NAME (Print): _____

EID _____

SIGNATURE: _____

Chemistry 320N
1st Midterm Exam
February 12, 2026

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

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

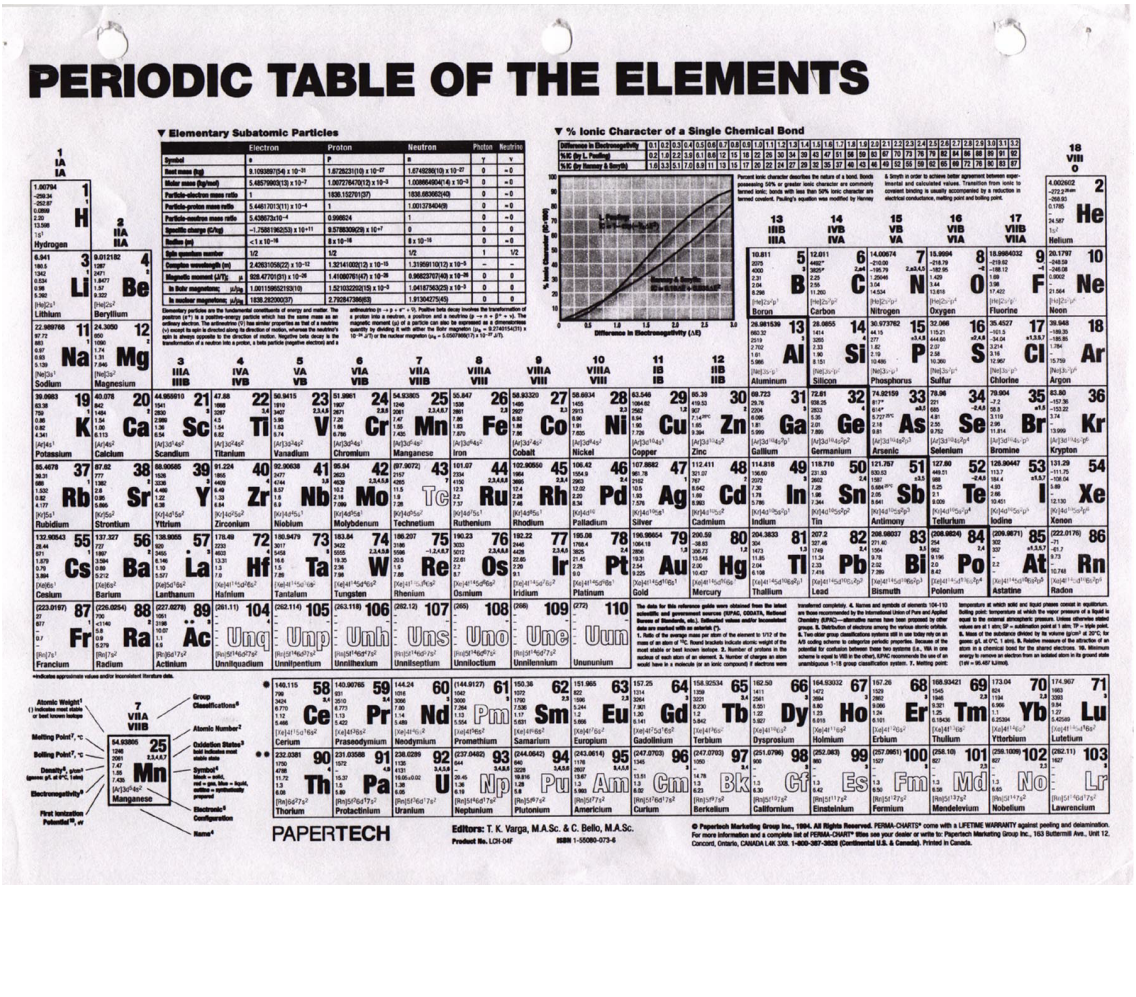
"I pledge, as a member of The University of Texas at Austin community, to do my work honestly, respectfully, and through the intentional pursuit of learning and scholarship."

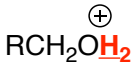
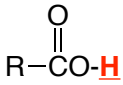
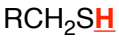
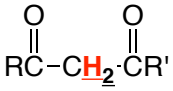
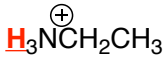
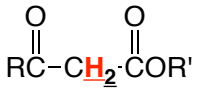
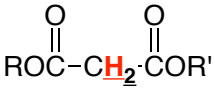
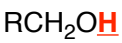
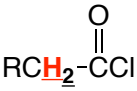
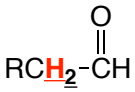
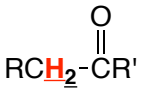
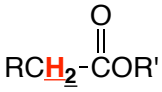
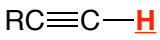
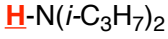
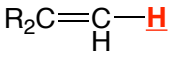
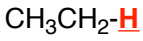
Elaboration

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)



Compound		pK_a
Hydrochloric acid		-7
Protonated alcohol		-2
Hydronium ion		-1.7
Carboxylic acids		3-5
Thiols		8-9
Ammonium ion		9.2
β-Dicarbonyls		10
Primary ammonium		10.5
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

Signature_____ Pg 1 _____(29)

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

Where are the electrons?

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 1. **diagnostic** technique of 2. **magnetic**

3. **resonance** 4. **imaging** (**MRI**) is based on the same principles

as 5. **NMR**, namely the 6. **flipping** (i.e. resonance) of 7. **nuclear**

spins of H atoms by radio 8. **frequency** 9. **irradiation** when a patient is

placed in a strong magnetic field. Magnetic field 10. **gradients** are used to

gain imaging information, and 11. **rotation** of the 12. **gradient** around the

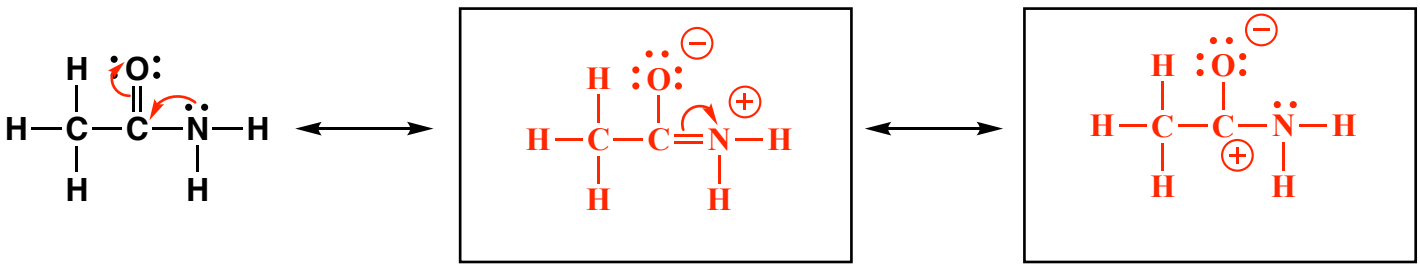
center of the object gives imaging in an entire 13. **plane** (i.e. slice inside patient).

In an MRI image, you are looking at individual slices that when stacked make up the three-

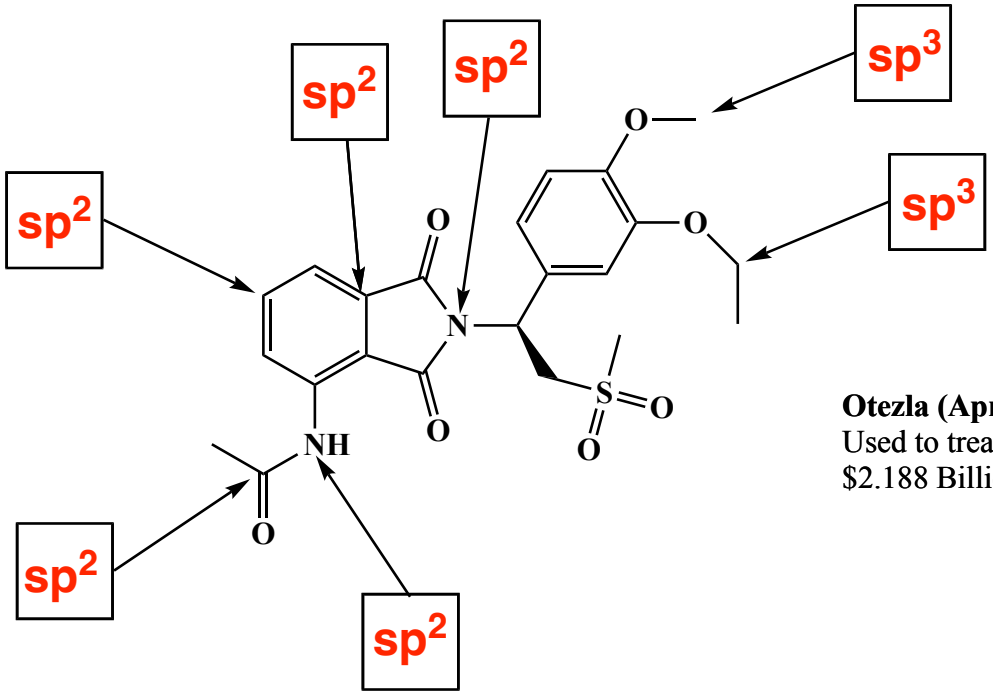
dimensional image of relative amounts of H atoms, especially the H atoms from

14. **water** and 15. **fat**, in the different tissues.

3. (9 pts) Amides are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. For the two structures on the left, use arrows to indicate the movement of electrons to give the structures you drew.

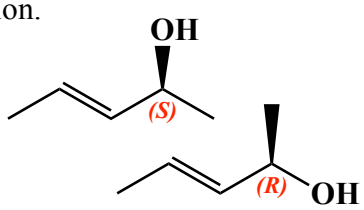


4. (1 pt each) In the boxes provided, write the hybridization state of the atoms indicated by the arrow.

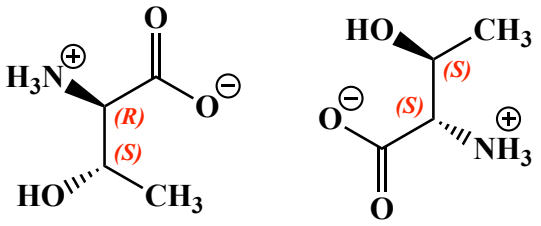


Otezla (Apremilast)
Used to treat plaque psoriasis
$2.188 Billion in sales 2023

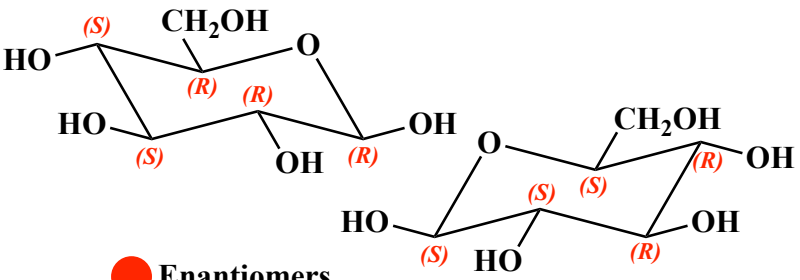
5. (3 pts each) Fill in the circle to identify the stereochemical relationship between each pair of molecules. Hint: You might want to determine *R* or *S* for each chiral center to help you answer the question.



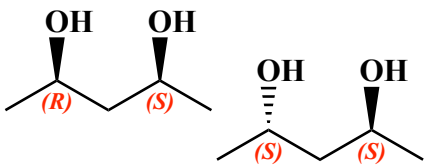
● Enantiomers
○ Diastereomers
○ Same Molecule



○ Enantiomers
● Diastereomers
○ Same Molecule

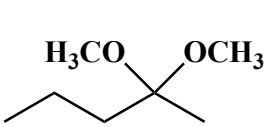


● Enantiomers
○ Diastereomers
○ Same Molecule

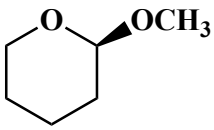


○ Enantiomers
● Diastereomers
○ Same Molecule

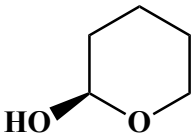
6. (2 pt each) Fill in each circle to indicate the appropriate name for the functional group in the following molecules and then indicate whether or not the fourth species is the favored species at equilibrium.



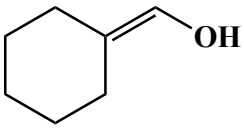
- ○ Enol
- ○ Hemiacetal or Cyclic hemiacetal
- ● Acetal or Cyclic acetal



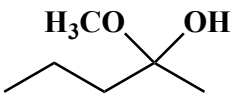
- ○ Enol
- ○ Hemiacetal or Cyclic hemiacetal
- ● Acetal or Cyclic acetal



- ○ Enol
- ● Hemiacetal or Cyclic hemiacetal
- ○ Acetal or Cyclic acetal

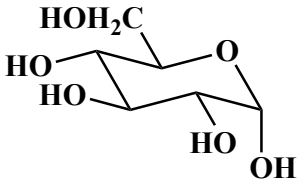


- ● Enol
- ○ Hemiacetal or Cyclic hemiacetal
- ○ Acetal or Cyclic acetal
- ○ Favored at equilibrium
- ● Not favored at equilibrium

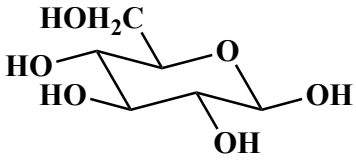


- ○ Enol
- ● Hemiacetal or Cyclic hemiacetal
- ○ Acetal or Cyclic acetal

7. (2 pts each) Fill in the circle to indicate the correct name for the glucose molecules shown.

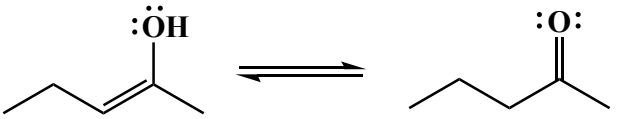


- ● alpha(α) - D - Glucose
- ○ beta(β) - D - Glucose

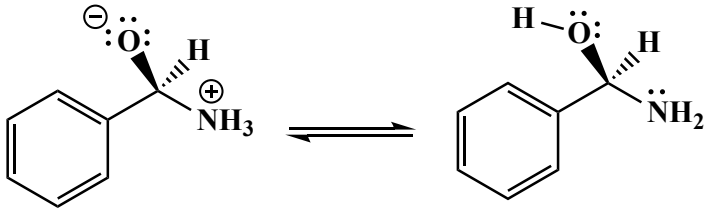


- ○ alpha(α) - D - Glucose
- ● beta(β) - D - Glucose

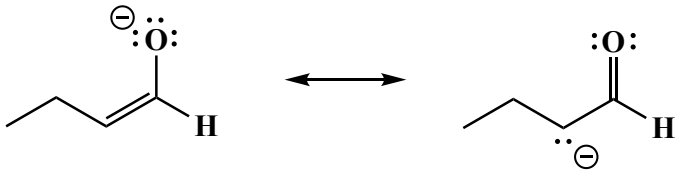
8. (2 pts each) Fill in the circle to indicate the correct way to describe the pair of molecules shown



- ○ Contributing Structures
- ● Keto-Enol Tautomerization
- ○ Proton Transfer



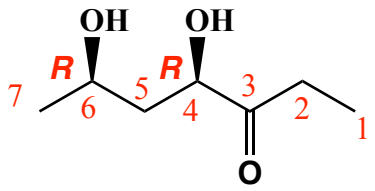
- ○ Contributing Structures
- ○ Keto-Enol Tautomerization
- ● Proton Transfer



- ● Contributing Structures
- ○ Keto-Enol Tautomerization
- ○ Proton Transfer

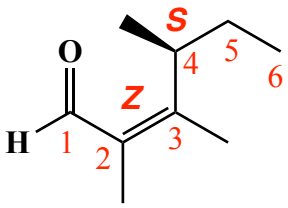
9. (4 pts each) Write an acceptable IUPAC name or draw a structural formula for the following molecules:

A.



(4*R*,6*R*)-4,6-dihydroxy-3-heptanone
or
(4*R*,6*R*)-4,6-dihydroxyheptan-3-one

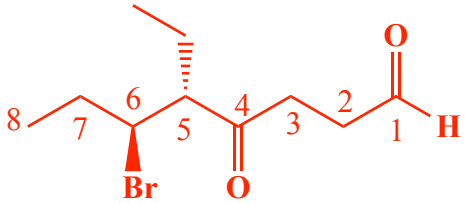
B.



(*S*,*Z*)-2,3,4-trimethyl-2-hexenal **(4*S*,2*Z*)-2,3,4-trimethyl-2-hexenal**
(*S*,*Z*)-2,3,4-trimethylhex-2-enal **(4*S*,2*Z*)-2,3,4-trimethylhex-2-enal**

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

(5*R*,6*S*)-6-bromo-5-ethyl-4-oxooctanal

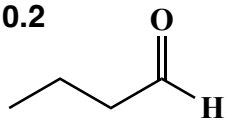


10. (14 pts) Being able to recognize the chemical personality of different species is one of the most important skills you can develop in Organic Chemistry. Fill in the appropriate circle to indicate whether each structure would participate as a nucleophile or electrophile in the mechanisms we have seen. Note that these species might be acids or bases in certain situations, but we will ignore that for this problem.

10.1

○ Electrophile
● Nucleophile

10.2

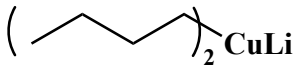


● Electrophile
○ Nucleophile

10.3

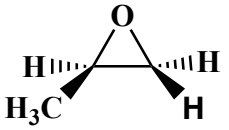
○ Electrophile
● Nucleophile

10.4



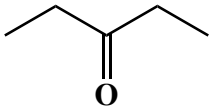
○ Electrophile
● Nucleophile

10.5



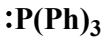
● Electrophile
○ Nucleophile

10.6



● Electrophile
○ Nucleophile

10.7

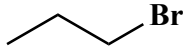


○ Electrophile
● Nucleophile

10.8

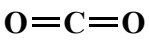
○ Electrophile
● Nucleophile

10.9



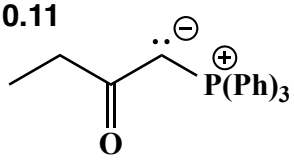
● Electrophile
○ Nucleophile

10.10



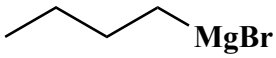
● Electrophile
○ Nucleophile

10.11



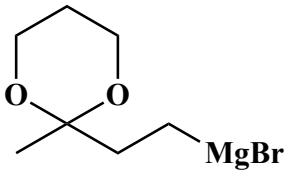
○ Electrophile
● Nucleophile

10.12



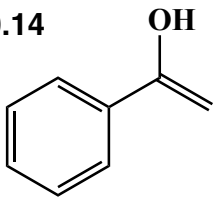
○ Electrophile
● Nucleophile

10.13



○ Electrophile
● Nucleophile

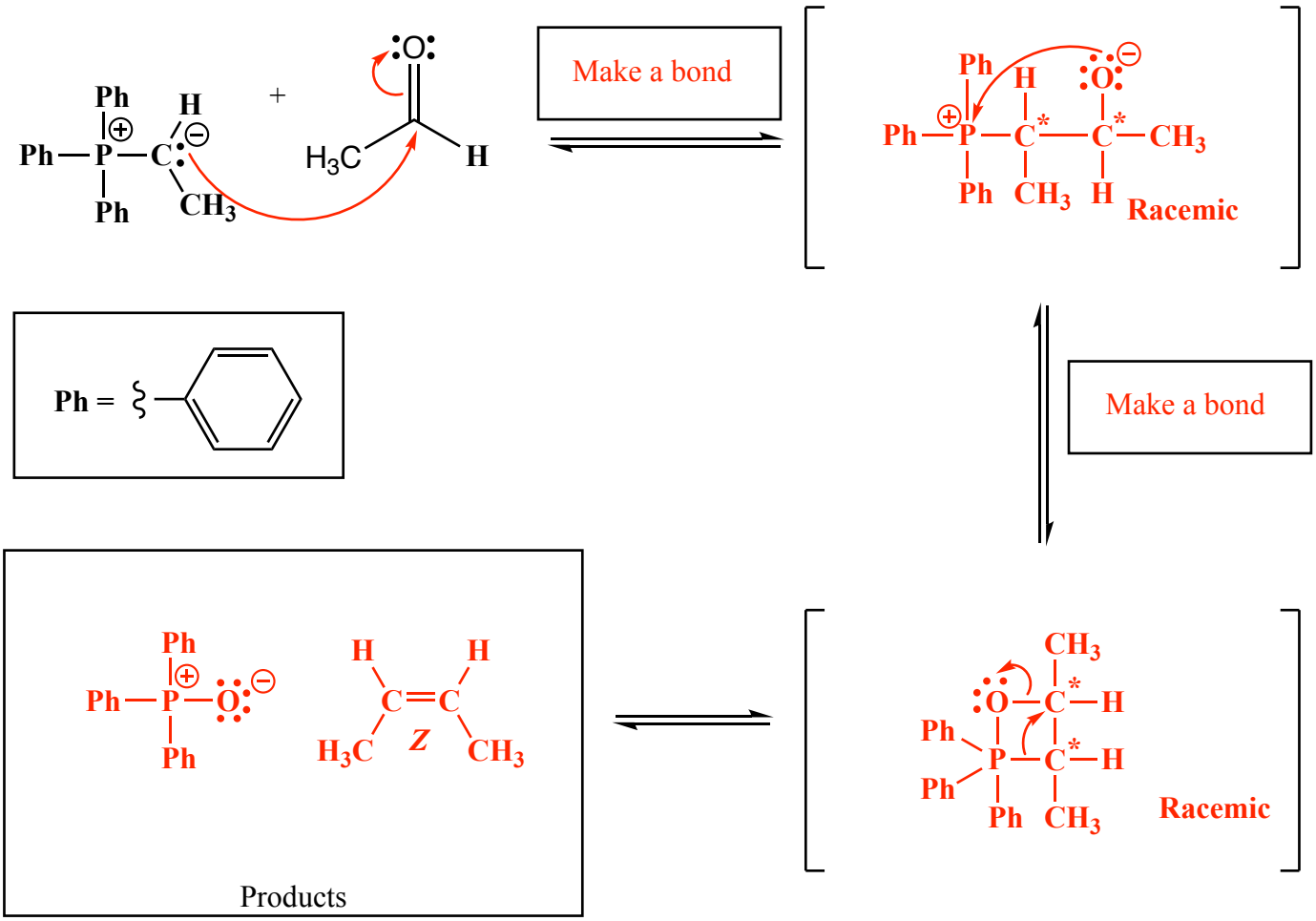
10.14



○ Electrophile
● Nucleophile

11. (17 pts) For this Wittig reaction, use **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, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. <u>FOR ALL CHIRAL FINAL "PRODUCTS" YOU MUST DRAW ALL ENANTIOMERS WITH WEDGES AND DASHES AND WRITE "RACEMIC' IF APPROPRIATE</u>. 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.).**

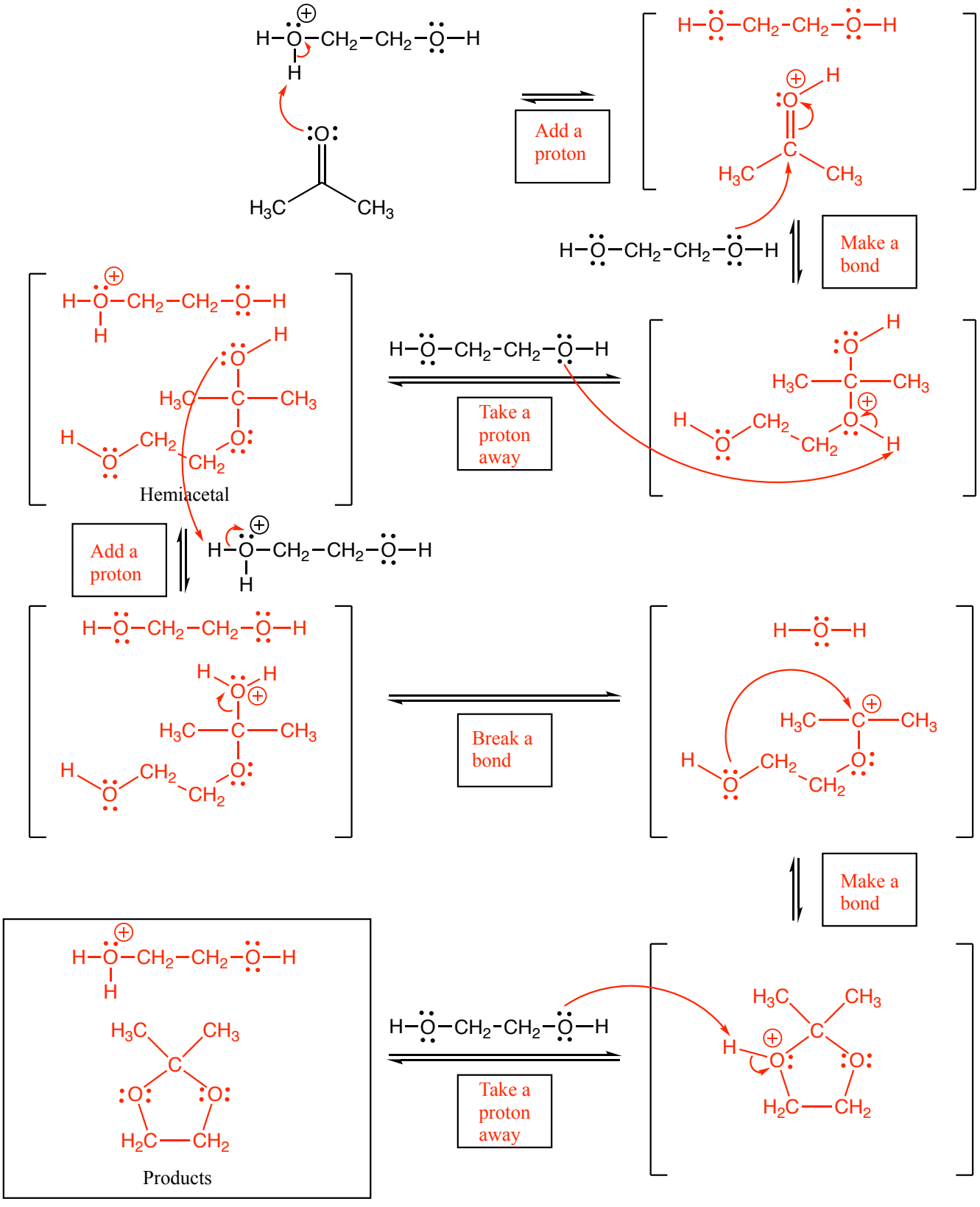
Wittig Reaction with an Aldehyde



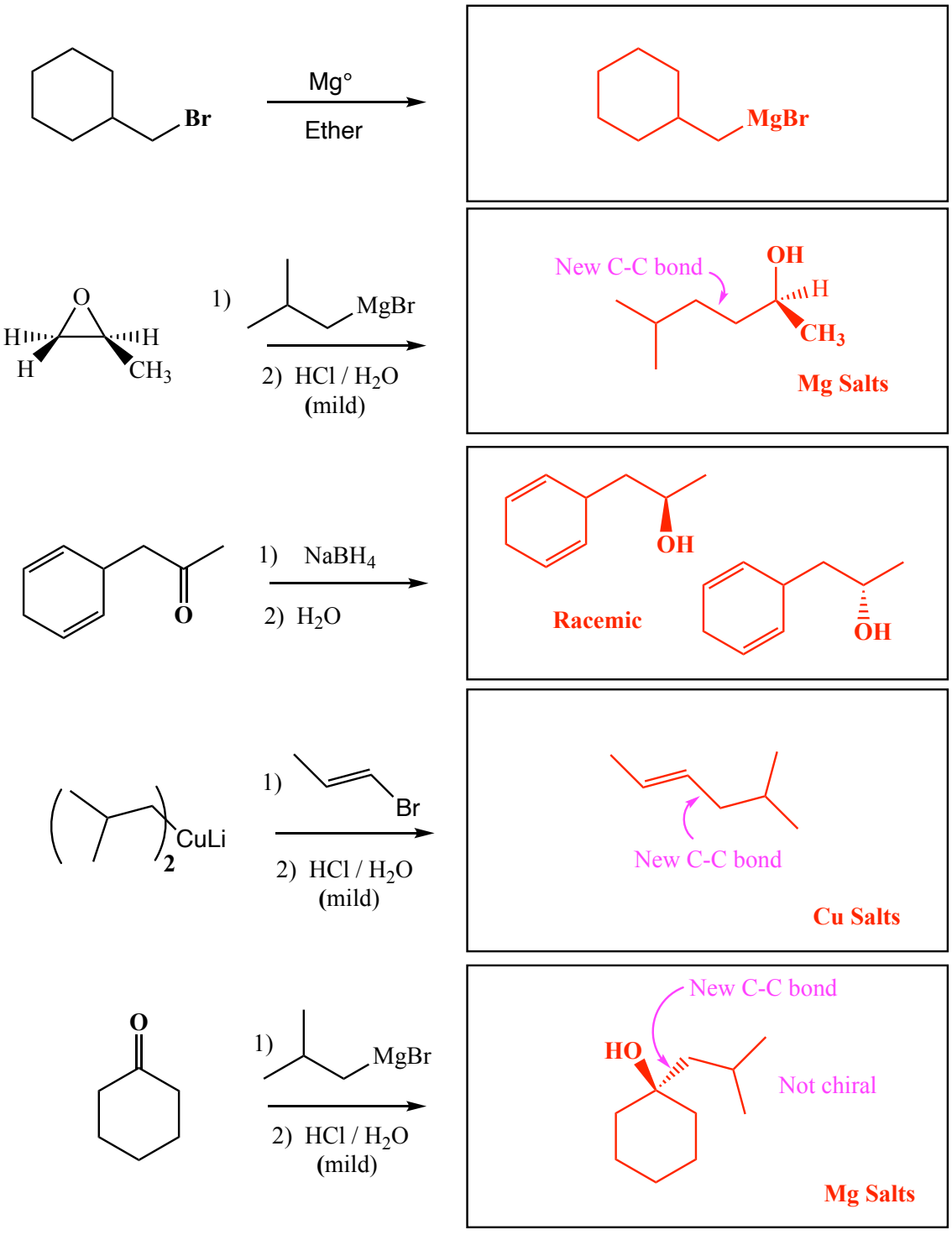
12. (45 pts) For the cyclic acetal reaction mechanism ON THE NEXT PAGE, use **arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step.** Remember, I said <u>all</u> the products for each step. **IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. <u>FOR ALL CHIRAL "PRODUCTS" YOU MUST DRAW ALL ENANTIOMERS WITH WEDGES AND DASHES AND WRITE "RACEMIC' IF APPROPRIATE</u>. 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.).**

The mechanism did not fit on the same page as the directions, so use the directions on this page to fill in the mechanism on the next page!

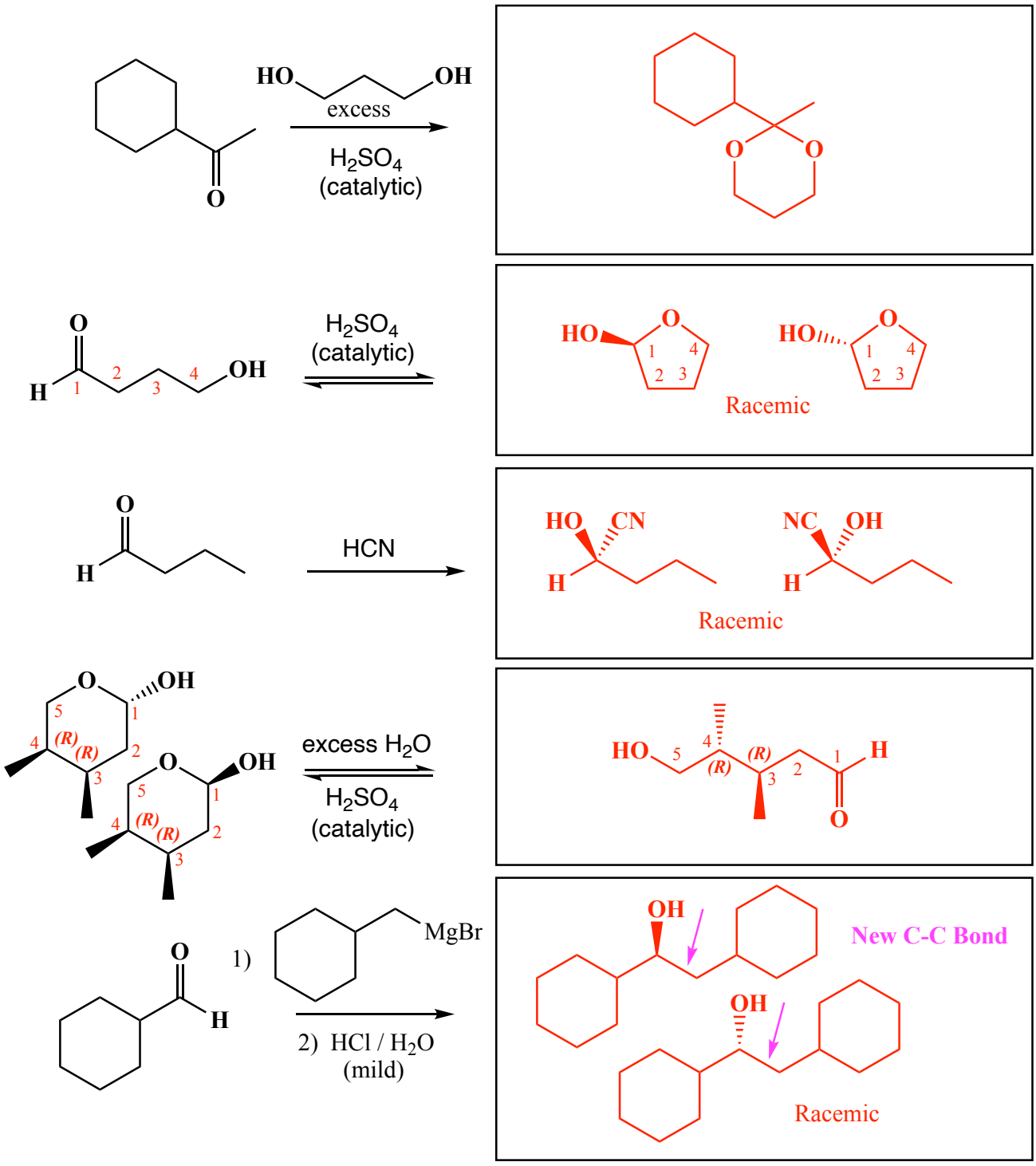
Note: For intermediates that I drew as two contributing structures in class, you only need to draw one contributing structure. Either one will be correct. Just make sure your arrows are accurate for the contributing structure you draw.


Add a proton
Make a bond
Hemiacetal
Take a proton away
Add a proton
Break a bond
Make a bond
Products
Take a proton away

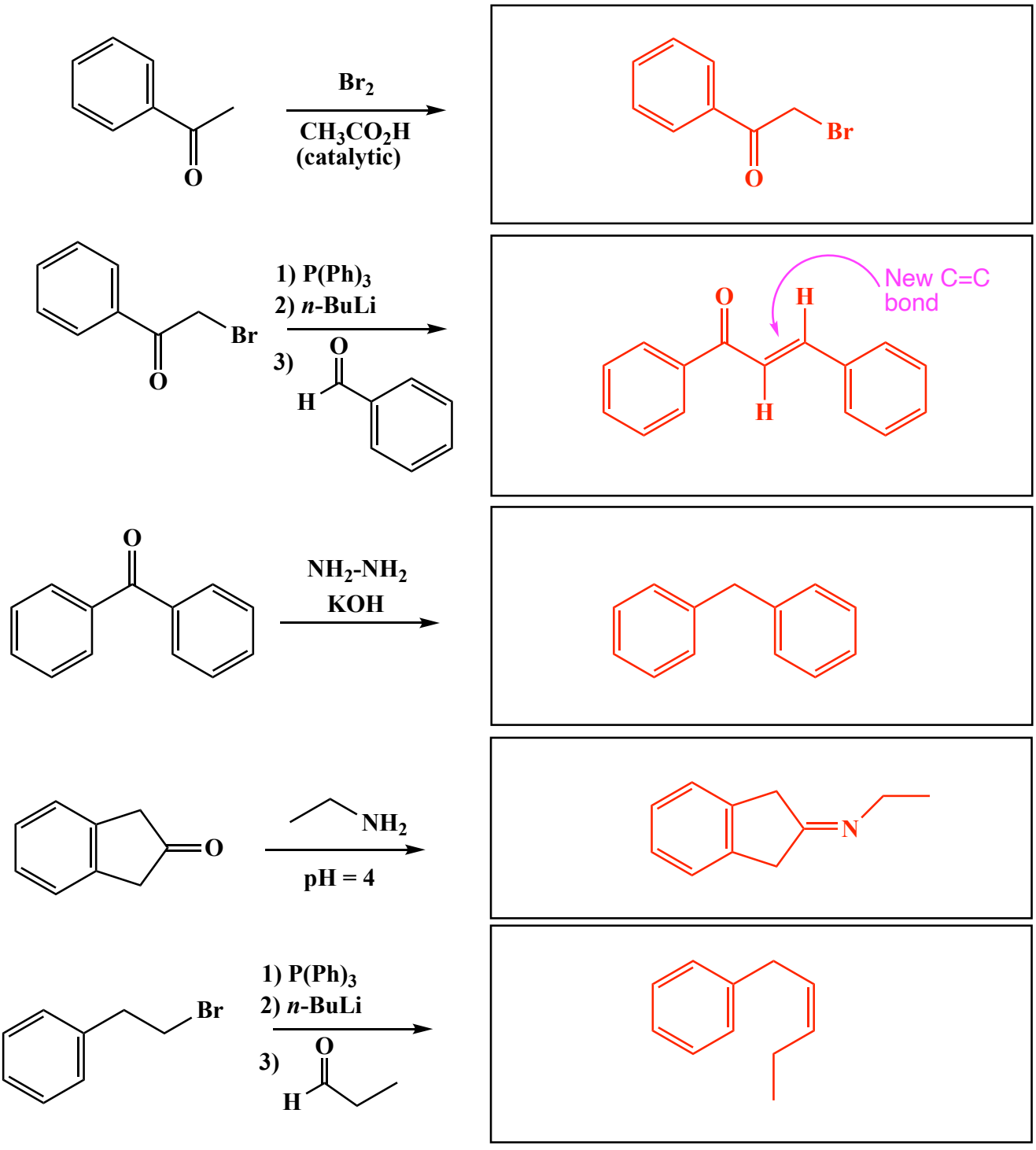
13. (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (◄) and dashes (·····) to indicate stereochemistry.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



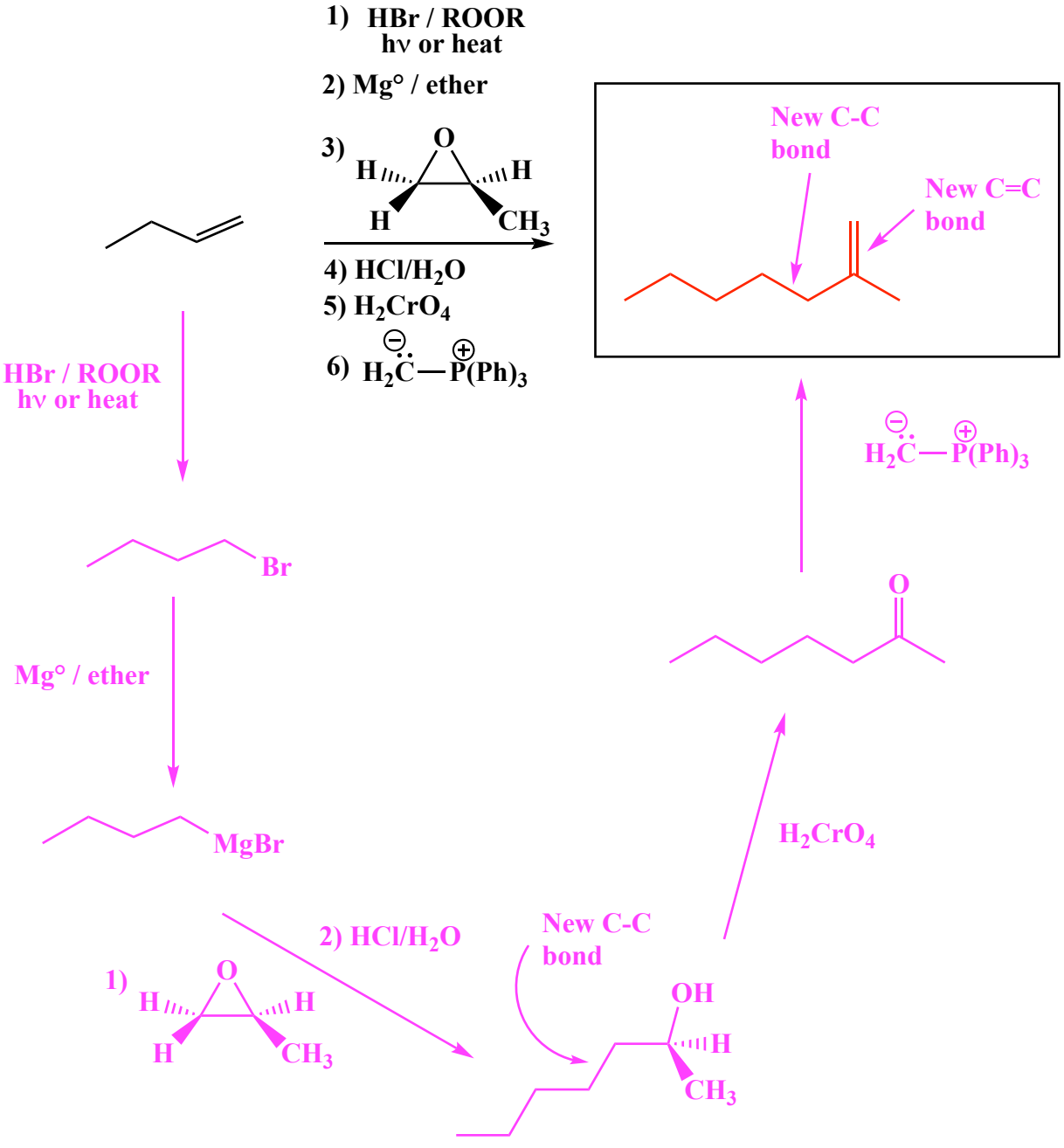
13. (cont.) (3, 4 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (◄) and dashes (·····) to indicate stereochemistry. 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 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 ( ) and dashes ( ) 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.

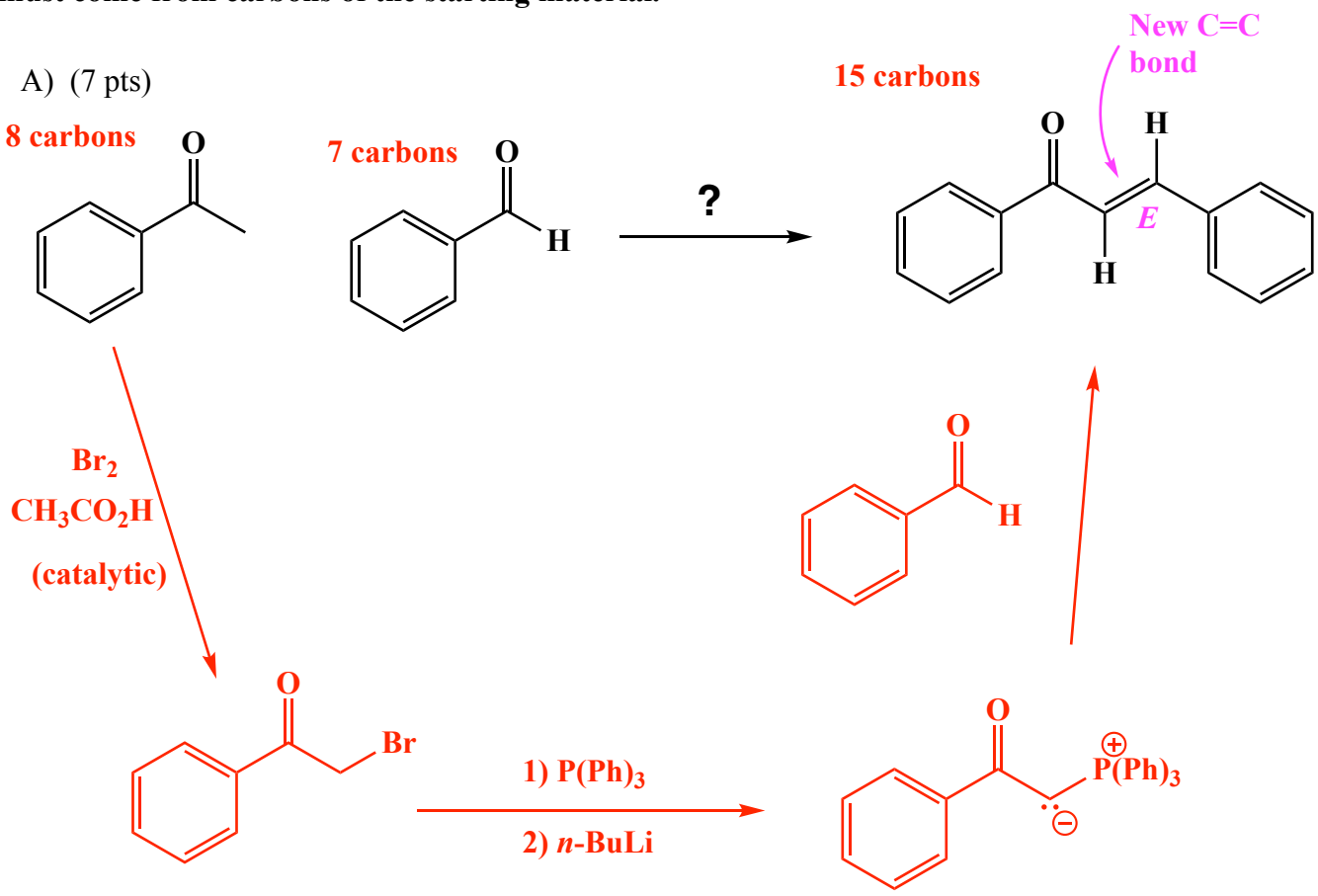


14. (10 pts) Here is a warm-up for the synthesis problems. For the following series of reactions, write the **final** product(s) that you will see. Make sure draw all stereoisomers produced and to use wedges and dashes to indicate all stereochemistry, and you must write racemic if appropriate.



15. 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.**

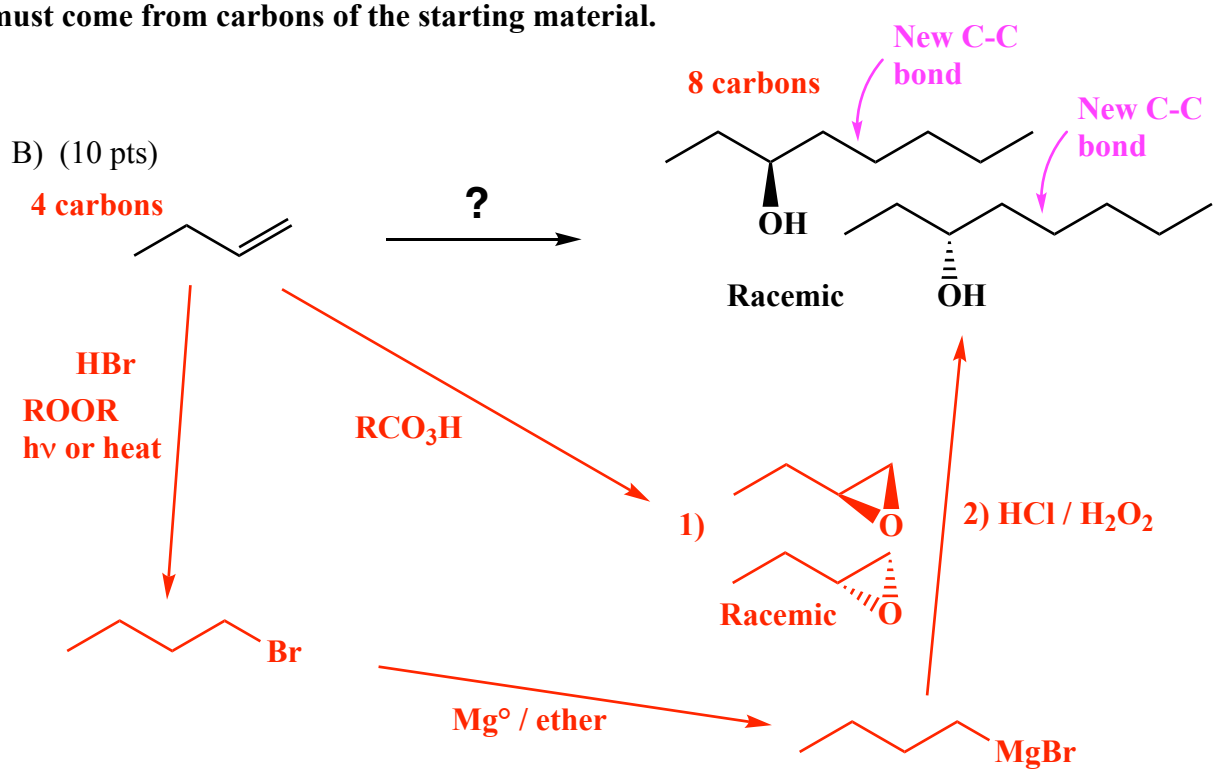
A) (7 pts)



Recognize that the product has 15 carbons and the starting materials have 8 and 7 carbons. Therefore predict that the new C=C is exactly as shown. **Recognize** further that the product is a Z alkene, the KRE of a Wittig reaction between an 8 carbon ylide containing the carbonyl as shown and benzaldehyde, the 7 carbon starting material. **Recognize** further that the bromomethyl ketone needed to make the Wittig reagent can be made from the starting 8 carbon methyl ketone using the α-halogenation reaction using Br_2 and catalytic CH_3CO_2H.

15. 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.**

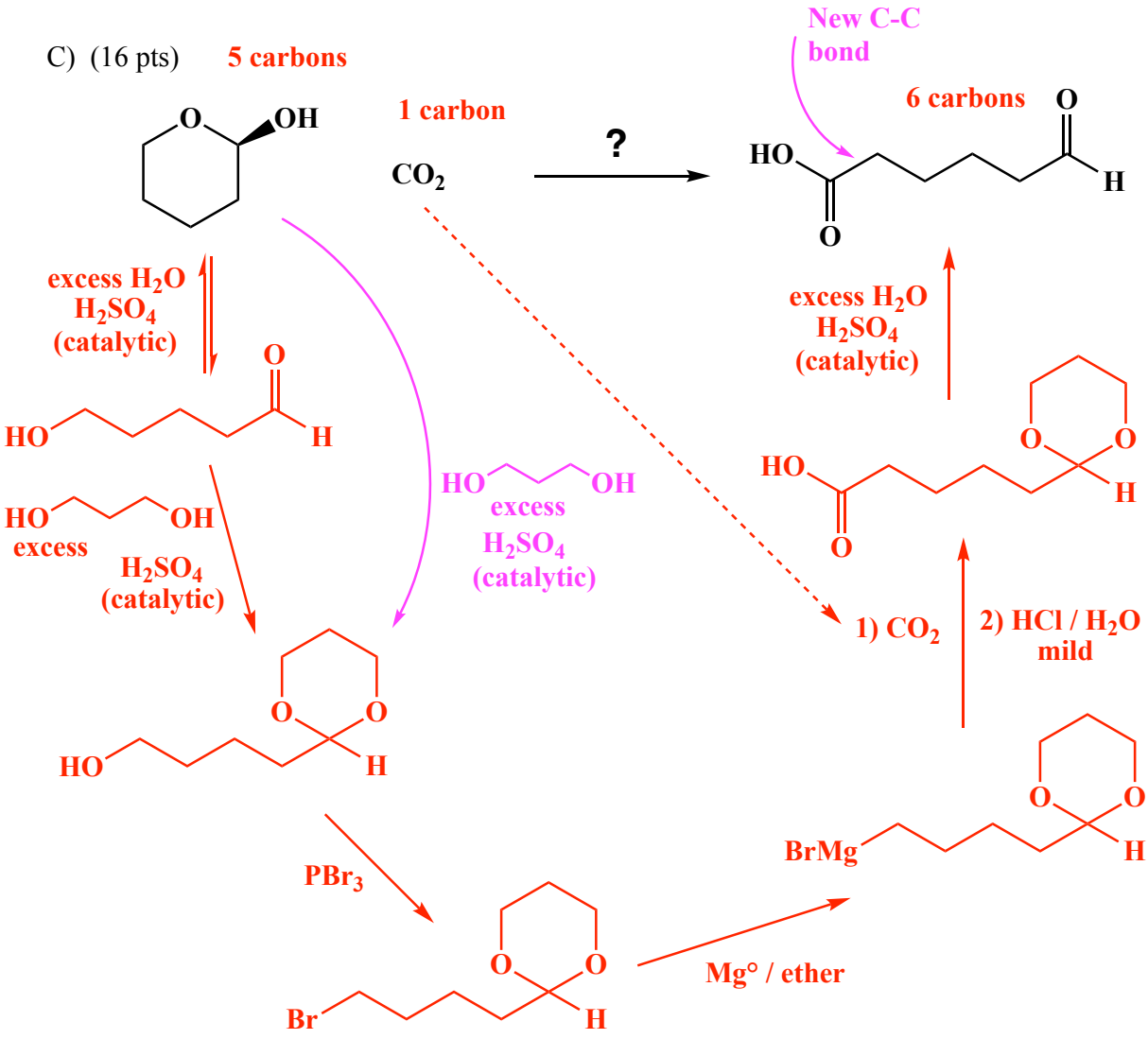
B) (10 pts)



Recognize that the product has 8 carbons and the starting material has 4 carbons. Therefore predict that the new C-C bond is between atoms 4 and 5 as shown. **Recognize** further that the product has a new C-C bond two carbons away from the OH group, the KRE of a Grignard reagent reacting with an epoxide. **Recognize** that the Grignard reagent can be made from the starting alkene by reacting with HBr in the presence of ROOR and light or heat to give the non-Markovnikov product followed by the usual reaction with Mg° in ether. **Recognize** that the epoxide required for the last step can be made by reacting the starting alkene with RCO_3H to give a racemic mixture.

15 (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.**

C) (16 pts) **5 carbons** **1 carbon** **New C-C bond** **6 carbons**

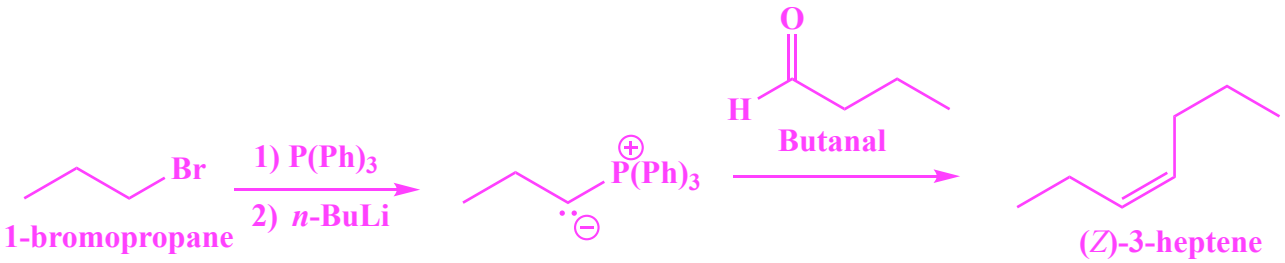


Recognize that the product has 6 carbons and the starting materials have 5 and 1 carbon. The new C-C bond must therefore be on one end or the other. Assume that the new C-C bond is next to the -CO_2H group, because this is the KRE of a Grignard reagent reacting with CO_2, the one carbon starting material. **Recognize** that the required Grignard reagent would have an aldehyde group, so it must be protected as a cyclic acetal (a 5 or 6 membered ring is fine, I happened to choose the 6-membered ring). **Recognize** that the required Grignard reagent can be made by reacting the appropriate protected primary alcohol with PBr_3 followed by the normal reaction with Mg° in ether. **Recognize** that the needed protected primary alcohol can be made by using the linear 5-carbon alcohol with an aldehyde that comes from opening up the cyclic hemiacetal starting material. I have drawn this as two steps (open the ring then add the protecting group), but a chemist would do it in one step, adding the 1,3 propane diol in excess directly to the starting cyclic hemiacetal. The protected aldehyde would form as the ring opened up, all in one reaction! Note, we give full credit if you used either one or two steps.

16. (8 pts) On the MCAT and other standardized tests, it is common to use IUPAC names instead of structures. Use what you have learned this semester to answer the following questions.

A) A chemist wishes to synthesize (Z)-3-heptene using a Witting reaction. She makes a Wittig reagent (an ylide) using 1-bromopropane that reacts with 1) $P(Ph)_3$ and 2) n-BuLi Which aldehyde will she use to complete the synthesis of (Z)-3-heptene?

◯ **Propanal** ● **Butanal** ◯ **Pentanal** ◯ **Hexanal**

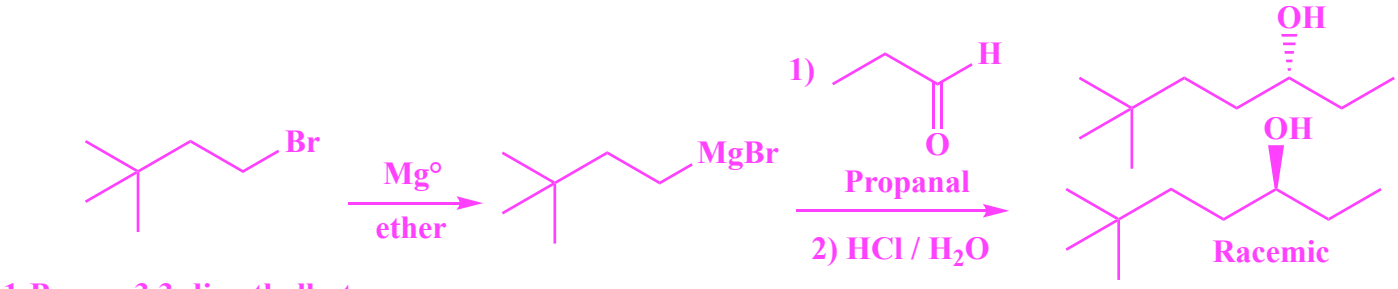


1-bromopropane (*Z*)-3-heptene

B) A chemist wishes to synthesize racemic 6,6-dimethyl-3-heptanol using a Grignard reaction. He starts with propanal, then makes a Grignard reaction from which haloalkane:

◯ **1-Bromo-2,2-dimethylbutane** ◯ **1-Bromo-4,4-dimethylpentane**

● **1-Bromo-3,3-dimethylbutane** ◯ **1-Bromo-2,2-dimethylbutane**



1-Bromo-3,3-dimethylbutane 6,6-Dimethyl-3-heptanol