

NAME (Print): _____

Chemistry 320N
1st Midterm Exam
February 12, 2026

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

Electron	Proton	Neutron	Photon	Neutrino
Symbol	e ⁻	p ⁺	n ⁰	ν
Rest mass (kg)	9.10938356 × 10 ⁻³¹	1.67262161 × 10 ⁻²⁷	1.6749286 × 10 ⁻²⁷	0
Rest mass (eV/c ²)	0.5109989461	938.27208816	939.5654133	0
Electric charge (e)	-1	+1	0	0
Spin (ħ)	1/2	1/2	1/2	1/2
Spin quantum number	±1/2	±1/2	±1/2	±1/2
Spin magnetic moment (μ _B)	-8.64824 × 10 ⁻²⁶	1.32808 × 10 ⁻²⁶	1.31824 × 10 ⁻²⁶	0
Spin magnetic moment (μ _N)	0	1.852628 × 10 ⁻⁸	1.81827 × 10 ⁻⁸	0
Spin magnetic moment (μ _B)	0	1.852628 × 10 ⁻⁸	1.81827 × 10 ⁻⁸	0
Spin magnetic moment (μ _N)	0	1.852628 × 10 ⁻⁸	1.81827 × 10 ⁻⁸	0
Spin magnetic moment (μ _B)	0	1.852628 × 10 ⁻⁸	1.81827 × 10 ⁻⁸	0
Spin magnetic moment (μ _N)	0	1.852628 × 10 ⁻⁸	1.81827 × 10 ⁻⁸	0

% Ionic Character of a Single Chemical Bond

Percent ionic character depends on the value of Δχ. Bonded ions (ionic) or greater ionic character are associated with Δχ values greater than 1.7. This character is based on the Pauling scale. Bonding is based on the Pauling scale. Bonding is based on the Pauling scale.

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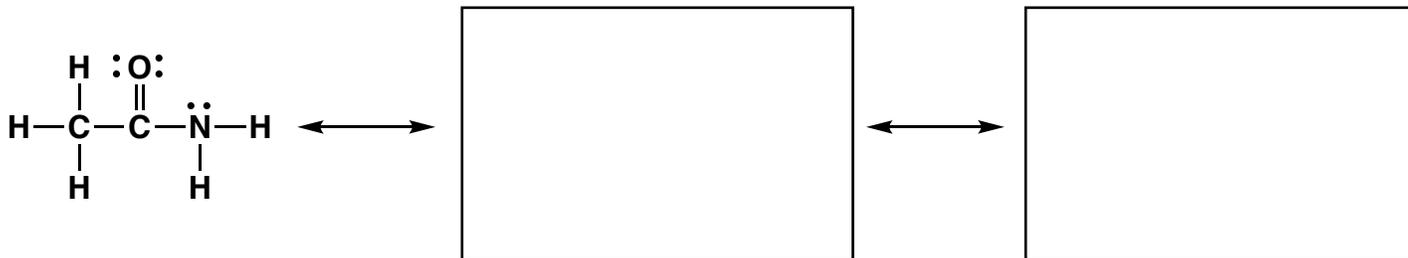
Compound		pK _a
Hydrochloric acid	H-Cl	-7
Protonated alcohol	$\text{RCH}_2\text{OH}_2^+$	-2
Hydronium ion	H_3O^+	-1.7
Carboxylic acids	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	3-5
Thiols	RCH_2SH	8-9
Ammonium ion	H_4N^+	9.2
β-Dicarbonyls	$\text{RC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{R}'$	10
Primary ammonium	$\text{H}_3\text{N}^+\text{CH}_2\text{CH}_3$	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?

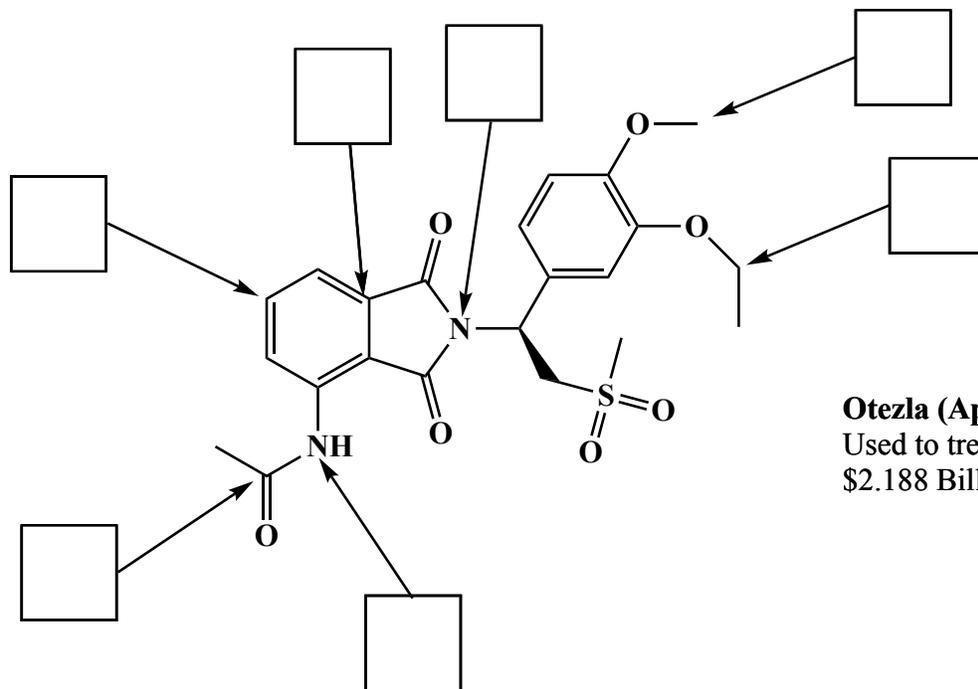
2. (1 pt each) Fill in each blank with the word that best completes the sentences. Yep, this is the MRI paragraph!

The popular medical 1. _____ technique of 2. _____
 3. _____ 4. _____ (_____) is based on the same principles
 as 5. _____, namely the 6. _____ (i.e. resonance) of 7. _____
 spins of H atoms by radio 8. _____ 9. _____ when a patient is
 placed in a strong magnetic field. Magnetic field 10. _____ are used to
 gain imaging information, and 11. _____ of the 12. _____ around the
 center of the object gives imaging in an entire 13. _____ (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. _____ and 15. _____, 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.

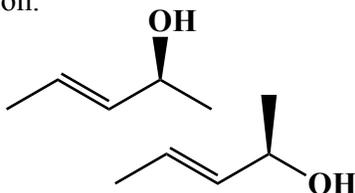


4. (1 pt each) In the boxes provided, write the hybridization state of the atoms indicated by the arrow.

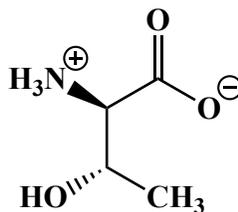


Otezla (Apremilast)
Used to treat plaque psoriasis
\$2.188 Billion in sales 2023

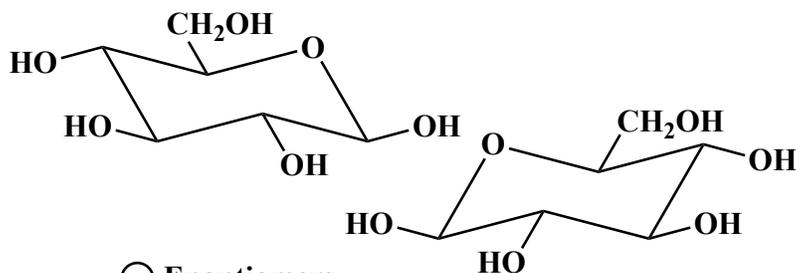
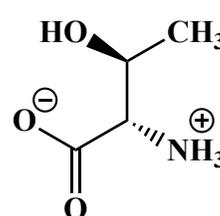
5. (3 pts each) Fill in the circle to identify the stereochemical relationship between each pair of molecules. Hint: You might want to determine *R* or *S* for each chiral center to help you answer the question.



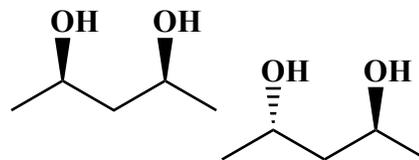
- Enantiomers
 Diastereomers
 Same Molecule



- Enantiomers
 Diastereomers
 Same Molecule

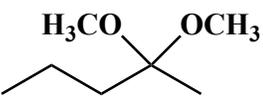
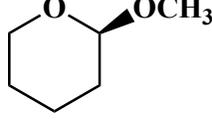
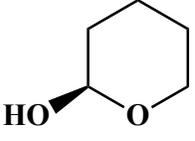
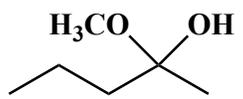
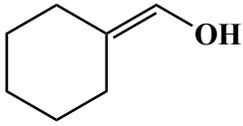


- Enantiomers
 Diastereomers
 Same Molecule

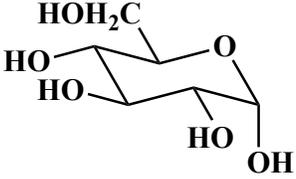
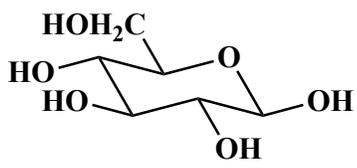


- Enantiomers
 Diastereomers
 Same Molecule

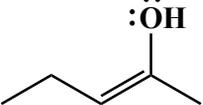
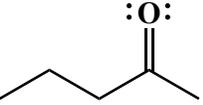
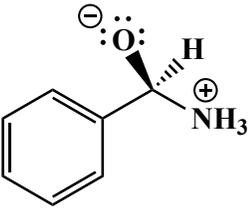
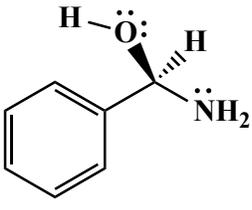
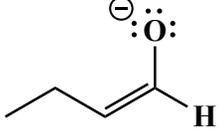
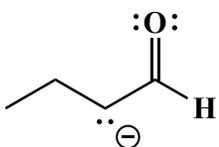
6. (2 pt each) Fill in each circle to indicate the appropriate name for the functional group in the following molecules and **then indicate whether or not the last species is the favored species at equilibrium.**

				
<input type="radio"/> Enol	<input type="radio"/> Enol	<input type="radio"/> Enol	<input type="radio"/> Enol	<input type="radio"/> Enol
<input type="radio"/> Hemiacetal or Cyclic hemiacetal	<input type="radio"/> Hemiacetal or Cyclic hemiacetal			
<input type="radio"/> Acetal or Cyclic acetal	<input type="radio"/> Acetal or Cyclic acetal			
				<input type="radio"/> Favored at equilibrium
				<input type="radio"/> Not favored at equilibrium

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

	
<input type="radio"/> alpha(α) - D - Glucose	<input type="radio"/> alpha(α) - D - Glucose
<input type="radio"/> beta(β) - D - Glucose	<input type="radio"/> beta(β) - D - Glucose

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

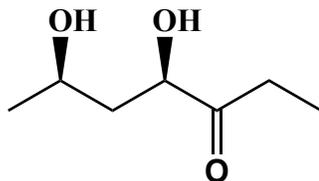
	\rightleftharpoons		<input type="radio"/> Contributing Structures
			<input type="radio"/> Keto-Enol Tautomerization
			<input type="radio"/> Proton Transfer
	\rightleftharpoons		<input type="radio"/> Contributing Structures
			<input type="radio"/> Keto-Enol Tautomerization
			<input type="radio"/> Proton Transfer
	\rightleftharpoons		<input type="radio"/> Contributing Structures
			<input type="radio"/> Keto-Enol Tautomerization
			<input type="radio"/> Proton Transfer

Signature _____

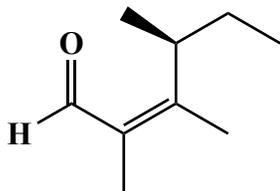
Pg 4 _____(12)

9. (4 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.

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



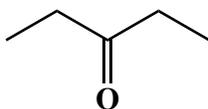
10. (14 pts) Being able to recognize the chemical personality of different species is one of the most important skills you can develop in Organic Chemistry. Fill in the appropriate circle to indicate whether each structure would participate as a nucleophile or electrophile in the mechanisms we have seen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

10.1



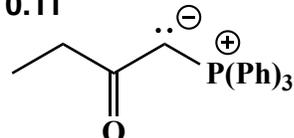
- Electrophile
 Nucleophile

10.6



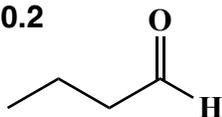
- Electrophile
 Nucleophile

10.11



- Electrophile
 Nucleophile

10.2



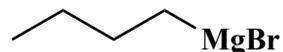
- Electrophile
 Nucleophile

10.7



- Electrophile
 Nucleophile

10.12



- Electrophile
 Nucleophile

10.3



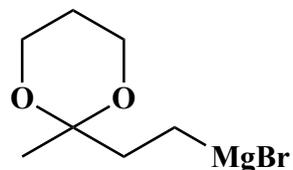
- Electrophile
 Nucleophile

10.8



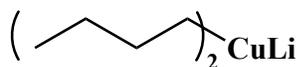
- Electrophile
 Nucleophile

10.13



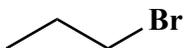
- Electrophile
 Nucleophile

10.4



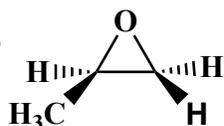
- Electrophile
 Nucleophile

10.9



- Electrophile
 Nucleophile

10.5



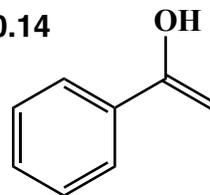
- Electrophile
 Nucleophile

10.10



- Electrophile
 Nucleophile

10.14



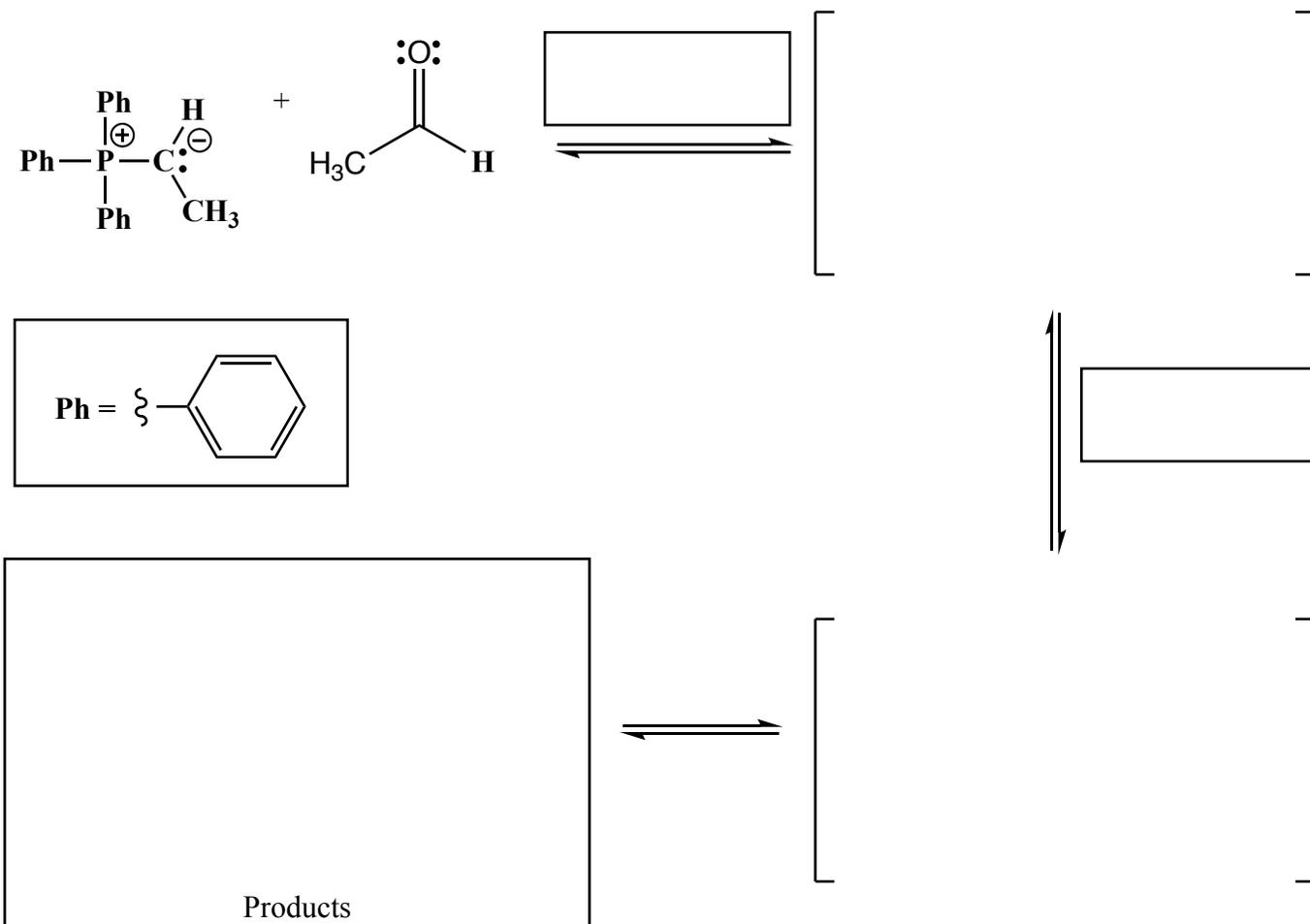
- Electrophile
 Nucleophile

Signature _____

Pg 6 _____(17)

11. (17 pts) For this Wittig 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 FINAL “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.).

Wittig Reaction with an Aldehyde



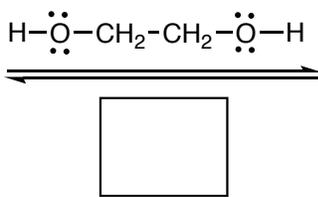
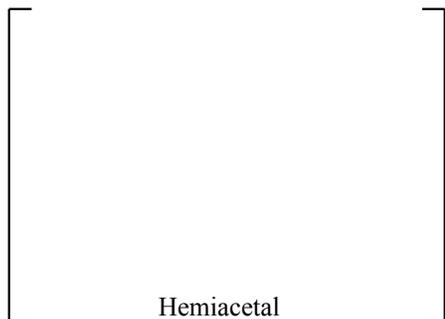
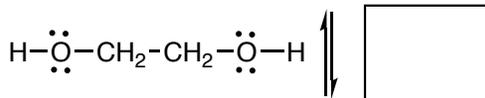
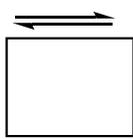
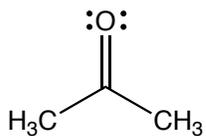
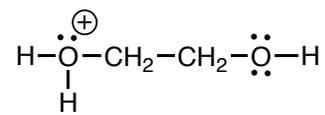
Signature _____

Pg 7 _____(-)

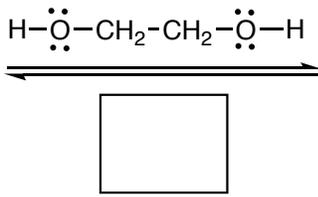
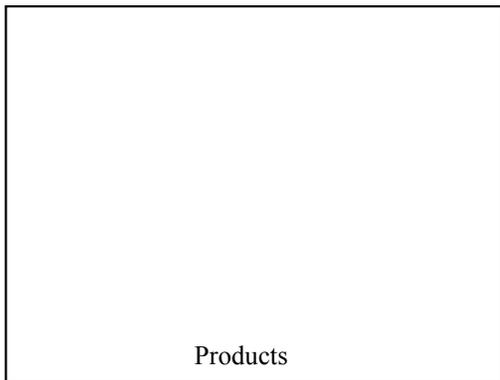
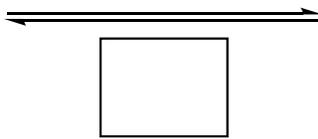
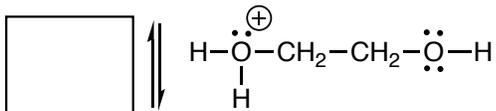
12. (45 pts) For the cyclic acetal reaction mechanism ON THE NEXT PAGE, use arrows to indicate movement of all electrons, write all lone pairs, all formal charges, and all the products for each step. Remember, I said all the products for each step. IF A NEW CHIRAL CENTER IS CREATED IN AN INTERMEDIATE, 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.).

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!

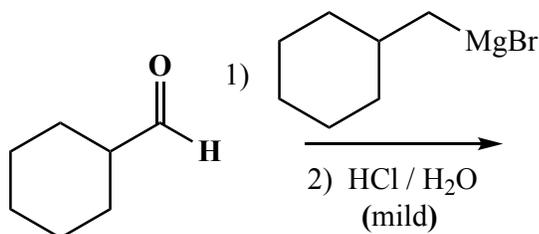
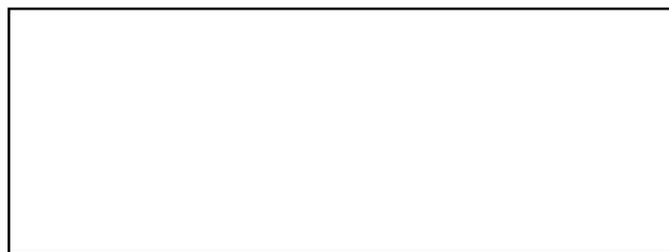
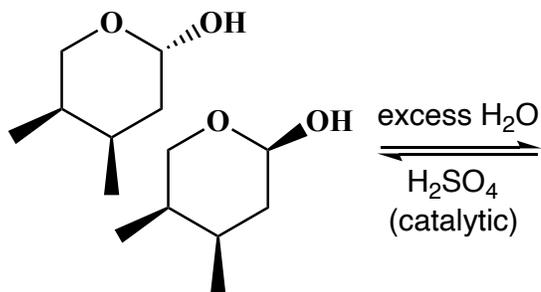
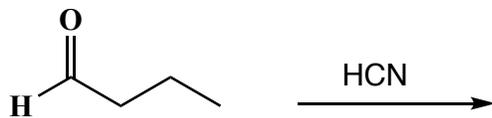
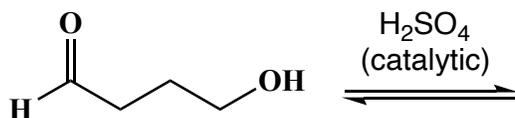
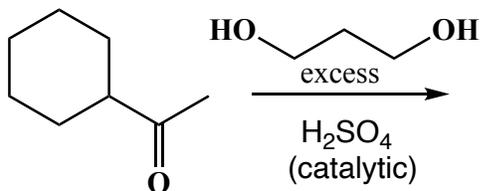
Note: For intermediates that I drew as two contributing structures in class, you only need to draw one contributing structure. Either one will be correct. Just make sure your arrows are accurate for the contributing structure you draw.



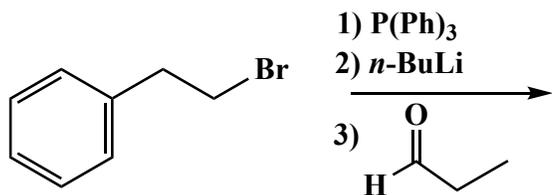
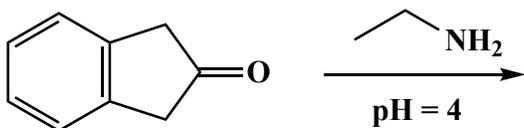
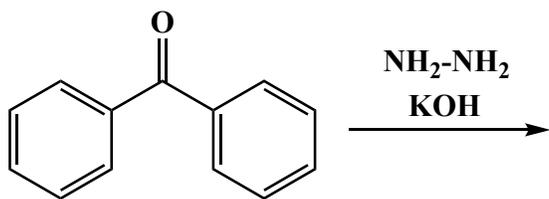
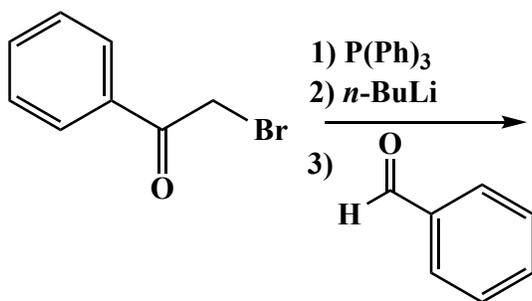
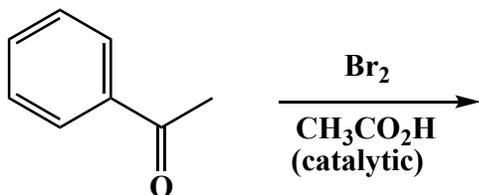
Hemiacetal



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.



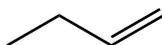
13. (cont.) (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges () and dashes () to indicate stereochemistry.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



Signature _____

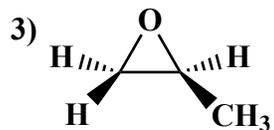
Pg 12 _____(10)

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.



1) HBr / ROOR
 $h\nu$ or heat

2) $\text{Mg}^\circ / \text{ether}$



4) $\text{HCl} / \text{H}_2\text{O}$

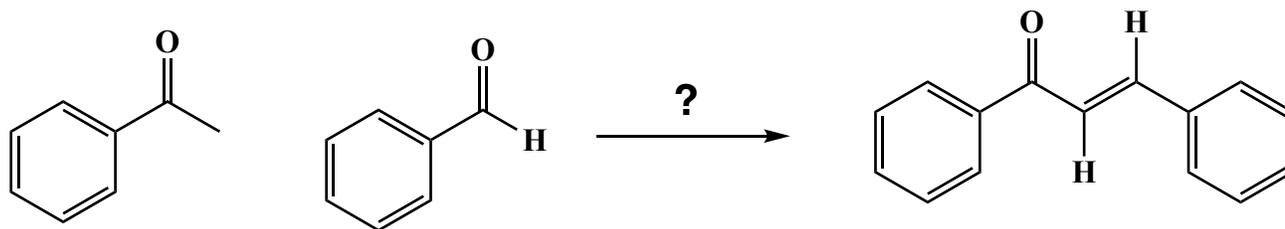
5) H_2CrO_4

6) $\text{H}_2\text{C}^\ominus - \text{P}^\oplus(\text{Ph})_3$



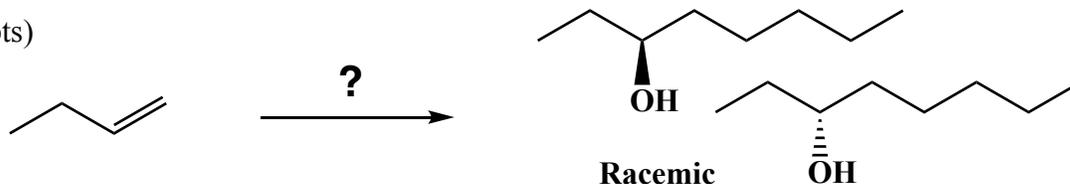
15. These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule synthesized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



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)

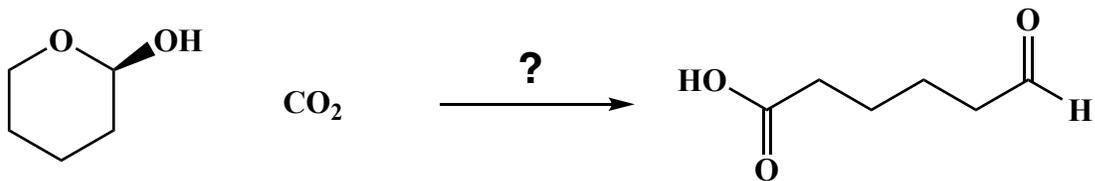


Signature _____

Pg 15 _____ (16)

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)



Signature _____

Pg 16 _____(8)

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

- Propanal Butanal Pentanal Hexanal

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-3,3-dimethylpentane