Organic Chemistry Peer Tutoring Department
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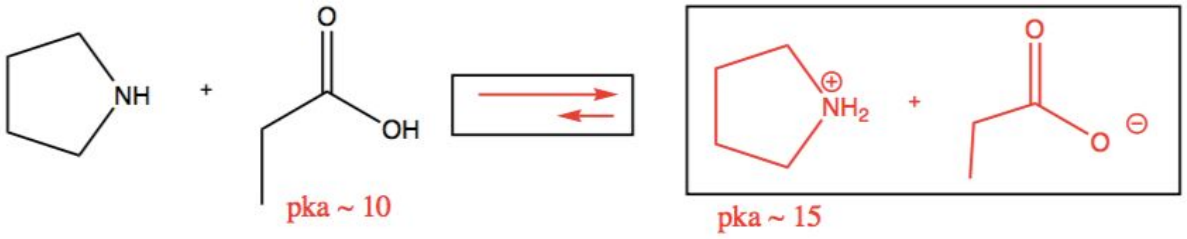
Chem 51A
Professor King
https://sites.uci.edu/ochemtutors/

Midterm 1 Review Worksheet

1. Complete the following acid-base reaction and use an arrow to indicate which direction the equilibrium lies. Use the pKa values rounded to the nearest 5 to help determine the answer. Give the approximate ratio of reactants to products at equilibrium.



Approximate ratio: $1:10^5$

Remember: An acid can be deprotonated by the conjugate base of any acid having a higher pKa.

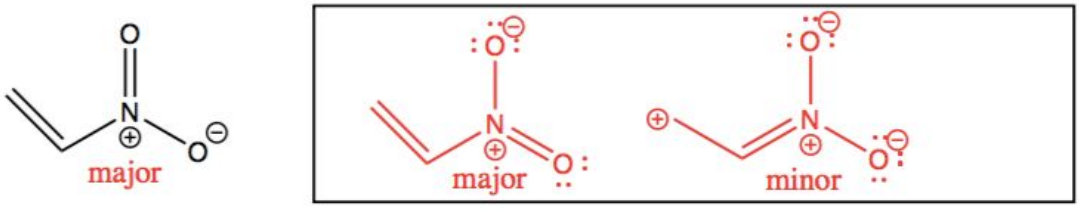
Use the approximate pKA values table to determine the pKas of the structure in order to assign bases/acids.

Equilibrium is always favored in the direction in which the weaker acid is formed. The larger the pKa of an acid, the weaker the acid is. Therefore, the reaction favors the products, because the conjugate acid has a pKa 15, which is higher than a pKa of 10.

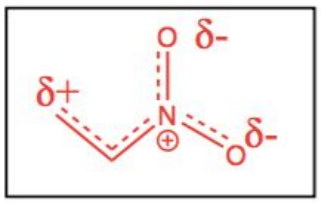
Because this reaction is product favored, we will be following the ratio form of $1: 10^x$.

$x = 15\text{-}10 = 5$

2. Draw all the possible resonance structures for the following molecule. Label the resonance structures as major or minor. Finally, draw the hybrid structure.



hybrid stucture:



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When drawing resonance structures, look for **π bonds** & **lone pairs.**

- Always remember the two commandments:
  1. Thou shalt not break a single bond when drawing resonance
  2. Thou shalt not exceed an octet for 2nd row elements
- Remember:
  - Its okay to have a C without an octet but **NEVER** draw O, N, or halogens without an octet
  - **NEVER** draw a resonance structure w a 2+ or 2- charge

TIP: make sure to draw all lone pairs in before drawing resonance structures.

REMEMBER THESE RULES :

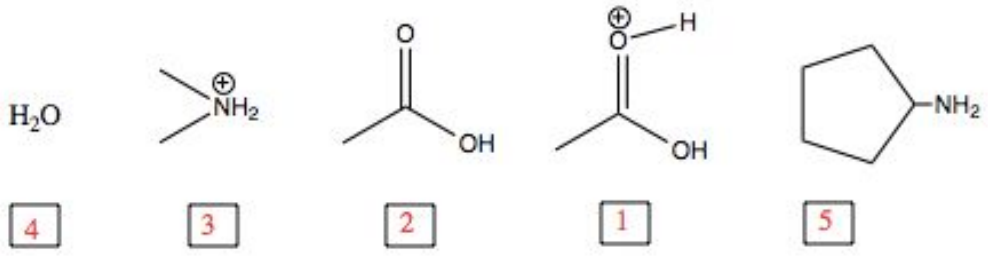
(in order of importance)

1. Structures with more bonds and fewer changes are more stable
2. Structures in which every atom has an octet are more stable
3. Structures that places negative charge on more electronegative atoms are more stable

Drawing a Hybrid:

1. Draw all single bonds
2. Draw dotted lines for π bonds changing locations/not showing in every resonance structure
3. Draw partial charges for charges changing locations/ not showing in all (use symbols δ+ or δ-)
4. Leave out lone pairs

3. Rank the following in order of decreasing acidity. (1 = strongest acid)



TIP: always begin by assigning approximate pKa values

If you are unable to determine acidity from approximate pKa values alone, use the following steps:

1. Identify atoms bound to the acidic hydrogens & use period trends to assign relative acidity (element effect)
2. If the two H's are bound to the same atom, draw the conjugate bases and look for other points of differences (inductive effects, resonance effects, hybridization effects)

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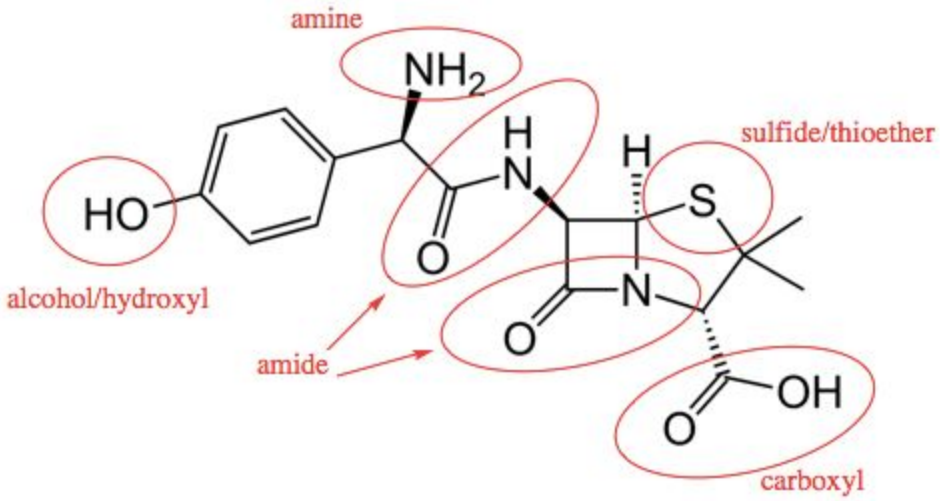
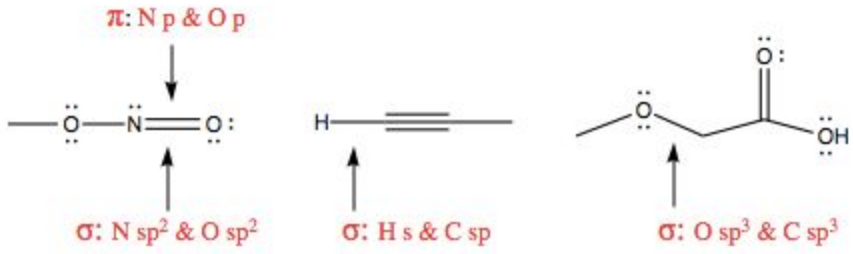
4. Circle and label all the functional groups in *amoxicillin.*



5. Use the above molecule to answer the following questions
   a. How many pi bonds are in *amoxicillin* ? 6 pi bonds
      Double bonds consist of one sigma bond & one pi bond
   b. Which bond is the most polar ? the O-H bond in the carboxylic acid

6. For the indicated bonds below, label the types of bond and atomic orbitals that overlap to make that bond.σ



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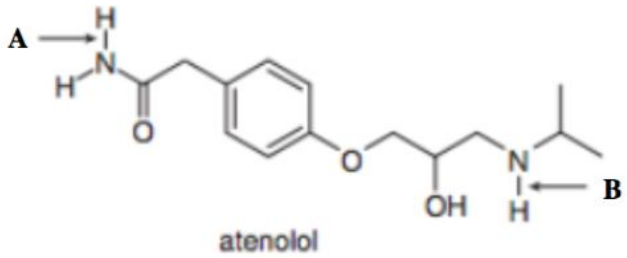
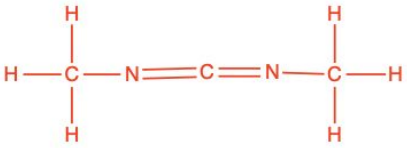
7. *Atenolol* is a β (beta) blocker, a drug used to treat high blood pressure. Which of the indicated N – H bonds is more acidic? Explain your reasoning.

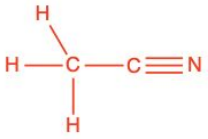


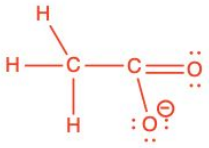
A is more acidic due to the resonance effect. A is part of an amide group, so the conjugate base would be more stable due to the delocalization of the electrons in the C=O pi bond to form resonance structures. The acidity of H-A increases when conjugate base, $A:^-$ is resonance stabilized.

8. Draw a lewis structure for each of the following molecules and assign charges if applicable.

a. CH_3NCNCH_3 b. C_2H_3N c. $[C_2H_3O_2]^-$







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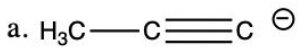
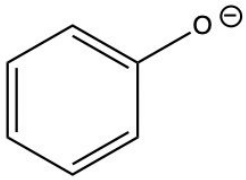
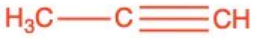
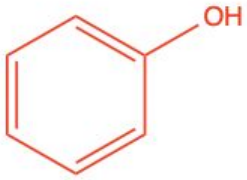
9. Draw the structure of the conjugate acid of each of the following compounds.

a. 

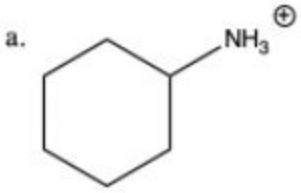
b. 

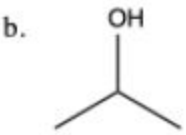
c. 

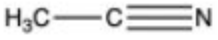


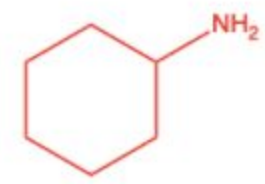


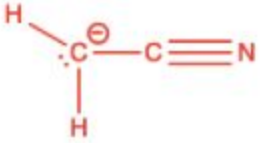
10. Draw the structure of the conjugate base of each of the following compounds.

a. 

b. 

c. 

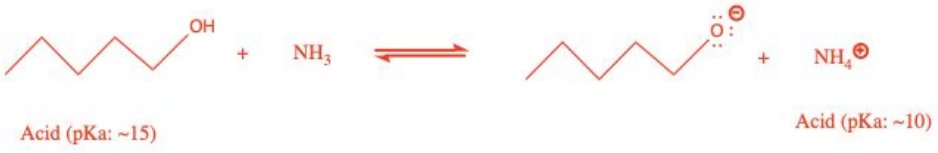




11. Define the following terms:
    a. Bronsted-Lowry Acid: A species that donates a proton (H+).
    b. Bronsted-Lowry Base: A species that must be able to form a new bond with a proton, must contain an available electron pair that can easily be donated to form this new bond.
    c. Polar Covalent Bond: Bonding electrons are NOT shared equally (two atoms with different electronegativities).
    d. Nonpolar Covalent Bond: Bonding electrons are shared equally (both atoms have the same electronegativity).
    e. Resonance Hybrid Structure: The “net” sum of valid resonance structures, represents the overall delocalization of electrons within the molecule.

f. Lewis Structure - Diagrams that show connectivity and the location of all bonding and non-bonding electrons as well as formal charges.

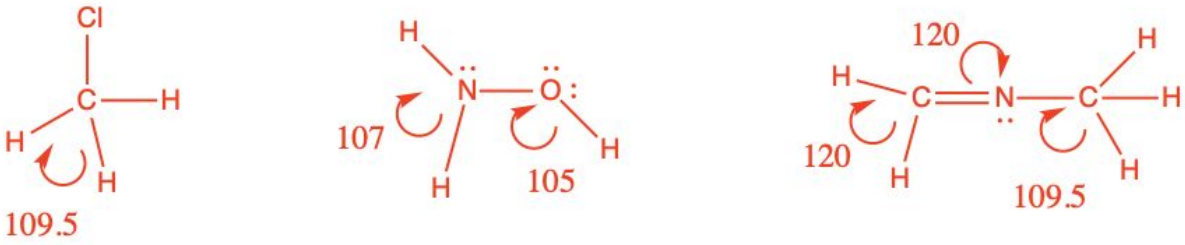
12. Draw the products of the following acid-base reaction and determine if the equilibrium favors the reactants or products.



Acid-base reactions favor the formation of the weaker acid/base. The larger the pKa, the weaker the acid. With this in mind, the equilibrium favors the reactants.

13. Predict the bond angles in each compound.

a. CH_3Cl b. NH_2OH c. $H_2C{=}{=}NCH_3$



14. Rank the conjugate bases of the following acids in order of increasing basicity.

a. NH_3 b. H_2O c. CH_4

2 1 (least basic) 3 (most basic)

A larger pKa corresponds to a weak acid and thus, a stronger conjugate base.

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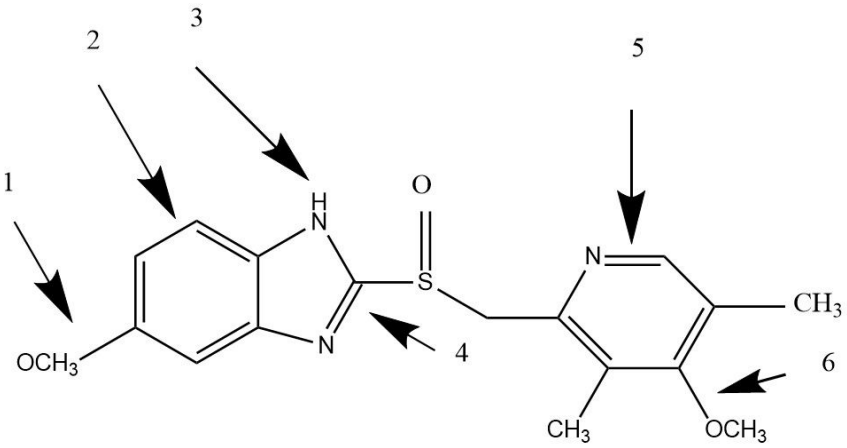
15. Omeprazole is a proton-pump inhibitor used to reduce the amount of stomach acid your body makes.



a. Label all of the indicated functional groups in the chemical structure of Omeprazole above.
   1. Ether, 2. Benzene ring, 3. Amine, 4. Imine, 5. Imine, 6. Ether

b. Describe the hybridization of all of the double bonds and state the number of sigma and pi bonds.
   Benzene ring (C=C bonds): 3 pi bonds total, and 2 pi bonds total in the second aromatic ring
   Overlapping in each pi bond: 1 sigma bond: Overlap of Csp^2 and Csp^2 and 1 pi bond: overlap of Cp and Cp.
   2 C=N bonds: 1 sigma bond: Overlap of Csp^2 and Nsp^2 and 1 pi bond: overlap of Cp and Np.
   S=O bond: 1 sigma bond: Overlap of Ssp^2 and Osp^2 and 1 pi bond: overlap of Sp and Op.

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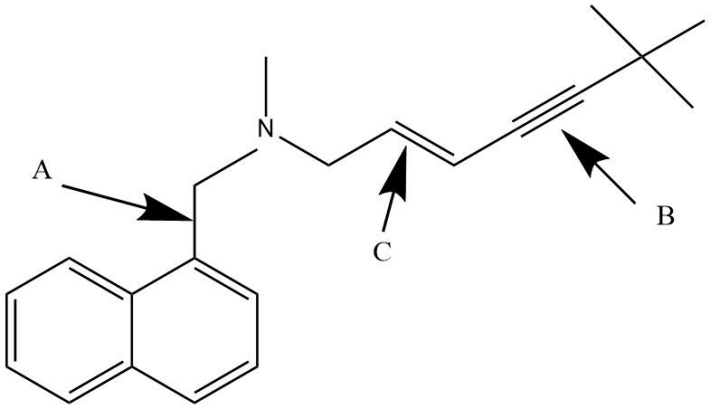
16. Terbinafine is an antifungal drug used to treat fungal infections of the scalp. Of the labeled bonds below, order the bonds from strongest to shortest (with 1 being the strongest).



B > C > A
The triple bond is the strongest bond listed due to the optimal overlapping, followed by the double bond and the single bond is the weakest.

17. For the structure of Terbinafine above, state the molecular geometry, hybridization, and approximate bond angle for the nitrogen atom.

Molecular geometry: trigonal pyramidal (due to the lone pair present on the nitrogen atom)
Hybridization: sp^2
Approximate bond angle: little less than 120° (due to the lone pairs on nitrogen)

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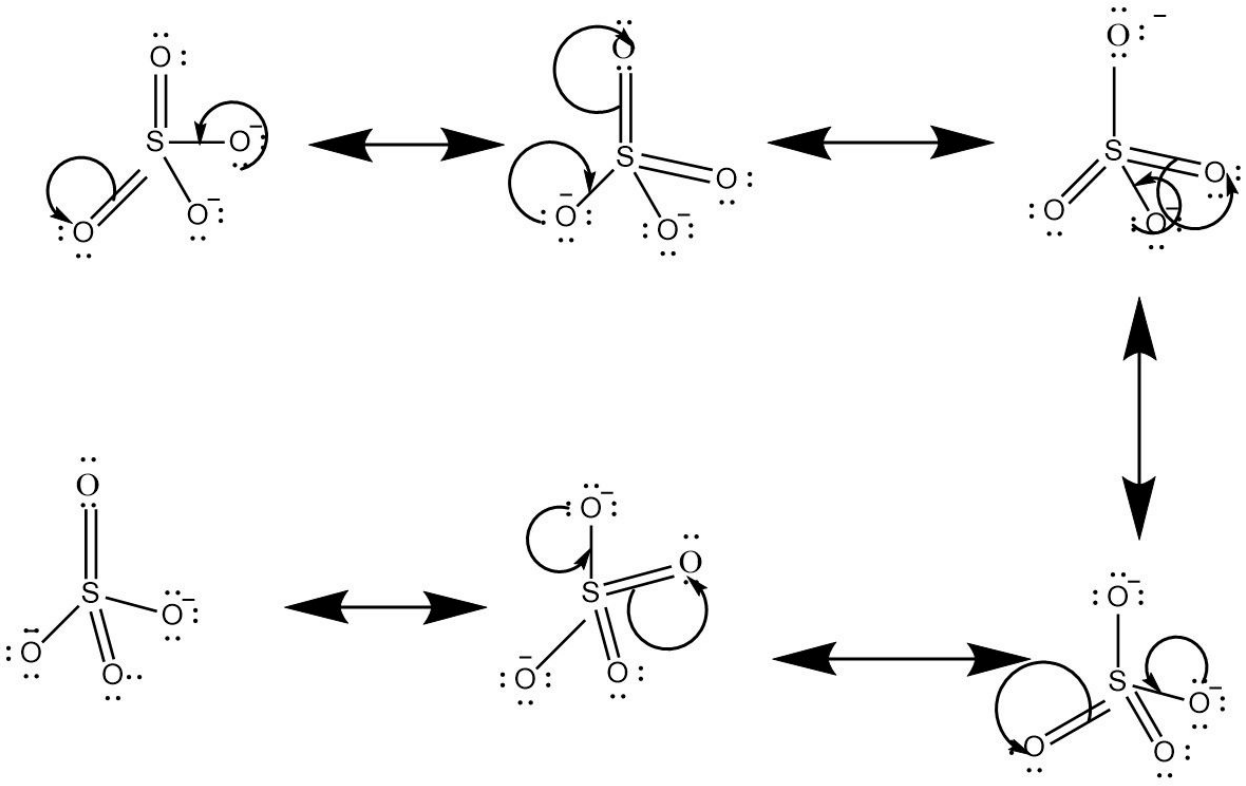
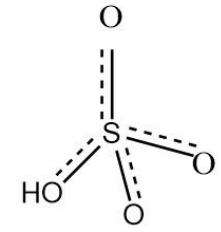
18. Draw all the possible resonance structures for the following compound. Be sure to include all lone pairs and formal charges. Then, draw the corresponding hybrid structure.





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Definitions/Things to Memorize!

19. The more bonds and fewer charges when drawing resonance structures are:
    More stable or Less stable

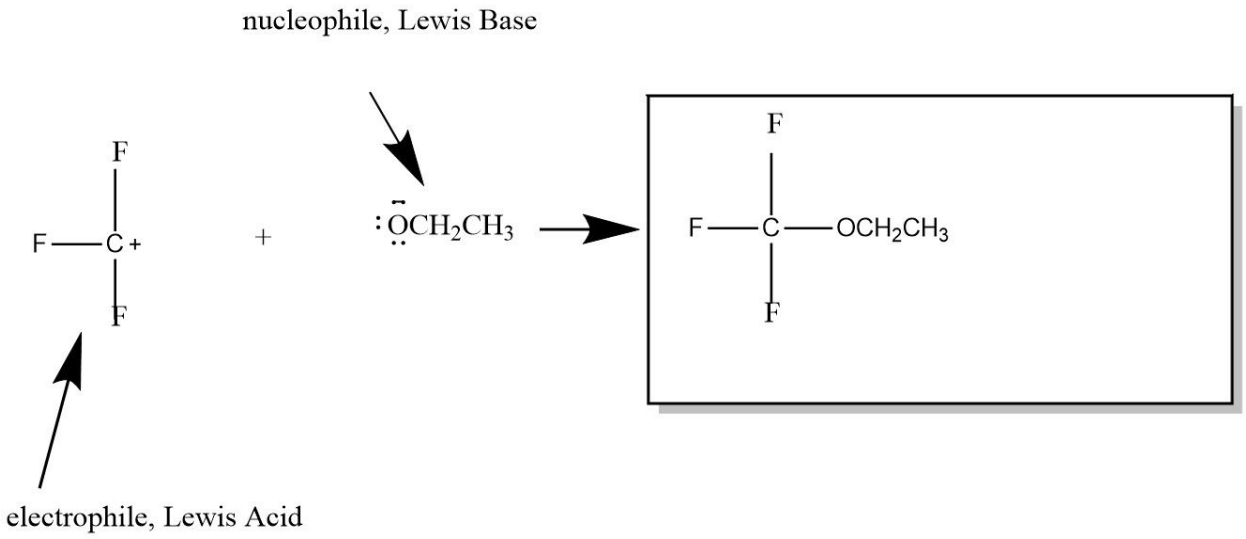
    Strong acids have WEAK _conjugate bases

    Weak acids have STRONG _conjugate bases

20. Acid-Base Reactions Tips:

- At equilibrium, the weaker acid and the weaker base are favored.
- pKa values can be used to determine the ratio of reactants to products at equilibrium.

Predict the products for the following acid-base reaction and identify the electrophile, nucleophile, lewis acid, and lewis base.



GOOD LUCK!!!