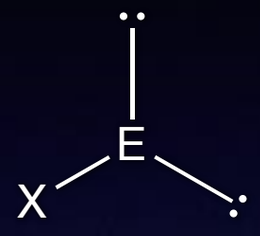
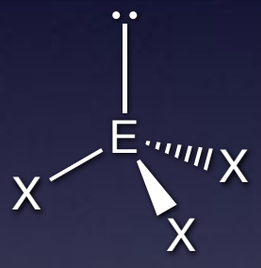
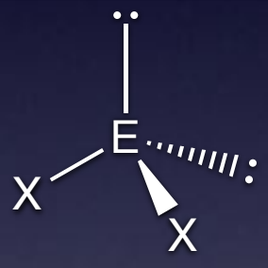
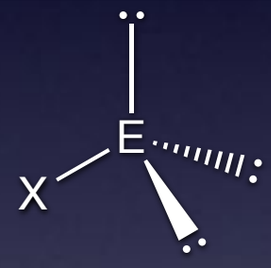
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6						

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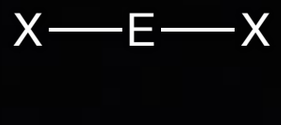
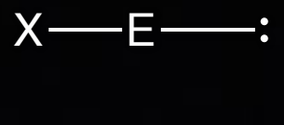
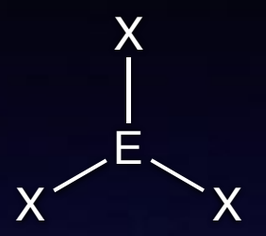
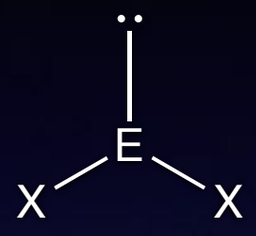
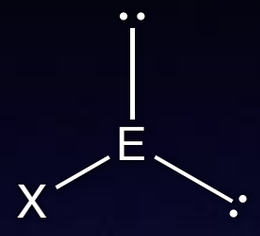
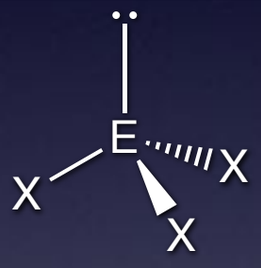
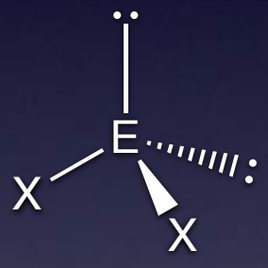
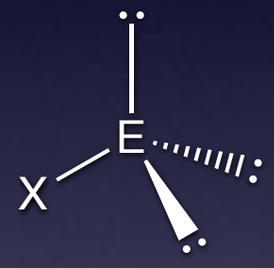
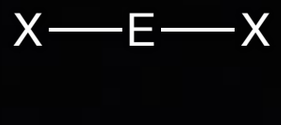
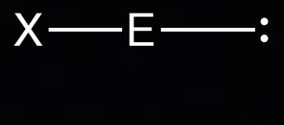
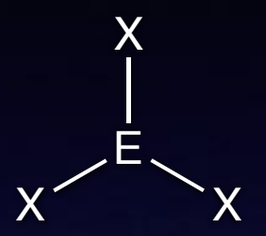
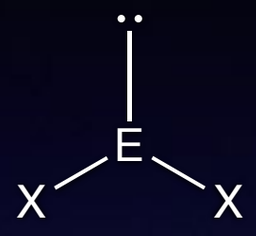
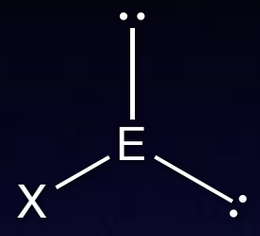
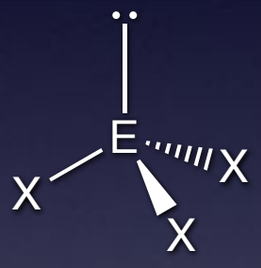
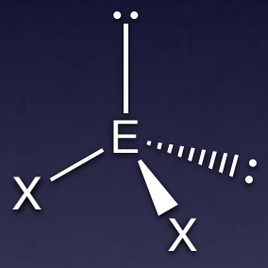
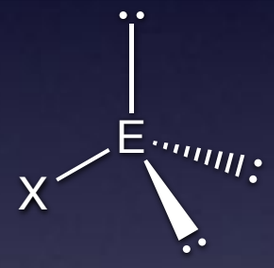
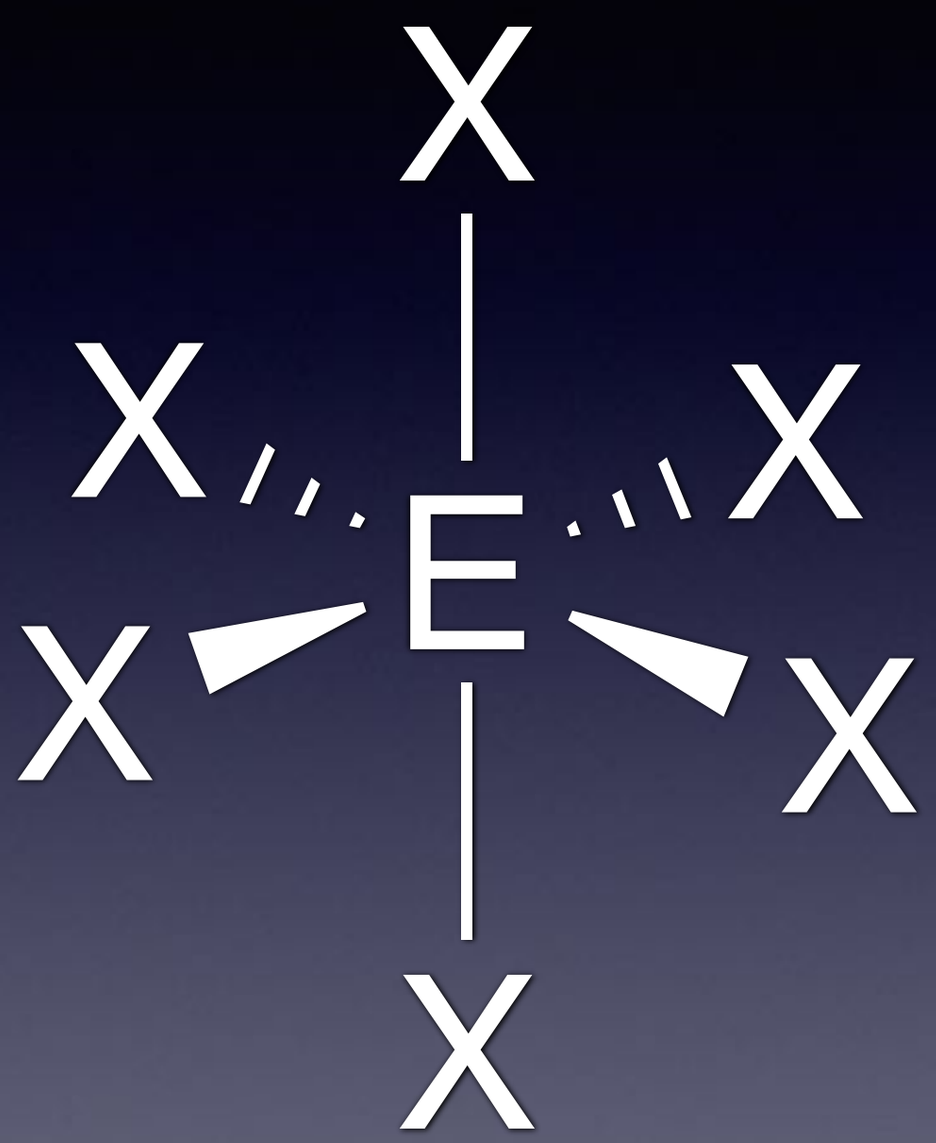
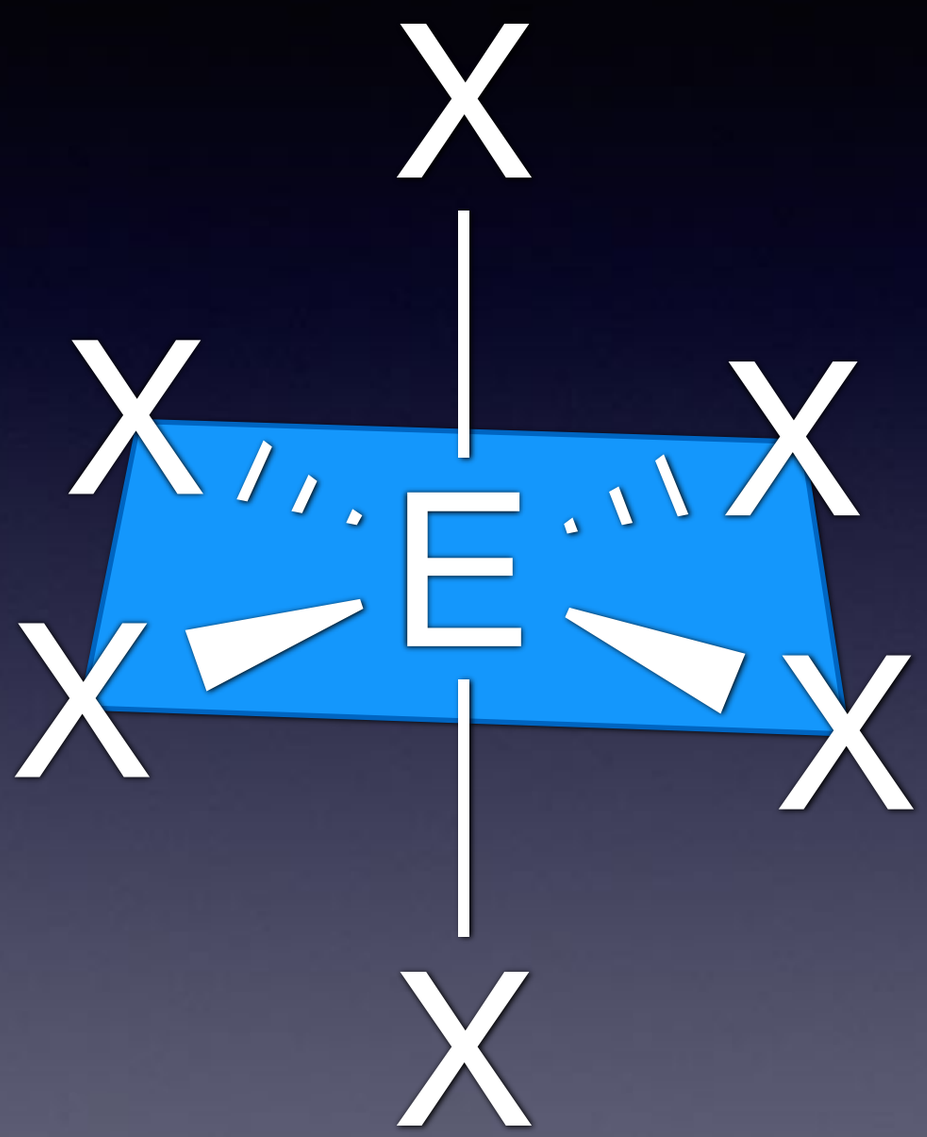
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6						

SN	0 LP	1 LP	2 LP	3 LP	4 LP	5 LP
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6	 Octahedral					

SN 6: Octahedral



SN 6: Octahedral



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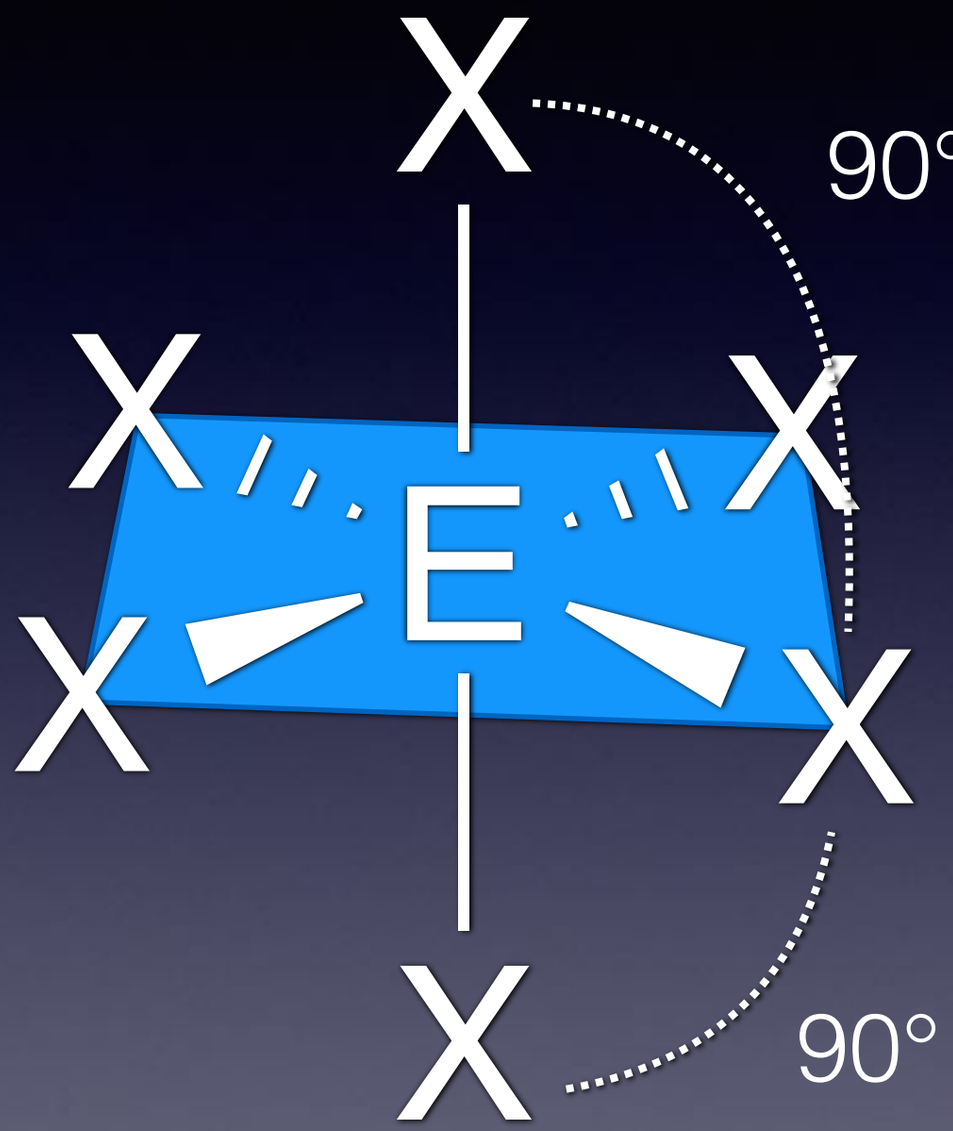
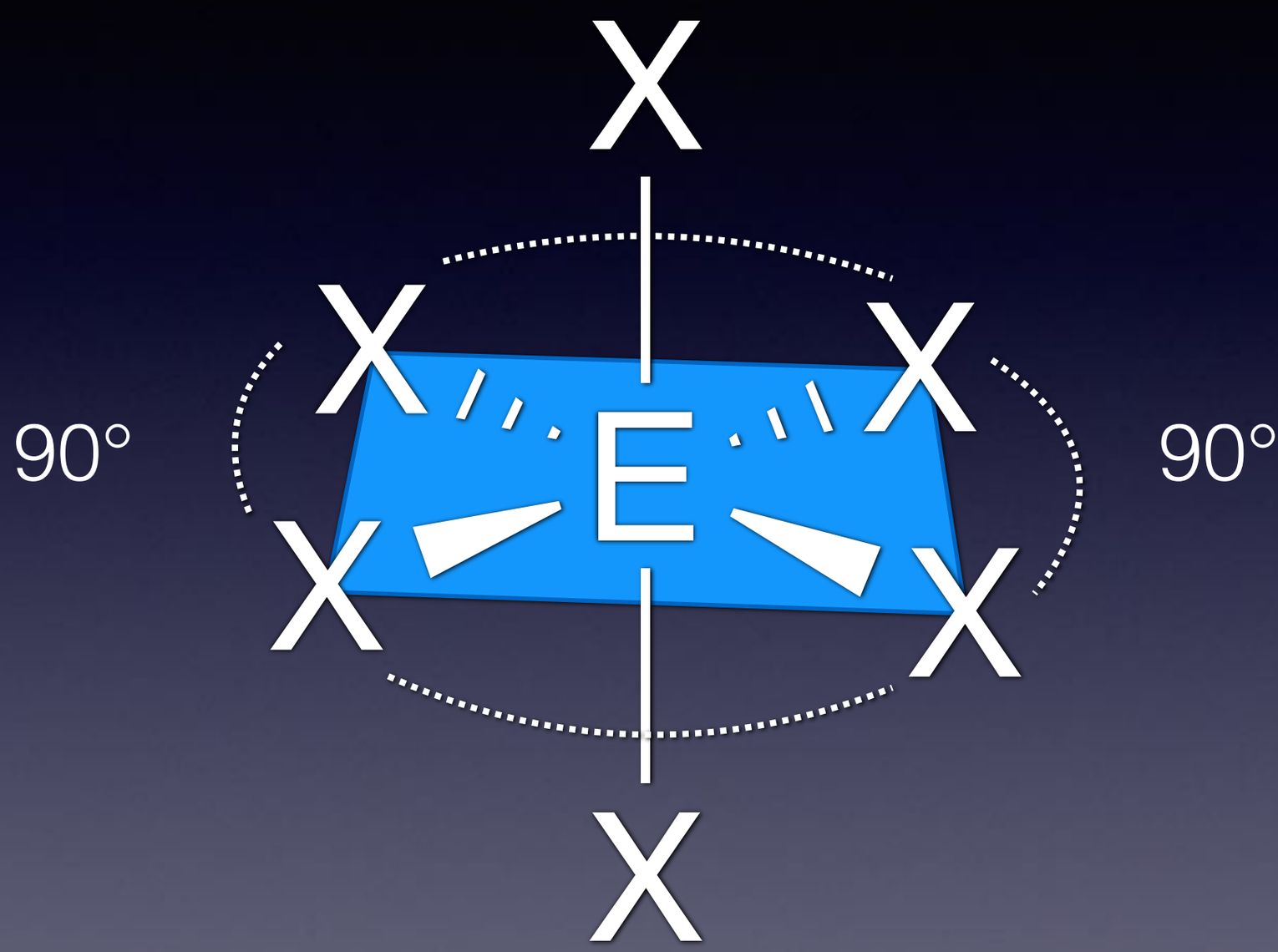


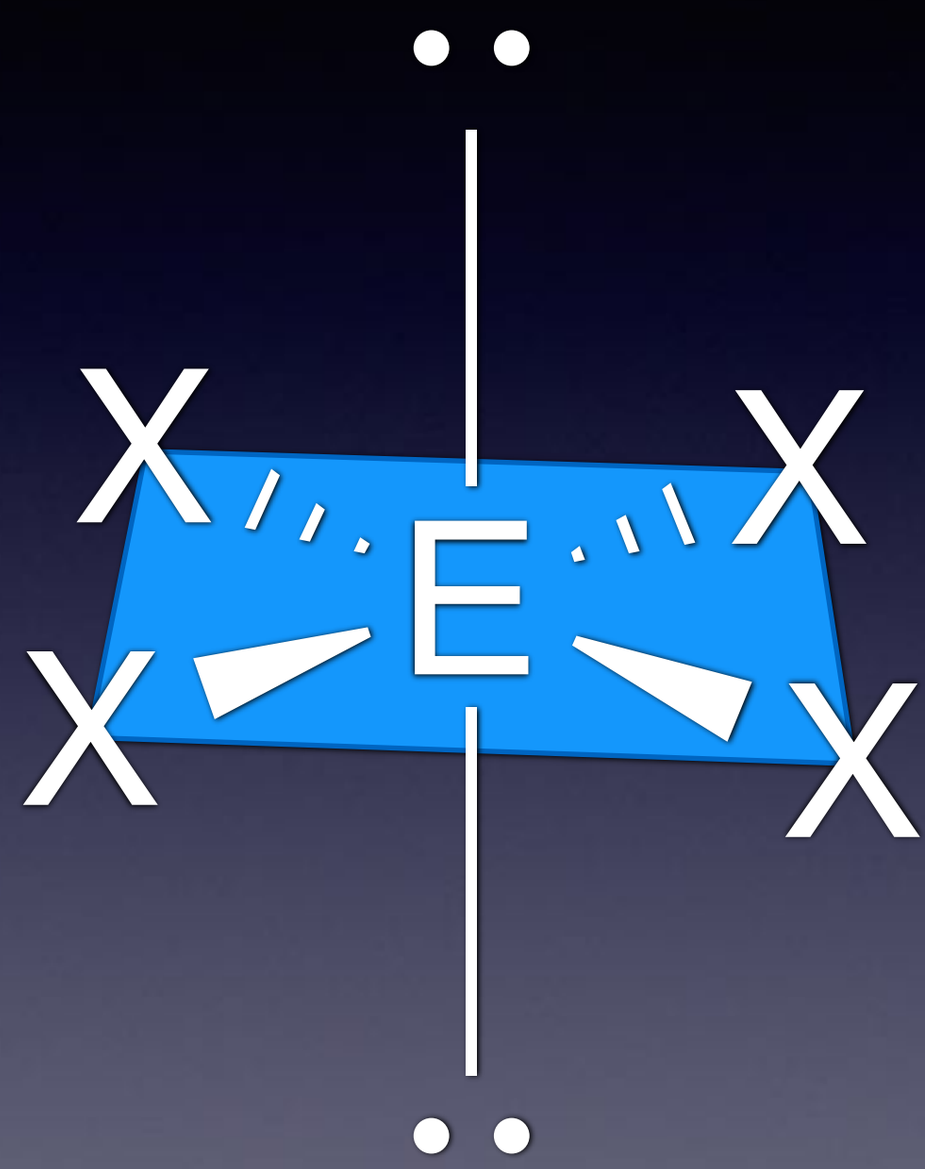
SN 6: Octahedral

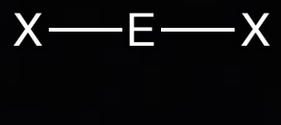
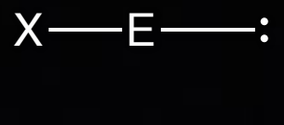
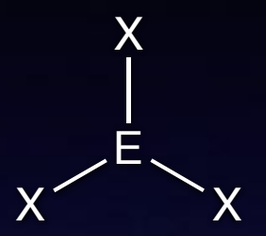
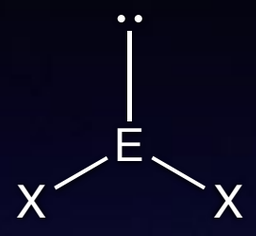
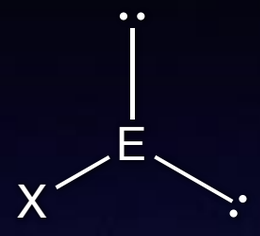
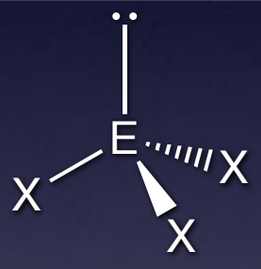
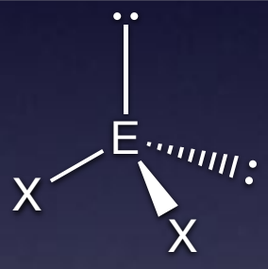


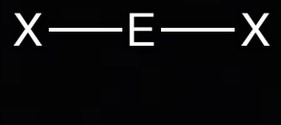
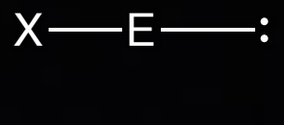
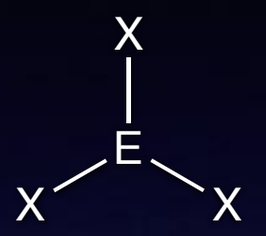
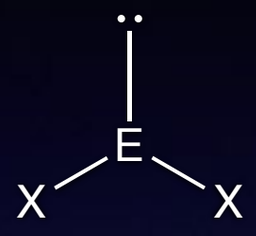
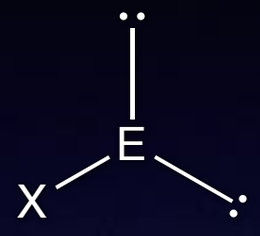
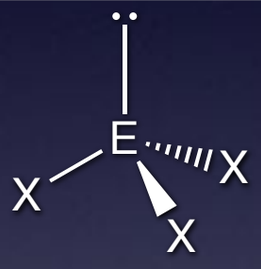
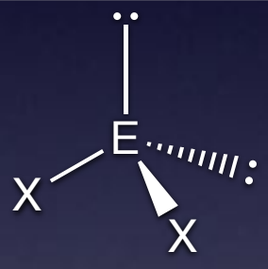
Lone pairs are fat #2

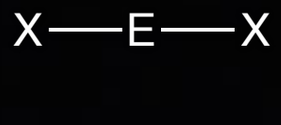
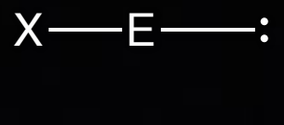
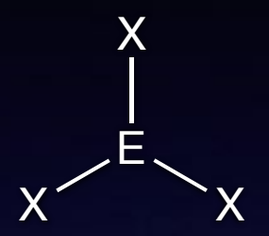
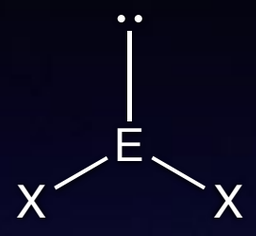
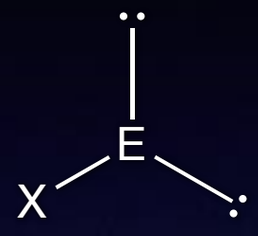
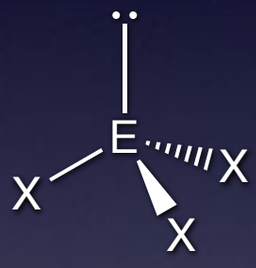
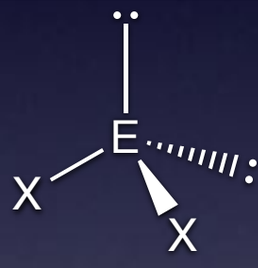
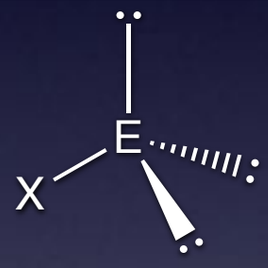
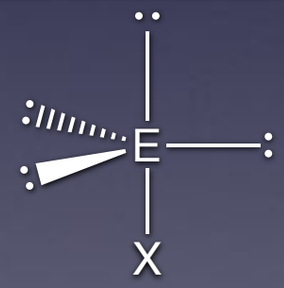
- In an octahedral arrangement with two lone pairs…

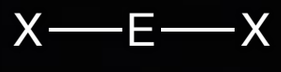
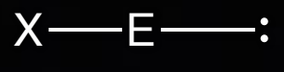
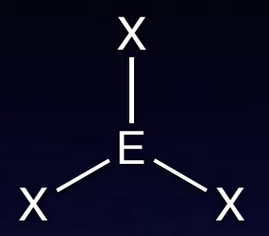
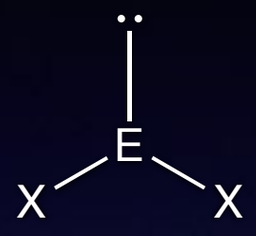
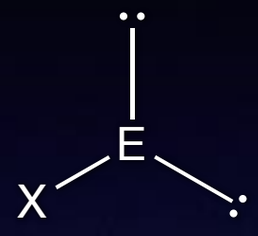
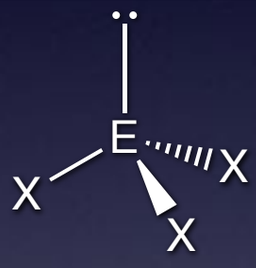
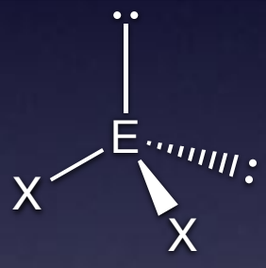
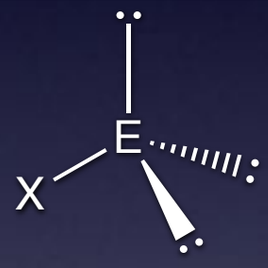
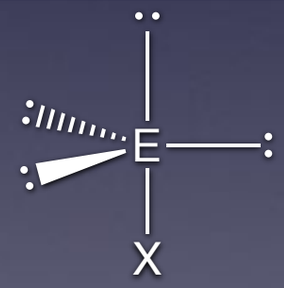
- … lone pairs will occupy the opposite positions around that central atom

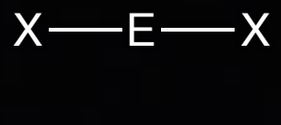
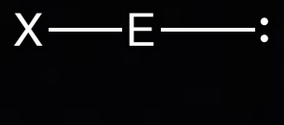
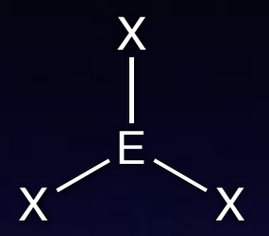
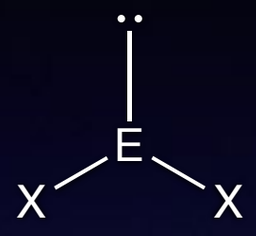
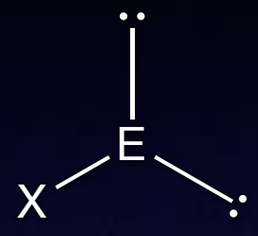
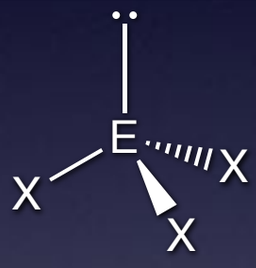
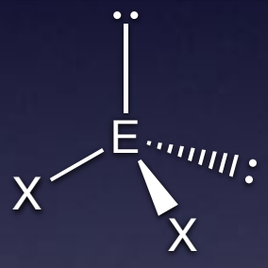
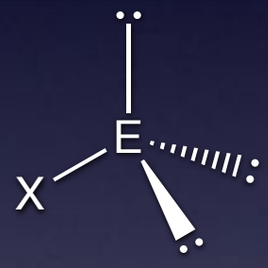
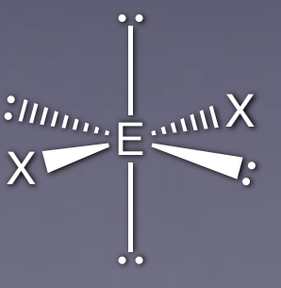


SN	0 LP	1 LP	2 LP	3 LP	4 LP	5 LP
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6	 Octahedral	 Sq. pyramidal				

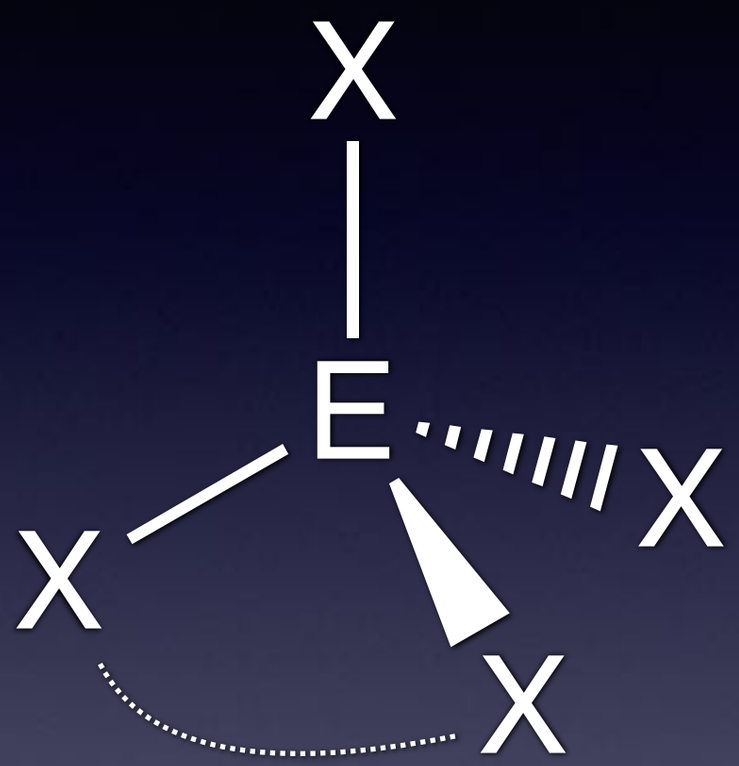
SN	0 LP	1 LP	2 LP	3 LP	4 LP	5 LP
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6	 Octahedral	 Sq. pyramidal	 Sq. planar			

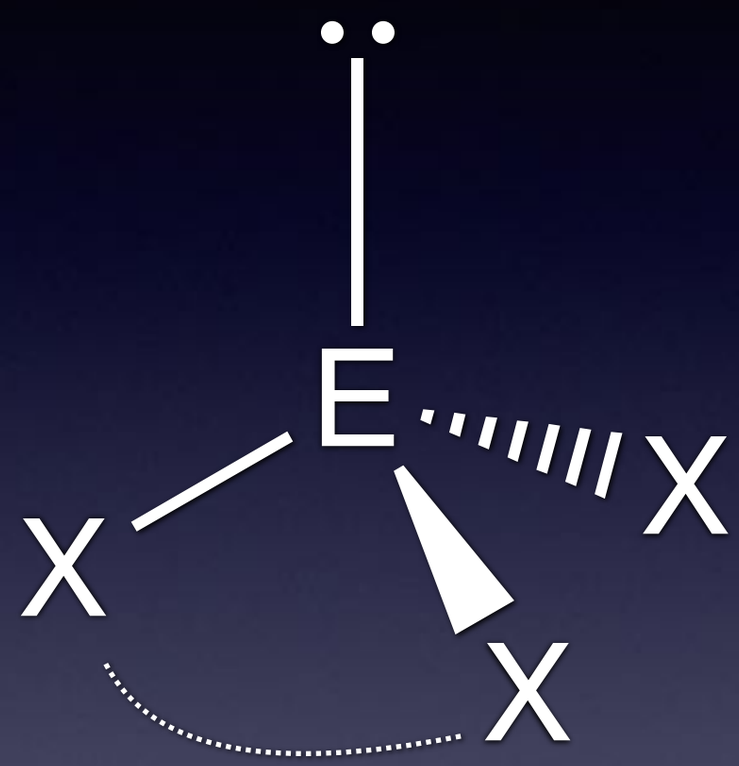
SN	0 LP	1 LP	2 LP	3 LP	4 LP	5 LP
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6	 Octahedral	 Sq. pyramidal	 Sq. planar	 T-shaped		

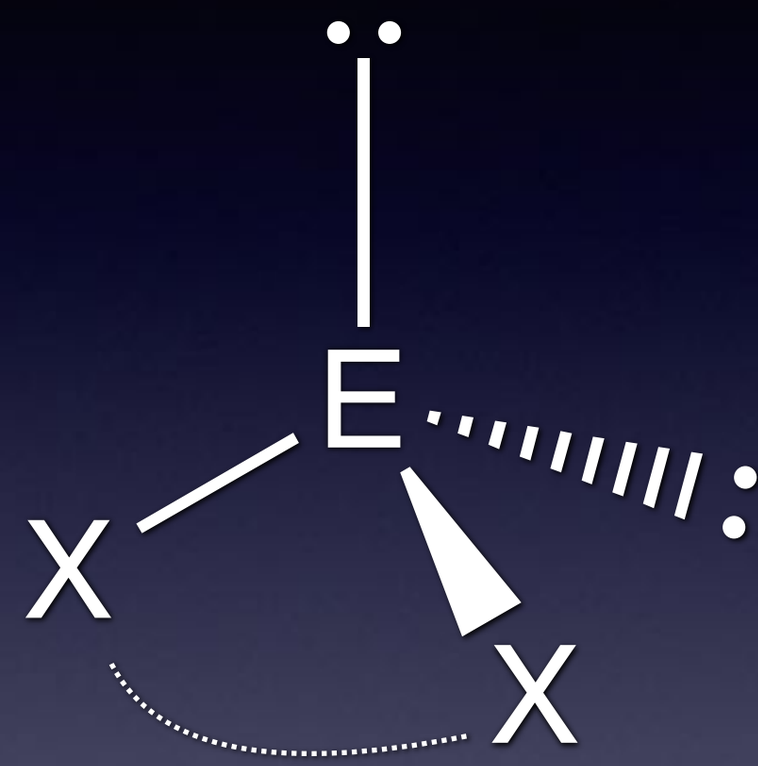
SN	0 LP	1 LP	2 LP	3 LP	4 LP	5 LP
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6	 Octahedral	 Sq. pyramidal	 Sq. planar	 T-shaped	 Linear	

SN	0 LP	1 LP	2 LP	3 LP	4 LP	5 LP
2	 Linear					
3	 Trigonal planar	 120° Bent				
4	 Tetrahedral	 Trig. pyramidal	 109.5° Bent			
5	 Trig. bipyrimidal	 See-saw	 T-shaped	 Linear		
6	 Octahedral	 Sq. pyramidal	 Sq. planar	 T-shaped	 Linear	

Lone pairs are fat #3







109.5° in CH_4

107° in NH_3

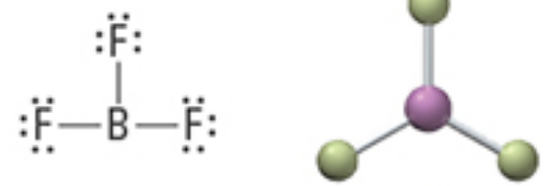
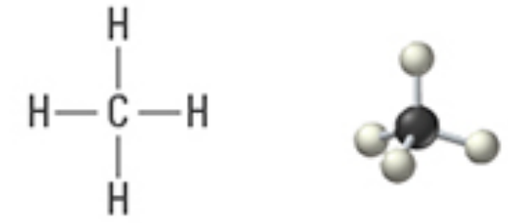
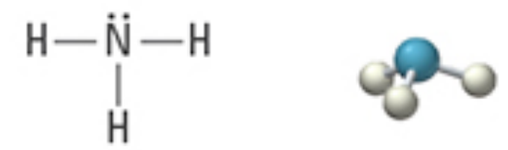
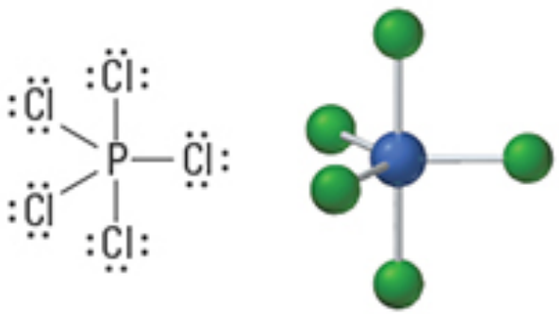
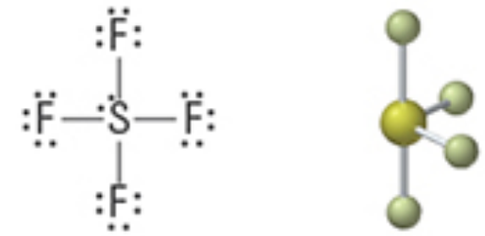
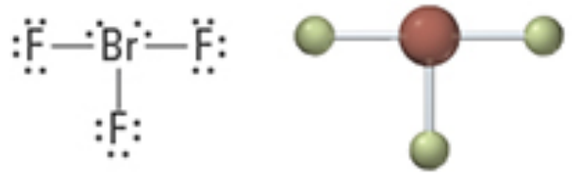
104.5° in H_2O

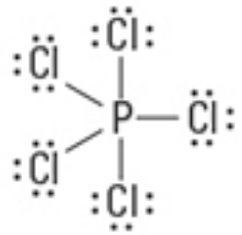
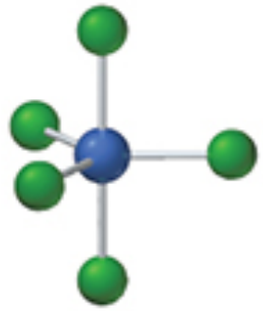
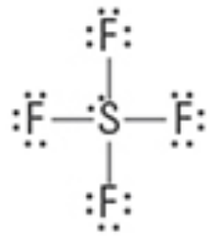
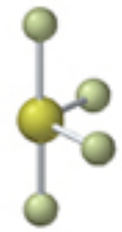
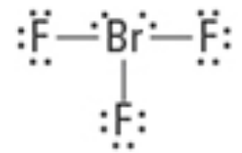
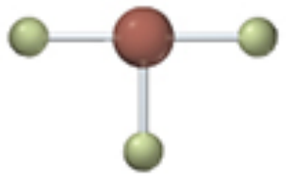
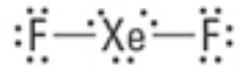
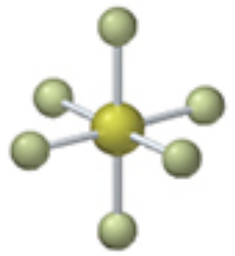
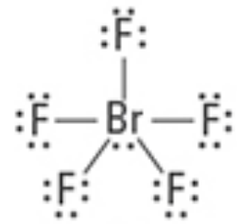
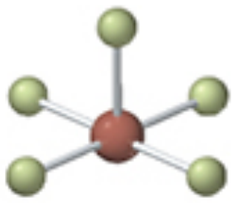
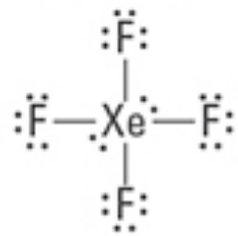
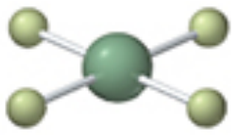
Can you predict changes to bond angles from lone pairs?

VSEPR Expectations

- Given a chemical formula (or name), can you…
- …draw the correct Lewis dot structure that identifies the correct number of atoms and lone pairs around a central atom?
- …identify the steric number of the central atom
- …properly place bonded atoms and lone pairs around the central atom?
- …draw the correct structure with particular attention to in-plane and out-of-plane bonds?
- …name the geometric structure of bonded atoms around the central atom? (*i.e.* tetrahedral, 109.5° bent, trigonal planar, trigonal bipyrimidal, etc.)
- … estimate how lone pairs affect bond angles (i.e. why is H–O–H 104.5° in water?)

TABLE 5.5 Electron and Molecular Geometries

Electron Groups*	Bonding Groups	Lone Pairs	Electron Geometry	Molecular Geometry	Approximate Bond Angles	Example
2	2	0	Linear	Linear	180°	
3	3	0	Trigonal planar	Trigonal planar	120°	
3	2	1	Trigonal planar	Bent	<120°	
4	4	0	Tetrahedral	Tetrahedral	109.5°	
4	3	1	Tetrahedral	Trigonal pyramidal	<109.5°	
4	2	2	Tetrahedral	Bent	<109.5°	
5	5	0	Trigonal bipyramidal	Trigonal bipyramidal	120° (equatorial) 90° (axial)	
5	4	1	Trigonal bipyramidal	Seesaw	<120° (equatorial) <90° (axial)	
5	3	2	Trigonal bipyramidal	T-shaped	<90°	

5	5	0	Trigonal bipyramidal	Trigonal bipyramidal	120° (equatorial) 90° (axial)		
5	4	1	Trigonal bipyramidal	Seesaw	<120° (equatorial) <90° (axial)		
5	3	2	Trigonal bipyramidal	T-shaped	<90°		
5	2	3	Trigonal bipyramidal	Linear	180°		
6	6	0	Octahedral	Octahedral	90°		
6	5	1	Octahedral	Square pyramidal	<90°		
6	4	2	Octahedral	Square planar	90°		

*Count only electron groups around the central atom. Each of the following is considered one electron group: a lone pair, a single bond, a double bond, a triple bond, or a single electron.

VSEPR Practice

- Find the most stable or preferred structure for:
  PCl_5, PCl_4I, PCl_3I_2, PCl_2I_3, $PClI_4$, PI_5

- Tro Problems 5.57–68…
  Problems like 5.63–68 might end up on the exam (hint, hint)

Where did we go today?

Ch1010-A17-A03 Lecture 16

- §5.7 VSEPR: Fundamental Structures
- §5.8 VSEPR: Effect of Lone Pairs
- §5.9 VSEPR: Predicting Geometries

Next time…

- § 5.10 Bond polarity & dipole moment

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