NAME (Print): _____

EID _____

SIGNATURE: _____

Chemistry 320N
1st Midterm Exam
February 15, 2024

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!!!

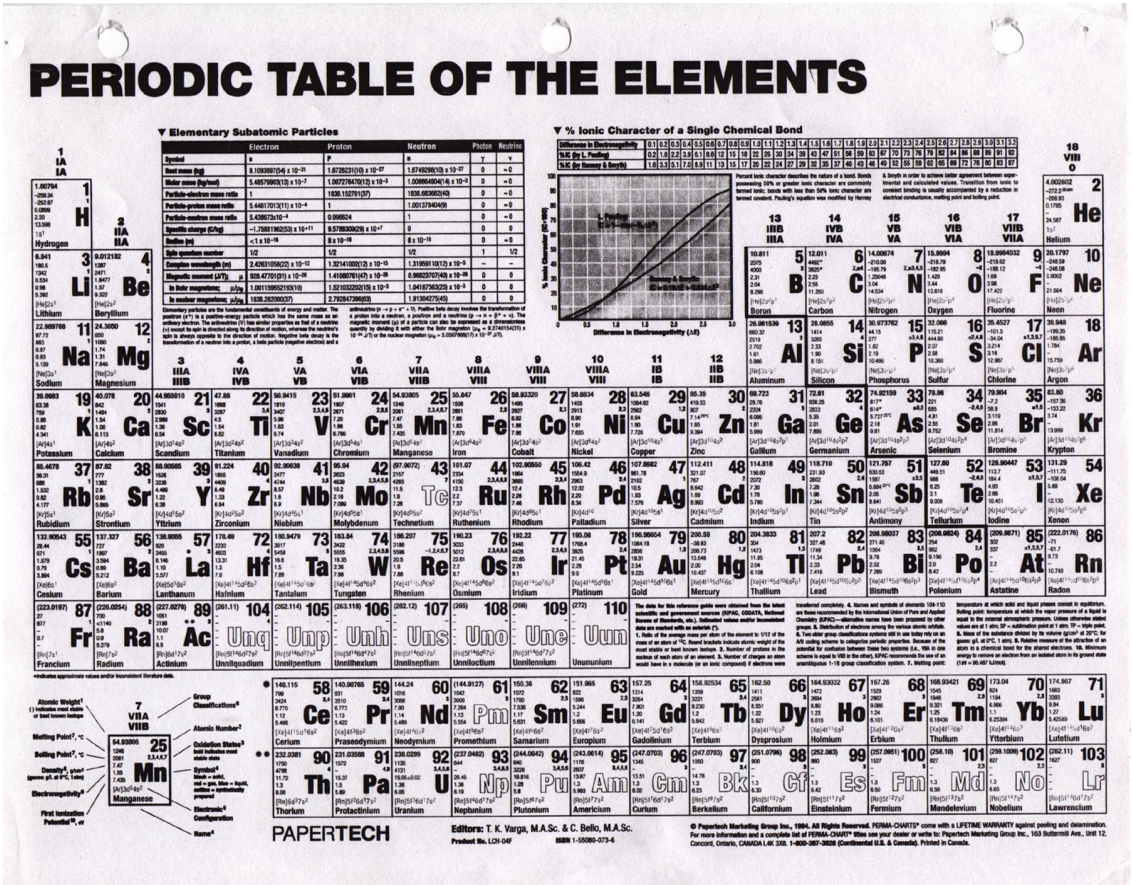
Student Honor Code for the University of Texas at Austin

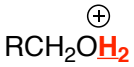
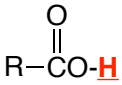
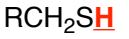
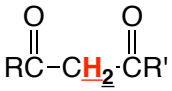
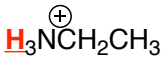
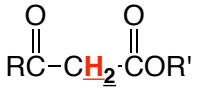
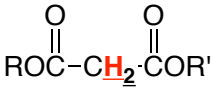
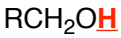
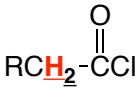
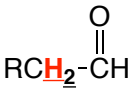
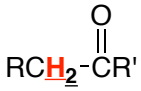
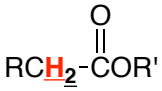
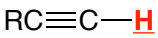
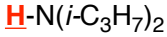
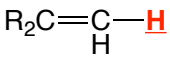
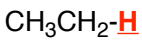
"I pledge, as a member of The University of Texas at Austin community, to do my work honestly, respectfully, and through the intentional pursuit of learning and scholarship."

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 _____(27)

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 1._____ diagnostic technique of 2._____

3._____ 4._____ (_5._____) is based on the same

principles as NMR, namely the 6._____ (i.e. resonance) of

7._____ spins of 8. _____ atoms by radio 8._____

9._____. 10. _____ 11._____

gradients are used to gain imaging information, and 12. _____ of the

13. _____ around the 14. _____ of the object gives imaging in

an entire plane (i.e. slice inside 15._____). In an MRI image, you are looking at

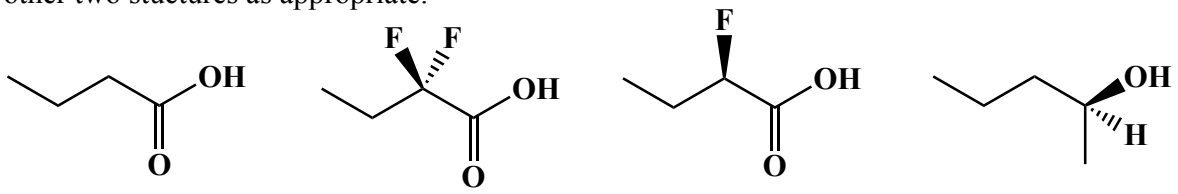
individual 16._____ that when 17._____ make up the three-

dimensional image of relative amounts of 18. _____ atoms,

especially the 19._____ atoms from 20._____ and

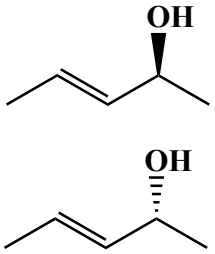
21._____, in the different 22._____.

3. (1 pt each) Predict the relative acidities of the following molecules. Put the number 1 under the most acidic molecule, the number 4 under the least acidic molecule, and the numbers 2 and 3 under the other two stuctures as appropriate.

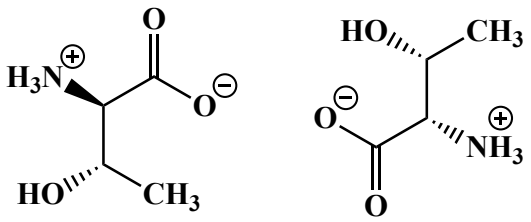


_____ _____ _____ _____

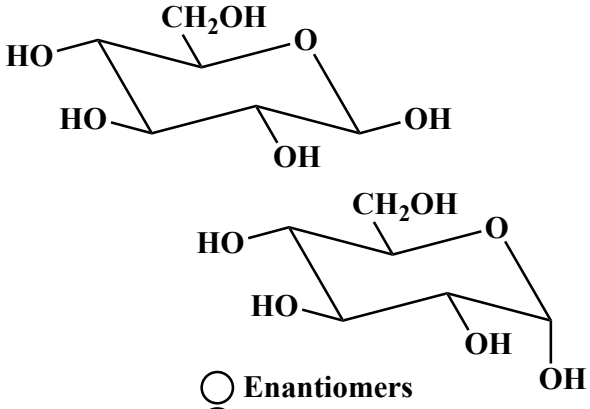
4. (3 pts each) Fill in the circle to identify the stereochemical relationship between each pair of molecules. Hint: You might want to determine *R* or *S* for each chiral center to help you answer the question.



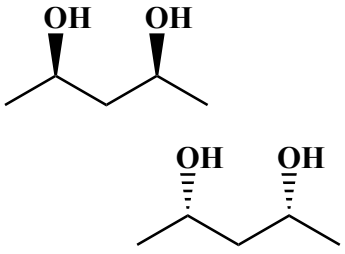
◯ **Enantiomers**
◯ **Diastereomers**
◯ **Same Molecule**



◯ **Enantiomers**
◯ **Diastereomers**
◯ **Same Molecule**



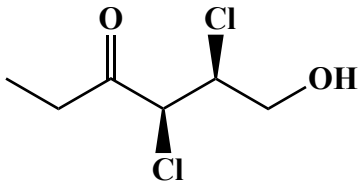
◯ **Enantiomers**
◯ **Diastereomers**
◯ **Same Molecule**



◯ **Enantiomers**
◯ **Diastereomers**
◯ **Same Molecule**

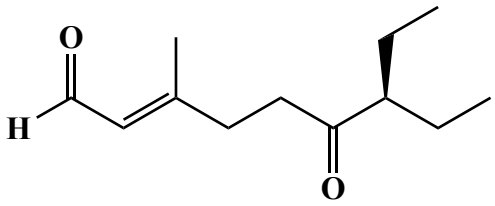
5. (6 pts each) Write an acceptable IUPAC name or draw a structural formula for the following molecules:

A.



_____

B.



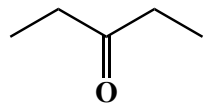
_____

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

(*R*)-2-Methyl-3-oxopentanedial

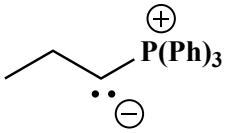
6. (13 pts) Being able to recognize the chemical personality of different species is one of the most important skills you can develop in Organic Chemistry. Fill in the appropriate circle to indicate whether each structure is a nucleophile or electrophile in the mechanisms we have seen. **Note that these species might be proton acids or bases in certain situations, but we will ignore that for this problem.**

6.1



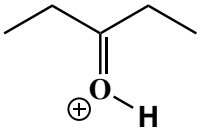
◯ Electrophile
◯ Nucleophile

6.2



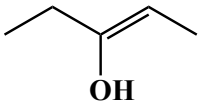
◯ Electrophile
◯ Nucleophile

6.3



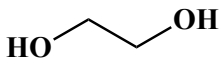
◯ Electrophile
◯ Nucleophile

6.4



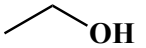
◯ Electrophile
◯ Nucleophile

6.5



◯ Electrophile
◯ Nucleophile

6.6



◯ Electrophile
◯ Nucleophile

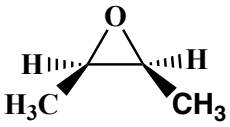
6.7 $NaBH_4$

◯ Electrophile
◯ Nucleophile

6.8 Br_2

◯ Electrophile
◯ Nucleophile

6.9

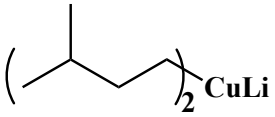


◯ Electrophile
◯ Nucleophile

6.10

◯ Electrophile
◯ Nucleophile

6.11

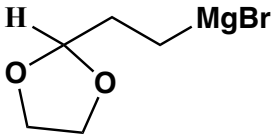


◯ Electrophile
◯ Nucleophile

6.12

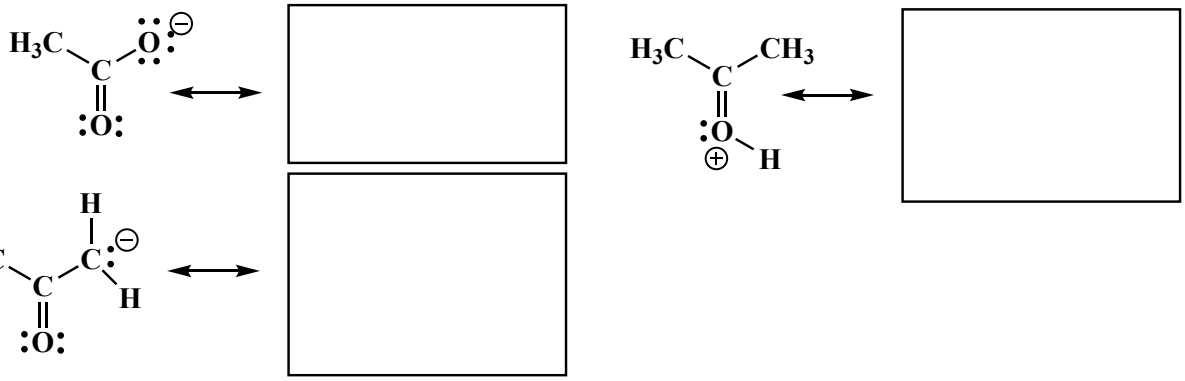
◯ Electrophile
◯ Nucleophile

6.13

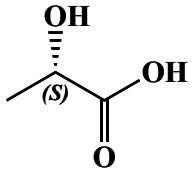


◯ Electrophile
◯ Nucleophile

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



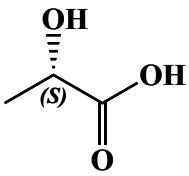
7. (4 pts each) (S)-Lactic acid is produced in our muscles during intense excercise when oxygen is scarce, such as **RUNNING 3.1 MILES or even farther**. The concentration of blood lactic acid is usually 1–2 mM at rest, but can rise to over 20 mM during intense exertion and as high as 25 mM afterward. Below are the two measured pKa values for (S)-lactic acid.



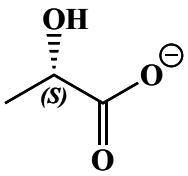
(*S*)-(+)-Lactic acid

pKa1 = 3.86 pKa2 = 15.1

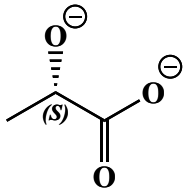
At neutral pH = 7.0, fill in the circle under the structure that is the predominant form of (*S*)-(+)-lactic acid.



○ **Predominant form at pH = 7.0**

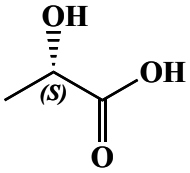


○ **Predominant form at pH = 7.0**

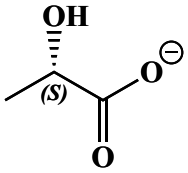


○ **Predominant form at pH = 7.0**

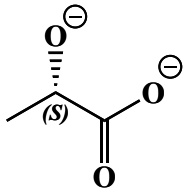
Lactic acid is commonly found is some foods such as sauerkraut and pickles. The pH of both of these foods can fall below 3. The low pH is important for keeping these foods from spoiling.



○ **Predominant form at pH = 3.0**

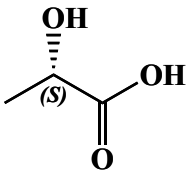


○ **Predominant form at pH = 3.0**

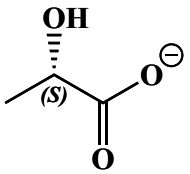


○ **Predominant form at pH = 3.0**

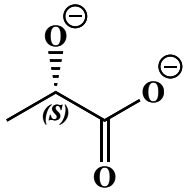
Lactic acid is soluble in alkaline solutions as well. What would be the predominant form of (*S*)-(+)-lactic acid in a solution of pH = 9.0



○ **Predominant form at pH = 9.0**



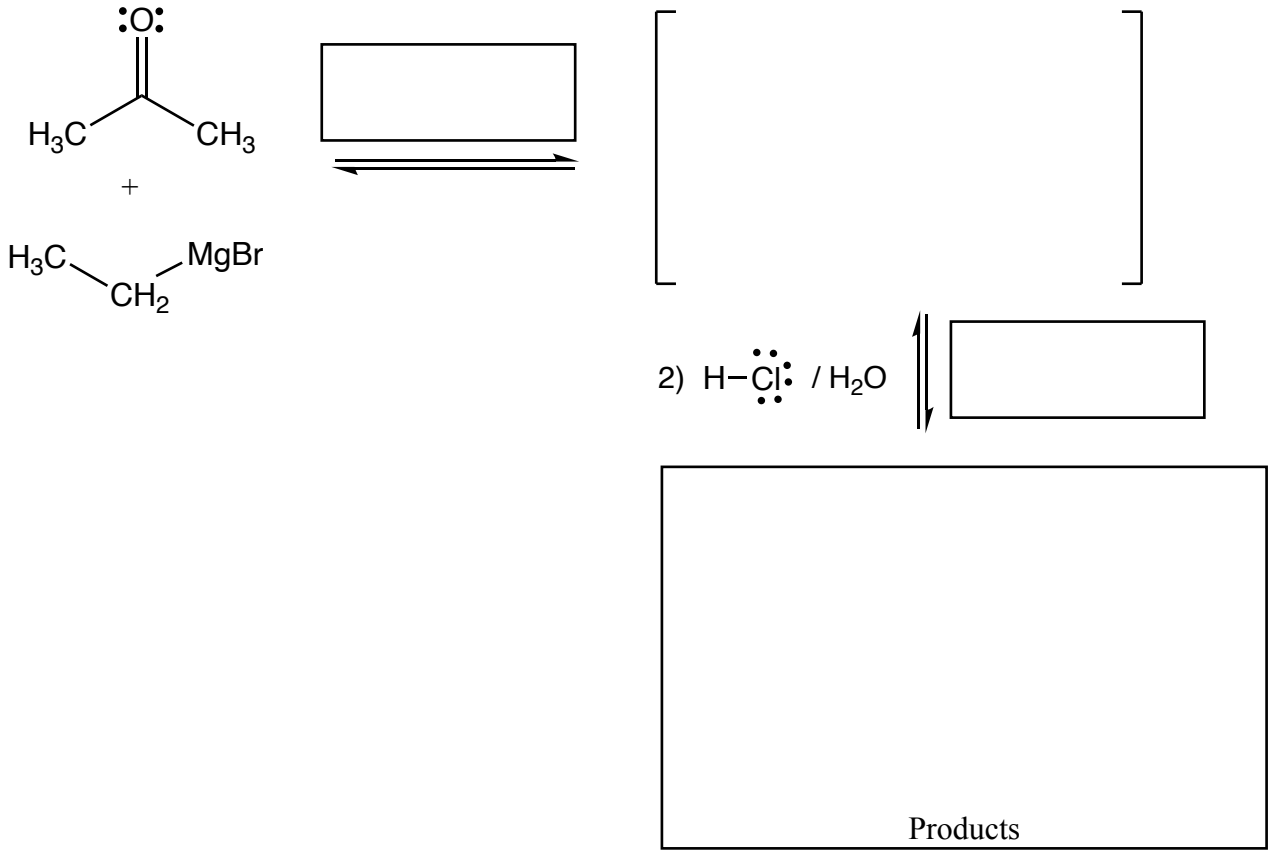
○ **Predominant form at pH = 9.0**



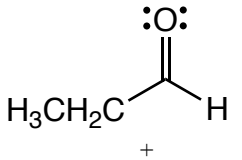
○ **Predominant form at pH = 9.0**

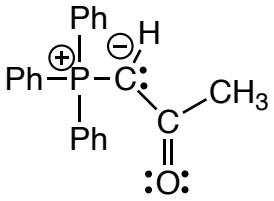
8. (15 pts) For these this reaction, use **arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step.** Remember, I said <u>all</u> the products for each step. **IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE AS "RACEMIC" IF APPROPRIATE. <u>FOR ALL CHIRAL 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.).**

Grignard Reaction with a Ketone



9. (21 pts) For the following 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 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.).**

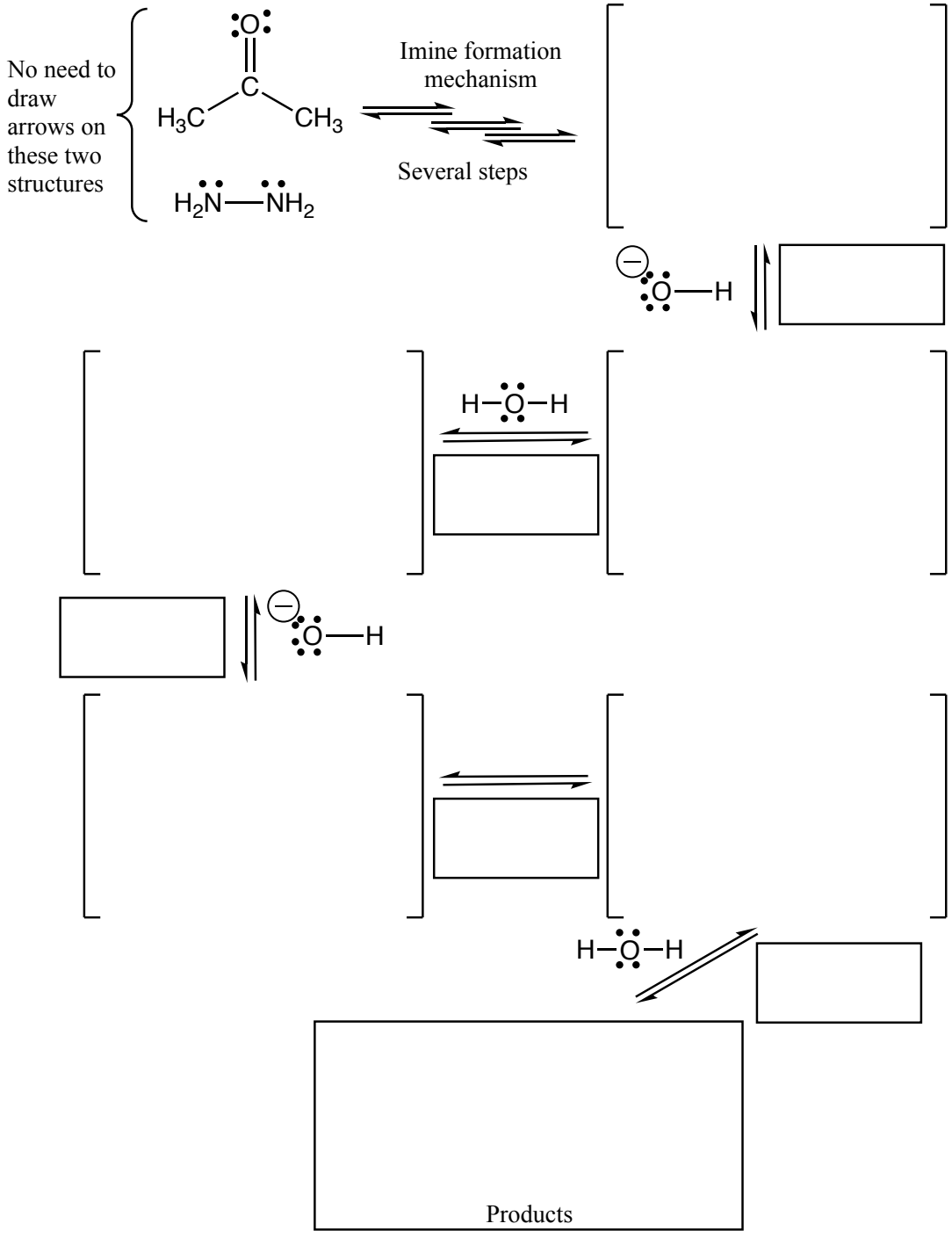




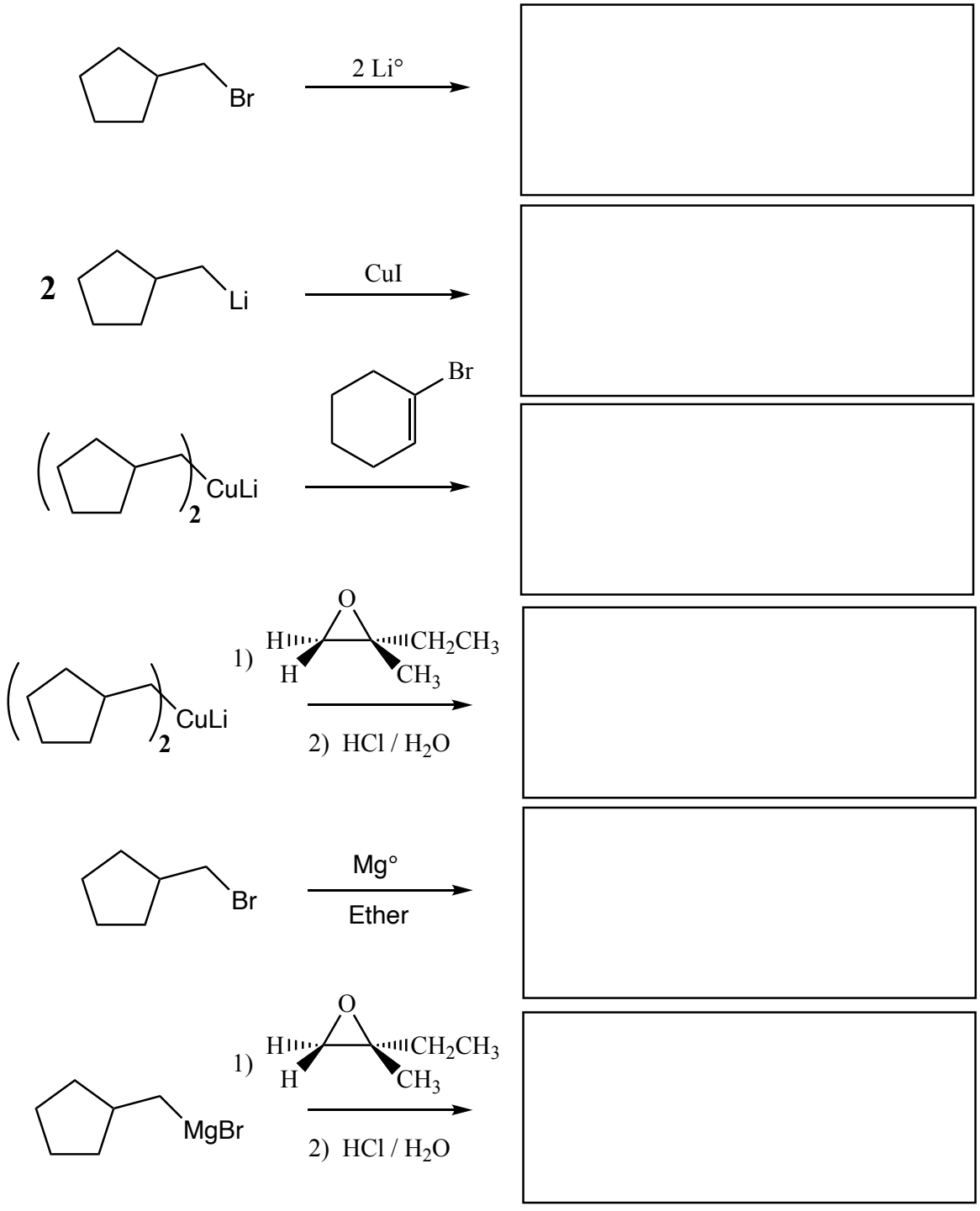
Products

(No box to fill in here)

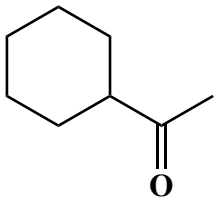
10. (34 pts) For this Wolff-Kishner reaction, use **arrows to indicate movement of <u>all</u> electrons, write <u>all</u> lone pairs, <u>all</u> formal charges, and <u>all</u> the products for each step. IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE, MARK IT WITH AN ASTERISK AND LABEL THE MOLECULE 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.).**



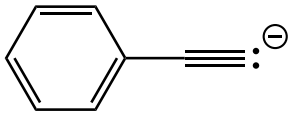
11. (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (◄) and dashes (·····) to indicate stereochemistry. 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.

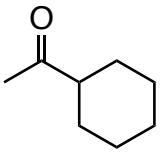


11. (cont.) (3, 4 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (◄) and dashes (····ıı) to indicate stereochemistry.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

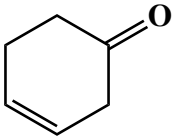


HCN →

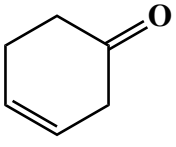


1) 

2) HCl / H_2O →

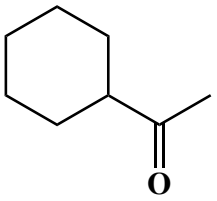


1) $NaBH_4$
2) H_2O →



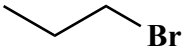
excess H_2
Pd° →

11. (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.

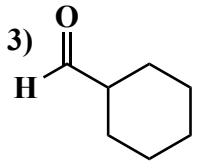


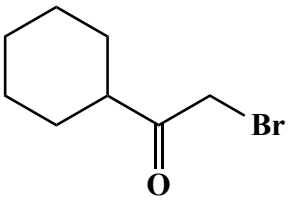
Br_2

CH_3CO_2H
(catalytic)

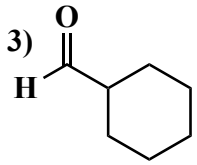


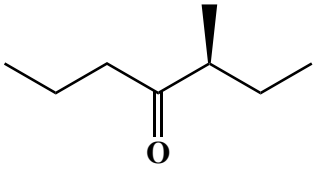
1) $P(Ph)_3$
2) *n*-BuLi
3)



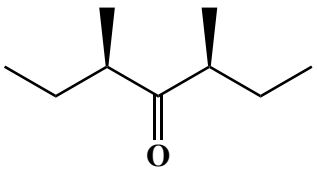


1) $P(Ph)_3$
2) *n*-BuLi
3)



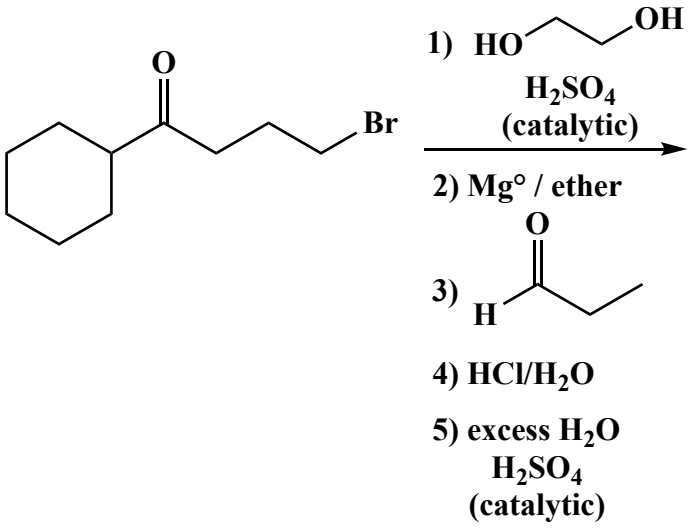


NH_2-NH_2
KOH

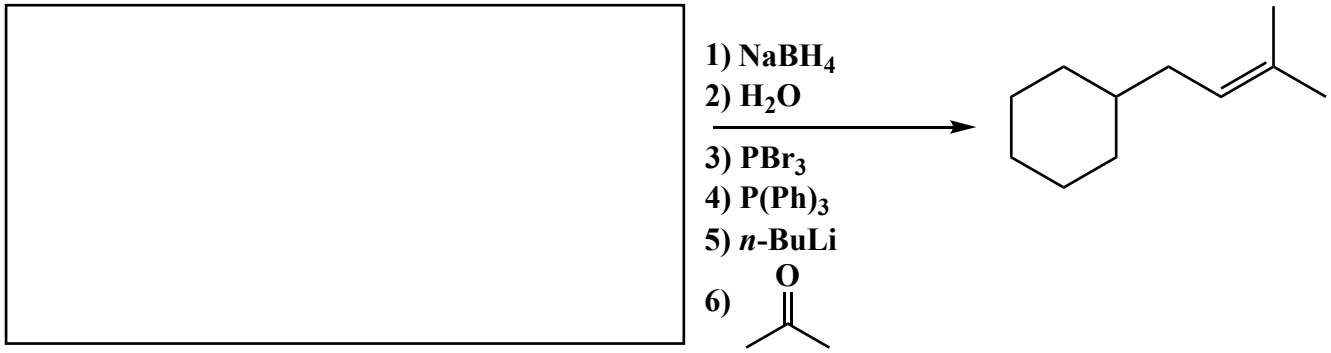


pH = 4

12. (12 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.

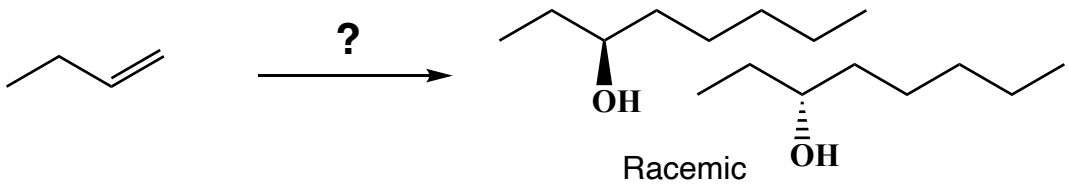


13. (12 pts) Here is a second warm-up for the synthesis problems. For the following series of reactions, we have given you the final product. Work backwards and **in the box provided write the structure of the starting material that would generate the final product shown.**



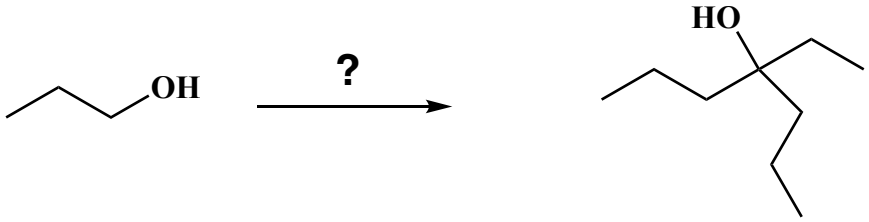
14. These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule synthesized 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)



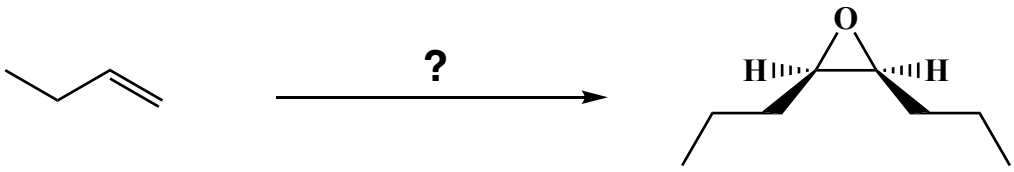
14. (cont.). These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule 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)



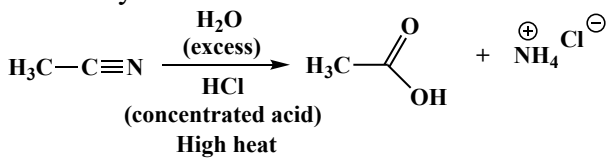
14. (cont.) These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule 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) (15 pts)

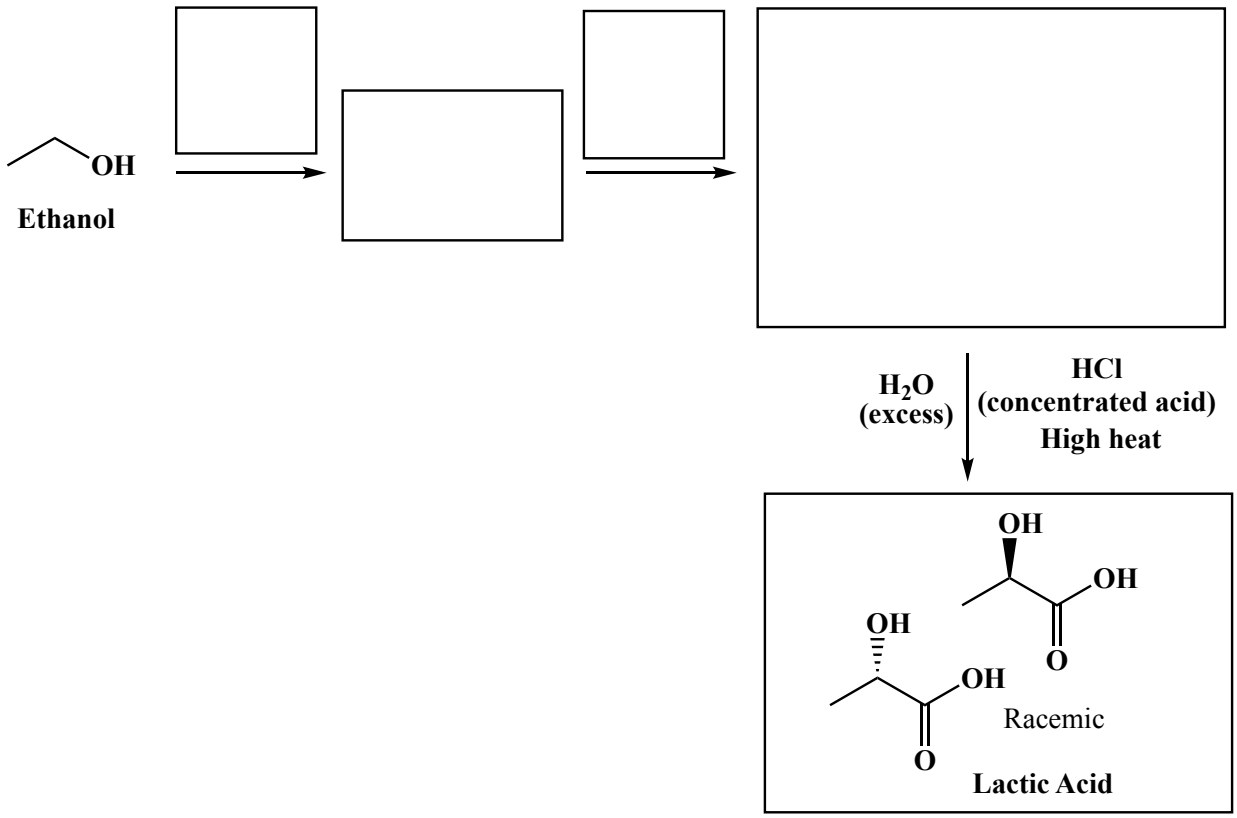


15. (12 pts) Here is an "Apply What you Know" problem. You have not seen all of this directly, but based on what you know you CAN figure it out. **Polylactides**, more commonly known as polylactic acid (PLA), are a type of biodegradable plastic. PLA is part of the polyester family. PLA is known for its rigidity, glossiness, and clarity. It has good mechanical properties and is suitable for various processing techniques similar to conventional plastics. PLA is used for packaging materials (bottles, films, cups), biodegradable medical devices (sutures, pins, rods), 3D printing filaments, disposable tableware (plates, utensils) and agricultural products. One of the key benefits of PLA is its reduced environmental footprint during production because it is not derived from petroleum. Another key reason people are interested in PLA is that is biodegradable under industrial composting conditions. In other words, it can be broken down into water and carbon dioxide in only a few weeks. That contrasts with many common plastics that will remain in landfills for 400 to 1,000 years!

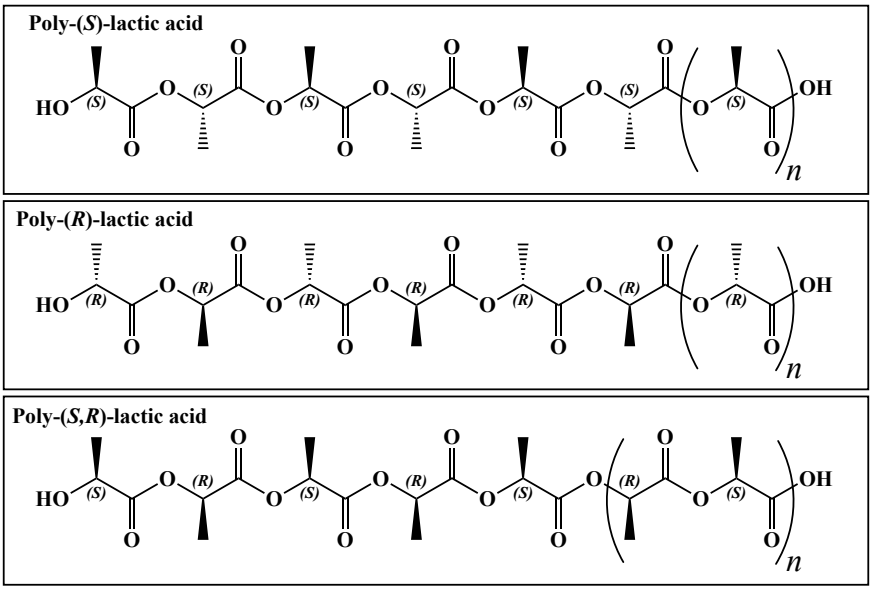
PLA is made entirely from lactic acid, which we saw on page 5 of this exam. One method of synthesizing lactic acid begins with ethanol. Here is what you have not learned yet: Nitrile groups react in water in the presence of concentrated HCl and heat to give carboxylic acids:

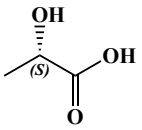


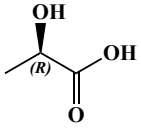
A) Racemic lactic acid can be synthesized starting with ethanol, a renewable source of carbons atoms. Using chemistry you have learned, fill in the boxes with both the reagents and synthetic intermediates to complete the following synthesis of lactic acid:



B) Because lactic acid is chiral, polylactic acid comes in three forms. Below is the structure of the three polylactic acids. They are polymers in which the lactic acid units are bonded into a long chain through what are called ester bonds.




(*S*)-Lactic Acid


(*R*)-Lactic Acid

Note: The (*S*)-lactic acid is often called L-lactic acid, and the (*R*)-lactic acid is often called D-lactic acid in accordance with an older method of naming stereoisomers in biochemistry. We are using the organic chemistry designations of (*S*) and (*R*) for this problem because you are more familiar with them.

As shown above, polylactic acid can be made from (*S*)-lactic acid, (*R*)-lactic acid or a racemic mixture of (*S,R*) lactic acid. Predict what will be true about the polylactic acids made from these three different starting materials and fill in the circle for the statement that is correct:

○ **All three materials will have identical properties (such as melting temperature, strength and brittleness).**

○ **The poly-(*S*)-lactic acid made from (*S*)-lactic acid and the poly-(*S,R*)-lactic acid made from (*S,R*)-lactic acid will have the same properties (such as melting temperature, strength and brittleness), the poly-(*R*)-lactic acid made from (*R*)-lactic acid will have different properties.**

○ **The poly-(*R*)-lactic acid made from (*R*)-lactic acid and the poly-(*S,R*)-lactic acid made from (*S,R*)-lactic acid will have the same properties (such as melting temperature, strength and brittlenesss), the poly-(*S*)-lactic acid made from (*S*)-lactic acid will have different properties.**

○ **The poly-(*S*)-lactic acid made from (*S*)-lactic acid and the poly-(*R*)-lactic acid made from (*R*)-lactic acid will have the same properties (such as melting temperature, strength and brittleness), the poly-(*S,R*)-lactic acid made from (*S,R*)-lactic acid will have different properties.**

This page is not graded, it is here to help us create a better learning experience as we begin to work with AI.

Have you used Felix, the AI tutor?

○ Yes ○ No

If you answered “yes”, rate (from 1 - 10) how much you feel that Felix helped you learn the material, with 10 being best.

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10