

Key

CHEM 3311-200
Exam 1
February 9, 2016

Assigned Seat # _____

Time: 2 Hours

Please sign the Honor Pledge.

I pledge that

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

PRINT Last Name, First Name, Middle Initial _____

Please Sign Here _____

Recitation TA's name: _____

Recitation Day and Time: _____

PLEASE legibly print your name on each page of the exam.

Partial Periodic Table

1A												8A	
1 H	2A											2 He	
3 Li	4 Be											10 Ne	
11 Na	12 Mg	5 B	6 C	7 N	8 O	9 F					17 Cl	18 Ar	
		13 Al	14 Si	15 P	16 S					35 Br			
										53 I			

215	EKLC M2B36	Mon	1:00-1:50 PM	Matthew Farmer
227	EKLC M2B36	Tue	3:00-3:50 PM	Ethan Miller
234	EKLC M2B36	Wed	12:00-12:50 PM	Matthew Farmer
236	EKLC M2B36	Wed	2:00-2:50 PM	Ethan Miller
238	EKLC M2B36	Wed	4:00-4:50 PM	Thomas Carey
245	EKLC M2B36	Thu	11:00-11:50 AM	Aaron Crossman
245	EKLC M2B36	Thu	1:00-1:50 PM	Aaron Crossman

PLEASE read the questions very carefully!

This is a closed-book exam.

The use of notes, calculators, scratch paper, or cell phones will not be allowed during the exam.

You may use models brought in a clear ziploc bag.

Please put all your answers on the test in the appropriate place. Use the backs of the pages for scratch (there are two additional blank scratch sheets after the last page of the exam). **DO NOT PUT ANSWERS ON THE SCRATCH SHEETS.**

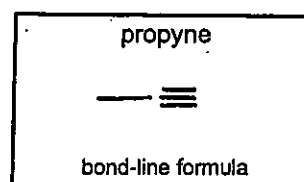
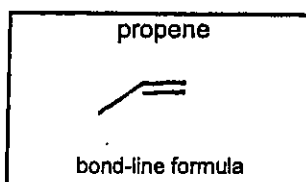
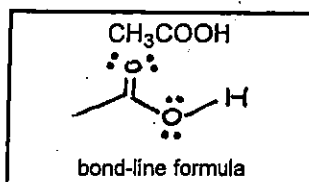
Table of Acidities

<u>Acid</u>	<u>pK_a Value</u>	<u>Acid</u>	<u>pK_a Value</u>	<u>Grading (Points Earned)</u>
HI	-10	Thiol (RSH)	10-12	
HBr	-8.5	H ₂ O	15.7	Question 1 (17) _____
HCl	-6	Alcohol (ROH)	16-18	Question 2 (12) _____
H ₃ O ⁺	-1.7	HC≡CH	26	Question 3 (5) _____
HF	3.2	NH ₃	36	Question 4 (10) _____
CH ₃ COOH	4.7	H ₂	37	Question 5 (22) _____
HN ₃ (hydrazoic acid)	4.7	H ₂ C=CH ₂	45	Question 6 (17) _____
NH ₄ ⁺	9.3	CH ₄	60	Question 7 (17) _____
Phenol	10			
				TOTAL _____

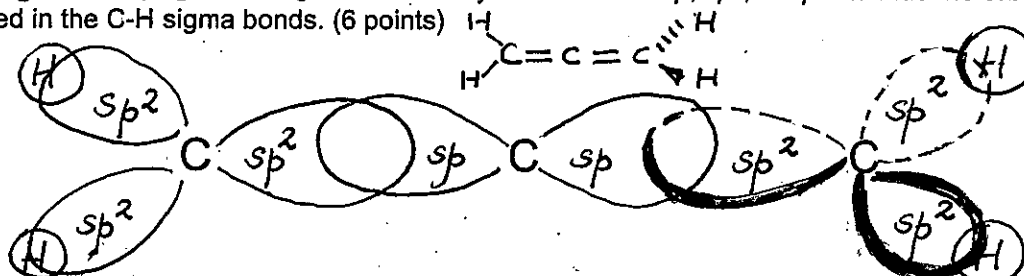
Name: Key

1 A. Draw **bond-line formulas** for the molecules shown below and **circle all the molecules containing one or more sp^2 -hybridized carbon atoms**. Show all lone pairs and formal charges if applicable. (7 points)

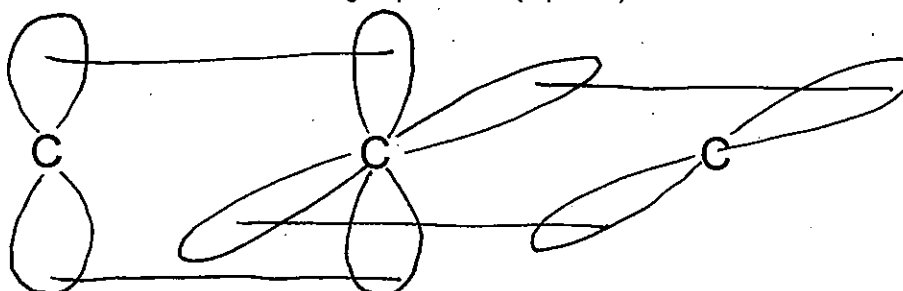
Example: Bond-line formula for butane is 



1 B. Using the skeletal framework below, draw all the **hybrid orbitals** participating in **sigma bonding** in allene, H₂C=C=CH₂. Label each hybrid orbital as sp , sp^2 , or sp^3 . Include the orbitals involved in the C-H sigma bonds. (6 points)



Using the skeletal framework below, draw the orbitals participating in **pi bonding** in allene, H₂C=C=CH₂, and show the interactions resulting in pi bonds. (4 points)

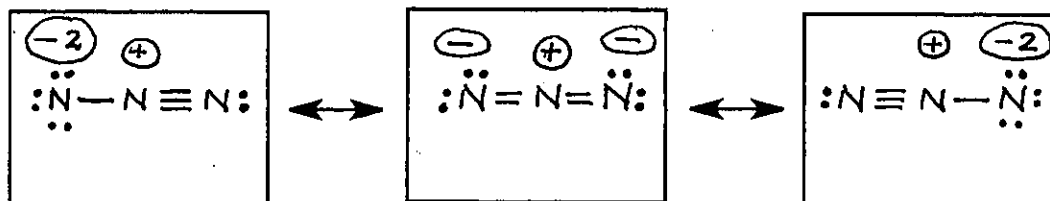


2. The azide ion, N₃⁻, is a good nucleophile in substitution reactions of alkyl halides such as CH₃I.

How many valence electrons are there in the azide ion? 16 (2 points)

Draw **three** Lewis structures (all atoms have octets) for the resonance-stabilized azide ion. You must show **all lone pairs and formal charges**. Circle the major contributing structure. (10 points)

(NOTE: On scratch paper, you may use the curved arrow notation to guide you in this process.)

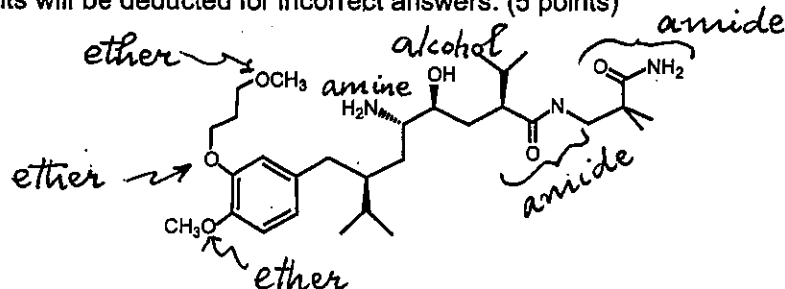


Points earned: Question 1 _____

Question 2 _____

Name: Key

3. Aliskiren (Tekturna) is an antihypertensive agent that blocks the enzyme renin, an important regulator of blood pressure. Which of the listed functional groups does Aliskiren contain? Circle ALL that apply. Points will be deducted for incorrect answers. (5 points)



alcohol	alkene	aldehyde	amide	amine
aromatic ring	ester	ether	ketone	phenol

4. Draw, using only bond-line formulas, all constitutionally isomeric cycloalkanes and substituted cycloalkanes with the molecular formula C₅H₁₀. Write the correct IUPAC name for each. NOTE: Be careful to draw each isomer only once; points will be taken off for missing and redundant (unnecessary repetition) structures. (10 points)

Bond-line formula	IUPAC Name
	cyclopentane
	methylcyclobutane
	ethylcyclopropane
	1,2-dimethylcyclopropane
	1,1-dimethylcyclopropane

Points earned: Question 3 _____

Question 4 _____

Name: Key

5 A. For each pair of molecules or charged species, circle the stronger Brønsted acid, and indicate with a check mark the best reason for your choice. (6 points)

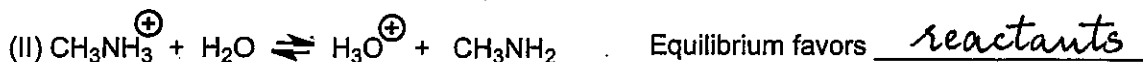
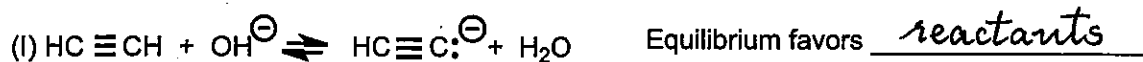
		Charge Effect	Element Effect	Hybridization Effect	Resonance Effect	Inductive Effect
CH ₃ CH ₂ CH ₃	<u>CH₃C≡CH</u>			✓		
CH ₃ CH ₂ OH	<u>CH₃CH₂SH</u>		✓			
CH ₃ COOH	<u>CCl₃COOH</u>					✓

5 B. Consider these bases: CH₃CH₂NH₂, CH₃CH₂CH₂CH₂⁻, and CH₃CH₂O⁻. (4 points)

Select the most basic species: CH₃CH₂CH₂CH₂⁻

Select the least basic species: CH₃CH₂NH₂

5 C. For each reaction, indicate whether equilibrium favors reactants or products. (4 points)



5 D. Use the curved arrow notation to represent proton transfer in the reaction shown below: Draw lone pairs on the S and O atoms in the reactants and products. (8 points)



Points earned: Question 5 _____

Name: Key

6 A. Consider these compounds: CH_3F , CH_3OH , and CH_3NH_2 .

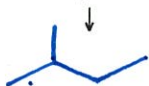
Select the compound with the **lowest** boiling point: CH_3F (2 points)

Select the compound with the **highest** boiling point: CH_3OH (2 points)

6 B. Consider these compounds: 2-methylbutane, 2,2-dimethylpropane, and pentane.

Draw **bond-line formulas** for each compound. (3 points)

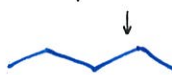
2-methylbutane



2,2-dimethylpropane



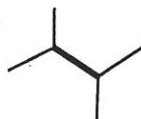
pentane



Select the compound with the **lowest** boiling point: 2,2-dimethylpropane (2 points)

Select the compound with the **highest** boiling point: pentane (2 points)

6 C. Draw Newman projections for the (I) most stable and (II) least stable conformations of 2,3-dimethylbutane (structure shown below), **sighting along the C2-C3 bond**. The information provided may be useful; you are not required to complete any detailed energy calculations. (6 points)



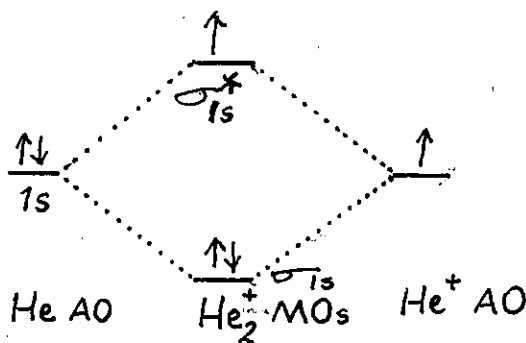
Interaction	Energy Cost (kcal/mol)
H/H eclipsed	0.97
H/ CH_3 eclipsed	1.3
CH_3/CH_3 eclipsed	3.4
CH_3/CH_3 gauche	0.9

Most Stable Conformation	Least Stable Conformation

Points earned: **Question 6** _____

Name: Key

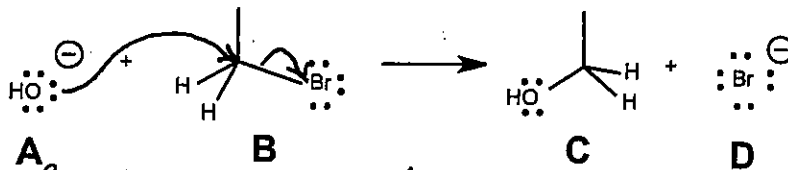
7 A. Draw the MO diagram for He_2^+ . Clearly label atomic and molecular orbitals, and indicate electron occupancy in each of these. (8 points)



What is the bond order for He_2^+ ? 0.5 (1 point)

7 B. Draw the curved arrows to illustrate the mechanism for product formation in each reaction. Identify the HOMO and LUMO in each reaction. Identify the electrophile and nucleophile in (I) and the Brønsted acid and base in (II). (8 points)

(I)



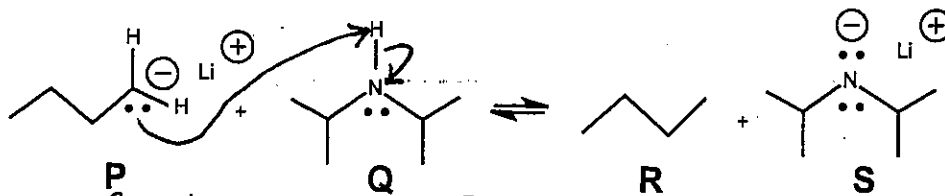
HOMO: nonbonding MO in A

LUMO: $\sigma^*_{\text{C-Br}}$ in B

Electrophile: B

Nucleophile: A

(II)



HOMO: nonbonding MO in P

LUMO: $\sigma^*_{\text{N-H}}$ in Q

Brønsted acid: Q

Brønsted base: P

Points earned: **Question 7** _____