CHEM 3311-200 **Assigned Seat # _____**

Exam 3 ANSWER KEY

April 14, 2015 **Time: 2 Hours**

Please ***sign*** the Honor Pledge.

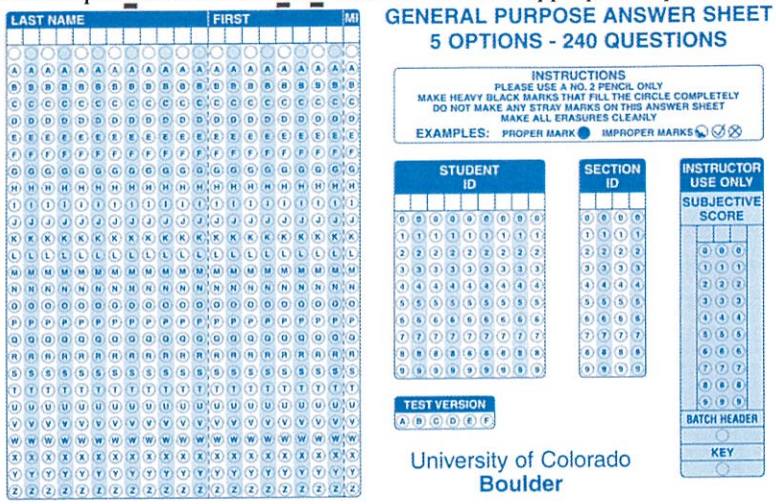
I pledge that

"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 _____

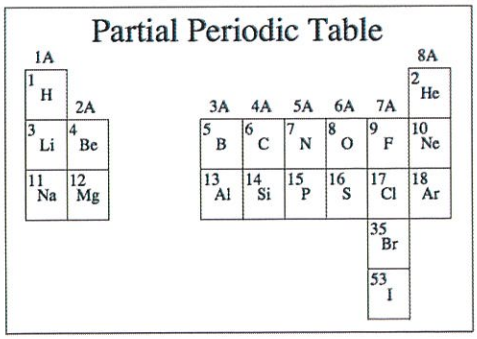
General Instructions: (I) Scantron: Questions 1-13 (50 pts) & (II) Short Answers: Questions 14--17 (50 pts)

Section I: Complete the information requested on the scantron and bubble in the appropriate spaces using a No. 2 pencil.



If you change an answer, erase the undesired mark thoroughly. Mark only the best answer to each multiple-choice question. Use the back of the exam pages (for multiple choice questions 1-13 only) as scratch paper. There are 7 exam pages (with 13 MC questions and 4 short answer questions), a cover page, and two blank pages (scratch paper). When you are instructed to begin the exam, please check that you have all pages. Good luck!

Please return the completed scantron sheet, SHORT ANSWER section, and this cover page (sign Honor Code) to the exam proctors. You may take the MULTIPLE-CHOICE section of the exam and scratch paper with you.



Recit.	Location	Day	Time	TA
221	EKLC M2B26	Tue	9:00 AM - 9:50 AM	Ed Guzman
222	EKLC M2B26	Tue	10:00 AM - 10:50 AM	Ed Guzman
226	EKLC M2B26	Tue	12:00 PM - 12:50 PM	Will Hartwig
230	EKLC M2B26	Wed	8:00 AM - 8:50 AM	Jordan Theriot
238	EKLC M2B26	Wed	4:00 PM - 4:50 PM	Jordan Theriot
244	EKLC M2B26	Thu	11:00 AM - 11:50 AM	Will Hartwig
247	EKLC M2B26	Thu	1:00 PM - 1:50 PM	Price Kirby

Table of Acidities

Acid	pK_a Value	Acid	pK_a Value
HI	–10.1	H_2O	15.7
HCl	–3.9	Alcohols	16-18
H_3O^+	–1.7	HC≡CH	26
CH_3COOH	4.7	NH_3	36
NH_4^+	9.3	H_2	37
Phenol	10	$H_2C{=}CH_2$	45
CH_3CH_2SH	10.5	CH_4	60

Section IA: Question 1 (2 points)

1) Which structure represents a thiol?

(A) CH_3SCH_3 (B) $CH_3S\text{-}SCH_3$ **(C) CH_3SH** (D) $(CH_3)_3SO$

Section IB: Question 2-13 (4 points each; total: 48 points)

2) What is the strongest intermolecular force in CH_3CH_2F?

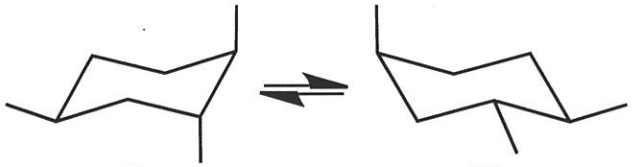
(A) Dispersion forces **(B) Dipole-dipole** (C) Hydrogen Bonding (D) Ion-dipole

3) Rank compounds I, II and III in order of ***increasing*** boiling point.

I. CH_3CH_2OH II. $CH_3CH_2CH_3$ III. CH_3CH_2F

(A) I < II < III (B) II < I < III (C) III < II < I **(D) II < III < I**

4) Which statement is ***correct*** concerning the relative stabilities of conformations **I** and **II**?



I **II**

(A) **I** is more stable than **II**.

(B) II is more stable than I.

(C) **I** and **II** have equal stabilities.

(D) More information is required to answer this question.

5) How are these two structures related?

(A) Constitutional isomers (B) Different conformations of the same compound

(C) Homomers (identical) **(D) Stereoisomers**

6) In the ***most stable*** conformation of *cis*-1-*tert*-butyl-3-methylcyclohexane,

(A) both substituents are equatorial.

(B) both substituents are axial.

(C) the *tert*-butyl substituent is equatorial and the methyl group is axial.

(D) the *tert*-butyl substituent is axial and the methyl group is equatorial.

7) Select the answer that describes the ***best*** method to prepare the nucleophile $C_2H_5S^-$.

(A) $C_2H_5SH + H_2O \rightleftharpoons$

(B) $C_2H_5SH + I^- \rightleftharpoons$

(C) $C_2H_5SH + CH_3COO^- \rightleftharpoons$

(D) $C_2H_5SH + {}^-OC_2H_5 \rightleftharpoons$

8) When 1-chloro-4-fluorobutane is reacted with 1 equivalent of NaI in acetone, a precipitate is formed. What is the chemical identity of the precipitate?

(A) NaCl (B) NaF (C) 1-fluoro-4-iodobutane (D) 1-chloro-4-iodobutane

9) Which bromide reacts fastest with CH_3OH by the S_N1 mechanism?

(A) 1-Bromopentane **(B) 2-Bromo-2-methylbutane**

(C) 3-Bromopentane (D) 1-Bromo-2,2-dimethylpropane

10) Which statement does ***not correctly*** describe S_N2 reactions of alkyl halides?

(A) Reaction rate is first-order in both [alkyl halide] and [nucleophile].

(B) The nucleophile approaches from the backside of the carbon-halogen bond.

(C) Tertiary halides react faster than secondary halides.

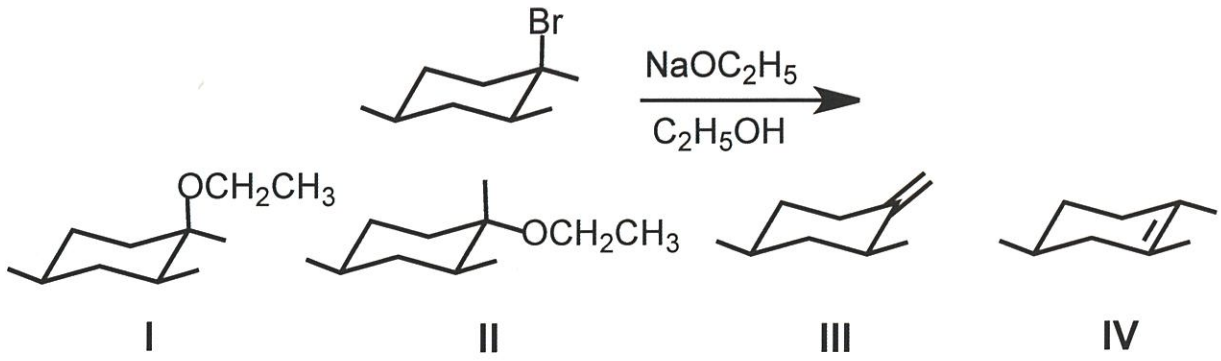
(D) The mechanism is best described as a concerted, one-step mechanism.

11) Select all the polar, aprotic solvents.

I. CH_3OH **II.** CH_3COCH_3 (acetone) **III.** DMF (N,N-dimethylformamide)

(A) **I** and **II** **(B) II and III** (C) **I** and **III** (D) **I, II** and **III**

12) Select the ***major*** product in the reaction shown.



(A) **I** (B) **II** (C) **III** **(D) IV**

13) Which reaction produces the highest yield of $CH_3CH_2OCH(CH_3)_2$?

(A) $CH_3CH_2O^- + (CH_3)_2CHBr \rightarrow$

(B) $(CH_3)_2CHO^- + CH_3CH_2Br \rightarrow$

(C) $(CH_3)_2CHO^- + CH_3CH_2OH \rightarrow$

(D) $CH_3CH_2O^- + (CH_3)_2CHOH \rightarrow$

CHEM 3311-200
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Assigned Seat # _____
Recitation Section # _____
(Note: –5 points for missing Recitation section #)

Please ***sign*** the Honor Pledge.

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PRINT Last Name, First Name, Middle Initial **Please Sign Here**

Section II: SHORT ANSWER Questions 14-17 (total: 50 points)

For Grading Purposes Only

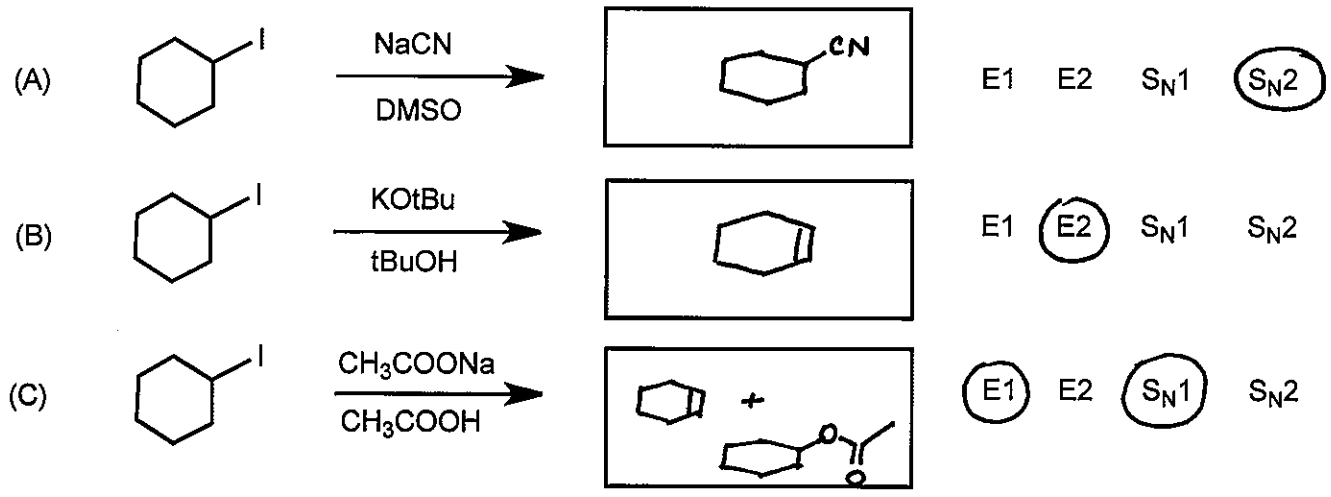
Points Earned on Short Answer Section

Question 14 (10 points) _____
Question 15 (13 points) _____
Question 16 (12 points) _____
Question 17 (15 points) _____
Bonus Question (10 points) _____

Total Points (50 possible) _____

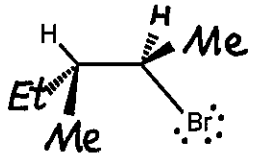
14) 10 points

Draw the structure of the product(s) formed in each reaction, showing stereochemistry where appropriate. Circle the mechanism(s) using the labels on the right.

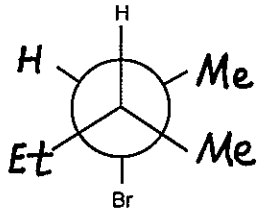


15) 13 points
When (2*R*,3*R*)-2-bromo-3-methylpentane reacts in the presence of C_2H_5ONa in C_2H_5OH, an alkene is formed.

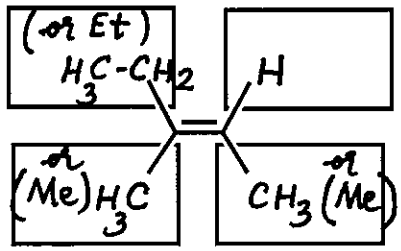
(A) Draw the structure of (2*R*,3*R*)-2-bromo-3-methylpentane using the skeletal line-and-wedge projection shown below. NOTE: You must draw the atoms (H) or groups (Me for methyl and Et for ethyl) attached to the solid- and dotted-wedges to represent (2*R*,3*R*)-2-bromo-3-methylpentane!!!!

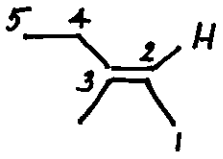


(B) Complete the Newman projection (using the skeletal framework shown) for the anti-coplanar arrangement that leads to the product.



(C) Draw the structure of the major product, showing correct stereochemistry. Place H, CH_3 or CH_3CH_2 in the appropriate boxes.

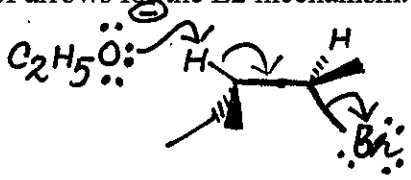




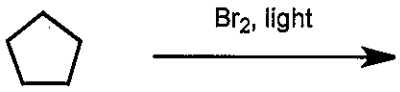
(D) Write the correct IUPAC name of this compound.

(E)-3-methyl-2-pentene

(E) Draw the line-and-wedge projection for (2*R*,3*R*)-2-bromo-3-methylpentane, as in part (A), and show the direction of arrows for the E2 mechanism. You must include the base and show how it participates,

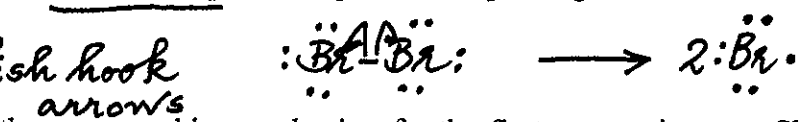


16) 12 points
For the reaction shown below:

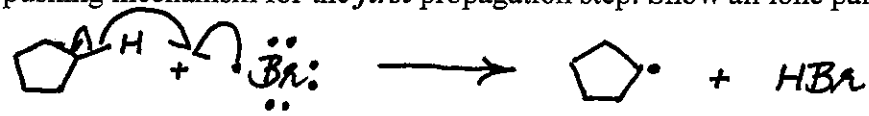


(A) Write the initiation step, showing the arrow pushing mechanism for this step. Show all lone pairs.

fish hook arrows



(B) Write the arrow pushing mechanism for the ***first*** propagation step. Show all lone pairs.



(C) Calculate ΔH for the ***first*** propagation step using the bond energies provided.

Bond Type	Bond Energy (kJ/mol)
C-H in cyclopentane	395
C-Br in bromocyclopentane	284
Br-Br	192
H-Br	366

Show your calculations.

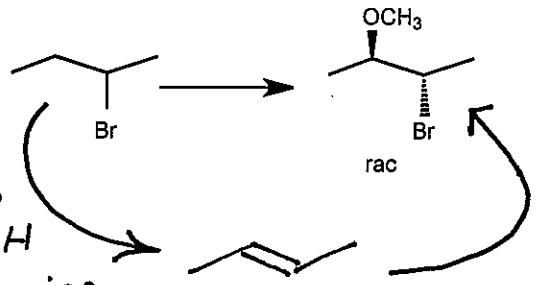
Break C-H bond in cyclopentane : +395 kJ/mol
endothermic

Form H-Br bond: −366 kJ/mol ; ΔH = +395 kJ/mo
−366 kJ/mol
+29 kJ/mo

ΔH = +29 kJ/mol Show sign and magnitude.

17) 15 points
Propose a synthetic route to the desired product using the starting material shown and any other reagents you need. If more than one step is necessary, show the product of each step. Do NOT show mechanisms. Some types of reactions such as hydroboration-oxidation, oxymercuration-reduction, etc. should be presented as a single step using (1), (2), etc. to represent the reactions involved. Please show stereochemistry where necessary.

(A) 6 points



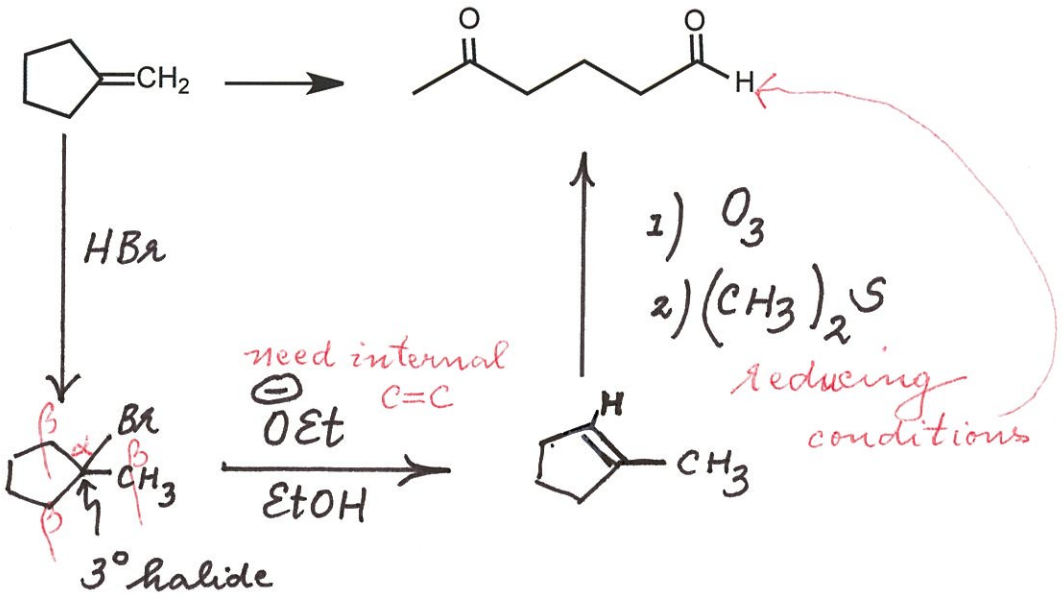
Partial Credit
EtO⁻/EtOH
SN2/E2

tBuO⁻, tBuOH (maximize E2)

Br2, CH3OH

Propose a synthetic route to the desired product using the starting material shown and any other reagents you need. If more than one step is necessary, show the product of each step. Do NOT show mechanisms. Some types of reactions such as hydroboration-oxidation, oxymercuration-reduction, etc. should be presented as a single step using (1), (2), etc. to represent the reactions involved. Please show stereochemistry where necessary.

(B) 9 points



BONUS SYNTHESIS QUESTION (10 points)