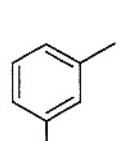
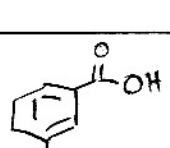
1) Predict the major organic product of each of the following reactions or reaction sequences. If no reaction occurs, write "N.R." Assume *para* is the major product (and separable from *ortho*) in *ortho, para* mixtures (35 pts)

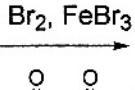


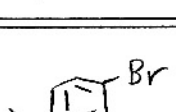
$KMnO_4$

H_2O, Δ



1. $Br_2, FeBr_3$

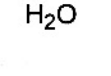
2.  $/AlCl_3$



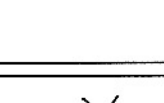
Br_2

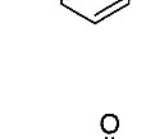
H_2O

N.R.



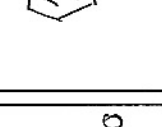
trace H_2SO_4

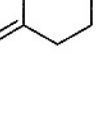




Na

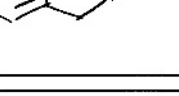
NH_3, CH_3OH

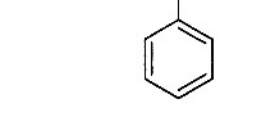




1. NBS, CCl_4, Δ

2. NaOH

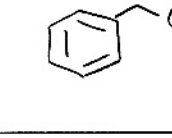




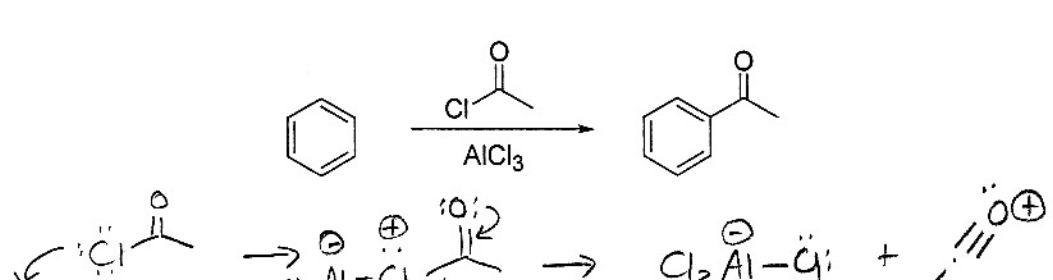
1. $SOCl_2$

2. $AlCl_3$

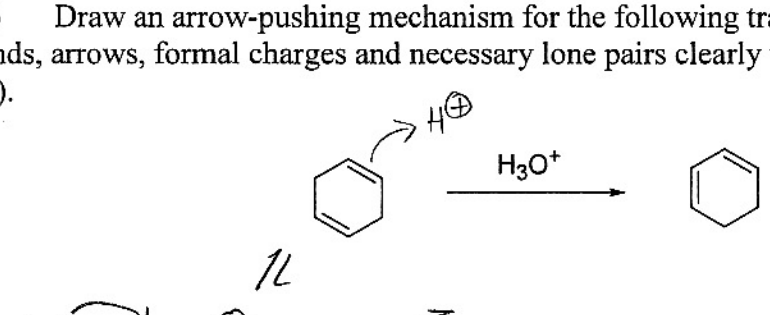
3. H_2NNH_2, KOH, Δ, triethylene glycol



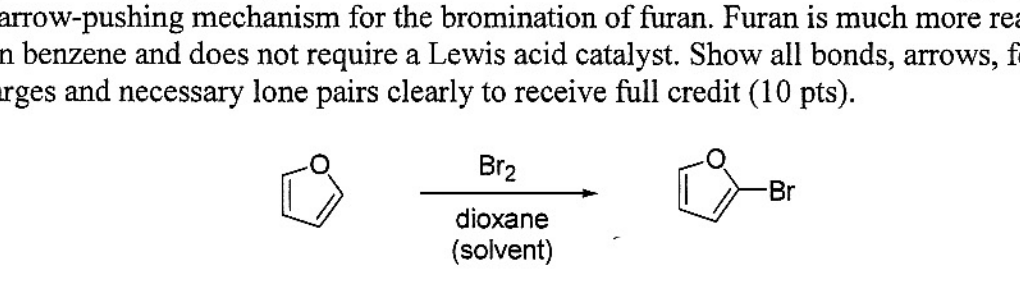
2a) Draw an arrow-pushing mechanism for *the formation of the electrophile only* in the following transformation. Show all bonds, arrows, formal charges and necessary lone pairs clearly to receive full credit (10 pts).



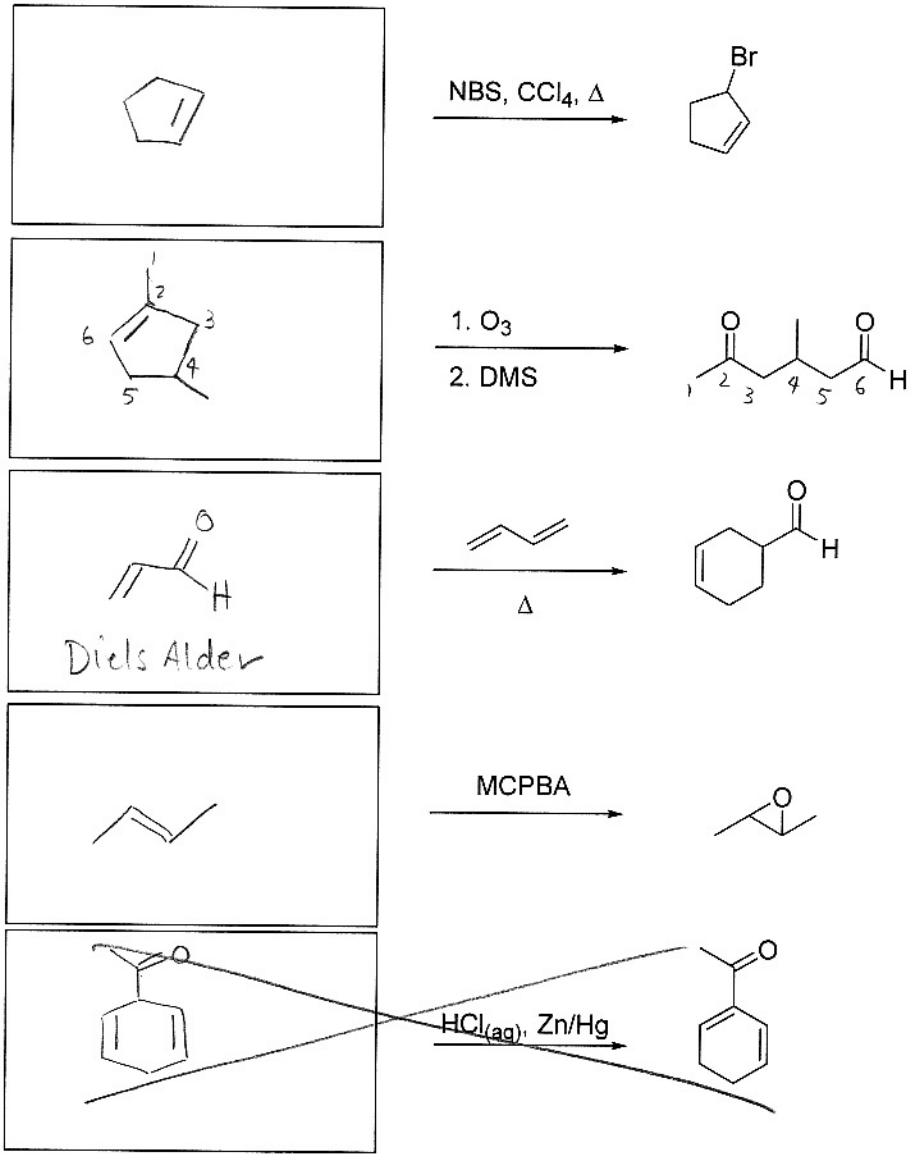
2b) Draw an arrow-pushing mechanism for the following transformation. Show all bonds, arrows, formal charges and necessary lone pairs clearly to receive full credit (10 pts).



2c) Using the principles of electrophilic aromatic substitution mechanisms, propose an arrow-pushing mechanism for the bromination of furan. Furan is much more reactive than benzene and does not require a Lewis acid catalyst. Show all bonds, arrows, formal charges and necessary lone pairs clearly to receive full credit (10 pts).



3) Provide the starting material necessary to produce each of the molecules shown using the given reagents. Some may have more than one possible precursor, but you just have to draw one (15 pts).



4) Propose multi-step syntheses of each of the following target molecules using the starting materials shown. You may use any inorganic reagents and organic reagents containing four or fewer carbons. You don't have to draw any mechanisms, just write the reagents needed for each step and the product of each step (20 pts).