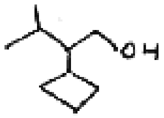
**Question 1 (20 points)** **Name** Key

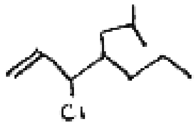
Draw stable structures that match each of the following descriptions:

a. (4 pts) Any structure which has *both* an aldehyde and a secondary amine.

b. (4 pts) 2-cyclobutyl-3-methyl-1-butanol

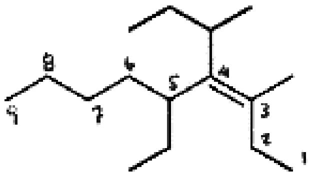


c. (4 pts) 3-chloro-4-isobutyl-1-heptene



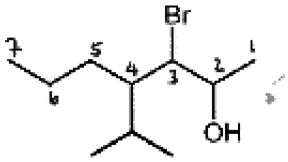
Give the correct IUPAC name for the following molecules. You may use common names for any substituents.

d. (4 pts)



4-secbutyl - 5-ethyl - 3-methyl - 3-nonene
or
5-ethyl-3-methyl-4-(1methyl propyl)-3-nonene

e. (4 pts)



3-bromo-4-isopropyl-2-heptanol
or
3-bromo-4-(1methylethyl)-2-heptanol

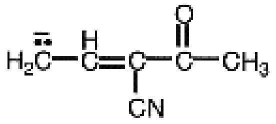
**Question 2 (18 points)** **Name** Key

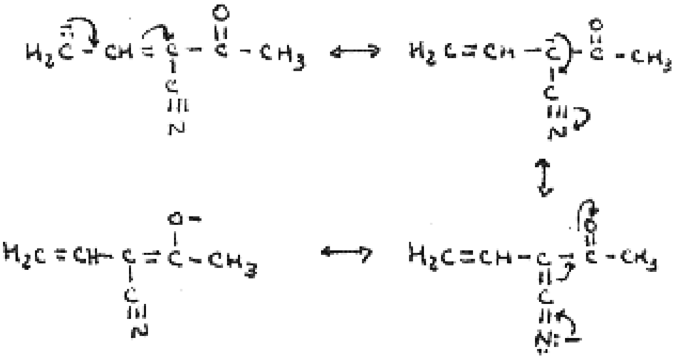
a. (4 pts) Rank the following bonds in order of decreasing dipole moment. (NO PARTIAL CREDIT)

H-O H-N H-F H-C

| | | | | | | |
|---|---|---|---|---|---|---|
| H-F | > | H-O | > | H-N | > | H-C |
| **Most** | | | | | | **Least** |

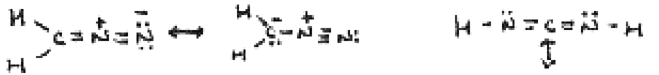
b. (6 pts) Draw the three *significant* resonance structures of the anion shown below. Use the correct curved arrow notation.

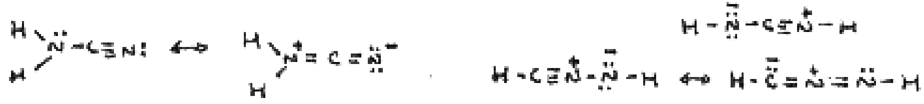




Draw stable Lewis structures for the following molecules. Include all lone pairs and formal charges, if necessary.

c. (4 pts) **$CH_2N_2$**

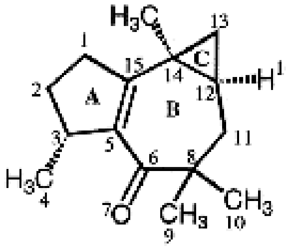




d. (4 pts) **$BF_4$**

**Question 3 (16 points)** **Name** Key

Africanone, drawn below, is a naturally occurring plant-leaf oil. Using the numbering system shown on the drawing, fill in the blanks:



Ring C has the most ring strain. (**A**, **B**, or **C**)

The hybridization state of C-15 is $sp^2$.

The hybridization state of C-3 is $sp^3$.

The hybridization state of O-7 is $sp^2$.

The functional group containing C-6 and O-7 is a/an ketone.

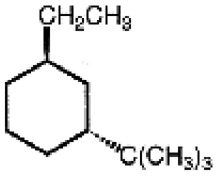
The functional group containing C-5 and C-15 is a/an alkene.

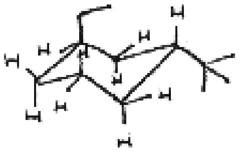
The methyl group on C-14 is cis to H-16 on C-12. (cis, trans)

Oxygen-7 is a Brønsted-Lowry base.

**Question 4 (12 points)** **Name** Key

a. (5 pts) Draw a three dimensional representation in the **lowest energy** conformation of the following molecule. Show the hydrogens on the cyclohexane ring.





b. (4pts) Rank the following molecules in order of increasing boiling point. (NO PARTIAL CREDIT)

octane 2-methylpentane decane pentane

2methylpentane < pentane < octane < decane
**Lowest** **Highest**

c. (3 pts) Why did you rank the boiling point of the alkanes in part b in the manner that you did?

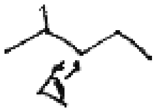
2 methylpentane < pentane branched isomers have fewer places for induced dipole induced dipole interaction than unbranched Isomers. Smaller van der waals forces ⇒ lower b.p.

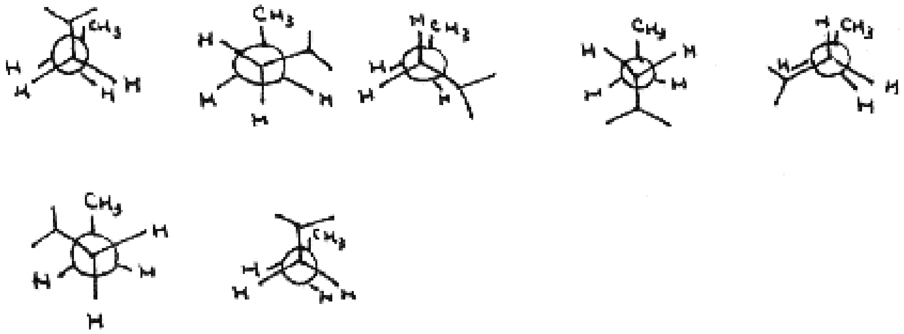
pentane < octane < decane As the number of carbons increases in the chain, there are more places for induced dipole induced dipole interaction. More van der waals forces ⇒ higher boiling point

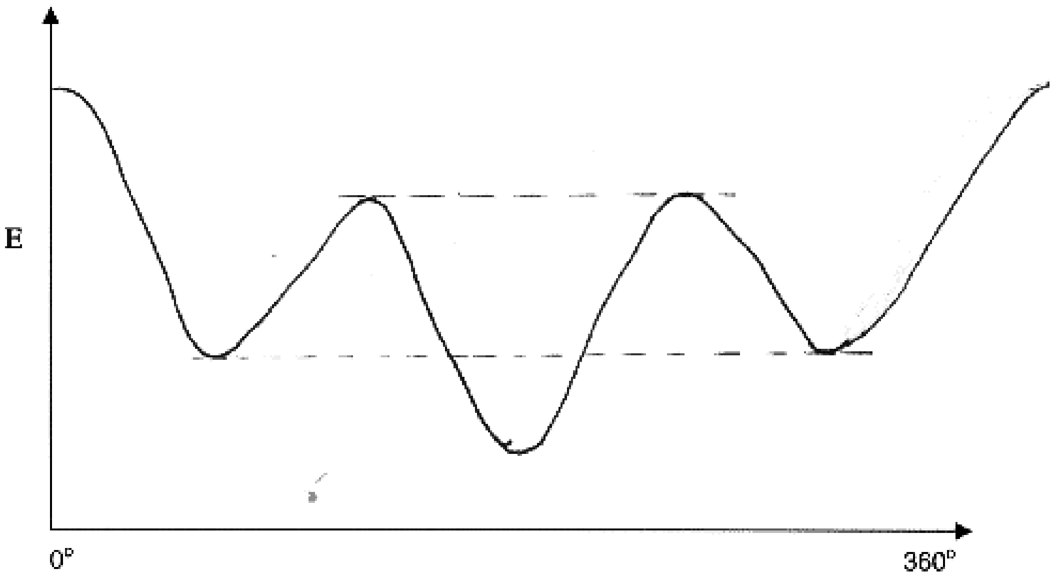
**Question 5 (14 points)** **Name** Key

Consider 2-methylpentane. Draw the **Newman projection for each 60° conformation** from 0° to 360° looking down the **C3-C4** bond from C3 to C4. Sketch an approximate potential energy diagram for rotation about the C3-C4 bond with **the highest energy conformation at 0°.**

If you draw a structure for 2-methylpentane on this page, make sure that it is complete and correct.



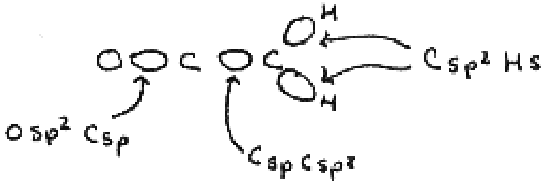




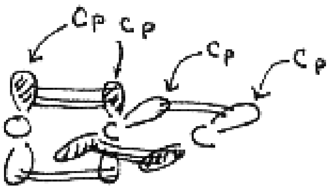
**Question 6 (12 points)** **Name** key

Determine a molecular orbital picture for ketene (O=C=CH$_2$) as follows:

a. (6 pts) Sketch all the σ bonds. Indicate which atomic orbitals are involved in forming the σ bonds.



b. (6 pts) Sketch the π bonds. Indicate which atomic orbitals are involved in forming the π bonds. Indicate the relative orientation of the π bonds.



The π bonds are perpendicular to each other

**Question 7 (8 points)** **Name** Key

Using bond dissociation energies, calculate the $\Delta H^{\circ}_{rxn}$ for the reaction shown below. Some useful BDE's are listed below.

$$CH_3OH + H_2C{=}CH_2 \longrightarrow CH_3OCH_2CH_3$$

| Bond | Energy (KJ/mol) |
|---|---|
| C=C | 611 |
| C-C π | 234 |
| C-C σ | 377 |
| C-C | 377 |
| C-H | 410 |
| C-O | 389 |
| H-O | 435 |

| bonds broken | bonds made |
|---|---|
| O-H | O-C |
| C=C | C-C |
| | C-H |

$\Delta H^{\circ}_{rxn}$ = Sum bonds broken - Sum bonds formed

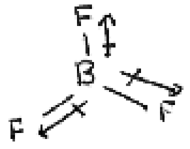
$\Delta H^{\circ}_{rxn}$ = BDE(O-H) + BDE(C=C) - BDE(O-C) - BDE(C-C) - BDE(C-H)

$\Delta H^{\circ}_{rxn}$ = 435 kJ/mol + 611 kJ/mol − 389 kJ/mol − 377 kJ/mol − 410 kJ/mol

$\Delta H^{\circ}_{rxn}$ = −130 kJ/mol

**Extra Credit (5 points)** **Name** Key

Explain why $BF_3$ does not have a molecular dipole moment, while $NF_3$ has a molecular dipole moment.



$BF_3$ is trigonal planar - the bond dipole moments cancel each other

$\ddot{N}F_3$ is pyramidal - the bond dipole moments do not cancel each other out