Additional Problems for practice:

1. Use the VSEPR rules to determine the shape of each of the following molecules:

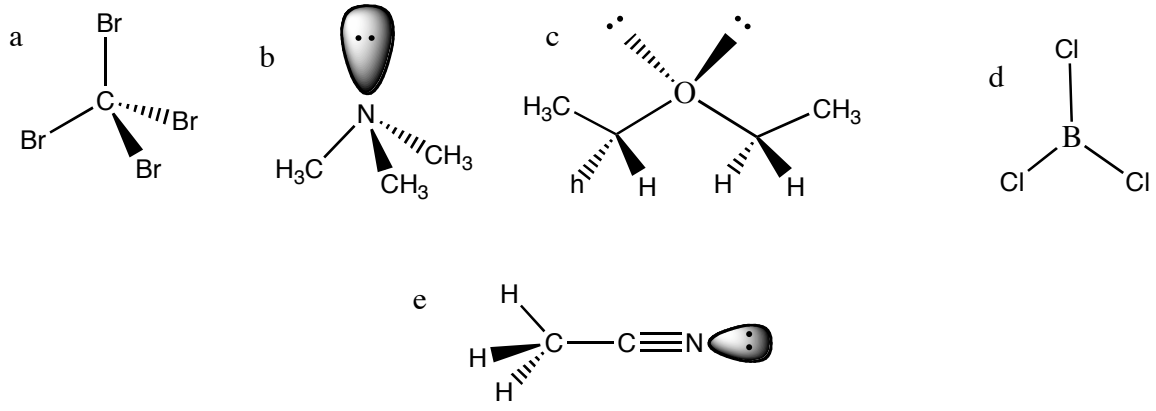
(a) CBr_4 With four substituents around carbon, according to VSEPR theory, each of the bonds should be 109.5° apart and the overall molecule has a tetrahedral geometry

(b)$(CH_3)_3N$ Although there are 3 atoms bonded to Nitrogen, the steric number of this compound is 4 since there is also a lone pair on nitrogen. With four bonds/lone pairs around nitrogen, the overall molecule has a tetrahedral geometry (each methyl group is also tetrahedral), with the bond angles compressed slightly from their ideal value of 109.5° due to the larger steric requirement of a lone pair. This molecule may also be thought of as pyramidal or a trigonal pyramid if the lone pair is discounted in drawing the molecule

(c)$(CH_3CH_2)_2O$ This molecule has two bonds and two lone pairs on the central oxygen, and so tetrahedral geometry around oxygen is expected (of course, each carbon is tetrahedral as well!). The "bent" geometry at oxygen is obvious when the lone pairs are discounted in drawing the molecule.

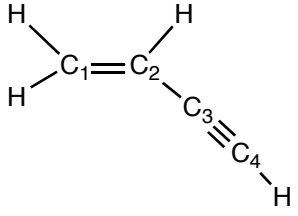
(d)BCl_3 : there are three bonds and no lone pairs around B atom, so we expect a trigonal planar geometry.

(e) $CH_3C{\equiv}N$ The central carbon atom has two atoms bonded to it, and thus a linear geometry is expected (both carbons and nitrogen are in a straight line), bond angles 180°. The CH_3 group is tetrahedral at carbon. The nitrogen has one lone pair and one other atom bonded to it, so it also has a linear geometry, with the lone pair oriented 180° away from the C-N triple bond.



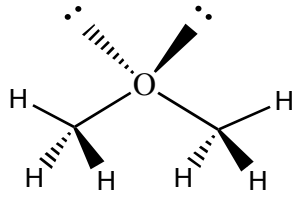
2. Indicate the kind of hybridization you might expect for each carbon atom in these molecules:

Draw out the Lewis structure for each molecule

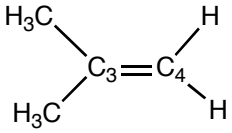


(a) $CH_2{=}CHC{\equiv}CH$

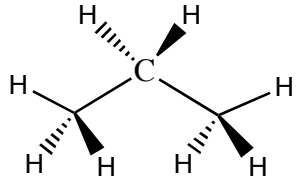
Carbon 1 has 3 sigma bonds, no lone pairs, (remember pi bonds are formed from p orbitals, which are not hybridized) and thus displays sp^2 hybridization. Carbon 2 has 3 sigma bonds, no lone pairs, and thus has sp^2 hybridization. Carbons 3 and 4 each have 2 sigma bonds, no lone pairs, and thus each has sp hybridzation



(b) CH_3OCH_3 Both carbon atoms have four sigma bonds and thus sp^3 hybridization; oxygen has 2 sigma bonds and 2 lone pairs (4 total) and thus has sp^3 hybridization.



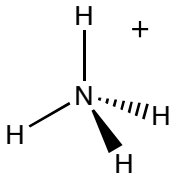
(c) $(CH_3)_2C=CH_2$ The two methyl groups have sp^3 hybridization, since they each have four sigma bonds; C3 and C4 have three sigma bonds, no lone pairs, and thus each has sp^2 hybridization.



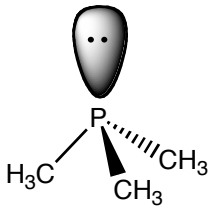
(d) $CH_3CH_2CH_3$ All carbon atoms have four sigma bonds, and thus each has sp^3 hybridization.

3. What shape would you expect these species to have?

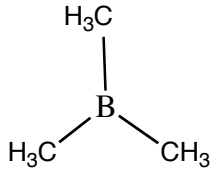
(a) NH_4^+ :four sigma bonds, no lone pairs, tetrahedral



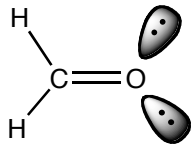
(b) $(CH_3)_3P$:three sigma bonds, one lone pair, tetrahedral (pyramidal)



(c) $(CH_3)_3B$: three sigma bonds, no lone pairs, trigonal planar geometry

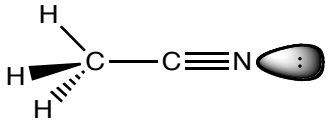


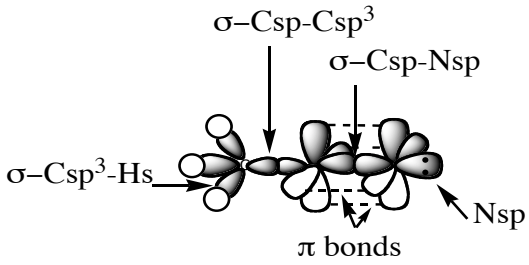
(d) $H_2C=O$: carbon has three sigma bonds, no lone pairs, trigonal planar geometry; oxygen has two lone-pairs, one sigma bond, also trigonal planar geometry.



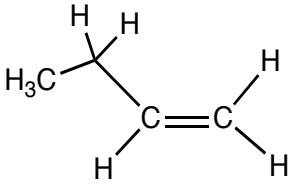
4. Draw the structure of the following molecules, indicating the types of bonds involved and the hybrid orbitals on each atom:

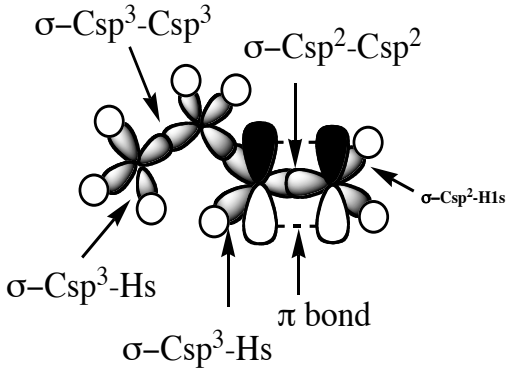
(a) $CH_3C\equiv N$



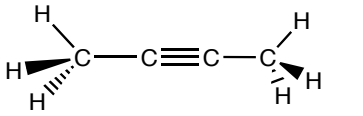


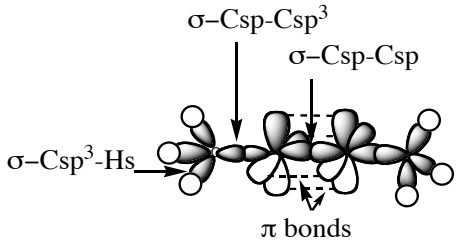
(b) $CH_3CH_2CH=CH_2$



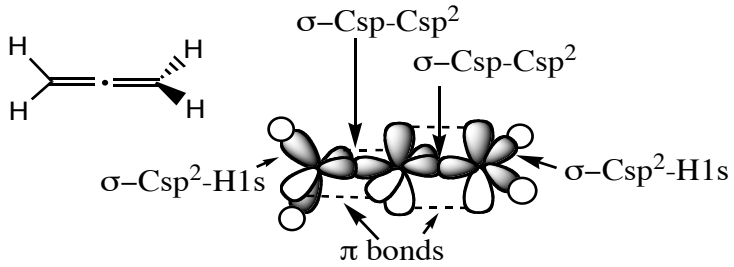


(c) $CH_3C\equiv CCH_3$



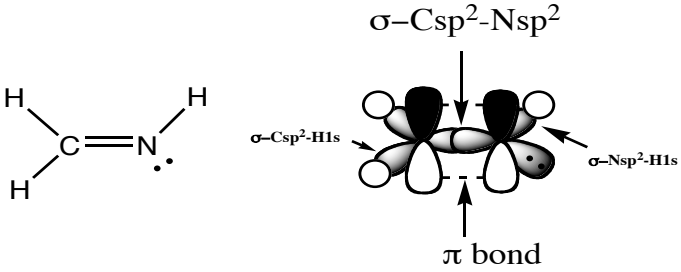


(d) $CH_2=C=CH_2$



(e)

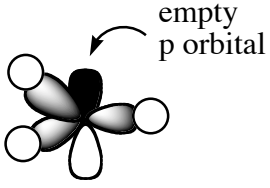
(f) $CH_2=NH$



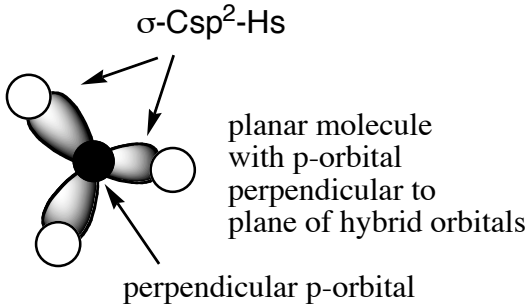
5. Draw an orbital diagram for the following species, showing the hydrid orbitals that combine to form bonds. Indicate the geometry of each:

(a) CH_3^+ planar:

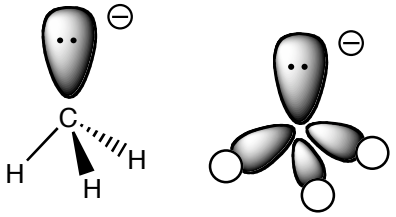
side view



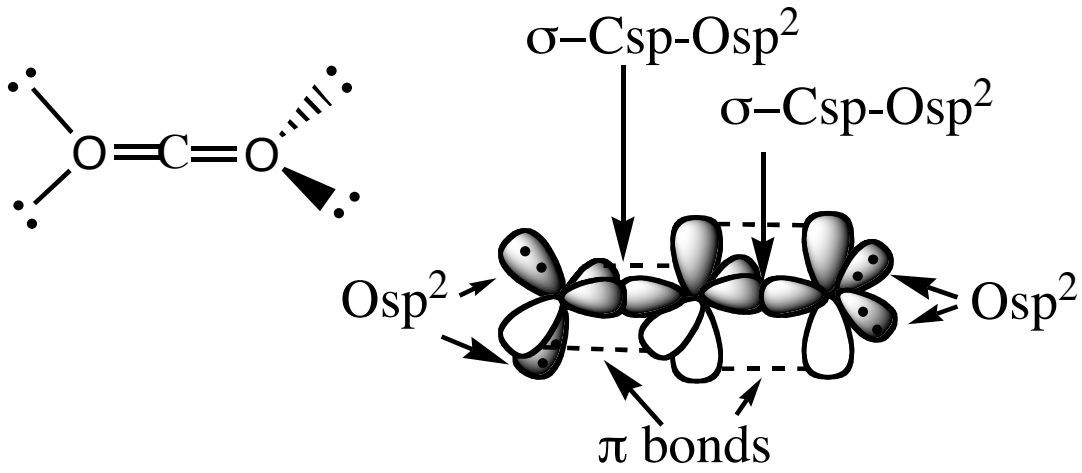
top view



(b) $H_3C:^-$; tetrahedral



(c) CO_2 linear



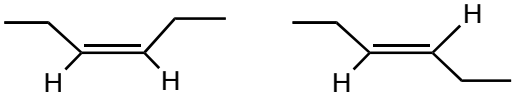
6. In which of the following molecules do you expect to observe cis/trans isomerism? Draw Lewis structures for the different possibilities.

(a) $CH_3CH_2CH_2CH_3$ No double bond, no cis/trans iomerism

(b) $(CH_3)_2C=CH_2$ Only one possibility, no cis-trans isomerism possible

(c) $CH_2=CHCl$ Again, only one possibility, no cis-trans isomerism possible

(e) $CH_3CH_2CH=CHCH_2CH_3$ yes, cis,trans possible:



cis trans