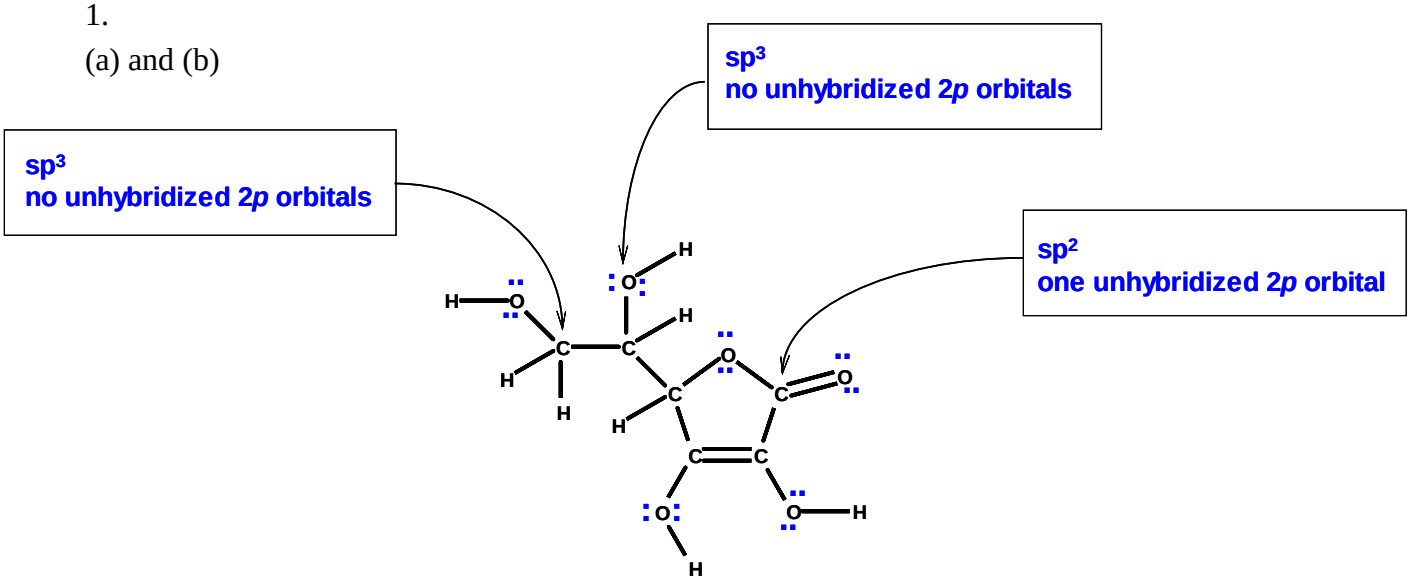
Answers to Practice Test Questions 5B
Valence Bond Theory

1.

(a) and (b)

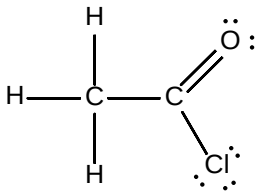


(c) 20

(d) 2

2.

(a)



(b) C (of CH_3) is tetrahedral C (of COCl) is trigonal planar

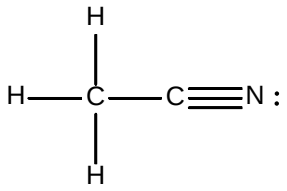
(c) C (of CH_3) is sp^3 hybridized C (of COCl) is sp^2 hybridized

(d) 6

(e) 1

3.

(a)



(b) C (of CH_3) is tetrahedral C (of CN) is linear

(c) C (of CH_3) is sp^3 hybridized C (of CN) is *sp* hybridized

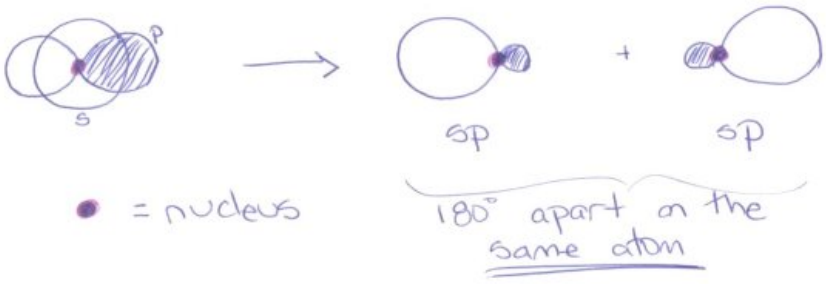
(d) 5

(e) 2

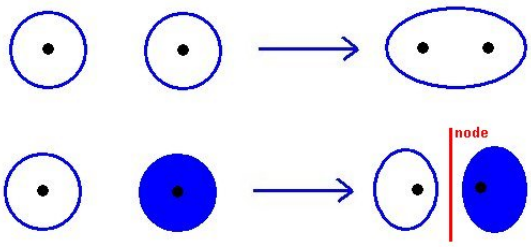
4. An *s* orbital and a *p* orbital *in the same shell* **<u>of the same atom</u>** combine to make two *sp* orbitals:

5.

(a) Hybrid atomic orbitals are formed by mixing orbitals on the <u>same</u> atom.



Molecular orbitals are formed by mixing orbitals on <u>different</u> atoms.

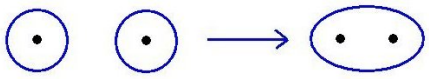


In both cases, the total number of orbitals is not changed. Mixing two atomic orbitals gives two new orbitals – be they hybrid atomic orbitals or be they molecular orbitals.

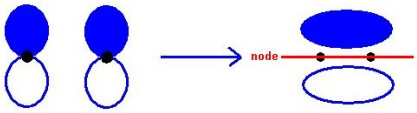
(b) A sigma (σ) bond has electron density along the line connecting the nuclei of the two bonded atoms.

A pi (π) bond has a node along the plane of the molecule.

Sigma:



Pi:



6. Hybridization of atomic orbitals is a way to rationalize bond angles that cannot be explained by simple combination of *s* and *p* orbitals on bonded atoms (e.g. the 109.5° angle of tetrahedral molecules or the 120° angle of trigonal planar molecules).

In a diatomic molecule, both atoms are terminal so this is unnecessary. Bonds can be formed through combination of unhybridized *s* and/or *p* orbitals.

7. MO theory combines AOs on DIFFERENT atoms to make MOs (LCAO). VB theory combines AOs on the same atomic orbitals on the SAME atom (i.e. 2s and 2p orbitals are combined to give sp, sp^2 or sp^3).

MO theory has electrons distributed over whole molecule. VB theory localizes an electron pair between two atoms.

In MO theory the symmetry (or antisymmetry) must be retained in each orbital. In VB theory all orbitals must be viewed simultaneously to see retention of the molecule's symmetry.

8. *Your answers must be Lewis diagrams (not just the formulas provided below).*

(a) *any molecule containing a carbon atom with tetrahedral electron group geometry*

e.g. CH_4, C_2H_6, CH_3OH

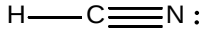
(b) *any molecule containing a carbon atom with trigonal planar electron group geometry*

e.g. CH_2O, C_2H_4

(c) *any molecule containing a carbon atom with linear electron group geometry*

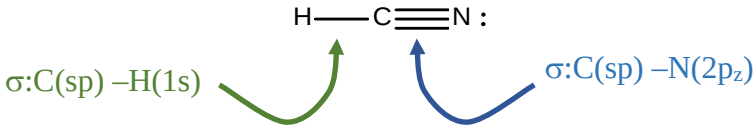
e.g. CO_2, HCN, C_2H_2

9.

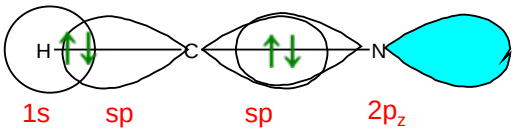
(a) 

(b) *sp*

(c)

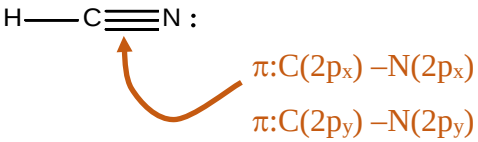


Therefore:

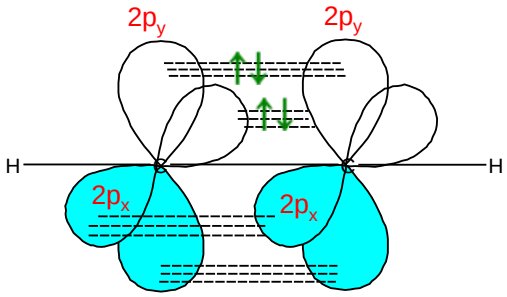


In the semester in which this question was used on a test, the lower notation had been explicitly used in lecture. Words like "sketch", "draw" or "picture" indicate that the instructor is looking for a picture of the orbitals (not just their names).

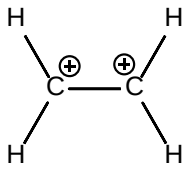
(d)



Therefore:



10.



Each carbon atom is trigonal planar therefore sp^2 hybridized.

All of the valence electrons are used in the C-H bonds, so there is no π bond between the two carbon atoms (unlike in ethene). As a result, there is nothing holding the six atoms all in the same plane.

Since the atoms are not held in the same plane, the four hydrogen atoms will arrange themselves so that they are spaced out as much as possible, giving a staggered arrangement: