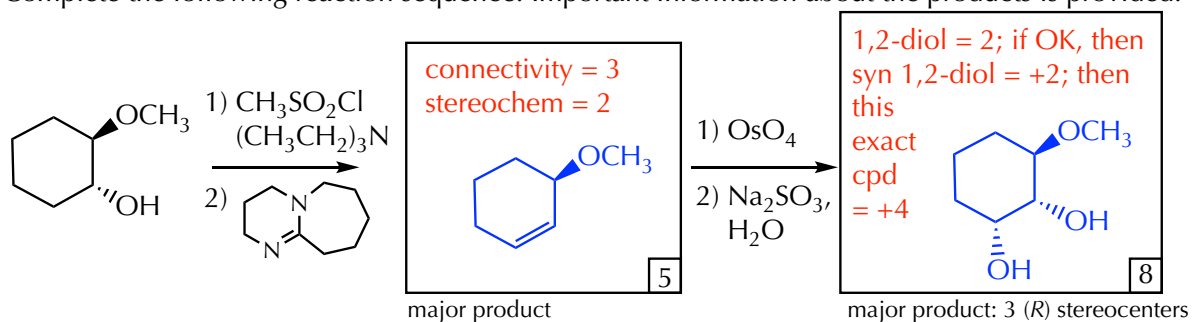
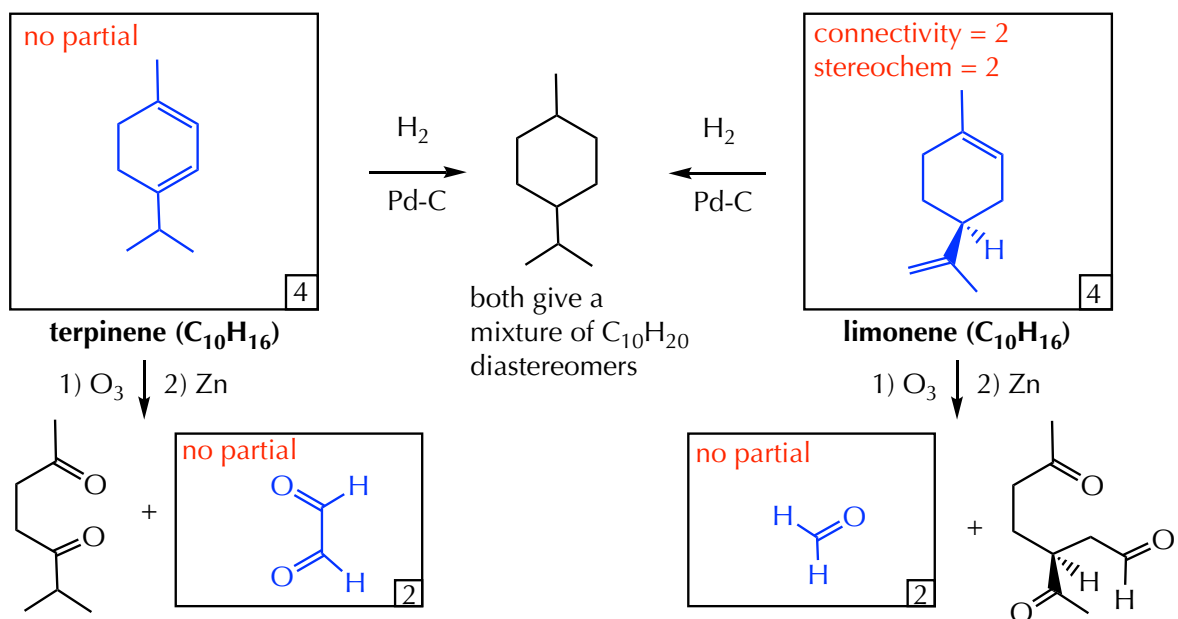


### Question I (31 points)

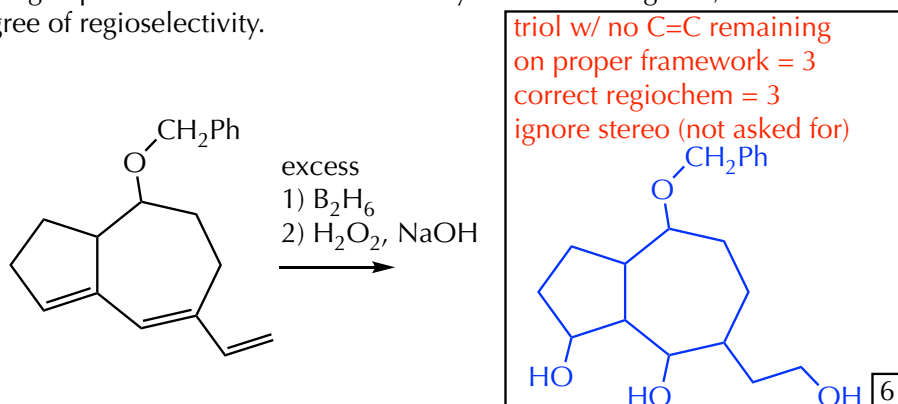
A. Complete the following reaction sequence. Important information about the products is provided.



B. Terpinene and limonene are  $C_{10}H_{16}$  structural isomers. Use the information below to complete the two ozonolysis reactions of these compounds (both of which give two products) and deduce their structures (including stereochemistry). As gases, both hydrogen and ozone are used in excess.

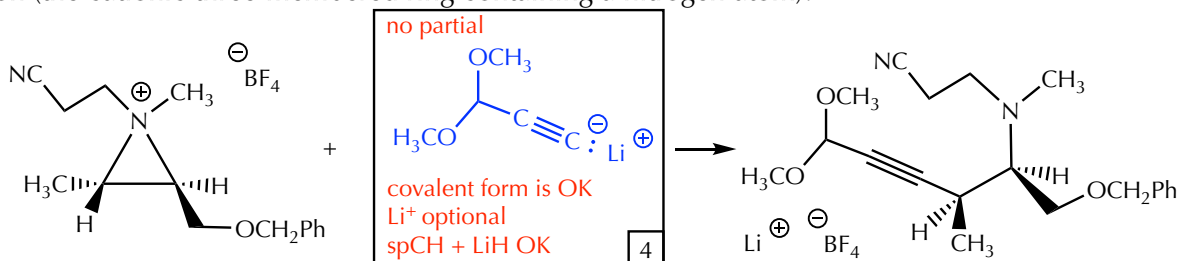


C. The following compound was treated with an excess of diborane ( $B_2H_6$ ) followed by basic hydrogen peroxide. Draw the connectivity of the resulting triol, which was formed with a high degree of regioselectivity.



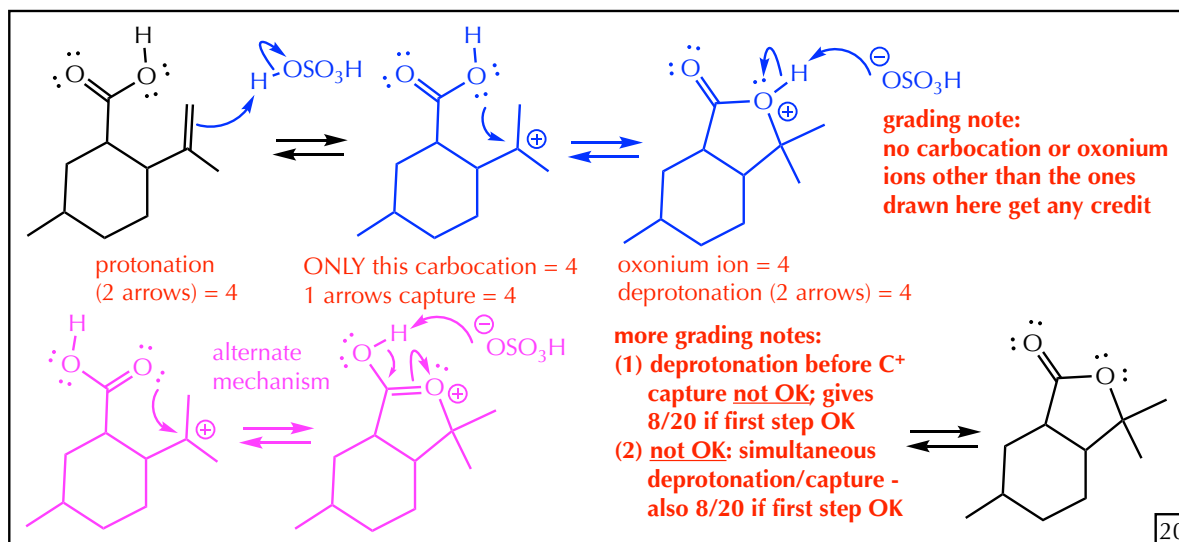
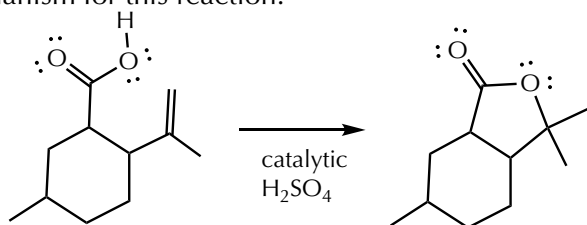
**Question II (28 points)**

- A. Halonium ions are only one type of cationic three-membered ring that can be opened by nucleophiles. What is the structure of the nucleophile that opens the following aziridinium ion (the cationic three-membered ring containing a nitrogen atom)?

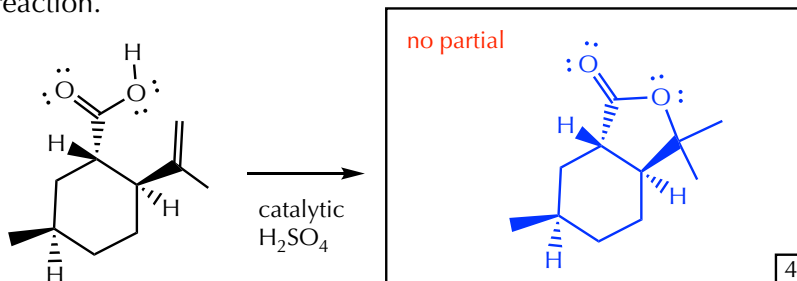


- B. When treated with a catalytic amount of sulfuric acid, the following compound undergoes the reaction shown here.

- (a) Using H-OSO<sub>3</sub>H as your acid and <sup>⊖</sup>OSO<sub>3</sub>H as its conjugate base, provide the stepwise, curved arrow mechanism for this reaction.



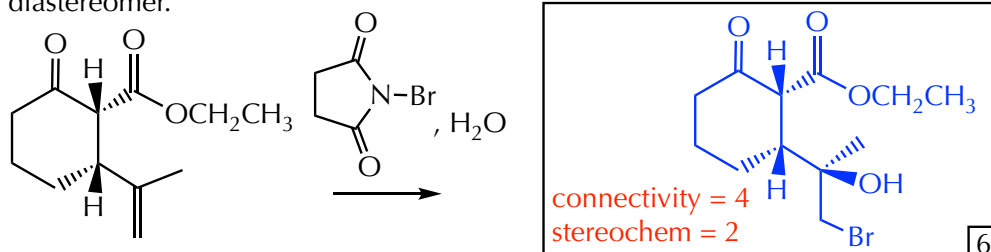
- (b) Based upon the information above, draw the single stereoisomeric product from the following reaction.



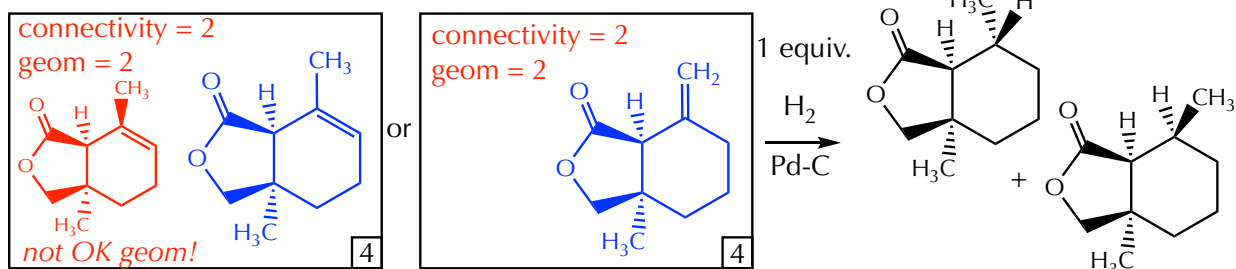
**Question III (30 points)**

General reminder to pay attention to drawing the proper geometry at atoms where it is changing during a reaction.

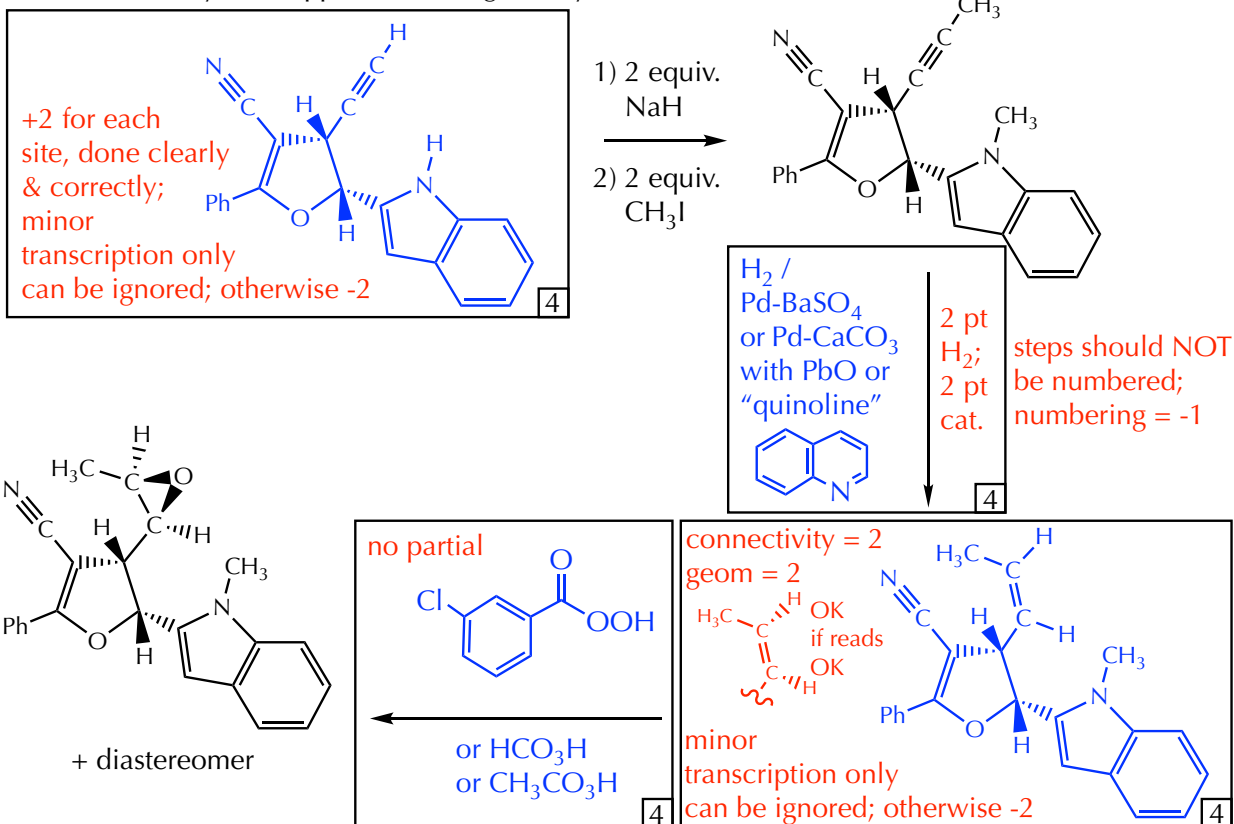
- A. The following reaction, using *N*-bromosuccinimide and water, gives a mixture of stereoisomeric products. The major diastereomer has the (*R*) configuration at all of its stereocenters. Draw this major diastereomer.



- B. Draw the structures for the two isomeric starting materials that, upon catalytic hydrogenation, give this pair of stereoisomeric products.

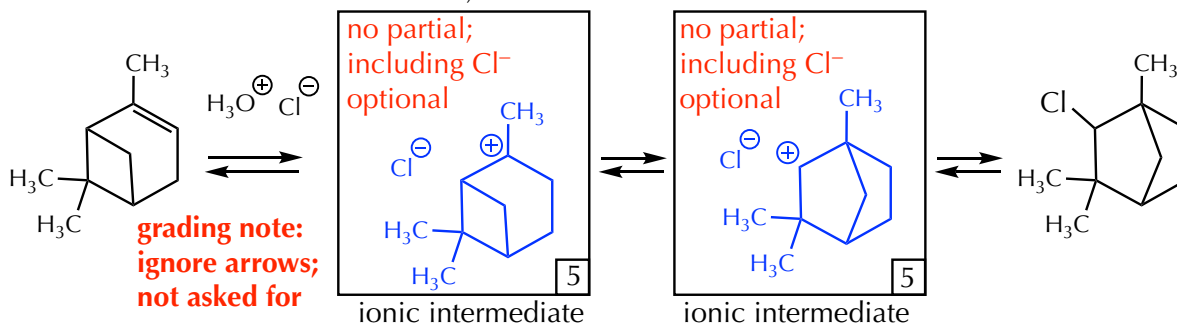


- C. Complete the following (*Org Lett*, **2021**, 10.1021/acsorglett.1c03225); draw out the reagents and/or catalysts as opposed to using acronyms and abbreviations.

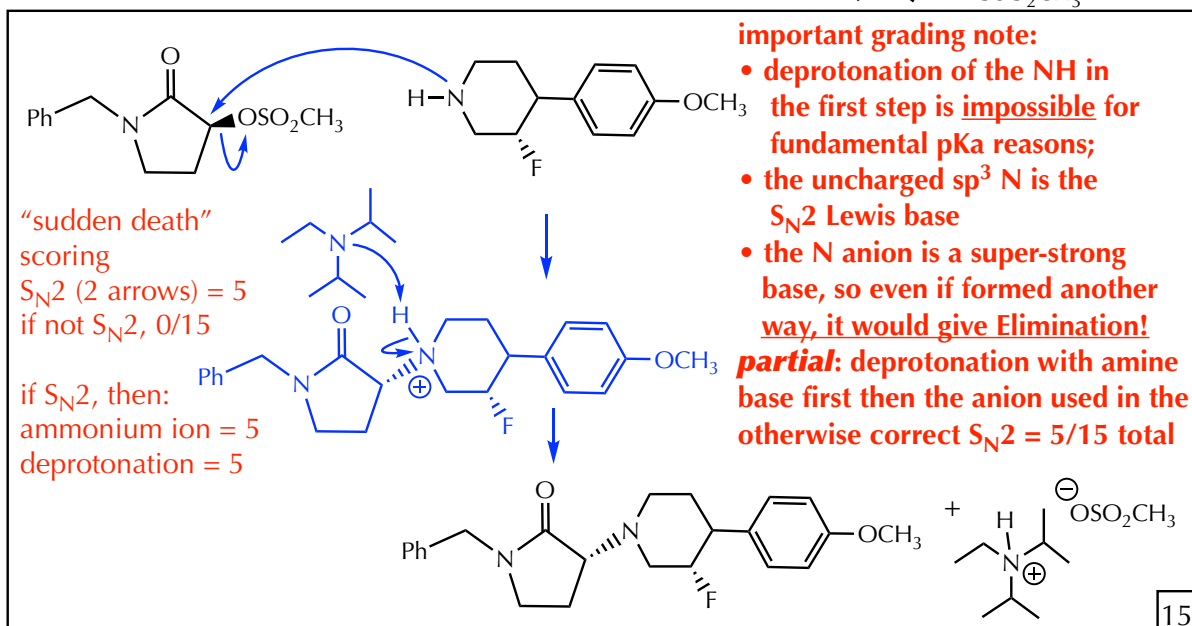
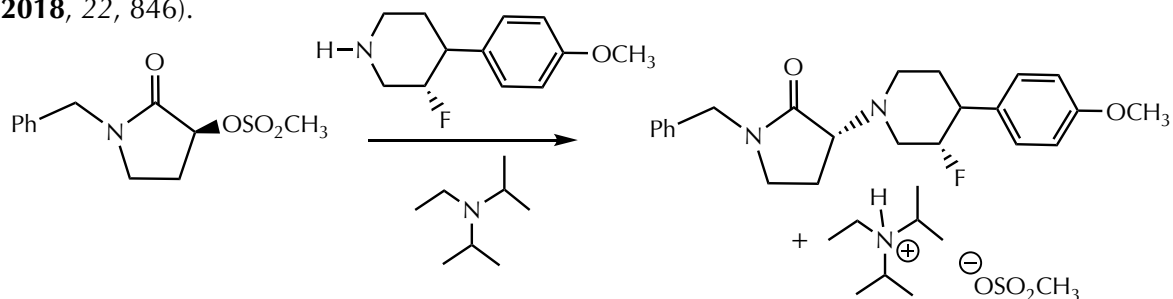


### Question IV (25 points)

- A. When the natural terpene named  $\alpha$ -pinene is treated with concentrated aqueous HCl, a new compound (bornyl chloride) is formed. The reaction mechanism is proposed to require two ionic intermediates. What are they (note: arrows are not being asked for here, only the structures of the ionic intermediates)?

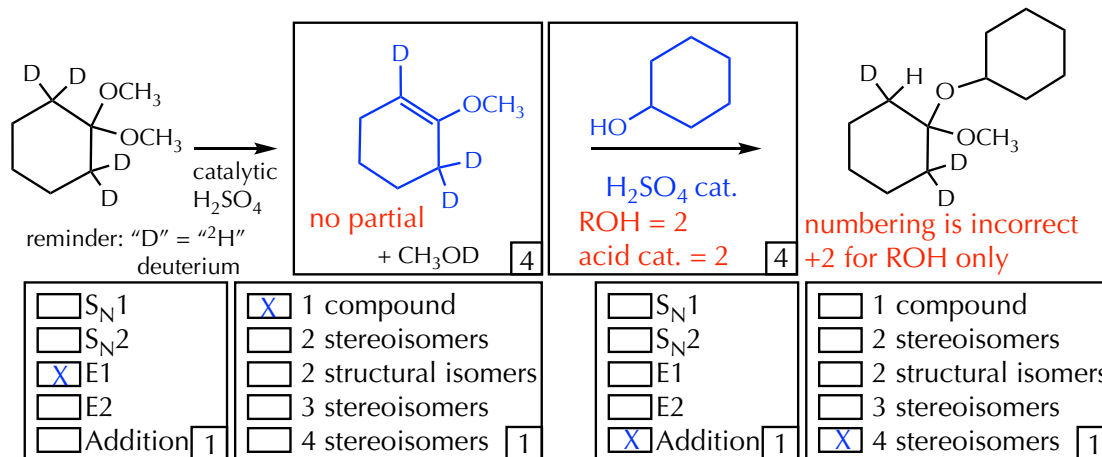


- B. Provide the curved arrow mechanism for the following transformation (*Org Process Res Dev*, 2018, 22, 846).



**Question V (26 points)**

- A. Complete the following reaction sequence with structures, reagents, and/or catalysts, as needed, and select the descriptor(s) that apply to each step and its product(s).



- B. Complete the following reaction sequence with structures, reagents, and/or catalysts, as needed, and select the descriptor(s) that apply to each step and its product(s).

