NAME (Print): _____

SIGNATURE: _____

Chemistry 310N
Dr. Brent Iverson
2nd Midterm
March 25, 2010

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

Please Note: This test may be a bit long, but there is a reason. I would like to give you a lot of little questions, so you can find ones you can answer and show me what you know, rather than just a few questions that may be testing the one thing you forgot. **I recommend you look the exam over and answer the questions you are sure of first**, then go back and try to figure out the rest. Also make sure to **look at the point totals** on the questions as a guide to help budget your time.

You must have your answers written in PERMANENT ink if you want a regrade!!!! This means no test written in pencil or ERASABLE INK will be regraded.

Please note: We routinely xerox a number of exams following initial grading to guard against receiving altered answers during the regrading process.

FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENCTS 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!!!

Page	Points	
1		(26)
2		(28)
3		(18)
4		(18)
5		(18)
6		(18)
7		(16)
8		(33)
9		(28)
10		(17)
11		(14)
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14		(18)
15		(10)
16		(16)
17		(6)
Total		(294)
%		
T Score		
HW		
Total Grade		

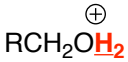
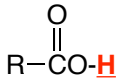
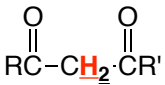
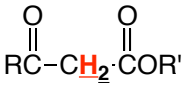
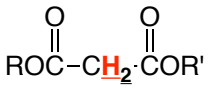
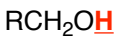
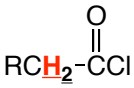
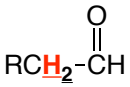
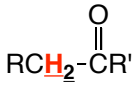
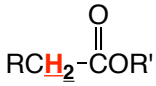
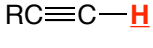
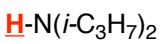
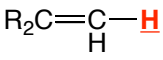
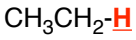
(HW score + Exam Grade) ⟹

Honor Code

The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community.

_____

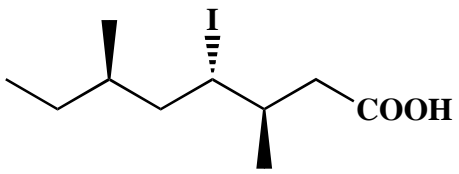
(Your signature)

Compound		pK_a
Hydrochloric acid		-7
Protonated alcohol		-2
Hydronium ion		-1.7
Carboxylic acids		3-5
Ammonium ion		9.2
β-Dicarbonyls		10
β-Ketoesters		11
β-Diesters		13
Water		15.7
Alcohols		15-19
Acid chlorides		16
Aldehydes		18-20
Ketones		18-20
Esters		23-25
Terminal alkynes		25
LDA		40
Terminal alkenes		44
Alkanes		51

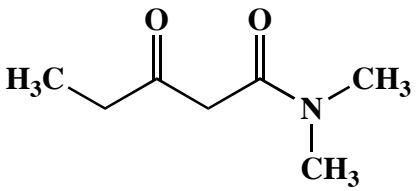
1. (14 points) Suppose a relative of yours is having an MRI. In no more than four sentences, explain to them what is happening when they have the MRI scan. We wil be looking for a minumum of 7 key points here.

The popular medical diagnostic technique of **magnetic resonance imaging (MRI)** is based on the **same principles as NMR**, namely the **flipping (i.e. resonance) of nuclear spins of protons** by **radio frequency irradiation** when a patient is placed in a **strong magnetic field**. **Magnetic field gradients** are used to gain imaging information, and **rotation of the gradient around the center of the object** gives imaging in an entire plane **(i.e. slice inside patient)**. In an MRI image, you are looking at **individual slices** that **when stacked make up the three-dimensional image** of **relative amounts of protons, especially the protons from water and fat, in the different tissues**.

2. (4 pts each) In the space provided, write the IUPAC name (including stereochemistry where appropriate) for the following two molecules:



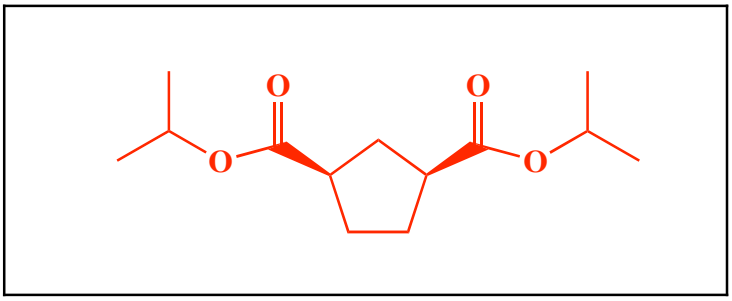
(3*R*,4*S*,6*R*)-4-Iodo-3,6-dimethyloctanoic acid



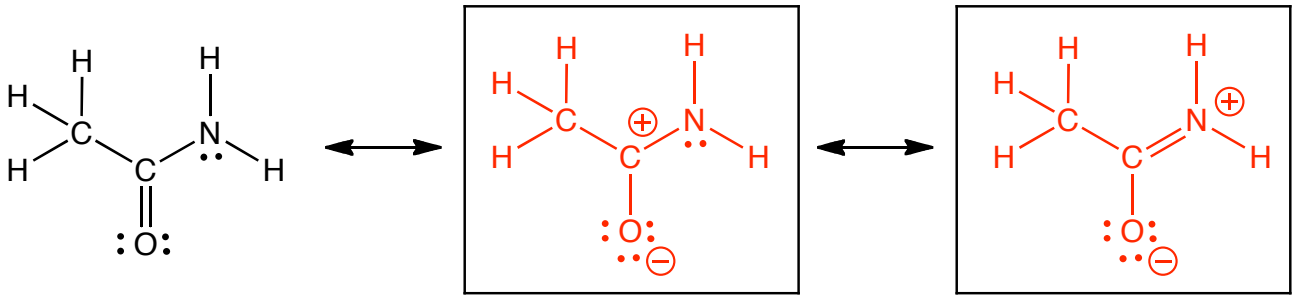
***N*,*N*-Dimethyl-3-oxopentanamide**

3. (4 pts) In the space provided, draw the following molecule:

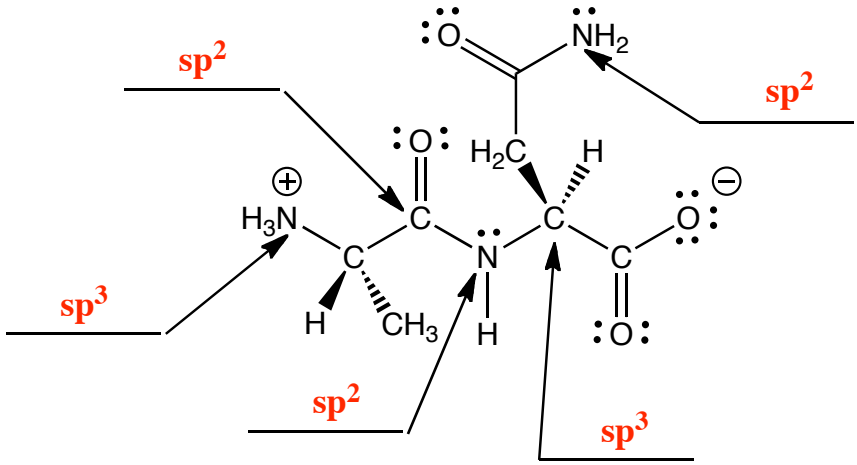
***Cis*-Diisopropyl cyclopentane-1,3-dicarboxylate**



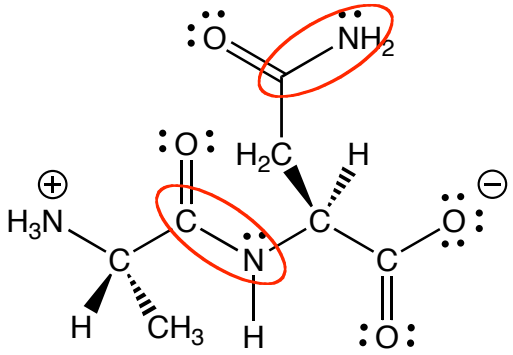
4. (8 points) Draw the two most important resonance contributing structures of the amide shown below. Be sure to show all lone pairs and formal charges. You do not have to draw arrows on this one.



5. (10 points) On the lines, indicate the hybridization state of each atom indicated by the arrows.



6. (6 points) On the following structure **circle all of the C-N bonds that DO NOT ROTATE.**

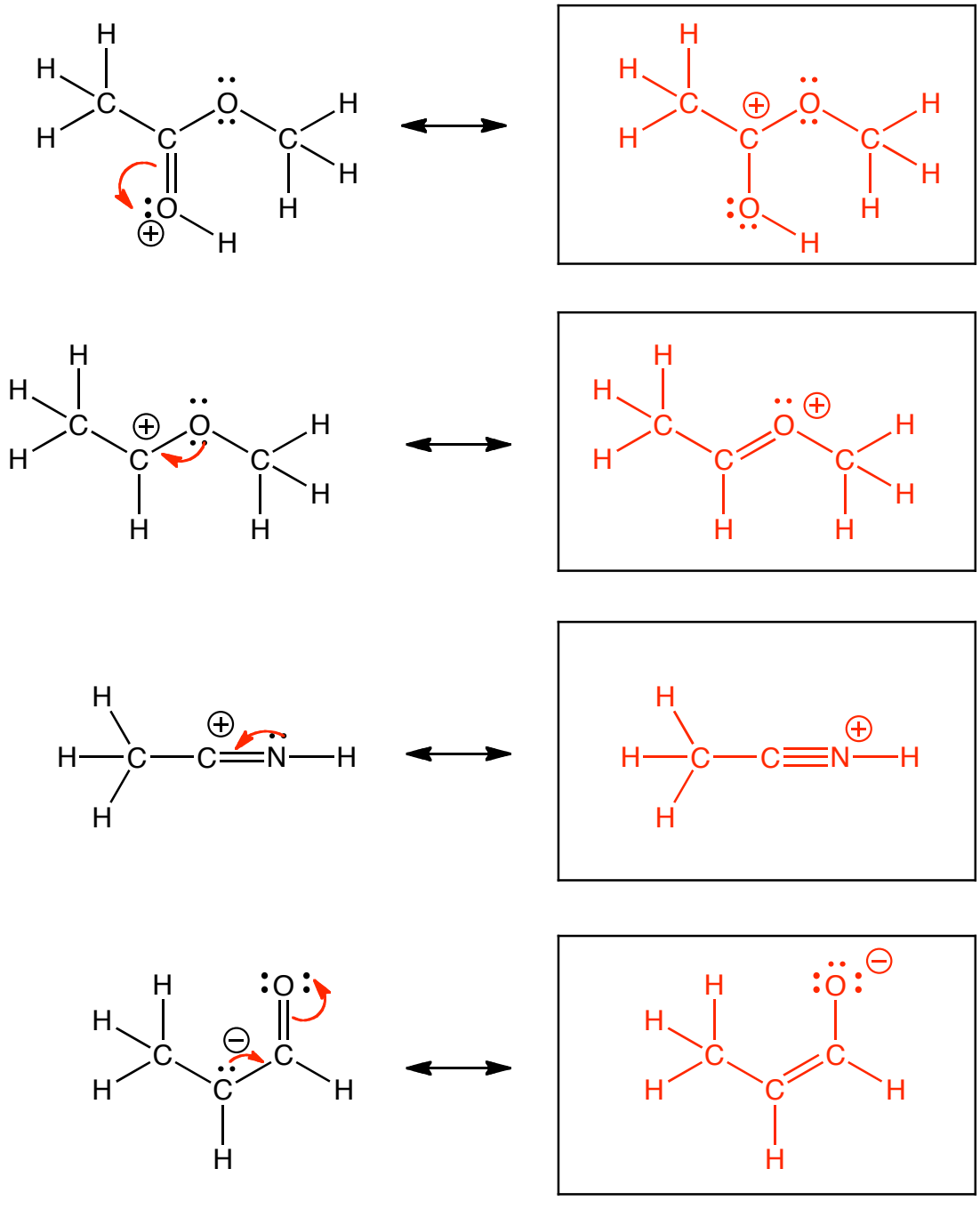


(4 pts) For the above stucture, is this the appropriate protonation state for pH 2.0, 7.0, or 10.0?

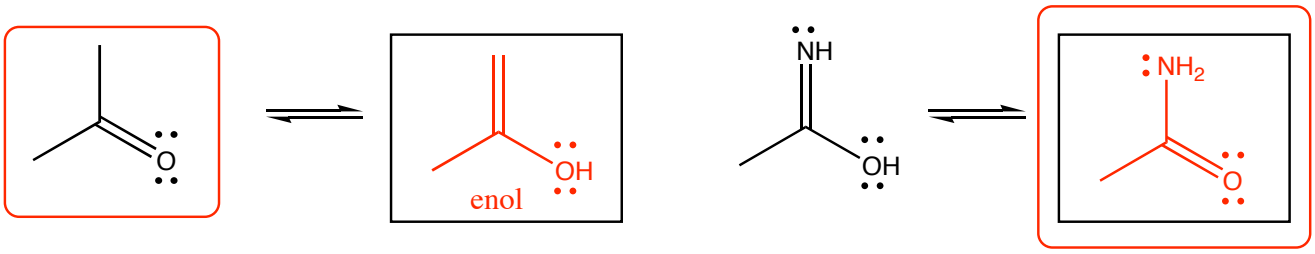
7.0

⟸ Notice This

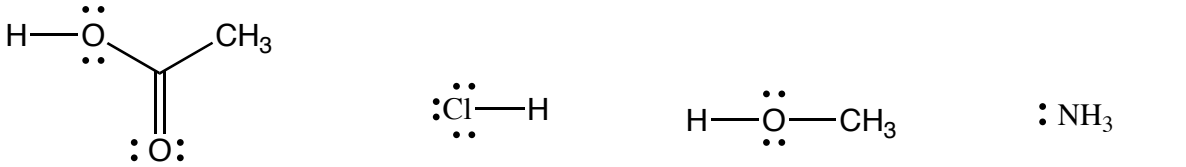
7. (18 points) For each of the following molecules, draw the other important resonance contributing structure. Be sure to show all lone pairs and formal charges. **In each case, add arrows to the structure on the left to indicate electronic rearrangement leading to the structure you drew on the right.**



8. (6 points) Each of the following undergo the process of tautomerization. For each draw the other major tautomer, then for each pair, circle the tautomer that is more stable.



9. (4 points) Rank the following in terms of relative acidity, with a 1 under the most acidic, and a 4 under the least acidic molecule.

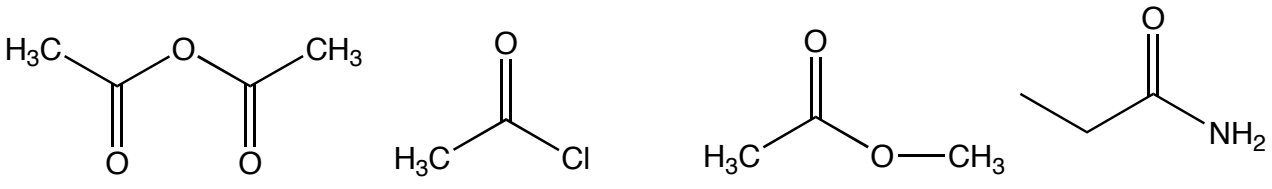


2 **1** **3** **4**

10. (4 points) Rank the following with respect to anion stability. Write a 1 under the most stable anion, and a 4 under the least stable anion.

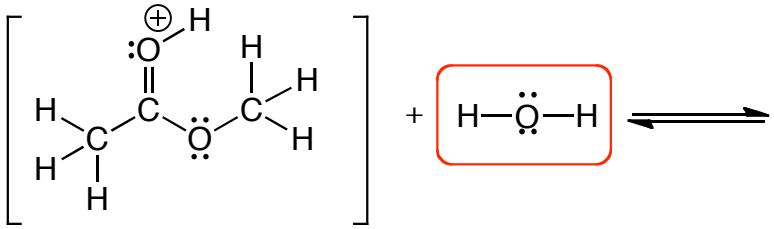
2 **1** **3** **4**

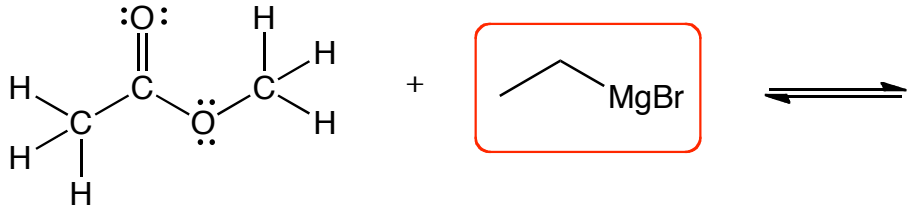
11. (4 points) Rank the following carboxylic acid derivatives with respect to reactivity with a nucleophile. Write a 1 under the most reactive, and a 4 under the least reactive derivative.

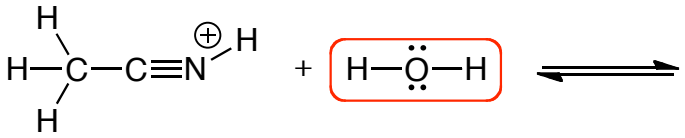


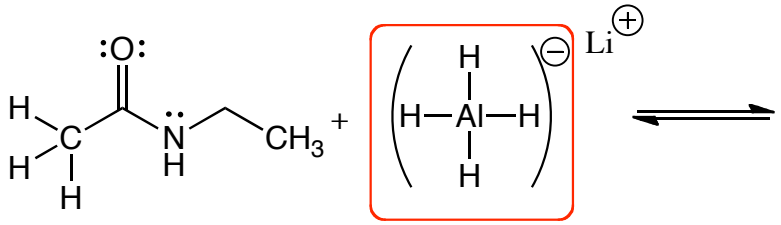
2 **1** **3** **4**

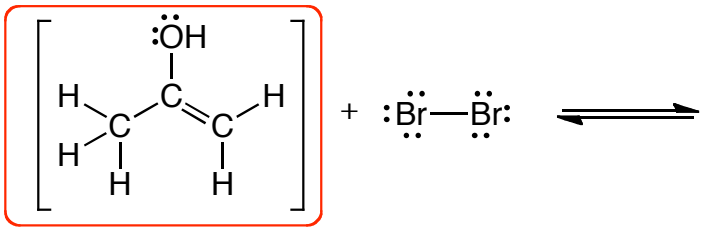
12. (3 pts each) The mechanisms we have been studying largely involve nucleophiles of various types attacking electrophiles of various types, with protons being transferred quite often as well. The following reagents represent individual steps from some of these mechanisms. **For each pair of molecules, draw a circle around the nucleophile.** DO NOT DRAW THE PRODUCTS OF THESE STEPS. Do not make this hard. We are just checking that you are understanding these mechanisms, not just memorizing them.

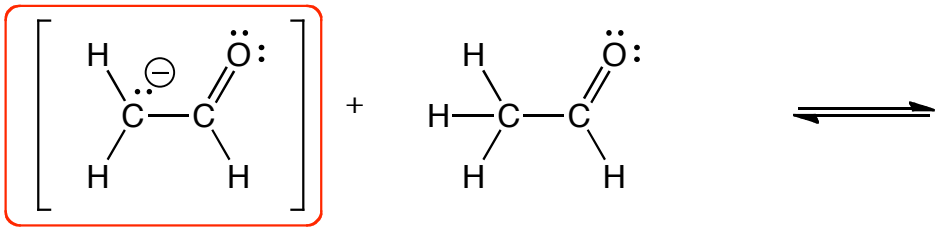




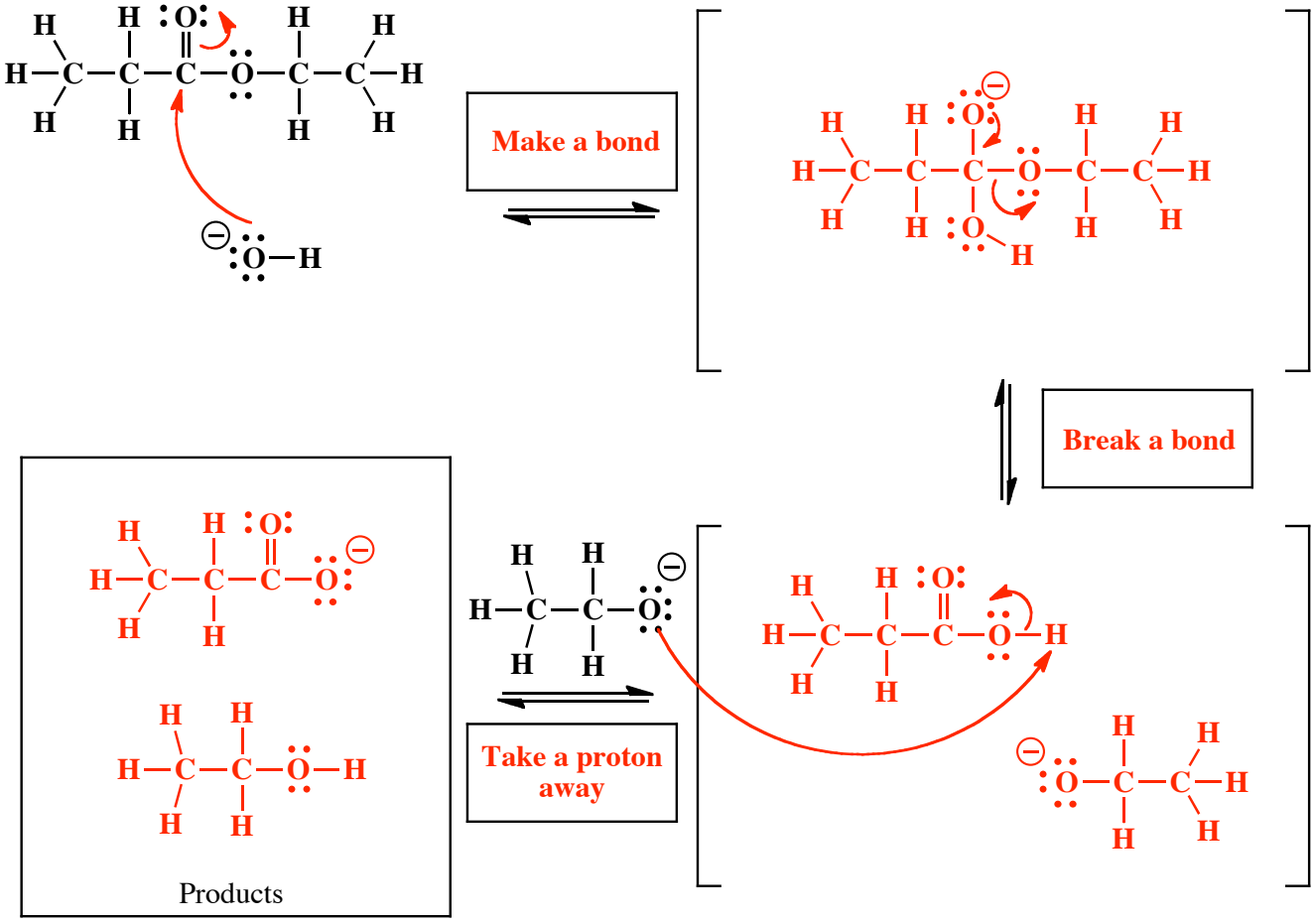








13. (18 pts. total) Complete the mechanism for the following **base promoted ester hydrolysis** reaction. **Be sure to show arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step.** Remember, I said <u>all</u> the products for each step. **IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR THE PRODUCTS, MARK IT WITH AN ASTERISK and WRITE RACEMIC IF RELEVANT.**



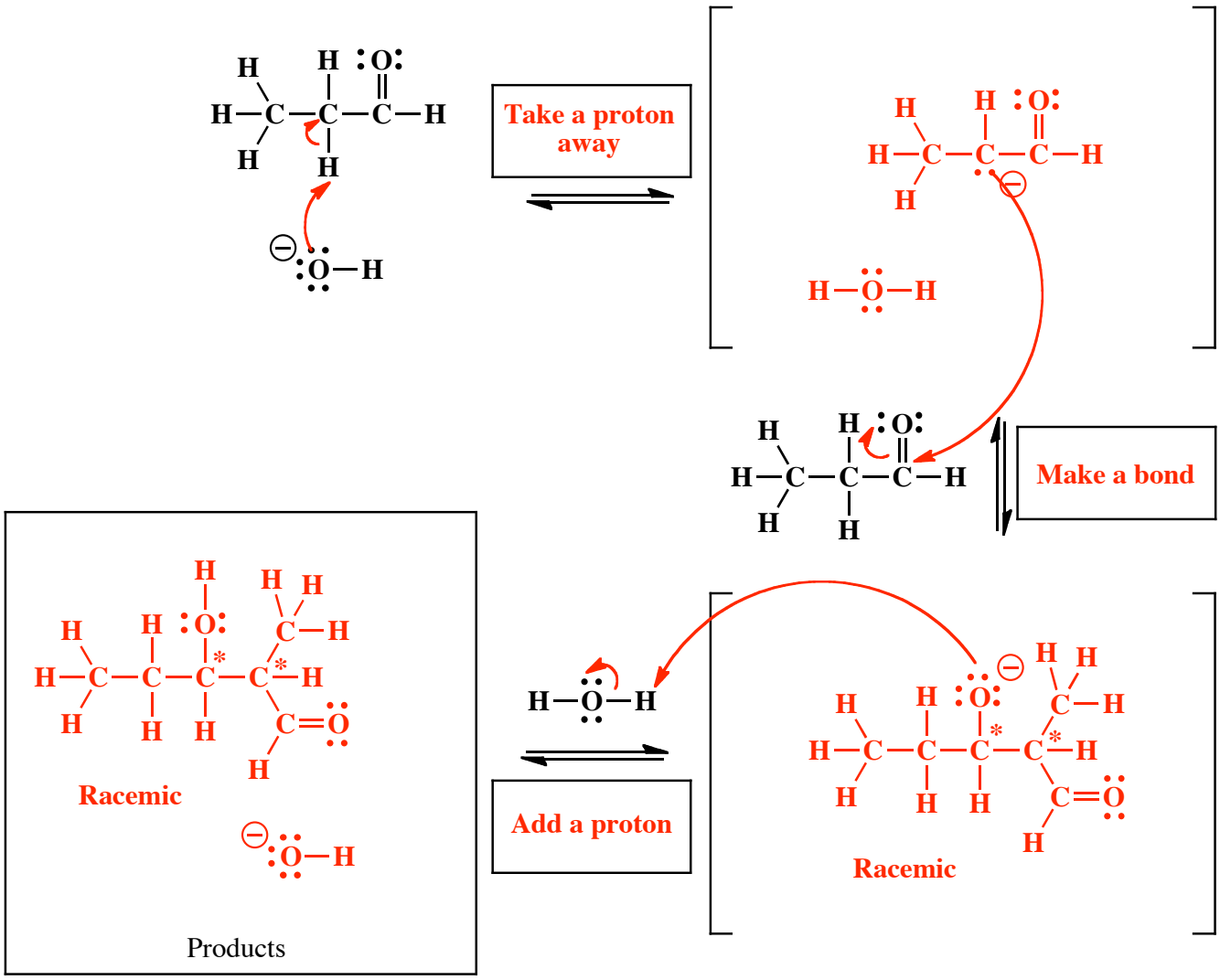
(1 pt each) **In the boxes provided adjacent to the first two sets of arrows, write which of the four basic mechanistic elements are involved (i.e. "Make a bond", "Add a proton", etc.**

NOTICE THESE

(4 Pts) **In one sentence explain why this reation is reffered to as base "promoted" rather than base "catalyzed".**

The reaction requires HO- in the first step, but the HO- is consumed during the reaction leaving a carboxylate (a much weaker base) as the negatively charged product.

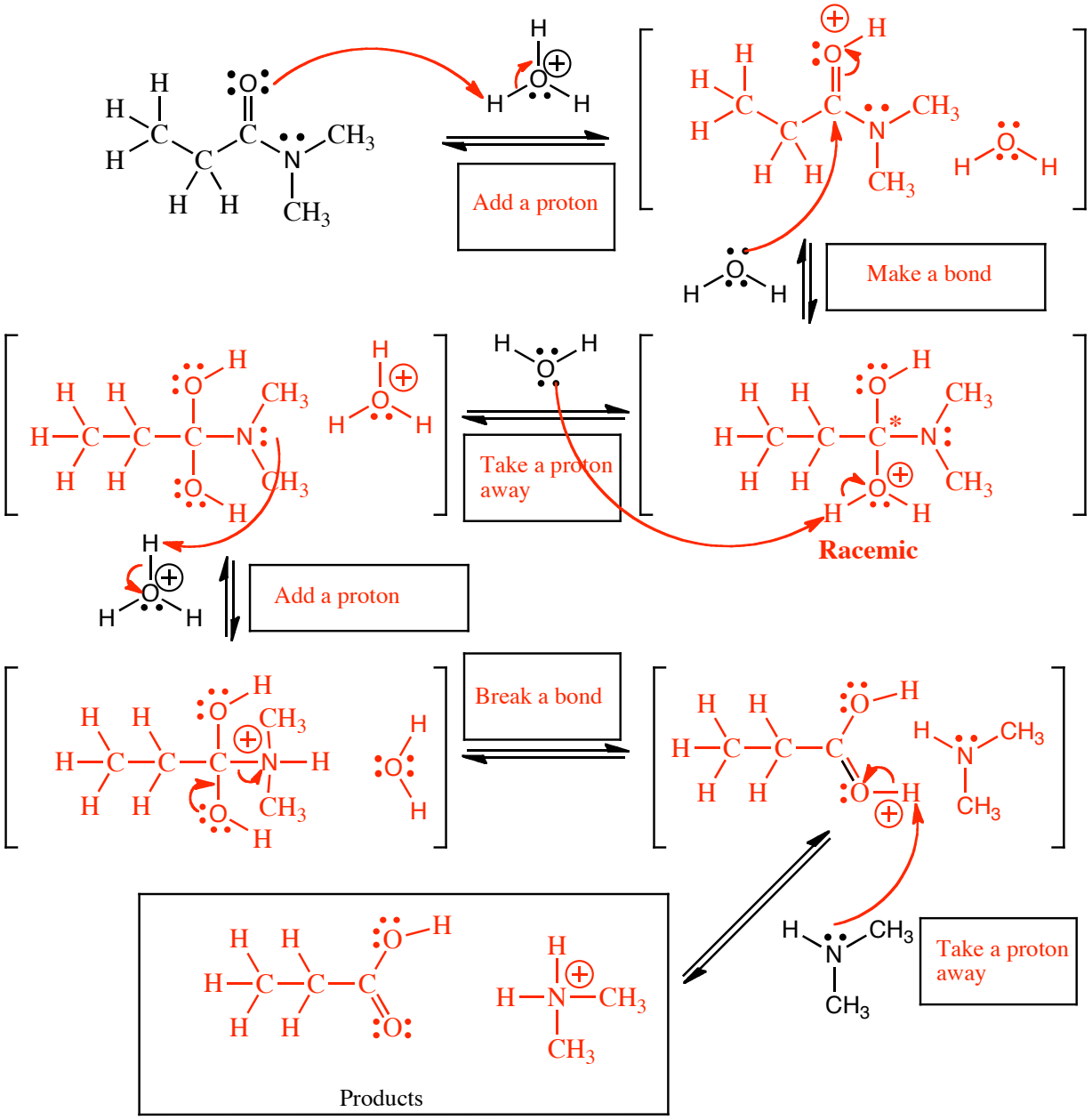
13. (16 pts. total) Complete the mechanism for the following **aldol** reaction. **Be sure to show arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step.** Remember, I said <u>all</u> the products for each step. **IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE OR THE PRODUCTS, MARK IT WITH AN ASTERISK and WRITE RACEMIC IF RELEVANT.**



(1 pts each) **In the boxes provided adjacent to the first two sets of arrows, write which of the four basic mechanistic elements are involved (i.e. "Make a bond", "Add a proton", etc.**

NOTICE THIS

13. (33 pts. total) Complete the mechanism for the following **acid promoted amide hydrolysis** reaction. **Be sure to show 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 OR THE PRODUCTS, MARK IT WITH AN ASTERISK and WRITE RACEMIC IF RELEVANT.**



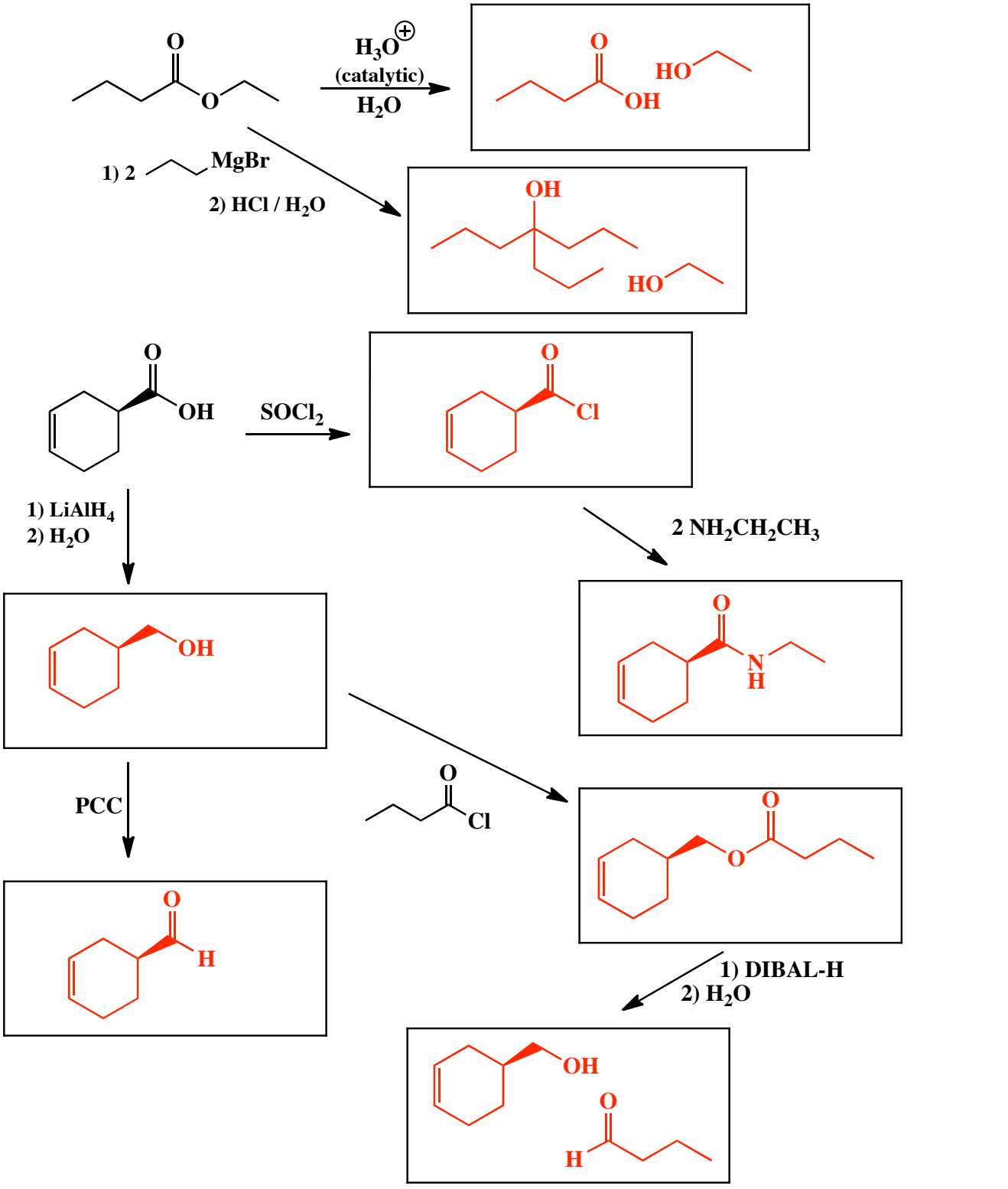
(1 pt each) **In the boxes provided adjacent to the first two sets of arrows, write which of the four basic mechanistic elements are involved (i.e. "Make a bond", "Add a proton", etc.**

NOTICE THESE

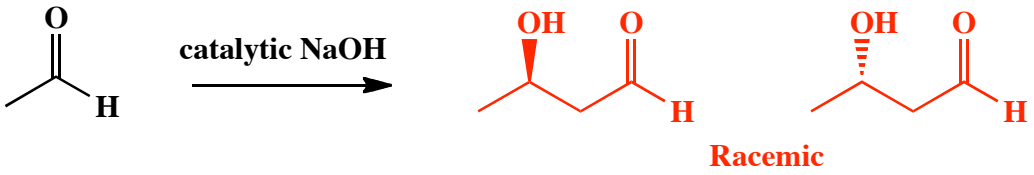
(4 Pts) **In one sentence explain why this reation is reffered to as acid "promoted" rather than acid "catalyzed".**

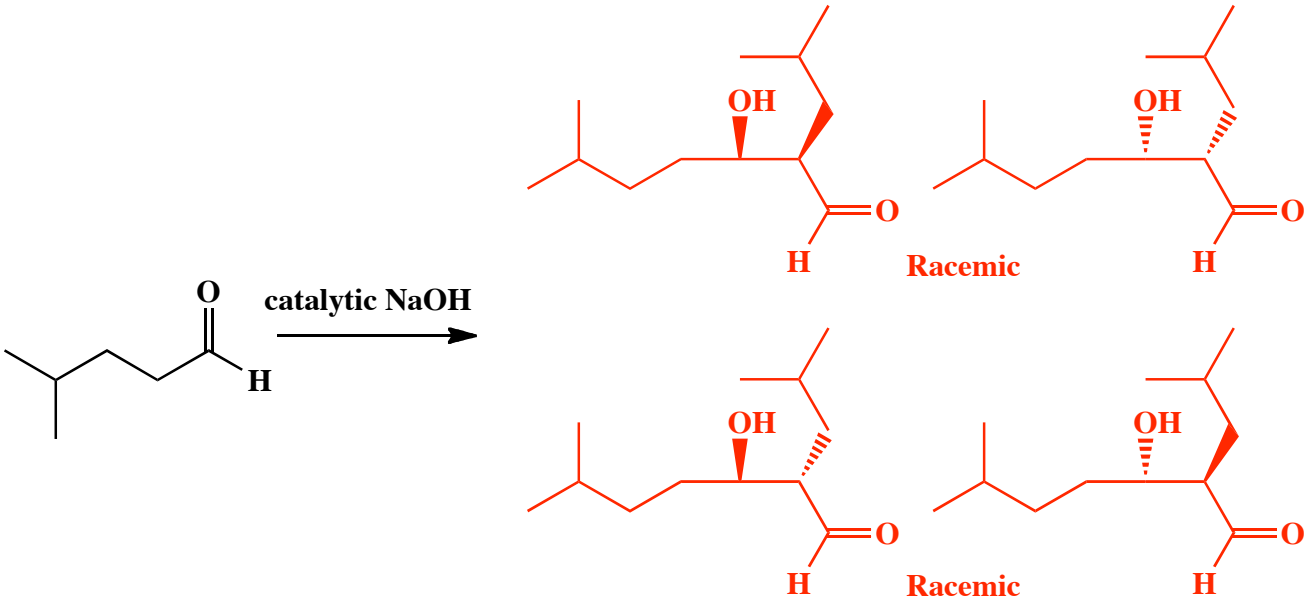
The reaction requires acid in the first step, but the proton is consumed during the reaction leaving an ammonium ion (a much weaker acid) as the protonated product.

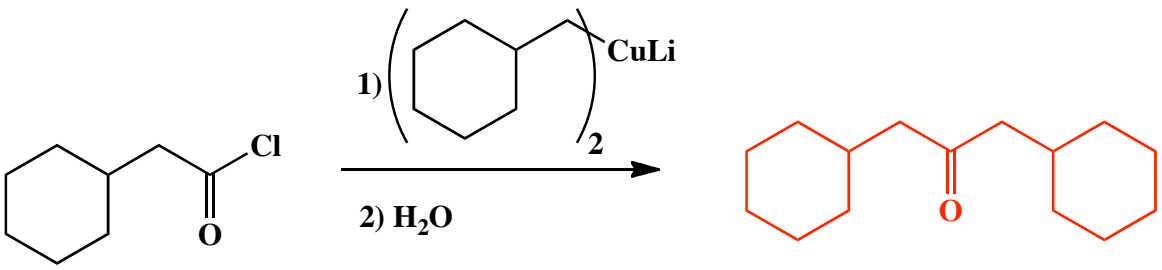
14. (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. **If a new chiral center is created and a racemic mixture is formed, you must draw *all* enantiomers and write "racemic" under the structure. Use wedges (◄) and dashes (····ıllll) to indicate stereochemistry. To get full credit, you must write proucts that accout for ALL of the carbon atoms of the starting material even in multi-step reactions. DO NOT DEHYDRATE DURING AN ALDOL REACTION -WRITE THE NON-DEHYDRATED PRODUCT.**



15. (3, 5 or 9 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 *all* enantiomers and write "racemic" under the structure. Use wedges (◄) and dashes (····ıllll) to indicate stereochemistry. DO NOT DEHYDRATE DURING AN ALDOL REACTION -WRITE THE NON-DEHYDRATED PRODUCT.**

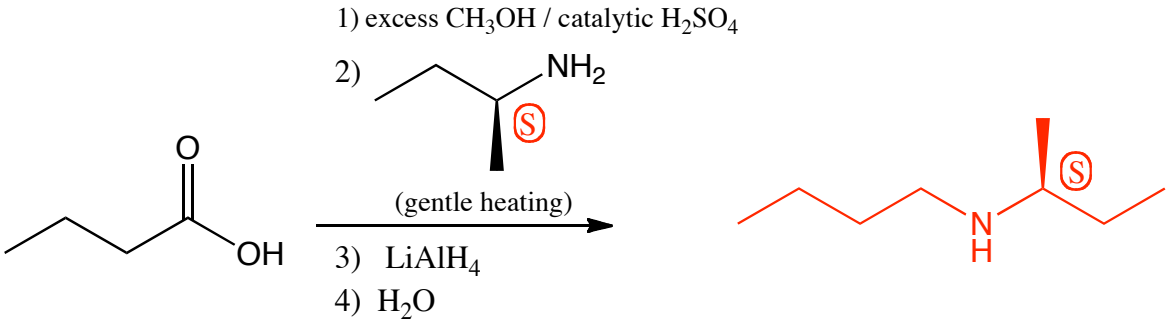




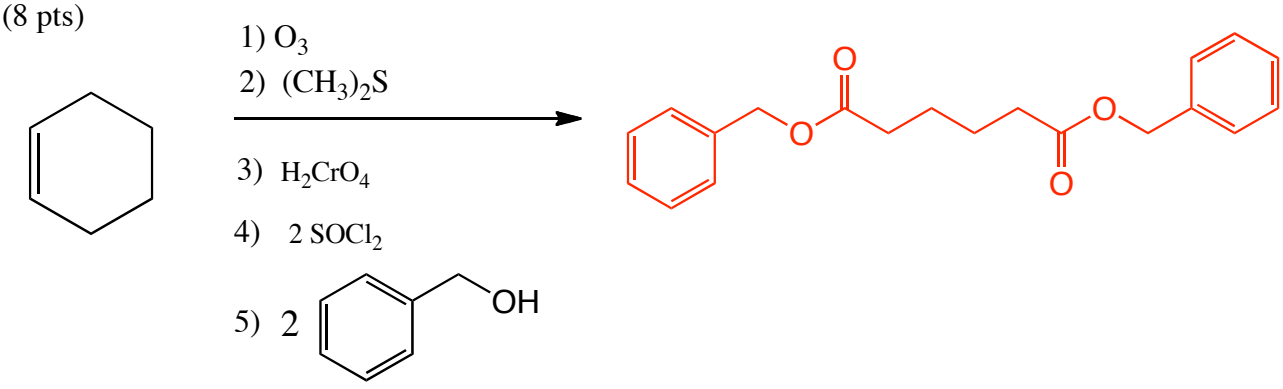


16. (14 points) For the following sequences of reactions, draw the final organic product or products after ALL the steps have been completed. You do not need to draw the molecules synthesized along the way, **only the last product that is formed**. If a new chiral center is created in the reaction that produces a racemic mixture, label the chiral center with an asterisk (*) and write "***racemic***" underneath. You do not have to draw all of the enantiomers for this one.

(6 pts)

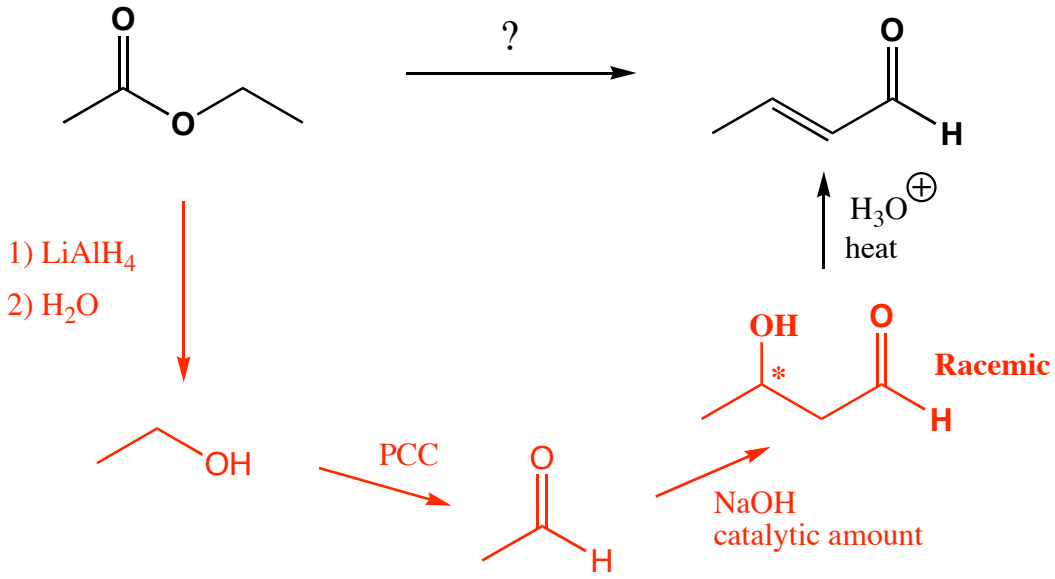


(8 pts)



17. 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. 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.

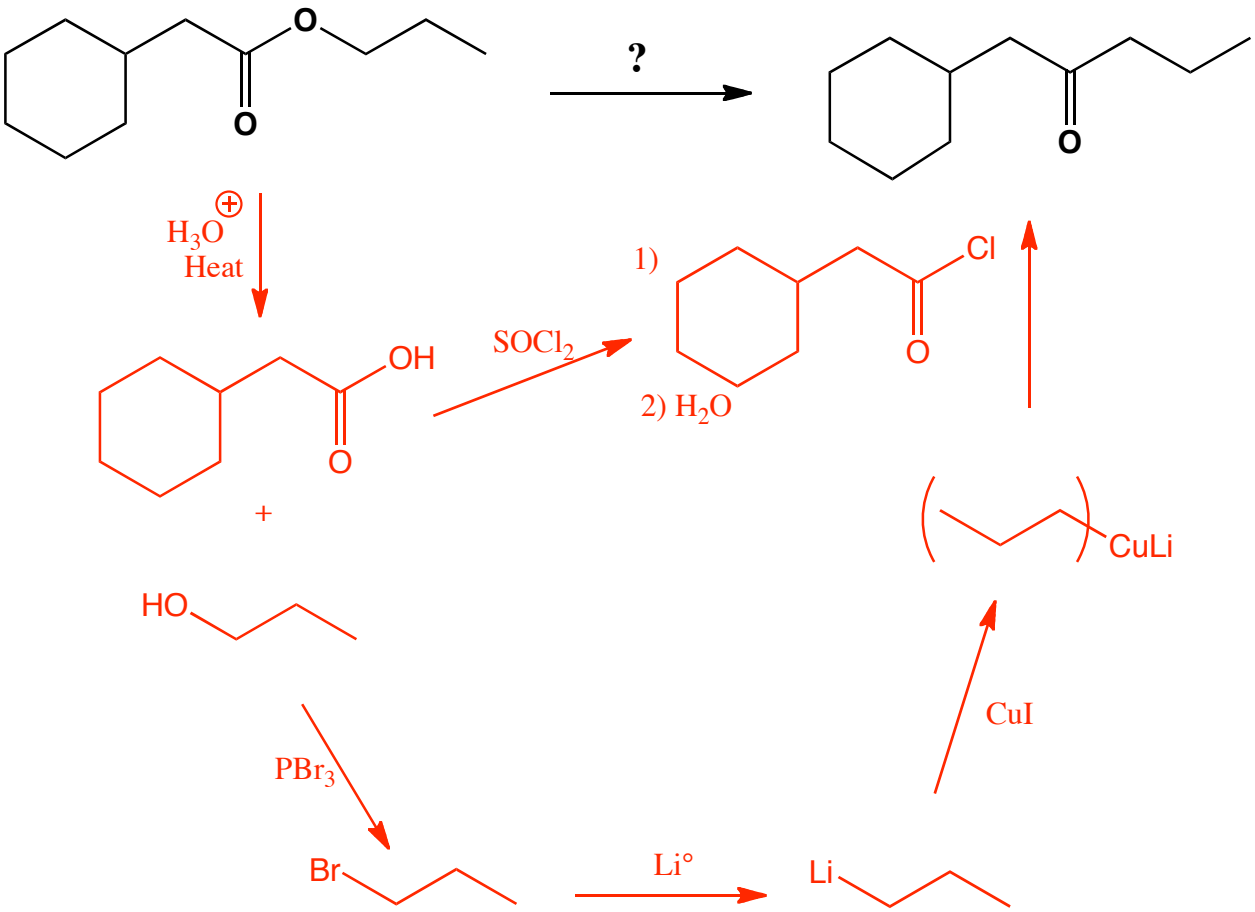
(10 pts) **All of the carbon atoms of the products must come from the starting materials for this one!**



Recognize the product as an α,β–unsaturated aldehyde, which is the product of an aldol reac tion folowed by dehyrdation in acid with heat. This aldol requires acetaldehyde, which is made conveniently from reduction of the ethyl acetate starting material using $LiAlH_4$, followed by oxidation using PCC. Note there are several acceptable alternative ways to make the acetaldhyde from ethyl acetate including DIBAL-H reduction or hydrolysis followed by oxidation/reduction.

17. 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. 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.

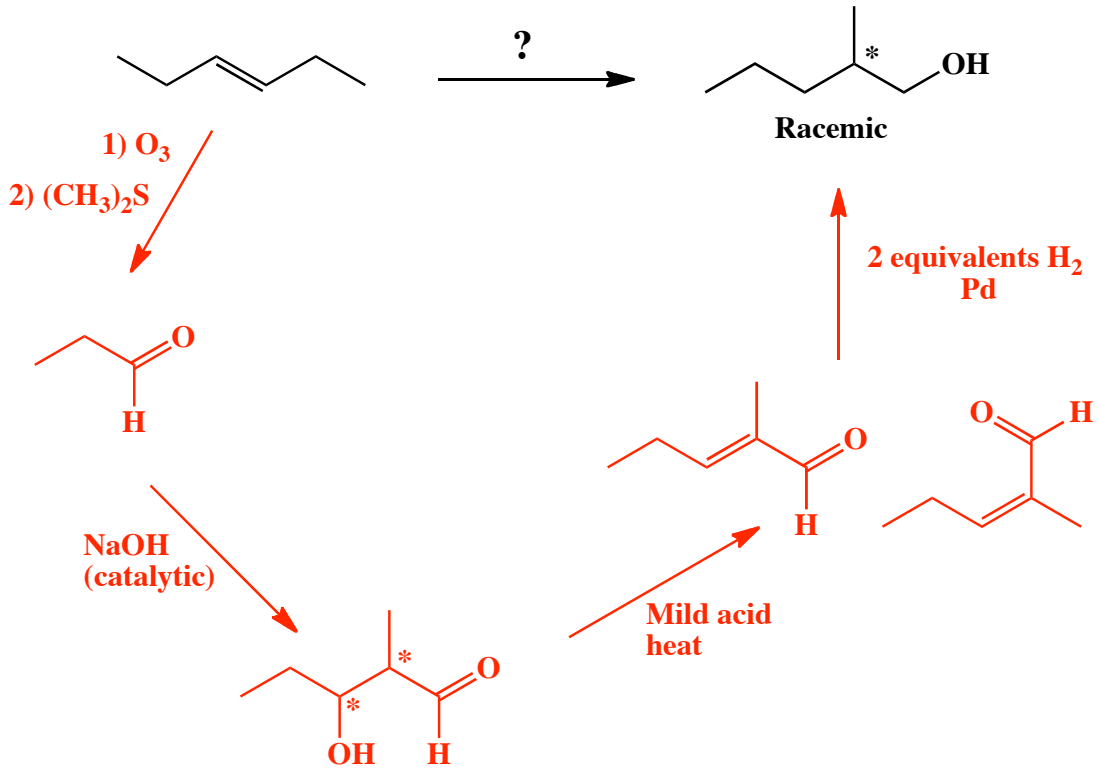
(18 pts) **All of the carbon atoms of the products must come from the starting materials for this one!**



Recognize the product as being a ketone, the only reaction that creates a ketone with carbon-carbon bond formation is an acid chloride plus a Gilman reagent. The required acid chloride and Gilman reaction can be derived from the ester starting material via hydrolysis, formation of an acid chloride from the acid portion, and formation of a Gilman from the alcohol portion. Alternatively, the product ketone could be made from the oxidation of the corresponding secondary alcohol, which was synthesized using a Grignard reaction. The components of the Grignard reaction could once again come from hydrolysis of the starting ester.

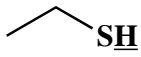
17. These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned. Show all the reagents you need. Show each molecule synthesized along the way and be sure to pay attention to the regiochemistry and stereochemistry preferences for each reaction.

(10 pts) **All of the carbon atoms of the products must come from the starting materials for this one!**

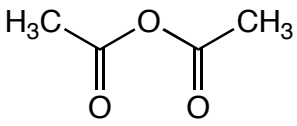


Recognize that the product has six carbons like the starting material, however, the carbon atoms are connected differently between the two. Hypothesize that C-C bonds were broken then remade. Here is the hard part of this one. You need to **recognize** that the pattern of C atoms in the product matches the pattern you get in an aldol reaction, even though it is not a β-hydroxy aldehyde or an α,β-unsaturated aldehyde. Going with this idea, you need to **recognize** further that the product is what you would obtain if you carry out a hydrogenation reaction on an α,β-unsaturated aldehyde (remember that hydrogenation will reduce both the alkene and aldehyde carbonyl). Continuing to work backwards notice that the aldol reaction requires propanal, which is conveniently the product obtained upon ozonolysis of the starting (*E*)-3-hexene.

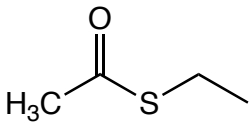
18. (16 pts) Here is an "apply what you know" question. The pKa for a thiol is given below. Given this information, predict the relative reactivities with nucleophiles of all of the following four carboxylic acid derivatives. Place a "1" under the most reactive and a "4" under the least reactive species.



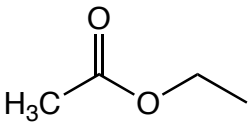
pK_a = 10.6



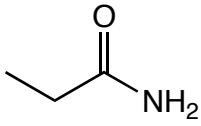
1



2



3

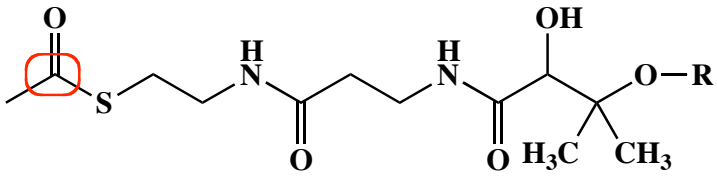


4

In no more than three sentences explain your reasoning for the rankings you gave above.

The relative reactivities of carboxylic acid derivatives are based upon relative leaving group abilities, which correspond to anion stabilities and therefore pKa. The lower the pKa of the parent acid, the better the leaving group ability. Thiols, with a pKa around 11 rank between alcohols (pKa = 16) and carboxylic acids (pKa = 3-5), so that makes thioesters the second most reactive in the above ranking.

The molecule AcetylCoA is very important in biochemistry. It reacts to make new bonds to carbon using mechanisms very similar to those we have seen for the carboxylic acid derivatives discussed in this class. On the following structure of Acetyl CoA, DRAW A CIRCLE AROUND THE ATOM that you predict will be attacked by nucleophiles to make new bonds. Base your answer on your responses to the first two parts of this question.

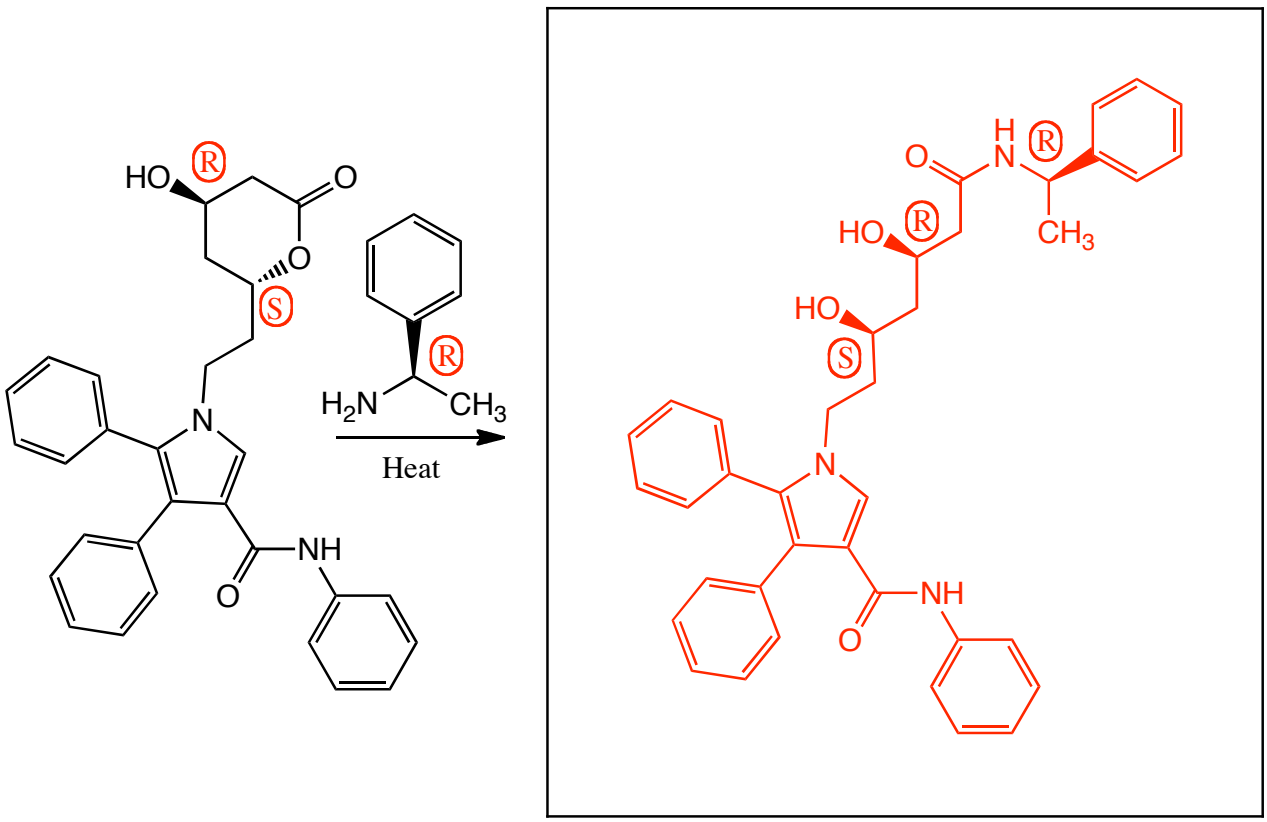


Acetyl CoA

In no more than two sentences explain your reasoning for the atom you circled.

The thioester group is a reactive carboxylic acid derivative so nucleophiles will attack the carbonyl carbon atom in analogy to all the other reactions of carboxylic acid derivatives we have seen.

19. (6 pts) One of the fundamental paradigms of organic chemistry is that a functional group reacts the same in a complex molecule as it does in a simple molecule. The following step was used in the synthesis of atorvastatin (Lipitor). Write the predominant product of the following transformation, including the correct stereochemistry. This will take you a while to draw and it is not worth that many points, so definitely leave it until the end.



The key to this problem is to realize that the upper cyclic portion of the starting molecule is a lactone, a cyclic ester. Esters react with amines with heating to give amides as shown in the product. Keeping track of the stereochemistry can be accomplished by labeling each chiral center.