

NAME (Print): _____

Chemistry 320N
2nd Midterm Exam
March 7, 2024

EID _____

SIGNATURE: _____

**Please print the
first three letters
of your last name
in the three boxes**

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Please Note: Please take your time. You have three hours to take this exam. Please do not rush, we want you to show us everything you have learned this semester so far! Making careless mistakes is not good for anyone! If you find yourself getting anxious because of a problem, skip it and come back. Please do not second guess yourself! Keep track of the questions worth a lot of points. (This does not mean they are hard, it just means we think they cover important material.)

One last thing: I recommend you close your eyes for a moment, then take some nice deep breaths before you begin. YOU GOT THIS!

FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENTS YOU ARE NOT ALLOWED TO INTERACT WITH YOUR CELL PHONE IN ANY WAY. IF YOU TOUCH YOUR CELL PHONE DURING THE EXAM YOU WILL GET A "0" NO MATTER WHAT YOU ARE DOING WITH THE PHONE. PUT IT AWAY AND LEAVE IT THERE!!!

Student Honor Code for the University of Texas at Austin

"I pledge, as a member of The University of Texas at Austin community, to do my work honestly, respectfully, and through the intentional pursuit of learning and scholarship."

Elaboration

1. I pledge to be honest about what I create and to acknowledge what I use that belongs to others.
2. I pledge to value the process of learning in addition to the outcome, while celebrating and learning from mistakes.
3. This code encompasses all of the academic and scholarly endeavors of the university community.

(Your signature)

PERIODIC TABLE OF THE ELEMENTS

Elementary Subatomic Particles

Symbol	Electron	Proton	Neutron	Positron	Neutrino
Rest mass (kg)	$9.10938291 \times 10^{-31}$	$1.67262161 \times 10^{-27}$	$1.67492729 \times 10^{-27}$	0	0
Relative mass (dalton)	0.000548579909	1.007276467	1.008664915	0	0
Particle-antiparticle mass ratio	1	1.001072435	1.001308533	0	0
Specific charge (C/kg)	$-1.759820029 \times 10^{11}$	$9.58297246 \times 10^{10}$	0	0	0
Spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Spin quantum number	$\pm \frac{1}{2}$	$\pm \frac{1}{2}$	$\pm \frac{1}{2}$	$\pm \frac{1}{2}$	$\pm \frac{1}{2}$
Charge/mass ratio (C/kg)	$-1.759820029 \times 10^{11}$	$5.64617957 \times 10^{10}$	0	0	0
g-factor	2.00183828	1.81827152	1.81827152	1.81827152	1.81827152
g-factor anomaly (ppm)	0.001167418	0.00000000	0.00000000	0.00000000	0.00000000
g-factor anomaly (ppm)	0.001167418	0.00000000	0.00000000	0.00000000	0.00000000
g-factor anomaly (ppm)	0.001167418	0.00000000	0.00000000	0.00000000	0.00000000

Ionic Character of a Single Chemical Bond

Percent ionic character describes the nature of a bond. Bonded pairs of electrons are shared between atoms, but with less than 50% ionic character an ionic bond is formed. The percent ionic character is usually accompanied by a reduction in electron density, which is not reflected by the graph.

Atomic Weights

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Group Classifications

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Editors: T. K. Varma, M.A.Sc.; C. Bello, M.A.Sc.

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Compound		pK _a
Hydrochloric acid	H-Cl	-7
Protonated alcohol	$\text{RCH}_2\text{OH}_2^{\oplus}$	-2
Hydronium ion	$\text{H}_3\text{O}^{\oplus}$	-1.7
Carboxylic acids	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	3-5
Thiols	RCH_2SH	8-9
Ammonium ion	$\text{H}_4\text{N}^{\oplus}$	9.2
β-Dicarbonyls	$\text{RC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}'$	10
Primary ammonium	$\text{H}_3\text{N}^{\oplus}\text{CH}_2\text{CH}_3$	10.5
β-Ketoesters	$\text{RC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}'$	11
β-Diesters	$\text{ROC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}'$	13
Water	HOH	15.7
Alcohols	RCH_2OH	15-19
Acid chlorides	$\text{RCH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl}$	16
Aldehydes	$\text{RCH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	18-20
Ketones	$\text{RCH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}'$	18-20
Esters	$\text{RCH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OR}'$	23-25
Terminal alkynes	$\text{RC}\equiv\text{C}-\text{H}$	25
LDA	$\text{H}-\text{N}(\text{i-C}_3\text{H}_7)_2$	40
Terminal alkenes	$\text{R}_2\text{C}=\underset{\text{H}}{\text{C}}-\text{H}$	44
Alkanes	$\text{CH}_3\text{CH}_2-\text{H}$	51

1. (5 pts) What is the most important question in organic chemistry?

2. (1 pt each) Fill in each blank with the word that best completes the sentences. Yep, this is the MRI paragraph!

The popular medical diagnostic technique of 1. _____ 2. _____

3. _____ (_____) is based on the same principles as 4. _____,

namely the flipping (i.e. 5. _____) of nuclear spins of H atoms by

6. _____ frequency irradiation when a patient is placed in a strong

7. _____ 8. _____. Magnetic field 9. _____

are used to gain 10, _____ information, and rotation of the

11. _____ around the center of the object gives imaging in an entire plane (i.e.

12. _____ inside patient). In an MRI image, you are looking at individual

13. _____ that when 14. _____ make up the three-

dimensional image of 15. _____ amounts of 16. _____ atoms,

especially the 17. _____ atoms from 18. _____ and

19. _____, in the different 20. _____.

3. (10 pts) Amides are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided. (No need to draw any arrows for this.)

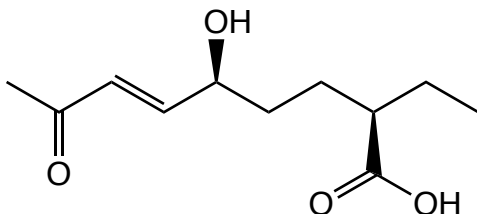


Signature _____

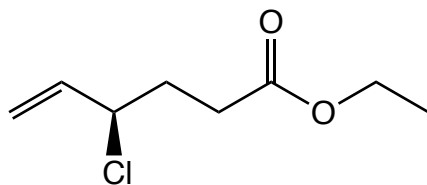
Pg 2 _____ (18)

4. (6 pts each) Write an acceptable IUPAC name or draw a structural formula for the following molecules:

A.

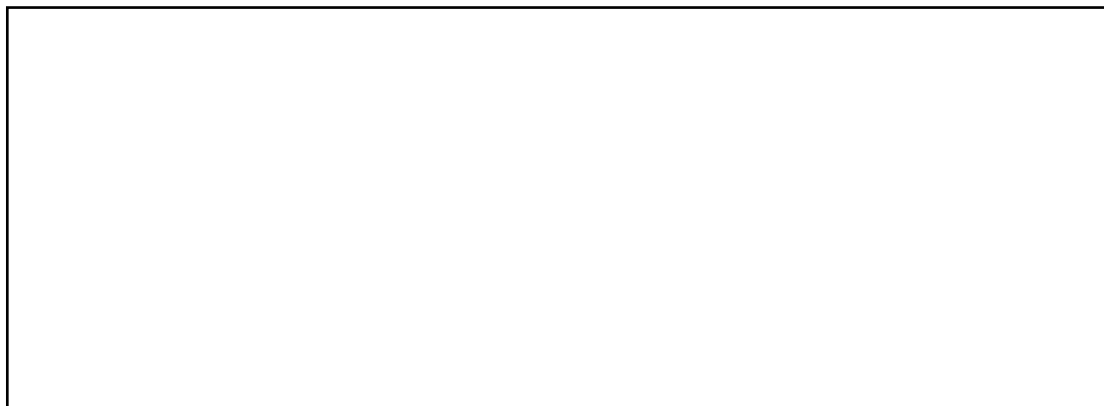


B.

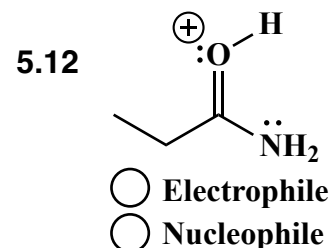
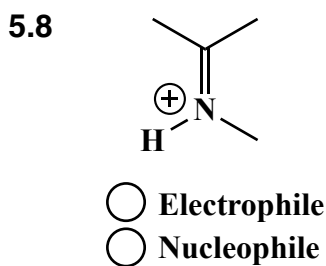
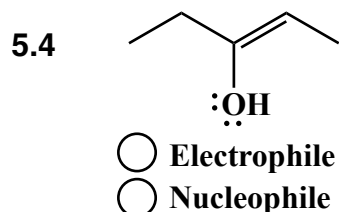
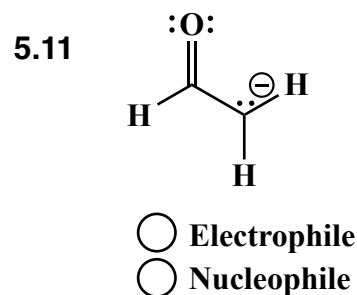
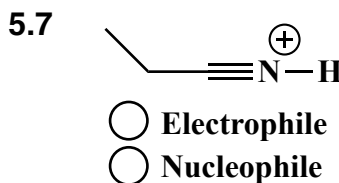
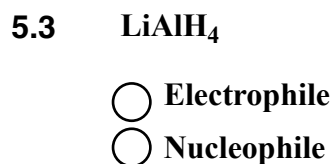
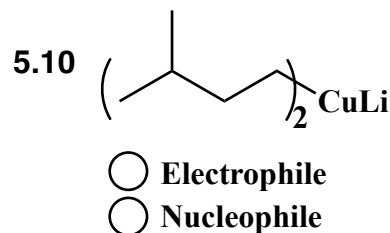
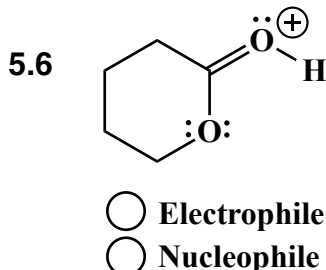
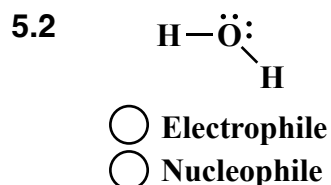
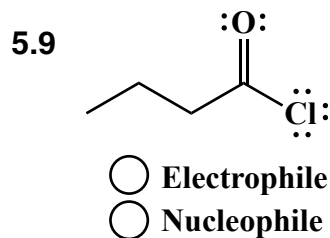
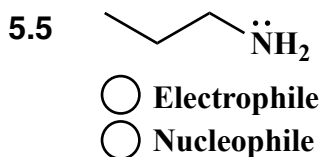
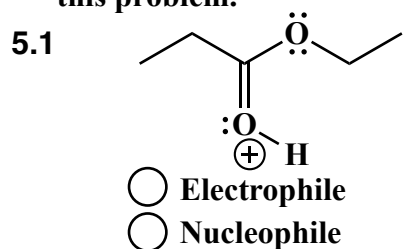


C. In the box, draw the structure corresponding to the following IUPAC name.

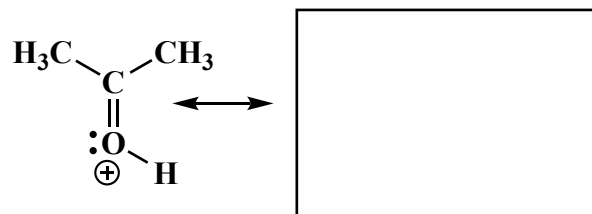
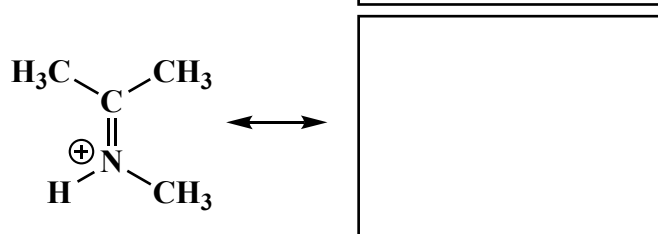
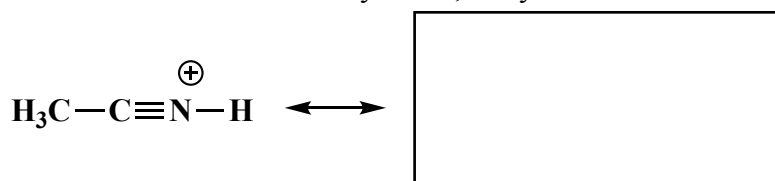
(*E*)-*N,N*-diethyl-3-methylpent-2-enamide
or (*E*)-*N,N*-diethyl-3-methyl-2-pentenamide



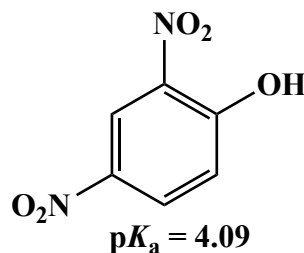
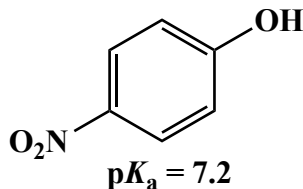
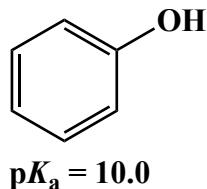
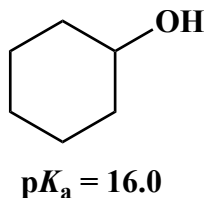
5. (12 pts) Being able to recognize the chemical personality of different species is one of the most important skills you can develop in Organic Chemistry. Fill in the appropriate circle to indicate whether each structure is a nucleophile or electrophile in the mechanisms we have seen. Note that these species might be proton acids or bases in certain situations, but we will ignore that for this problem.



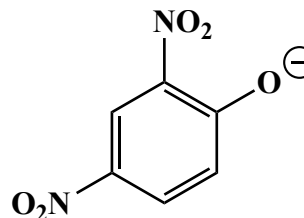
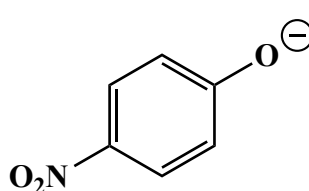
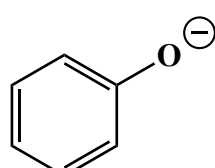
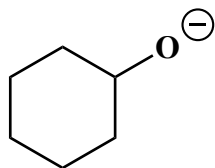
6. (6 pts) For each structure below, draw the other important contributing structure. You do not need to draw arrows anywhere, but you must include all lone pairs and formal charges.



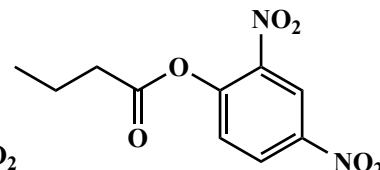
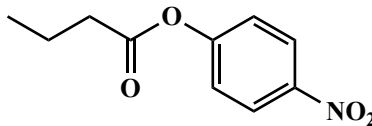
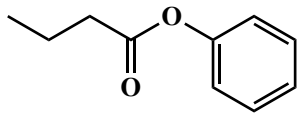
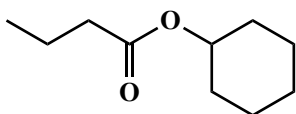
7. (16 pts) As described in class, the reactivity of carboxylic acid derivatives with nucleophiles is correlated with leaving group ability. We also pointed out that leaving group ability can be correlated with the pK_a of the protonated form of the leaving group anion. Here are a series of related alcohols with their pK_a values listed below each one.



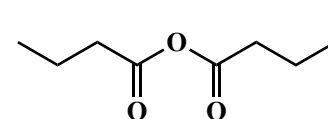
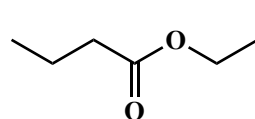
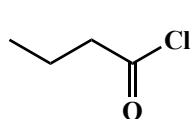
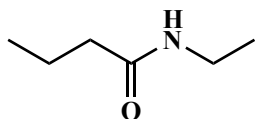
A) (1 pt each) Rank the stabilities of each of the following anions from 1-4. Put a "1" under the most stable anion, and a "4" under the least stable anion (then a "2" and "3" as appropriate).



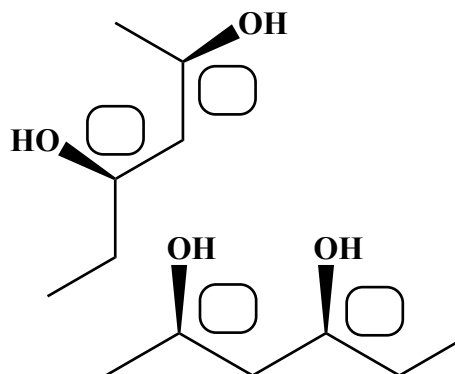
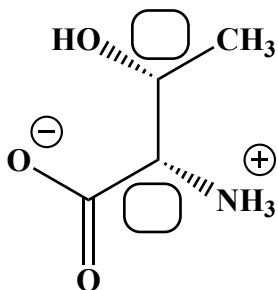
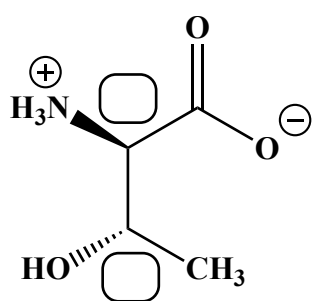
B) (1 pt each) Rank the following esters from 1-4 for reactivity with nucleophiles such as HO^- or an amine. Put a "1" under the most reactive with nucleophiles, and a "4" under the least reactive with nucleophiles (then a "2" and "3" as appropriate).



C) (2 pts each) Rank the following carboxylic acid derivatives from 1-4 for reactivity with nucleophiles such as water or an amine. Put a "1" under the most reactive with nucleophiles, and a "4" under the least reactive with nucleophiles (then a "2" and "3" as appropriate).



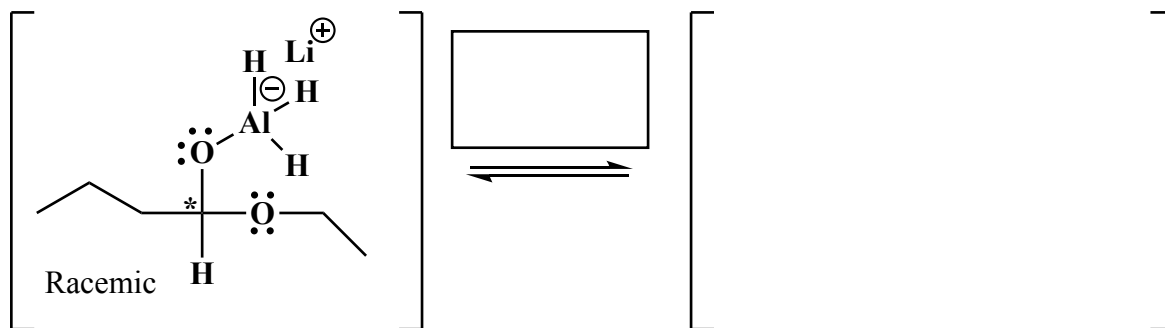
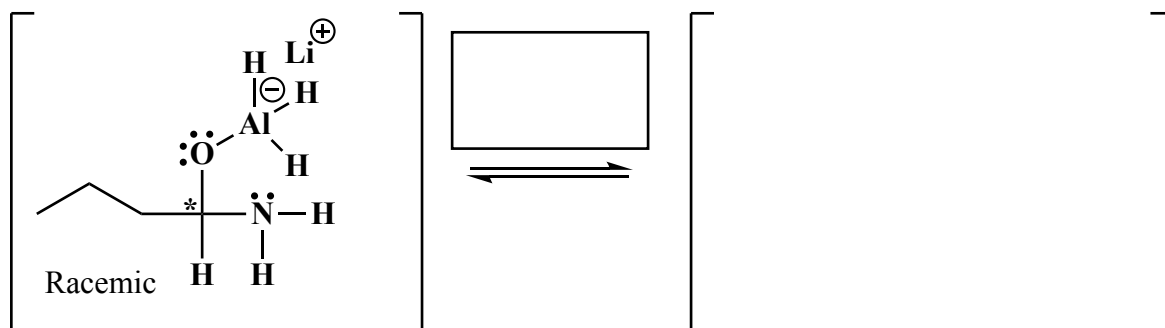
8. (12 pts) Being good at identifying relationships between molecules is an important skill in Organic Chemistry. **Fill in the circle to identify the stereochemical relationship between each pair of molecules. In the boxes provided, you need to write whether each chiral center is "R" or "S".**



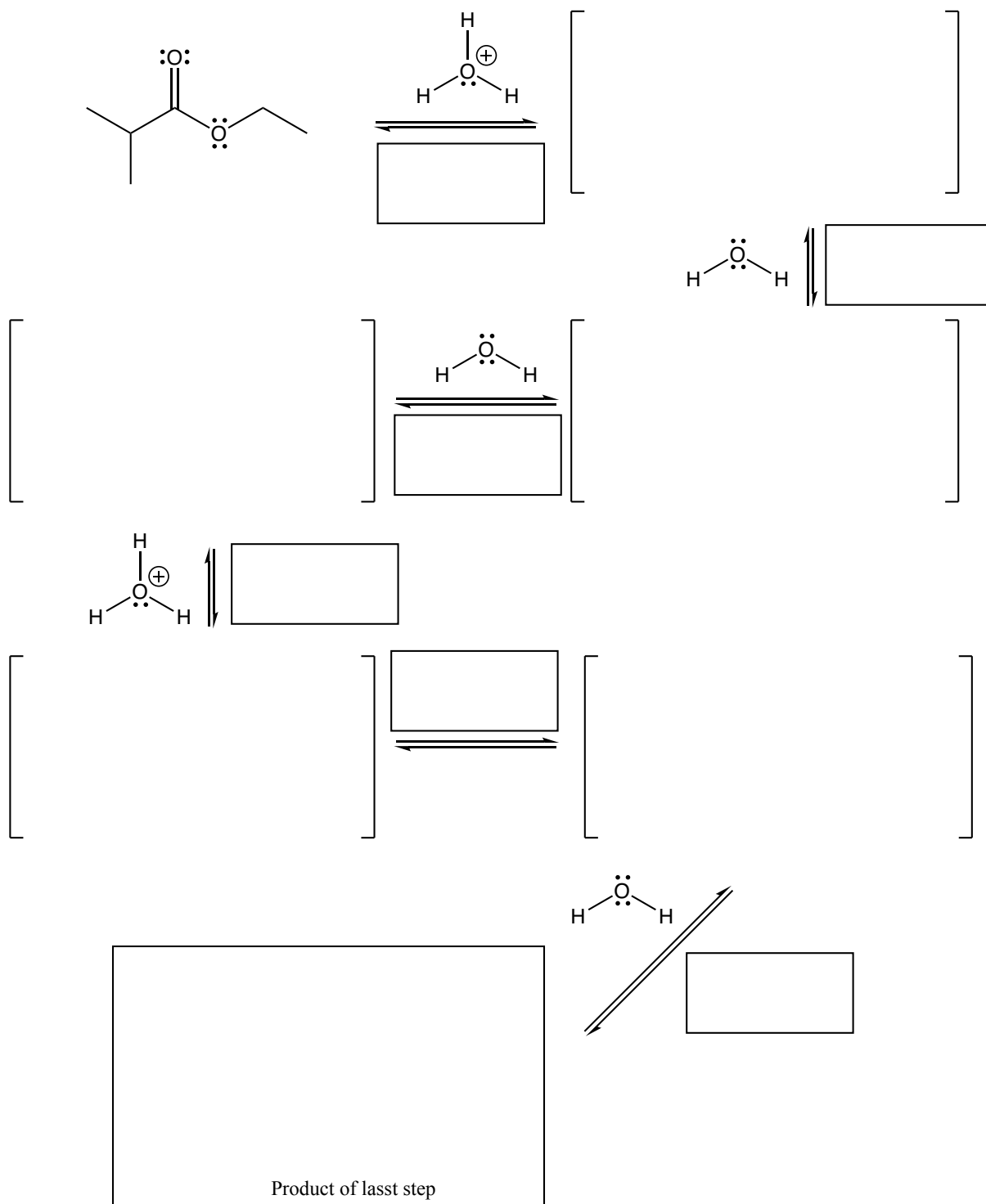
- Enantiomers
 Diastereomers
 Same Molecule

- Enantiomers
 Diastereomers
 Same Molecule

9. (14 pts) The following two intermediates are encountered in the reaction of LiAlH_4 with amides and esters, respectively. In each case, draw the appropriate arrows and only the next intermediate of the mechanism. No need to continue on with the mechanisms, we only want arrows on the structures we drew, and we only want you to draw the next intermediate in the mechanism. Remember to write all products of the step, and include all lone pairs and all formal charges. In the box over the arrow, indicate what type of step this is (add a proton, make a bond, etc.) HINT: *These are not the last steps of the mechanisms, so writing "Aluminum Salts" is not appropriate, you need to indicate the structure of the Aluminum species produced in this step.*

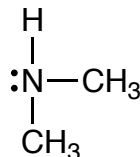
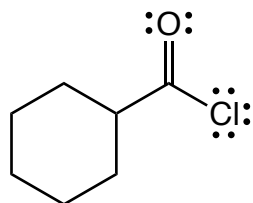


10. (35 pts) For this reaction, use **arrows to indicate movement of all electrons**, write **all lone pairs**, **all formal charges**, and **all the products for each step**. Remember, I said **all** the products for each step. **IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. FOR ALL CHIRAL PRODUCTS YOU MUST DRAW ALL ENANTIOMERS WITH WEDGES AND DASHES AND WRITE "RACEMIC" IF APPROPRIATE.** In the boxes provided by the arrows, write which of the 4 most common mechanistic elements describes each step (make a bond, break a bond, etc.).

Ester Hydrolysis

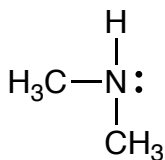
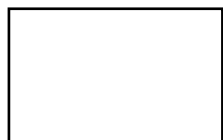
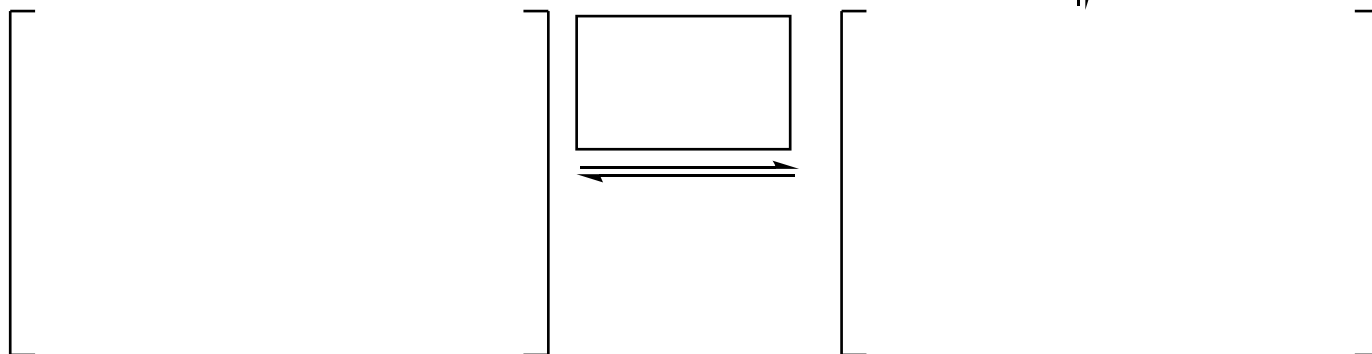
11. (24 pts) For this reaction, use **arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step. IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. FOR ALL CHIRAL PRODUCTS YOU MUST DRAW ALL ENANTIOMERS WITH WEDGES AND DASHES AND WRITE "RACEMIC" IF APPROPRIATE. In the boxes provided by the arrows, write which of the 4 most common mechanistic elements describes each step (make a bond, break a bond, etc.).**

Acid Chlorides Reacting with Amines



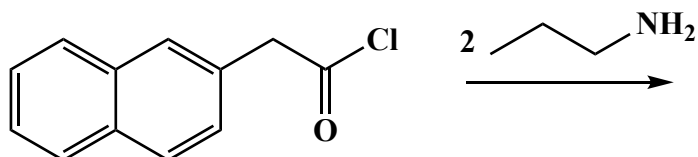
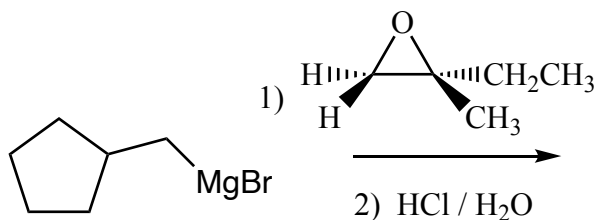
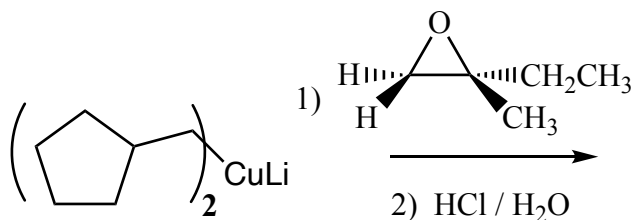
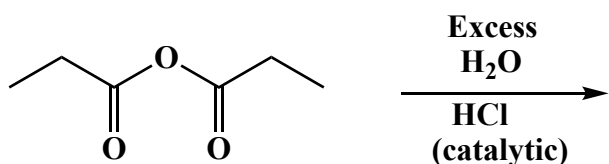
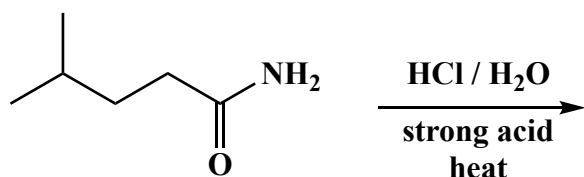
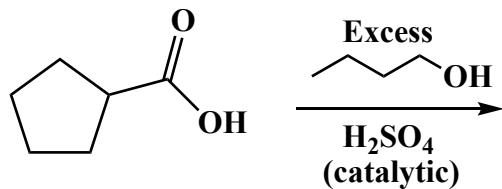
No need to draw arrows

Proton Transfer

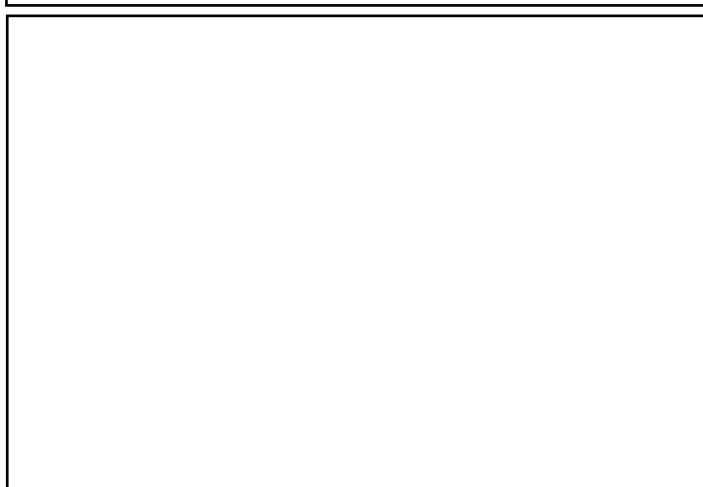
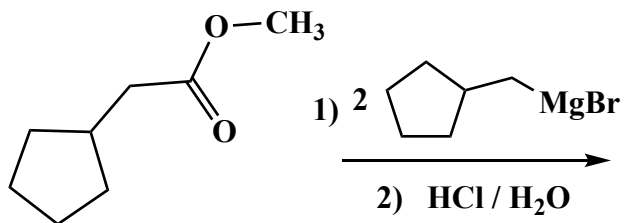
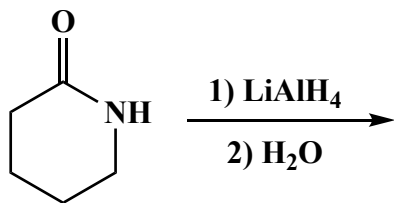
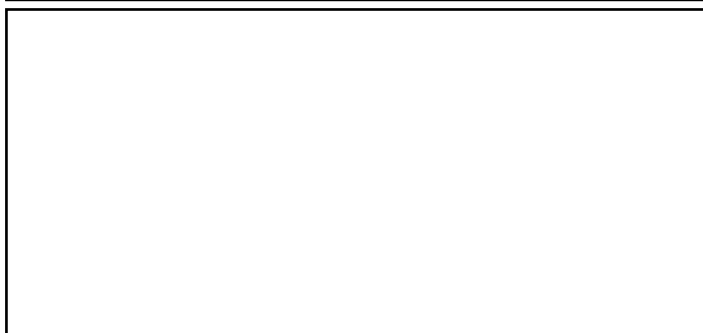
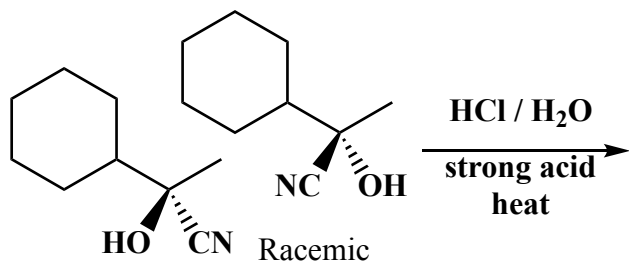
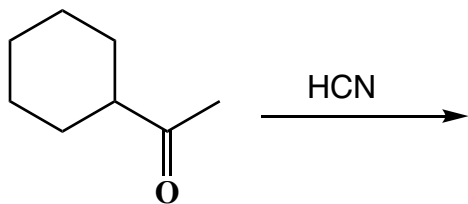


Products of last step

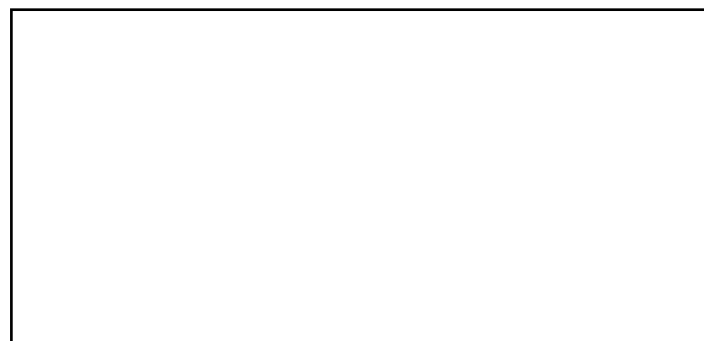
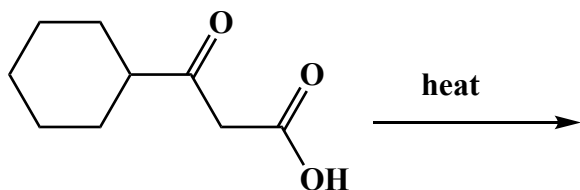
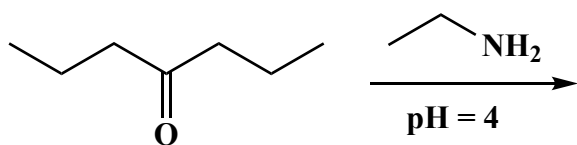
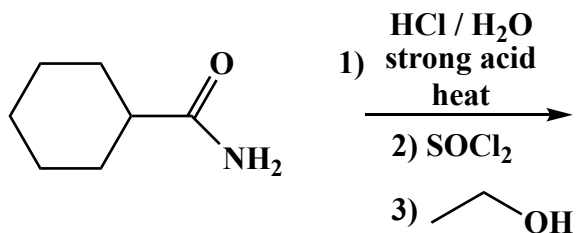
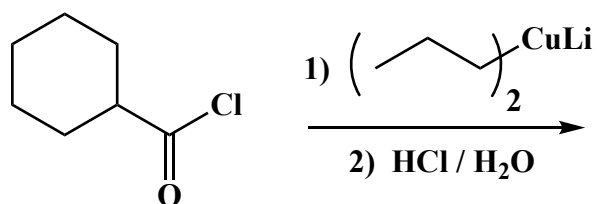
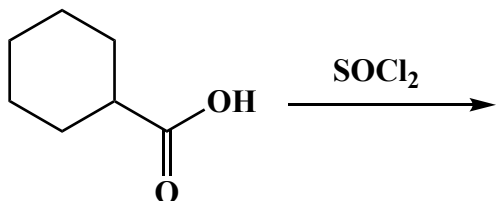
13. (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangleleft) and dashes (\cdots) to indicate stereochemistry. NOTE:



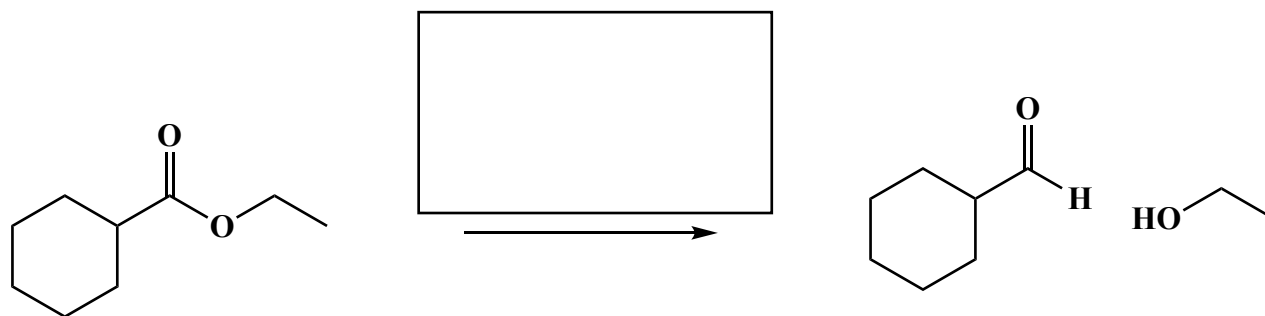
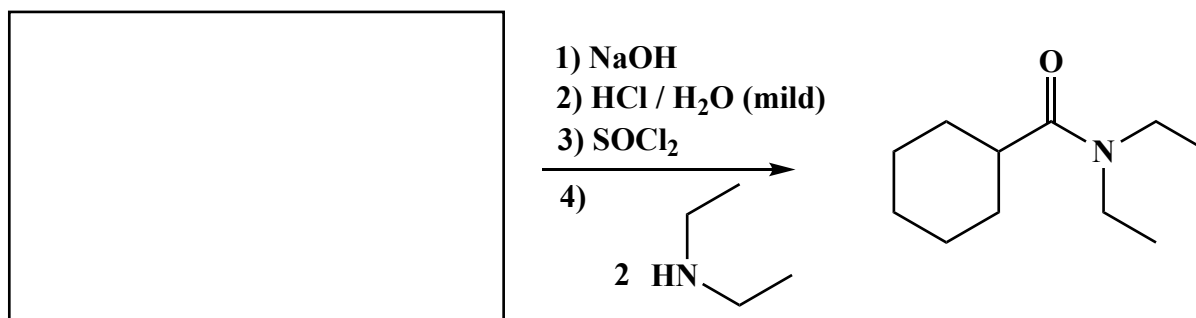
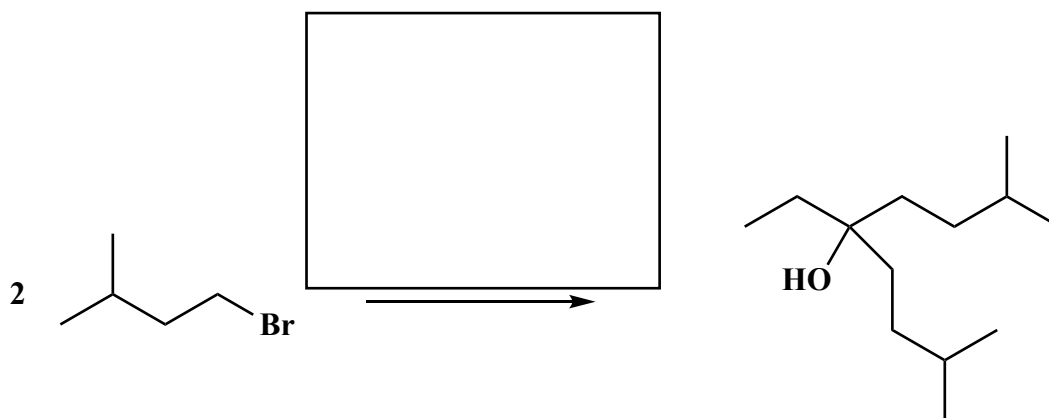
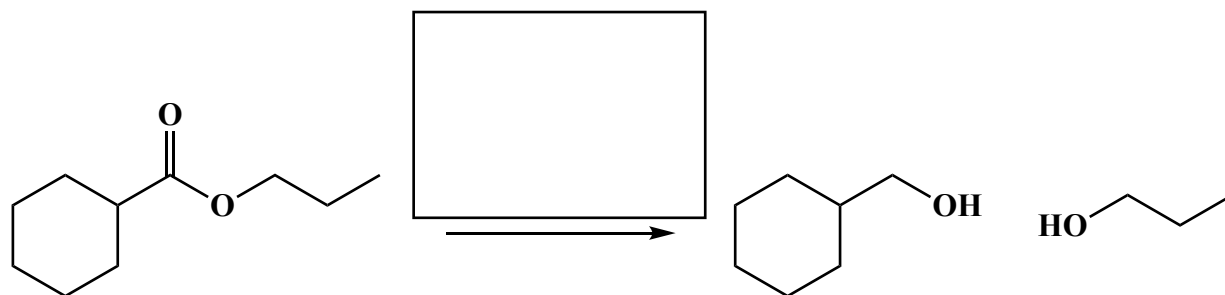
13. (cont.) (3, 4 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangleleft) and dashes (\cdots) to indicate stereochemistry. To get full credit, you only need to write the the major organic product for these. You do not have to worry about the other products.



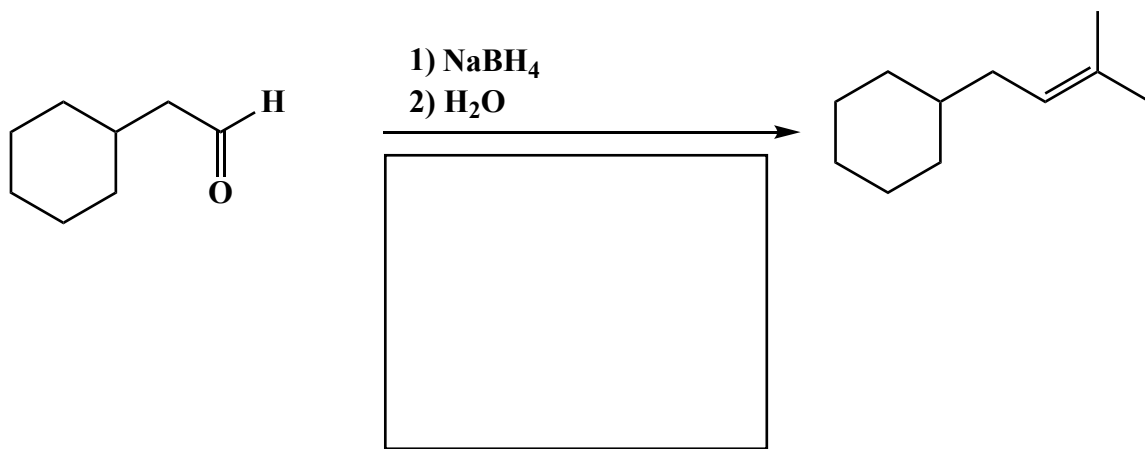
13. (cont.) (3, 4 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangleleft) and dashes ($\cdots\cdots\cdots$) to indicate stereochemistry. To get full credit, you only need to write the the major organic product for these. You do not have to worry about the other products.



14. (13 pts) For these, you need to fill in the box with the starting material or reagents as appropriate. Note, this is **NOT** a synthesis problem, the product can contain carbon atoms from your reagent!

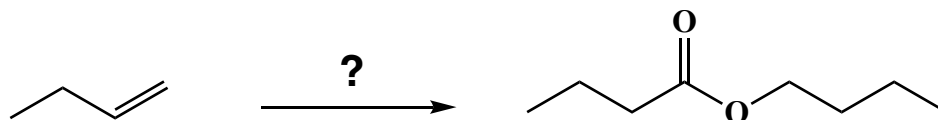


15. (8 pts) Here is a synthesis warm-up. For the following series of reactions, we have given you the final product and starting material. Work backwards and **in the box provided write the missing reagents**. **Note: we gave you the first two**



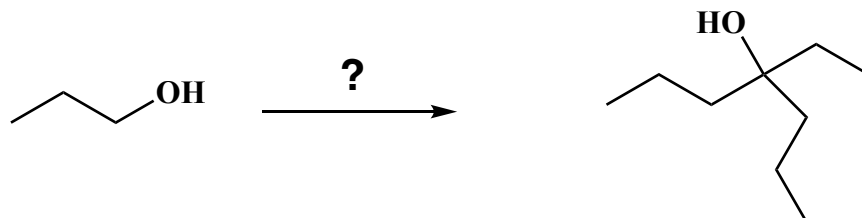
16. These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule synthesized along the way and be sure to pay attention to the regiochemistry and stereochemistry preferences for each reaction. You must draw all stereoisomers formed, and use wedges and dashes to indicate chirality at each chiral center. Write racemic when appropriate. **All the carbons of the product must come from carbons of the starting material.**

A) (10 pts)



16. (cont.). These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule synthesized along the way and be sure to pay attention to the regiochemistry and stereochemistry preferences for each reaction. You must draw all stereoisomers formed, and use wedges and dashes to indicate chirality at each chiral center. Write racemic when appropriate. **All the carbons of the product must come from carbons of the starting material.**

B) (16 pts)



Nope, there are no MCAT style questions on this exam.
Have a relaxing and safe spring break. And remember to exercise every chance you get!