

MTW5: 2-13

2023年2月13日 17:07



Sp23 1st Midterm-2-8

NAME (Print): _____

EID _____

SIGNATURE: _____

Chemistry 320N
1st Midterm Exam
February 9, 2023

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

"As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity."

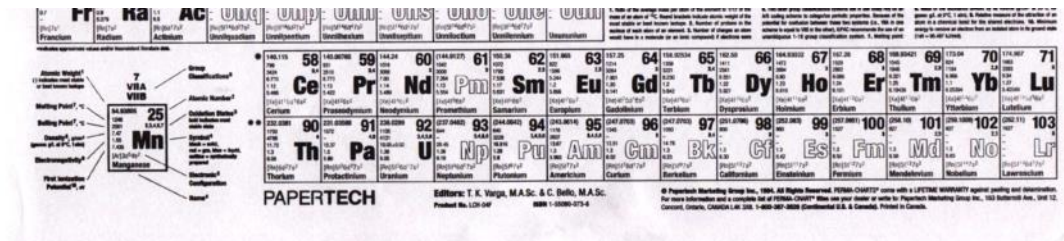
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PERIODIC TABLE OF THE ELEMENTS

Elementary Subatomic Particles										Ionic Character of a Single Chemical Bond									
Electron	Proton	Neutron	Positron	Alpha	Beta	Gamma	Neutrino	Antineutrino	Photon	Electron	Proton	Neutron	Positron	Alpha	Beta	Gamma	Neutrino	Antineutrino	Photon
1.674927 × 10 ⁻²⁷ kg	1.672621 × 10 ⁻²⁷ kg	1.674927 × 10 ⁻²⁷ kg	1.672621 × 10 ⁻²⁷ kg	4.001506 × 10 ⁻²⁷ kg	9.109382 × 10 ⁻³¹ kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.602176 × 10 ⁻¹⁹ C	1.602176 × 10 ⁻¹⁹ C	0	1.602176 × 10 ⁻¹⁹ C	3.203352 × 10 ⁻¹⁹ C	1.602176 × 10 ⁻¹⁹ C	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1.674927 × 10 ⁻²⁷ kg	1.672621 × 10 ⁻²⁷ kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ionic Character of a Single Chemical Bond									
Electron	Proton	Neutron	Positron	Alpha	Beta	Gamma	Neutrino	Antineutrino	Photon
1.674927 × 10 ⁻²⁷ kg	1.672621 × 10 ⁻²⁷ kg	1.674927 × 10 ⁻²⁷ kg	1.672621 × 10 ⁻²⁷ kg	4.001506 × 10 ⁻²⁷ kg	9.109382 × 10 ⁻³¹ kg	0	0	0	0
1.602176 × 10 ⁻¹⁹ C	1.602176 × 10 ⁻¹⁹ C	0	1.602176 × 10 ⁻¹⁹ C	3.203352 × 10 ⁻¹⁹ C	1.602176 × 10 ⁻¹⁹ C	0	0	0	0
0	0	1.674927 × 10 ⁻²⁷ kg	1.672621 × 10 ⁻²⁷ kg	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Periodic Table of the Elements																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA	VIIIA	VIIIA	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIII
1 H 1.00794	2 He 4.002602	3 Li 6.941	4 Be 9.012182	5 B 10.811	6 C 12.0107	7 N 14.00643	8 O 15.9994	9 F 18.998403	10 Ne 20.1797	11 Na 22.989769	12 Mg 24.30409	13 Al 26.981538	14 Si 28.08558	15 P 30.973762	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955912	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938044	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.630	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90584	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc 98.90625	44 Ru 101.07	45 Rh 101.07	46 Pd 106.36	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.6	53 I 126.90548	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.90471	58 Ce 140.12	59 Pr 140.90765	60 Nd 144.242	61 Pm 144.9126	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.5001	67 Ho 164.93032	68 Er 167.259	69 Tm 168.93032	70 Yb 173.054	71 Lu 174.967	
87 Fr [223]	88 Ra [226]	89 Ac [227]	90 Th [232]	91 Pa [231]	92 U [238]	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [260]	



Compound

pK_a

Hydrochloric acid	H-Cl	-7
Protonated alcohol	$\text{RCH}_2\text{O}^+\text{H}_2$	-2
Hydronium ion	H_3O^+	-1.7
Carboxylic acids	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	3-5
Thiols	$\text{RCH}_2\text{S}^+\text{H}$	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	HO^+H	15.7
Alcohols	$\text{RCH}_2\text{O}^+\text{H}$	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

Ketones	$\text{RCH}_2\text{-}\overset{\text{O}}{\parallel}\text{CR}'$	18-20
Esters	$\text{RCH}_2\text{-}\overset{\text{O}}{\parallel}\text{COR}'$	23-25
Terminal alkynes	$\text{RC}\equiv\text{C-H}$	25
LDA	$\text{H-N}(i\text{-C}_3\text{H}_7)_2$	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

Signature _____

Pg 1 _____ (25)

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

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

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

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

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

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

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

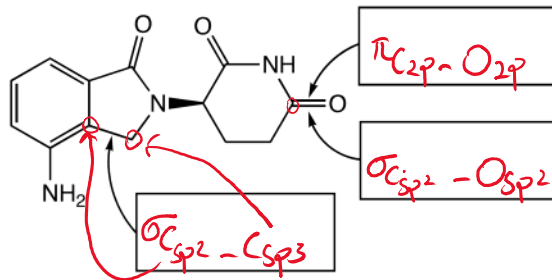
are used to gain 10. _____ information, and rotation of the

7. _____ 8. _____ . Magnetic field 9. _____
 are used to gain 10. _____ information, and rotation of the
 11. _____ around the center of the object gives imaging in an entire plane (i.e.
 12. _____ inside patient). In an MRI image, you are looking at individual
 13. _____ that when 14. _____ make up the three-
 dimensional image of 15. _____ amounts of 16. _____ atoms,
 especially the 17. _____ atoms from 18. _____ and
 19. _____, in the different 20. _____.

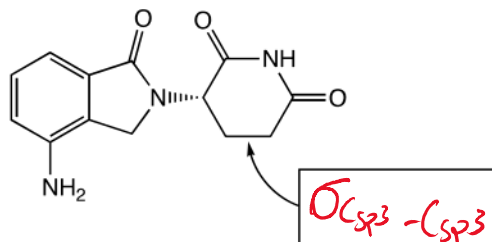
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Pg 2 _____ (13)

3. (2 pts each) In the spaces provided, indicate the type of bond, and the hybridized orbitals that overlap to form the bond. For example, one answer could be: σ_{Csp^3-H1s}



Note: for the multiple bonds, you can put the orbitals in any order, you just need to describe all the bonds.



Revlimid (sold as a racemic mixture)

Company: Bristol Myers Squibb
 2022 sales: \$9.5 billion

Use: Treats cancers such as multiple myeloma

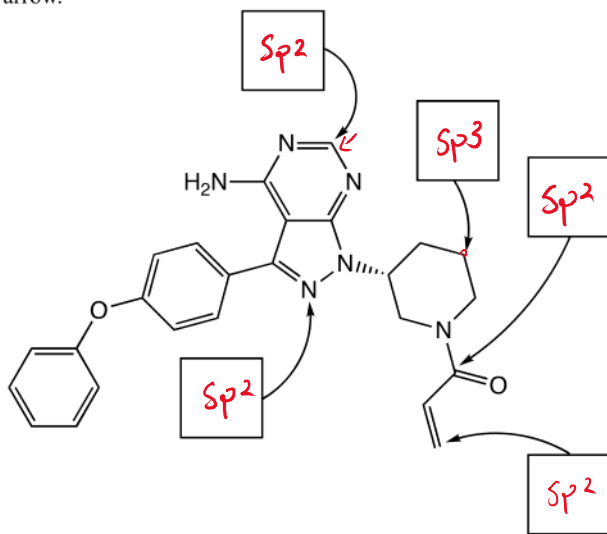
NH₂



2022 sales: \$9.5 billion

Use: Treats cancers such as multiple myeloma

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



Imbruvica

Comanics AbbVie, Johnson & Johnson

2021 sales: \$9.8 billion

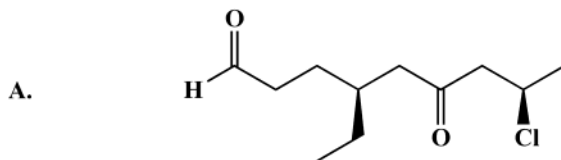
Use: Mantle cell lymphoma, chronic lymphocytic leukemia, Waldenstrom's macroglobulinemia, marginal zone lymphoma, chronic graft-versus-host disease

Diseases: Nonvalvular atrial fibrillation, deep vein thrombosis and pulmonary embolism

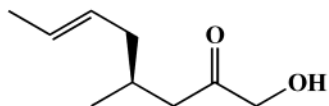
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Pg 3 _____ (18)

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



B.



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

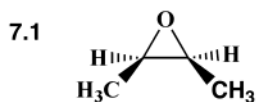
(4S,5S,6R)-4,5,6-trimethyl-8-oxononanal



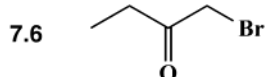
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Pg 4 _____ (17)

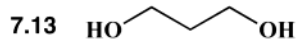
7. (17 pts) Being able to recognize the chemical personality of different species is one of the most important skills you can develop in Organic Chemistry. Fill in the appropriate circle to indicate whether each structure is a nucleophile or electrophile. Note that these species might be acids or bases in certain situations, but we will ignore that for this problem.



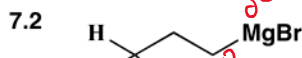
Electrophile
 Nucleophile



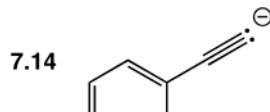
Electrophile
 Nucleophile

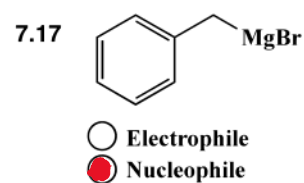
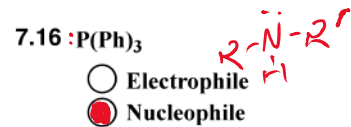
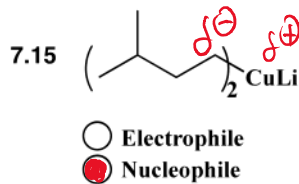
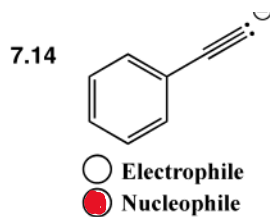
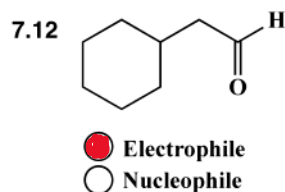
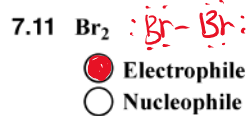
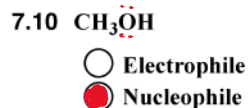
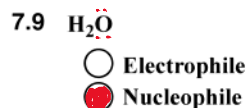
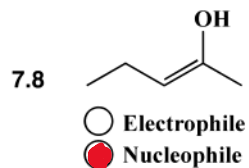
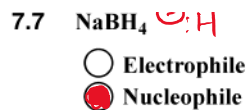
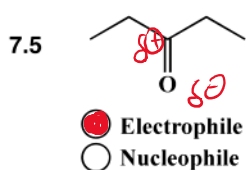
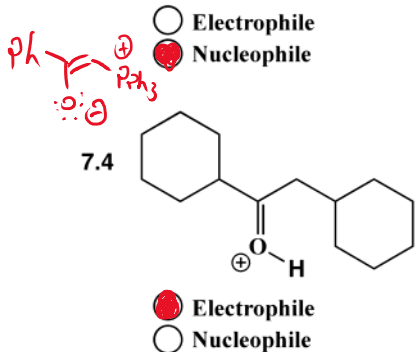
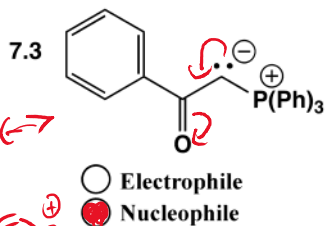
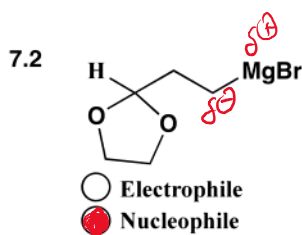


Electrophile
 Nucleophile



7.7
 Electrophile
 Nucleophile

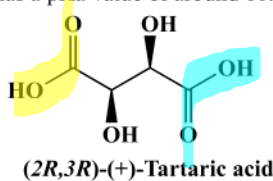




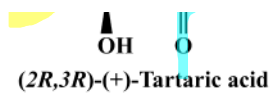
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Pg 5 _____ (12)

8. (4 pts each) (2R,3R)-(+)-Tartaric acid is found in wine. The two carboxylic acid groups have slightly different pKa values as listed below. The small difference makes sense because after the first carboxylic acid is deprotonated, that carboxylate slightly raises the pKa of the second carboxylic acid in the molecule. Recall that an alcohol has a pKa value of around 16.



$\text{pH} > \text{pKa} \rightarrow$ acid is deprotonated
 $\text{pH} < \text{pKa} \rightarrow$ protonated



pH > pKa

either deprotonate H⁺ → deprotonate the second H⁺, to make the di-anion

At neutral pH = 7.0, fill in the circle under the structure that is the predominant form of (2R,3R)-(+)-Tartaric acid.

7.0 > 4.4 > 2.98

<input checked="" type="radio"/> Predominant form at pH = 7.0	<input type="radio"/> Predominant form at pH = 7.0	<input type="radio"/> Predominant form at pH = 7.0

The pH of wine is below neutral and considered acidic, usually in the pH = 3-4 range. Fill in the circle under the structure that is the predominant form of (2R,3R)-(+)-Tartaric acid if the pH of the wine is exactly pH = 3.5

4.4 > 3.5 > 2.98

<input type="radio"/> Predominant form at pH = 3.5	<input checked="" type="radio"/> Predominant form at pH = 3.5	<input type="radio"/> Predominant form at pH = 3.5

At a highly acidic pH = 2.0, fill in the circle under the structure that is the predominant form of (2R,3R)-(+)-Tartaric acid.

4.4 > 2.98 > 2.0

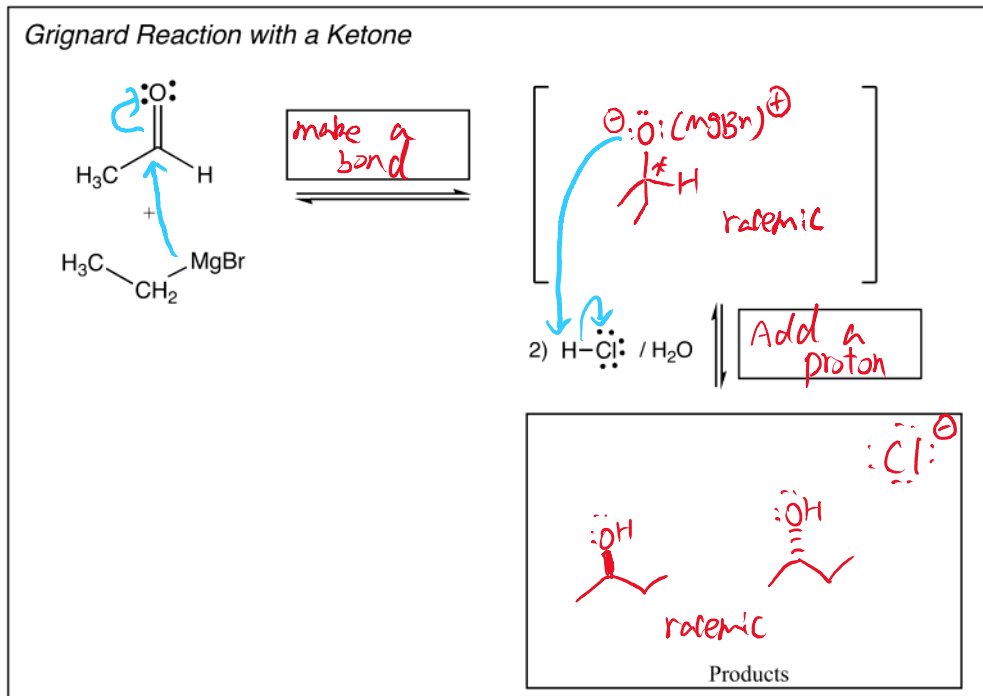
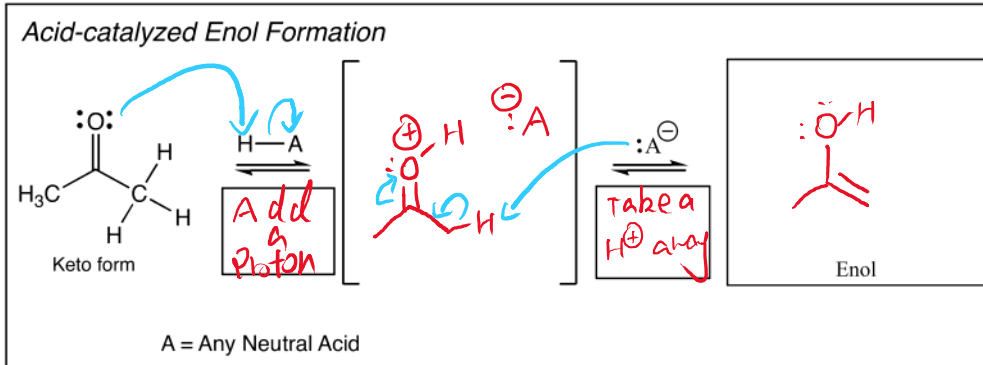
<input type="radio"/> Predominant form at pH = 2.0	<input type="radio"/> Predominant form at pH = 2.0	<input checked="" type="radio"/> Predominant form at pH = 2.0

Signature _____

Pg 6 _____ (32)

9. (32 pts) For these two reactions, 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.).

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.).

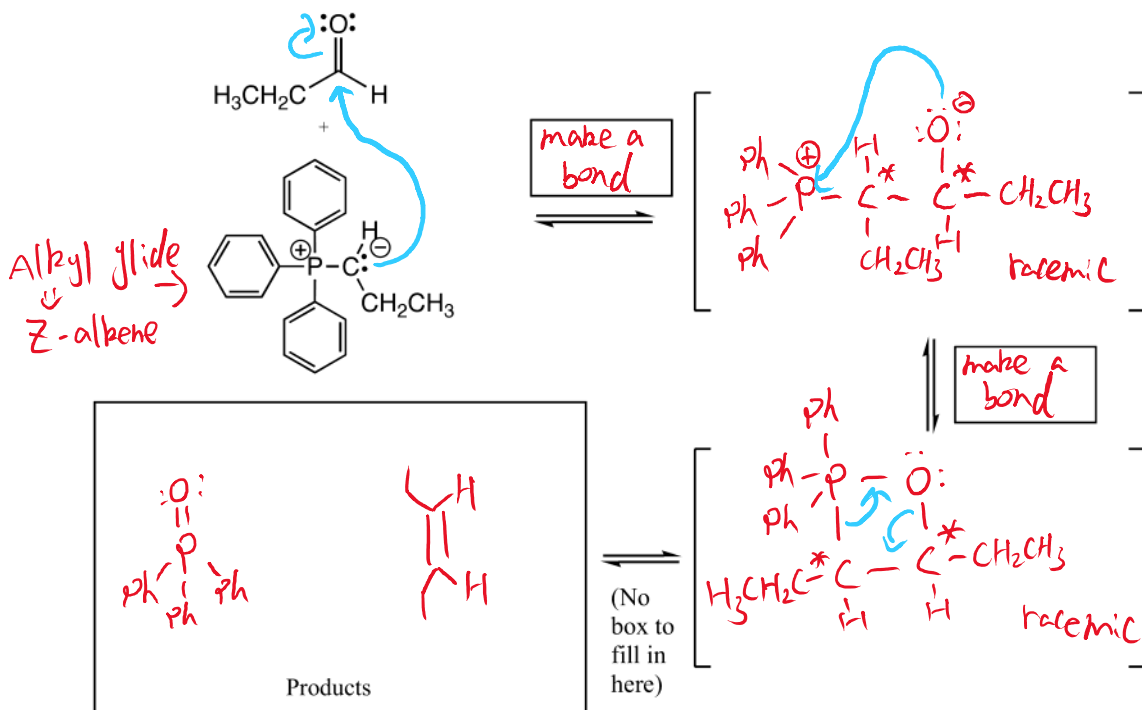


Signature _____

Pg 7 _____ (21)

10. (21 pts) For the following Wittig reaction, use **arrows to indicate movement of all electrons**, write all

10. (21 pts) For the following 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 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.).



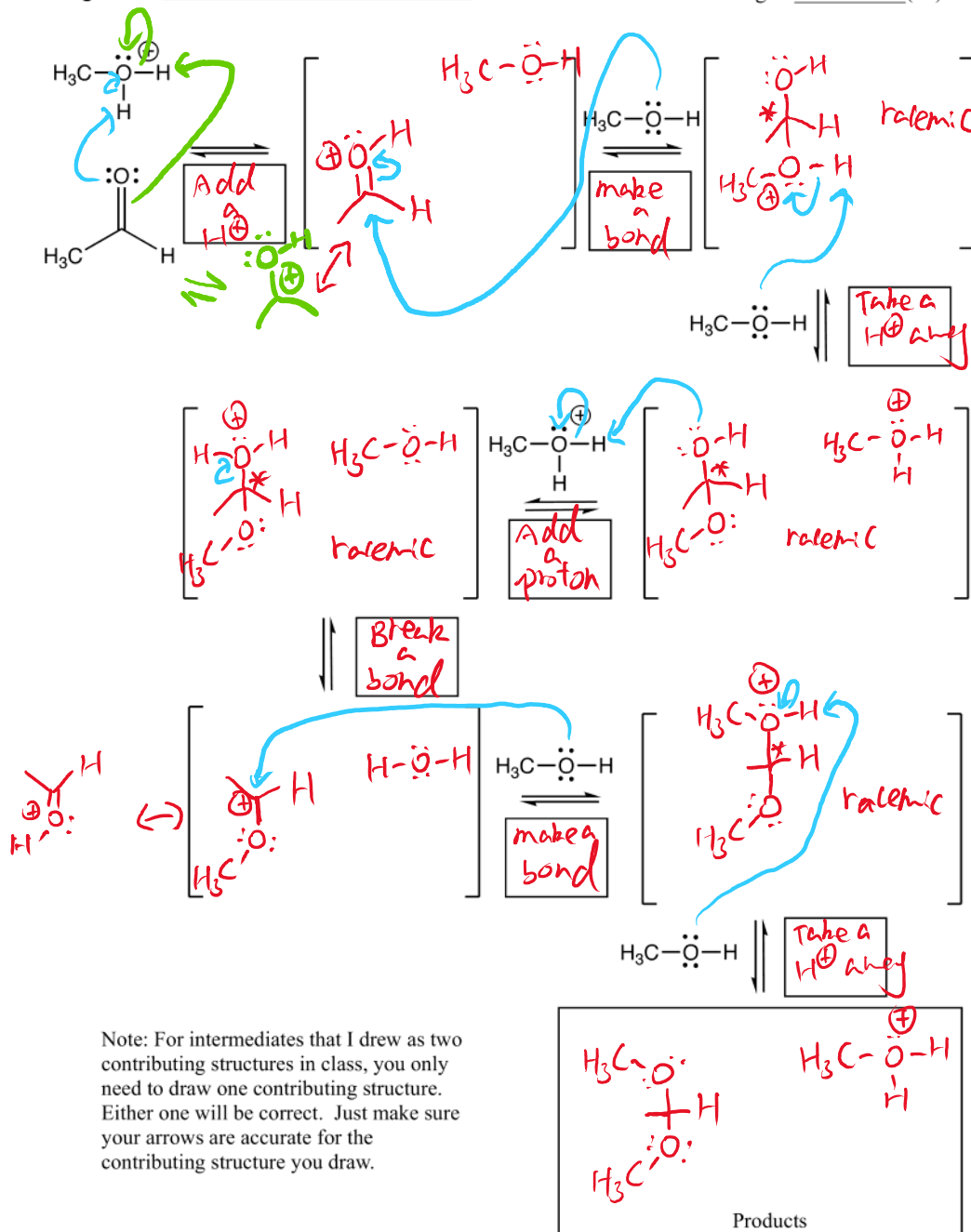
Signature _____

Pg 8

11. (54 pts) For the acetal formation mechanism on the following 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.). I put this on its own page so you have more room to draw the structures.

Signature _____

Pg 9 _____ (54)

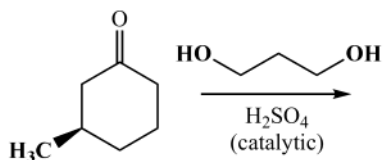
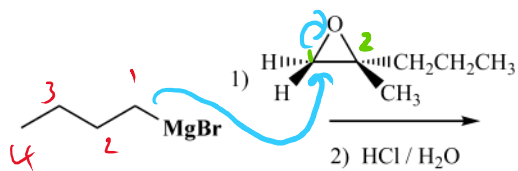
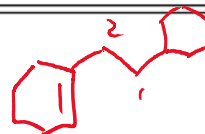
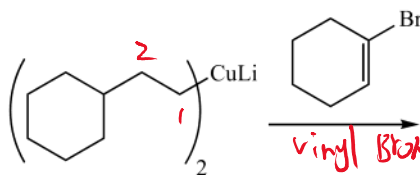
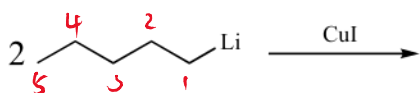
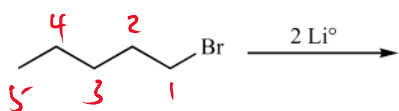
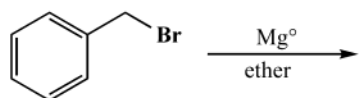


Note: For intermediates that I drew as two contributing structures in class, you only need to draw one contributing structure. Either one will be correct. Just make sure your arrows are accurate for the contributing structure you draw.

Signature _____

Pg 10 _____ (18)

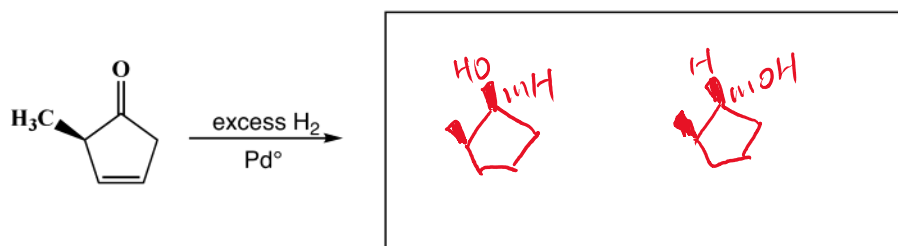
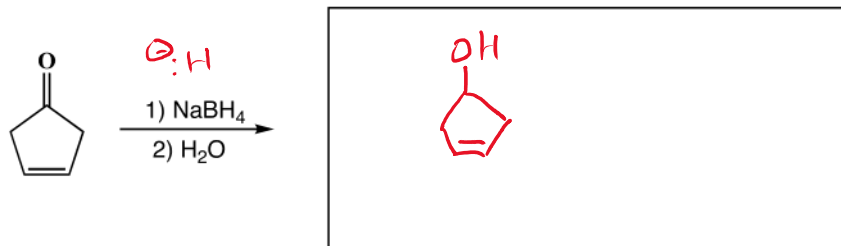
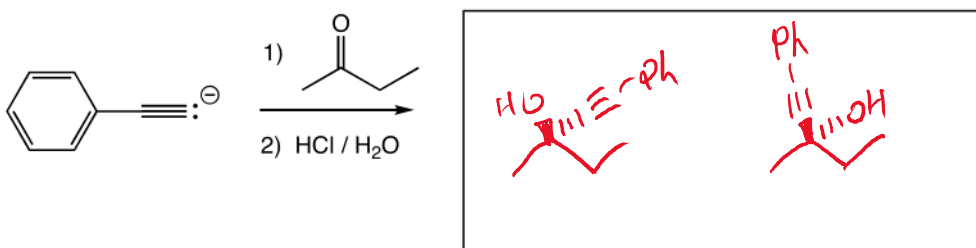
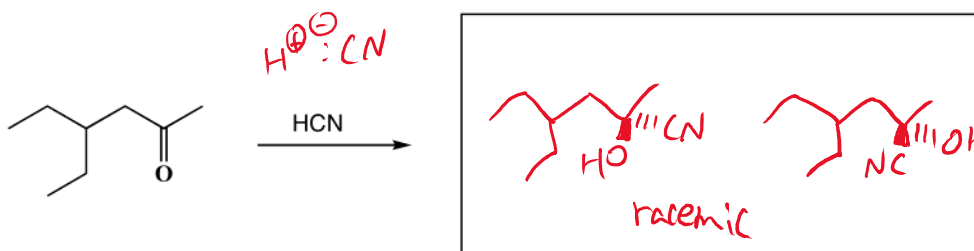
12. (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangleleft) and dashes (\dashv) to indicate 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.



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Pg 11 _____ (17)

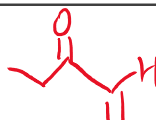
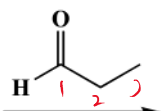
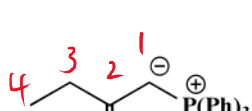
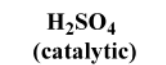
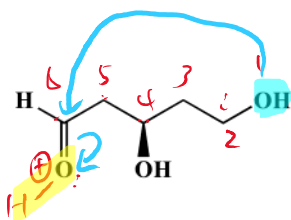
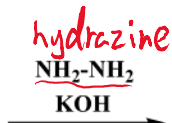
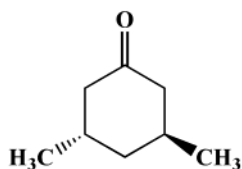
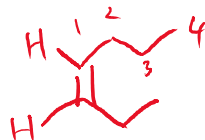
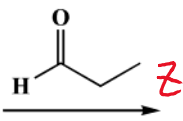
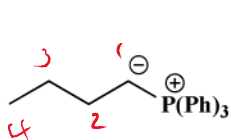
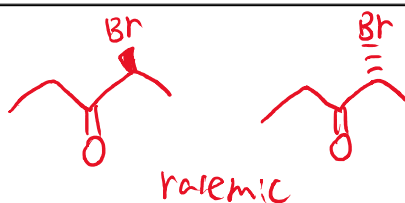
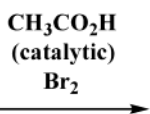
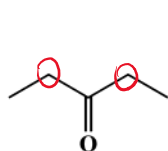
12. (cont.) (3, 4 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangleleft) and dashes (\dashv)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

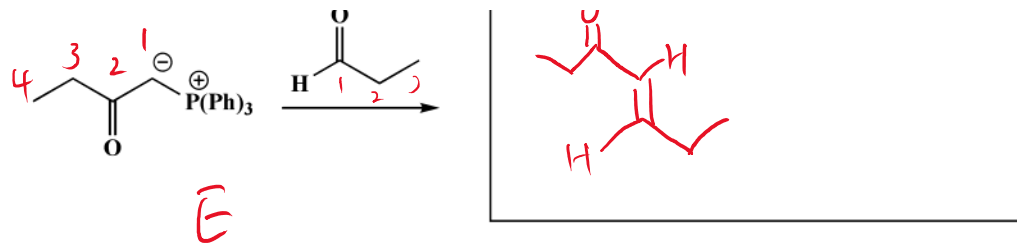


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Pg 12 _____ (19)

12. (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 (\dashv) 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.

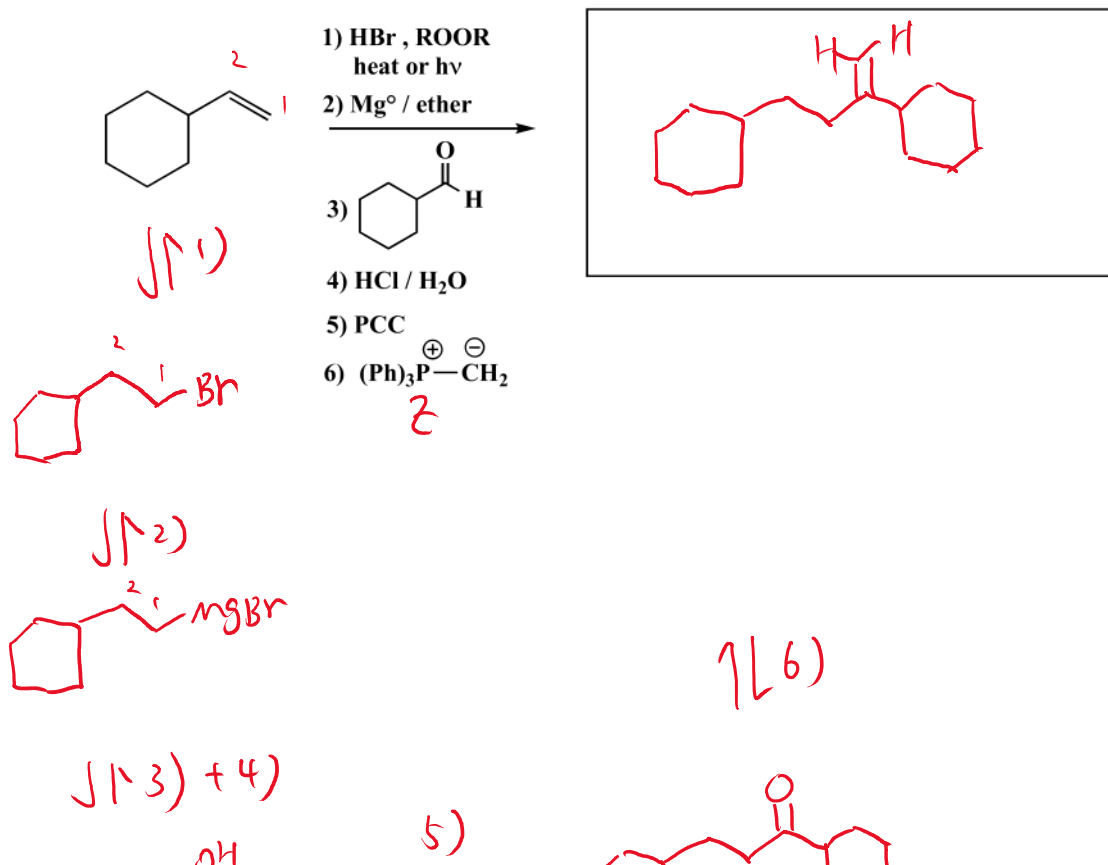


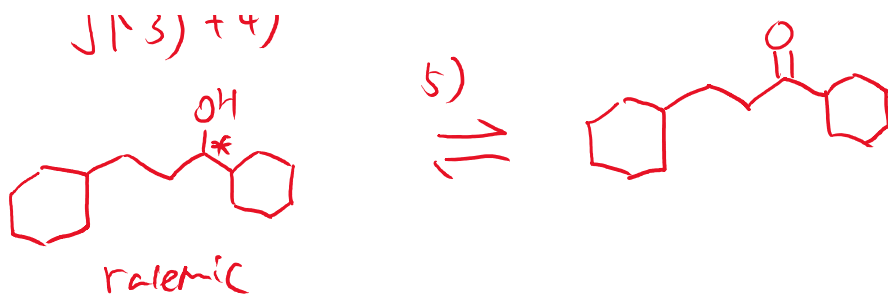


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Pg 13 _____ (12)

13. (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.

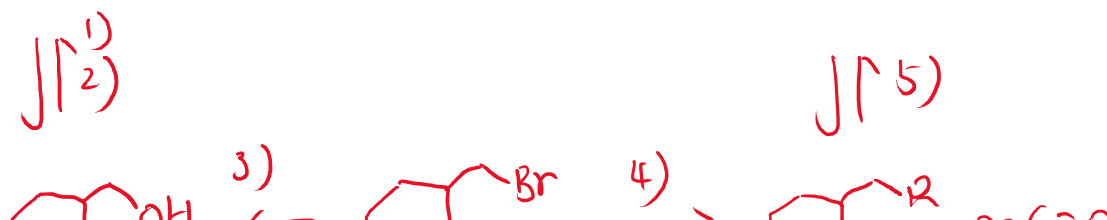
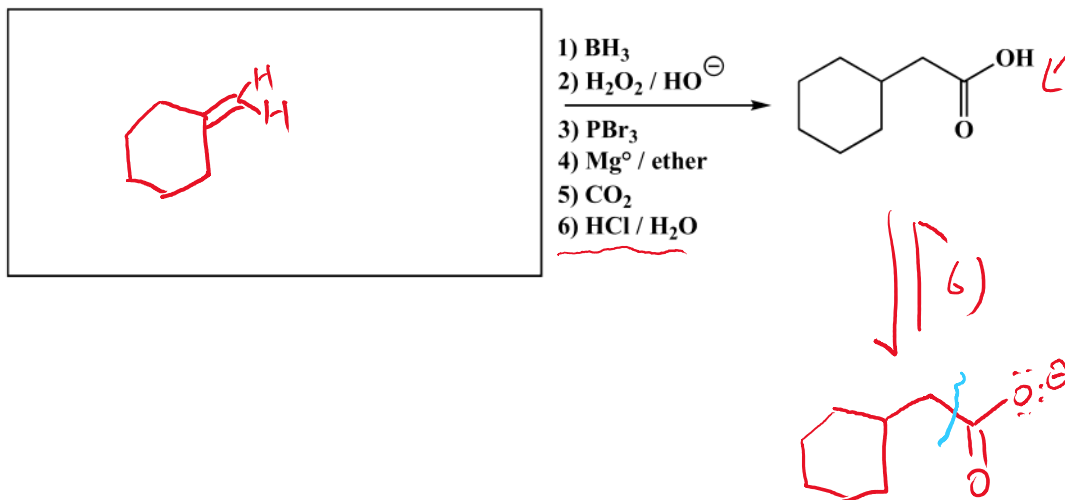


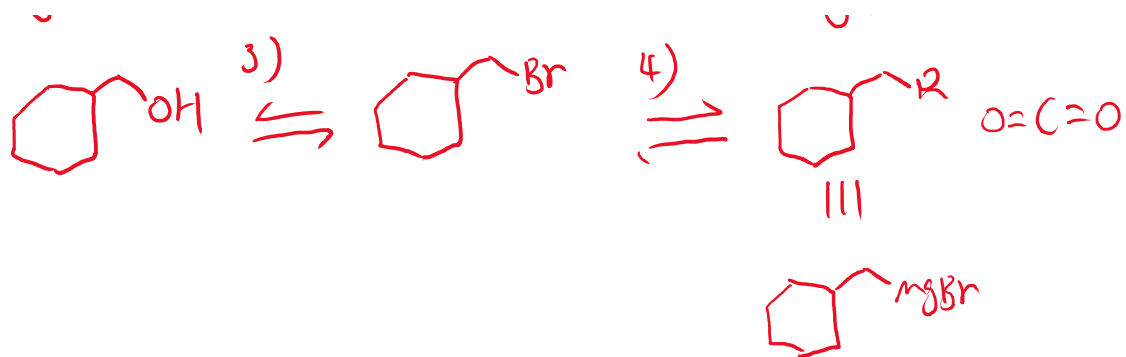


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Pg 14 _____ (12)

14. (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.**

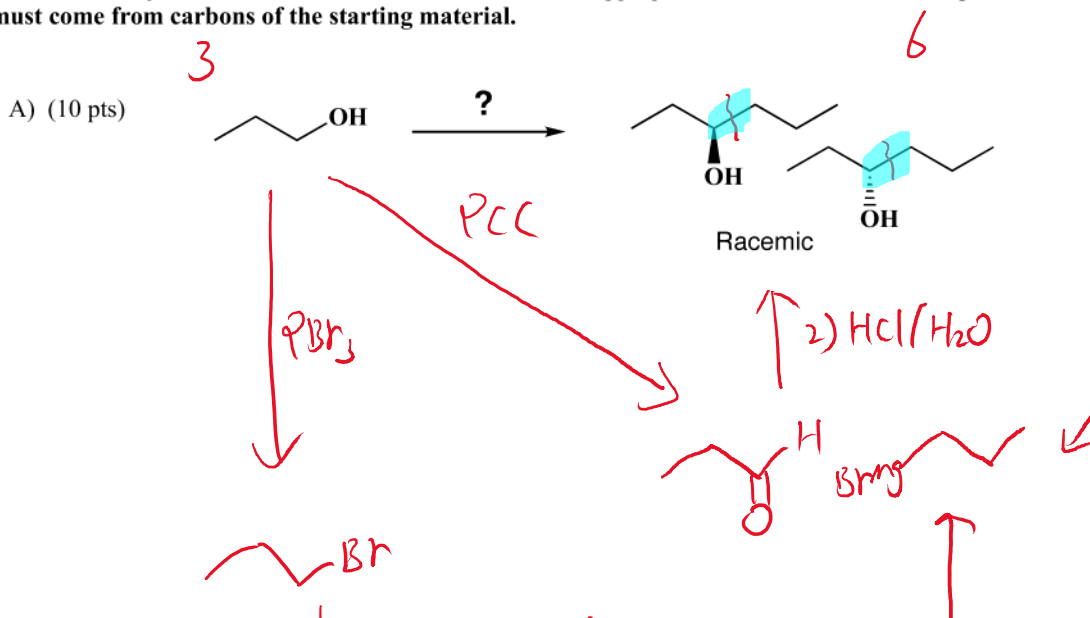




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Pg 15 _____ (10)

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.**

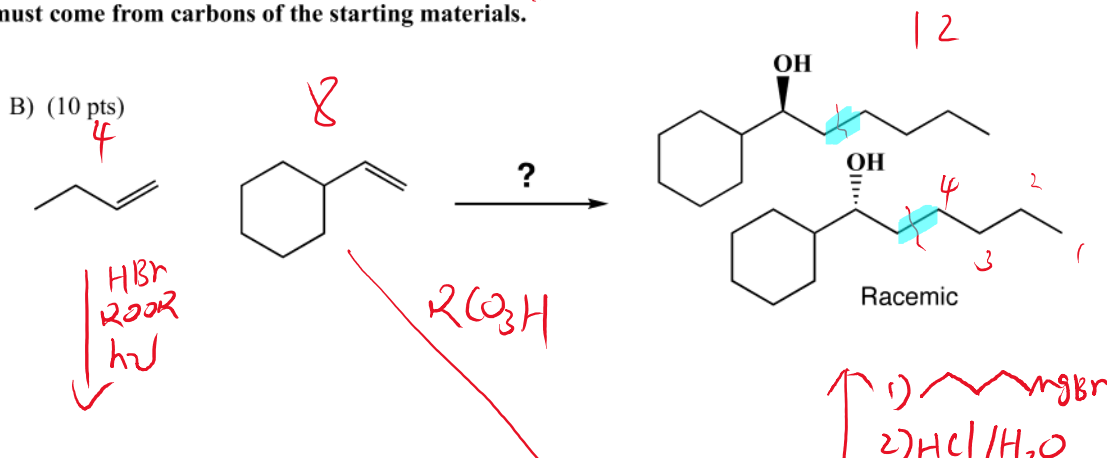


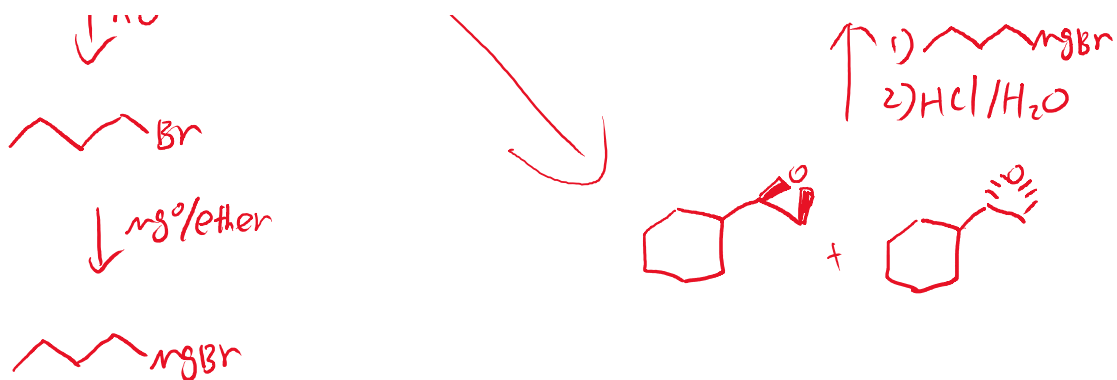


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Pg 16 _____ (10)

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 materials.**



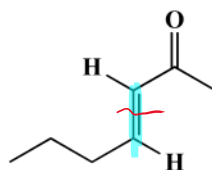
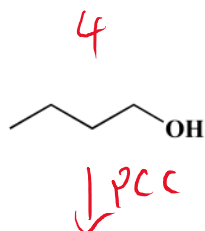
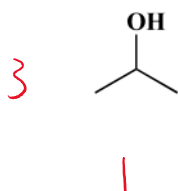


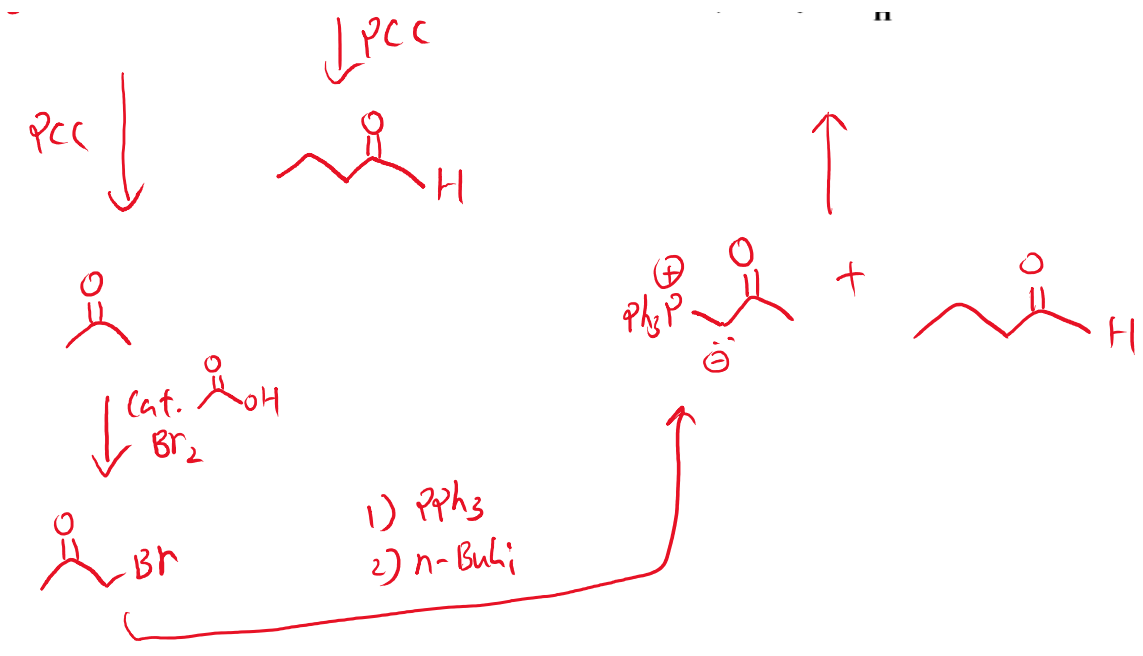
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Pg 17 _____ (13)

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.**

C) (13 pts)

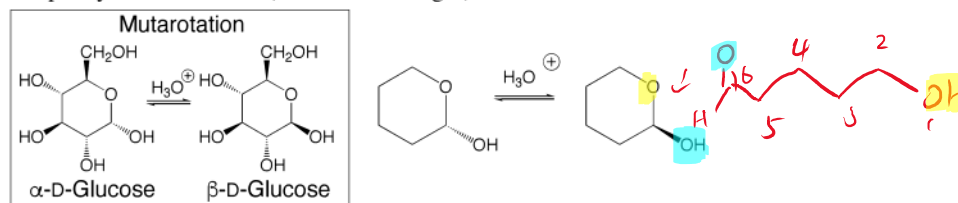




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Pg 18 _____ (24)

16. (24 pts) Here is an "Apply What you Know" Problem. You have not seen this directly, but based on what you know you CAN figure it out. We talked about the process called "mutarotation" in which alpha-D-glucose equilibrates with beta-D-glucose. The process emphasizes the reversible nature of cyclic hemiacetal formation. Shown below is mutarotation of D-Glucose as well as the analogous cyclic hemiacetal equilibration on the structurally most simple cyclic hemiacetal (shown on the right).



Recall that reversible reaction mechanisms involve the exact same intermediates in both directions, use what you know about hemiacetal formation to fill in the mechanism sheet below to complete the mechanism for



Recall that reversible reaction mechanisms involve the exact same intermediates in both directions, use what you know about hemiacetal formation to fill in the mechanism sheet below to complete the mechanism for how acid can catalyze the equilibration between cyclic hemiacetals.

