

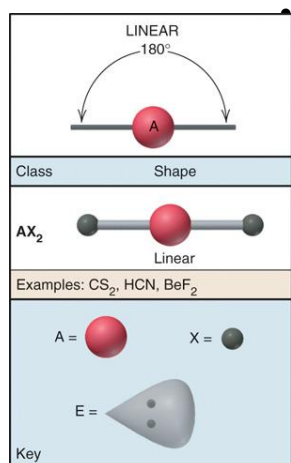
VSEPR for Chemistry 1000: The Silberberg Summary and Representation on Paper

e ⁻ Group arrangement (no. of groups)	Linear (2)	Trigonal planar (3)		Tetrahedral (4)			
Molecular shape (class)	Linear (AX ₂)	Trigonal planar (AX ₃)	V shaped or bent (AX ₂ E)	Tetrahedral (AX ₄)	Trigonal pyramidal (AX ₃ E)	V shaped or bent (AX ₂ E ₂)	
No. of bonding groups	2	3	2	4	3	2	
Bond angle	180°	120°	<120°	109.5°	<109.5°	<109.5°	
e ⁻ Group arrangement (no. of groups)	Trigonal bipyramidal (5)				Octahedral (6)		
Molecular shape (class)	Trigonal bipyramidal (AX ₅)	Seesaw (AX ₄ E)	T shaped (AX ₃ E ₂)	Linear (AX ₂ E ₃)	Octahedral (AX ₆)	Square pyramidal (AX ₅ E)	Square planar (AX ₄ E ₂)
No. of bonding groups	5	4	3	2	6	5	4
Bond angle	90° (ax) 120° (eq)	<90° (ax) <120° (eq)	<90° (ax)	180°	90°	<90°	90°

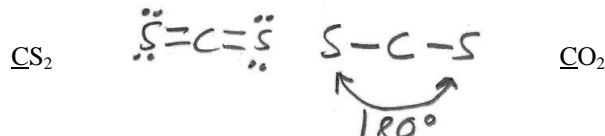
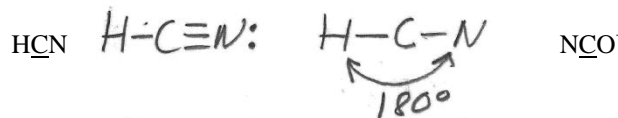
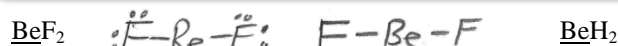
The Two-Electron Pair Shape Family

Examples

Practice



Note that *separate diagrams* should be used for the Lewis Diagram and the VSEPR structure. The VSEPR diagram should be *accurate for structure* and does not show bonding. Always indicate the bond angles, (i) on the diagram as shown, or (ii) catalogued beside the picture as follows: $\angle(\text{FBeF}) = 180^\circ$ This method is useful when there are *lots* of values.

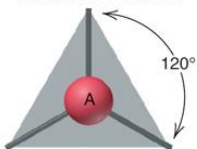
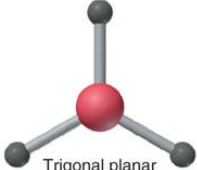
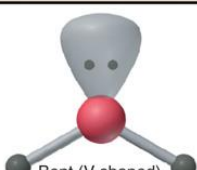


The \angle symbol means “angle” and is taken from geometry. Thus the $\angle(\text{ABA}) = 120^\circ$ or $\angle(\text{ABA}) > 120^\circ$ or $\angle(\text{ABA}) < 120^\circ$ are all possible designations.

The Three-Electron Pair Shape Family

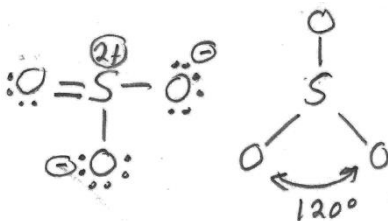
Examples

Practice

TRIGONAL PLANAR	
	120°
Class	Shape
AX ₃	
Trigonal planar	
Examples: SO ₃ , BF ₃ , NO ₃ ⁻ , CO ₃ ²⁻	
AX ₂ E	
Bent (V shaped)	
Examples: SO ₂ , O ₃ , PbCl ₂ , SnBr ₂	

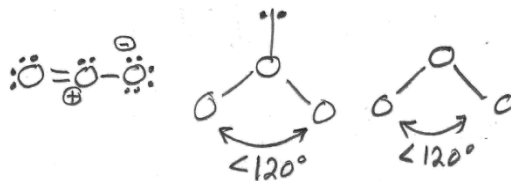
- Any valid resonance "isomer" can be used to determine the structure.
- Remember, that for the purpose of determining shape, multiple bonds count as single structure-determining electron pairs around a central atom.
- For AX₂E and other "XE" structure the VSEPR diagram is best drawn with the position of the "invisible" lone pairs shown (O₃ middle); alternate (O₃ r.h.s.) is permitted.

SO₃



CO₃²⁻

O₃

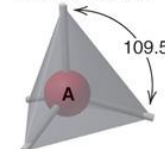
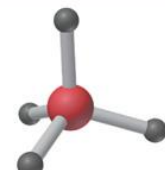




SO₂

The Four-Electron Pair Shape Family

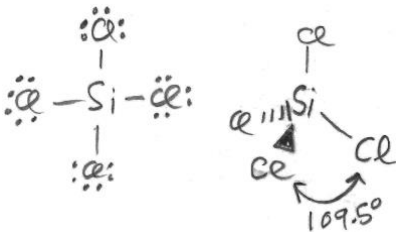
Examples

Practice

TETRAHEDRAL	
	109.5°
Class	Shape
AX ₄	
Tetrahedral	
Examples: CH ₄ , SiCl ₄ , SO ₄ ²⁻ , ClO ₄ ⁻	
AX ₃ E	
Trigonal pyramidal	
Examples: NH ₃ , PF ₃ , ClO ₃ ⁻ , H ₃ O ⁺	
AX ₂ E ₂	
Bent (V shaped)	
Examples: H ₂ O, OF ₂ , SCl ₂	

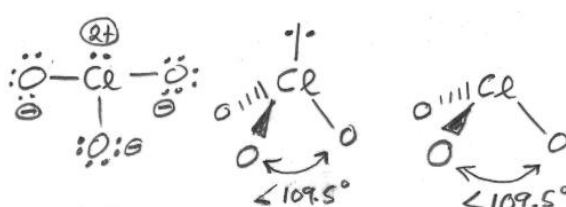
- For *non-flat* structures you **must** use "Wedges notation" to represent the 3D shape.
- The shapes drawn here attempt to be accurate perspective renderings of the views shown by the computer graphics at l.h.s. from Silberberg.
- Solid wedges come **forward** of the paper; dashed wedges go **behind** the paper.
- Wedges are *shorter* than line bonds because the perspective reduces apparent length.

SiCl₄



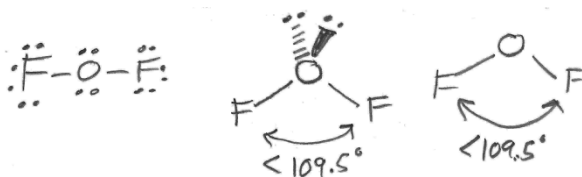
ClO₄⁻

ClO₃⁻



H₃O⁺

OF₂



SCl₂

- For AX₂E₂, where the *shape* is flat, it is **highly preferable** to rotate the view so that the three visible atoms are drawn in the page of the paper.
- The first view (middle) showing the location of lone pairs in perspective is preferred.

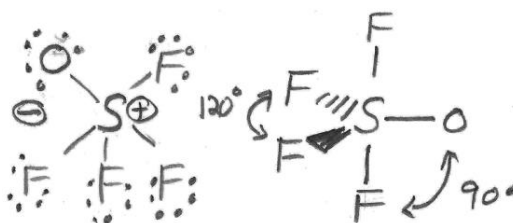
The Five-Electron Pair Shape Family

Examples

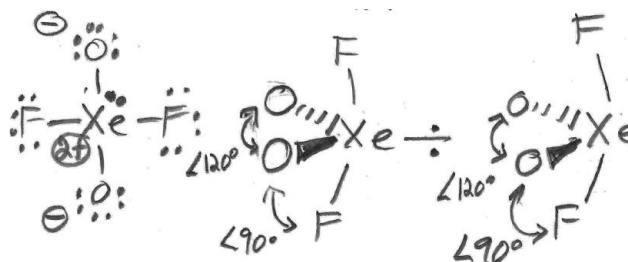
TRIGONAL BIPYRAMIDAL	
Class	Shape
AX ₅	<p>Trigonal bipyramidal</p>
Examples: PF ₅ , AsF ₅ , SOF ₄	
AX ₄ E	<p>Seesaw</p>
Examples: SF ₄ , XeO ₂ F ₂ , IF ₄ ⁺ , IO ₂ F ₂ ⁻	
AX ₃ E ₂	<p>T shaped</p>
Examples: ClF ₃ , BrF ₃	
AX ₂ E ₃	<p>Linear</p>
Examples: XeF ₂ , I ₃ ⁻ , IF ₂ ⁻	

- The more structural electron pairs, the more space that is typically needed!
- SOF₄ is an interesting example of AX₅ geometry where the bond angles are probably *not* quite ideal, but without further knowledge it's hard to be sure.
- Also note that the O atom is *equatorial*: for **all trigonal bipyramidal** shape family structures, **the most electronegative atoms always are in the axial position**.
- Again the option exists to draw in the LP or to leave them off; the first is better.
- Note that in XeO₂F₂ and ClF₃, the axial bonds bend back from perfect linear.
- But in XeF₂, all forces balance out and the shape is perfectly linear.

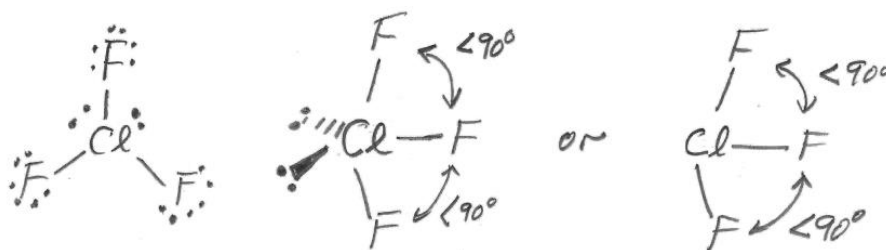
SOF₄



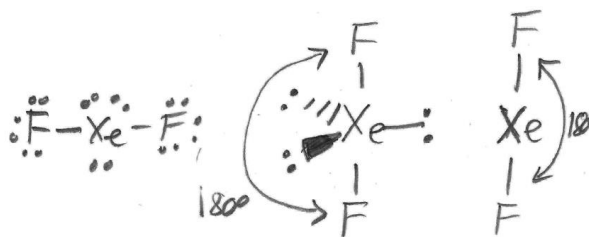
XeO₂F₂



ClF₃



XeF₂



Practice

AsF₅

SF₄

BrF₃

I₃⁻

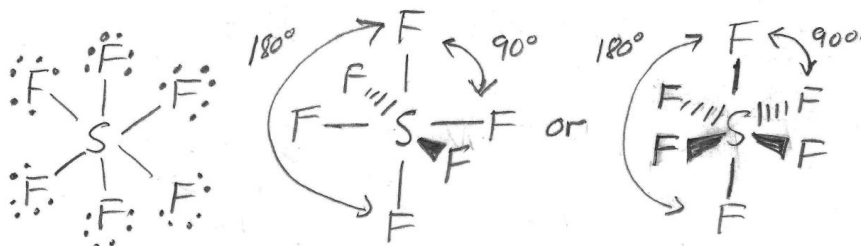
The Six-Electron Pair Shape Family

Examples

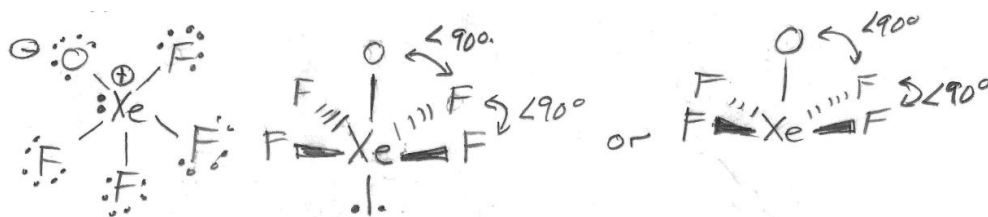
OCTAHEDRAL	
Class	Shape
AX ₆	<p>Octahedral</p>
Examples: SF ₆ , IOF ₅	
AX ₅ E	<p>Square pyramidal</p>
Examples: BrF ₅ , TeF ₅ ⁻ , XeOF ₄	
AX ₄ E ₂	<p>Square planar</p>
Examples: XeF ₄ , ICl ₄ ⁻	

- For the names of the shape, always use the name provided by Silberberg inside the respective boxes.
- Remember that in an AX₆ structure, *any atom can point up*, but in mixed terminal atoms there is again a tendency for the most electronegative atoms to go opposite.
- In the AX₅E square pyramidal case, the four equatorial atoms are *bent upwards* with the consequence that the central atom strangely points below the square plane.
- In the AX₄E₂ geometry, the lone pairs go opposite, so that the five atoms are found to be in a perfectly planar array. However, drawing with the LP is preferred.

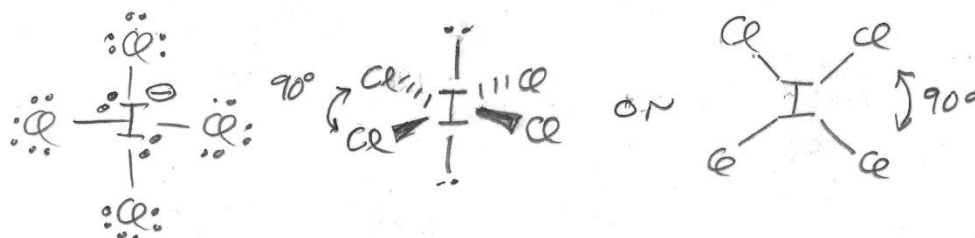
SF₆



XeOF₄



ICl₄⁻



Practice

XeOF₄

TeF₅⁻

XeF₄