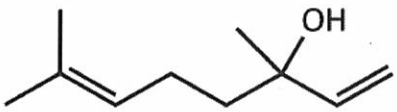
1. The natural product linalool is found in many fragrant plants and spices. It smells like citrus mixed with roses. (10 points)



a. What is the *molecular formula* for linalool? $C_{10}H_{18}O$

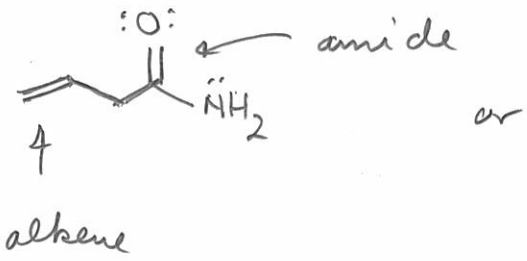
b. How many valence electrons does linalool have? Are they all shown in the structure above? If not, what's missing?

40 + 18 + 16 = 74
C H O

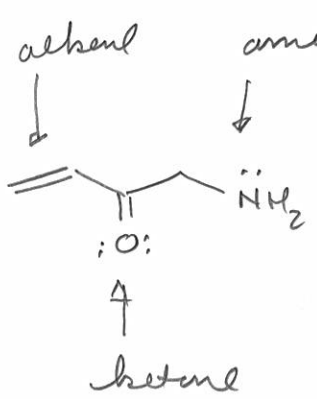
two lone pairs on the oxygen are not shown above

2. Draw a molecule that has the molecular formula C_4H_7NO. The structure must contain only the "common" functional groups discussed in Chapter 2 (it could have more than one!) and should be shown using *bond-line* structures *with lone pairs of electrons clearly shown*.

Also, name the *functional groups* shown in your structure. (20 points)



or



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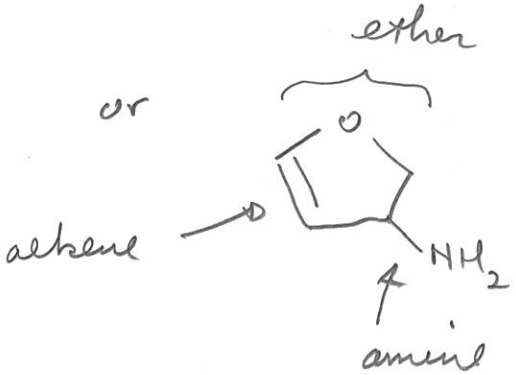
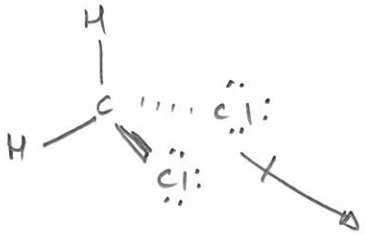


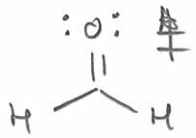
3. For the following molecules,

   a. Draw *bond-line* drawings that show the expected *geometry* (use dashes and wedges where necessary).
   b. In your structures, show all of the lone pairs of electrons.
   c. Indicate whether the molecule has a permanent dipole moment ($\mu \neq 0$ D), if it does, then indicate the direction of the overall dipole, or if it doesn't have a permanent dipole moment ($\mu = 0$ D) (15 points)

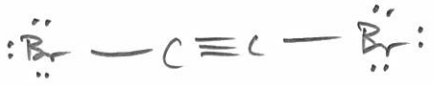
CH_2Cl_2



CH_2O

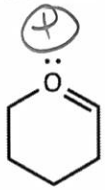


C_2Br_2

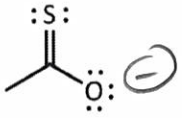


4. Assign formal charges (if non-zero) to the appropriate atoms in the following molecules (or ions). (Note that *all* lone pairs of electrons are shown in each structure) (10 points)

a.

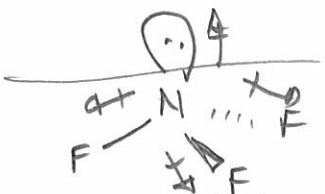


b.



5. Ammonia (NH_3) has a dipole moment (μ) of 1.42 D, whereas nitrogen trifluoride (NF_3) has a value of 0.234 D. Suggest a reason for the dramatic difference between these two otherwise similar molecules. (Hint: carefully consider the structure, polarity, and geometry) (10 points)

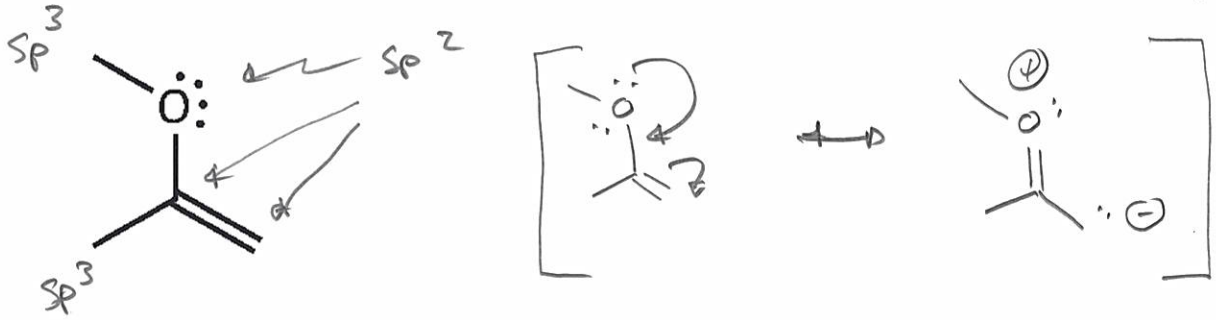
all dipoles contribute in same direction



lone pair and N-F dipoles partially cancel

bond dipoles, N-F, combine to give a net in opposite direction of electron pair dipole

6. Consider the structure shown below. (20 points)



a. Label the hybridization for each of the atoms (except hydrogen).

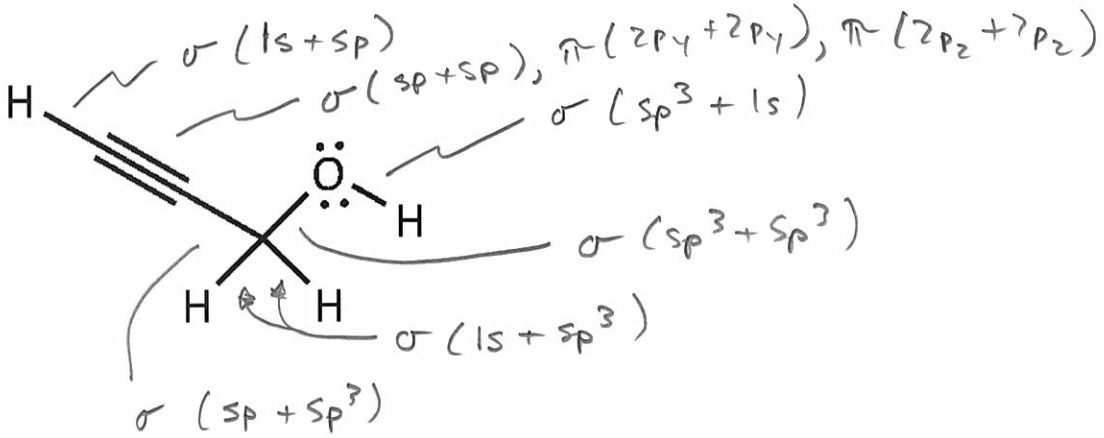
b. What type of atomic orbital(s) do both lone pairs on the oxygen occupy?

one L.P. is in 2p, the other is in sp^2 orbital

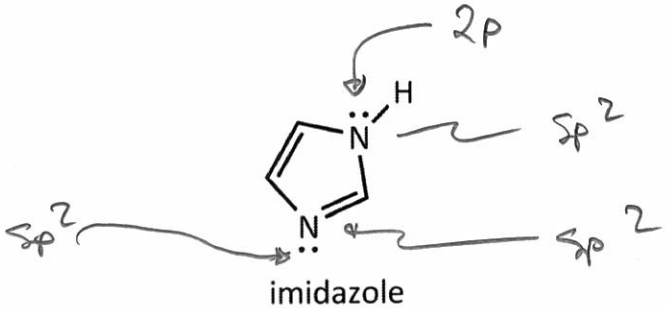
c. Is there a resonance structure for this compound? If so, show it using electron pushing.

Yes

7. For every bond in the molecule, indicate which *type* of bond it is (π or σ) and what atomic orbitals are used to form them (hybridized orbitals are considered atomic orbitals). Also, what type of orbitals are the lone pair of electrons in. (note: there are eight unique bonds that need identifying). (20 points

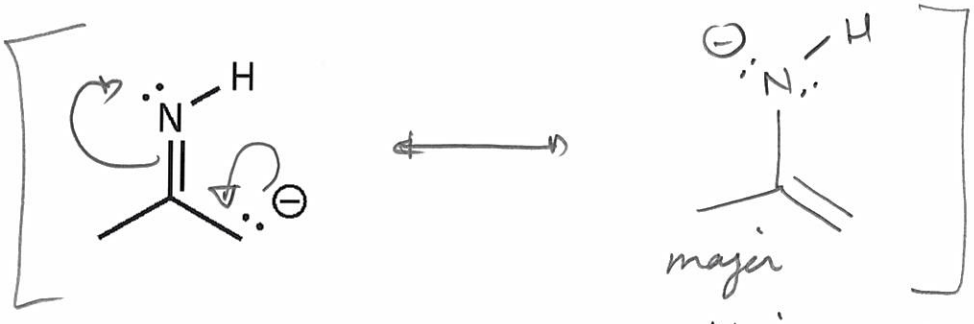


8. Imidazole is shown below. Indicate the hybridization for each of the nitrogen atoms and what type of orbital each of the lone pair of electrons is in. (10 points)



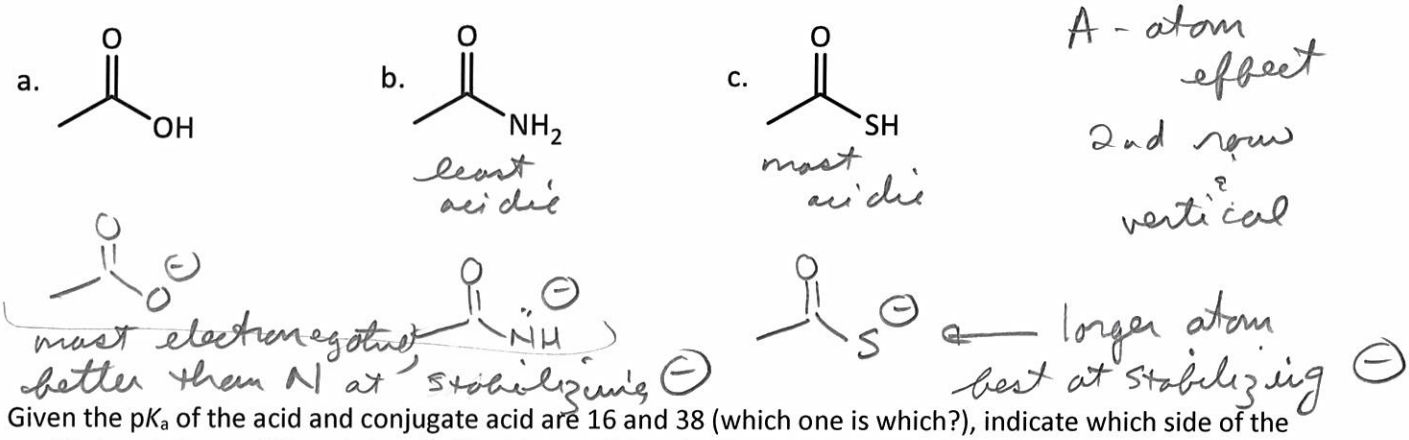
imidazole

9. Push electrons to show the other resonance form for the ion shown below. Circle the *major* resonance form and provide the reason for your choice. (10 points)



– N is more electronegative so holds L.P. better

10. Consider the three compounds below. Indicate which compound is the most acidic and which is the least acidic. Use ARIO to justify your answers (don't forget about the conj. bases) (20 points)



least acidic

most acidic

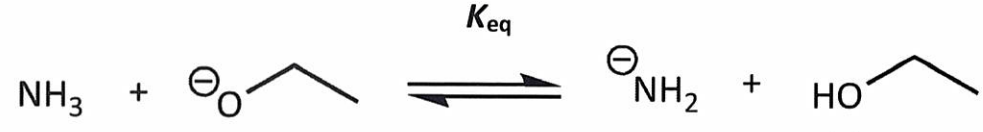
A - atom effect

2nd row vertical

most electronegative, better than N at stabilizing ⊖

longer atom best at stabilizing ⊖

11. Given the pK_a of the acid and conjugate acid are 16 and 38 (which one is which?), indicate which side of the equilibrium is favored (i.e., right or left). Also, explain why the data indicate this – be clear about this. Calculate the equilibrium constant (K_{eq}) – show your calculation. (15 points)



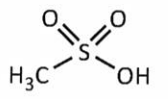
38 16

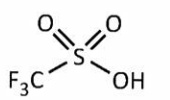
Nature favors weakest acid, which is NH_3 w/ the higher pKa value

Higher pKa means smaller Ka

$K_{eq} = 10^{16-38} = 10^{-22}$ which favors left side (by alot!)

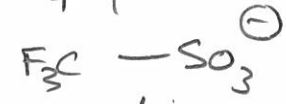
12. Trifluoromethanesulfonic acid (aka *triflic* acid) is one of the strongest known acids. Use ARIO to explain the difference in acidity between methanesulfonic acid and trifluoromethanesulfonic acid (don't forget about the conjugate base). (10 points)

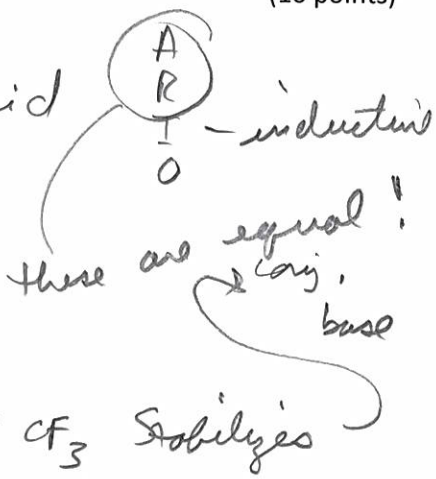




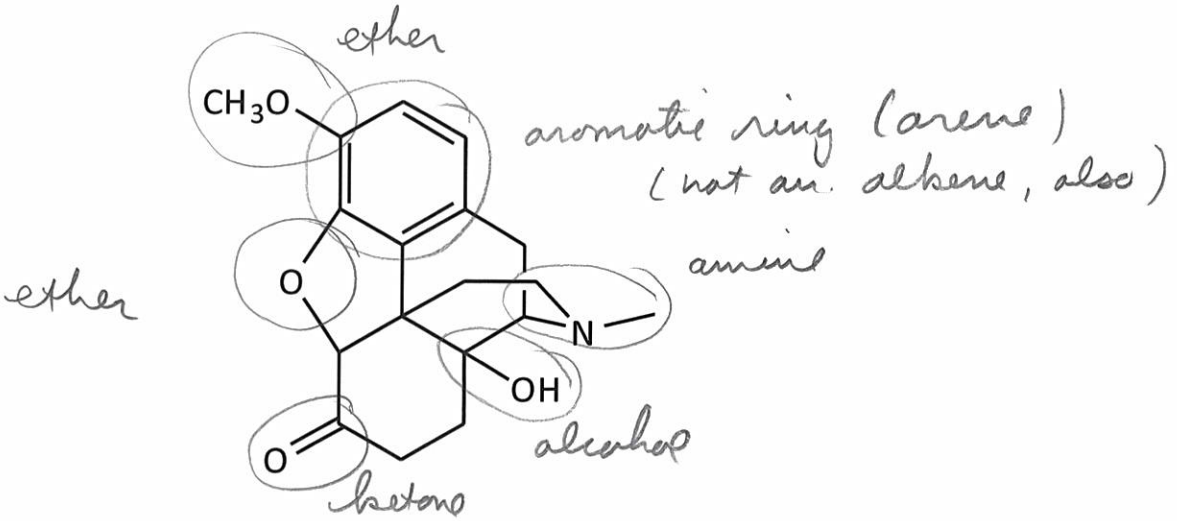
	H_3C–SO_3H	F_3C–SO_3H
pK_a	-2.6	-12
	methane sulfonic acid	trifluoromethane sulfonic acid

Stronger acid





13. Oxycodone is a "semi-synthetic" product derived from opium poppy extracts. It is a widely prescribed (and abused) narcotic pain killer that is the active ingredient in OxyContin®. Circle and identify as many of the common functional groups as you can. (30 points)



oxycodone