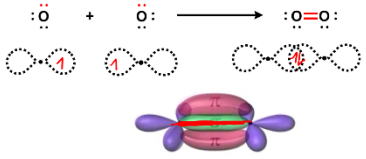
Major Concepts Covered (these questions cover all lectures from 1 to 21 and serve as a practice for the midterm)

Theories of Covalent Bonding (Hybridization/VSEPR)

Valence Bond Theory:

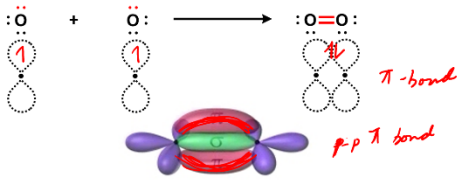
Formation of single and double bonds

A covalent bond forms when orbitals of two atoms overlap and a pair of electrons occupy the overlap region



σ-bond – formed from overlap of two orbitals. Is cylindrically symmetrical around bond axis

- The two electrons move over to the new **σ-bonding** orbital
- The two electrons in the bonding orbital have opposite spin (Pauli's exclusion principle still followed)



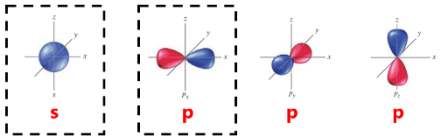
π-bond – formed from overlap of two orbitals. Is not symmetrical around bond axis. Side to side overlap

- The two electrons move over to the new **π -bonding** orbital
- The two electrons in the bonding orbital have opposite spin (Pauli's exclusion principle still followed)

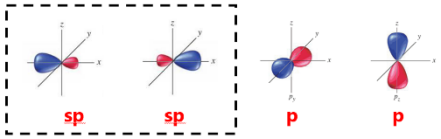
Hybridization

sp

Atomic Be Valence Orbitals:

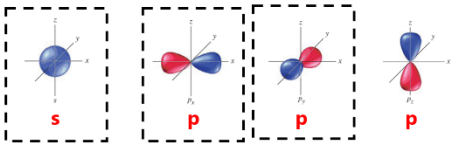


Be atoms in $BeCl_2$ Valence Orbitals:

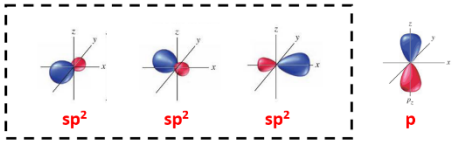


sp^2

Atomic B Valence Orbitals:

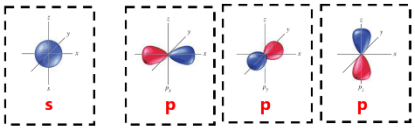


B atoms in BF_3 Valence Orbitals:

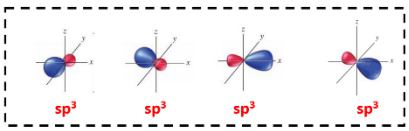


sp^3

Atomic B Valence Orbitals:

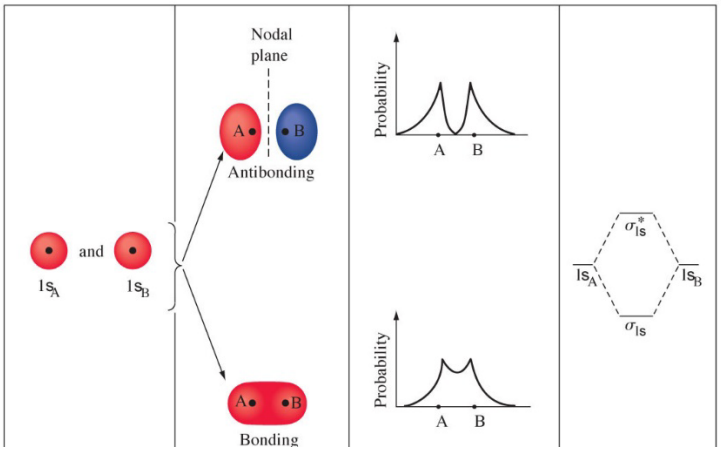


C atoms in CH_4 Valence Orbitals:



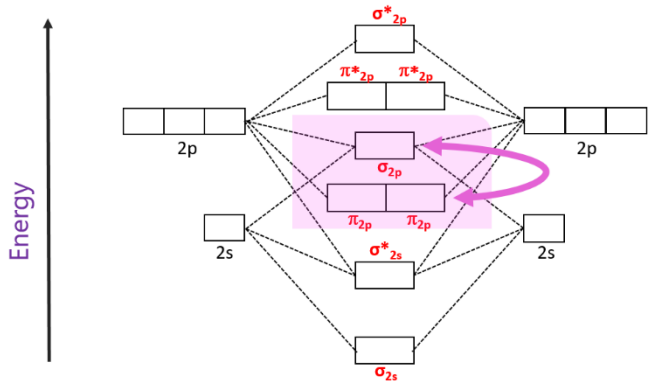
Molecular Orbital Theory

Period 1: Drawing Molecular Orbital Diagram

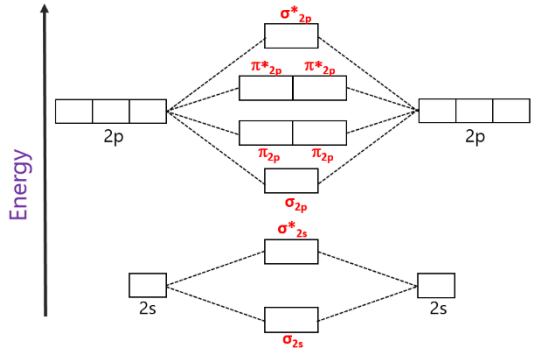


Period 2:

MO Diagram for Li_2 to N_2



MO Diagram for O_2 and F_2



Be able to determine bond order, compare bond length, magnetism, and write molecular configuration

Tutorial Questions (these questions cover all lectures from 1 to 21 and serve as a practice for the midterm)

1) The subsequent **ionization energies (in kJ/mol)** for an imaginary element **(X)** are given below.

	IE_1	**IE_2**	**IE_3**	**IE_4**	**IE_5**	**IE_6**	**IE_7**	**IE_8**
X	1215	2214	3123	13215	15612	18145	23412	28361

Which main group would you place this element in? Briefly explain your reasoning.

Calculate the **longest wavelength** (in nm) of a photon that can remove an electron from the ground state atom X (from part a)? Show complete calculations.

2)

a) The work function of the metal is 1.42×10^{-18} J. Among the given wavelengths (i, ii, iii, or iv), which is the *longest wavelength* that will cause an electron to be ejected from the surface? Show calculations to explain your answer. **6**

(i) 50 nm (ii) 100 nm (iii) 150 nm (iv) 200 nm

b) Without doing any calculations, predict the change (increase, decrease, or no change) for the following, if the wavelength of the photon is shorter than the longest wavelength calculated in Part A.

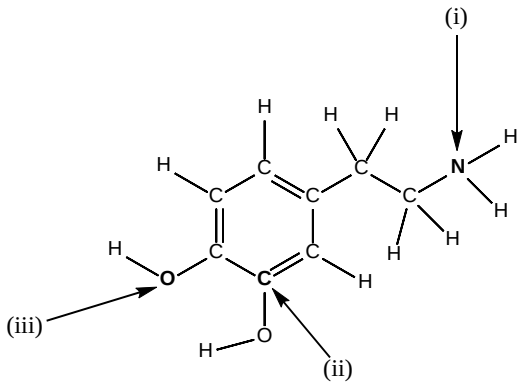
i. Work function of the metal:

ii. Velocity of the electron:

iii. Number of electrons ejected:

iv. Kinetic energy of the electron:

3)



For the indicated atoms (denoted with an arrow), (i) to (iii), answer the following questions. Lone pairs are **not** indicated in the structure. Consider the structure as given (no need to consider resonance structures). All atoms have formal charge of 0. (Use valence bond theory and hybridization to describe the bonding.)

a) For (i)

1. Describe the orbitals involved in all bonds formed by N (i). Designate sigma and pi bonds

2. What is the electron **and** molecular geometry at N?

b) For (ii)

1. What is the molecular geometry at C (ii).

2. Circle the one value that best describes the O-C-C bond angle.

>90° to <109.5° 109.5° 120° >120° to <180

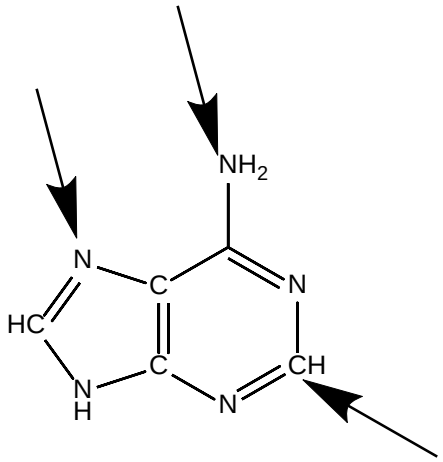
c) For (iii)

1. What is the electron **and** molecular geometry at O (iii).

2. Circle the one value that best describes the H-O-C bond angle.

>90° to <109.5° 109.5° >109.5° to <120° 120° >120° to <180

4) Consider the structure shown below.
In this structure all atoms have a formal charge of zero.



a. Identify the hybridization for the atoms indicated by the arrow

b. Describe the orbitals involved in bonding for each atom indicated by an arrow. Distinguish sigma and pi bonds for each.

5) Draw the Lewis structures, and predict the hybridization of the underlined atom(s). What is the molecular geometry around the underlined atom?

a. $CH_3CH_2CH_2\underline{\mathbf{O}}H$

b. $\underline{\mathbf{S}}OCl_2$

c. $CH_2\underline{\mathbf{C}}H\underline{\mathbf{C}}H_3$

6. Based on what you have learned in Chem110, arrange the following in the increasing order of

1. Bond angle (for the most stable Lewis Structure)

(None of the molecules contain any O-O bonds)

$[H_5IO_6]$ PH_3 SO_2

2. Ionic radius

I^- Sr^{2+} Ca^{2+}

Briefly explain you reasoning for each.

7. Draw the molecular orbital diagram for Cl_2. Assume 3s and 3p orbitals show similar LCAO as 2s and 2p orbitals (Label increasing energy using an arrow next to the diagram. Label each atomic and each molecular orbital)
   Calculate the bond order and give the molecular orbital configuration for the **valence** electrons.

8. a. Draw the complete MO diagram for the molecule NeO. Make sure to label atomic and molecular orbitals. Label the energy axis. What is the bond order?

b. Arrange the following in the increasing order of their bond length

NeO, NeO^-, NeO^+
Explain your answer – based on MO theory.