

NAME (Print): _____

Chemistry 320N
1st Midterm Exam
February 13, 2025

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

Symbol	Electron	Proton	Neutron	Photon
Rest mass (kg)	9.10938291 × 10 ⁻³¹	1.67262161 × 10 ⁻²⁷	1.67492716 × 10 ⁻²⁷	0
Rest mass (MeV/c ²)	0.5109989461	938.27208816	939.565366	0
Relative electric charge (e)	-1	+1	0	0
Relative magnetic moment (e)	-1.8361199 × 10 ⁻¹⁸	1.8361199 × 10 ⁻¹⁸	1.8361199 × 10 ⁻¹⁸	0
Spin quantum number (h)	1/2	1/2	1/2	0
Compton wavelength (m)	2.426310238 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	∞
Compton wavelength (fm)	2.426310238 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	∞
Compton wavelength (fm)	2.426310238 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	∞
Compton wavelength (fm)	2.426310238 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	∞
Compton wavelength (fm)	2.426310238 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	1.321409876 × 10 ⁻¹²	∞

% Ionic Character of a Single Chemical Bond

1 IA																		2 IIA										3 IIIA										4 IVA										5 VA										6 VIA										7 VIIA										8 VIIIA										9 VIIIA										10 VIIIA										11 IB										12 IIB										13 IIIA										14 IVA										15 VA										16 VIA										17 VIIA										18 VIIIA																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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1.00794	4.002602	6.941	9.01224	10.811	12.0107	14.00307	15.999	18.9984	20.1797	22.98976928	24.30409	26.9815386	28.0855	30.973762	32.06	34.96885268	36.4609	39.0983	39.948	40.078	44.9559376	47.88	50.9415	52.0042	55.93493649	58.933200	60.9310	62.9296713	64.9274	68.94588	70.92314189	72.9431529	75.90938	78.9064848	80.90444	83.90484	86.90888092	88.90584	90.90733	92.90638	95.94	97.906287	100.906325	102.90550	105.90732	107.8672	108.9062500	110.904190	112.904153	114.90408	117.904	118.9053	121.757	123.76	126.90509	127.90426	128.90626	132.9050912	132.909473	135.90473	137.603	138.90491	140.90764	142.90377	144.90327	146.90519	148.90519	150.90731	151.90731	153.90949	154.90949	156.90759	157.90759	158.90759	160.90759	161.90759	162.90759	163.90759	164.90759	165.90759	166.90759	167.90759	168.90759	169.90759	170.90759	171.90759	172.90759	173.90759	174.90759	175.90759	176.90759	177.90759	178.90759	179.90759	180.90759	181.90759	182.90759	183.90759	184.90759	185.90759	186.90759	187.90759	188.90759	189.90759	190.90759	191.90759	192.90759	193.90759	194.90759	195.90759	196.90759	197.90759	198.90759	199.90759	200.90759	201.90759	202.90759	203.90759	204.90759	205.90759	206.90759	207.90759	208.90759	209.90759	210.90759	211.90759	212.90759	213.90759	214.90759	215.90759	216.90759	217.90759	218.90759	219.90759	220.90759	221.90759	222.90759	223.90759	224.90759	225.90759	226.90759	227.90759	228.90759	229.90759	230.90759	231.90759	232.90759	233.90759	234.90759	235.90759	236.90759	237.90759	238.90759	239.90759	240.90759	241.90759	242.90759	243.90759	244.90759	245.90759	246.90759	247.90759	248.90759	249.90759	250.90759	251.90759	252.90759	253.90759	254.90759	255.90759	256.90759	257.90759	258.90759	259.90759	260.90759	261.90759	262.90759	263.90759	264.90759	265.90759	266.90759	267.90759	268.90759	269.90759	270.90759	271.90759	272.90759	273.90759	274.90759	275.90759	276.90759	277.90759	278.90759	279.90759	280.90759	281.90759	282.90759	283.90759	284.90759	285.90759	286.90759	287.90759	288.90759	289.90759	290.90759	291.90759	292.90759	293.90759	294.90759	295.90759	296.90759	297.90759	298.90759	299.90759	300.90759																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

Atomic Weights (11) are the most accurate values of best available data.

Atomic Number is the number of protons in the nucleus of an atom.

Group Classification is the number of valence electrons in the outer shell of an atom.

Periodic Law states that the physical and chemical properties of the elements are a periodic function of their atomic number.

Block Classification is based on the subshell being filled: s-block (groups 1 and 2), p-block (groups 13-18), d-block (transition metals, groups 3-10), and f-block (lanthanides and actinides, groups 7 and 8).

Transition Metals are elements in the d-block of the periodic table.

Lanthanides and **Actinides** are elements in the f-block of the periodic table.

Unlabeled Elements (Unq, Unr, Uns, Uno, Une, Uun) are elements that have not yet been discovered or synthesized.

PAPERTECH

Editors: T. K. Varga, M.A.Sc. & C. Bello, M.A.Sc.

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Compound		pK _a
Hydrochloric acid	H-Cl	-7
Protonated alcohol	$\text{RCH}_2\text{OH}_2^{\oplus}$	-2
Hydronium ion	$\text{H}_3\text{O}^{\oplus}$	-1.7
Carboxylic acids	$\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	3-5
Thiols	RCH_2SH	8-9
Ammonium ion	$\text{H}_4\text{N}^{\oplus}$	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	$\text{H}_3\text{N}^{\oplus}\text{CH}_2\text{CH}_3$	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

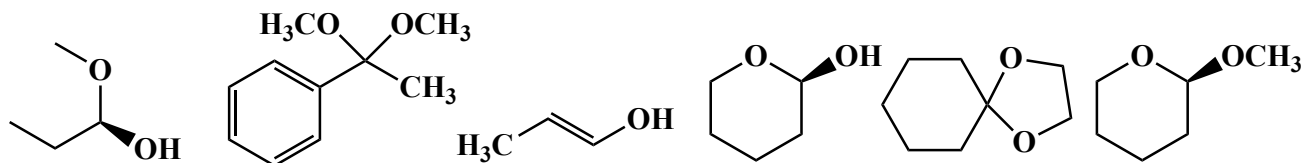
1. (5 pts) What is the most important question in organic chemistry?

Where are the electrons?

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

The popular medical diagnostic technique of 1. magnetic 2. resonance
 3. imaging (MRI) is based on the same principles as 4. NMR,
 namely the flipping (i.e. 5. resonance) of nuclear spins of H atoms by
 6. radio frequency irradiation when a patient is placed in a strong
 7. magnetic 8. field. Magnetic field gradients are used to
 gain imaging information, and rotation of the gradient around the center of the object gives imaging
 in an entire plane (i.e. slice inside patient). In an MRI image, you are looking at individual
 9. slices that when 10. stacked make up the three-
 dimensional image of 11. relative amounts of H atoms, especially the H atoms
 from 12. water and 13. fat, in the different
 14. tissues.

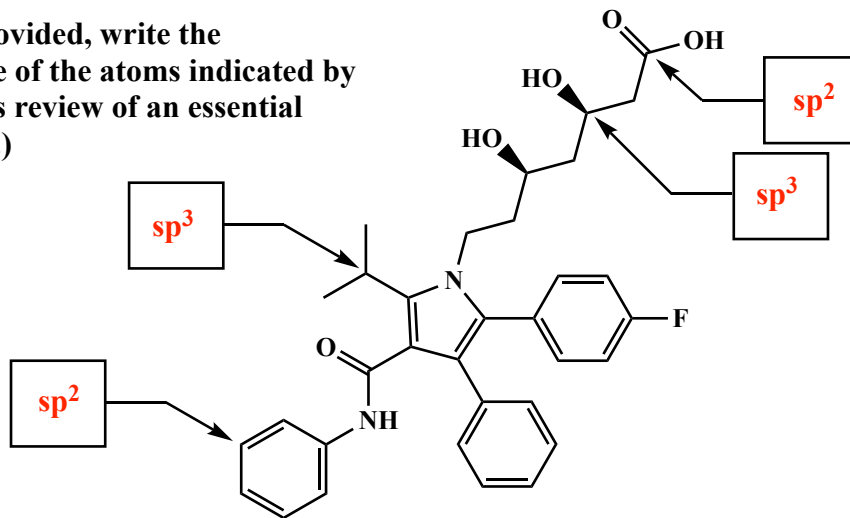
3. (2 pt each) Fill in each circle to indicate the appropriate name for the functional group in the following molecules and then indicate whether or not they are favored species at equilibrium.



- | | | | | | |
|---|---|---|---|---|---|
| <input type="radio"/> Enol | <input type="radio"/> Enol | <input checked="" type="radio"/> Enol | <input type="radio"/> Enol | <input type="radio"/> Enol | <input type="radio"/> Enol |
| <input checked="" type="radio"/> Hemiacetal | <input type="radio"/> Hemiacetal | <input type="radio"/> Hemiacetal | <input checked="" type="radio"/> Hemiacetal | <input type="radio"/> Hemiacetal | <input type="radio"/> Hemiacetal |
| <input type="radio"/> Acetal | <input checked="" type="radio"/> Acetal | <input type="radio"/> Acetal | <input type="radio"/> Acetal | <input checked="" type="radio"/> Acetal | <input checked="" type="radio"/> Acetal |
| <input type="radio"/> Favored at equilibrium | <input checked="" type="radio"/> Favored at equilibrium | <input type="radio"/> Favored at equilibrium | <input checked="" type="radio"/> Favored at equilibrium | <input checked="" type="radio"/> Favored at equilibrium | <input checked="" type="radio"/> Favored at equilibrium |
| <input checked="" type="radio"/> Not favored at equilibrium | <input type="radio"/> Not favored at equilibrium | <input checked="" type="radio"/> Not favored at equilibrium | <input type="radio"/> Not favored at equilibrium | <input type="radio"/> Not favored at equilibrium | <input type="radio"/> Not favored at equilibrium |

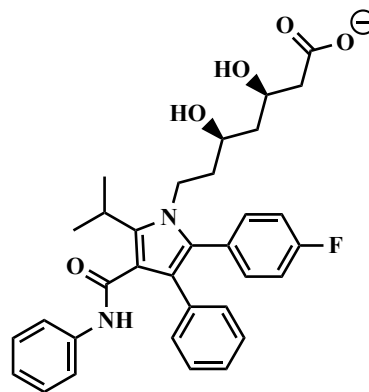
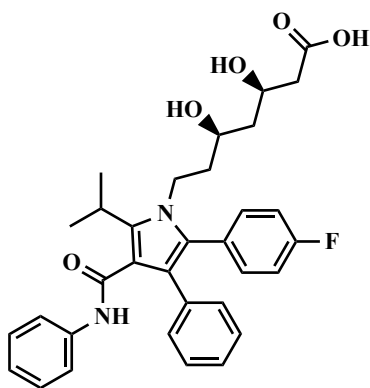
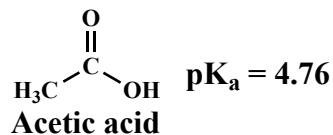
4. (8 pts) Lipitor (Atorvastatin) is a very important drug used to treat prevent atherosclerosis and heart disease. In 2023 it was 24th best selling drug, earning \$2.2 billion in sales. Answer the following questions about lipitor.

A. In the boxes provided, write the hybridization state of the atoms indicated by the arrow. (This is review of an essential OChem 1 concept.)



Lipitor (Atorvastatin)

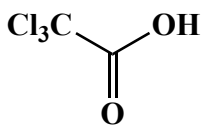
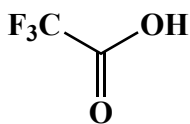
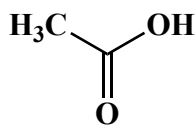
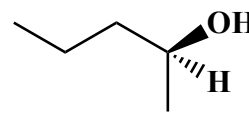
B. (6 pts) Given that the pK_a value shown for acetic acid is typical for a carboxylic acid group, fill in the circle to indicate the pH at which the protonation state of lipitor shown above would be present. You might need to fill in more than one circle, as the given structure might be present at more than one of the pH values listed.



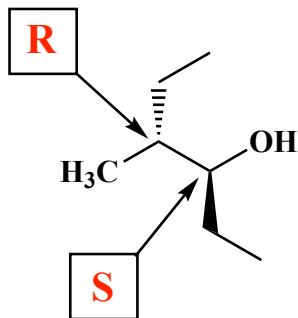
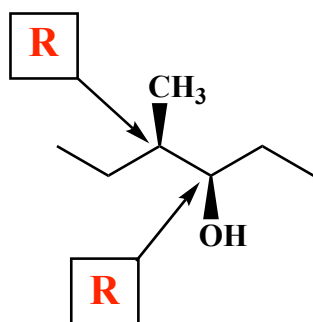
- The predominant form present at pH = 2
 The predominant form present at pH = 7
 The predominant form present at pH = 10

- The predominant form present at pH = 2
 The predominant form present at pH = 7
 The predominant form present at pH = 10

5. (4 pts) 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 structures as appropriate.

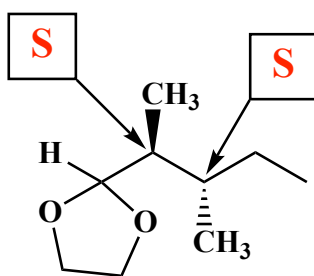
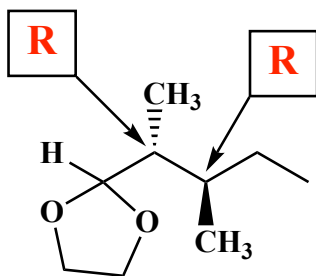
2134

6. (12 pts) For each pair of molecules, fill in the boxes to label each chiral center as R or S then fill in the circle that indicates the appropriate relationship between the two molecules.



Relationship:

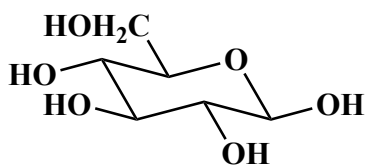
- Enantiomers
 Diastereomers
 Same molecule



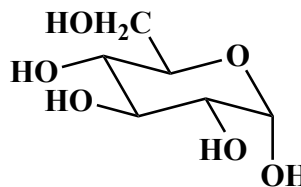
Relationship:

- Enantiomers
 Diastereomers
 Same molecule

7. (4 pts each) Fill in the circle to indicate the correct name for the glucose molecules shown.



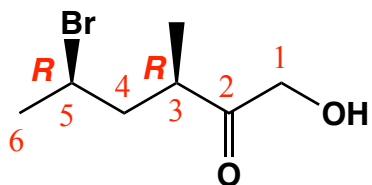
- alpha(α) - D - Glucose
 beta(β) - D - Glucose



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

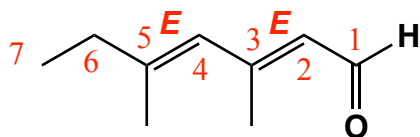
8. (4 pts each) Write an acceptable IUPAC name or draw a structural formula for the following molecules:

A.



(3*R*,5*R*)-5-bromo-1-hydroxy-3-methyl-2-hexanone
or
(3*R*,5*R*)-5-bromo-1-hydroxy-3-methylhexan-2-one

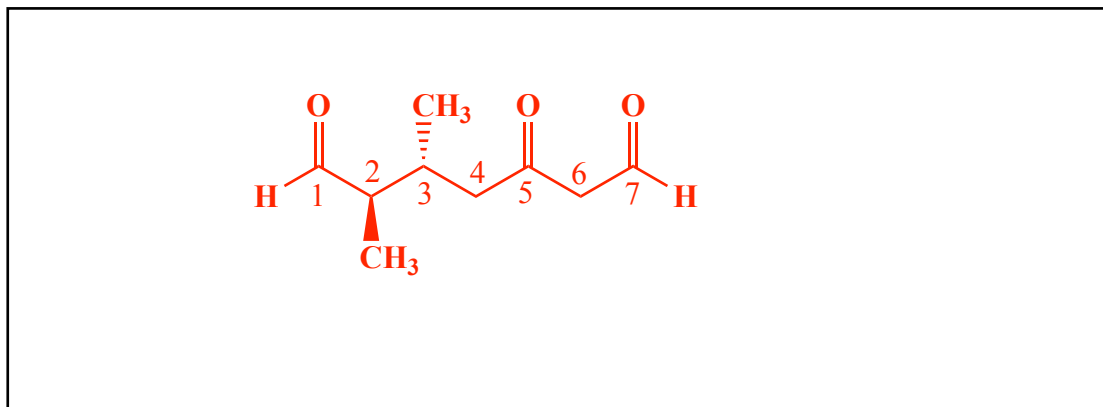
B.



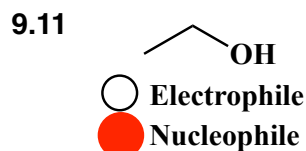
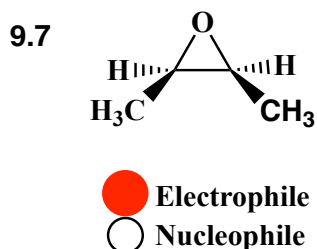
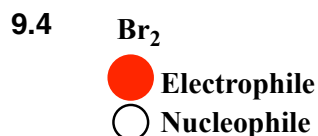
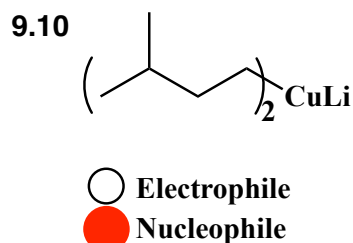
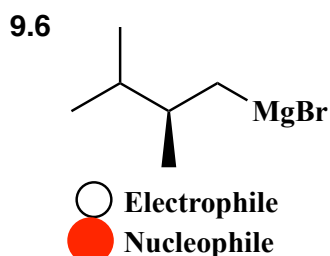
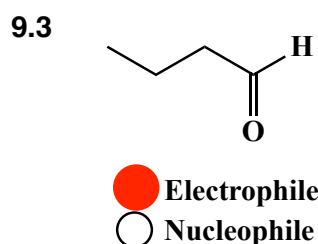
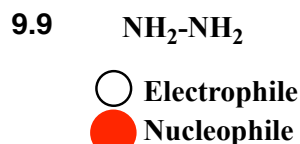
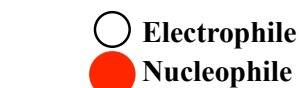
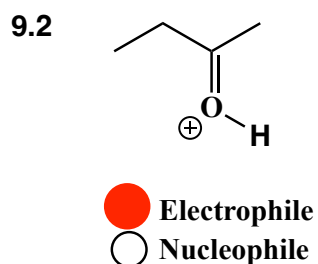
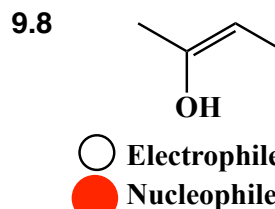
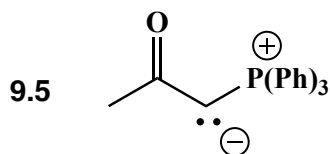
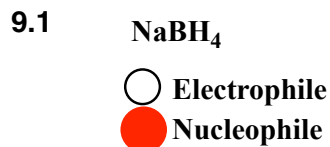
(2*E*,4*E*)-3,5-dimethyl-2,4-heptadienal
or
(2*E*,4*E*)-3,5-dimethylhepta-2,4-dienal

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

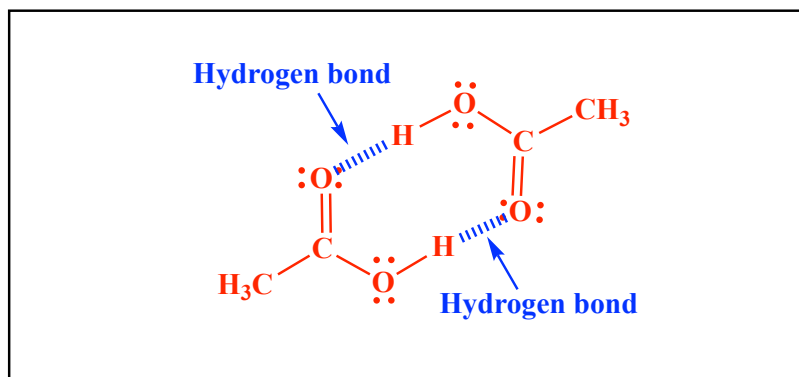
(2*R*,3*R*)-2,3-dimethyl-5-oxoheptanedial



9. (11 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 acids or bases in certain situations, but we will ignore that for this problem.



10. (6 pts) Carboxylic acids exist as a characteristic dimer in solution, held together with hydrogen bonds. In the box provided, draw the hydrogen bonded dimer of acetic acid. Indicate the hydrogen bonds as a dashed line, and draw all lone pairs on your structures. You saw this in lecture last Thursday.

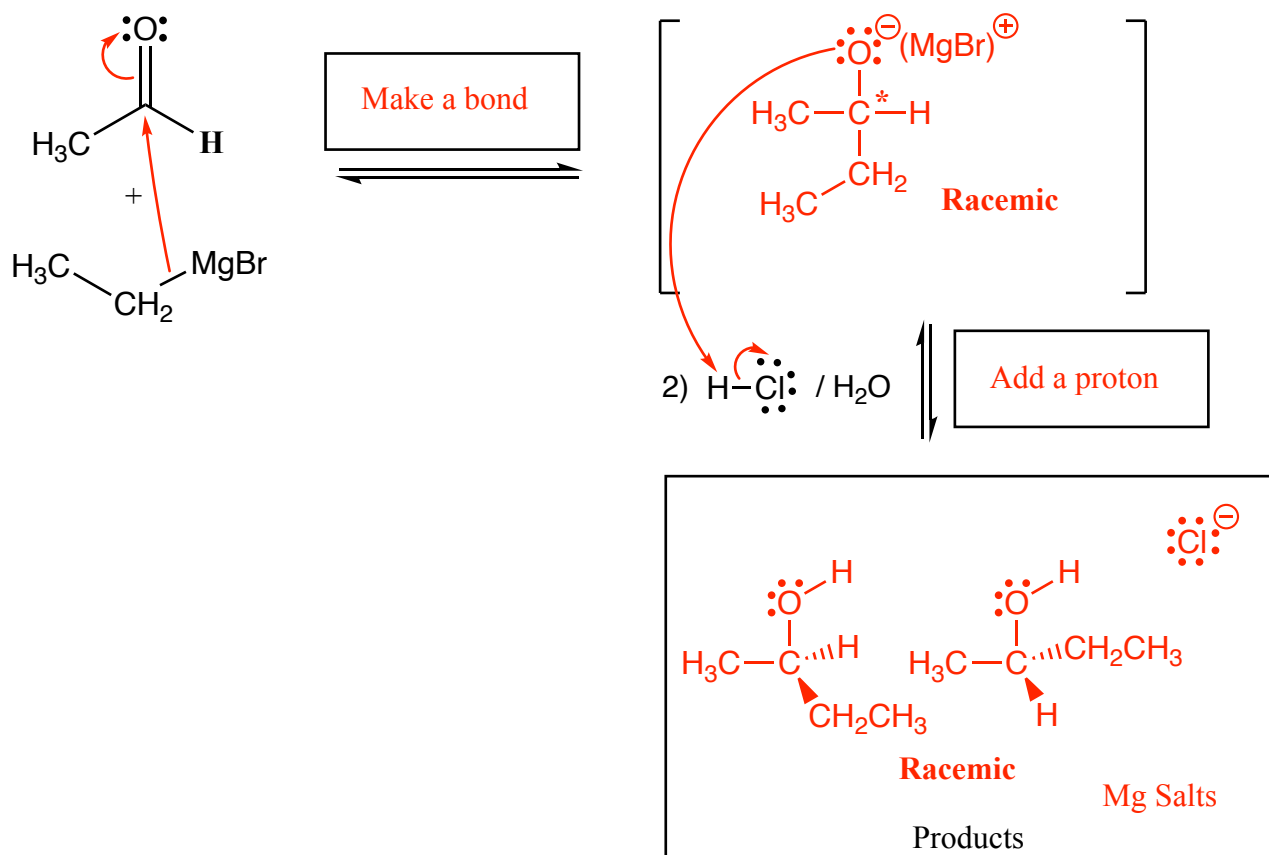


Signature _____

Pg 6 _____ (12)

11. (12 pts) For this Grignard 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.).

Grignard Reaction with an Aldehyde

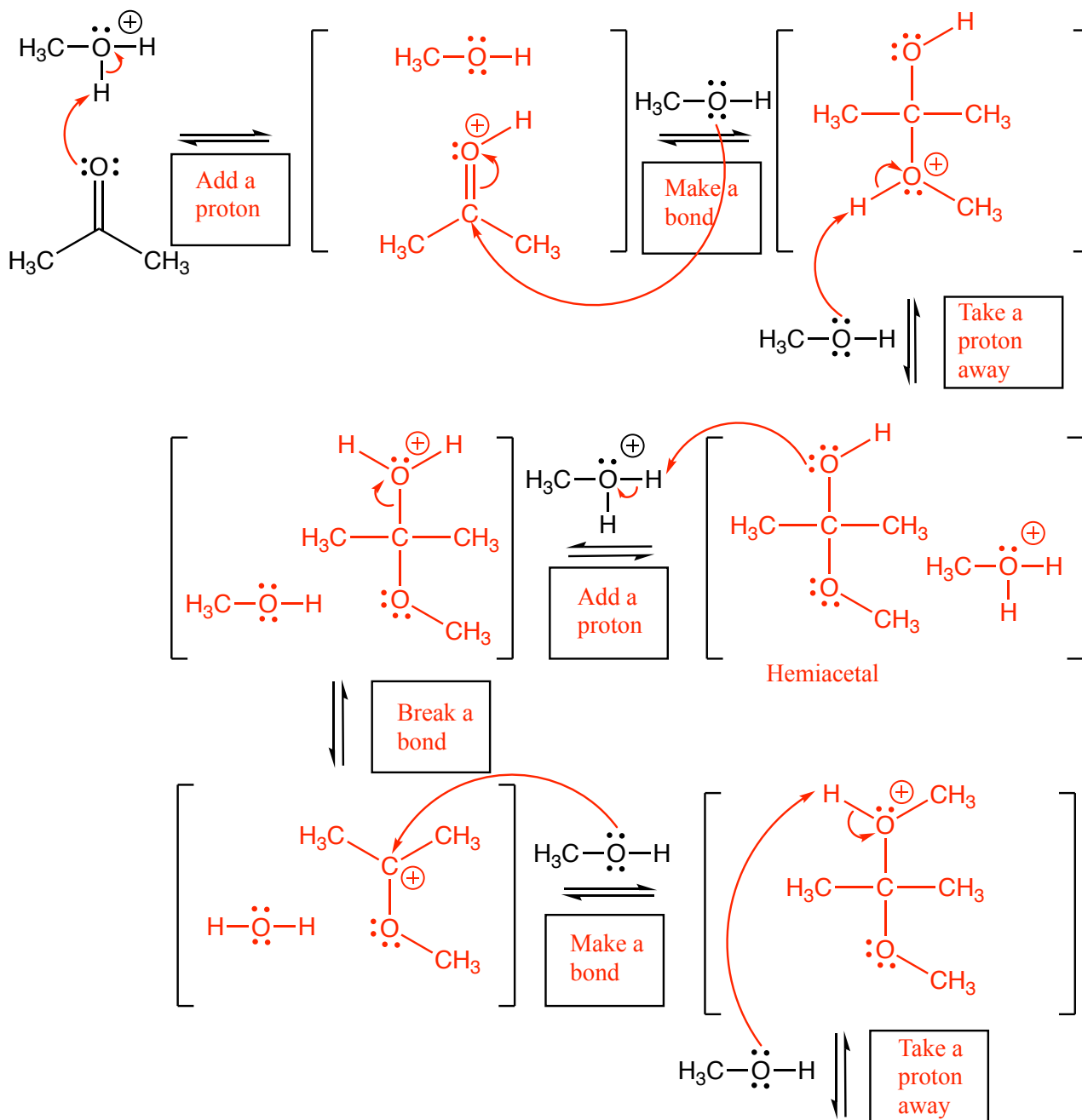


Signature _____

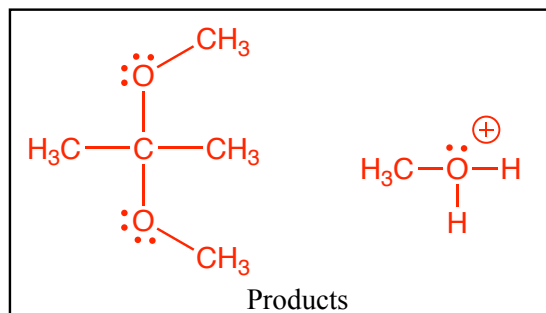
Pg 7 _____(-)

12. (45 pts) For the 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.).

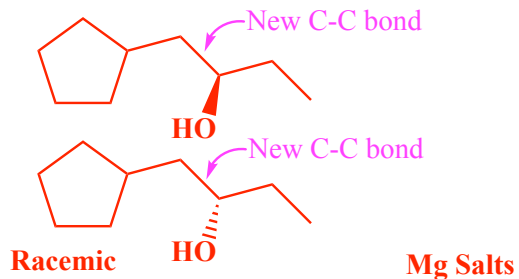
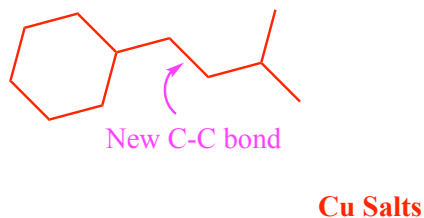
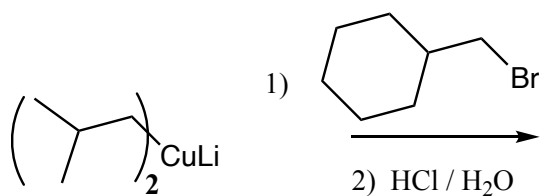
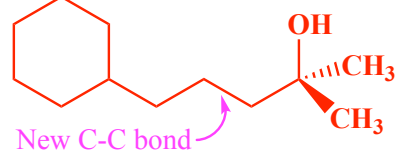
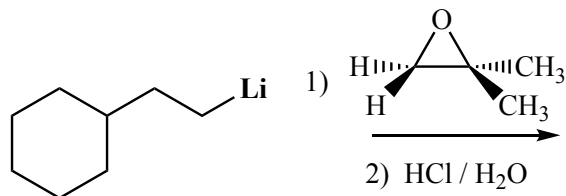
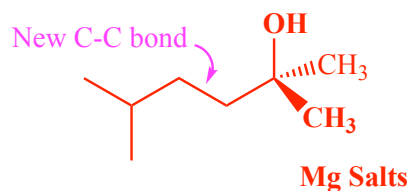
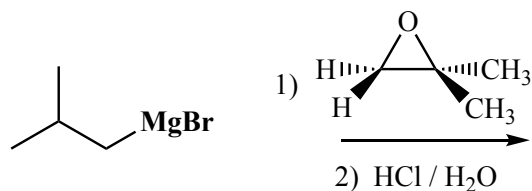
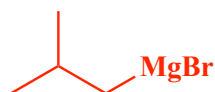
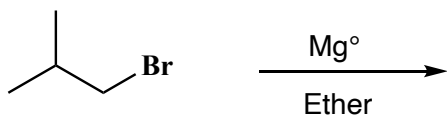
The mechanism did not fit on the same page as the directions, so use the directions on this page to fill in the mechanism on the next page!



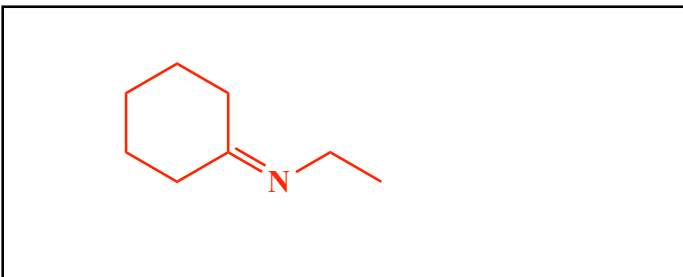
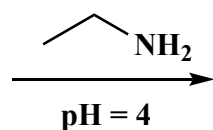
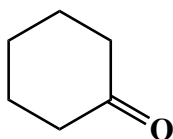
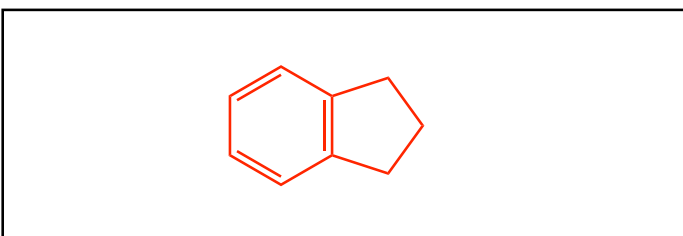
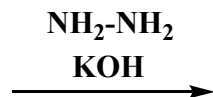
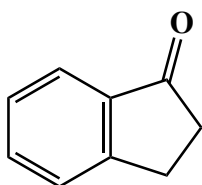
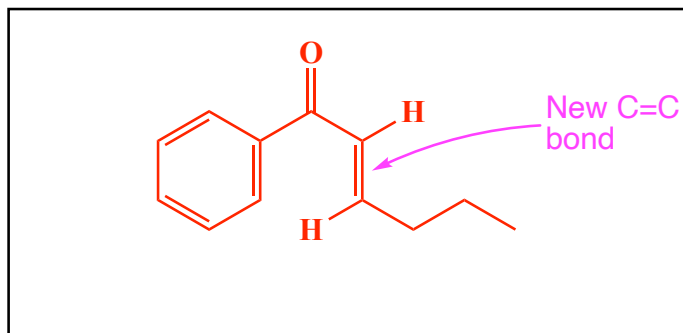
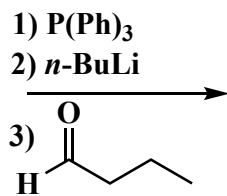
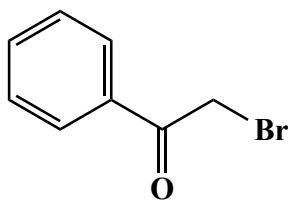
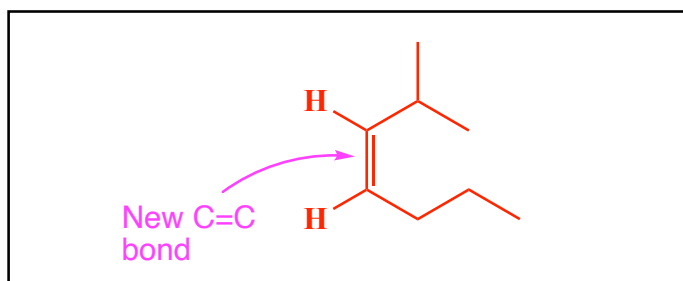
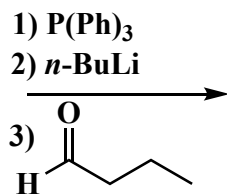
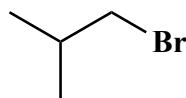
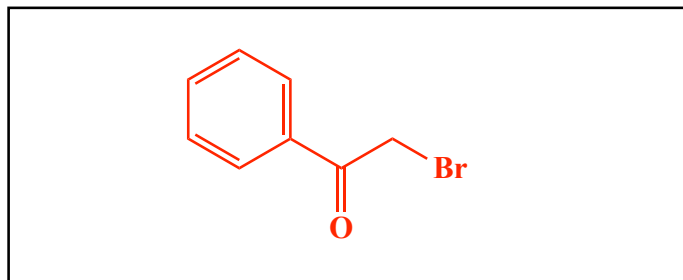
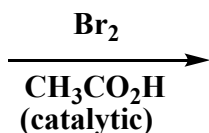
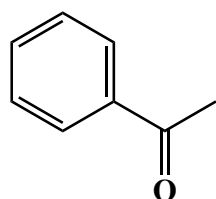
Note: For intermediates that I drew as two contributing structures in class, you only need to draw one contributing structure. Either one will be correct. Just make sure your arrows are accurate for the contributing structure you draw.



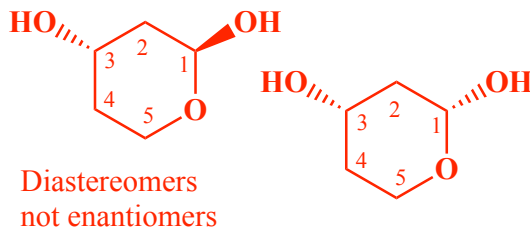
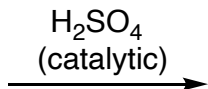
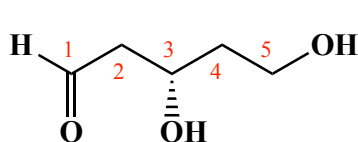
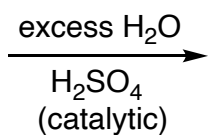
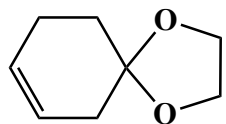
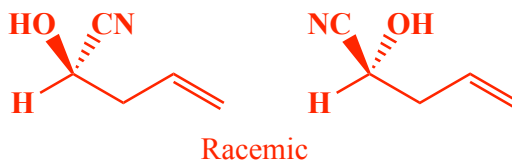
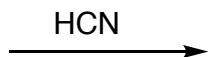
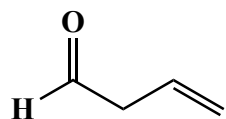
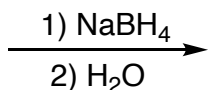
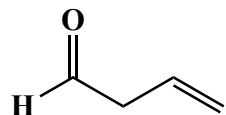
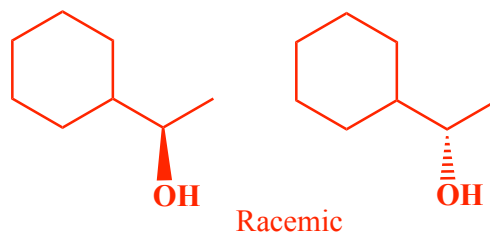
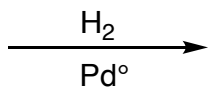
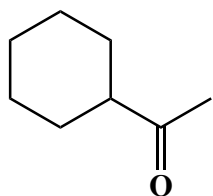
13. (3 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangle) and dashes (\cdots) to indicate stereochemistry.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



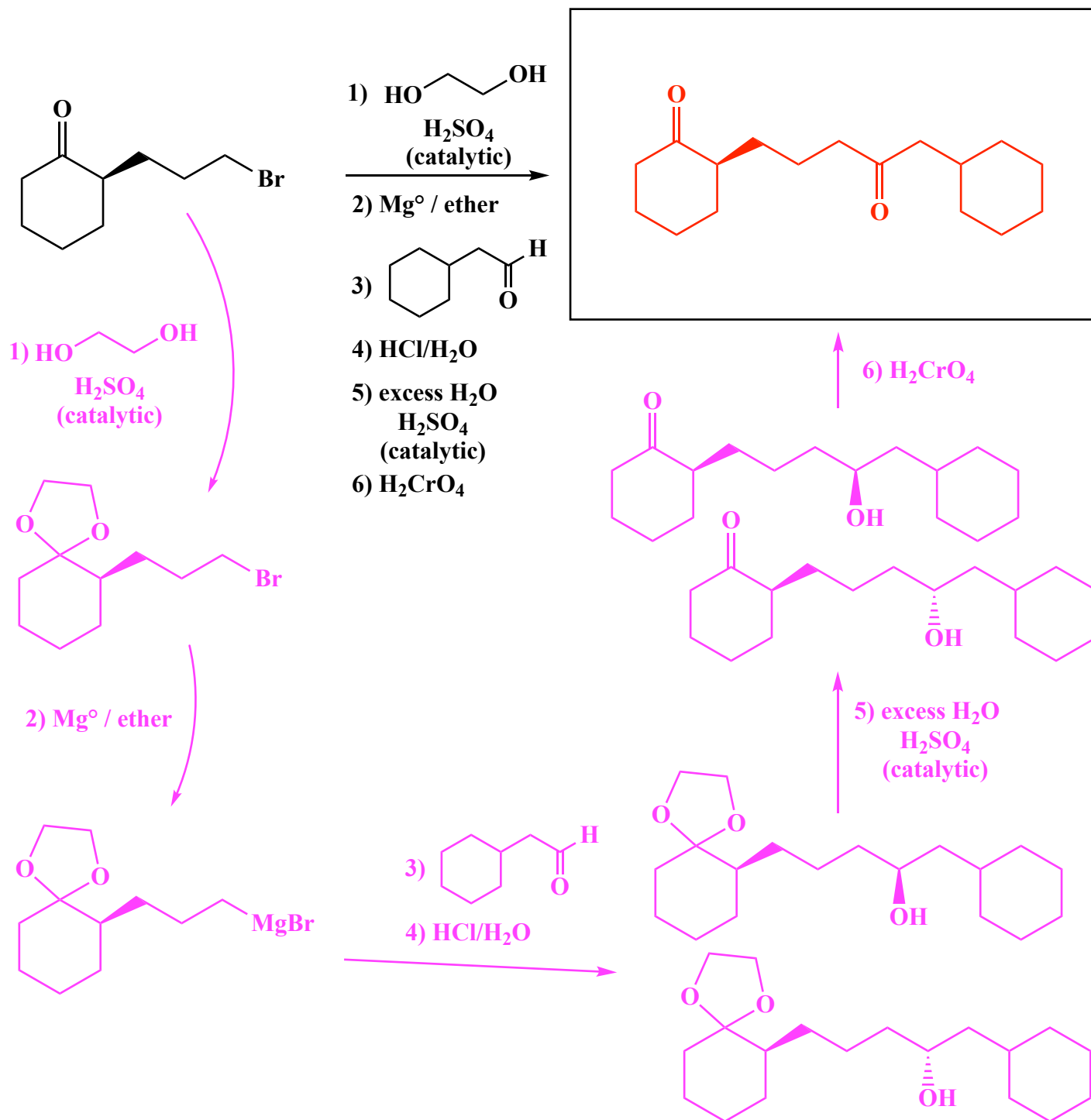
13. (cont.) (3, 4 or 5 pts.) Write the predominant product or products that will occur for each transformation. If a new chiral center is created and a racemic mixture is formed, you must draw both enantiomers and write "racemic" under the structure. Use wedges (\blacktriangleleft) and dashes (\cdots)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

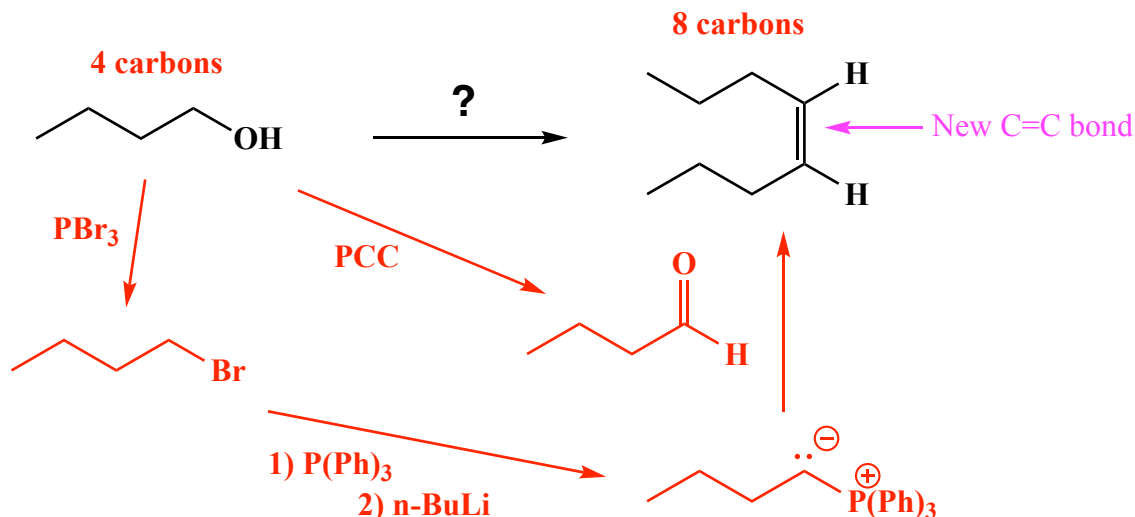


14. (10 pts) Here is a warm-up for the synthesis problems. For the following series of reactions, write the **final** product(s) that you will see. Make sure draw all stereoisomers produced and to use wedges and dashes to indicate all stereochemistry, and you must write racemic if appropriate.



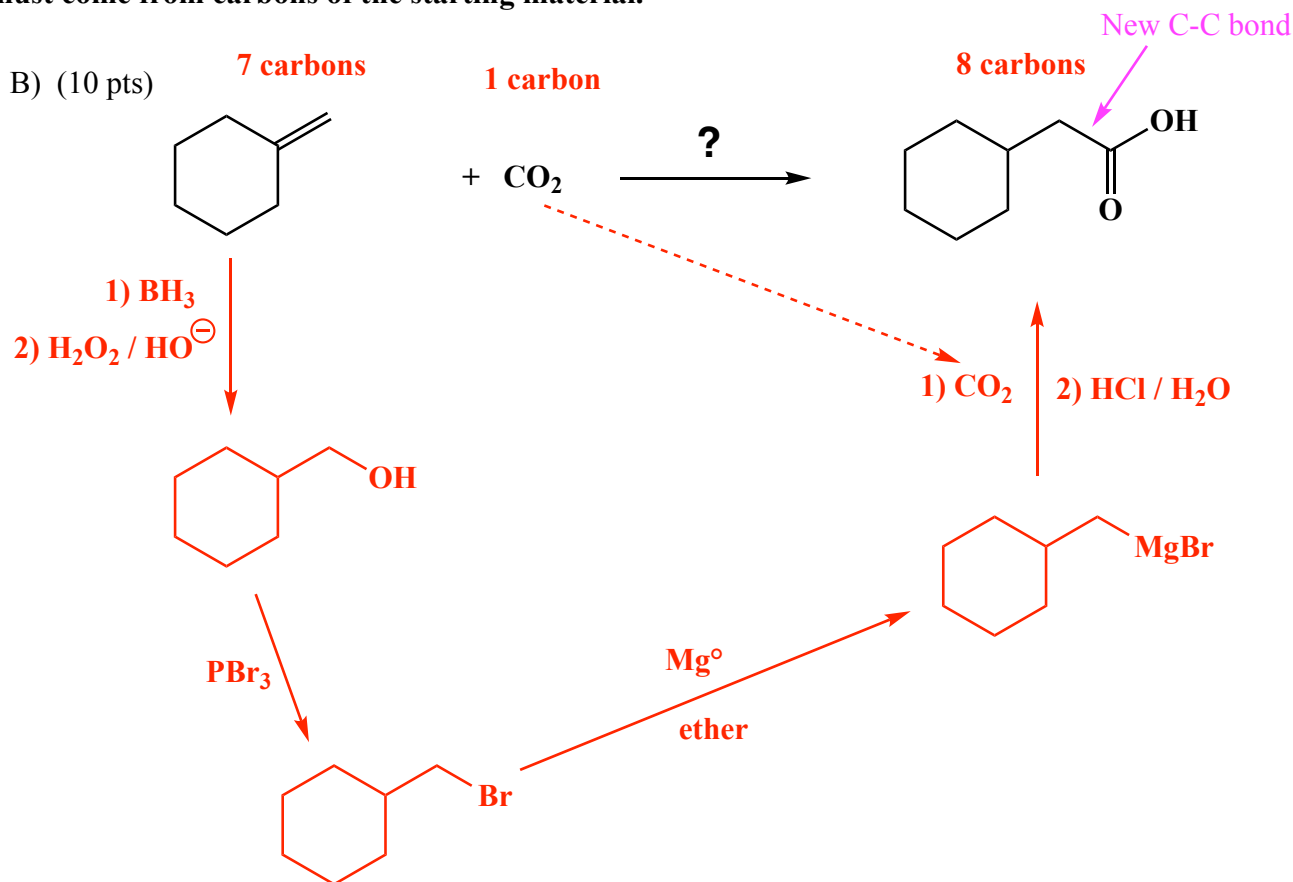
15. These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule synthesized along the way and be sure to pay attention to the regiochemistry and stereochemistry preferences for each reaction. You must draw all stereoisomers formed, and use wedges and dashes to indicate chirality at each chiral center. Write racemic when appropriate. **All the carbons of the product must come from carbons of the starting material.**

A) (10 pts)

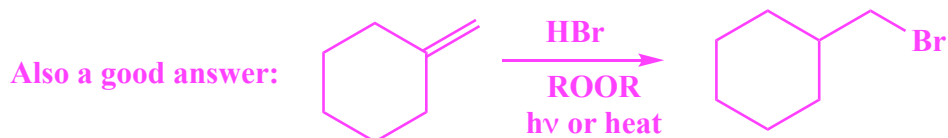


Recognize the product is a Z alkene with 8 carbons. The starting material has 4 carbons, so predict the new C=C bond is the alkene. **Recognize** that the Z alkene with a new C=C is the KRE of a Wittig reaction with two four carbon pieces. You can make the required four carbon aldehyde from the starting alcohol using PCC, and you can make the required four carbon Wittig reagent by converting the alcohol to the haloalkane using PBr_3 , followed by the usual reaction with 1) $\text{P}(\text{Ph})_3$ then 2) $n\text{-BuLi}$.

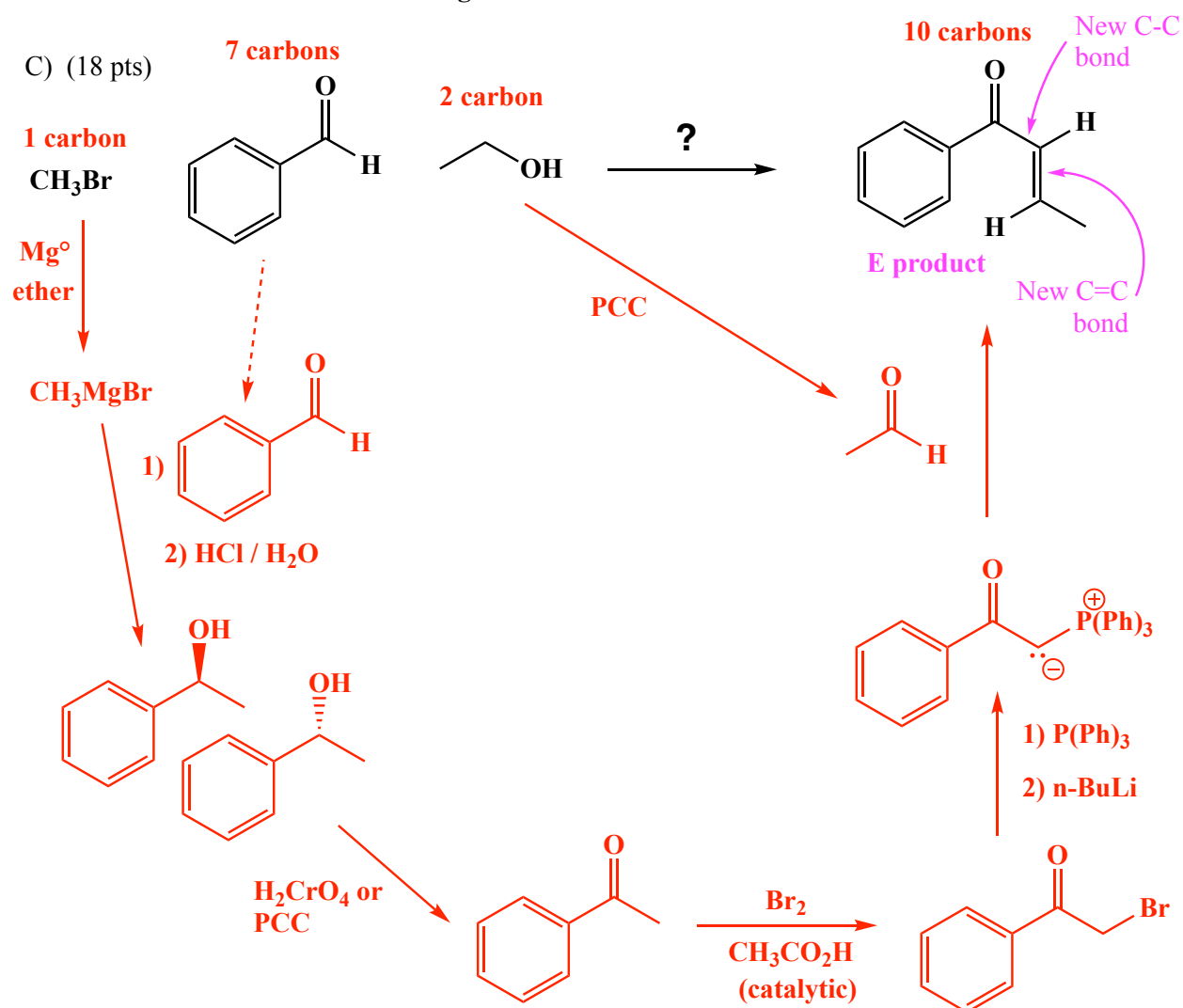
15. These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule synthesized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



Recognize that the product has 8 carbons and the starting materials have 7 carbons and 1 carbons. Therefore the new carbon-carbon bond is between the last two carbons as shown. **Recognize** that a carboxylic acid with a new carbon-carbon bond to the carboxylic acid carbon is the KRE of a Grignard reagent reacting with CO_2 , and of course, CO_2 is one of the starting materials. **Recognize** that the required 7-carbon Grignard reagent can be made from the starting 7 carbon alkene by first carrying out a non-Markovnikov addition of an OH group using 1) BH_3 followed by 2) $\text{H}_2\text{O}_2 / \text{HO}^\ominus$ to give the 7-carbon primary alcohol. Alternatively you could have created the 7-carbon primary bromoalkane directly from the starting alkene using HBr in the presence of peroxides (ROOR) with heat or light. Either way, treatment of the 7-carbon primary haloalkane with Mg^\ominus and ether gives the 7-carbon Grignard reagent.

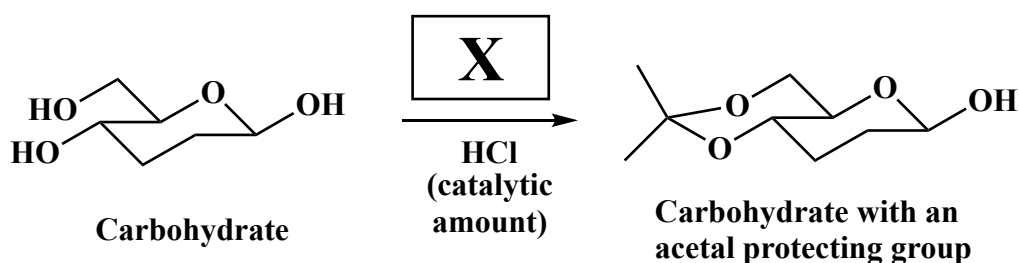


15 (cont.) These are synthesis questions. You need to show how the starting material can be converted into the product(s) shown. You may use any reactions we have learned provided that the product(s) you draw for each step is/are the predominant one(s). Show all the reagents you need. Show each molecule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

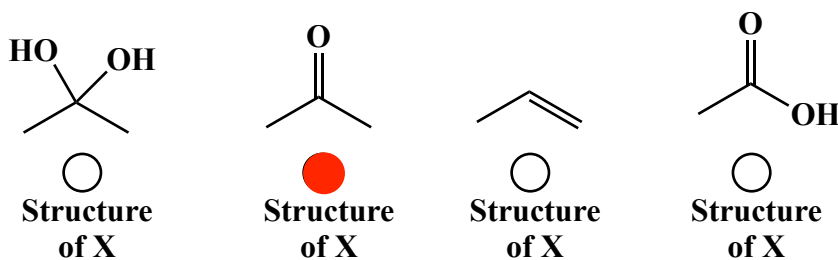


Recognize that the product has 10 carbons, and the starting materials have 1, 2, and 7 carbons, so all three starting materials are used once. **Recognize** an E alkene in the product with an adjacent carbonyl group, the KRE of a Wittig reaction using an enolate Wittig reagent. Therefore, predict the C=C is one new bond and the other new C-C bond must therefore be between the carbonyl and the alkene. **Recognize** further that the aldehyde needed for the final Wittig is made from the ethanol starting material using PCC. **Recognize** that the haloketone needed to make the Wittig reagent can be made from the corresponding 8-carbon methyl ketone using the alpha-halogenation reaction. The hard part of this synthesis is **recognizing** that the 8-carbon methyl ketone you need can be made from the starting aldehyde and methyl bromide by converting the latter into a Grignard reagent with Mg⁰/ether, carrying out the Grignard reaction then taking the resulting racemic secondary alcohol product to the 8-carbon methyl ketone using PCC or H₂CrO₄.

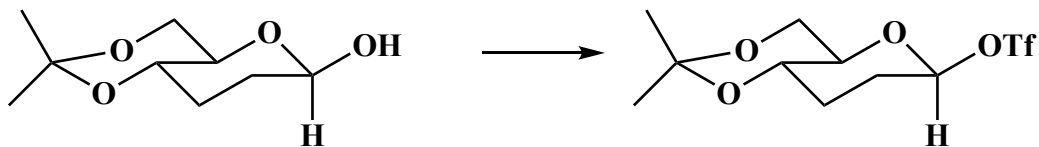
16. (12 pts) Here is an “Apply What you Know” problem. You have not seen all of this directly, but based on what you know you CAN figure it out. A major effort in modern organic chemistry involves the synthesis of carbohydrates so that we can study their properties and biochemistry. It is common to use a protecting group to prevent -OH groups on carbohydrates from taking part in unwanted reactions. The following is a common strategy to protect nearby -OH groups on a carbohydrate using an acetal.



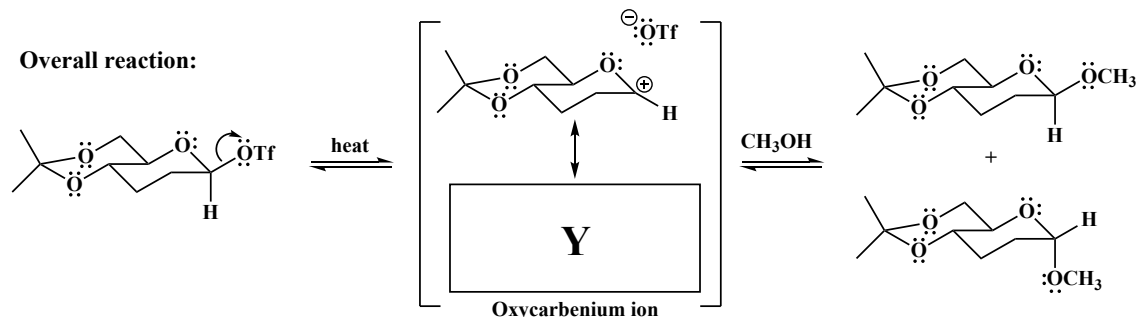
(4 pts) Look carefully at the carbohydrate with an acetal protecting group and fill in the circle beneath the molecule that corresponds to the appropriate structure “X”.



Chemists use these protected carbohydrates to make new bonds at the anomeric carbon atom. They first turn the OH on the anomeric carbon into a great leaving group. Here -OTf corresponds to something called a triflate group, the structure of which is not important. All you need to know is that the -OTf group is a great leaving group.



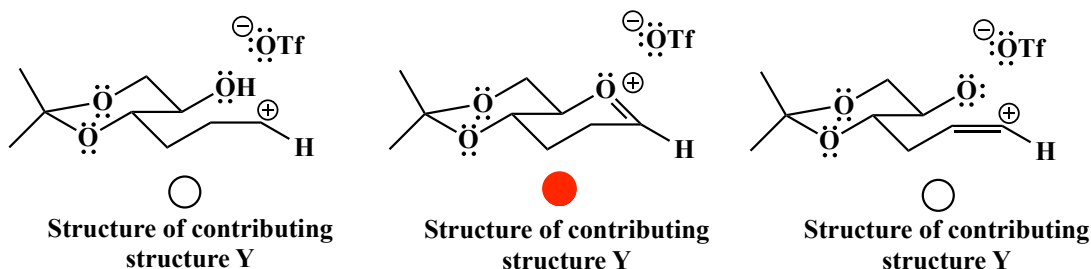
When these carbohydrates are heated, the leaving group departs to give a cation called an oxycarbenium ion intermediate that reacts with an alcohol such as methanol to make a new bond at the anomeric carbon as shown.



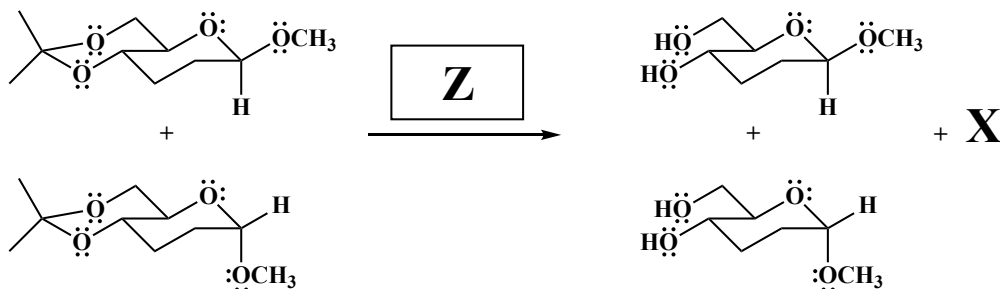
(4 pts) Fill in the appropriate circle. This overall reaction is best described as:

- An S_N1 reaction
 An S_N2 reaction
 An E1 reaction
 An E2 reaction

(4 pts). Fill in the circle beneath the structure for Y that corresponds to the other important contributing structure of the oxycarbenium ion intermediate shown above.



To finish the reaction, the chemist must remove the acetal protecting group to regenerate the two -OH groups as well as give the reagent "X" from the first part of this problem.



(4 pts) Based on what you know about acetals, fill in the circle under the reagent(s) "Z" that a chemist should use to remove the acetal protecting group.

- | | | | |
|--------------------------|---------------------------|--------------------------|---|
| CH_3OH | $\text{NH}_2\text{-NH}_2$ | 1) NaBH_4 | excess H_2O |
| <input type="radio"/> | HO^\ominus | 2) H_2O | HCl or H_2SO_4 |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | (catalytic amount) |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input checked="" type="radio"/> |
| Reagents that could be Z | Reagents that could be Z | Reagents that could be Z | Reagents that could be Z |