

**CHEM 3311-100**

**Exam 1, Fall 2010**

**Time: 2 Hours**

By printing my name below, I pledge that

“On my honor, as a University of Colorado-Boulder student, I have neither given nor received unauthorized assistance on this work.”

**Your Name (PRINTED IN CAPITAL LETTERS)**

\_\_\_\_\_  
**Last Name**

\_\_\_\_\_  
**First Name**

\_\_\_\_\_  
**Middle Initial**

**Your CU Student ID # (NOT Your Social Security Number)**

**Your Recitation TA's Name**

\_\_\_\_\_  
**Last Name**

\_\_\_\_\_  
**First Name**

[-1 if missing or incorrect]

**Circle Your Recitation Day & Time** [-1 if missing or incorrect]

Mon 8 AM    Mon 2 PM    Mon 5 PM    Tues 8 AM    Tues 5 PM

Wed 8 AM Denman                  Wed 8AM Hartwig

Wed 11 AM    Wed 12 PM    Wed 5 PM    Thurs 8 AM

**Grading Details**

Page # (Question #s)	Points Possible	Points Earned
2 (Q 1)	<b>20</b>	_____
3 (Q 1)	<b>20</b>	_____
4 (Q 2)	<b>11</b>	_____
5 (Q 3 & 4)	<b>16</b>	_____
6 (Q 5)	<b>11</b>	_____
7 (Q 6)	<b>10</b>	_____
8 (Q 7)	<b>12</b>	_____

**TOTAL SCORE (out of 100)** \_\_\_\_\_

**General Instructions**

- (1) This is a CLOSED BOOK exam; nothing is allowed except a few pencils or pens, eraser, and student ID.
- (2) Please WRITE LEGIBLY & CLEARLY; minimize erasing! Untidy/illegible work will NOT be graded.
- (3) Print your name after acknowledging the student honor code. Write your name on each exam page in the space provided.
- (4) Use the back of the exam pages as scratch paper, if necessary.
- (5) If suspected of or caught cheating, you will receive at best an F for the exam. The instructor reserves the right to proceed further in compliance with university policies on academic violations.
- (6) You may not leave the room after the exam has started. Please leave quietly after you submit your exam to the TA or instructor.

**(1) Multiple Choice Questions (4 points each)**

(i) Which compound/ion does NOT contain a triple bond in its best Lewis structure?

- (A)  $\text{N}_2$                       (B)  $\text{CN}^\ominus$                       (C)  $\text{C}_2\text{H}_2$                       (D)  $\text{C}_3\text{H}_6$

(ii) Which compound contains polar covalent bonds and is a polar molecule?

- (A)  $\text{CBr}_4$                       (B)  $\text{H}_3\text{C-O-CH}_3$                       (C)  $\text{CS}_2$                       (D) (E)-1,2-Dichloroethene

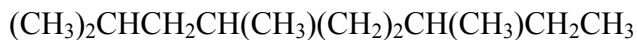
(iii) Draw the correct Lewis structure for the carbanion,  $\text{CH}_3^\ominus$  and select the hybridization of the carbon atom.

- (A) sp  
(B)  $\text{sp}^2$   
(C)  $\text{sp}^3$   
(D) none of these

(iv) Arrange the constitutional isomers of  $\text{C}_5\text{H}_{12}$  in order of increasing boiling points.

- (A)  $\text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < (\text{CH}_3)_4\text{C}$   
(B)  $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < \text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_4\text{C}$   
(C)  $(\text{CH}_3)_4\text{C} < \text{CH}_3(\text{CH}_2)_3\text{CH}_3 < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$   
(D)  $(\text{CH}_3)_4\text{C} < (\text{CH}_3)_2\text{CHCH}_2\text{CH}_3 < \text{CH}_3(\text{CH}_2)_3\text{CH}_3$

(v) What is the IUPAC name for the compound shown below?



- (A) 2,4,7-Trimethylnonane  
(B) 3,6,8-Trimethylnonane  
(C) 7-Ethyl-2,4-dimethyloctane  
(D) 2-Ethyl-5,7-dimethyloctane

(vi) Select the constitutional isomer of  $C_6H_{14}$  that has only primary and tertiary carbons.

- (A) Hexane
- (B) 3-Methylpentane
- (C) 2,2-Dimethylbutane
- (D) 2,3-Dimethylbutane

(vii) Which alkene would release the most heat on combustion?

- (A) 2-Methyl-2-pentene
- (B) 1-Hexene
- (C) (E)-3-Hexene
- (D) ((Z)-3-Hexene

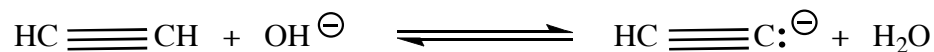
(viii) Which is the relatively strongest acid among the four choices listed?

- (A)  $CH_3OH$
- (B)  $NH_4^+$
- (C)  $NH_3$
- (D)  $H_2C=CH_2$

(ix) Which is the relatively strongest base among the four choices listed?

- (A)  $CH_3O^-$
- (B)  $NH_3$
- (C)  $OH^-$
- (D)  $Br^-$

(x) Predict the magnitude of the equilibrium constant for the reaction:



- (A)  $K = 0$
- (B)  $K = 1$
- (C)  $K > 1$
- (D)  $K < 1$

**2 (A) 8 Points**

Draw the orbital interaction diagram showing the overlap of  $2p_z$  orbitals to form bonding and antibonding  $\pi$  molecular orbitals of ethylene ( $\text{H}_2\text{C}=\text{CH}_2$ ). Clearly LABEL all pictures of atomic and molecular orbitals with appropriate labels AND symbols. Represent a  $2p_z$  atomic orbital as shown below:



**2 (B) (3 Points)** Apply Frontier Orbital Theory and select the HOMO and LUMO in the first mechanistic step for the reaction:  $\text{RCH}=\text{CHR} + \text{HCl} \rightarrow \text{RCH}_2\text{CHClR}$ .

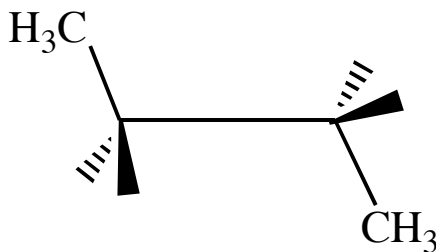
- (A) HOMO:  $\pi$ -MO of alkene; LUMO:  $\sigma_{\text{HCl}}$
- (B) HOMO:  $\pi$ -MO of alkene; LUMO:  $\sigma^*_{\text{HCl}}$
- (C) HOMO:  $\pi^*$ -MO of alkene; LUMO:  $\sigma_{\text{HCl}}$
- (D) HOMO:  $\pi^*$ -MO of alkene; LUMO:  $\sigma^*_{\text{HCl}}$

**(3) 12 Points**

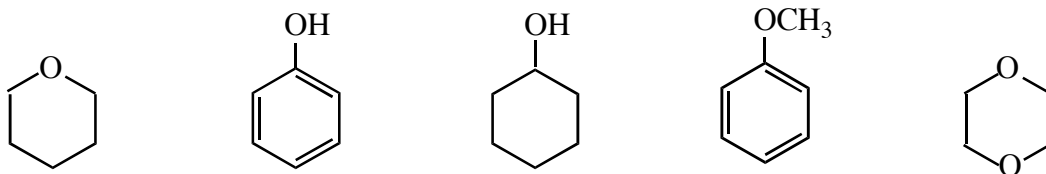
Looking down the C2-C3 bond in 2,3-dimethylbutane, draw Newman projections for (i) the least stable conformation and (ii) the most stable conformation. Label each conformation as anti, eclipsed or gauche.

Least Stable Conformation	Most Stable Conformation
Circle appropriate label for this conformation: anti                  eclipsed                  gauche	Circle appropriate label for this conformation: anti                  eclipsed                  gauche

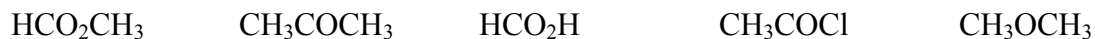
Draw the **line-and wedge projection formula** for a **gauche** conformation using the skeletal structure shown below:

**(4) Circle the best answer to each question (2 Points each)**

(A) Which structure represents a phenol?



(B) Which compound is an ether?



## (5) 11 Points

Draw **a more stable contributing structure** for each chemical species shown. Use the curved arrow formalism to show the conversion of the original structure to your new structure. Include all lone pairs and formal charges to receive full credit.

Original Structure	New Structure
$\text{H}_3\text{C}-\overset{\cdot\cdot}{\text{N}}=\overset{\oplus}{\text{N}}:$	
$\begin{array}{c} \text{H}-\text{C} \begin{array}{l} \nearrow \overset{\cdot\cdot}{\text{O}} \ominus \\ \searrow \overset{\oplus}{\text{O}}-\text{H} \end{array} \end{array}$	
$\overset{\oplus}{\text{H}_2\text{C}}-\text{CH}=\text{CH}-\overset{\ominus}{\text{C}}\text{H}_2$	

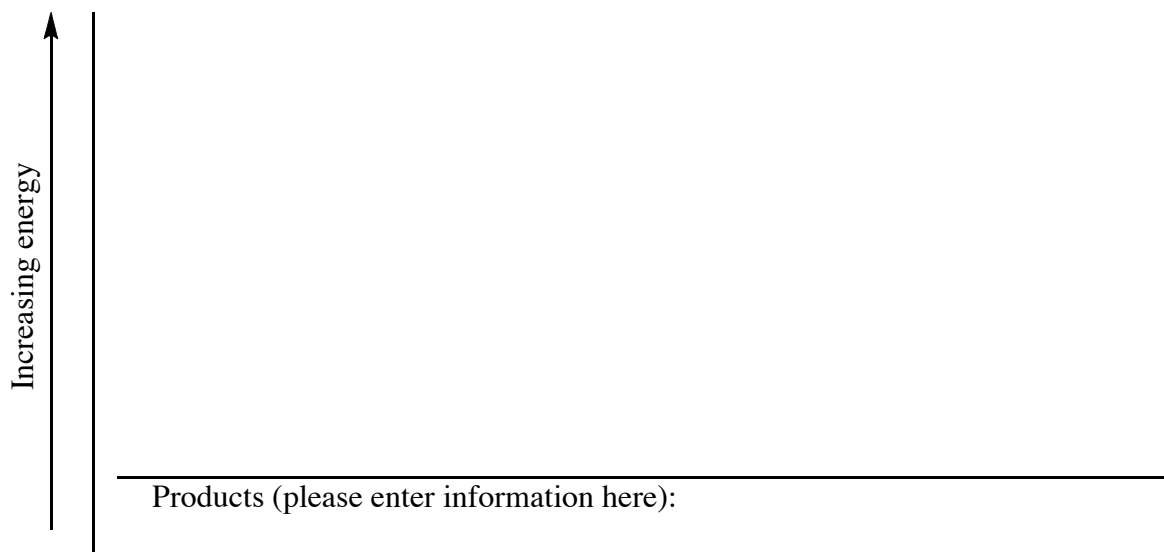
**(6) 10 Points**

The heats of combustion of some constitutional isomers of  $C_8H_{18}$  are shown below:

Compound	$\Delta H^\circ_{combustion}$ (kJ/mol)
2,2-Dimethylhexane	-5458
2-Methylheptane	-5466
Octane	-5471
2,2,3,3-Tetramethylbutane	-5452

Write a balanced equation for the complete combustion of  $C_8H_{18}$ .

Show the relative position of each reactant listed in the Table compared to the products of the combustion reaction. Represent each reactant by a horizontal line, along with the bond-line formula for that reactant. Use vertical lines to show the  $\Delta H^\circ_{combustion}$  (kJ/mol) for each reactant.



The most stable constitutional isomer shown above is

- (A) 2,2-Dimethylhexane
- (B) 2-Methylheptane
- (C) Octane
- (D) 2,2,3,3-Tetramethylbutane

