Final Exam Organic Chemistry I CHEM 340 Spring 16 5/11 W Dr. Hahn MWF 8 am Exam# _____

Sign Name key Print Name _____

(3 pt name sign & print above 3 pts scantron name) (12 pages + periodic table + equation + scantron)

Please show work on all questions for partial credit even on questions which do not specify. Please write legibly. If I cannot read your answer, I cannot grade your answer. (use back of exam for scratch paper – If you want me to grade something not in the space for the answer, clearly specify in writing. Telling me during the exam where to find the answer does not qualify because I will just vaguely remember someone telling me something during the exam not which one of 200 students told me what to grade on what page of the exam.)

Please READ and FOLLOW directions. This is a **TIMED EXAM**. (ex: don't give me 5 structures if I only ask for one or you will lose points on this exam by **RUNNING OUT OF TIME**)

Circle answer on this form for backup to the scantron for the multiple choice. R=alkyl, not hydrogen on all parts of this exam.

I. Multiple Choice (3 pts each, 27 pts) Choose the **one** best statement in each question.

NA = not attempted

1. For the reaction of an alkyne with the following.

(a) Reaction with Lindlar's catalyst results in ~~trans~~ cis alkene.

(b) Reaction with dissolving metal (Na^0 in NH_3) results in ~~cis~~ trans alkene

NW = no work

(c) Reaction with H_2 and metal catalyst Pt, Ni, Pd/C results in ~~cis alkene~~ alkane.

(d) None of the above are correct.

BA = bad attempt

2. Choose the **best statement** about intermolecular forces.

(a) $CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{N}}}-CH_3$ has hydrogen bonding

(b) $CH_3-\underset{\displaystyle H}{\overset{}{N}}-H$ has hydrogen bonding

(c) $Cl-\underset{\displaystyle Cl}{\overset{\displaystyle H}{\overset{|}{C}}}-H$ has hydrogen bonding

(d) All statements above are correct.

3. Choose the best statement.

(a) In proton NMR, protons closest to either an electronegative atom or π bond are shielded and have lower ppm numbers.

(b) Number of peaks in a splitting pattern for proton NMR coupling equals 2nI+1 where n = number of protons with that chemical shift and I = ½

(c) Hydrogens involved in hydrogen bonding such as carboxylic acid acidic hydrogen and amine hydrogens are exchanging protons which show a broad proton NMR peak and have shifting chemical shifts depending on solvent and concentration.

(d) The standard used in proton NMR is the molecule $(CH_3)_3$ Si which gives 1 peaks around zero ppm.

(e) All statements above are false.

4. For the element **Si**, circle the one **incorrect** statement.

(a) The number of electrons for a neutral atom is 28

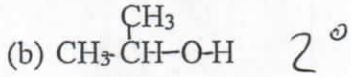
(b) The atomic number is 14

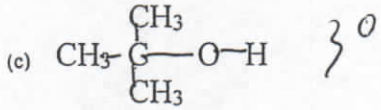
(c) The atomic mass is 28.09

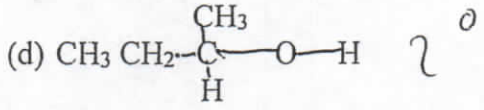
(d) The number of valence electrons is 4

5. Choose the **primary alcohol** from the list below

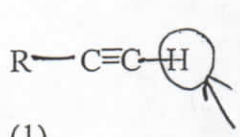
(a) CH_3CH_2OH

(b) 

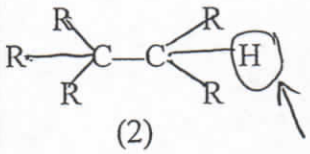
(c) 

(d) 

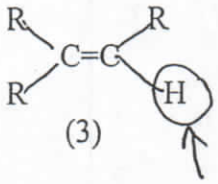
6. Given the following molecules: The most acidic proton among the protons shown is: (assuming all of the R groups shown are some sort of alkyl groups)



(1)



(2)



(3)

(a) Molecule (2)

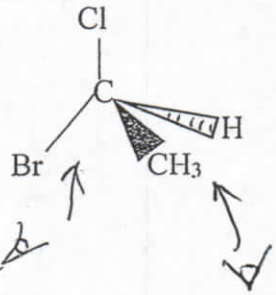
(b) Molecule (1)

(c) Molecule (3)

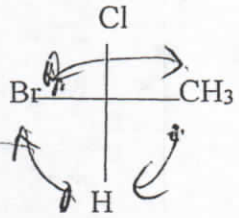
(d) None of the protons shown are the least bit acidic.

(e) All of the above are equally acidic.

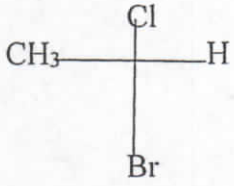
7. Which of the following are the same molecule as the molecule shown in 3D.



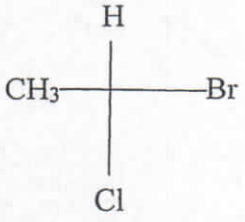
(a)



(b)

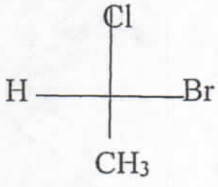


(c)



180°

(d)



(e) All of the above are the same molecule as the original molecule.

8. Choose the **best** statement.

(a) $CH_3CH_2CH_2CH_2CH_3$ and $CH_3CH(CH_3)CH_2CH_3$ are structural isomers

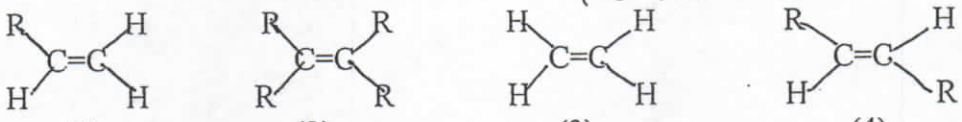
(b) CH_3CH_2OH and CH_3OCH_3 are structural isomers

(c) $CH_3CH_2CH(CH_2CH_3)CH_2CH_3$ & $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ are structural isomers

(d) All of the above are structural isomers.

(e) None of the above pairs of molecules are structural isomers.

9. According to Saytzeff's rule, given the following alkenes where R = alkyl and not hydrogen, If you assume that the alkenes shown below are possible products to an elimination reaction producing an alkene.



(1) (2) (3) (4)

(a) The most likely product is (3) (most likely) > (1) > (4) > (2) (least likely product)

(b) The most likely product is (2) (most likely) > (4) > (1) > (3) (least likely product)

(c) The most likely product is (4) (most likely) > (3) > (2) > (1) (least likely product)

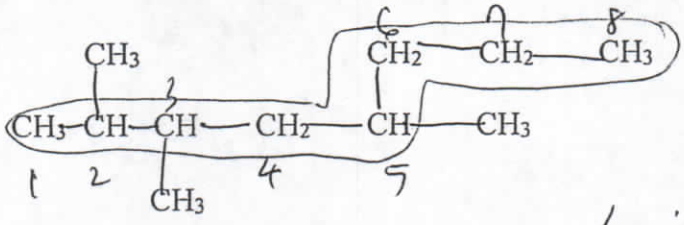
(d) None of the above are correct.

II. Short Answers (## pts)

A. Nomenclature: (2 pts each, 6 pts)

1. Given the structural formula shown below, give the IUPAC name of the molecule.

a. Name of molecule 2,3,5- trimethyloctane



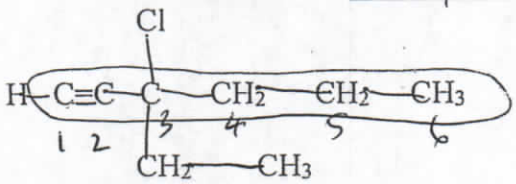
octane

2,3,5-trimethyl

BA -1/2

not longest chain -1/2

b. Name of molecule 3-chloro-3-ethyl-1-hexyne



-1-hexyne

3-ethyl

=

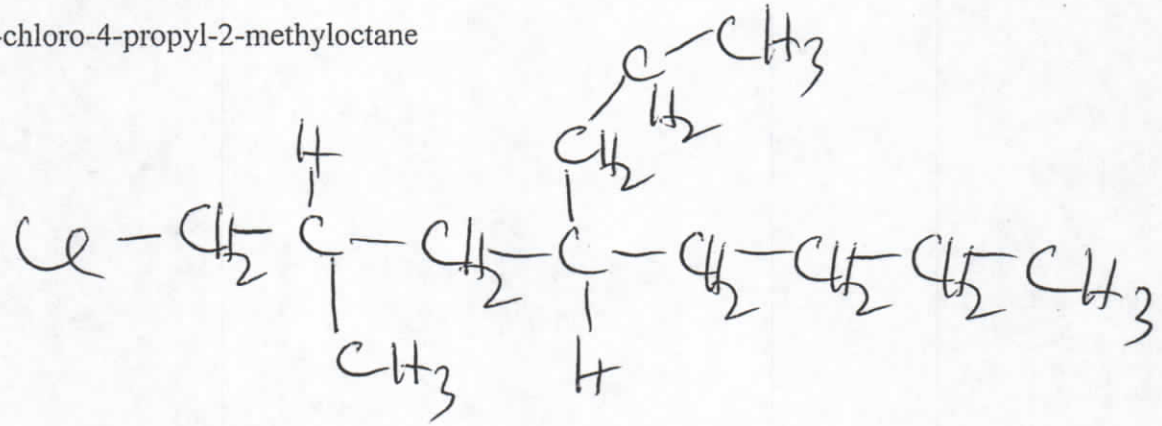
3-chloro

=

-1/2 each incorrect thing up to BA

2. Given the following IUPAC name, draw a structural formula of the molecule (skeletal formula acceptable, condensed structure, Lewis Dot structure acceptable, molecular formula not acceptable - don't forget to **show the hydrogens** in your formula unless you are using the skeletal structure.)

a. 1-chloro-4-propyl-2-methyloctane



C. Reactions Part of Short Answers: (2 pts per reaction, 14 pts total)

Complete the following reactions by giving the organic products. This is NOT mechanisms so you just need to give me the final product and no steps on the way to product. Reactions do NOT need to be balanced. (Circle the number of the **7 (seven)** of the following reactions you want graded.)

NFE = not far enough

TF = too far

ox + adding stuff −1

regio, stereo intermediate −1

1) CH_3CH_2, H, CH_3, H + H Br → mark

2) H, CH_3, H, CH_3 $\xrightarrow{H_2O,\ H^+}$ mark

3) CH_3, H, H, CH_3 $\xrightarrow{H_2,\ Ni}$

4) H, CH_3, H, CH_3 $\xrightarrow[NaBH_4]{Hg(OAc)_2\ H_2O}$ mark

5) H, H, H, H $\xrightarrow{MCPBA}$

6) $CH_3-C\equiv C-CH_3$ $\xrightarrow{Cl_2\ (one\ mole)}$

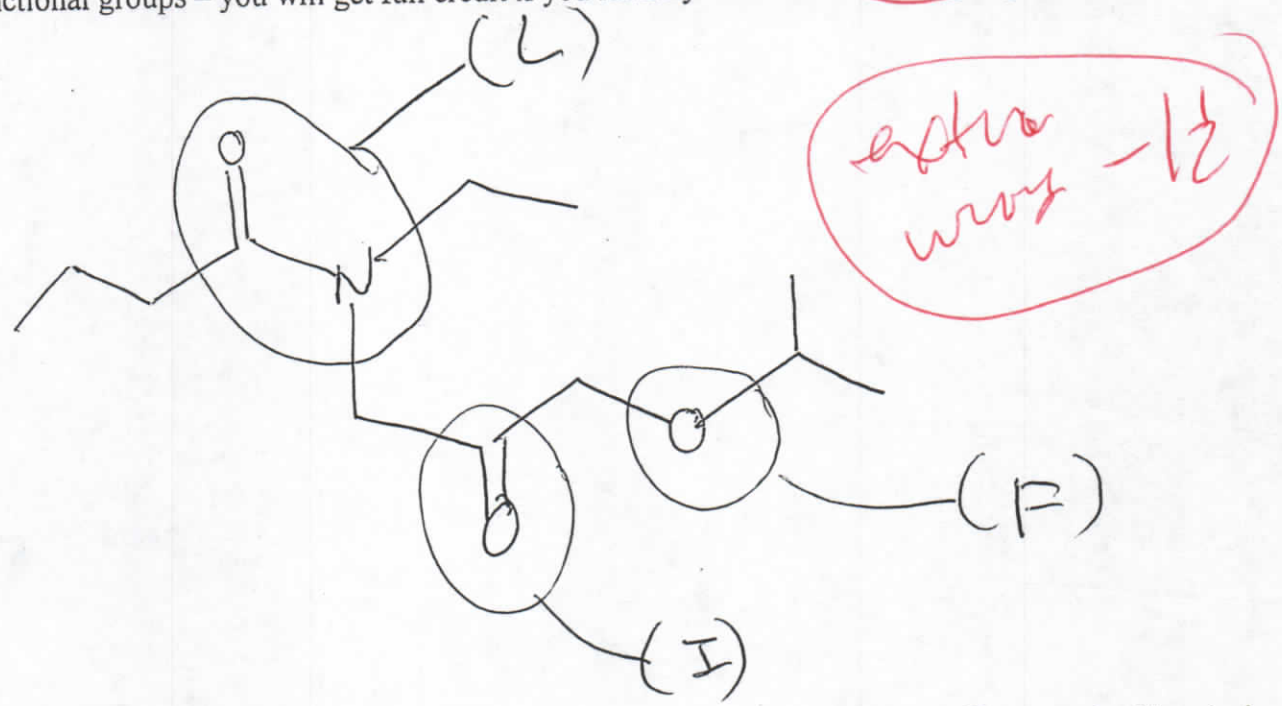
7) $CH_3CH_2-C\equiv C-CH_3$ $\xrightarrow{Na^o/NH_3\ (one\ mole)}$ NFE

8) $CH_3-C\equiv C-H$ $\xrightarrow[HgSO_4,\ H_2O]{mark}$ tautomerization

B. Short Answers Part of Short Answers (27 pts)

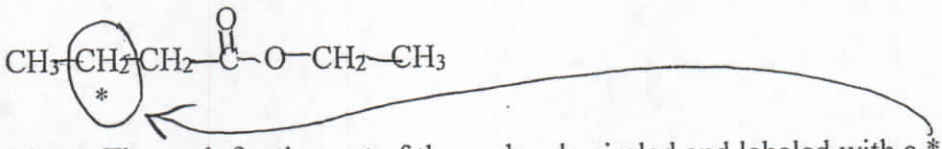
1. Given the following molecule, fill in the parenthesis with the letter of the functional group.

(A) alkene (B) alkyne (C) arene (D) alkyl halide (E) alcohol (F) ether (G) amine (H) aldehyde (I) ketone (J) carboxylic acid (K) ester (L) amide (M) acid halide (N) acid anhydride (You may use the same letter multiple times) (3 pts each, 6 pts total) There may be more than 2 functional groups – you will get full credit if you identify 2 of the functional groups correctly.



extra way -½

2. NMR Spectroscopy: Answer the following about the molecule below. Show work. (# peaks in coupling pattern = 2nI + 1 where I = ½ for proton NMR). (8 pts total)



(a) The peak for the part of the molecule circled and labeled with a * has integration number of

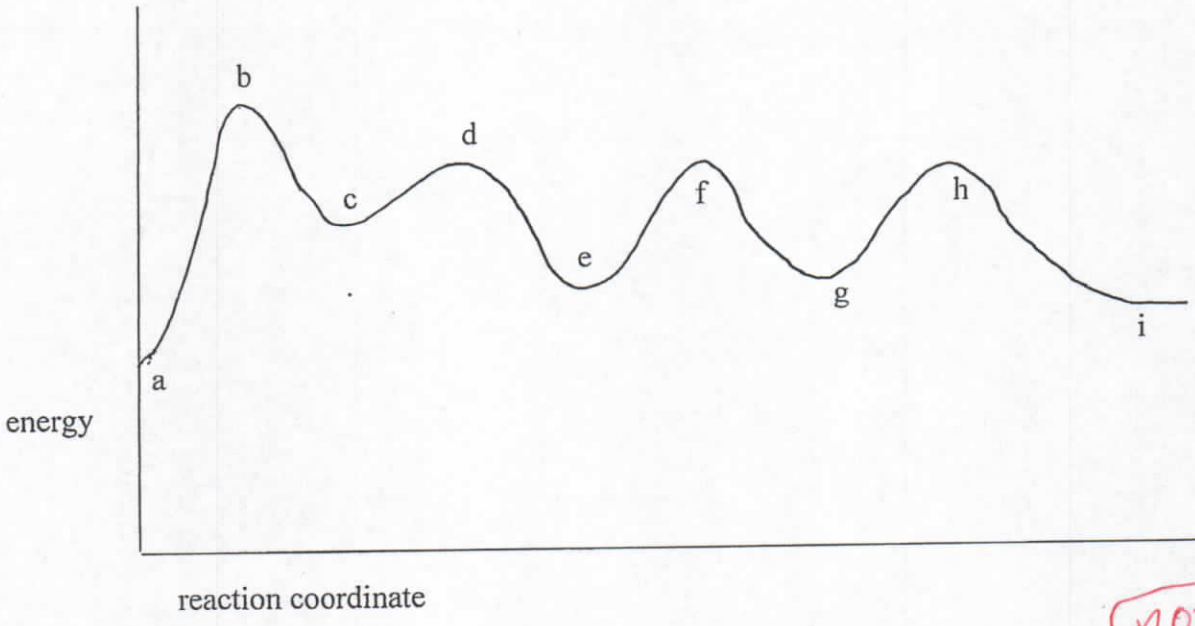
2 (assuming integration number one for each proton) (2 pt)

(b) The proton with * has coupling of 6. (2 pt) Show work for your coupling number. (4 pts)

n = 5, 2nI + 1 =

2(5)½ + 1 = 6

3. Given the following labeled energy diagram, complete the following by circling the answers (8 pts total)



not circled #4 -2

(a) The above reaction mechanism energy diagram has

[(1) (2) (3) (4) (5)] **transition states** (circle one correct number) (2 pts)

(b) The **transition states are labeled** [(a) (b) (c) (d) (e) (f) (g) (h) (i)] (circle all correct) (2 pts)

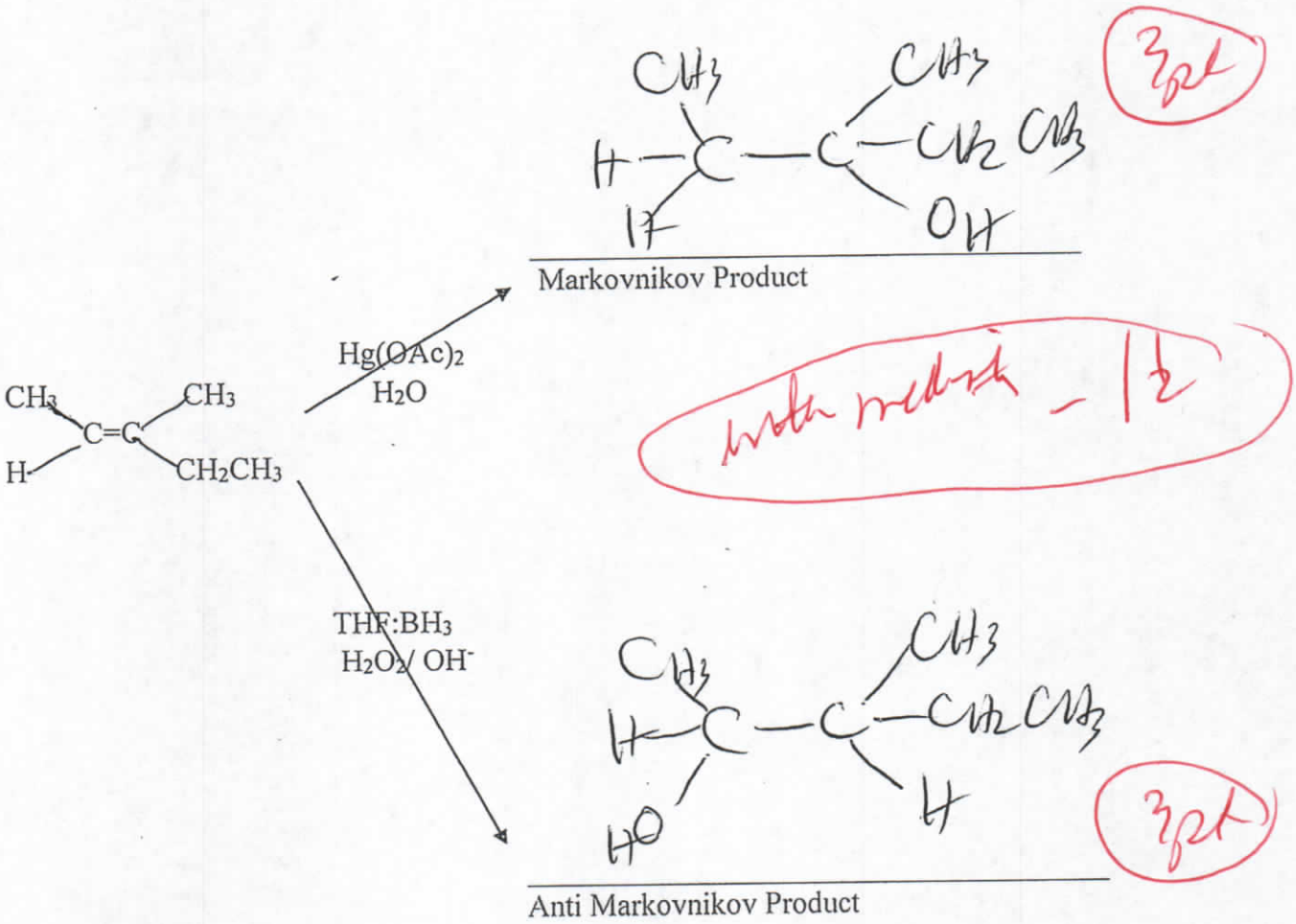
(c) The above energy diagram has: [(1) (2) (3) (4) (5)] **intermediates** (circle one correct number) (2 pts)

(d) The intermediates are labeled [(a) (b) (c) (d) (e) (f) (g) (h) (i)] (circle all that match) (2 pts)

-½ off

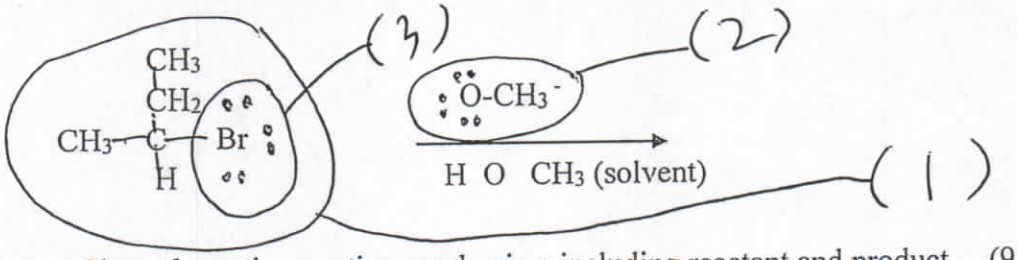
circled b, d, f, h -2

4. Give the Markovnikov's Rule and anti Markovnikov's Rule products for regioselectivity of the electrophilic addition of H—O-H to the alkene. H-OH is not the actual reaction reagent. **Actual Reagent is shown below.** (6 pts total, 3 pts each)

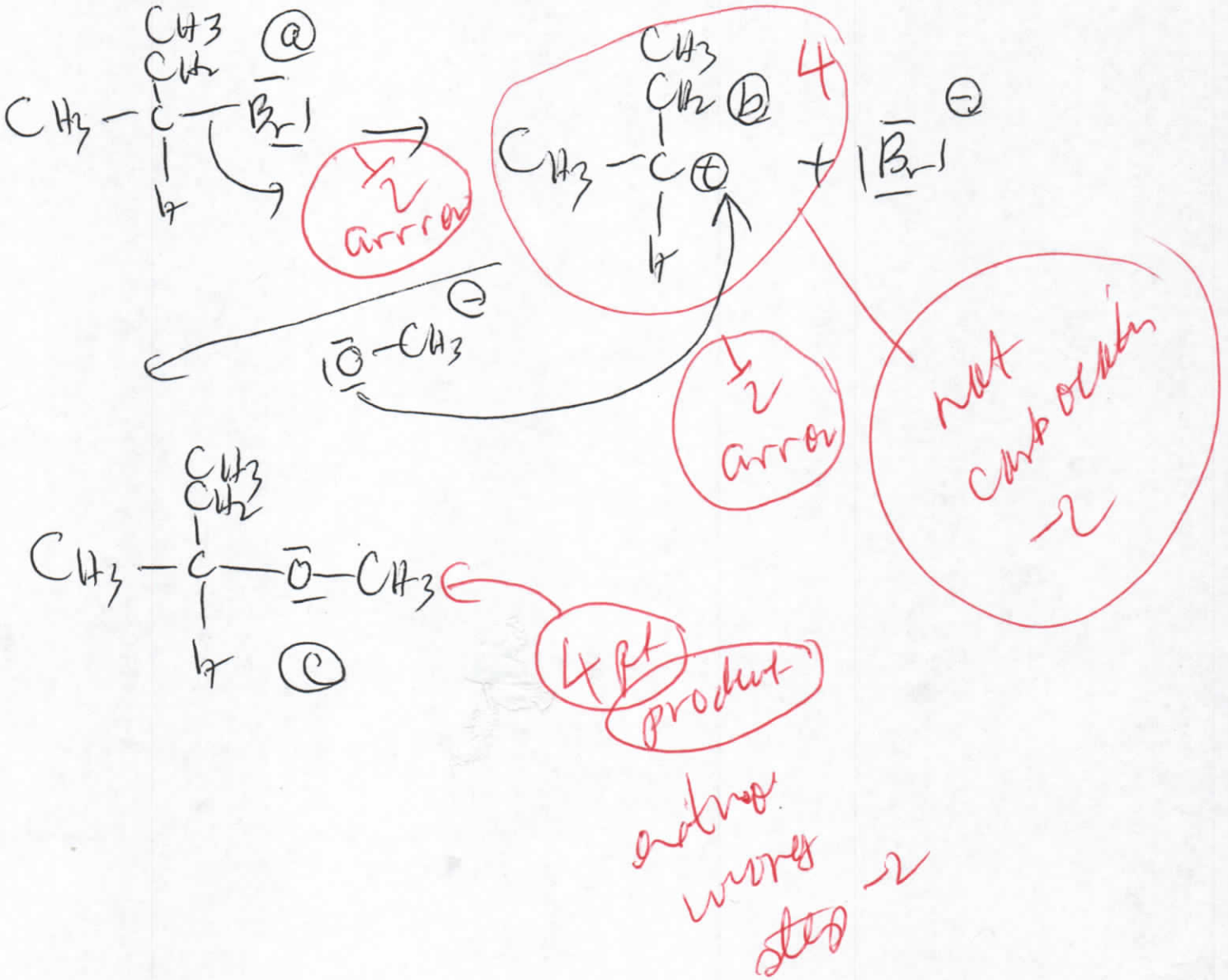


Part III. Long Answers (29 pts) Show work. Note that you earn partial credit for "attempt" in the mechanism. "Attempt" is defined as not just rewriting the question but doing something towards getting the final answer. If you just rewrite the same thing multiple times as an additional step in the mechanism, you will get no additional points.

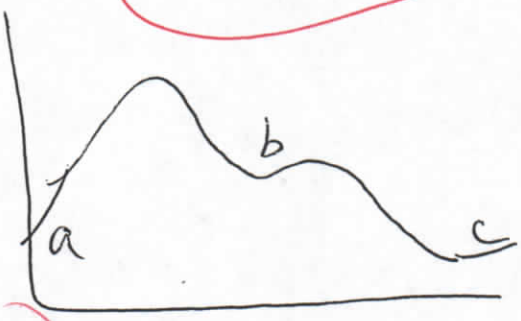
1 (S_N1) Reaction Mechanism. (19 pts) A. Label the circled parts of the molecule with one of the numbers (1) substrate (2) nucleophile (3) leaving group (3 pts)



B. Show the entire reaction mechanism including reactant and product. (9 pts)



C. Draw an energy diagram which matches the above mechanism in part B. Label your reaction mechanism (ex: a,b,c,etc) and label your energy diagram to match the mechanism above. (2 pts)



reaction progress (time)

label ✓

mechanism messed up or energy wrong

-½ energy

too many steps ✓

D. Write the rate law for the reaction mechanism using the actual molecule in your reaction above. If you write the rate law using the words substrate or nucleophile, I will count off. (2 pts)

rate = $k_2[CH_3CH_2CH(Br)CH_3]$ — in words -1

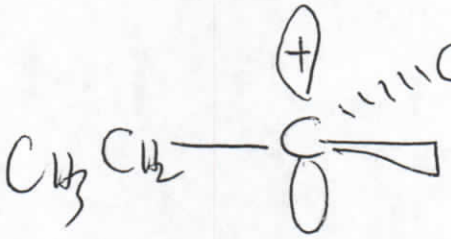
give rate = k[substrate][nu] ✓

1pt

E. If you started the reaction with a chiral center of R (at the carbon attached to the Bromine), what is the chirality at the end of the reaction ? [(R) or (S) or (racemic)] (circle one)(1 pt) Explain (2 pts)

said C=O ✓

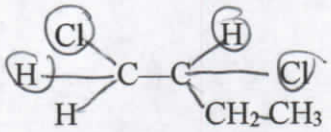
mechanism goes by carbocation intermediate



The "Nu" can come in from either the top or bottom with equal probability so you would get both R + S products equally = racemic mix

2 Complete the following synthesis by filling in the blank. I have provided some hints to help you come up with the answers. NOTE: The way I grade this is for you to fill in reasonable molecules based on the immediate prior molecule. i.e. If you fill in part A with the wrong molecule and then do the next reaction to molecule B correctly you will get half credit for answering B correctly. If you fill in B with what you would have gotten if you got A correctly but which cannot possibly be generated from your wrong A, you will lose all credit even if it matches what you should have gotten for B. (2 pts each, 10 pts total)

2 pts each



KOH
- 2 HCl

$H-C\equiv C-CH_2CH_3$

(A) IR shows C≡C stretch C_4H_6

incorrect prior step
impossible current RXN from incorrect prior but matches current answer
-2 pt

$Na^{\oplus}\ :C\equiv C-CH_2CH_3$

$NaNH_2$

(B) IR still shows C≡C stretch $Na\ C_4H_5$

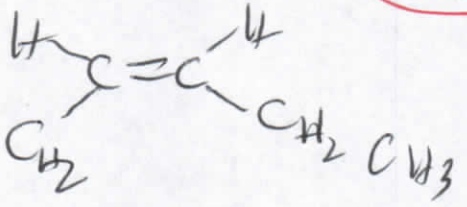
CH_3CH_2Cl

$CH_3CH_2-C\equiv C-CH_2CH_3$

(C) IR still shows C≡C stretch
C_6H_{10}

incorrect prior step does not match answer but correct RXN -1 pt

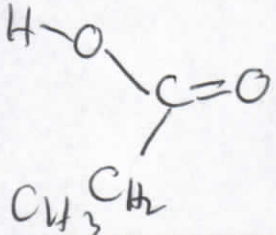
Stereo -1



Lindlar's Catalyst

(D) C_6H_{12}

NFE, TF-1



hot $KMnO_4$

(E) you get 2 of the same molecule IR shows C=O stretch $C_3H_6O_2$