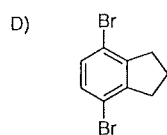
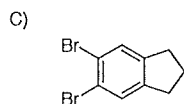
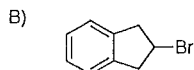
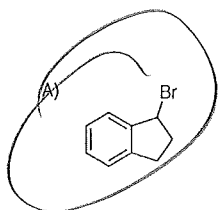
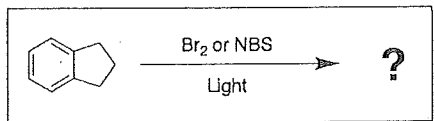


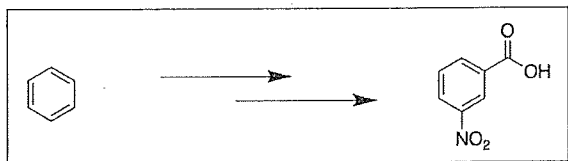
# You are not allowed to post this key on the internet!

Questions 1 to 31 please use the front of the Scantron form

1. Which of the following is a major product of the reaction shown in the box? –  $^{13}\text{C}$  NMR: 9 signals.



2. Which of the following will convert benzene into 3-nitrobenzoic acid in high yield?



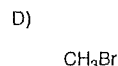
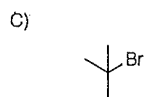
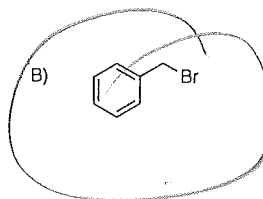
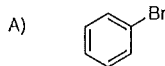
A) 1.  $\text{CH}_3\text{MgBr}$  2.  $\text{HCl}$ ,  $\text{H}_2\text{O}$  3.  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$  4.  $\text{H}_2\text{CrO}_4$

B) 1.  $\text{CH}_3\text{Cl}$ ,  $\text{AlCl}_3$  2.  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$  3.  $\text{H}_2\text{CrO}_4$

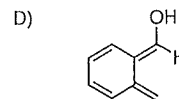
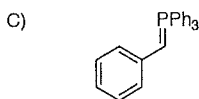
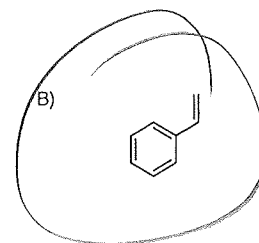
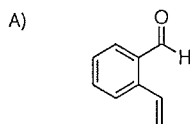
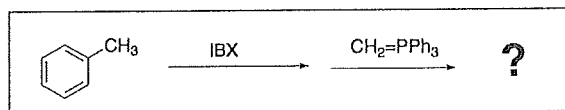
C) 1.  $\text{CH}_3\text{Cl}$ ,  $\text{AlCl}_3$  2.  $\text{H}_2\text{CrO}_4$  3.  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$

D) 1.  $\text{H}_2\text{CrO}_4$  2.  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$  3.  $\text{CH}_3\text{Cl}$ ,  $\text{AlCl}_3$

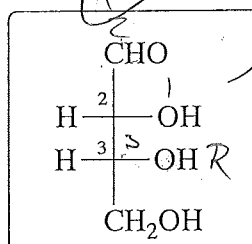
3. Which of the following has the ability to react via both  $\text{S}_{\text{N}}1$  and  $\text{S}_{\text{N}}2$  mechanism?



4. What is major product of the reaction sequence shown in the box? –  $^{13}\text{C}$  NMR: 6 signals.



5. The structure of D-erythrose is shown in the box. What is the configuration (*R* or *S*) at the carbon atoms 2 and 3?



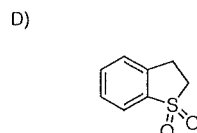
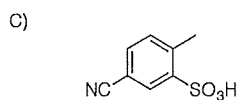
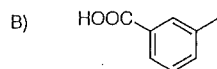
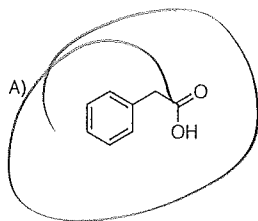
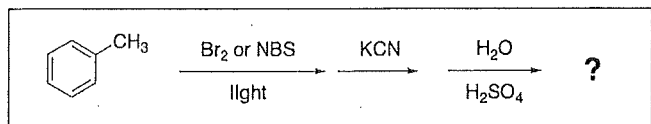
A) 2*R*,3*R*

B) 2*S*,3*R*

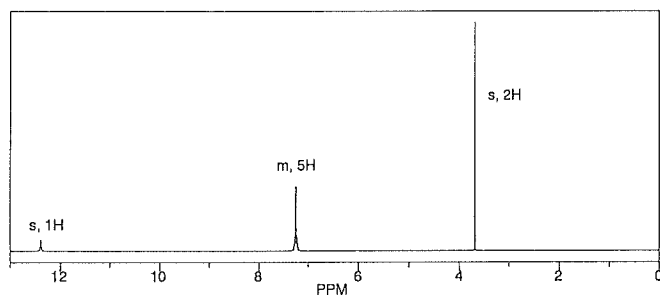
C) 2*R*,3*S*

D) 2*S*,3*S*

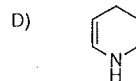
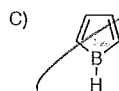
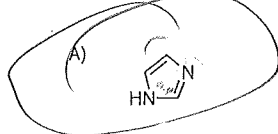
6. What is a major product of the reaction sequence shown in the box?



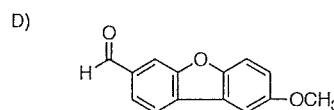
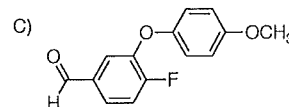
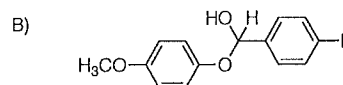
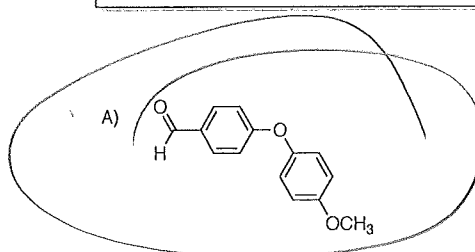
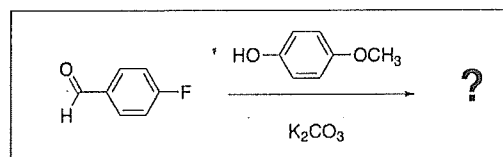
$^1\text{H}$  NMR of the major product:



7. Which of the following is aromatic?

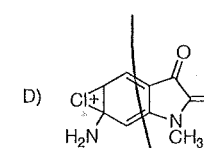
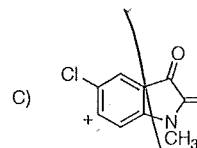
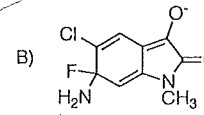
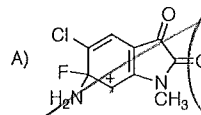
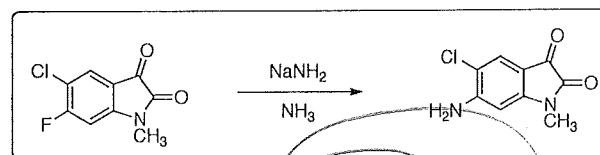


8. Nucleophile aromatic substitution: What is a major product of the reaction in the box?

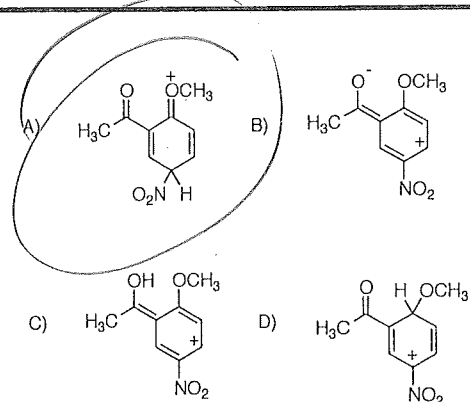
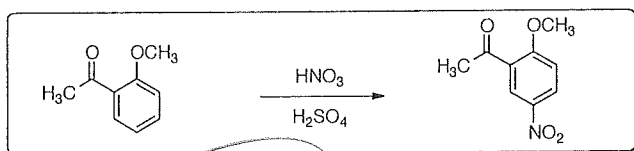


9. Nucleophilic aromatic substitution:

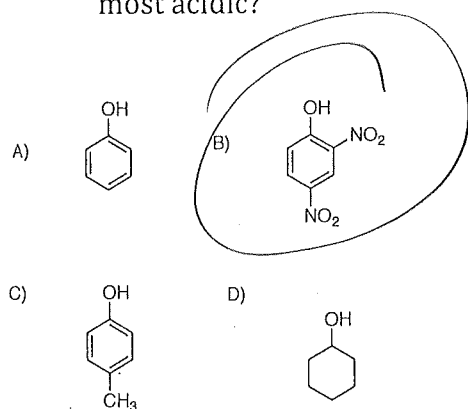
Which of the following is a key intermediate of the reaction in the box?



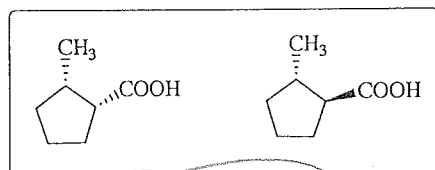
10. Electrophilic aromatic substitution: Which of the following is a key intermediate for the transformation in the box?



11. Which of the following is expected to be most acidic?



12. How are the structures in the box related?



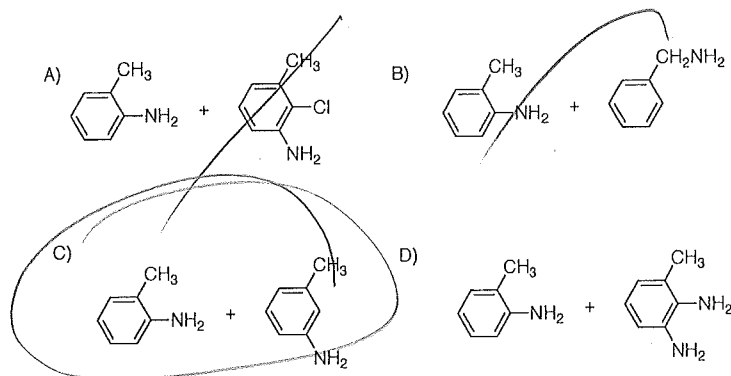
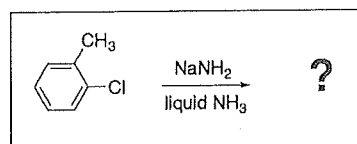
A) Diastereomers

B) Constitutional Isomers

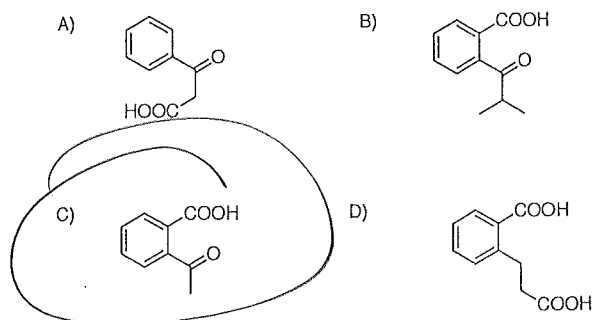
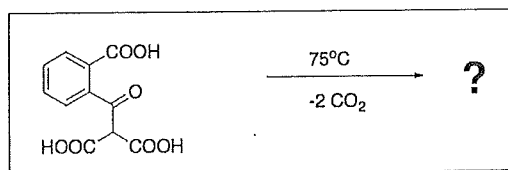
C) The same compound

D) Enantiomers

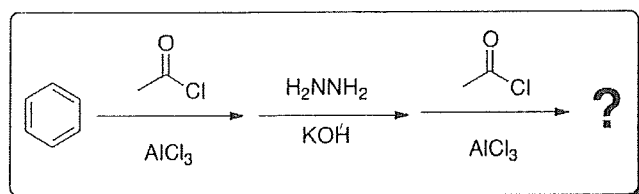
13. The nucleophilic aromatic substitution reaction shown in the box proceeds via a benzyne intermediate and results in two organic products. What are structures of these products?



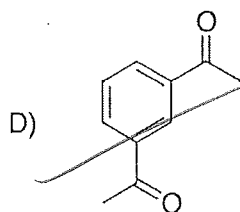
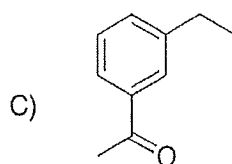
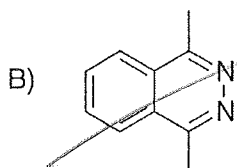
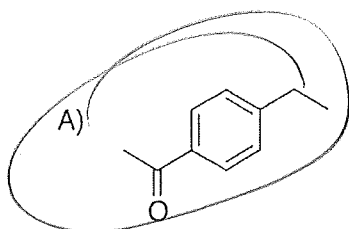
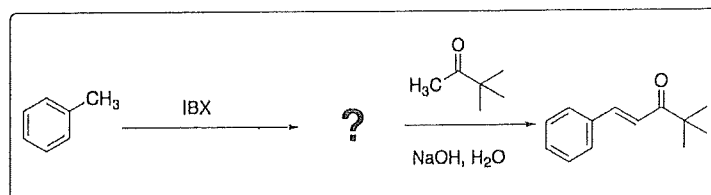
14. What is the product of the following decarboxylation?



15. What is a major product of the reaction in the box?



17. What is the name of the intermediate of the reaction sequence shown in the box?



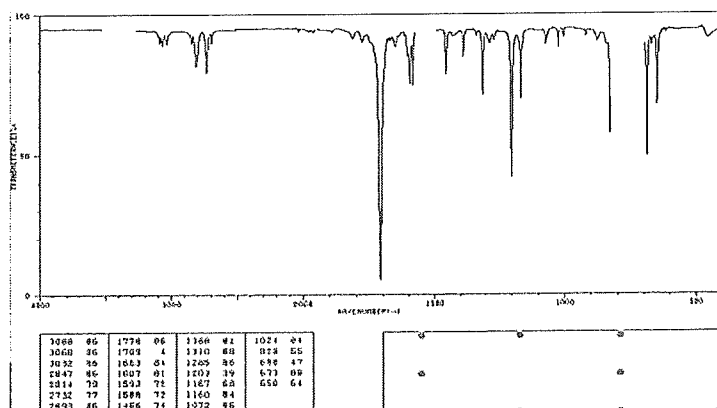
A) Benzoic acid

B) Benzaldehyde

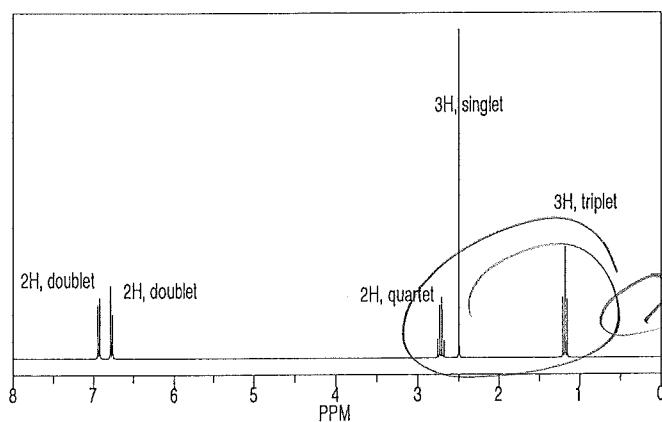
C) Aniline

D) Phenol

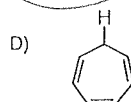
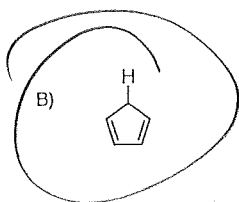
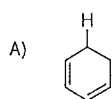
IR spectrum of the intermediate:



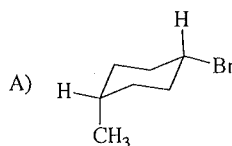
<sup>1</sup>H NMR of the correct answer:



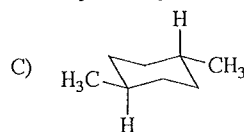
16. Which is the most acidic hydrogen atom? – The conjugate base will be AROMATIC!!!



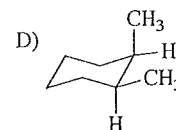
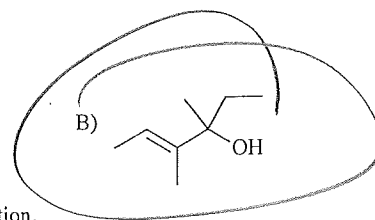
18. Which one of the following molecules is chiral?



(methyl group in axial position, bromine in equatorial position)

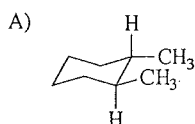
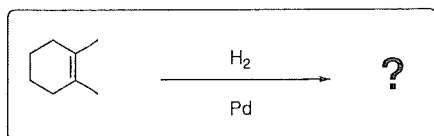


(both methyl groups in equatorial position)

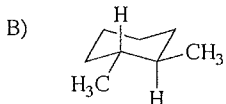


(one methyl group in axial position, the other one equatorial position)

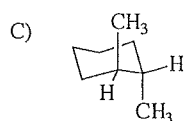
19. The reaction in the box gives a meso compound. Which of the following is a chair presentation of this compound?



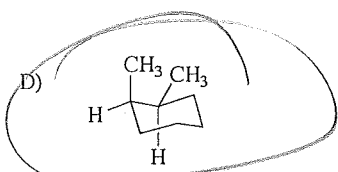
(both methyl groups equatorial position)



(both methyl groups equatorial position)

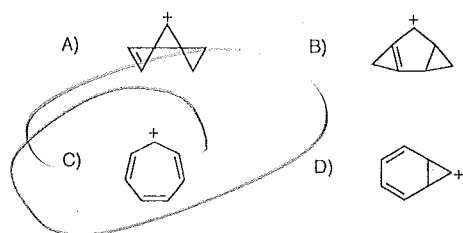


(both methyl groups axial position)



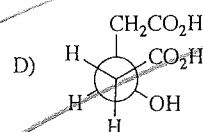
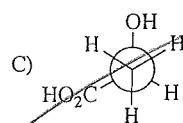
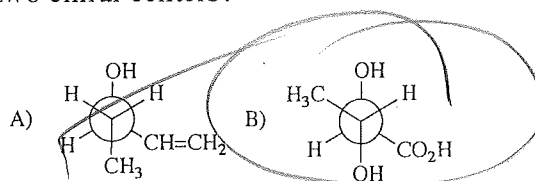
(one methyl group in axial position, the other one equatorial position)

20. Under the harsh conditions of the mass spectrometer both fragmentation and rearrangements to more stable ions may occur. For example toluene shows a base of  $m/z=91$  ( $=C_7H_7^+$ ). What is most likely the structure of this ion? - Note: This question asks for the most stable of the ions shown below - You are looking for the ion that is aromatic!!!

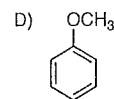
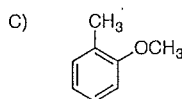
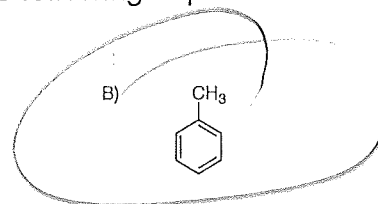
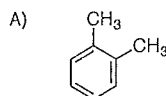


All ions have a formula of  $C_7H_7^+$

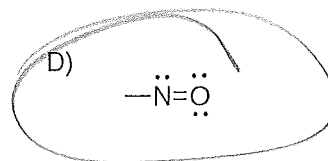
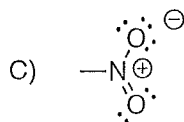
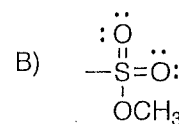
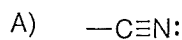
21. Which of the following molecules contains two chiral centers?



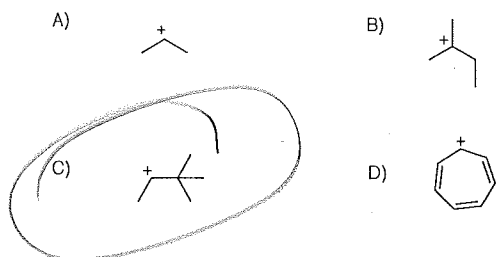
22. Which of the following depicts toluene?



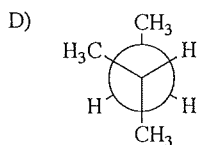
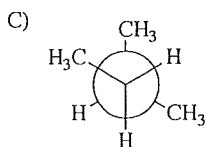
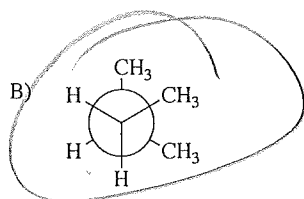
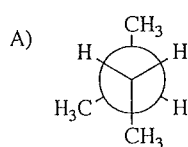
23. Predict which of the following groups will be ortho/para-directing in the electrophilic aromatic substitution reaction?



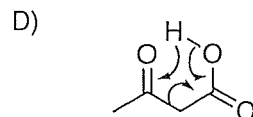
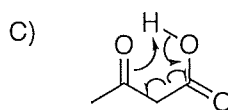
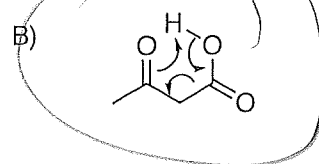
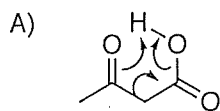
24. Which of the following is most likely to rearrange via 1,2-alkyl shift to form a more stable carbocation?



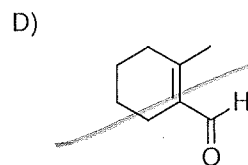
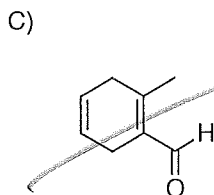
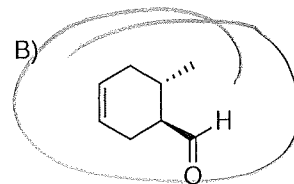
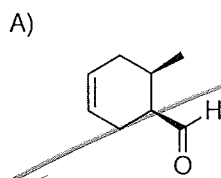
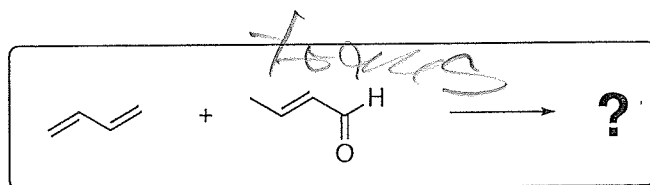
25. Which one of the following conformers of 2-methylbutane has the highest energy (= least stable)?



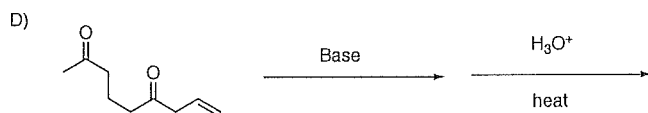
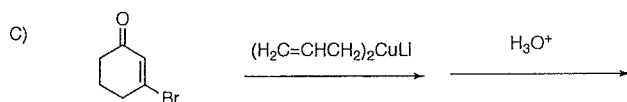
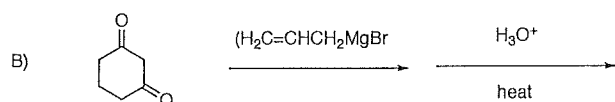
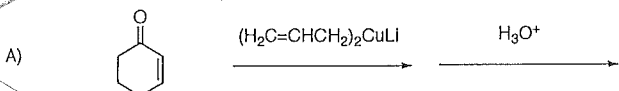
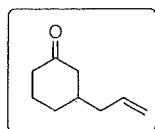
26. Which of the following correctly describes the flow of electrons in the heat induced decarboxylation of acetoacetic acid ( $\text{CH}_3\text{COCH}_2\text{COOH}$ )?



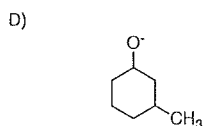
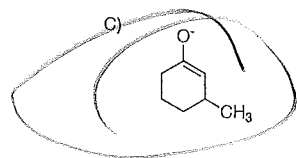
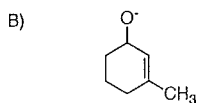
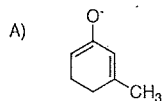
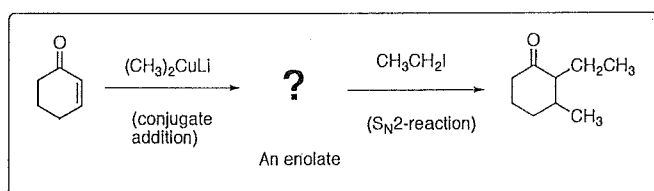
27. What is the major product of the Diels Alder reaction of 1,3-butadiene with E-2-butenal?



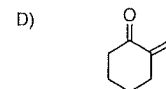
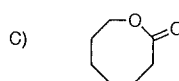
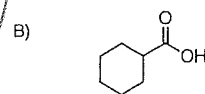
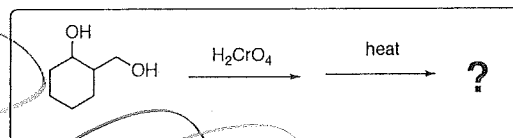
28. How would you synthesize the compound in the box?



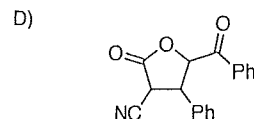
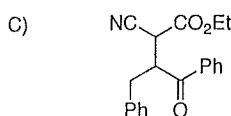
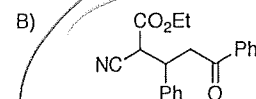
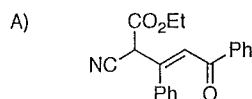
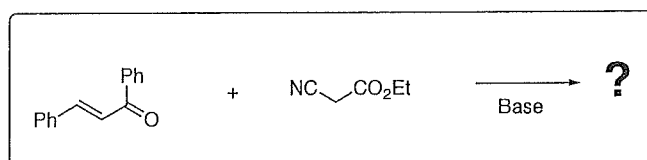
29. The intermediate of the reaction sequence in the box is an enolate. Which of the following depicts a structural representation of this enolate?



30. What is a major product of the reaction shown in the box? –  $\text{H}_2\text{CrO}_4$  is an oxidation agent. Spectroscopic data of the major product: IR:  $1715\text{ cm}^{-1}$ ,  $^{13}\text{C}$  NMR: 4 signals.



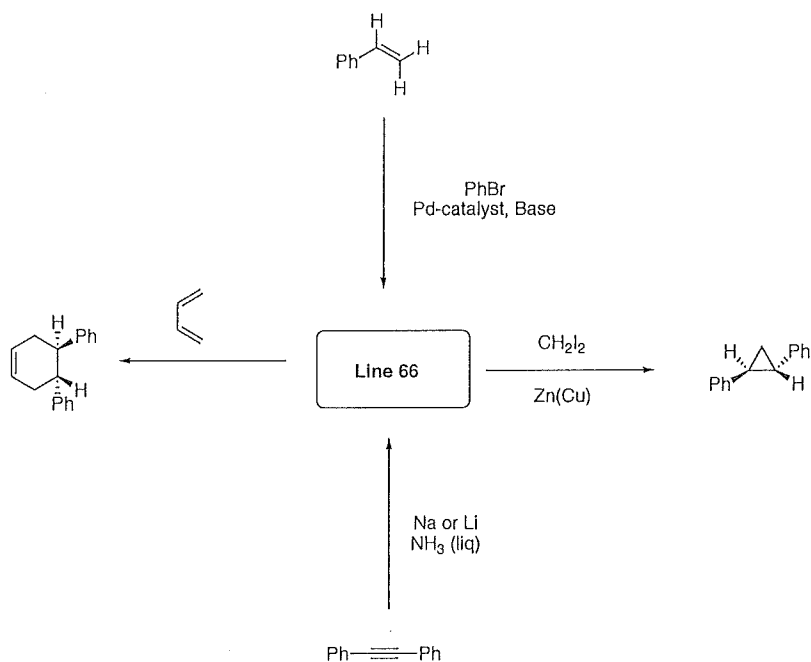
31. What is a major product of the conjugate addition reaction shown in the box?



Please use the back of the Scantron form to answer question 32

32 Please provide the structure of the product or the reactant

Line 66 – For full credit you need to indicate any applicable stereochemistry!



Line 68

