



# CHE 322 Organic Chemistry II

Final Exam Form 1

Thursday May 12, 2022

11:15 AM – 1:45 PM

1. Write your nine digit University ID number in the nine boxes provided and then bubble in each of the nine digits.
2. Print your name and sign your answer form using the spaces provided.
3. Questions 1 to 20 are multiple choice questions worth 5 points. Bubble your answers on the answer form. Questions 21-31 are short answer questions with points as indicated. Write out your answers in the indicated place on the answer form.

## Effects of Substituents on Electrophilic Aromatic Substitution

### **Ortho-Para Directors**

#### Strongly Activating

-NH<sub>2</sub> -NHR -NR<sub>2</sub>  
-OH -O<sup>-</sup>

#### Moderately Activating

-NHCOCH<sub>3</sub> -NHCOR  
-OCH<sub>3</sub> -OR

#### Weakly Activating

-CH<sub>3</sub> -C<sub>2</sub>H<sub>5</sub> -R -C<sub>6</sub>H<sub>5</sub>

#### Weakly Deactivating

-F -Cl -Br -I

### **Meta Directors**

#### Moderately Deactivating

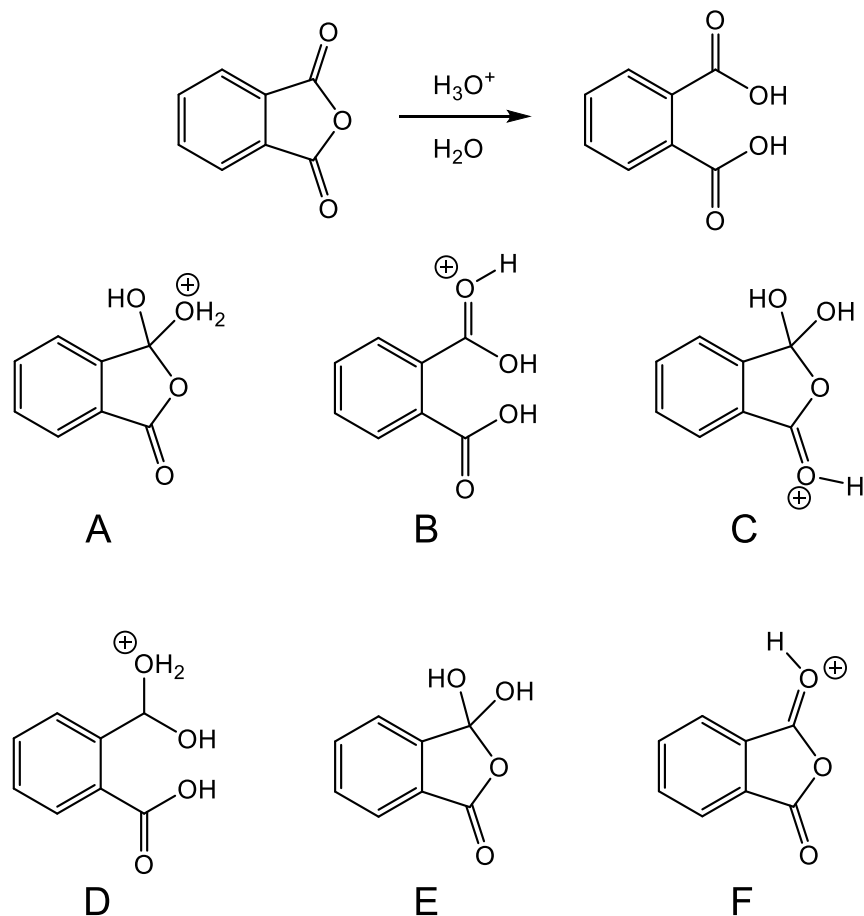
-C≡N  
-SO<sub>3</sub>H  
-CO<sub>2</sub>H -CO<sub>2</sub>R  
-CHO -COR

#### Strongly Deactivating

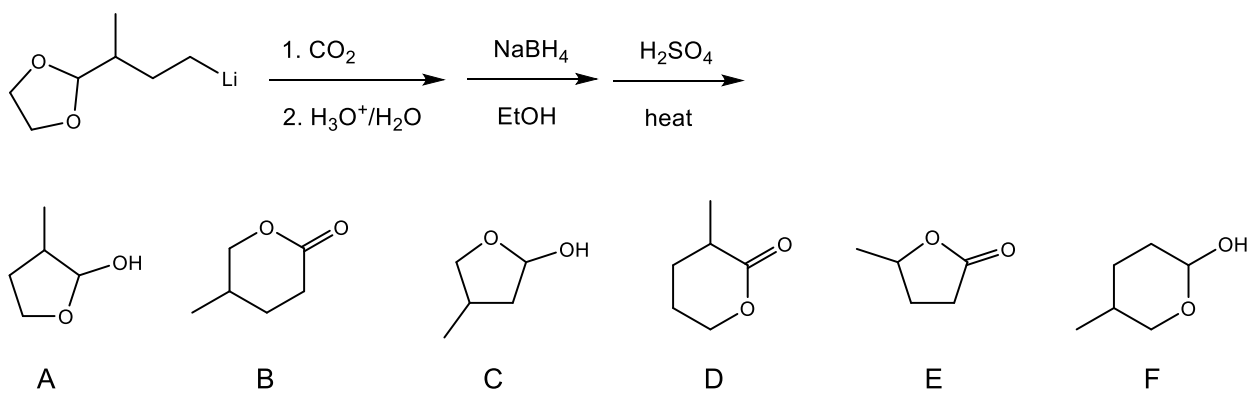
-NO<sub>2</sub>  
-NH<sub>3</sub><sup>+</sup> -NR<sub>3</sub><sup>+</sup>  
-CF<sub>3</sub> -CCl<sub>3</sub>

		Group																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period	1	H																	He
	2	Li	Be											B	C	N	O	F	Ne
	3	Na	Mg											Al	Si	P	S	Cl	Ar
	4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	6	Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	7	Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

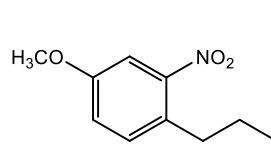
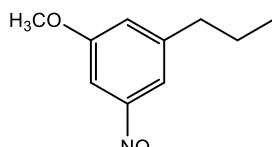
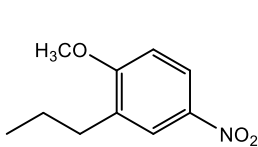
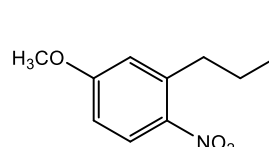
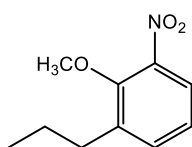
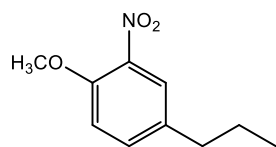
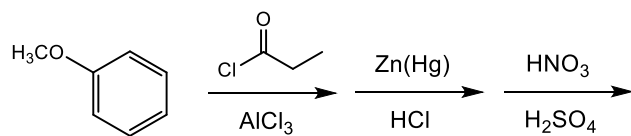
1. Select the species that is least likely an intermediate formed during the following acid-catalyzed hydrolysis.



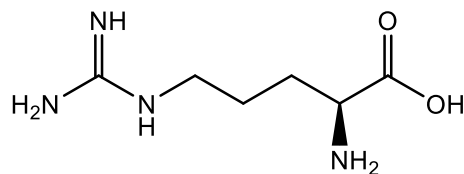
2. Select the major product of the following reaction sequence.



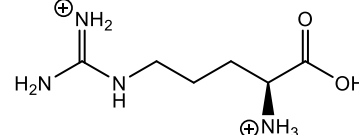
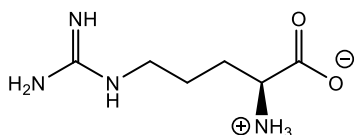
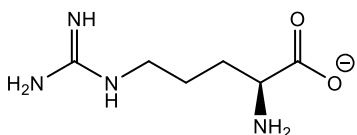
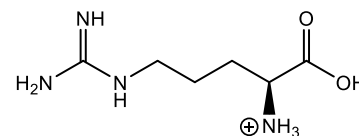
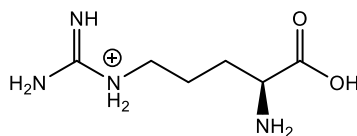
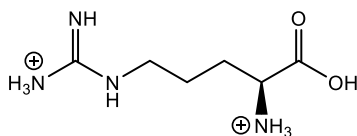
3. Choose the major product of the following reaction sequence.



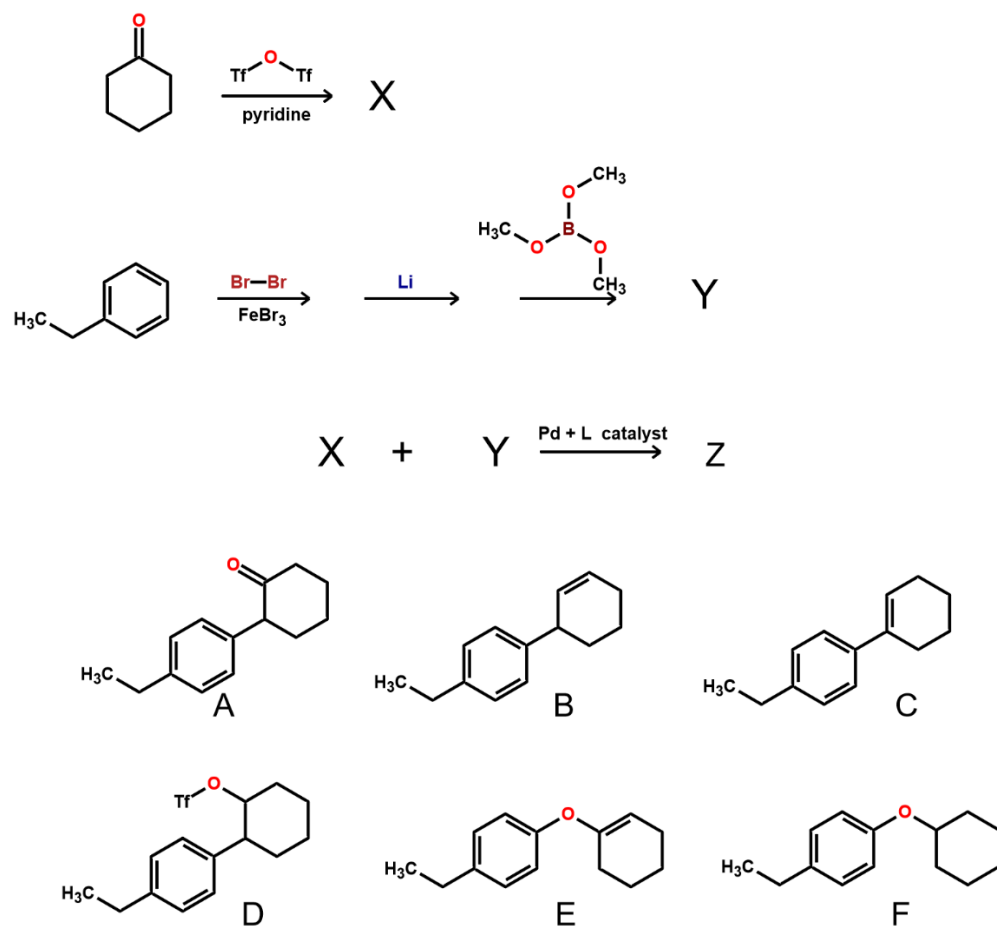
4. The  $\text{pK}_a$  values of L-arginine are: 2.2 (for the carboxylic acid group), 9.0 (for the amino group), and 12.5 (for the side chain). The structure shown below is that of L-arginine in its hypothetical neutral form.



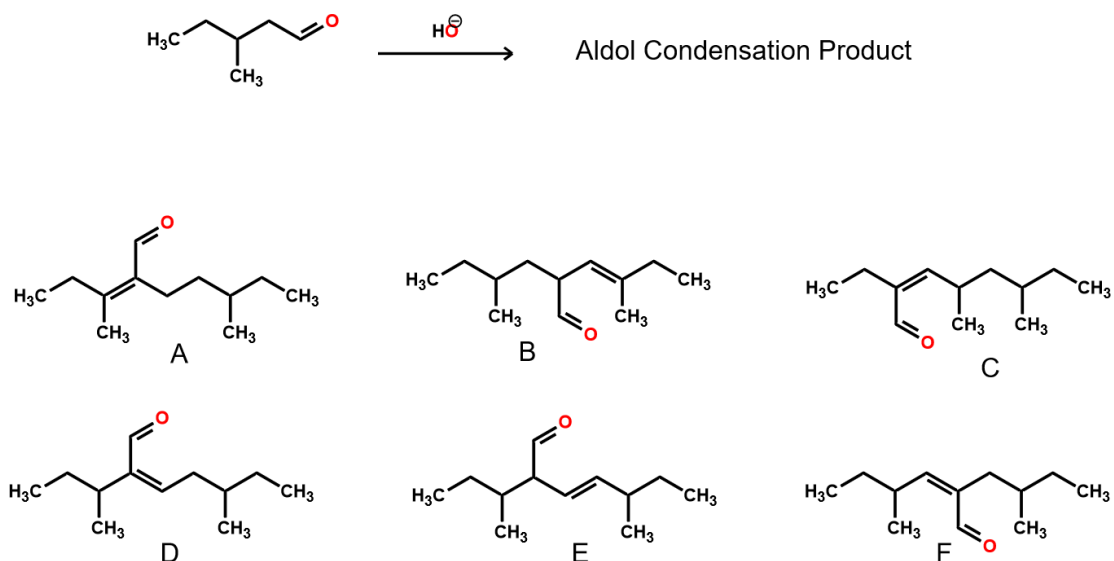
Choose the more predominant structure of L-arginine in a solution of  $\text{pH} = 1$ .



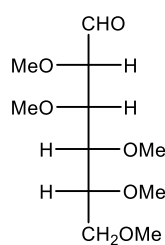
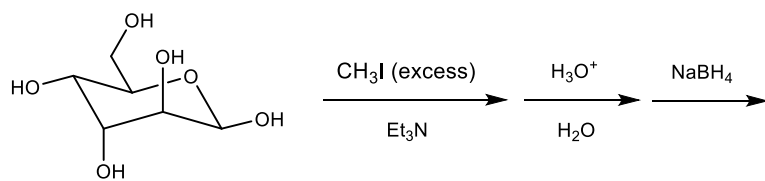
5. Predict the product **Z** of the following Pd coupling reaction.



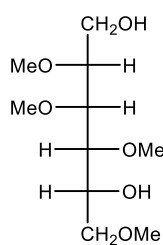
6. Predict the main product of the following aldol condensation.



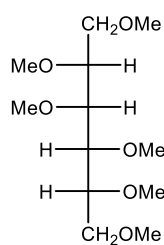
7. Choose the product of the following reaction sequence.



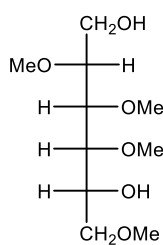
A



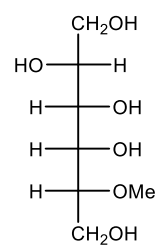
B



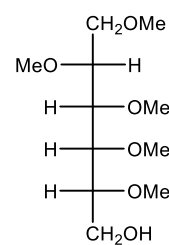
C



D

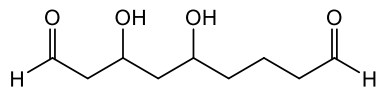
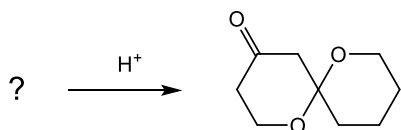


E

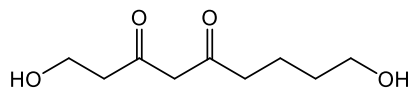


F

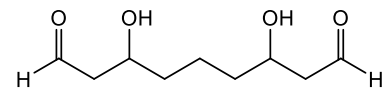
8. Choose the correct open chain that would produce the following bicyclic acetal upon treatment with acid.



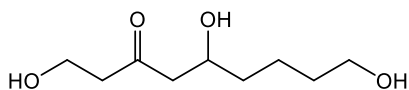
A



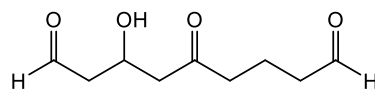
B



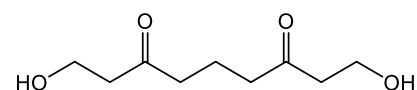
C



D

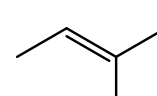
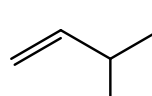
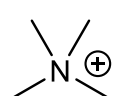
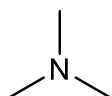
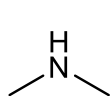
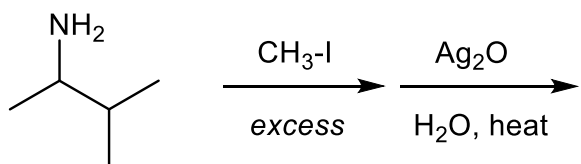


E



F

9. What are the major products of the following Hofmann elimination?



A. 1 and 4

B. 1 and 5

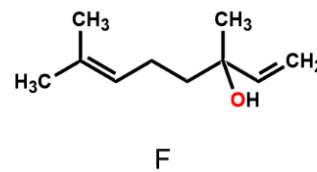
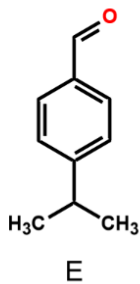
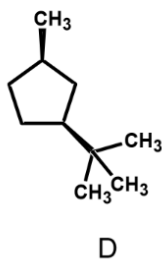
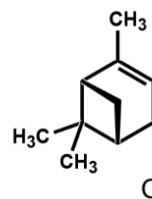
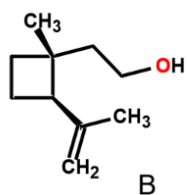
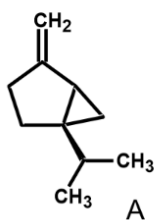
C. 2 and 4

D. 2 and 5

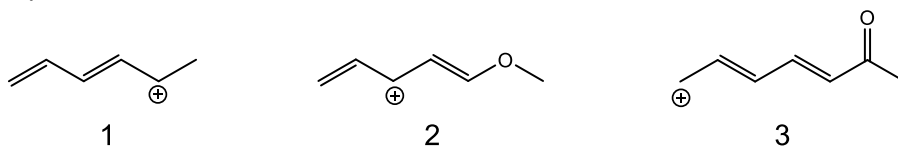
E. 3 and 4

F. 3 and 5

10. The compounds shown below all have ten carbon atoms. Five of them are real examples of terpene structures. One is not. Identify the structure that is not a terpene.

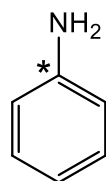
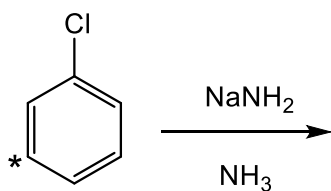


11. Choose the order that has the following pentadienyl cations correctly arranged with respect to increasing stability.

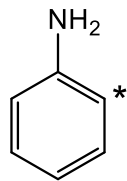


- A  $\xrightarrow{\text{increasing stability}}$  1 2 3      B  $\xrightarrow{\text{increasing stability}}$  1 3 2      C  $\xrightarrow{\text{increasing stability}}$  2 1 3      D  $\xrightarrow{\text{increasing stability}}$  2 3 1      E  $\xrightarrow{\text{increasing stability}}$  3 1 2      F  $\xrightarrow{\text{increasing stability}}$  3 2 1

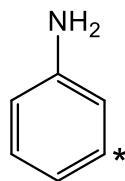
12. Choose the major product(s) of the following reaction that utilizes a reactant containing one carbon radiolabeled with a C-14 isotope (shown with an asterisk).



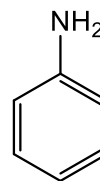
1



2



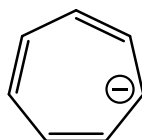
3



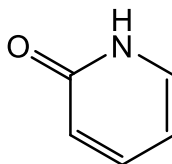
4

- A. 1 and 2    B. 2 and 3    C. 3 and 4    D. 1, 2 and 3    E. 2, 3 and 4    F. 1, 2, 3 and 4

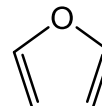
13. Which of the following are considered aromatic compounds?



1



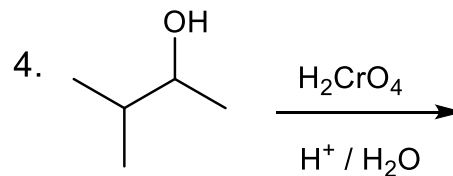
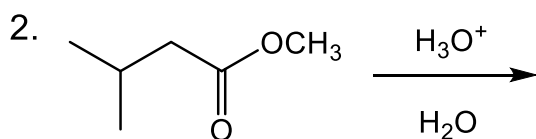
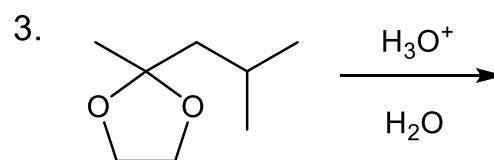
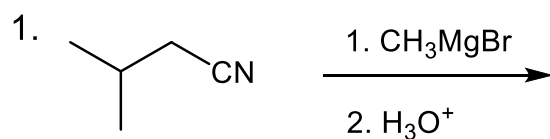
2



3

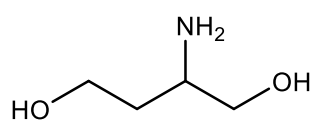
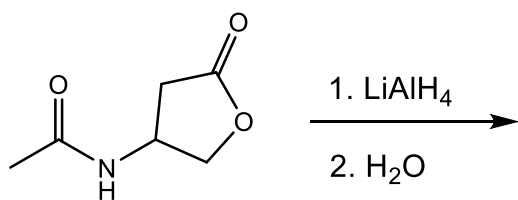
- A. 1 only    B. 2 only    C. 3 only    D. 1 and 2    E. 1 and 3    F. 2 and 3

14. Which two reactions lead to the same major product?

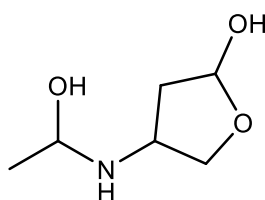


- A. 1 and 2    B. 1 and 3    C. 1 and 4    D. 2 and 3    E. 2 and 4    F. 3 and 4

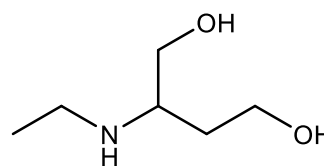
15. Select the expected major product of the following reduction reaction.



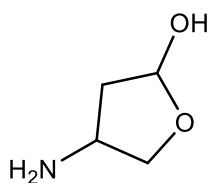
A



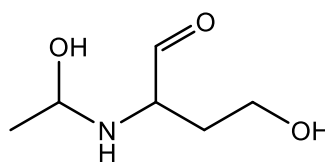
B



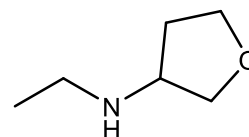
C



D



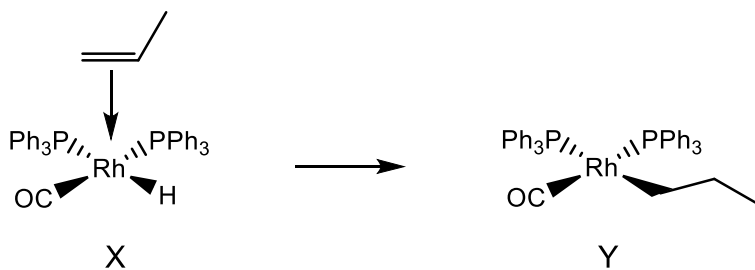
E



F

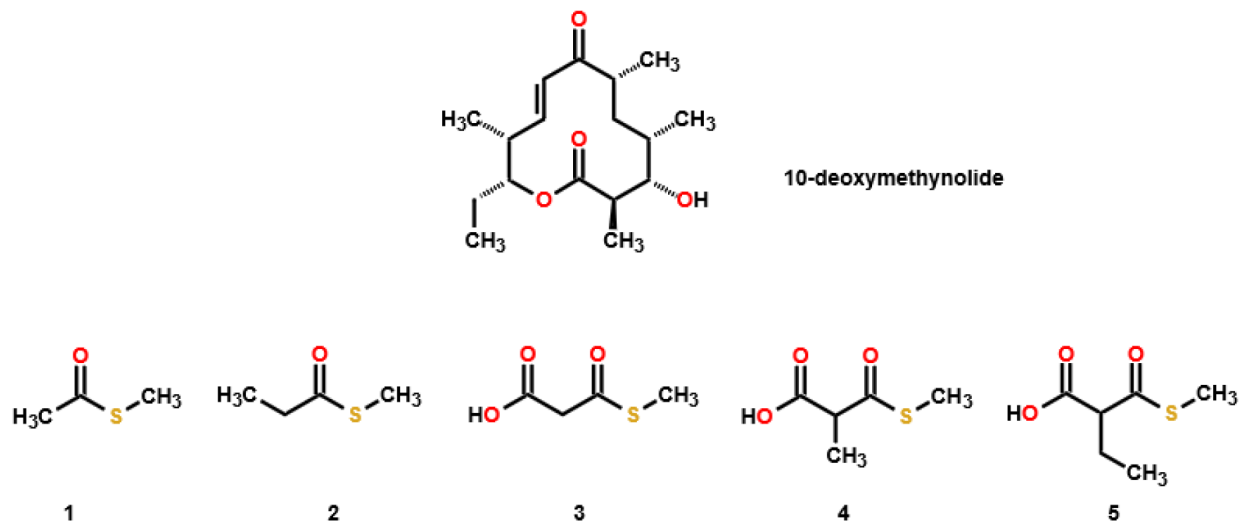


16. Choose the correct reaction type of the following mechanistic step, and choose the correct electron counts for intermediate X and intermediate Y.



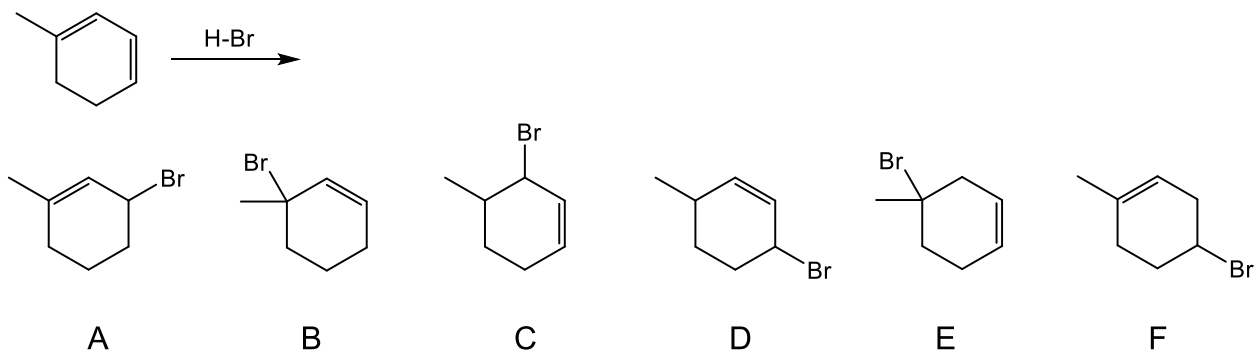
Answer Choice	Reaction Type	Intermediate X	Intermediate Y
A	Oxidative addition	16	16
B	Ligand association	16	18
C	Ligand insertion	18	18
D	Oxidative addition	18	16
E	Ligand association	16	16
F	Ligand insertion	18	16

17. What starters and extenders would be required for the biosynthesis of 10-deoxymethynolide?

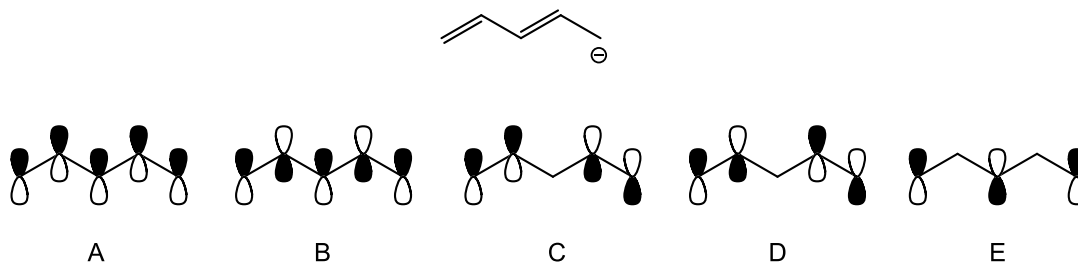


- A. One mole of **2**, one mole of **3**, four moles of **4**  
 B. One mole of **1**, one mole of **3**, four moles of **4**  
 C. One mole of **2**, two moles of **3**, four moles of **4**  
 D. One mole of **1**, five moles of **4**, one mole of **5**  
 E. One mole of **2**, five moles of **4**, one mole of **5**  
 F. One mole of **1**, four moles of **4**, one mole of **5**

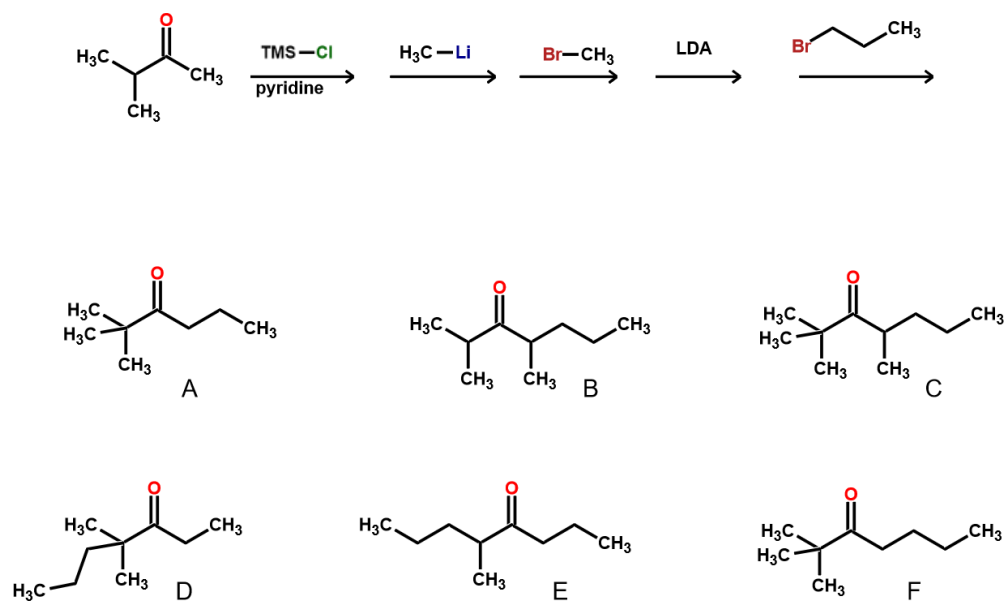
18. The following addition reaction only produces one major product, which is both the kinetic and thermodynamic product. Choose the major product.



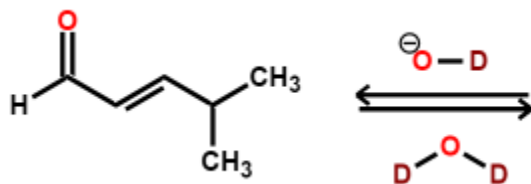
19. Select the highest occupied molecular orbital (HOMO) from the  $\pi$  molecular orbitals for the pentadienyl anion shown below.



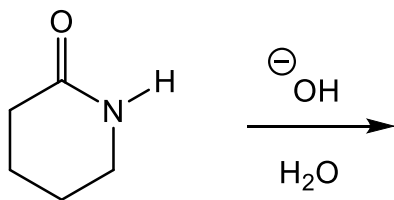
20. Choose the major product of the following reaction sequence.



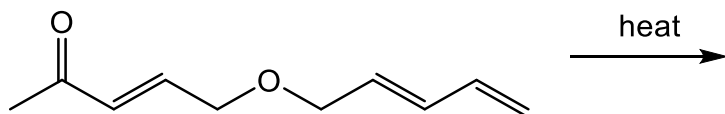
21. Draw the major product of the following deuterium exchange reaction. (5 points)



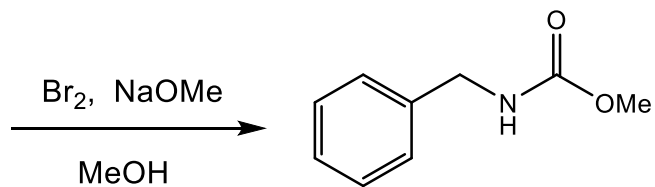
22. Draw the major product of the following hydrolysis. (5 points)



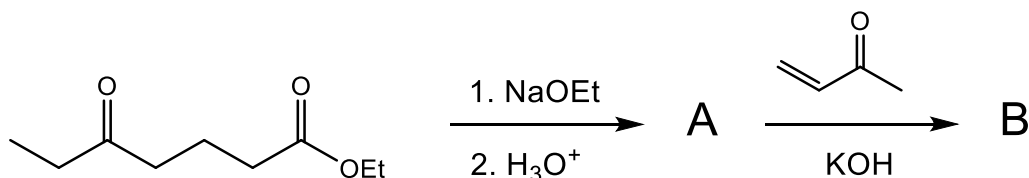
23. Draw the major product of the following intramolecular Diels-Alder reaction. Use wedged and dashed bonds only where appropriate. The reaction produces a pair of enantiomers. Only draw one enantiomer. (5 points)



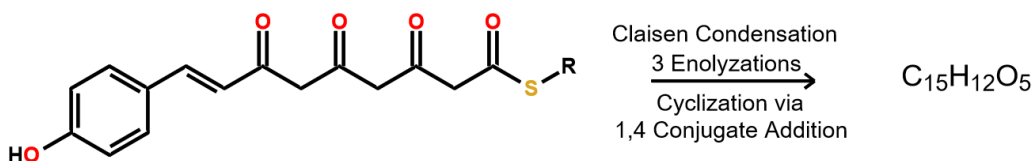
24. Draw the reactant that would give the major product shown of the following reaction. (5 points)



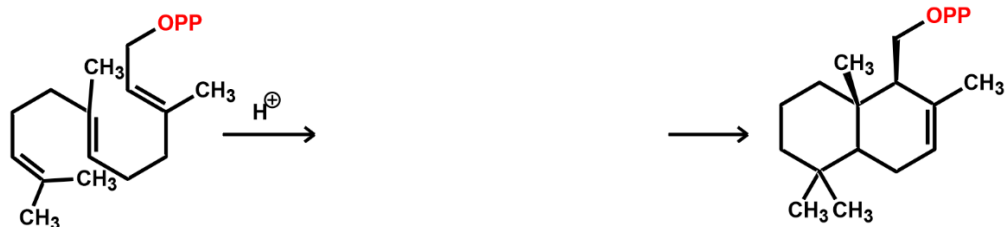
25. Determine and draw the structures of compounds **A** and **B**. (10 points)



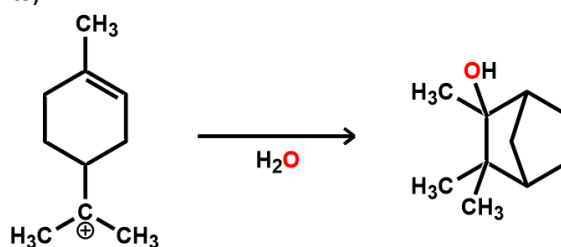
26. The biosynthetic pathway shown below leads to a compound called a flavanone. It starts with an enzymatic synthesis of the intermediate compound shown below and continues with a Claisen condensation, three enolizations and a final cyclization via a 1-4 conjugate addition. Draw the structure of the product. (5 points)



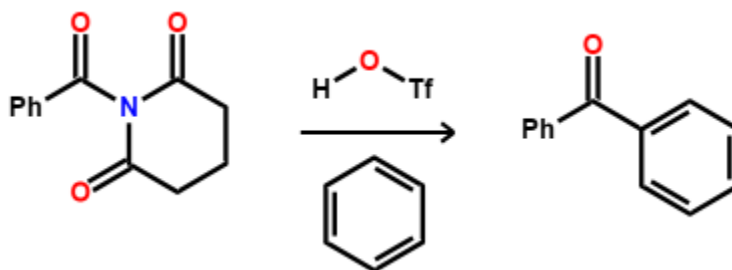
27. Various bacteria are known to catalyze the cyclization of farnesyl pyrophosphate to the sesquiterpene Diemenol pyrophosphate. Draw a curved arrow mechanism for this transformation. Do this in two steps. The first step forms the rings; the second step forms the final product. (5 points)



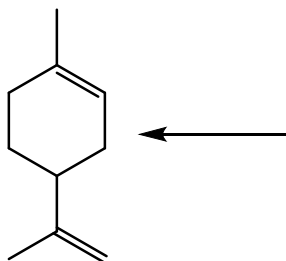
28. Draw a curved arrow mechanism for the conversion of the  $\alpha$ -terpinyl cation into the compound camphene hydrate. (10 points)



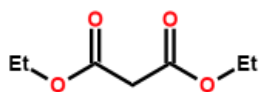
29. Draw a curved arrow mechanism for the following reaction. Hint: The triflic acid  $\text{TfOH}$  is a strong acid. (10 points)



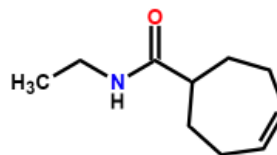
30. Propose a synthesis of the terpene limonene. You may use any compounds containing four carbon atoms or less. **You MUST use a Diels-Alder reaction in your synthesis.** HINT: make sure the diene and dienophile each contain an appropriate EDG or EWG. (10 points)



31. Propose a synthesis of the following amide starting from diethyl malonate. You may use any other reagents/reactants that contain 4 carbon atoms or less. (10 points)



starting material



target compound







