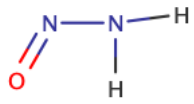
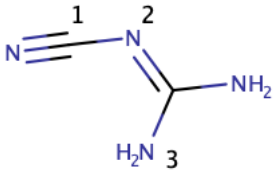
Structure and Bonding Tutorial 3

1. 

Fill the following table based on the information for N atoms attached to O and H in the molecule.

	N bound to O	**N bound to H**
Valance electrons around the central atom		
Number of VSEPR pairs		
Number of lone pairs		
Shape		

2. Use VSEPR theory to deduce the shapes around the following atoms indicated by 1, 2, 3.

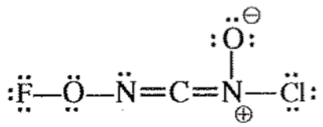


3.

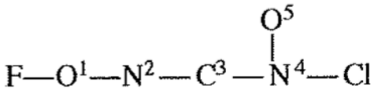
	C_1	**N_2**	**N_3**
Valance electrons around the central atom			
Number of VSEPR pairs			
Number of lone pairs			
Shape			

(iii) Based on the Lewis dot-dash structure given below, state the following regarding the C, N and O atoms given in the table.

I. VSEPR pairs around the atom
II. electron pair geometry around the atom
III. shape around the atom
IV. hybridization of the atom



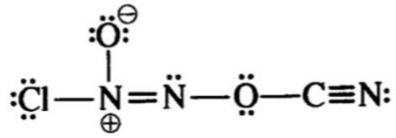
The atoms are numbered as follows.

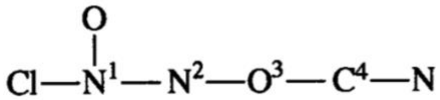


		O^1	N^2	C^3	N^4
I.	VSEPR pairs				
II.	electron pair geometry				
III.	shape				
IV.	hybridization				

4.

Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.





	N^1	N^2	O^3	C^4
VSEPR pairs around the atom				
electron pair geometry around the atom				
shape around the atom				
hybridization of the atom				

5. What is the species having the same shape as PO_4^{3-} of the following?

a. $POCl_3$ b. $SiCl_4$ c. CH_4 d. ICl_4^- e. SO_4^{2-}

6. Noble gas Xe forms XeF_4 a covalent compound. Determine the most suitable structure for the compound

a. Tetrahedral b. Square planer c. Octahedral d. Trigonal pyramid e. sea saw

7. Which of the following is the most suitable shape of the ClO_3^- anion?

a. Tetrahedral b. Planer c. T-shaped d. Trigonal pyramid e. Trigonal planer

8. The shape of ClBrFPO is

a. Tetrahedral b. Planer c. Trigonal by pyramid d. Octahedral

e. none of the above

9. Which species out of the following shows a different shape than that of SO_3^{2-} ?

a. ClO_3^- b. PCl_3 c. $SOCl_2$ d. H_3O^+ e. NO_3^-

10. Which pair out of the following has the same shape?

a. NH_3 b.H_3O^+ c. ClF_3 d. BCl_3 e.PCl_3

i) A&C ii) D&C ii) A, B&E iv) C, D&E v) B&C

11. What is the electron pair geometry of Sb around SbF_5^{2-}

a. Octahedral b. square pyramid c. Trigonal bipyramid d. square planer e. pentagonal pyramid

12. Which one of the following species has a different shape than others?

a. SO_4^{2-} b. $S_2O_3^{2-}$ c. PCl_4^+ d. NH_4^+ e. SF_4

13. Which one of the following contain species with a different shape?

a. CO_2, $BeCl_2$ b. PO_4^{3-}, $S_2O_3^{2-}$ c. NO_2^-, SO_3 d. HOBr, H_2S e. NCl_3, BCl_3

14. Which of the following has the same shape as ICl_2^-?

a. SO_2 b. O_3 c. $BeCl_2$ d. H_2S e. HOCl

15. Which one of the following has a significant difference to the shape of SO_4^{2-} ion?

a. NH_4^+ b. BCl_4^- c. SF_4 d. $S_2O_3^{2-}$ e. CH_4

16. What is the shape of ClF_4^+ out of the following?

a. Tetrahedral b. Sea saw c. Pyramidal d. Trigonal pyramid e. Octahedral

17. What is shape of BrF_3 out of the following?

a. Trigonal bipyramid b. Octahedral c. Square pyramidal d. Tetrahedral

e. None of the above

18. Which out of the following molecule contain 4 atoms on the same plane?

a. SF_4 b. BCl_3 c. PCl_3 d. NH_3 e. SiH_4

19. Shape and electron pair geometry of $ClF4O^-$ respectively are

a. Trigonal bipyramidal & square pyramidal

b. Square pyramidal & octahedral

c. Trigonal pyramid & Octahedral

d. square pyramid & Trigonal bipyramidal

e. Octahedral and square pyramidal

20. Which statement is true about NO_2^+?

a. This is linear in shape

b. There is a sigma bond

c. It has a bent shape

d. The valance shell of N in NO_2^+ contain less than 8 electrons

21. The electron pair geometry and the shape of the molecule of XeO_2F_2 respectively are

a. Trigonal bipyramid and seesaw

b. Trigonal bipyramid and tetrahedral

c. Tetrahedral and seesaw

d. seesaw and trigonal bipyramid

e. square planer and tetrahedral

22. Which molecule/ molecules out of the following have all the atoms on the same plane?

A. BF_3 B. NCl_3 C. ICl_3

1. Only A 2. Only B 3. Only C 4. Only A & B 5. Only A & C

Consider the following statements and state whether they are correct/ incorrect

	First Statement	Second statement
1	It is possible to identify polar covalent bond among two similar atoms.	H-Cl has a polar covalent bond
2	Nonpolar covalent bonds are formed only among two of the same atoms	π bonds are not formed when nonpolar covalent bonds are formed.
3	The bond in N_2 is a nonpolar covalent bond	There are 2 orbital overlaps in a molecule of N_2
4	There should be at least one lone pair to form a dative bond	A dative bond is formed only when the receptor atom contains a lone pair.
5	Formation of a dative bond is also considered as an acid base reaction	The species which donated a lone pair is considered as a Lewis acid.
6	The molecular orbital of a dative bond is exactly like the molecular orbital of a σ bond	A dative bond is formed only between an atom with an empty orbital and an atom with a lone pair.
7	BF_3 acts as a Lewis base	The octet in B of BF_3 is not completed
8	NH_4Cl contains a dative bond	The dative bond in NH_4Cl can be separately identified.
9	A dative bond can form between two molecules	The dative bond in H_3O^+ can be separately identified.
10	There is a dative bond in BF_3	BF_4- contains a dative bond formed by intermolecular electron donation
11	The shape around Al in Al_2Cl_6 is tetrahedral	It is possible to identify + and – ions in the structure of Al_2Cl_6
12	Dative bonds are formed between species that can form coordination bonds	Cu^{2+} can form complexes formed by dative bonds
13	Complexes formed by Co^{2+} with water is octahedral in shape	All complexes formed by d block elements are octahedral
14	Though PCl_5 can form NCl_5 cannot exist	Atomic radius of P is greater than N
15	Covalent bonds and dative bonds are the same	Dative bonds are formed when the electronegativity difference among atoms is larger than 2.1
16	One bond in NH_4^+ is different than the other N-H bonds.	It is possible to identify one N-H bond separately from other N-H bonds in the NH_4^+ ion.

Unit 2: Structure and Bonding- Tutorial 4

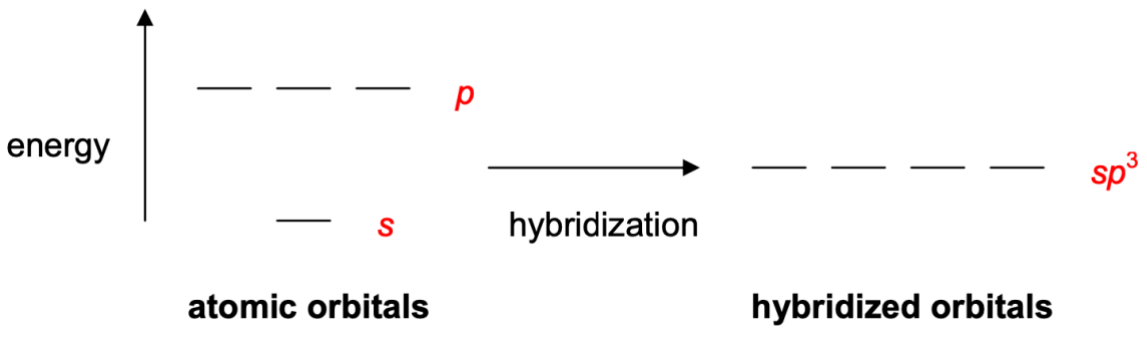
1. Determine whether the following compounds are polar or non-polar.

PF_5	CS_2	BrO_3^-
NH_4^+	SCl_4	BrF_5
BF_3	SCl_6	PH_3
NF_3	SO_4^{2-}	CO_3^{2-}
$SiCl_4$	ClO_3^-	CH_2O
NO_3^-	O_3	CCl_4
AlH_3	SO_2	SO_3
CO	$CHCl_3$	BrF_3
H_2S	I_3^-	H_3O^+

2. Draw Lewis structures, name shapes and indicate polar or non-polar for the following molecules:

a. CH_4	b. NCl_3	c. CCl_2F_2	d. CF_2H_2	e. CH_2O	f. CHN	g. PI_3
h. N_2O	i. SO_2	j. CS_2	k. CO	l. H_2O	m. COF_2	n. N_2
o. O_2	p. H_2	q. Cl_2	r. HF	s. O_3	t. NI_3	

3. Carbon has 4 valence electrons. Add these electrons to the atomic and molecular orbitals given below. This hybridization gives _____ **geometry.** With this hybridization, C will form **four equivalent σ bonds** in the molecule of CH_4.

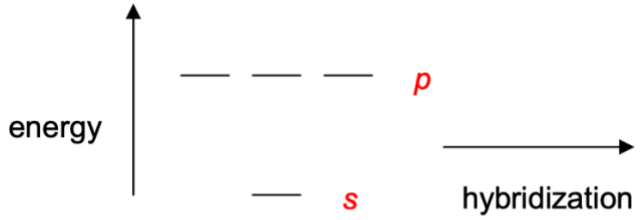


(I) Draw a similar energy diagram for sp^3 hybridized **oxygen in H_2O**.

(II) How many σ bonds are formed? How are the other sp^3 orbitals used?

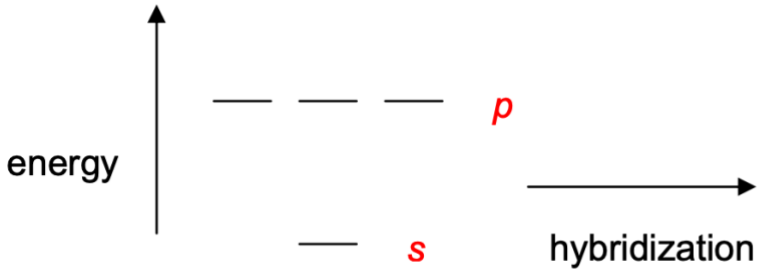
(III) Do the same exercise for sp^3 hybridized **nitrogen in NH_3.**

4. In some Lewis structures, there are only **three** equivalent bonds formed. To create three equivalent hybridized orbitals, mix **three** atomic orbitals. Draw the energy diagram for hybridization in BF_3.



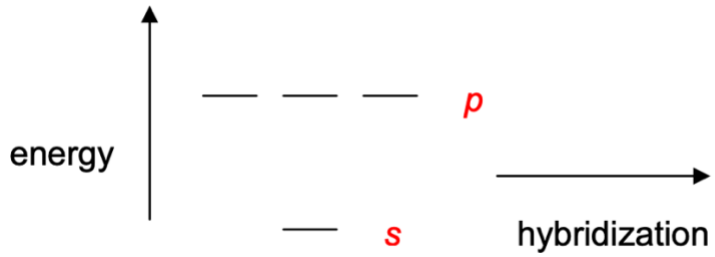
The hybridized orbitals will form _____ σ bond(s). The unhybridized orbital will form _____ π bond(s). There will be _____ lone pair(s). This hybridization gives **trigonal planar** geometry.

In **linear** molecules, like CO_2, the central atom has only **two** equivalent bonding orbitals. Draw the energy levels and name the orbitals formed in this hybridization.



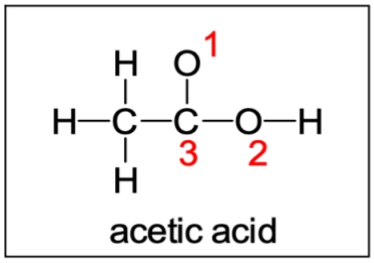
Fill in the electrons for **carbon** and determine the number and typed of bonds formed.

In CO_2, determine the hybridization of the **oxygen** atoms. Complete the energy diagram for the oxygens. Draw the structure of CO_2.



5. Fill in the chart below and then complete the Lewis structures for the molecules shown below and fill in those charts.

a.

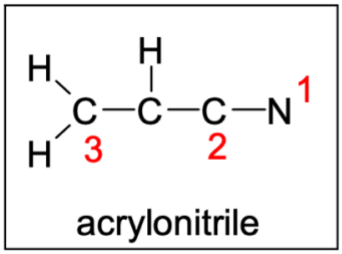


σ bonds ____

π bonds _____

atom #	bond angle	hybridization
1		
2		
3		

b.

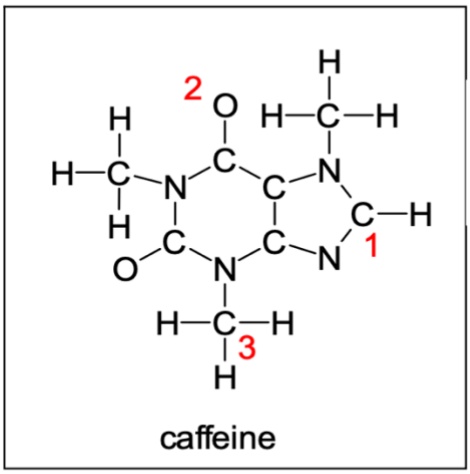


σ bonds ____

π bonds _____

atom #	bond angle	hybridization
1		
2		
3		

c.

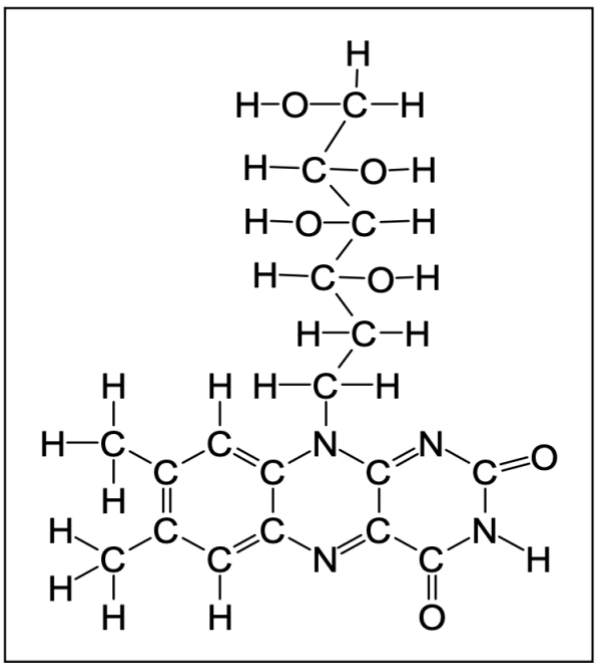


σ bonds ____

π bonds _____

atom #	bond angle	hybridization
1		
2		
3		

6. The molecule shown to the left, below is riboflavin (vitamin B2). Answer the following questions about its structure.



1. a) how many carbons are sp^3 hybridized?

   sp^2 hybridized?

   sp hybridized?

2. b) How many nitrogens are sp^3 hybridized?

   sp^2 hybridized?

   sp hybridized?

3. c) How many oxygens are sp^3 hybridized?

   sp^2 hybridized?

   sp hybridized?

d) How many σ bonds are there in total?

e) How many π bonds are there in total?

7. The acetate ion, $C_2H_3O_2^-$, has both oxygens bonded to the same carbon.

   a) Draw the Lewis structure.

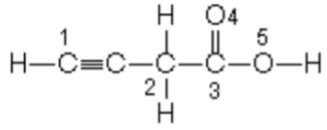
   b) Label the hybridization around each carbon.

   c) Label the hybridization of each oxygen.

   d) How many σ and π bonds are present?

   e) Which atom carries the formal negative charge?

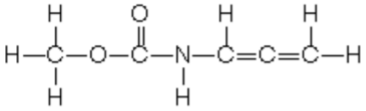
8. For the compound below, determine the hybridization, bond angles and lone pair electrons at each numbered atom.



	hybridization	bond angle	lone pair e^-
1			
2			
3			
4			
5			

9.

For the compound below determine



a. How many sp^3, sp^2 and sp hybridized atoms are present

b. How many lone pairs of e^- are present

c. How many σ-bonds are present

d. How many π-bonds are present

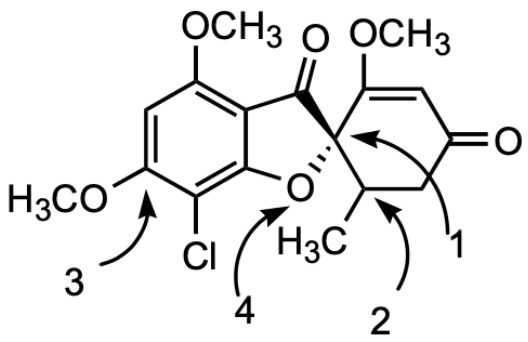
e. How many H-bond acceptors are present

f. How many H-bond donors are present

10. Determine the Hybridization around all atoms.

CH_4 Cl_2 NF_3 CH_2CH_2 CO_2 $CH_3CH_2CO_2H$ CHCH

11. The molecule shown below is Griseofulvin, an antifungal compound.

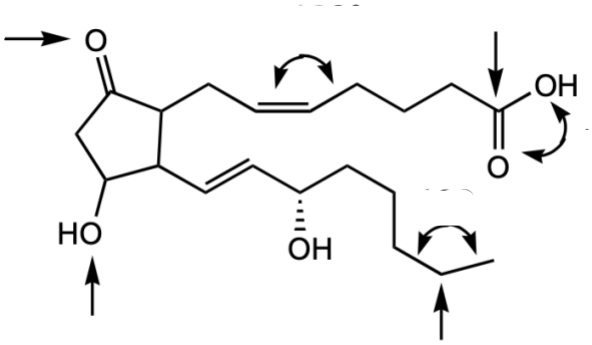


a. Give the hybridization of carbons 1, 2, 3 and oxygen 4. C1: C2: C3: O4:

b. What is the geometry at each of these atoms? C1: C2: C3: O4:

c. Fill in all lone pair electrons and H's on the structure assuming neutral charge.

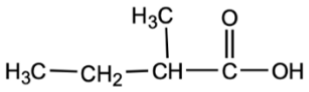
12. For the molecule shown give the information corresponding to each letter as indicated below.

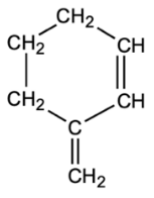


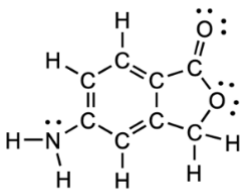
a. Give the hybridization of atoms indicated by arrows.

b. Give three bond angles indicated in the structure.

13. Indicate the hybridization of each atom in the following structures.

1. $CH_3CH_2CH_2CH(CH_3)_2$
2. $CH_3CH_2CHBrCH_2C(CH_3)_3$
3. 

4.
5. 



14. What hybridization do you predict for the carbonatom in CH_3^+, CH_3^-, and :CH_2? (b) What do you predict for the H-C-H bond angle for each of these species? What do you predict for the molecular geometry.

15. Provide the ground state electron configuration and the number of valence electrons for carbon and Silicon. Describe how these two atoms are similar. (b)Which bond do you think is stronger, C-C bond or the Si-Si bond, explain your answer.

16. Draw the Lewis structures for SiH_4, PH_3 and H_2S. Provide the electronic geometry and the molecular geometry for each as predicted by VSEPR theory.

17. Considerthe Lewis structure for PH_3.

(a) What value do you predict for the H-P-H bond?

(b) Is the P-H bond being a **stronger bond** or **weaker bond** than an **N-H** bond in NH_3? Explain.

(c)Is hybridization necessary to explain the trivalent nature of phosphorus? Explain.

(d) If it doesundergo hybridization? What hybridization state would PH_3 have and why would it undergo hybridization?

18. Draw the organic molecules which contain the following types of bonds

a. C-sp^3 – O-sp^3
b. N-sp^2-C-sp^2
c. C-sp^2-C-sp^2
d. N-sp^2-C-sp^2 (No π bond between N and C)

19. Why is an *sp* hybridized C-H bond is can break with Na than an sp^2 hybridized C-H bond?

20. Are the hydrogen atoms in the molecule $H_2C=C=C=CH_2$ in the same plane or in planes perpendicular to each other? Explain using the hybridization of eachcarbon atom.

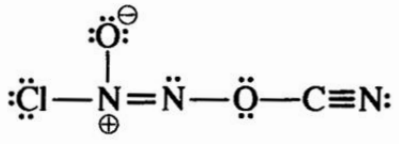
21.

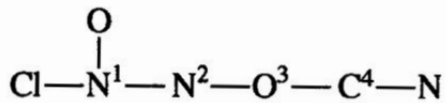
Answer	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement
(2)	True	True, but does **not** explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	1st statement	2nd statement
8	XeF_2 has a zero-dipole moment	All linear molecules are non-polar
9	Dipole moment is a vector	Dipole moment has a magnitude and a direction
10	CO_2 is a non-polar molecule	CO_2 contains polar bonds
11	The dipole moment increases whenever the electronegativity difference increases	The dipole moment does not depend on the length of the molecule.
12	If a molecule with the common formula AB_3 is polar, then its' shape is trigonal planer	All molecules which are trigonal planer in shape are non-polar
13	Dipole moment of NF_3 is larger than that of NH_3	The electronegativity difference of N-F bond is much higher than that of the N-H bond.
14	Dipole moment of a cis isomer is always higher than a trans isomer.	Dipole moment of a trans isomer is always zero
15	A molecule having a general formula of AX_4 having a dipole moment of zero is always tetrahedral.	AX_4 can take the shapes of tetrahedral, square planer, see saw.
16	Dipole moment of the CO_2 molecule is zero.	Electron pair geometry of CO_2 is linear.
17	A molecule with a general formula AB_2 having a dipole moment is always bent shaped.	If a molecule having a general formula of AB_2 with an electron geometry trigonal planer or tetrahedral it is always polar.

22.

Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.





	N^1	N^2	O^3	C^4
VSEPR pairs around the atom				
electron pair geometry around the atom				
shape around the atom				
hybridization of the atom				