

## Exam 2 Review Problems

Exam 2 will be held on Tuesday, October 30, in Porter Hall A18C. We will be there from 2:45 to 4:45 pm.

**Disclaimer:** This review sheet is not complete! This is a sample of some of the types of problems that may be on Exam 2. For a more complete review, also consult the homeworks and lecture notes.

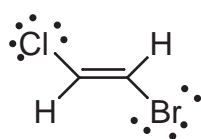
We will be holding two review sessions before the exam:

Sunday, October 27, 2001      5-7 pm      DH1217  
 Monday, October 28, 2001      7-9 pm      Porter 126A

Please come to the review sessions with questions! We will answer any reasonable question, but we will not prepare any additional review materials.

1. Consider the following molecule: trans CHCl=CHBr

a) Draw the Lewis structure for this molecule.



There are 24 electrons in this structure. The trans in the name indicates the opposite positions of the chlorine and bromine.

b) What is the bond order for each of the bonds in the molecule?

The bond between the two carbons has a bond order of 2. All other bonds are single bonds, so the bond order is 1.

c) What is the hybridization of each of the carbon atoms?

Each carbon is  $sp^2$  hybridized.

d) Is there a barrier to rotation about the bond connecting the two carbon atoms?

Yes. The pi bond between the two carbons prevents bond rotation.

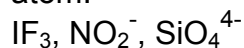
e) Sketch the bonding and anti-bonding molecular orbitals between the two carbon atoms.

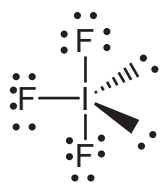


f) Does this molecule have a dipole moment, and if so, what direction does it have?

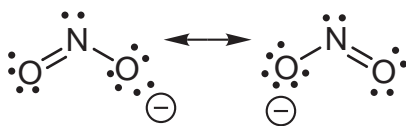
Yes, Cl is more electronegative than Br, so the dipole points toward Cl.

2. Draw the complete Lewis structures for the following molecules. Include formal charges and resonance structures, when necessary. Compute oxidation states for all atoms. Give the steric number, hybridization, and molecular geometry of the central atom.

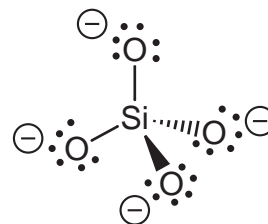




Oxidation States:  
 $I = 7 - 4 - 0 = +III$   
 Each  $F = 7 - 6 - 2 = -I$   
 $SN = 5$   
 $I = sp^3d$  hybridized  
 The molecular geometry is  
 T-shaped

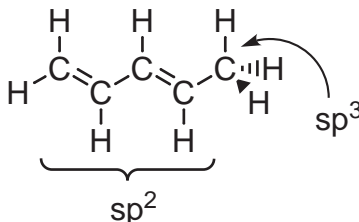


$N = 5 - 2 - 0 = +III$   
 $O_{\text{single}} = 6 - 6 - 2 = -II$   
 $O_{\text{double}} = 6 - 4 - 4 = -II$   
 $SN = 3$   
 $N = sp^2$  hybridized  
 Bent



$Si = 4 - 0 = +IV$   
 $O = 6 - 6 - 2 = -II$   
 $SN = 4$   
 $Si = sp^3$  hybridized  
 Tetrahedral

3. Consider the molecule  $CH_2CHCHCHCH_3$
- Draw the Lewis structure for this molecule.
  - What is the hybridization of each of the carbon atoms?



- Consider rotation about the bond between  $C_1$  and  $C_2$ ,  $C_2$  and  $C_3$ , and  $C_4$  and  $C_5$ . Which will have the highest barrier to rotation, and which will have the lowest barrier to rotation?

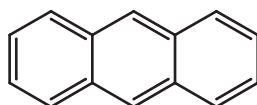
This system is a conjugated diene. The  $C_1$ - $C_2$  bond is double bond and will have the highest barrier to rotation. The  $C_2$ - $C_3$  bond is between two double bonds and, through resonance in the pi system, will have some double bond character, so it will have some barrier to rotation. The  $C_4$ - $C_5$  bond is a pure single bond, so it will have a *very* small barrier to rotation. That bond is outside of the conjugated system.

- How many pi molecular orbitals are there in this system? Sketch these molecular orbitals. How many of these pi molecular orbitals are filled?

There are four  $sp^2$  hybridized carbon, so there are 4 p orbitals making up the pi system. Since there are 4 atomic orbitals, there are 4 molecular orbitals. These orbitals will be the same as the butadiene orbitals from lecture.

- Does this molecule have a substantial dipole moment? **No.**

4. Consider the following molecule:

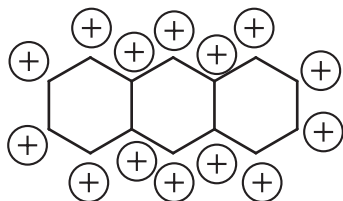


anthracene

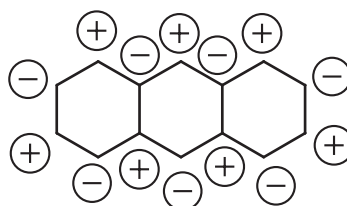
- a) What is the molecular formula for this molecule? **C<sub>14</sub>H<sub>10</sub>**  
 b) What is the hybridization of each of the carbon atoms? **sp<sup>2</sup>**  
 c) How many pi orbitals are in this molecule? How many of these orbitals are filled?

There are 14 pi orbitals in this molecule. 7 are filled.

- d) Sketch the lowest energy pi-orbital for this molecule. Sketch the highest-energy pi-orbital for this molecule. (The orbitals with intermediate energies are considerably more difficult to sketch.)



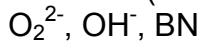
The lowest energy orbital has all phases aligned.



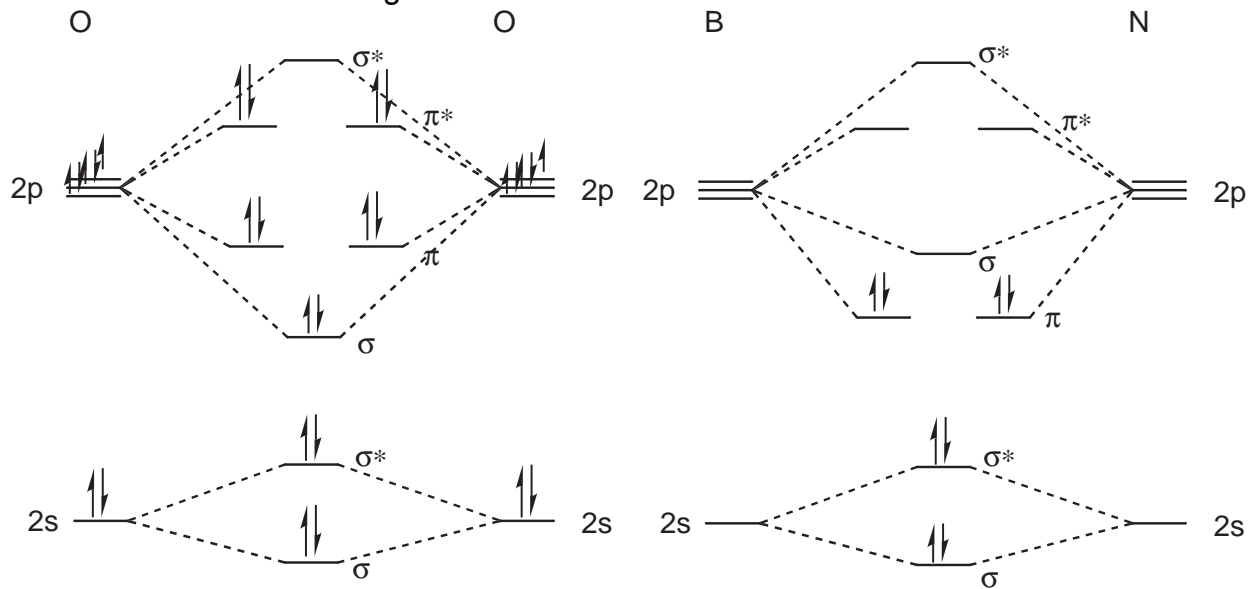
The highest energy orbital has alternating phases.

- e) Does this molecule have a substantial dipole moment? **No.**

5. Draw the MO (correlation) diagrams for the following diatomic molecules and ions:

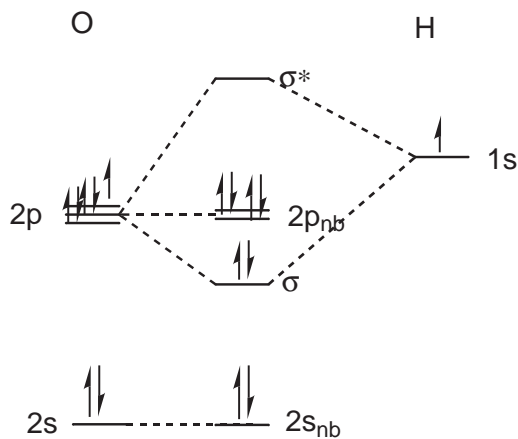
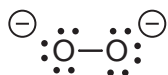


Calculate the bond orders for those molecules. For  $\text{O}_2^{2-}$ , draw a Lewis structure that is consistent with the MO diagram.



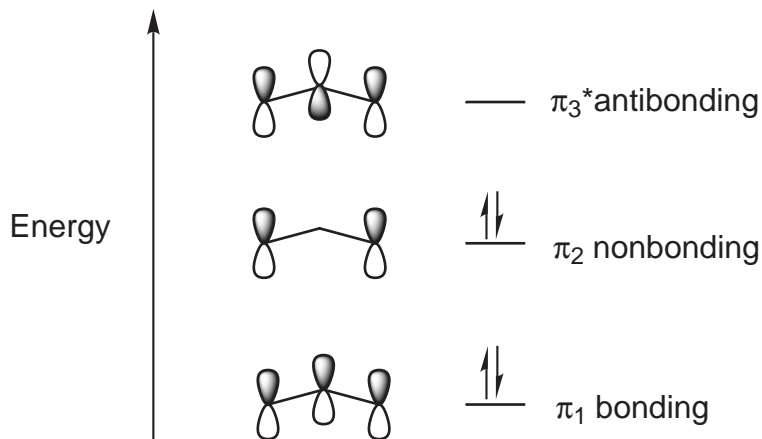
$$\text{Bond Order} = 1/2 (8-6) = 1$$

$$\text{Bond Order} = 1/2 (6-2) = 2$$

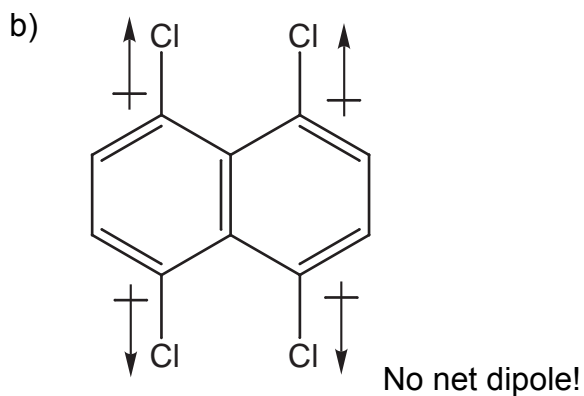
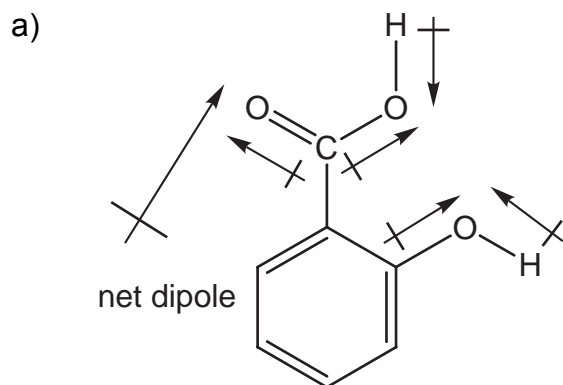


$$\text{Bond Order} = 1/2 (2-0) = 1$$

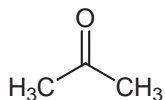
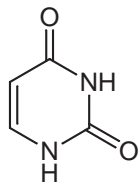
6. [Note that  $I_3^-$  was replaced with  $O_3$  (see web page)] Draw the MO diagram for the pi orbitals on  $O_3$ . How many pi orbitals are there? In what type of orbitals are the pi electrons?



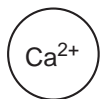
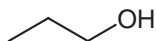
7. For the following molecules, draw all bond dipoles on the molecule. Does the molecule overall have a net molecular dipole (i.e. is the molecule polar)?



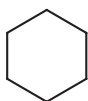
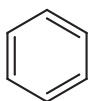
8. List all of the intermolecular forces found between each of the following pairs of molecules.



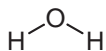
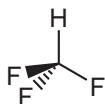
Dispersion  
Dipole-Dipole  
Hydrogen bonding



Dispersion  
Ion-Dipole

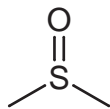


Dispersion

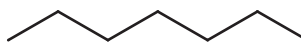


Dispersion  
Dipole-Dipole  
Hydrogen bonding

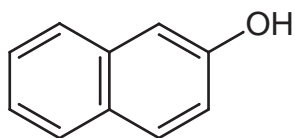
9. Select the best solvent, either dimethylsulfoxide (DMSO) or hexane, for the following molecules. If you think the molecule is soluble in both solvents, indicate that as well.



DMSO



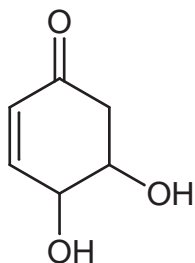
hexane



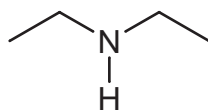
Hexane



Hexane



DMSO



DMSO