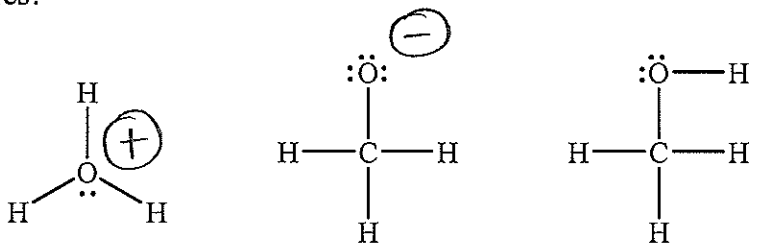
Key

Circle the single best answer to each multiple choice question (1-16). (4 pts each)

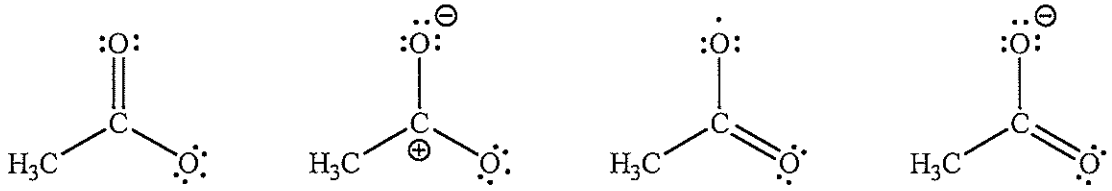
1. What is the formal charge on the oxygen atom in each of the following Lewis structures?



Structure I **Structure II** **Structure III**

a. **I,** 0, **II,** 1-, **III,** 1+
(b.) **I,** 1+, **II,** 1-, **III,** 0
c. **I,** 1-, **II,** 1+, **III,** 0
d. **I,** 1-, **II,** 1-, **III,** 1-
e. **I,** 1+, **II,** 1+, **III,** 1-

2. Which two of the following are *equivalent* resonance contributors?

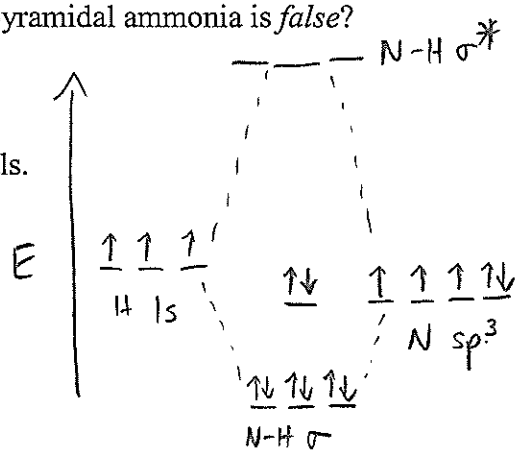


Structure W **Structure X** **Structure Y** **Structure Z**

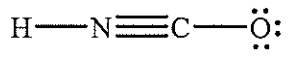
a. W and X
(b.) W and Y
c. X and Y
d. W and Z
e. All the structures are equivalent.

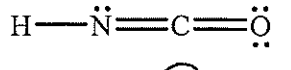
3. In class, we discussed a molecular orbital diagram for pyramidal ammonia that assumed an approximate sp^3 hybridization for nitrogen. Which of the following statements about the molecular orbital diagram for pyramidal ammonia is *false*?

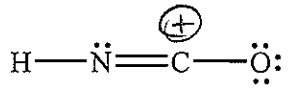
T a. There is one nonbonding orbital.
T b. There are three bonding molecular orbitals.
T c. There are three antibonding molecular orbitals.
T d. All bonding orbitals are occupied.
F (e.) All nonbonding orbitals are unoccupied.

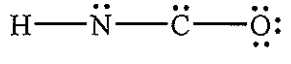


4. In which of the following structures does the carbon atom have a formal charge that is **not zero?** (All lone pairs are shown.)

a. 

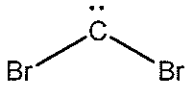
b. 

c. 

d. 

e. Both c and d

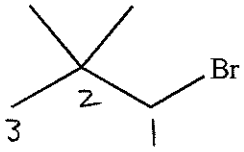
5. Dibromocarbene is an example of a chemical species called a carbene:



Carbenes exist in one of two forms. In one of these forms, called a singlet, both the nonbonding electrons occupy the same orbital. Approximately what type of orbital does the lone pair occupy?

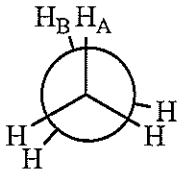
a. *sp*
b. sp^2
c. sp^3
d. 2*s*
e. 2*p*

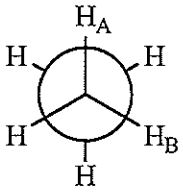
6. What is the systematic (IUPAC) name of this compound?

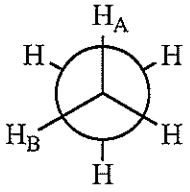


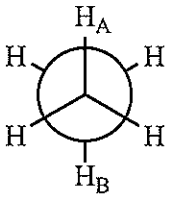
a. 1-bromobutane
b. 1-bromo-2-methylbutane
c. 1-bromo-2-methylpropane
d. 1-bromo-2,2-dimethylpropane
e. 3-bromo-2,2-dimethylpropane

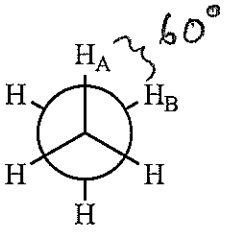
7. Which of the following Newman projections shows a dihedral angle of 60° between H_A and H_B?

a. 

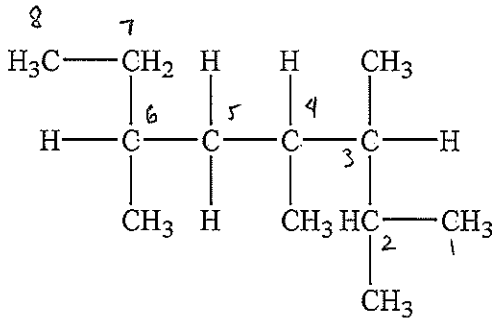
b. 

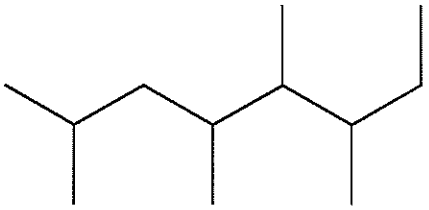
c. 

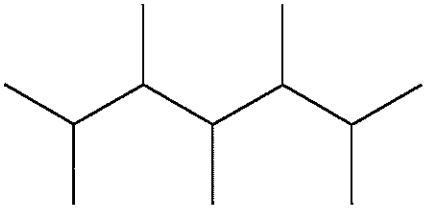
d. 

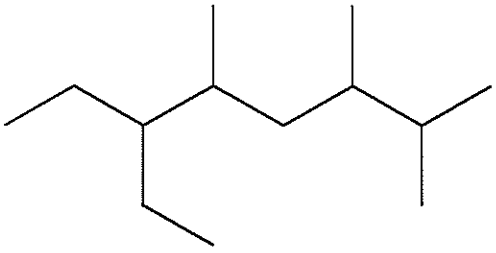
e. 

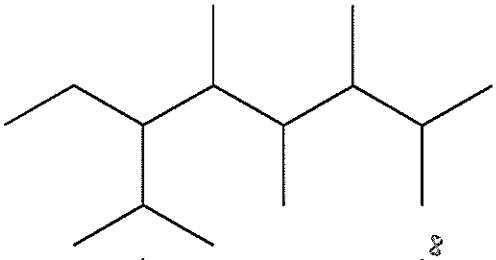
8. Which of the following skeletal structures corresponds to the Lewis structure shown?

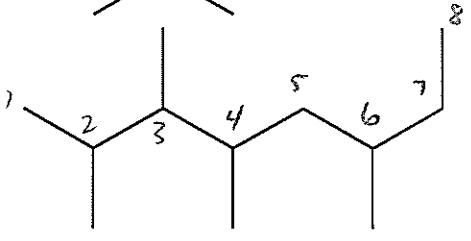


a. 

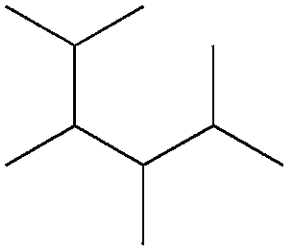
b. 

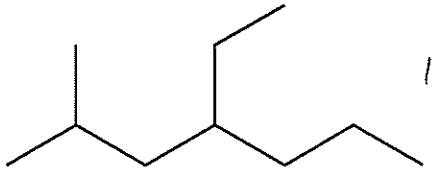
c. 

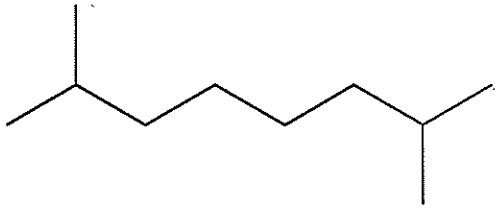
d. 

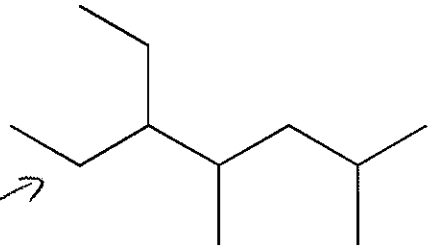
e. 

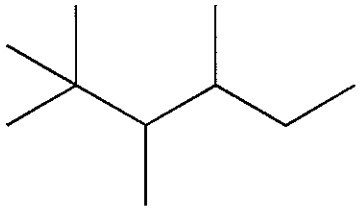
9. Which of the following compounds is *not* a constitutional isomer of the others?

a. 

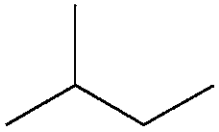
b. 

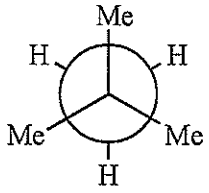
c. 

d. 

e. 

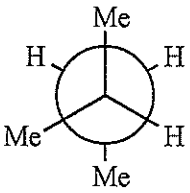
10. Which of the following structures is *not* a representation of 2-methylbutane?

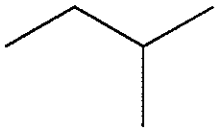
a. 

b. 

this is 

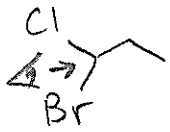
c. $(CH_3)_2CHCH_2CH_3$

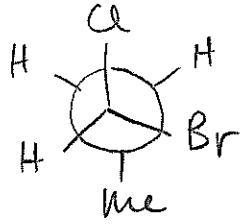
d. 

e. 

11. In which of the following molecules can a methyl group be eclipsed by either a chlorine atom or by a bromine atom?

a. 1-bromo-3-chloropropane
b. 1-bromo-1-chloropropane
c. 1-bromo-2-chloropropane
d. 2-bromo-1-chloropropane
e. 2-bromo-2-chloropropane





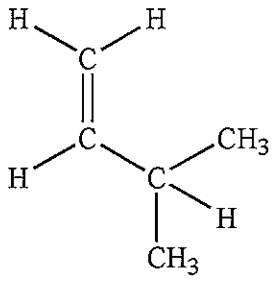
... then rotation around C1-C2 bond

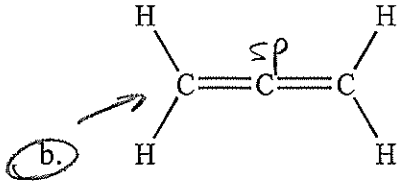
12. How many molecular orbitals are generated from all possible linear combinations of one 2*p* orbital on carbon and one 2*p* orbital on oxygen?

2 Atomic orbitals in → 2 Molecular orbitals out

a. 0
b. 1
c. 2
d. 3
e. 4

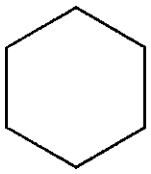
13. Which of the following structures contains a hybrid orbital with the *greatest* percentage of *s* character?

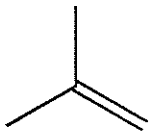
a. 

b. 

Sp = 50% s
50% p

c. 

d. 

e. 

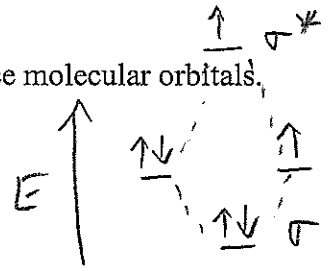
14. A certain orbital interaction diagram has four bonding molecular orbitals and four antibonding molecular orbitals. How many atomic orbitals were mixed to create all these molecular orbitals?

8 MO's so 8 AO's

a. 2
b. 4
c. 8
d. 16
e. It cannot be determined from the information given.

15. Which of the following statements about the orbital interaction diagram for H_2^- is *false*?

T a. There are two atomic orbitals that mix to produce molecular orbitals.
T b. There is one bonding molecular orbital.
T c. There is one antibonding molecular orbital.
T d. All bonding orbitals are occupied.
F (e.) All antibonding orbitals are unoccupied.



16. A set of π molecular orbitals were generated by various linear combinations of *p* orbitals. Which of the following π molecular orbitals is highest in energy?

a. 

b. 

(c.) 

d. 

e. All four orbitals shown are degenerate.

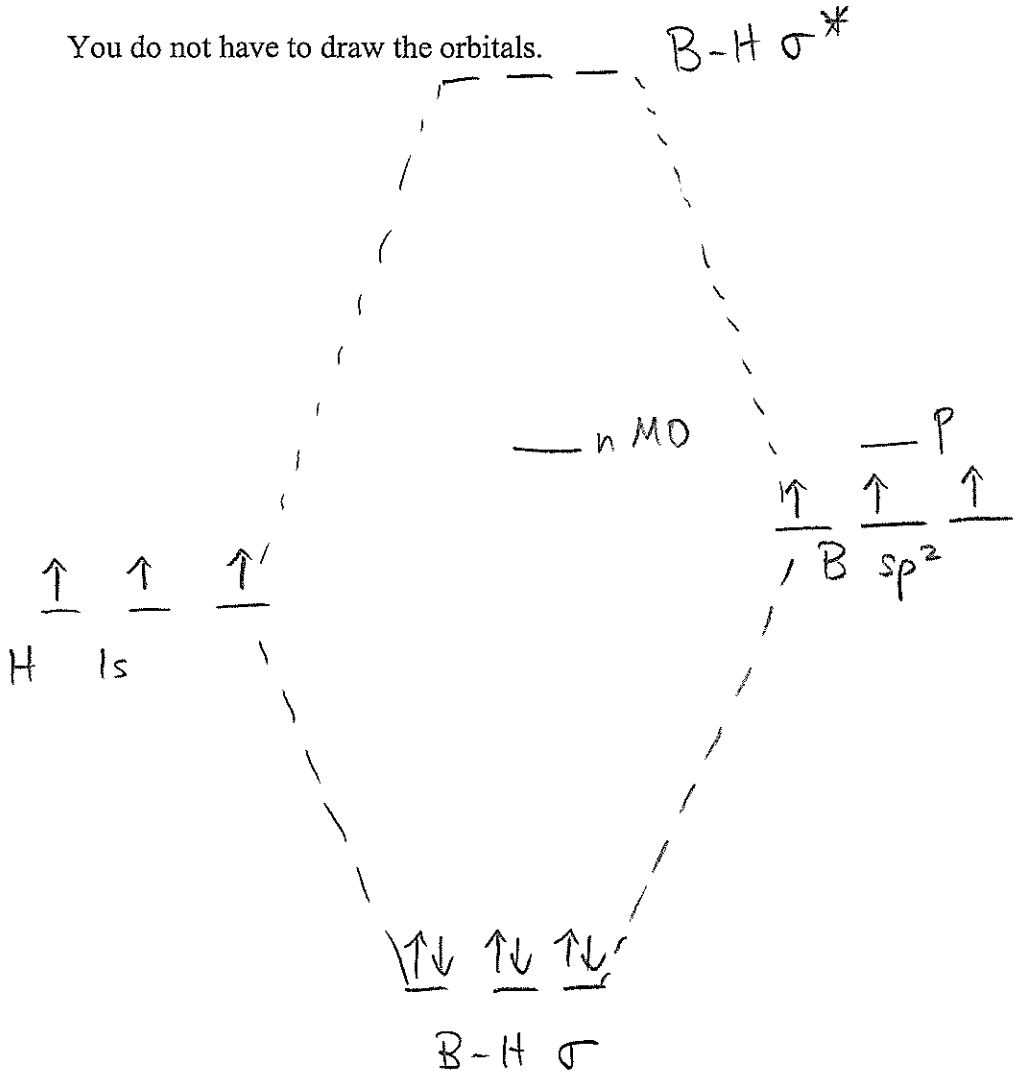
17. (15 pts) Draw an orbital interaction diagram for borane, BH_3, assuming a trigonal planar geometry. Your diagram should include the following:

Show all orbitals at their correct energy levels, including any and all bonding orbitals, antibonding orbitals, nonbonding orbitals, and atomic orbitals. Note that B is slightly *less* electronegative than H.

Label each orbital (*e.g. s, p, sp, sp^2, sp^3*, σ, σ*, π, π*, *n*).

Label the HOMO and the LUMO.

You do not have to draw the orbitals.



18. (15 pts) Define each of the following terms:

Torsional strain: Strain caused by bonding e⁻ areas approaching too closely

Van der Waals strain:

Strain caused by non-bonded atoms approaching each other too closely

Which of these types of strain is present in each of the following conformations? For each conformation, circle ALL types of strain that are present:

Eclipsed ethane	**Torsional**	**Van der Waals**	**Neither**
Staggered ethane	**Torsional**	**Van der Waals**	**Neither**
Anti butane (methyl groups anti)	**Torsional**	**Van der Waals**	**Neither**
Gauche butane	**Torsional**	**Van der Waals**	**Neither**
Eclipsed butane (methyl groups eclipsed)	**Torsional**	**Van der Waals**	**Neither**

19. (6 pts) Draw two more reasonable resonance contributors for the following structure (all lone pairs are shown). Show the interconversion of your structures using curved arrow notation. Include all non-zero formal charges.