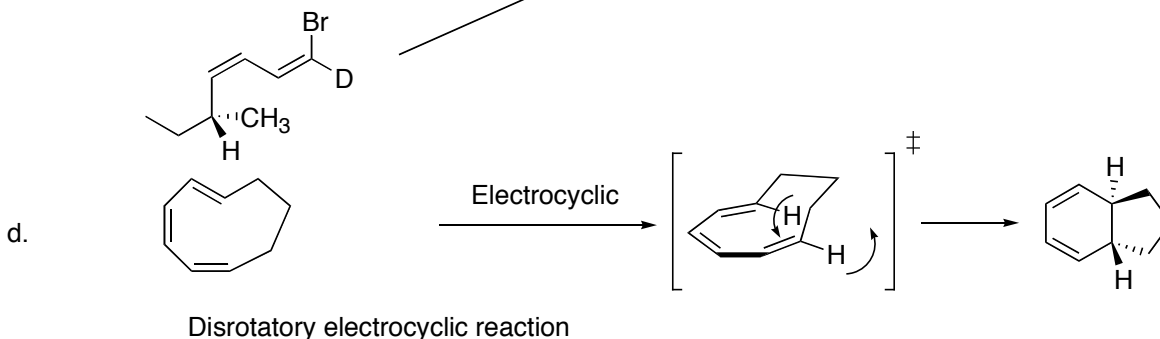
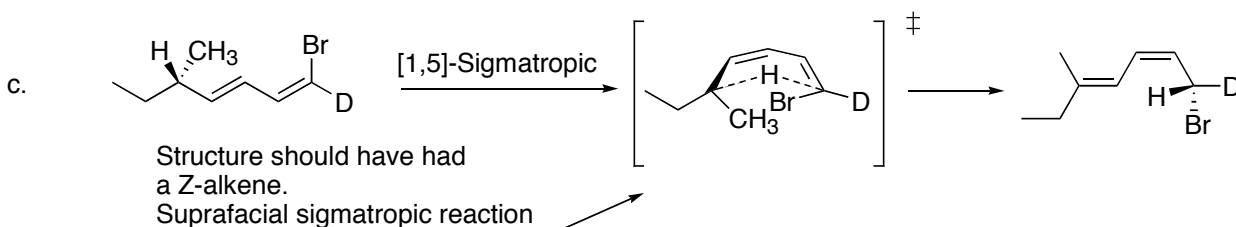
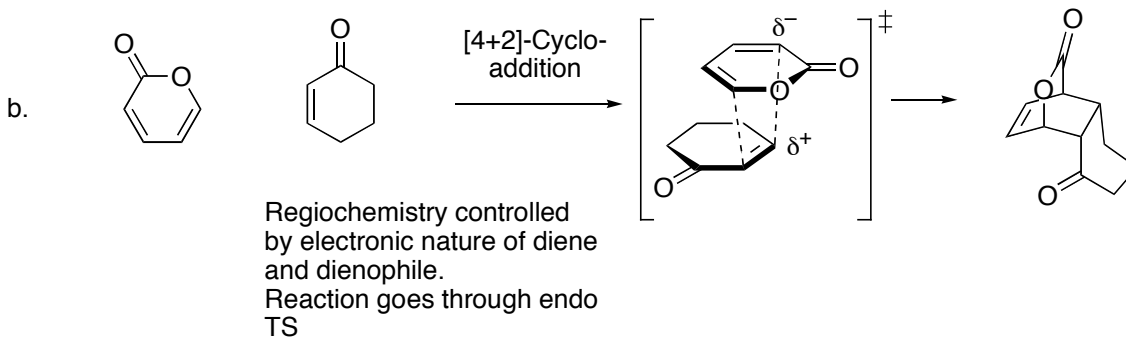
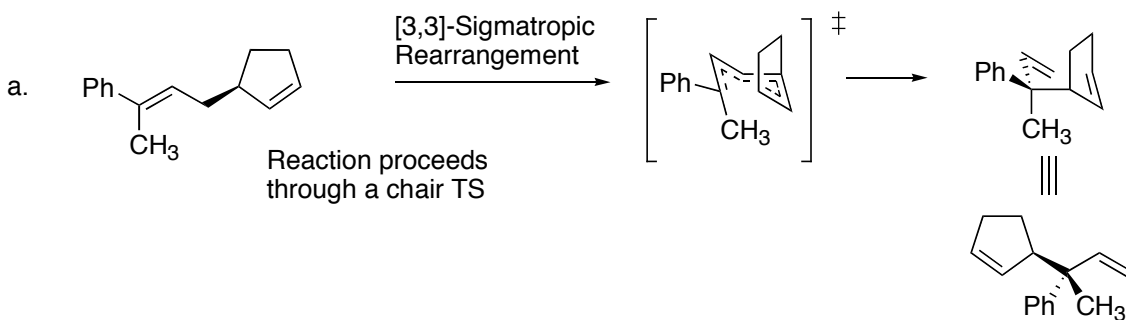
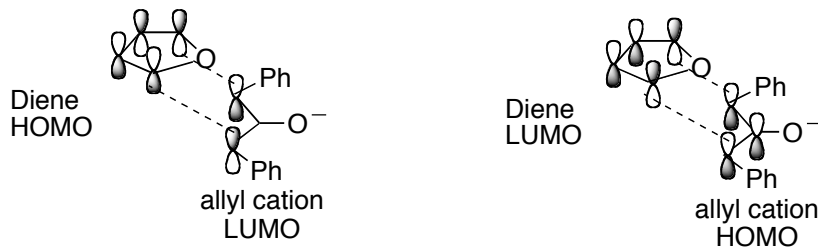
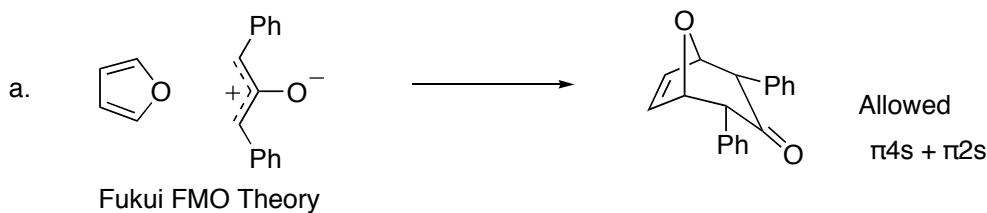


Names: ANSWER KEY

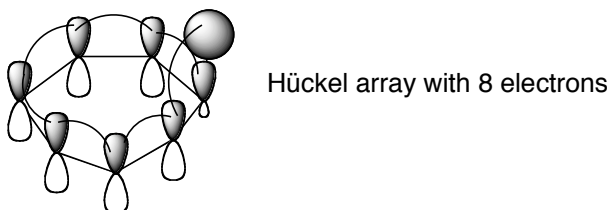
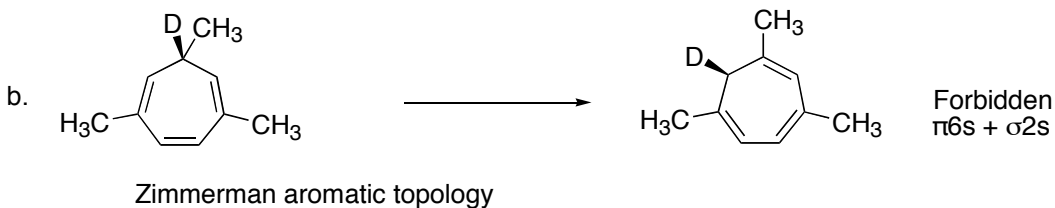
1. For each reaction below, draw the major product formed in the thermodynamically allowed pericyclic reaction indicated. Draw the transition state that leads to the expected product. Be sure to clearly indicate the stereochemistry of every stereogenic center in your product. (20 points)

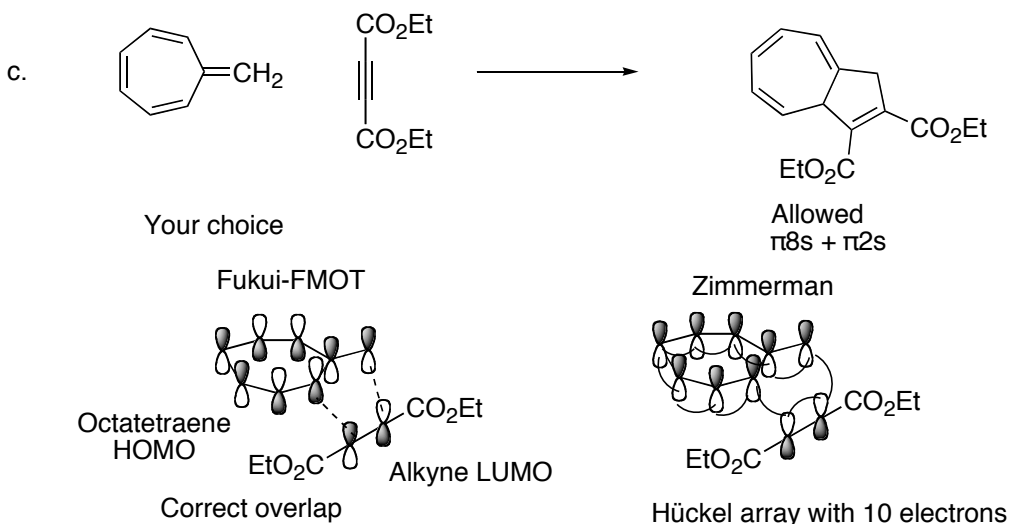


2, For the reactions below, use the indicated technique to determine whether the reaction as drawn would be thermally allowed or forbidden. In addition, describe each reaction using the Woodward-Hoffman designations (i.e. $\pi 2s$). (18 points)

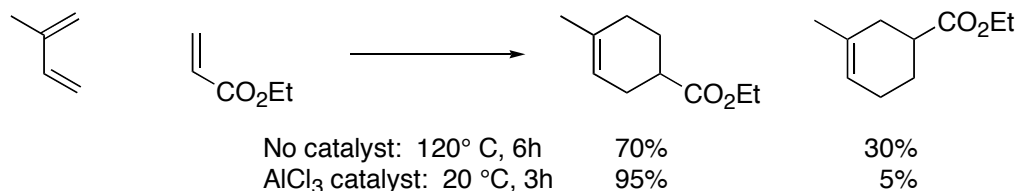


Correct overlap of HOMO and LUMO in each case





3. Lewis acids are often used to accelerate Diels-Alder reactions. Provide a brief explanation of why the Lewis acid would accelerate the reaction shown below. Also explain why the regioselectivity of the reaction improves when AlCl_3 is used. (12 points)



The Lewis acid coordinates to the ester function of the dienophile. This coordination makes the ester group a stronger electron withdrawing functionality. As a result the HOMO and LUMO of the dienophile are further lowered in energy. This lowering brings the dienophile LUMO closer in energy to the diene HOMO, which results in a better overlap and a faster reaction.

The regioselectivity increases because the Lewis acid increases the electrophilicity of the β -carbon (i.e. gives it a larger LUMO coefficient). The larger the difference in LUMO coefficients for the carbons on the dienophile, the more regioselective the reaction will be. Alternatively, the more electrophilic the β -carbon, the stronger the preference for the electron rich carbon of the diene to react at that site.

4. The synthesis of endriatic acid (**E**), which contains 8 chiral centers, is shown on the next page. **E** can be prepared as a single diastereomer starting from an achiral heptaene (**A**) by a series of 3 thermally allowed pericyclic reactions. **A** is converted to **B** which further reacts to give a diastereomeric mixture of **C** and **D**. Only **D** can go on to give **E**. (28 points)

- a. On the next page provide each missing structure showing the configuration of every stereogenic center.
- b. Classify each reaction below according to reaction type (electrocyclic cyclization (conrotatory or disrotatory), sigmatropic rearrangement (give numbering), or cycloaddition (endo or exo))

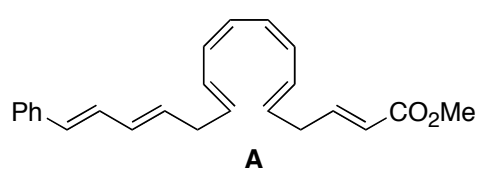
A → **B** 8 e conrotatory electrocyclic cyclization

B → **D** 6 e disrotatory electrocyclic cyclization

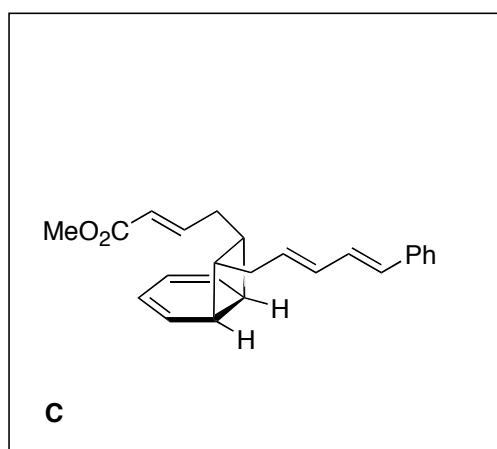
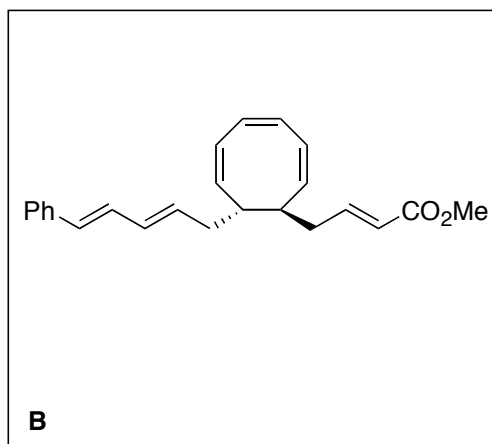
D → **E** [4+2] cycloaddition via exo TS

- c. Why is **D** converted to **E**, while the diastereomer **C** is not?

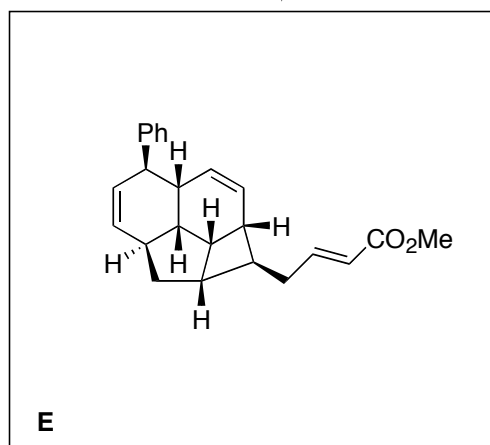
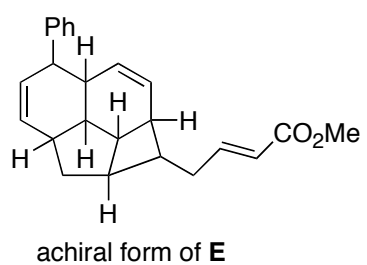
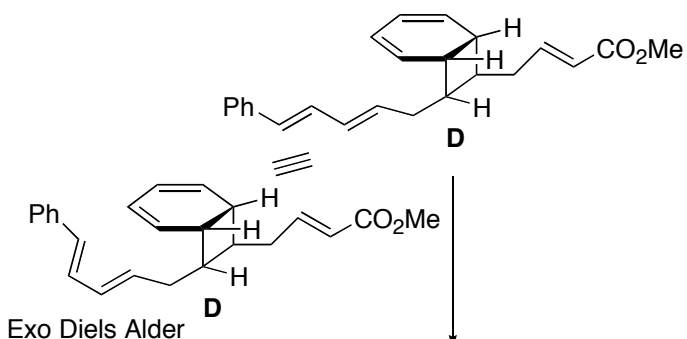
E is the diastereomer of **D** formed by cyclizing via the opposite rotation. This product has the diene pointed away from the cyclic dienophile, so no Diels-Alder reaction is possible.



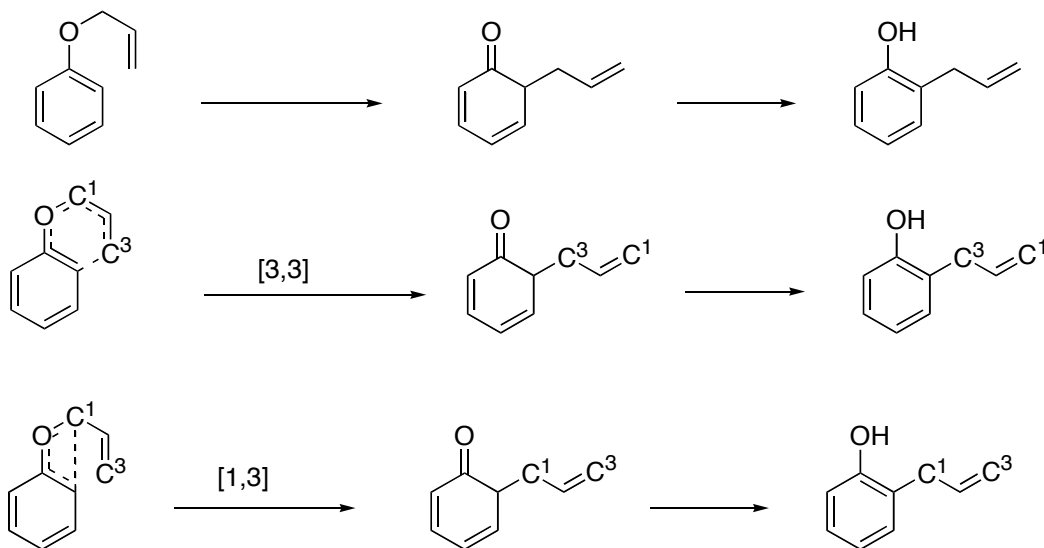
conrotatory 8 e
 electrocyclicization



disrotatory 6 e
 electrocyclicization

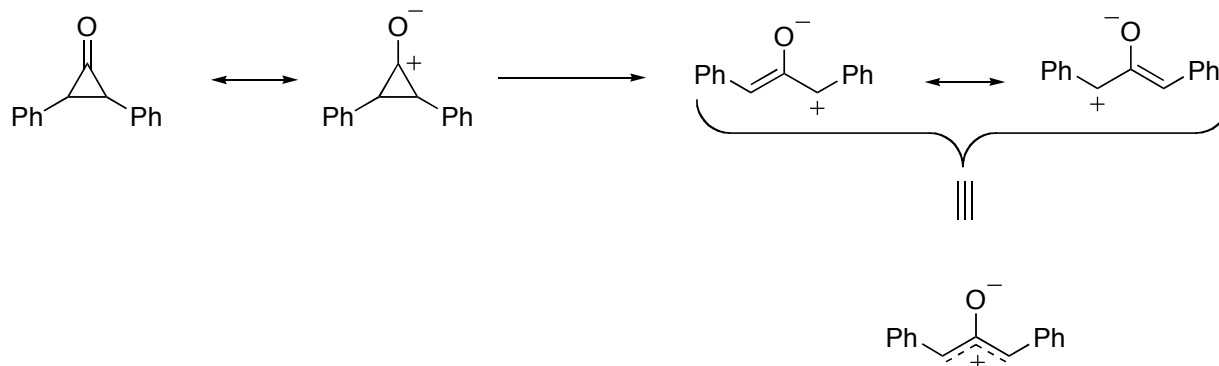


5. The rearrangement of allyl phenyl ethers could be imagined to occur by a [1,3]-sigmatropic rearrangement or a [3,3]-sigmatropic rearrangement. Both reactions could be thermally allowed and would give the same product. Provide a brief, but detailed description of how you could experimentally distinguish which type of sigmatropic reaction was truly occurring. You may use any experimental approach that seems appropriate, including the use of alternate substrates. (10 points)



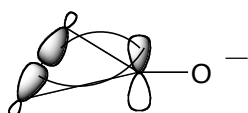
In the [1,3] rearrangement, C¹ forms the bond with the aromatic ring. In the [3,3]-sigmatropic RAR, it is C³ that forms the new bond to the ring. Anything that would allow you to distinguish C¹ from C³ in the product would work. For example, you could put D at either C¹ or C³, or label one of them with ¹³C.

6. The oxyallyl species shown in problem 2a can be derived from cyclopropanones by an electrocyclic ring opening. (12 points)



- a. Draw key molecular orbitals for the charge-separated cyclopropanone resonance structure and use FMO theory to determine whether this reaction should occur in a disrotatory or conrotatory fashion.

σ bond HOMO



C^+ LUMO

$\sigma 2s + \pi 0s$ reaction

A disrotatory ring opening is required to give the correct overlap.

- b. Which stereoisomer (*cis*- or *trans*-) of the diphenylcyclopropanone would be needed to provide the oxyallyl stereoisomer shown above?

Since the reaction must be disrotatory, you would need to start with the *cis*-isomer.

