



# CHE 322 Organic Chemistry II

Final Exam Form 1

Thursday May 11, 2023

2:15 PM – 5:00 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 22 are multiple choice questions worth 5 points. Bubble your answers on the answer form. Questions 23-31 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

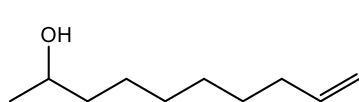
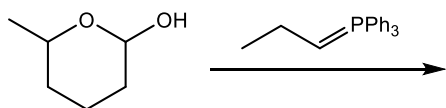
-C≡N  
-SO<sub>3</sub>H  
-CO<sub>2</sub>H -CO<sub>2</sub>R  
-CHO -COR

#### Strongly Deactivating

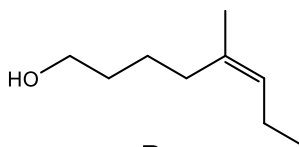
-NO<sub>2</sub>  
-NH<sub>3</sub><sup>+</sup> -NR<sub>3</sub><sup>+</sup>  
-CF<sub>3</sub> -CCl<sub>3</sub>

		Group																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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	

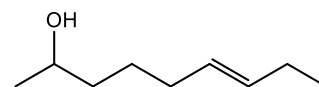
1. Choose the major product of the following Wittig reaction.



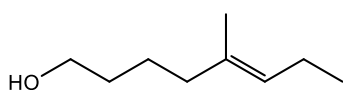
A



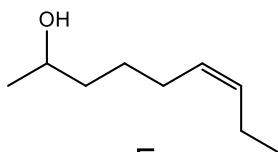
B



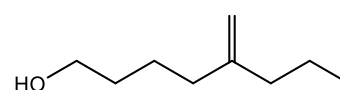
C



D

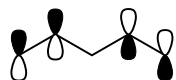
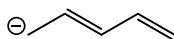


E

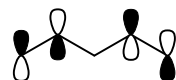


F

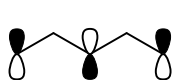
2. Choose the highest occupied  $\pi$  molecular orbital (HOMO) of the pentadienyl anion.



A



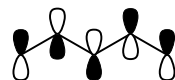
B



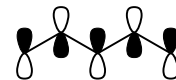
C



D

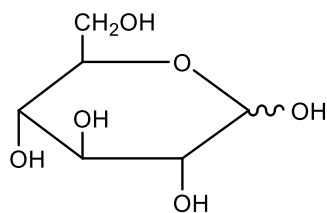
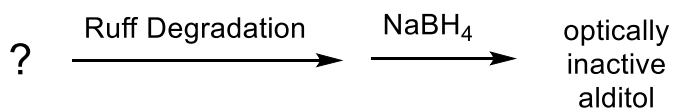


E

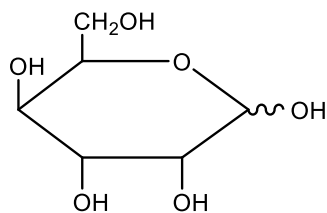


F

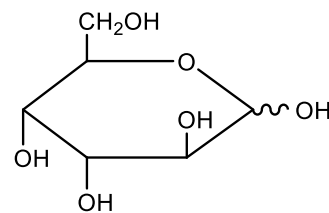
3. Which of the following aldohexoses will yield an optically inactive (achiral) alditol after undergoing a Ruff degradation, followed by  $\text{NaBH}_4$ ?



1



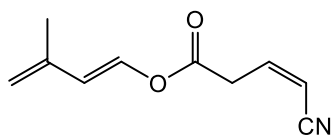
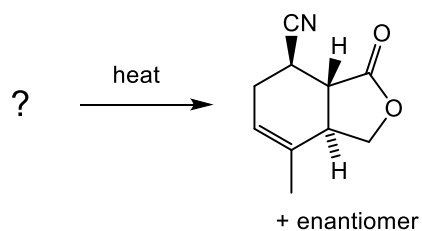
2



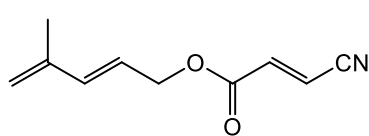
3

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

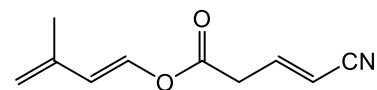
4. Choose the reactant that would give the product shown as the major one of the following intramolecular Diels-Alder reaction.



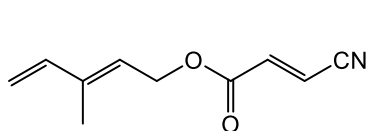
A



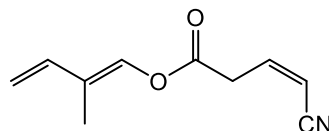
B



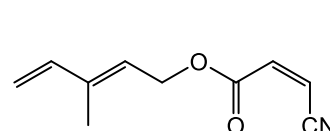
C



D

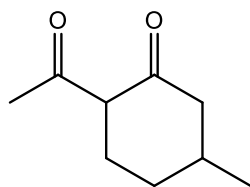
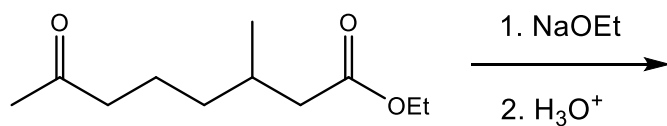


E

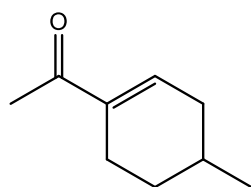


F

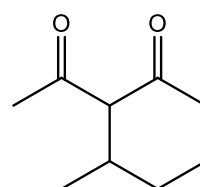
5. Choose the major product of the following intramolecular reaction.



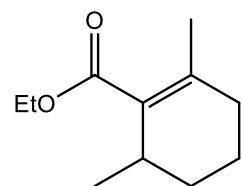
A



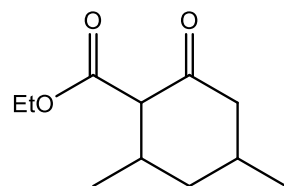
B



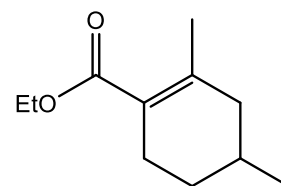
C



D

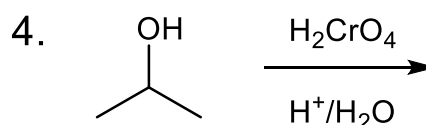
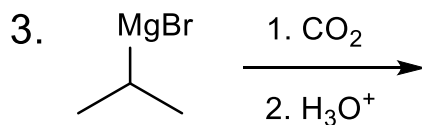
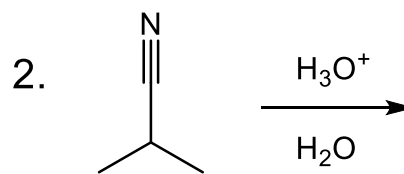
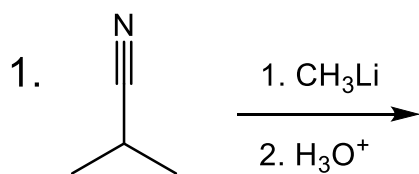


E



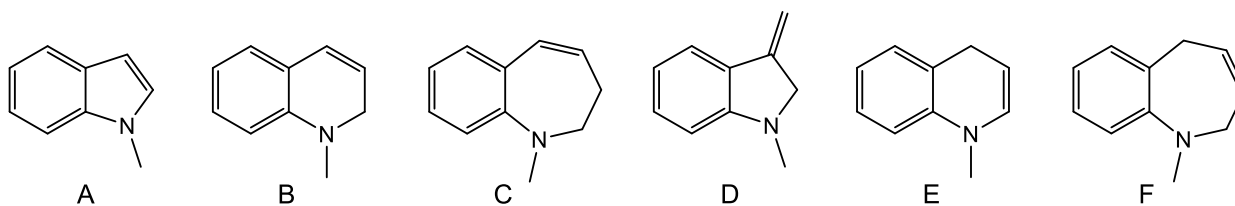
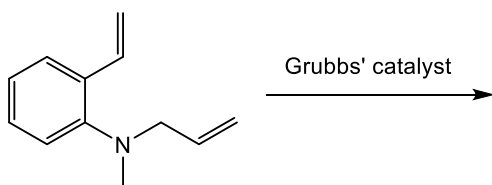
F

6. Which reactions will give the same major product?

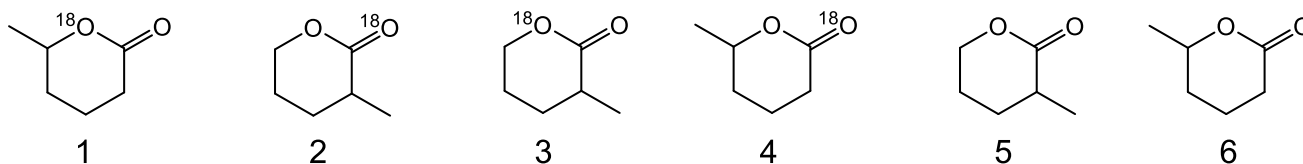
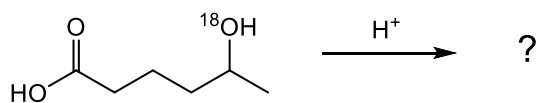


- A. 1 and 2    B. 1 and 3    C. 1 and 4    D. 2 and 3    E. 2 and 4    F. 3 and 4

7. Select the major product of the following ring-closing metathesis.

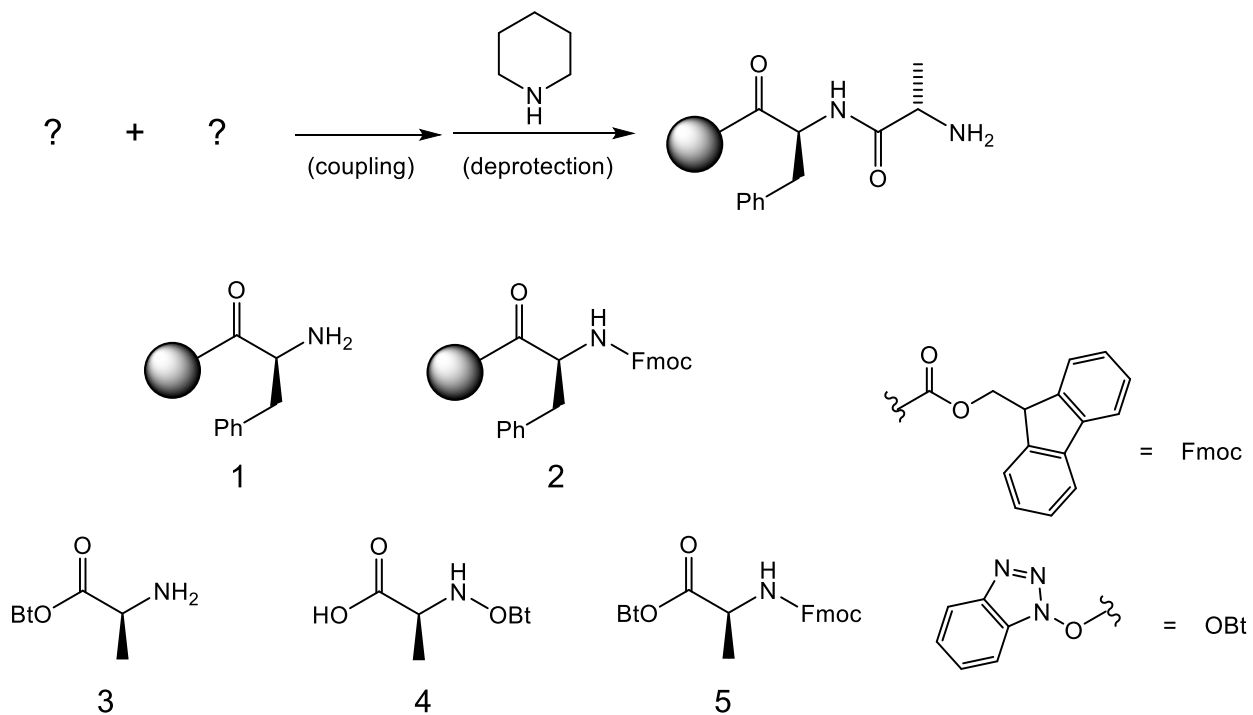


8. Select the expected major product(s) of the following reaction that utilizes oxygen-18 radiolabeling.



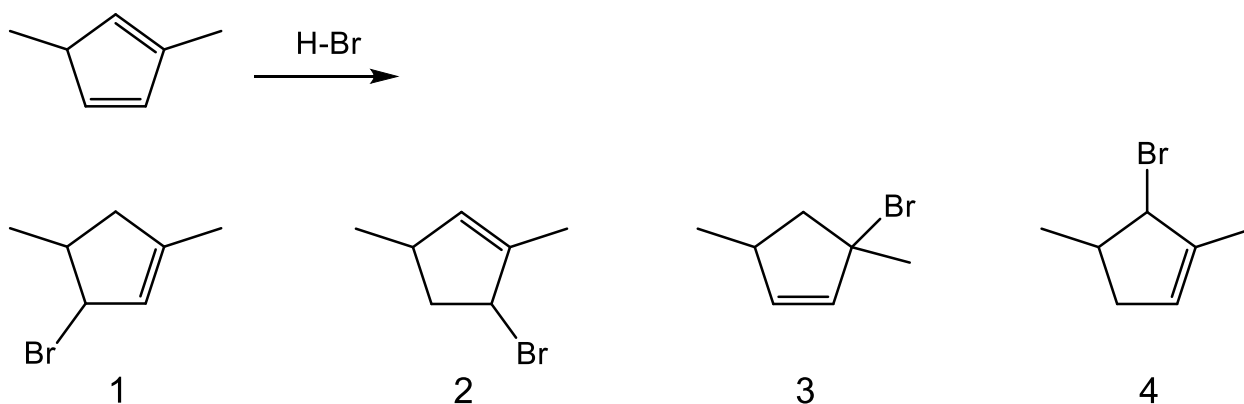
- A. 1 only    B. 3 only    C. 1 and 4    D. 2 and 3    E. 3 and 5    F. 1 and 6

9. The following is part of a solid-phase peptide synthesis. Choose the correct reagents for the coupling step to add alanine to the chain.



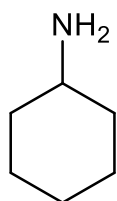
- A. 1 and 3    B. 1 and 4    C. 1 and 5    D. 2 and 3    E. 2 and 4    F. 2 and 5

10. Choose the two major products (kinetic and thermodynamic) of the following reaction.

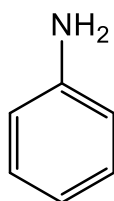


- A. 1 and 2    B. 1 and 3    C. 1 and 4    D. 2 and 3    E. 2 and 4    F. 3 and 4

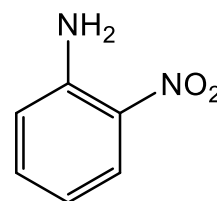
11. Select the order that has the following amines correctly arranged with respect to **increasing** basicity.



1



2



3

A 1 &lt; 2 &lt; 3

B 1 &lt; 3 &lt; 2

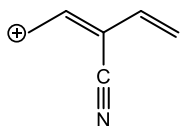
C 2 &lt; 1 &lt; 3

D 2 &lt; 3 &lt; 1

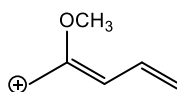
E 3 &lt; 1 &lt; 2

F 3 &lt; 2 &lt; 1

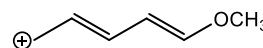
12. Choose the order that has the following pentadienyl cations correctly arranged with respect to **increasing** stability.



1



2



3

A  $\xrightarrow{\text{increasing stability}}$  1 2 3

B  $\xrightarrow{\text{increasing stability}}$  1 3 2

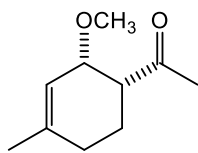
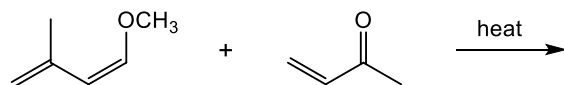
C  $\xrightarrow{\text{increasing stability}}$  2 1 3

D  $\xrightarrow{\text{increasing stability}}$  2 3 1

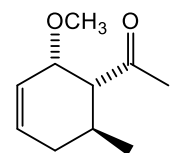
E  $\xrightarrow{\text{increasing stability}}$  3 1 2

F  $\xrightarrow{\text{increasing stability}}$  3 2 1

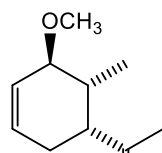
13. Choose the major product of the following Diels-Alder reaction. Each choice represents one enantiomer of a racemic mixture.



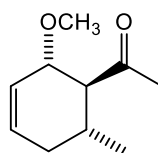
A



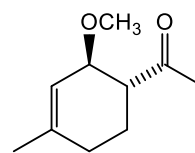
B



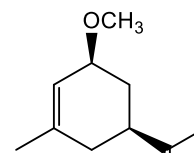
C



D

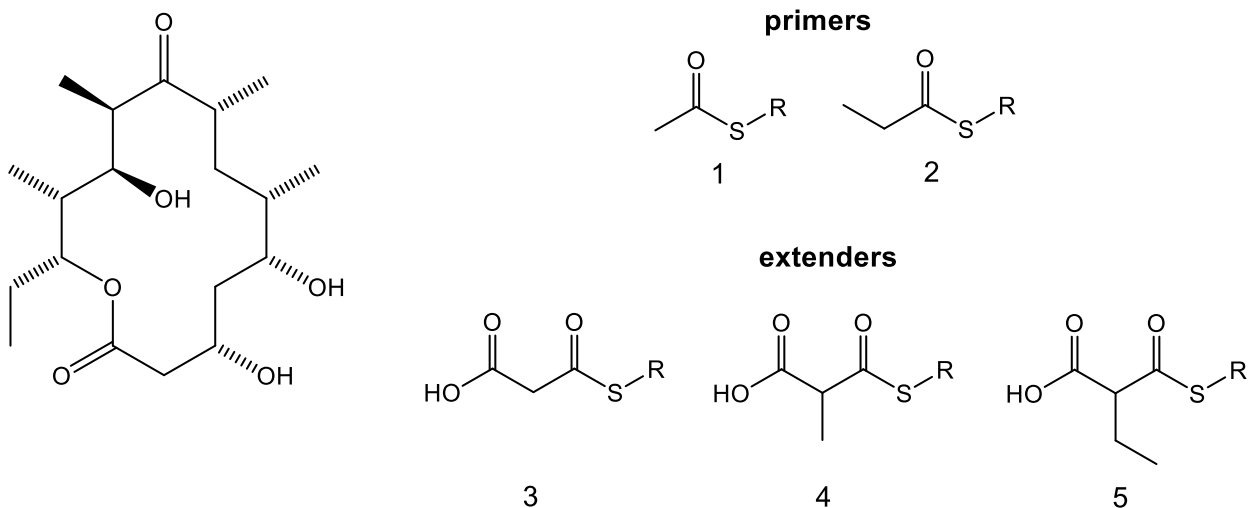


E



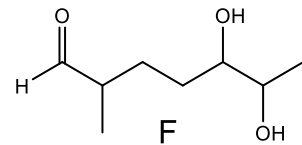
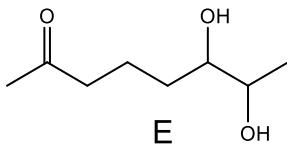
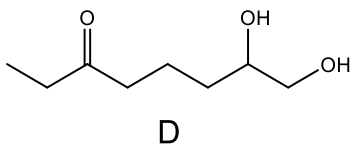
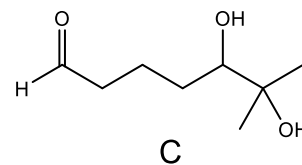
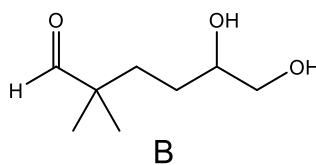
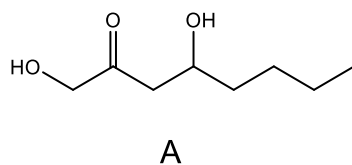
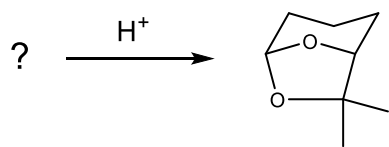
F

14. Which primer and extenders would be required for the biosynthesis of the following macrolide?

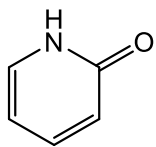


- A. One mole of **1**, two moles of **3**, four moles of **4**
- B. One mole of **1**, one mole of **3**, four moles of **4**, one mole of **5**
- C. One mole of **1**, five moles of **4**, one mole of **5**
- D. One mole of **2**, two moles of **3**, four moles of **4**
- E. One mole of **2**, one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

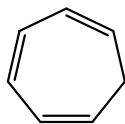
15. Select the reactant that would give the following acetal as the major product of the following reaction.



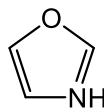
16. Which of the following compounds is(are) aromatic?



1



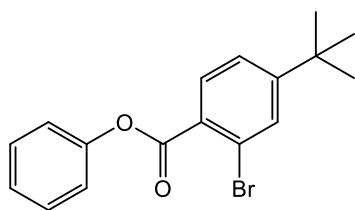
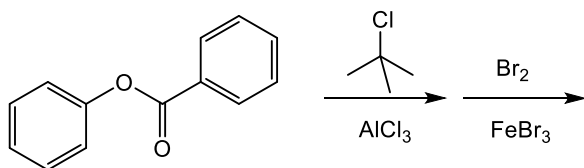
2



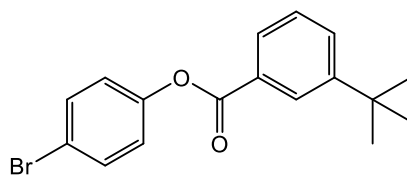
3

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

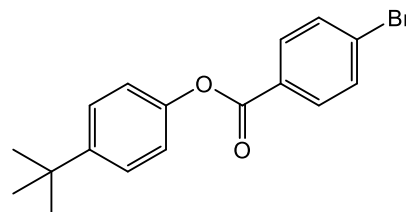
17. Choose the major product of the following reaction sequence.



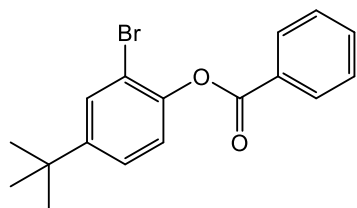
A



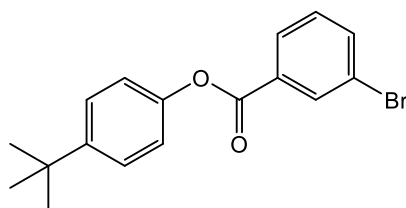
B



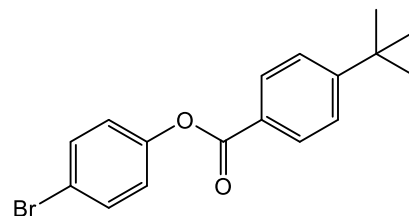
C



D

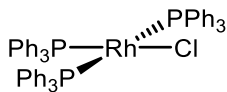


E



F

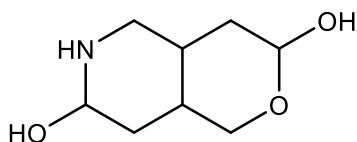
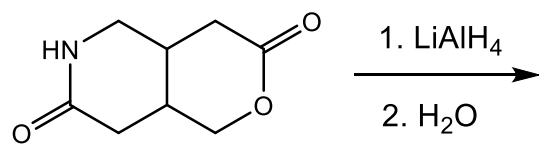
18. What is the oxidation state of Rh, and the total electron count of the following complex?



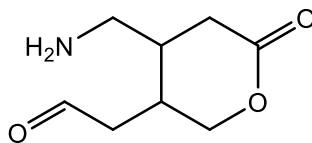
- A. Rh(I), 14 e<sup>-</sup>   B. Rh(I), 16 e<sup>-</sup>   C. Rh(I), 18 e<sup>-</sup>   D. Rh(III), 14 e<sup>-</sup>   E. Rh(III), 16 e<sup>-</sup>   F. Rh(III), 18 e<sup>-</sup>



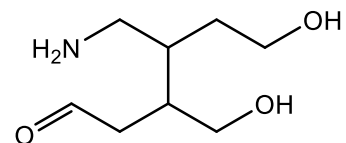
19. Choose the major product of the following reduction reaction.



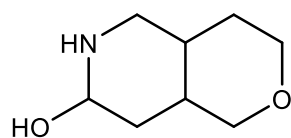
A



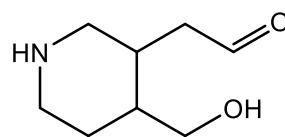
B



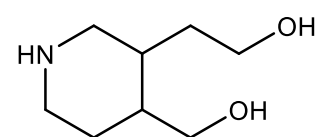
C



D

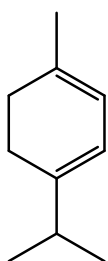
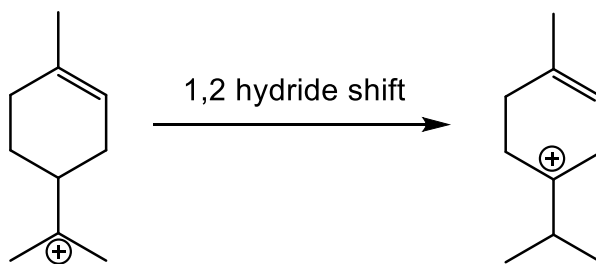


E

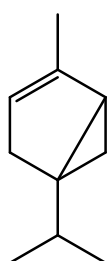


F

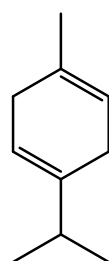
20. Terpinyl cation can undergo a 1,2 hydride shift to another cationic intermediate that is necessary to make several terpene molecules. Which of the 5 terpene molecules below will **NOT** be synthesized from this intermediate?



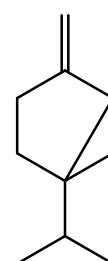
A



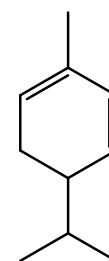
B



C

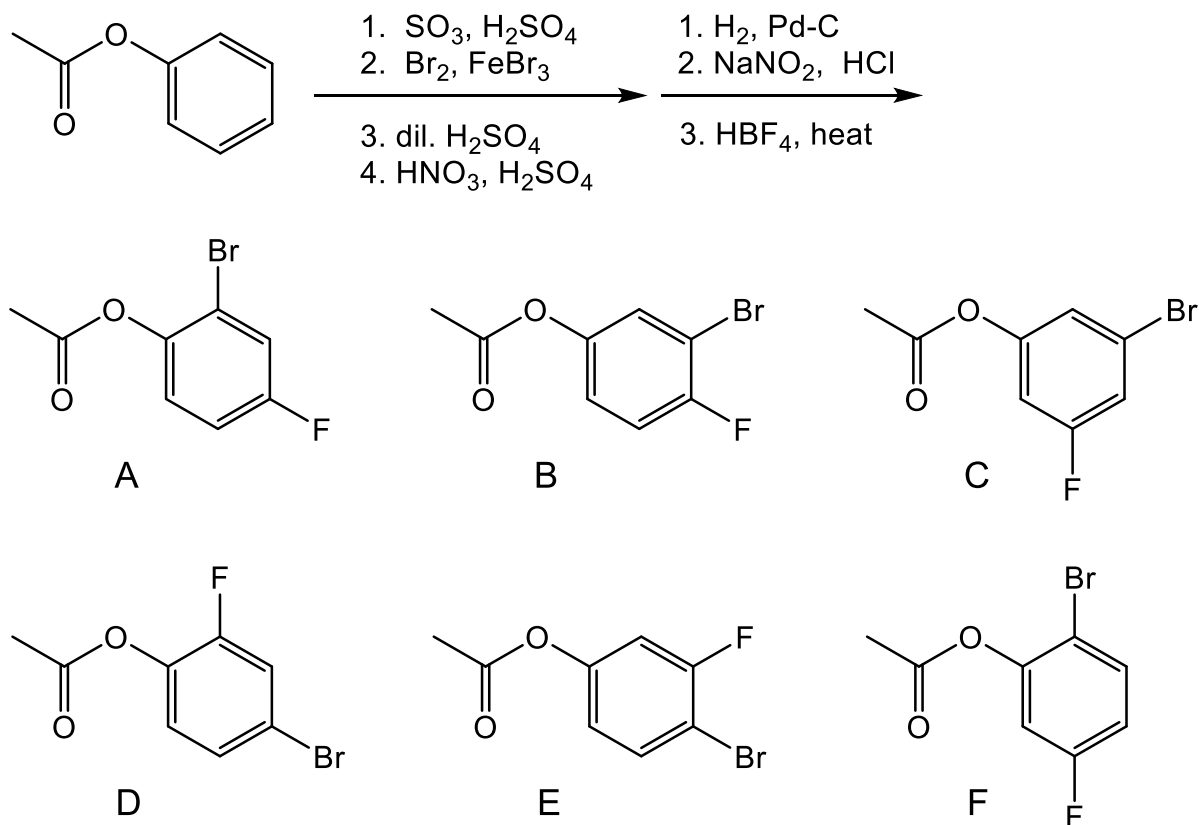


D

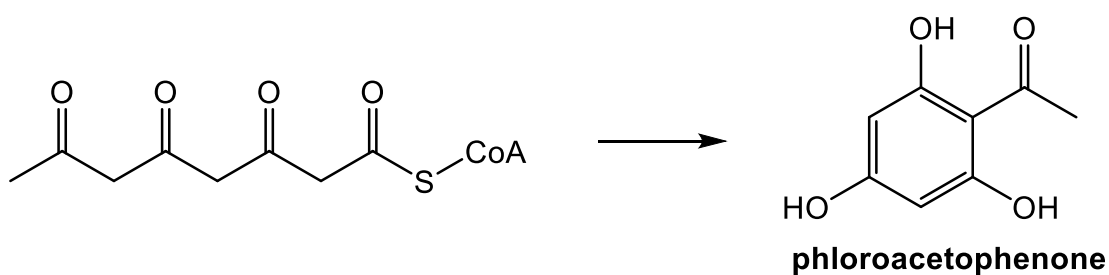


E

21. Select the expected major product of the following reaction sequence.

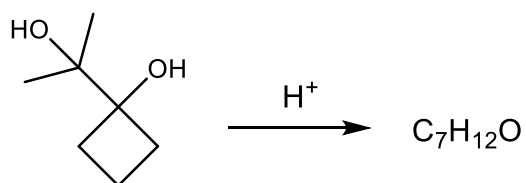


22. What mechanistic steps does the precursor shown below undergo to make phloroacetophenone?

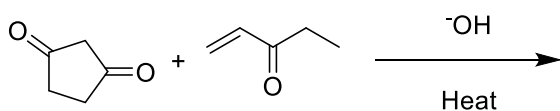


- Aldol condensation, followed by three tautomerizations
- Claisen condensation, followed by three tautomerizations
- Aldol condensation, followed by two tautomerizations, followed by an ester hydrolysis
- Claisen condensation, followed by two tautomerizations, followed by an ester hydrolysis
- Aldol condensation, followed by two tautomerizations, followed by decarboxylation
- Claisen condensation, followed by three tautomerizations, followed by decarboxylation

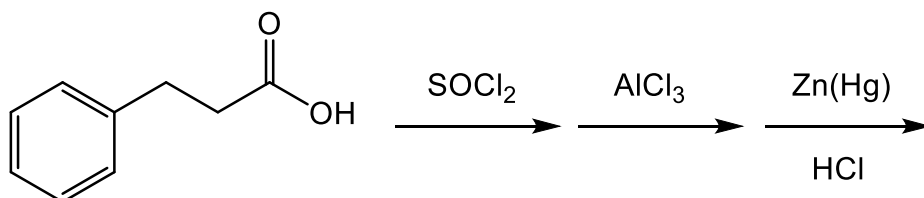
23. Draw the major product of the following pinacol rearrangement that will involve a ring expansion. (5 points)



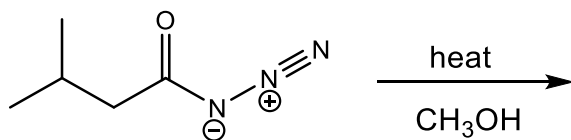
24. Draw the major product of the following intermolecular Robinson Annulation. (5 points)



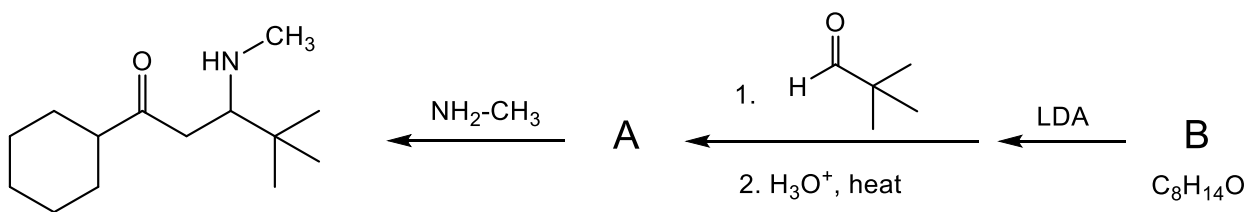
25. Draw the major product of the following reaction sequence. (5 points)



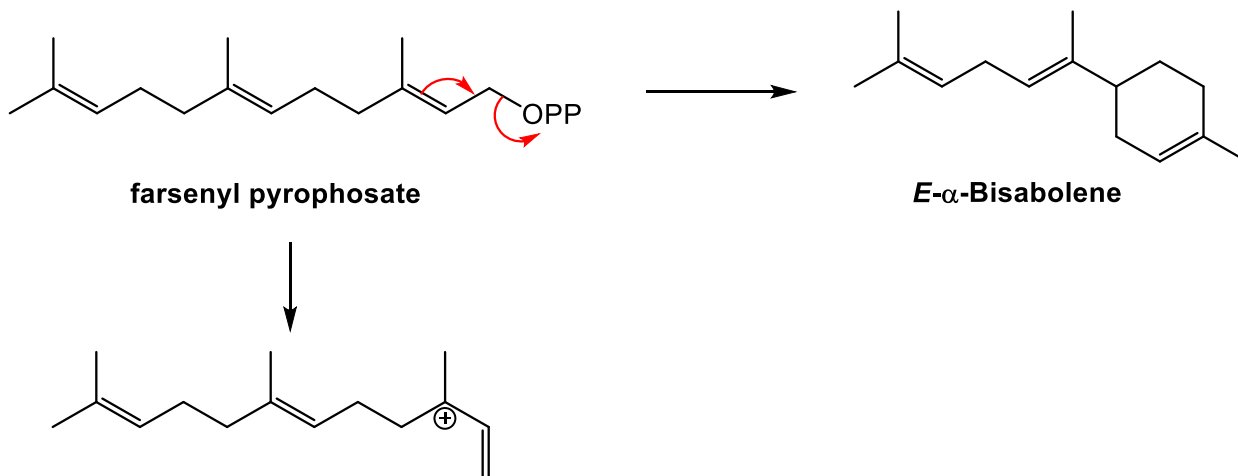
26. Draw the major product of the following rearrangement reaction. (5 points)



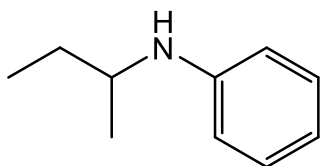
27. Determine and draw the structures of compounds **A** and **B**. (10 points)



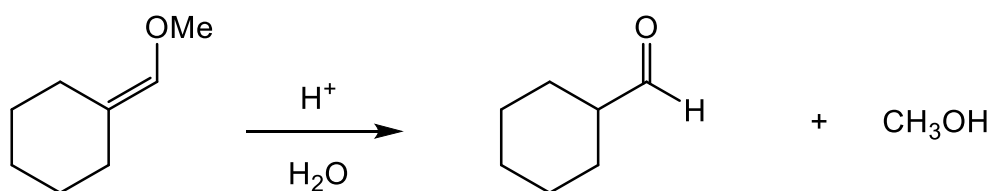
28. Farnesyl pyrophosphate is a precursor to the terpene *E*- $\alpha$ -Bisabolene. Propose a curved arrow biosynthetic pathway for its biosynthesis. The mechanism has already been started for you. Begin from the cation shown. HINT: redrawing the cation in a different conformation will make it easier for you to see the connection that must be made. (10 points)



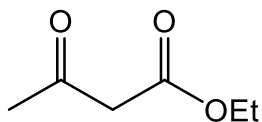
29. Propose a synthesis of the target compound starting from benzene. You may use any other reagents/reactants. (10 points)



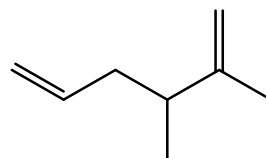
30. Draw a curved arrow mechanism of the following hydrolysis reaction. HINT: For the first step, think about how an enol would react with acid. (10 points)



31. Propose a synthesis of the target compound starting from ethyl acetoacetate using an acetoacetic ester synthesis. HINT: one Wittig reaction at the end may be a good idea. (10 points)



starting material



target compound







