CHEM 3311-100
Exam 1
Fall 2009

By printing my name below, I pledge that
"On my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this work."

Name Answer Key

Recitation TA's Name _____ (Richardson, Thomsen)

Recitation Day & Time _____ (example, Monday, 8 AM)

Grading Information

Page #	Points Possible	Your Score
2 (Questions 1 & 2)	24	
3 (Question 3)	13	
4 (Question 4)	15	
5 (Question 5)	18	
6 (Questions 6 & 7)	30	
	_____	TOTAL (out of 100)

Selected pK_a Values

HI	−10.1
HCl	−3.9
H_3O^+	−1.7
CH_3COOH	4.7
NH_4^+	9.3
Phenol	10
H_2O	15.7
R-OH	16-18
$HC\equiv CH$	26
NH_3	36
$H_2C=CH_2$	45
H_3C-CH_3	60

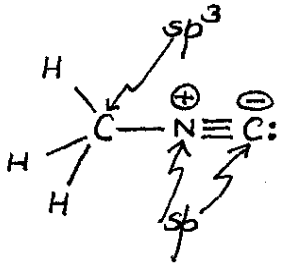
1 H					2 He
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar

General Instructions
(1) This is a CLOSED BOOK exam! No notes and molecular models are allowed.
(2) Please WRITE LEGIBLY & CLEARLY; minimize erasing and draw a line through information that should not be graded. Untidy work will NOT BE GRADED.
(3) You have 2 hours to complete the exam.
(4) Write your name at the top of each page, starting with page 2.
(5) Use the back of exam pages for scratch paper, if necessary.
(6) If caught cheating, you will receive at best an F for this exam. The instructor reserves the right to proceed further in compliance with university policies.
(7) If you complete the exam early, please leave quietly!

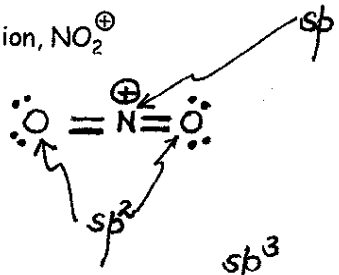
NAME: Answer Key

1. (9 points) Draw the best Lewis structure for each species shown below. Lone pairs and formal charges must be included. Show hybridization (using labels such as sp^3, sp^2, sp) on each non-hydrogen atom.

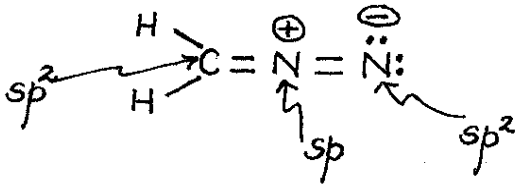
(A) CH_3NC



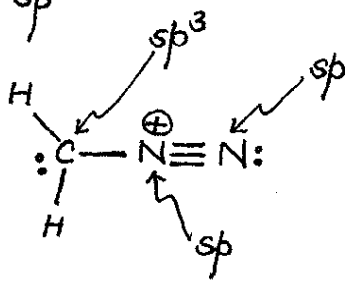
(B) Nitronium ion, $NO_2^{\oplus}$



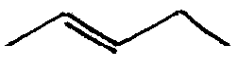
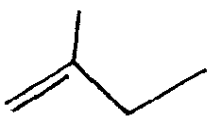
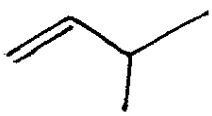
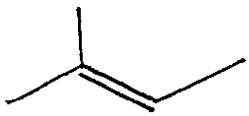
(C) Diazomethane, CH_2N_2



or



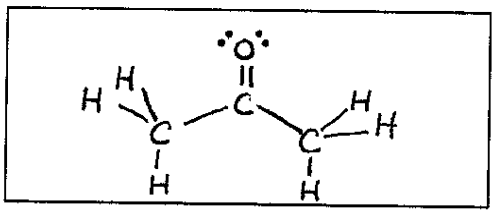
2. (15 points) Using **bond-line formulas**, draw any FIVE (5) constitutionally isomeric **alkenes** with the molecular formula C_5H_{10} and write the corresponding IUPAC name in the spaces provided. Please show hydrogen atoms clearly where necessary.

Structure of Alkene using **bond-line formula**	IUPAC Name
	1- Pentene
	2- Pentene
	2- Methyl - 1- butene
	3- Methyl - 1- butene
	2- Methyl - 2- butene

NAME: Answer Key

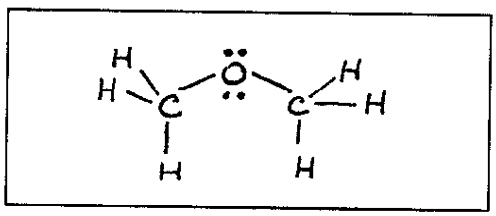
3. (13 points) Draw expanded structures for each of the following compounds:

(A) CH_3COCH_3



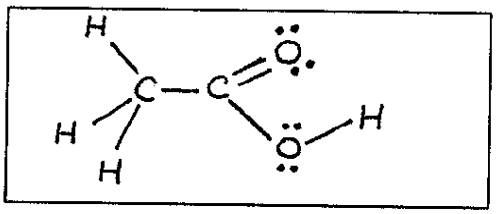
ketone

(B) CH_3OCH_3



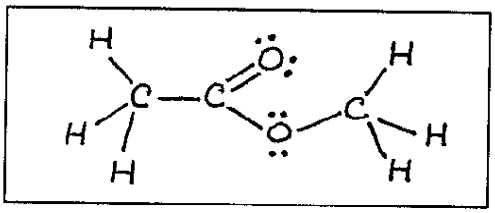
ether

(C) CH_3COOH



carboxylic acid

(D) CH_3COOCH_3



ester

Examine the structures above and circle the molecule in the condensed structural formulas shown below that contains an **ester** functional group.

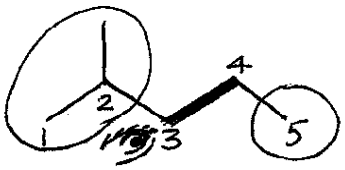
(A) CH_3COCH_3

(B) CH_3OCH_3

(C) CH_3COOH

(D) CH_3COOCH_3

NAME: Answer Key



(4) (15 points) Draw the conformational analysis diagram for 2-methylpentane, **looking down the C_3-C_4** bond with **carbon 3 closest to you** (carbon 4 is behind carbon 3). Start with the least stable eclipsed conformation at 0°. **Hold carbon 3 and its three substitutents stationary**, and rotate, in a clockwise direction, the substitutents attached to carbon 4 through dihedral angle increments of 60°. Please draw appropriate Newman Projections in the boxes below, following the instructions provided above.

Figure 1: Dihedral Angle = 0°
Least stable eclipsed conformation

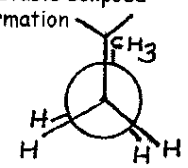


Figure 2: Dihedral Angle = 60°

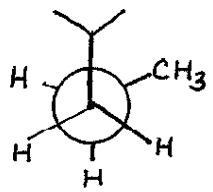


Figure 3: Dihedral Angle = 120°

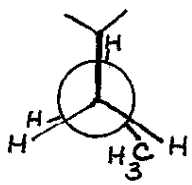


Figure 4: Dihedral Angle = 180°

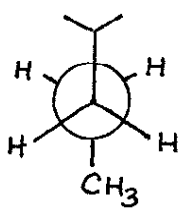


Figure 5: Dihedral Angle = 240°

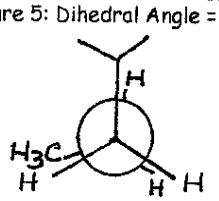
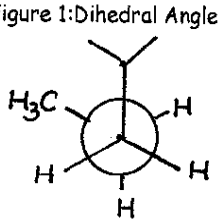
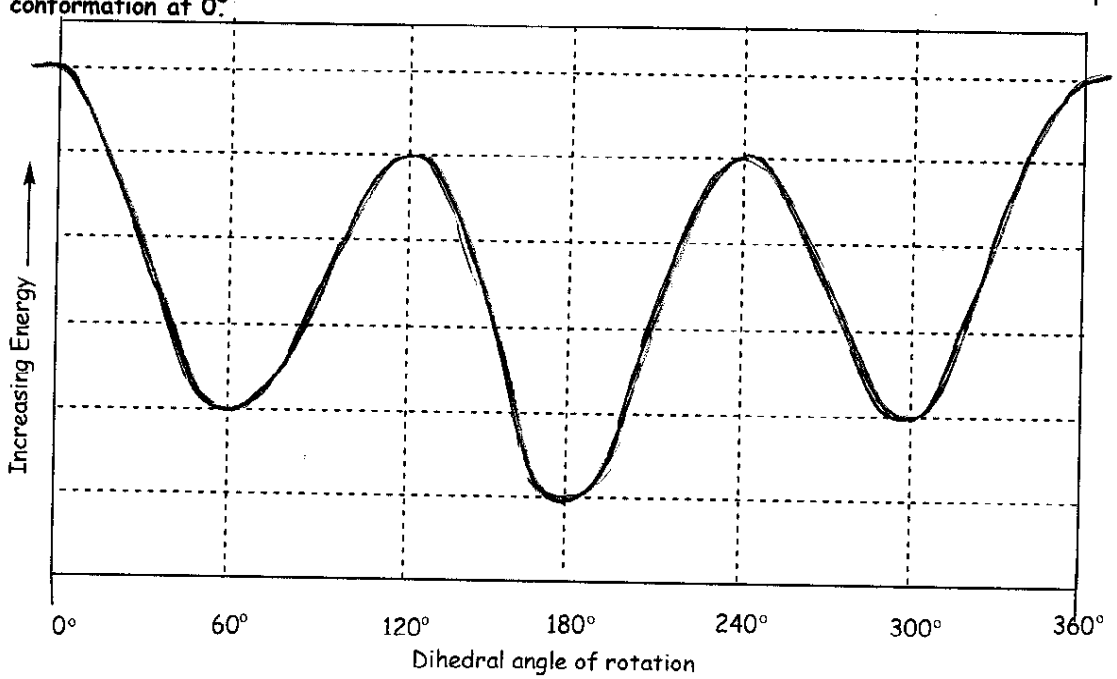


Figure 1:Dihedral Angle = 300°



Please draw the energy profile from 0° to 360° below. REMINDER: **Start with the least stable eclipsed conformation at 0°.**



NAME: _____

5. (18 points) Multiple Choice: **Circle the correct answer.**

(i) Select the stronger acid in each pair: (I) $ClCH_2CH_2CO_2H$ or $CH_3CHClCO_2H$; (II) $CH_3NH_3^+$ or CH_3NH_2.
(A) $ClCH_2CH_2CO_2H$ and $CH_3NH_3^+$
(B) $ClCH_2CH_2CO_2H$ and CH_3NH_2
(C) $CH_3CHClCO_2H$ and $CH_3NH_3^+$
(D) $CH_3CHClCO_2H$ and CH_3NH_2

(ii) Select the strongest base among the species listed below.
(A) $(CH_3)_3CO^-$
(B) CH_3O^-
(C) CH_3COO^-
(D) $HC\equiv C^-$

(iii) Which alkene releases the least amount of heat on combustion?
(A) 1-Hexene
(B) 2-Hexene
(C) 3-Hexene
(D) 2-Methyl-2-pentene

(iv) Estimate the approximate magnitude of the equilibrium constant for the reaction:

$$CH_3COCH_3 + OH^{\ominus} \rightleftharpoons CH_3\ddot{C}OCH_2^{\ominus} + H_2O$$

pKa: 19 (Weaker acid) | (Weaker base) | (Stronger base) | 15.7 (Stronger acid)

The pK_a of acetone, CH_3COCH_3, is 19.

(A) K = 0
(B) K = 1
(C) $K \ll 1$
(D) $K \gg 1$

(v) Select the molecular orbitals (using Frontier Orbital Theory) involved in the reaction between NH_3 and CH_3COOH.
(A) $\sigma^*_{N\text{-}H}$ of NH_3 and $\sigma_{O\text{-}H}$ of CH_3COOH
(B) $\sigma_{N\text{-}H}$ of NH_3 and $\sigma^*_{O\text{-}H}$ of CH_3COOH
(C) Nonbonding MO of NH_3 and $\sigma_{O\text{-}H}$ of CH_3COOH
(D) Nonbonding MO of NH_3 and $\sigma^*_{O\text{-}H}$ of CH_3COOH

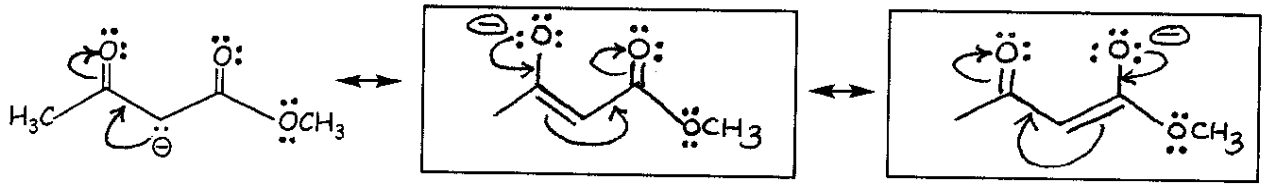
(vi) What is the correct name for this stereoisomer?

(A) (Z)-2-bromo-3-isopropyl-4,4-dimethyl-2-pentene
(B) (E)-2-bromo-3-isopropyl-4,4-dimethyl-2-pentene
(C) (Z)-4-bromo-3-isopropyl-2,2-dimethyl-3-pentene
(D) (E)-4-bromo-3-isopropyl-2,2-dimethyl-3-pentene

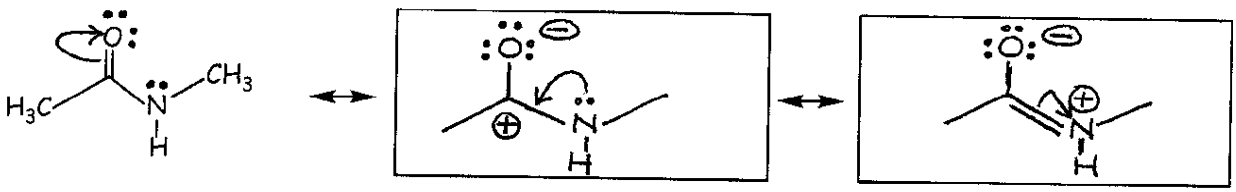
NAME: Answer Key

6. (16 points) Using the curved arrow notation, draw TWO other highly stable resonance structures for this species. Be sure to show ALL lone pairs and formal charges in your structures.

(A)



(B) Using the curved arrow notation, draw TWO other relatively stable resonance structures for this species. Be sure to show ALL lone pairs and formal charges in your structures.



7. (14 points) Write out the **STEPWISE** mechanism (Step 1, Step 2,.....) for the formation of the **major organic product** of the reaction shown below.