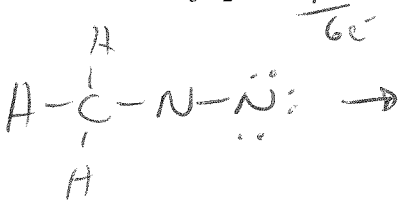
Chem 2061 – Fall 2007 – **Exam #1** Name KEY

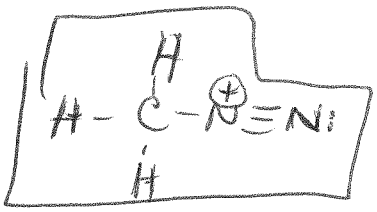
1. (5 pts) Draw the best Lewis structure for the following molecule. Show all valence electrons and all formal charges.

$CH_3N_2^+$

Val. e⁻
4
3
10
−1
16e⁻

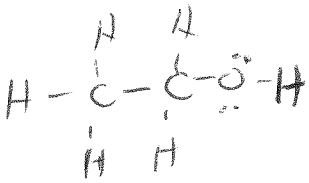
16
10
6e⁻



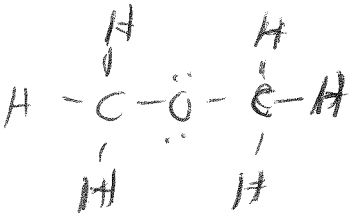


2. (5 pts) Draw a Lewis structure for C_2H_6O. *(Note: there are two constitutional (structural) isomers possible for a molecule with this formula. You only need to draw one of them).*

Val e⁻
8
6
6
20e⁻
−16
4e

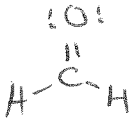


or

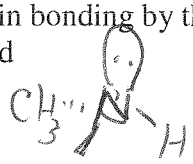


3. (8 pts) For the following molecules (given as condensed structural formulas) give the

a. electronic geometry around the central atom
b. molecular geometry around the central atom
c. hybrid orbitals used in bonding by the central atom
d. bond angles indicated



A) $(CH_3)_2\ddot{N}H$

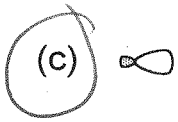


a) tetrahedral
b) trigonal pyramidal
c) sp^3
d) C-N-H bond angle 109.5°

B) $H_2C{=}\ddot{O}$

a) trigonal planar
b) trigonal planar
c) sp^2
d) H-C-O bond angle 120°

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

(a)  (b)  (c)  (d)  (e) 

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

$CH_3CH_2OH + NH_2^- \rightleftharpoons CH_3CH_2O^- + NH_3$

$pK_a \cong 16$ $pK_a \cong 35$

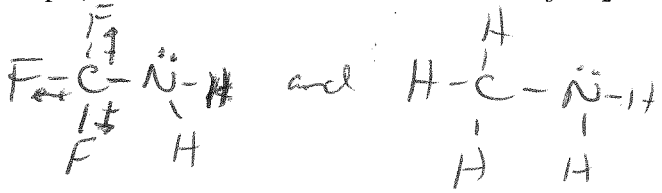
goes from strong acid to weak acid

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

(a) $CH_3—CH_3$ (b) $CH_2=CH_2$ (c) $HC\equiv CH$ (d) $CH_3—CH=CH_2$ (e) $CH_2=C=CH_2$

sp^3-sp^3 sp^2-sp^2 sp-sp sp^3-sp^2 sp^2-sp sp-sp^2

7. (5 pts) CF_3NH_2 is a *weaker* base than CH_3NH_2. **Briefly** explain why this is the case.

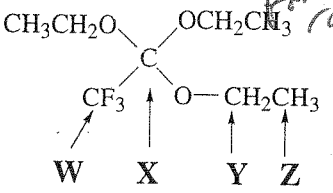


The fluorine groups are more electronegative on CF_3NH_2 than the Hs on CH_3NH_2. This makes the lone pair e⁻ density less available because some of the electron density is pulled along the bonds by the inductive effect + thus spread by the field effect - away from the nitrogen. Because e⁻ density is pulled away, it is less available for protonation & therefore CF_3NH_2 is a weaker base.

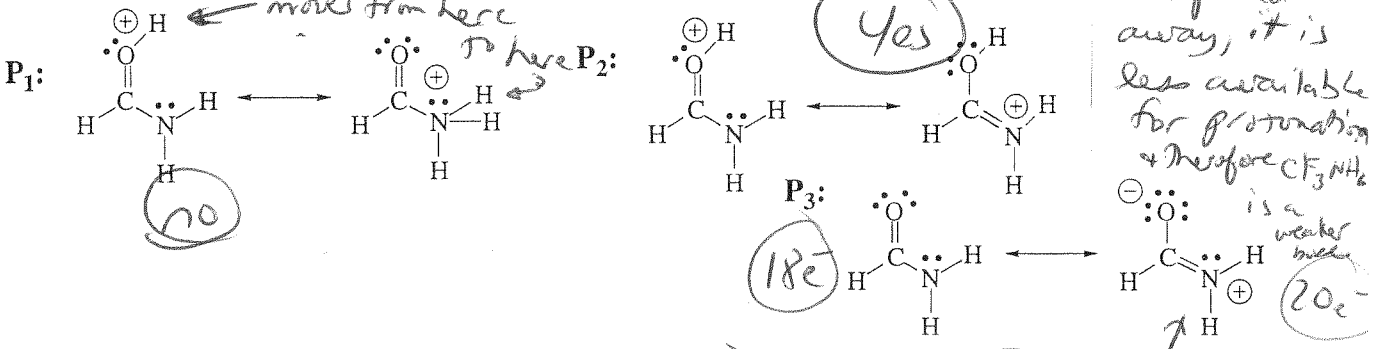
8. (4 pts) The four carbon atoms (**W, X, Y, Z**) of the compound shown here have very different electron densities. What is the order of electron densities ranked from the **least** electron rich carbon (most δ+) to the **most** electron rich carbon (least δ+)? Use most δ+ + least δ+ for ranking

a) **W > X > Y > Z** b) **X > W > Y > Z**

c) **Z > Y > X > W** ~~d) X > W > Y > Z~~



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



a) P_1, P_2, P_3 b) P_1, P_2 c) P_2, P_3 d) P_2 only

5 bonds to Nitrogen

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 ~~for~~ form pi (π) bonds do so by use of:

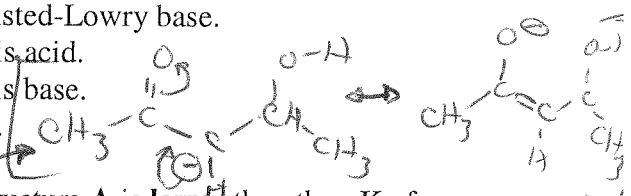
a) sigma (σ) orbitals b) 2s orbitals c) 2p orbitals d) 2d orbitals

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

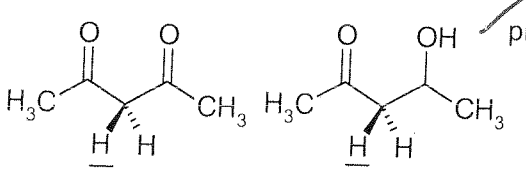
a) $CH_3CH_2O^-$ b) $CH_3CH_2^-$ c) Cl^- d) $CH_3CO_2^-$

13. (3 pts) Which statement best describes this reaction? $NH_3 + BF_3 \rightleftharpoons H_3N\text{-}BF_3$

a) an acid base reaction where NH_3 acts as a Bronsted-Lowry acid
b) an acid base reaction where the NH_3 acts as a Bronsted-Lowry base.
c) an acid base reaction where the NH_3 acts as a Lewis acid.
d) an acid base reaction where the NH_3 acts as a Lewis base.
e) none of the above adequately describe the reaction.



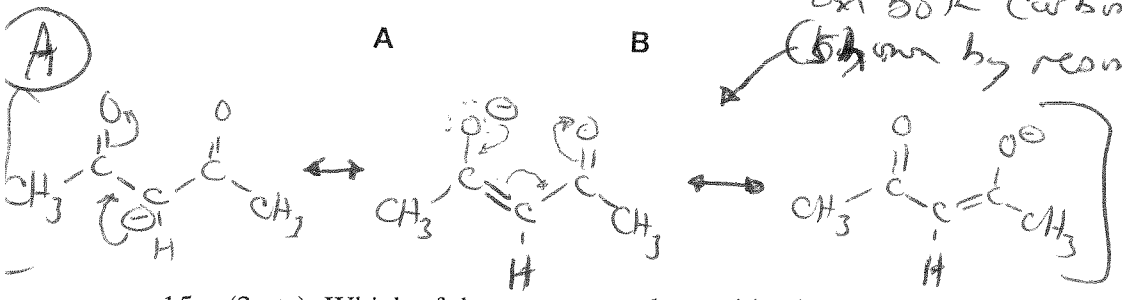
14. (6 pts) The pKa for the loss of the underlined proton in structure **A** is **lower** than the pKa for the loss of the indicated proton in structure **B**. Explain why this is the case.



pKa of A < pKa of B

A B

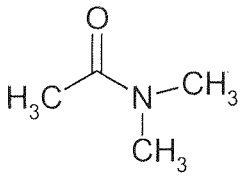
In structure (A) the anion can be stabilized by spreading out the (-1) charge on both carbonyl oxygens (5A) shown by resonance structures. In structure (B) only one resonance structure can be drawn. (Conj. base charge is less spread out, therefore less stable. Therefore less Acid B is less acidic.

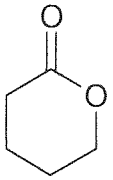


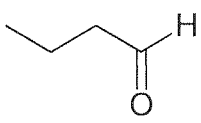
15. (3 pts) Which of these compounds would exhibit hydrogen bonding for intermolecular forces?

a) CH_3CH_2F b) $CH_3CH_2OCH_3$ c) $(CH_3)_3N$
d) $CH_3CH_2CH_2CH_3$ e) $CH_3CH_2CH_2NH_2$

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

a)  amide

b)  ester

c)  aldehyde

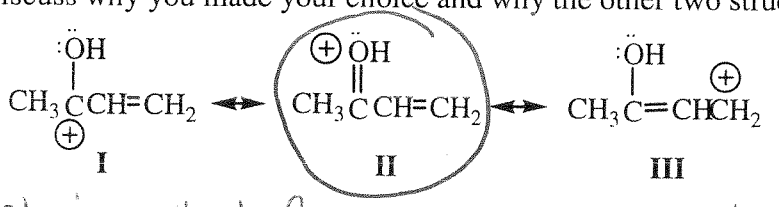
17. (3 pts) Which statement(s) is (are) true regarding molecular orbitals?

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. (Antibonding M.O. have nodes)
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.

Orbital hybridization occurs when s and 1, 2 or 3 p atomic orbitals mix and new "hybrid orbitals" are formed. These hybrid orbitals have different shapes and directionality than the atomic orbitals from which they came.

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.

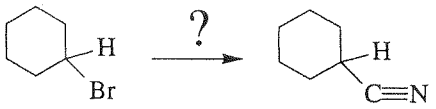


II is most important because every atom has a complete octet. I + III both have carbons which only have 3-bonds to them, which are not as stable as compared to a structure w/ complete octets

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.

1–hexyne: $CH_3CH_2CH_2CH_2-C\equiv C-H$

1–hexene: $CH_3CH_2CH_2CH_2-CH=CH_2$

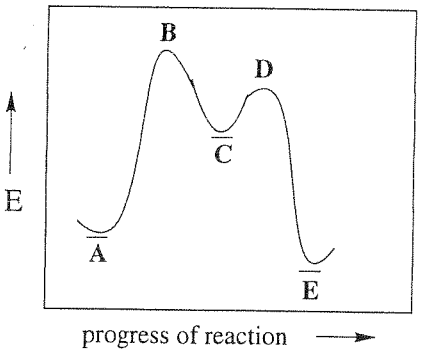
Which of the following statements is supported by this observation?

1. The reactive intermediate from the 1-hexyne reaction is lower in energy than that from the 1-hexene reaction.
2. The reaction product from the 1-hexene reaction is more stable than that from the 1-hexyne reaction.
3. The energy of activation for the protonation of 1-hexene is lower than that for the protonation of 1-hexyne.

rate related to Eact ($\Delta G^{\ddagger}$ for rate determining step)

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

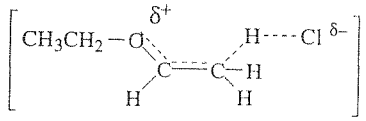
23. (4 pts) The electrophilic addition of HCl to ethyl vinyl ether ($CH_3CH_2OCH=CH_2$) can be respresented by an energy diagram. Which of the following corresponds to point B on the diagram?

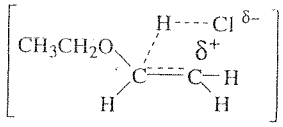


a) $CH_3CH_2\overset{\oplus}{O}CHCH_3$

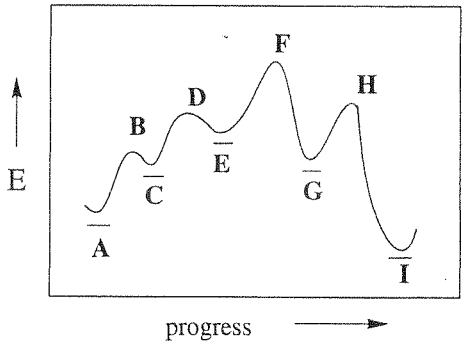
b) $CH_3CH_2OCH_2CH_2^{\oplus}$

c) $CH_3CH_2OCH(Cl)CH_3$

d) 

e) 

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**?



a) $K_{EQUILIBRIUM}$ = [**A**]/[**I**] is greater than 1, and $\Delta G°$ is greater than 0.

b) $K_{EQUILIBRIUM}$ = [**A**]/[**I**] is greater than 1, and $\Delta G°$ is less than 0.

c) $K_{EQUILIBRIUM}$ = [**I**]/[**A**] is less than 1, and $\Delta G°$ is less than 0.

d) $K_{EQUILIBRIUM}$ = [**I**]/[**A**] is greater than 1, and $\Delta G°$ is greater than 0.

e) $K_{EQUILIBRIUM}$ = [**I**]/[**A**] is greater than 1, and $\Delta G°$ is less than 0.