Name _____ Period _____ Date _____

Molecular Geometry

For each of the following molecules, draw the Lewis Diagram and tally up the electron pairs. Then, identify the correct the molecular shape and bond angle.

MOLECULE	LEWIS DIAGRAM	number of lone pais	NUMBER OF BONDED PAIRS	MOLECULAR GEOMETRY
1. CCl_4		0	4	tetrahedral
2. H_2O				
3. BF_3				
4. BeF_2				

MOLECULE	LEWIS DIAGRAM	e^- TALLY	SHAPE	BOND ANGLE
5. SiH_4				
6. SeH_2				
7. SF_4				
8.				

Molecular	Bond type	Polarity
CCl_4	3.0-3.5=0.5 polar	non polar

Name: _____

Predicting Molecular Geometry and Hybridization

1. In each case, predict (a) the *approximate bond angle(s)*, (b) the *hybridization* around the underlined atom. (Note: It is helpful to first sketch the Lewis stucture!)

Molecule or Ion →	(1) $\underline{O}F_2$	(2) $H_2\underline{C}O$	(3) $\underline{N}O_2^+$	(4) $\underline{B}F_3$	(5) SbF_5
(a) No. of valence e⁻'s					
(b) Lewis structure					
(c) Approximate bond angle(s)					
(d) Hybridization					
(e) Polar or non-polar molecule?			Ion: Not applicable		
(f) Geometry name					

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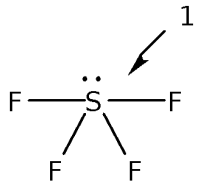
2. For each of the molecules below fill in the indicated items in the chart. The central atoms are underlined.

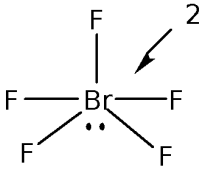
Molecule	(1) $\underline{S}O_2$	(2) $H\underline{B}F_2$	(3) $\underline{Xe}F_4$	(4) $\underline{C}H_2Cl_2$	(5) $\underline{N}F_3$
(a) No. of valence e⁻'s					
(b) Lewis structure					
(c) Approximate bond angle(s)					
(d) Hybridization					
(e) Polar or non-polar molecule?					

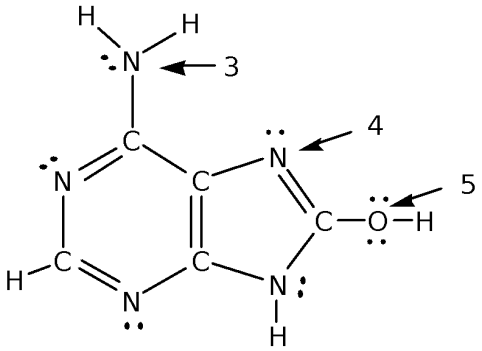
(f) Geometry name					

---

3. Predict (a) the *approximate bond angle*, (b) the *hybridization* around the indicated atoms (the atoms to which the arrows are drawn in the structures below). Write your answers near the corresponding labels (1 to 5) in the drawings. (Note: the lone pairs on the F atoms are omitted.)







1:

2:

3:

4:

5:

4) For the molecule $AsCl_5$, answer the following questions:

a) Draw the Lewis structure:

b) What type of hybridization does Arsenic exhibit in this molecule based on the number of hybrid orbitals required?

c) Show the ground state distribution of valence electrons on Arsenic.

d) Show the excited state distribution of valence electrons on Arsenic.

e) Show the hybridized state distribution of valence electrons on Arsenic.

f) What is the molecular shape of the molecule?

Answers:

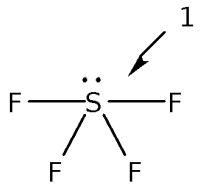
1. In each case, predict (a) the *approximate bond angle(s)*, (b) the *hybridization* around the underlined atom. (Note: It is helpful to first sketch the Lewis stucture!)

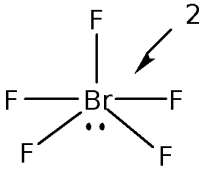
Molecule or Ion →	(1) $\underline{O}F_2$	(2) $H_2\underline{C}O$	(3) $\underline{N}O_2^+$	(4) $\underline{B}F_3$	(5) SbF_5
(a) No. of valence e⁻'s	20	12	16	24	40
(b) Lewis structure					
(c) Approximate bond angle(s)	109.5°	120°	180°	120°	90°, 120°
(d) Hybridization	sp^3	sp^2	sp	sp^2	sp^3d
(e) Polar or non-polar molecule?	polar	polar	Ion: Not applicable	non-polar	non-polar
(f) Geometry name	bent	trigonal planar	linear	trigonal planar	trigonal bypyramidal

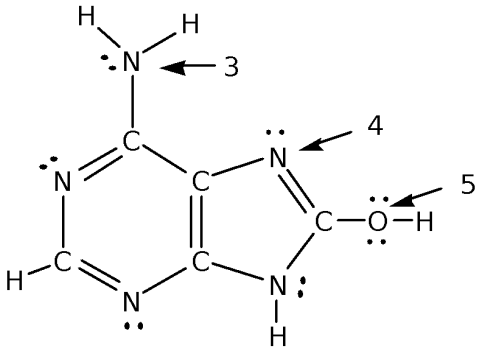
2. For each of the molecules below fill in the indicated items in the chart. The central atoms are underlined.

Molecule	(1) $\underline{S}O_2$	(2) $H\underline{B}F_2$	(3) $\underline{Xe}F_4$	(4) $\underline{C}H_2Cl_2$	(5) $\underline{N}F_3$
(a) No. of valence e⁻'s	18	18	36	20	26
(b) Lewis structure					
(c) Approximate bond angle(s)	120°	120°	90°	109.5°	109.5°
(d) Hybridization	sp^2	sp^2	sp^3d^2	sp^3	sp^3
(e) Polar or non-polar molecule?	polar	polar	non-polar	polar	polar
(f) Geometry name	bent	trigonal planar	square planar	tetrahedral	trigonal pyramidal

3. Predict (a) the *approximate bond angle*, (b) the *hybridization* around the indicated atoms (the atoms to which the arrows are drawn in the structures below). Write your answers near the corresponding labels (1 to 5) in the drawings. (Note: the lone pairs on the F atoms are omitted.)







(1) 90°, 120°; sp^3d (2) 90°; sp^3d^2 (3) 109.5°; sp^3 (4) 120°; sp^2 (5) 109.5°; sp^3

Name: _____

Section 9.4 and 9.5 Review Questions

1) a) What is meant by the term orbital overlap?

b) What is the significance of overlapping orbitals in valence-bond theory?

2) Draw sketches illustrating the overlap between the following orbitals on two atoms:

a) the *2s* orbital on each

b) the $_{2pz}$ orbital on each

c) the *2s* orbital on one and the $2p_z$ orbital on the other

3) Indicate the hybridization and bond angles associated with each of the following electron-domain geometries:

a) linear

d) trigonal bipyramidal

b) tetrahedral

e) octahedral

c) trigonal planar

4) What is the designation (meaning the name/notation) for the hybrid orbitals formed from each of the following combinations of atomic orbitals:

a) one *s* and two *p*

c) one *s*, three *p*, and two *d*

b) one *s*, three *p*, and one *d*

d) What characteristic bond angles are associated with each?

5) a) Starting with the orbital diagram of a sulfur atom, describe the steps needed to construct hybrid orbitals appropriate to describe the bonding in SF_2.

b) What is the name given to the hybrid orbitals constructed in part (a)?

c) Sketch the large lobes of the orbitals constructed in part (a).

d) Would the hybridization scheme in part (a) be appropriate for SF_4? Explain.

6) Indicate the hybrid orbital set used by the central atom in each of the following molecules or ions:

a) SiH_4 b) CH_3^+ c) ICl_2^-

d) $BeCl_2$ e) PF_6^-

Name: _____

More Section 9.5 Review Questions

1) a) Starting with the orbital diagram of a boron atom, describe the steps needed to construct hybrid orbitals appropriate to describe the bonding in BF_3.

b) What is the name given to the hybrid orbitals constructed in (a)?

c) Sketch the large lobes of the hybrid orbitals constructed in (a).

d) Are there any valence atomic orbitals of B that are left unhybridized? If so, how are they oriented relative to the hybrid orbitals?

2) What set of hybrid orbitals is used by the central atom in each of the following molecules and ions:

a) SO_2

b) AlH_4^-

c) CS_2

d) XeF_2

e) BrF_4^-

3.

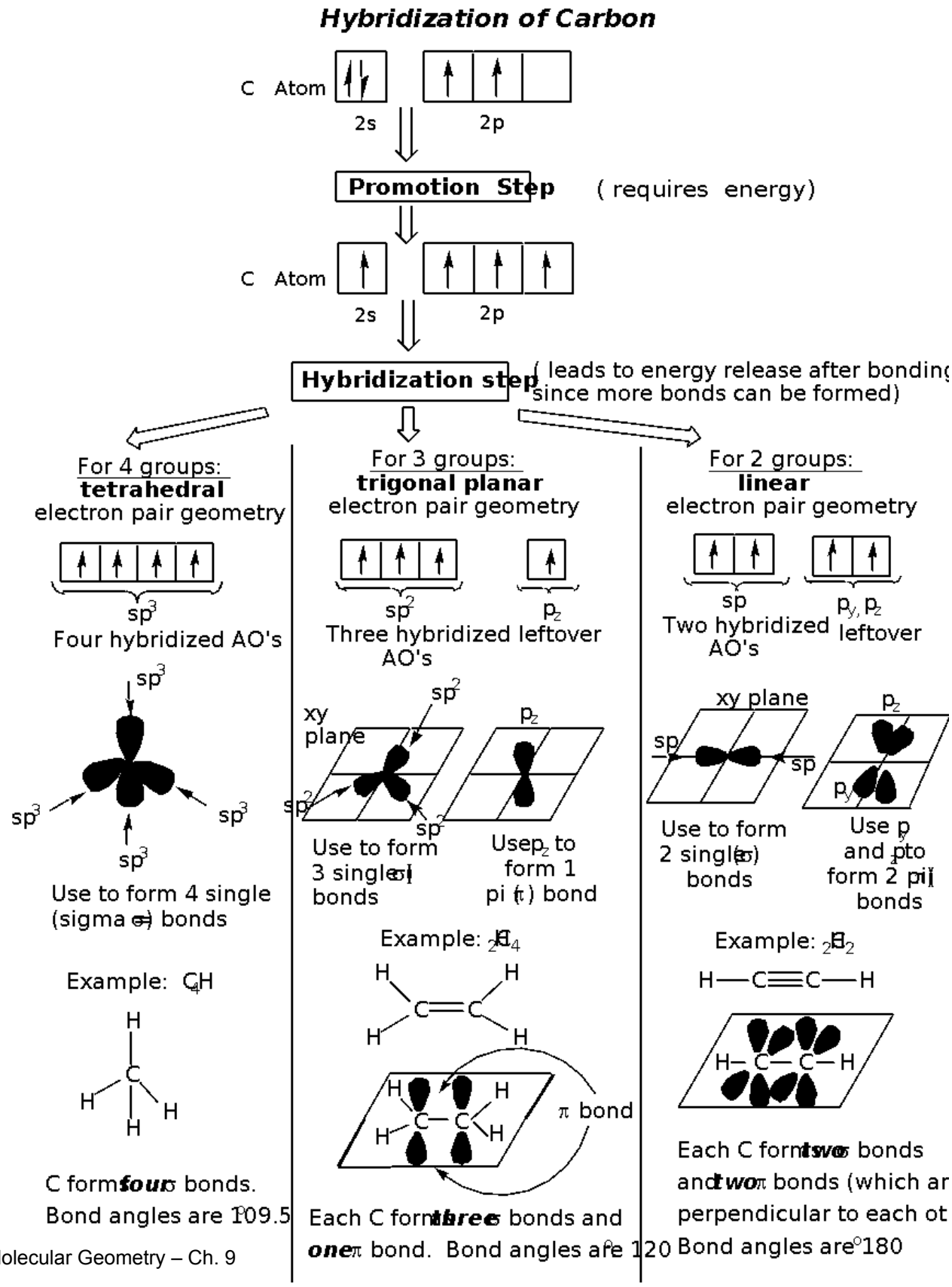
Formula	Orbital diagram of central atom	Orbital diagram of central atom after e- promotion	Orbital diagram after hybridization (include empty orbitals)
$AlCl_3$			
$BeBr_2$			
GeF_4			
SBr_6			

4. *Not all will need hybridization*

Formula	Orbitals used for bonding	Shape and bond angle
BBr_3		
CCl_4		
BI_3		
PCl_3		

SiH_4		

SECTION 9.6- MULTIPLE BONDS – EXAMPLE



Name _____

Section 9.6 Review Q's

1. a) Sketch a σ bond that is constructed from *p* orbitals.

   b) Sketch a π bond that is constructed from *p* orbitals.

2. a) How many σ and π bonds are generally part of a double bond?

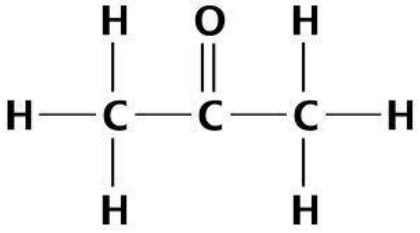
   b) How many σ and π bonds are generally part of a triple bond?

3. a) Draw Lewis structures for methane, CH_4, and formaldehyde, H_2CO.

   b) What is the hybridization of the carbon atom in CH_4 and H_2CO?

   c) The carbon atom in CH_4 cannot participate in multiple bonding, whereas that in H_2CO can. Explain this observation using the hybridization at the carbon atom.

4. Acetone, C_3H_6O, is a commonly used organic solvent that is the main component of nail-polish remover. Its Lewis structure is: *(add lone pairs to the oxygen)*



a) What is the total number of valence electrons in the molecule?

b) How many valence electrons are used to make σ bonds in the molecule?

c) How many valence electrons are used to make π bonds in the molecule?

d) How many valence electrons remain in nonbonding pairs in the molecule?

e) What is the hybridization at the central carbon atom of the molecule?

5. Explain the sigma and pi bonding in N_2H_2.
   a) Draw the Lewis structure.

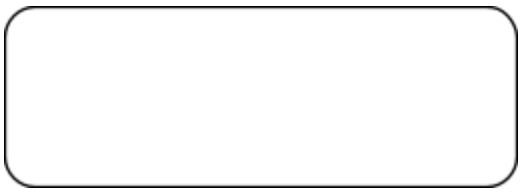
   b) What is the hybridization around each nitrogen atom?

   c) Draw the orbital diagram for nitrogen in its ground state.

   d) Draw the orbital diagram for nitrogen's hybridized orbitals.

f) Explain the sigma and pi bonding around each nitrogen, using its hybridized orbitals.
Sketch a picture of N_2H_2 with its hybrid orbitals, sigma bonding, and pi bonding.

Chemistry Practice – Chapter 9 – Molecular Geometry and Bonding Theories



Directions: For each of the following molecules:

	(a)draw the Lewis structure;	(2 points)
*	(b)name the electron geometry about the central atom;	(1 point)
*	(c)name the molecular geometry about the central atom;	(1 point)
*	(d)give the bond angles about the central atom;	(1 point)
*	(e)indicate the type of hybridization used by the central atom;	(1 point)
	(f)tell whether the entire molecule is polar or nonpolar;	(1 point)
	(g)give the total number of sigma and pi bonds for the entire molecule.	(2 points)

*If no single central atom exists, provide the requested information in b-e for each "centrally-located" atom. Be sure to list the atom that you are describing.

1. CH_3OH (a) Lewis structure

		Central Atom 1 _____	Central Atom 2 _____
b)	Electron geometry		
c)	Molecular geometry		
d)	Bond angles		
e)	Hybridization		
f)	Polarity		
g)	# sigma & pi bonds		

2. SF_4 (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

3. CCl_2O (a) Lewis structure: C is central and resonance forms do exist.

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

4. ICl_2^- (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	

e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

5. CS_2 (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

6. CN^- (a) Lewis structure

		Central Atom 1 _____	Central Atom 2 _____
b)	Electron geometry		
c)	Molecular geometry		
d)	Bond angles		
e)	Hybridization		
f)	Polarity		
g)	# sigma & pi bonds		

7. SeF_6 (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

8. NF_3 (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

9. ICl_3 (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	

10. XeF_4 (a) Lewis structure

b)	Electron geometry	
c)	Molecular geometry	
d)	Bond angles	
e)	Hybridization	
f)	Polarity	
g)	# sigma & pi bonds	