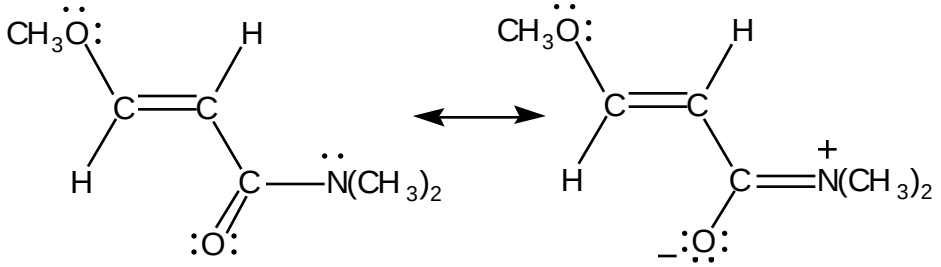
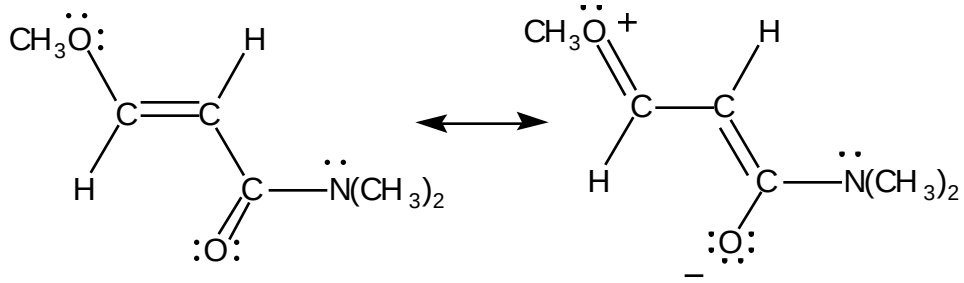
Answers to Hour examination #1, Chemistry 301-301A, 2003

1.

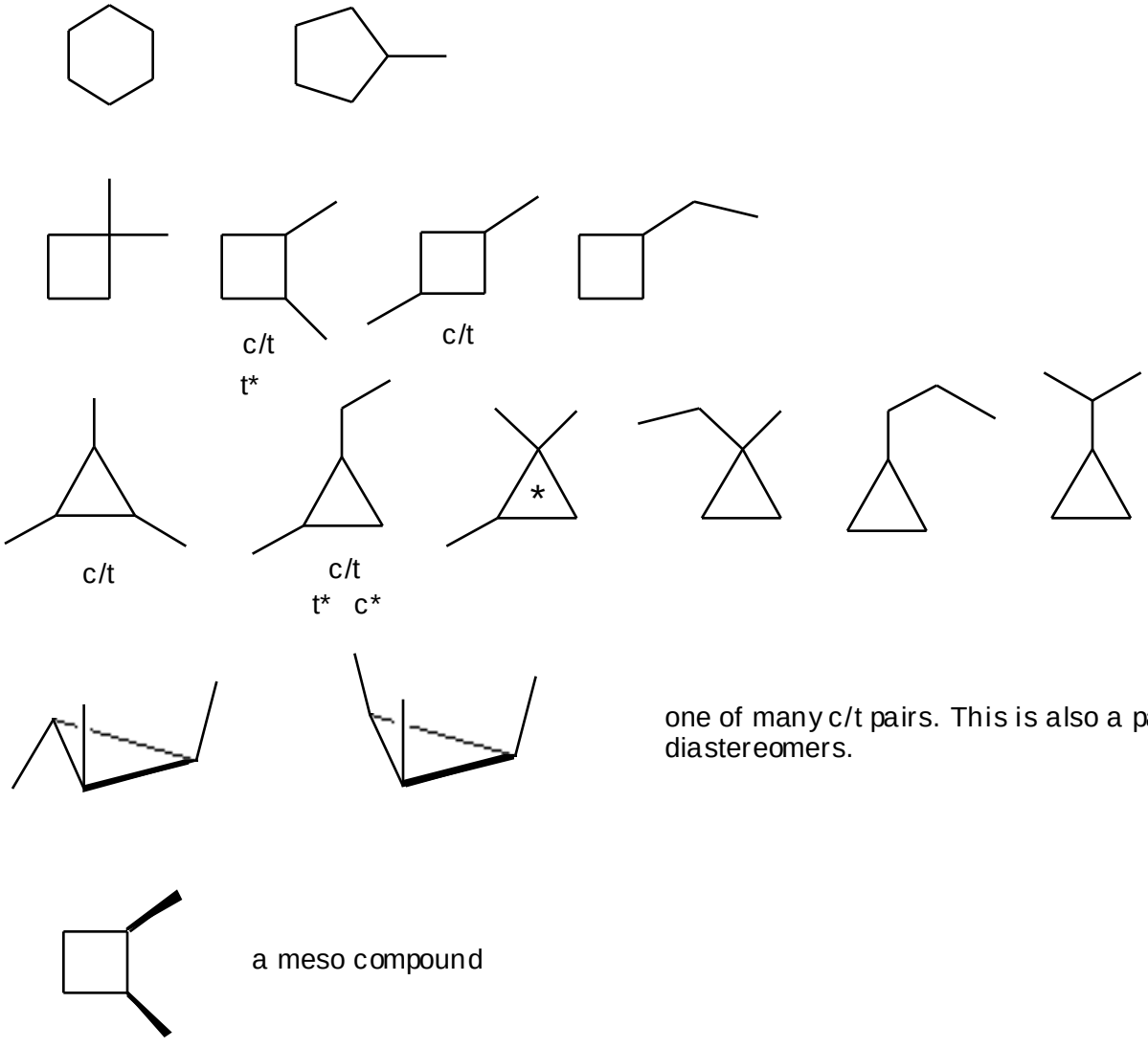
(a) yes
(b) no - atoms moved
(c) yes
(d) no - valence violated
(e) no - valence violated
(f) yes
(g) yes
(h) no - atoms moved

2.





3.

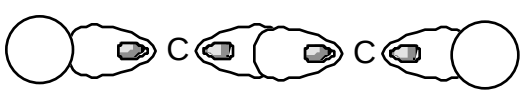


one of many c/t pairs. This is also a pair of diastereomers.

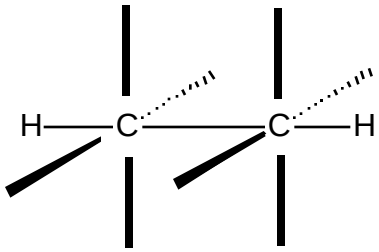
a meso compound

4. Each carbon must form two sigma bonds, one to the H and one to the other C. Accordingly, *sp* hybridization is appropriate. There are two perpendicular pi bonds, shown as wedges.

1*s* –*sp* *sp*-*sp* *sp* - 1*s*

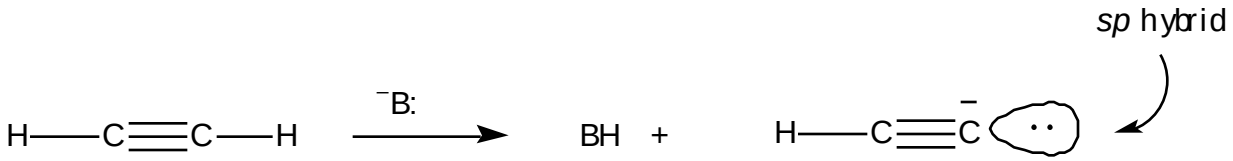


sigma system

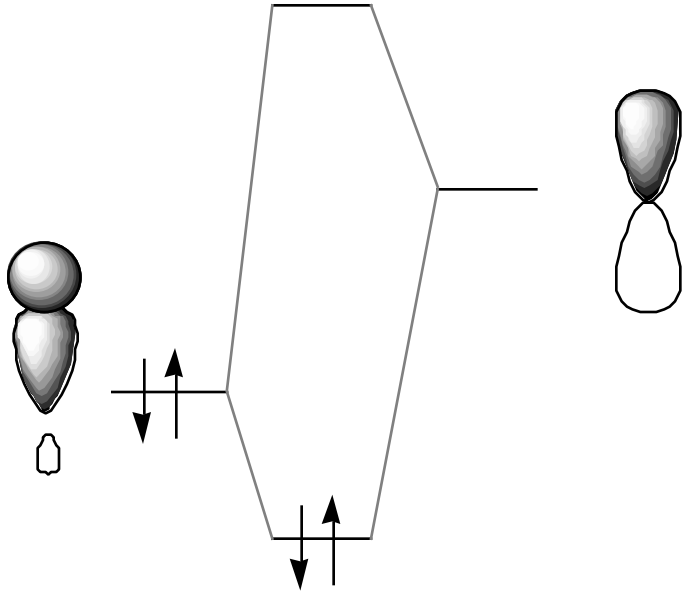


pi system

Alkynes are relatively strong acids because the lone pair electrons of the anion reside in a relatively low energy *sp* hybrid orbital, rather than in a relatively high energy sp^3 orbital (alkanes).

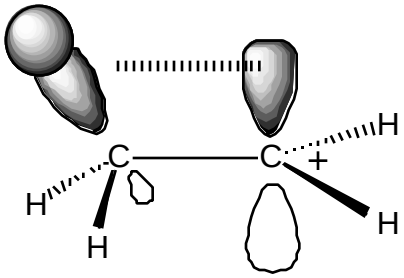


6. That filled C-H bond "wants" to line up with the empty 2*p* orbital of the carbocation. Interactions between filled and empty orbitals are stabilizing (see diagram).



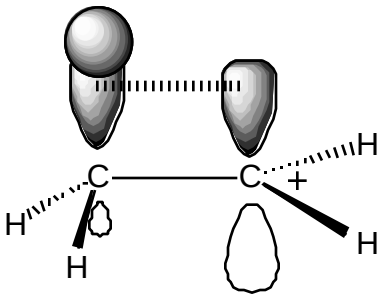
The C-H bond leans toward the other carbon because that helps increase the overlap between the C-H bond and the 2*p* orbital.

α ~ 109°



poorer overlap -
less stabilization

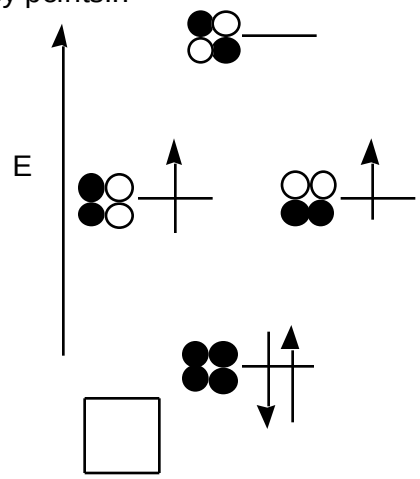
α ~ 90°



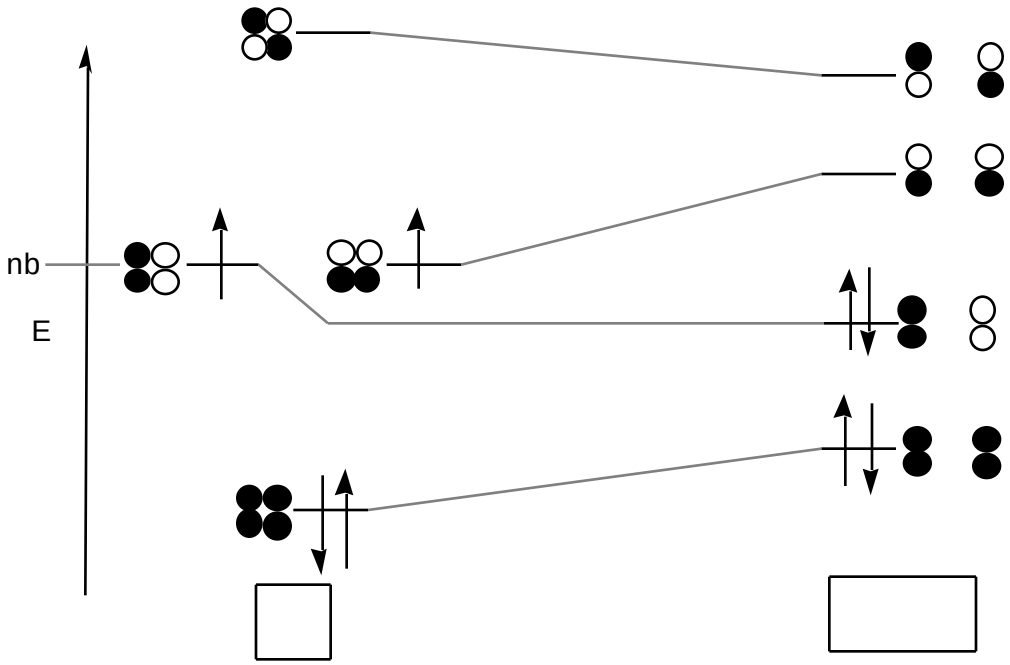
aligned for better overlap
more stabilization

5.

a) Easy points...



b) When a distortion occurs that lengthens a bonding interaction, orbital energy goes up. When a distortion occurs that lengthens an antibonding interaction, orbital energy goes down. An analogy is to compare Φ_A of H_2 with the nonbonding orbital of linear H_3...both have two lobes (derived from 1*s* orbitals) that are out of phase with each other. But, the nonbonding orbital of H_3 is lower than Φ_A of H_2 since the lobes are further apart, making the antibonding interaction weaker. So...



What you can see is that the two nonbonding orbitals of square H_4 have become one bonding and one antibonding orbital of rectangular H_4. Whereas square H_4 has only two electrons in bonding orbitals, rectangular H_4 has four electrons in bonding orbitals...so more electrons hold the molecule together than in the square case. This is the "motivation" for the Jahn-Teller distortion...more electrons in bonding orbitals when compared to what we started with, making rectangular H_4 lower in energy than square H_4.