

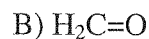
1. (5 pts) Draw the best Lewis structure for the following molecule. Show all valence electrons and all formal charges.



2. (5 pts) Draw a Lewis structure for  $\text{C}_2\text{H}_6\text{O}$ . (Note: there are two constitutional (structural) isomers possible for a molecule with this formula. You only need to draw one of them).

3. (8 pts) For the following molecules (given as condensed structural formulas) give the

- electronic geometry around the central atom
- molecular geometry around the central atom
- hybrid orbitals used in bonding by the central atom
- bond angles indicated



a) \_\_\_\_\_

a) \_\_\_\_\_

b) \_\_\_\_\_

b) \_\_\_\_\_

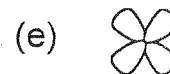
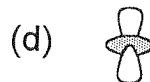
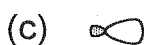
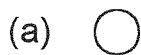
c) \_\_\_\_\_

c) \_\_\_\_\_

d) C-N-H bond angle \_\_\_\_\_

d) H-C-O bond angle \_\_\_\_\_

4. (3 pts) Which of the following represent a hybridized atomic orbital?



5. (5 pts) Give the products of the following acid-base reaction and indicate the direction of the equilibrium.



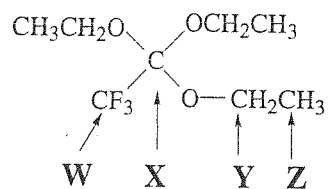
6. (3 pts) Which compound has the longest bond between adjacent carbon atoms?

- (a)  $\text{CH}_3\text{—CH}_3$     (b)  $\text{CH}_2=\text{CH}_2$     (c)  $\text{HC}\equiv\text{CH}$     (d)  $\text{CH}_3\text{—CH=CH}_2$     (e)  $\text{CH}_2=\text{C}=\text{CH}_2$

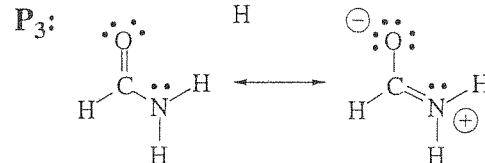
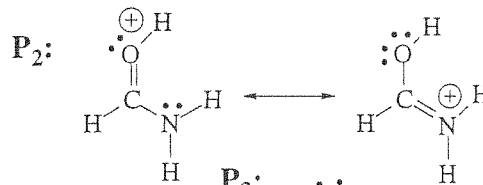
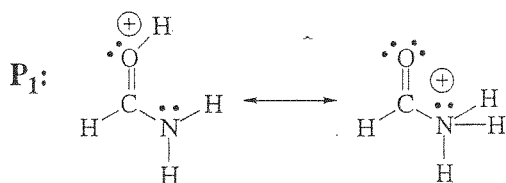
7. (5 pts)  $\text{CF}_3\text{NH}_2$  is a *weaker* base than  $\text{CH}_3\text{NH}_2$ . **Briefly** explain why this is the case.

8. (4 pts) The four carbon atoms (**W**, **X**, **Y**, **Z**) of the compound shown here have very different electron densities. What is the order of electron densities ranked from the **least** electron rich carbon (most  $\delta^+$ ) to the **most** electron rich carbon (least  $\delta^+$ )?

- a)  $\text{W} > \text{X} > \text{Y} > \text{Z}$                       b)  $\text{X} > \text{W} > \text{Y} > \text{Z}$   
c)  $\text{Z} > \text{Y} > \text{X} > \text{W}$                       d)  $\text{X} > \text{W} > \text{Y} > \text{Z}$



9. (3 pts) Which of the following pairs of structures represent resonance forms?



- a)  $\text{P}_1, \text{P}_2, \text{P}_3$                       b)  $\text{P}_1, \text{P}_2$                       c)  $\text{P}_2, \text{P}_3$                       d)  $\text{P}_2$  only

10. (3 pts) Which statement is NOT true of resonance structures?

- a) The arrangement of nuclei in all contributing structures must be the same.  
b) The arrangement of electrons in each contributing structure is different.  
c) Each atom in a contributing structure must have a completed valence shell.  
d) The contributing structures may have different energies.  
e) All contributing structures must have the correct number of valence electrons.

11. (3 pts) Those second-row elements which form pi ( $\pi$ ) bonds do so by use of:

- a) sigma ( $\sigma$ ) orbitals      b) 2s orbitals      c) 2p orbitals      d) 2d orbitals

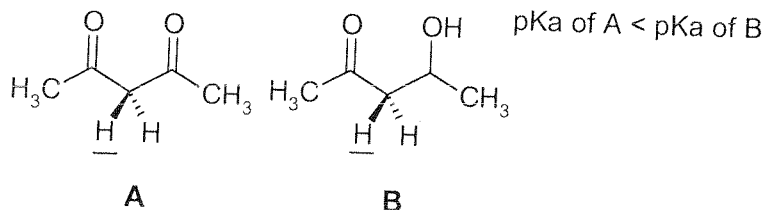
12. (3 pts) Which anion is the strongest base?

- a)  $\text{CH}_3\text{CH}_2\text{O}^-$       b)  $\text{CH}_3\text{CH}_2^-$       c)  $\text{Cl}^-$       d)  $\text{CH}_3\text{CO}_2^-$

13. (3 pts) Which statement best describes this reaction?  $\text{NH}_3 + \text{BF}_3 \rightleftharpoons \text{H}_3\text{N}^+\text{BF}_3^-$

- a) an acid base reaction where  $\text{NH}_3$  acts as a Bronsted-Lowry acid  
b) an acid base reaction where the  $\text{NH}_3$  acts as a Bronsted-Lowry base.  
c) an acid base reaction where the  $\text{NH}_3$  acts as a Lewis acid.  
d) an acid base reaction where the  $\text{NH}_3$  acts as a Lewis base.  
e) none of the above adequately describe the reaction.

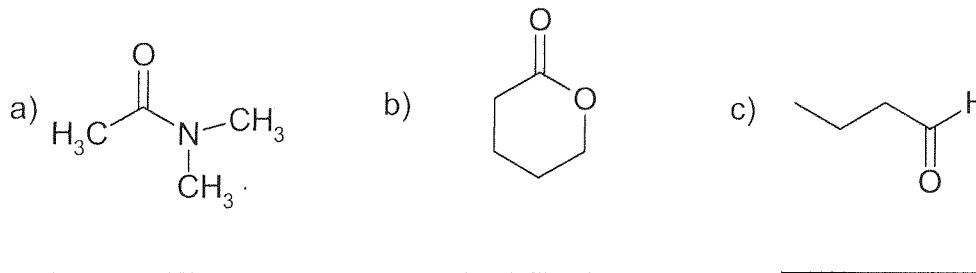
14. (6 pts) The  $\text{pK}_a$  for the loss of the underlined proton in structure **A** is **lower** than the  $\text{pK}_a$  for the loss of the indicated proton in structure **B**. Explain why this is the case.



15. (3 pts) Which of these compounds would exhibit hydrogen bonding for intermolecular forces?

- a)  $\text{CH}_3\text{CH}_2\text{F}$                       b)  $\text{CH}_3\text{CH}_2\text{OCH}_3$                       c)  $(\text{CH}_3)_3\text{N}$   
d)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$                       e)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$

16. (6 pts) Give the functional group of each molecule.

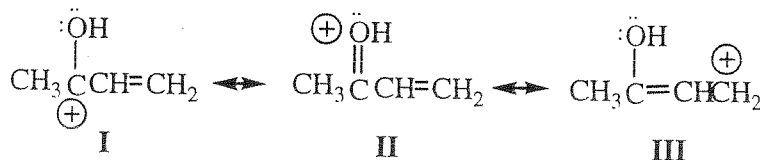


17. (3 pts) Which statement(s) is (are) true regarding molecular orbitals?

- a) The number of molecular orbitals is the same as the number of atomic orbitals from which they are derived.
- b) Bonding molecular orbitals have nodes (regions of no electron density) between the two nuclei of the bonded atoms.
- c) Antibonding molecular orbitals have the same energy as bonding molecular orbitals.
- d) a and b
- e) a, b and c

18. (5 pts) Explain what "orbital hybridization" means.

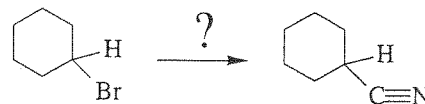
19. (6 pts) Choose the most important resonance structure for the molecule described by the 3 structures below. Discuss why you made your choice and why the other two structures are not as important.



20. (3 pts) Which of the following is NOT true.

- a) All Bronsted-Lowry bases are also Lewis bases.
- b) All Bronsted-Lowry acids are also Lewis acids.
- c) The strength of an acid refers to the degree it ionizes.
- d) The conjugate acid of a very weak base is strong.
- e) A strong acid has a high pKa.

21. (3 pts) What reagent can best give the change shown here?



a) NaCN

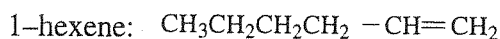
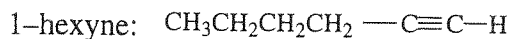
b) HCN

c) HBr

d) NaBr

e) CNBr

22. (4 pts) The electrophilic addition reaction of HBr to 1-hexyne is *significantly* slower than for 1-hexene.

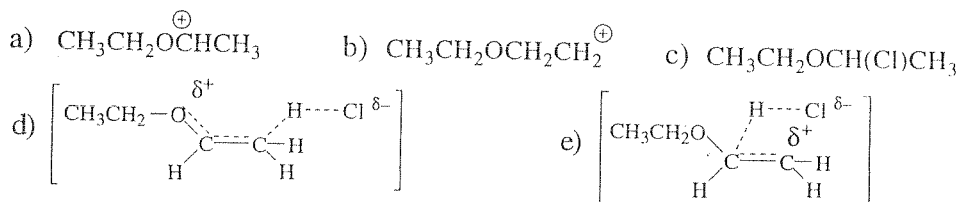
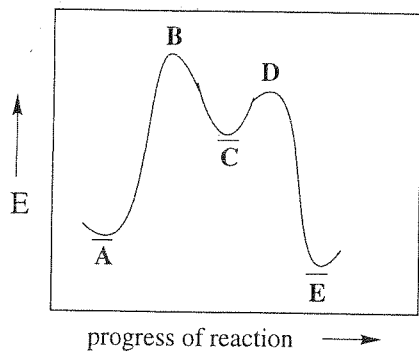


Which of the following statements is supported by this observation?

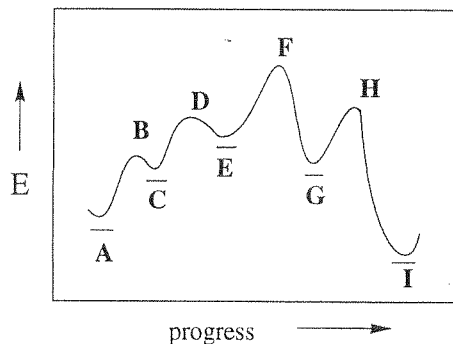
- The reactive intermediate from the 1-hexyne reaction is lower in energy than that from the 1-hexene reaction.
- The reaction product from the 1-hexene reaction ~~of~~ <sup>is</sup> more stable than that from the 1-hexyne reaction.
- The energy of activation for the protonation of 1-hexene is lower than that for the protonation of 1-hexyne.

a) 1 only      b) 2 only      c) 3 only      d) 1 and 2 only      e) 1 and 3 only

23. (4 pts) The electrophilic addition of HCl to ethyl vinyl ether ( $\text{CH}_3\text{CH}_2\text{OCH}=\text{CH}_2$ ) can be represented by an energy diagram. Which of the following corresponds to point B on the diagram?



24. (4 pts) Assuming that all of the steps shown on this energy diagram are reversible, what can be said about the overall transformation of A to I?



- $K_{\text{EQUILIBRIUM}} = [\text{A}]/[\text{I}]$  is greater than 1, and  $\Delta G^\circ$  is greater than 0.
- $K_{\text{EQUILIBRIUM}} = [\text{A}]/[\text{I}]$  is greater than 1, and  $\Delta G^\circ$  is less than 0.
- $K_{\text{EQUILIBRIUM}} = [\text{I}]/[\text{A}]$  is less than 1, and  $\Delta G^\circ$  is less than 0.
- $K_{\text{EQUILIBRIUM}} = [\text{I}]/[\text{A}]$  is greater than 1, and  $\Delta G^\circ$  is greater than 0.
- $K_{\text{EQUILIBRIUM}} = [\text{I}]/[\text{A}]$  is greater than 1, and  $\Delta G^\circ$  is less than 0.