Chem 115 POGIL Worksheet - Week 12
Molecular Shapes

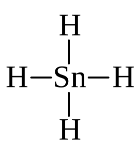
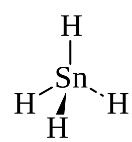
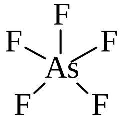
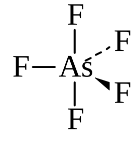
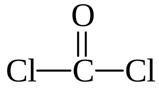
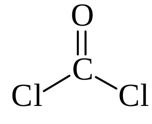
Key Questions

1. Give the names for the shapes of the domain geometries for two through six regions of electron density about a central atom.

Domains	Shape
2	linear
3	trigonal planar
4	tetrahedral
5	trigonal bipyramidal
6	octahedral

2. Draw Lewis structures for the following molecules, and predict the shapes on the basis of VSEPR considerations: SnH_4, CO_2, AsF_5, Cl_2CO.

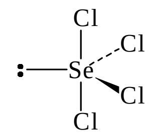
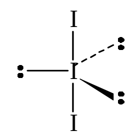
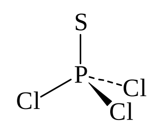
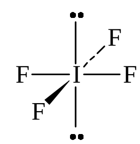
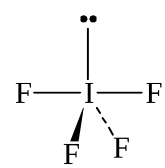
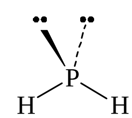
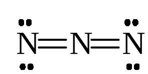
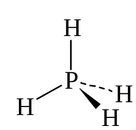
(Note: lone pairs of electrons on pendant atoms have been omitted in these drawings for simplicity.)

Lewis Structure	Domain & Shape Name	Shape Sketch
	four domains ⇒ tetrahedral	
O=C=O	two domains ⇒ linear	O=C=O
	five domains ⇒ trigonal bipyramid	
	three domains ⇒ trigonal planar	

3. For each of the following molecules or ions, sketch the shape and name it. You should start with a valid Lewis structure in each case, before applying VSEPR considerations.

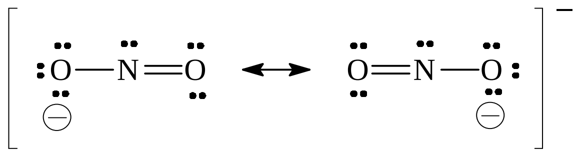
$$SeCl_4,\ I_3^-,\ PSCl_3,\ IF_4^-,\ IF_4^+,\ PH_2^-,\ N_3^-,\ PH_4^-$$

(Only the shapes and structurally important lone pairs are shown here.)

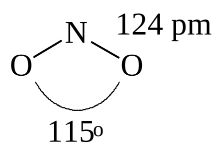
$SeCl_4$	Irregular tetrahedral or "see-saw"	
I_3^-	Linear	
$PSCl_3$	Approximately tetrahedral	
IF_4^-	Square planar	
IF_4^+	Irregular tetrahedral or "see-saw"	
PH_2^-	Bent (∠H–P–H < 109.5°)	
N_3^-	Linear	
PH_4^+	Tetrahedral	

4. Describe the structure and bonding of the nitrite ion, NO_2^-.

The nitrite ion can be described with two equivalent resonance forms:



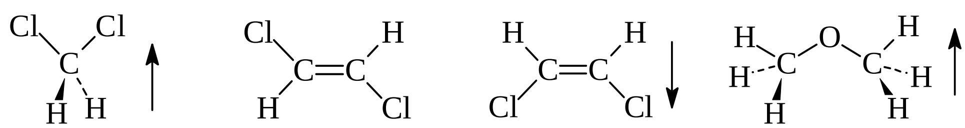
The N–O bonds are equivalent, with a bond order of approximately 1½. We should expect them to be somewhat shorter than a normal N–O single bond (~1.48 Å), and in fact the observed length is 1.24 Å. There are three electron domains, so the shape is bent. Based on a trigonal planar domain structure, we expect the bond angle to be somewhat less than 120°, but greater than the tetrahedral angle of 109.5°. The experimentally determined angle is 115°.



5. For all the molecules or ions whose shapes you determined in Key Question 3. indicate whether or not the species is polar.

$SeCl_4$	Irregular tetrahedral or "see-saw"	polar
I_3^-	Linear	nonpolar
$PSCl_3$	Approximately tetrahedral	polar (due to composition)
IF_4^-	Square planar	nonpolar
IF_4^+	Irregular tetrahedral or "see-saw"	polar
PH_2^-	Bent ($\angle$H–P–H < 109.5°)	polar
N_3^-	Liner	nonpolar
PH_4^+	Tetrahedral	nonpolar

6. Consider the following Lewis structures for some simple organic compounds. (Lone pairs on pendant atoms have been omitted for simplicity.) Redraw each of these on the basis of VSEPR considerations, and indicate whether or not the molecule is polar.



polar | nonpolar | polar | polar

7. A certain compound with a formula AB_4 is found to be polar. Moreover, it is determined that there are two different bond lengths, two long ones and two short ones. What is the probable shape of the molecule? Explain your reasoning.

The possible shapes for the formula AB_4 are tetrahedral (4 b.p.), irregular tetrahedron (4 b.p. + 1 l.p.), and square planar (4 b.p. + 2 l.p.). (See Appendix B.) Since all the pendant atoms are the same (B), the polarity must be the result of shape, and not composition. If AB_4 were tetrahedral or square planar, it would be nonpolar. Only an irregular tetrahedral ("see-saw") shaped AB_4 molecule would be polar. Because this shape results from a *tbp* domain structure, in which two bonds occupy axial positions and two bonds occupy equatorial positions, there would be two distinct bond lengths, two of each type. Those arising from the axial positions of the *tbp* geometry would be somewhat longer than those arising from the equatorial positions.