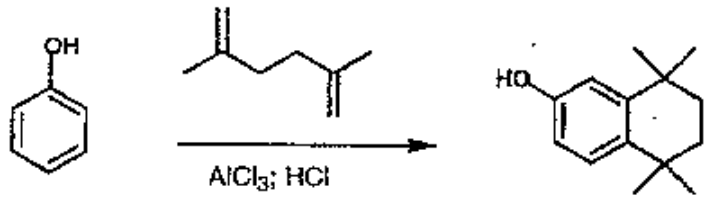
1. Provide an explanation for the following observations.

(a) Friedel-Crafts acylation with RCOCl/$AlCl_3$ becomes very slow if only a catalytic amount of $AlCl_3$ is used. **More than one equivalent** must be used to drive the reaction forward and to obtain good yields of product. (8 pts)
(b) Nucleophilic substitution S_N2 reactions of benzyl halides are relatively faster than primary alkyl halides such as isobutyl halides. (8 pts)

2. Suggest a mechanism for the each of the following reactions.

(a)



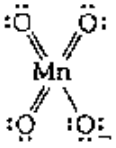
(10 pts)

(b)

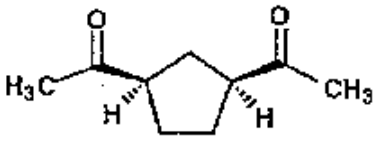
(10 pts)

參考用

3. Suggest a structure for the cyclic intermediate in the reaction of alkenes with $KMnO_4$. Show the formation of this intermediate with the curved-arrow formalism. (Hint: The Lewis structure of MnO_4^- can be written as follows.) (8 pts)



4. East Indian sandalwood oil contains a hydrocarbon given the name santene (C_9H_{14}). Ozonation of santene followed by hydrolysis gives compound A. What is the structure of santene? (8 pts)

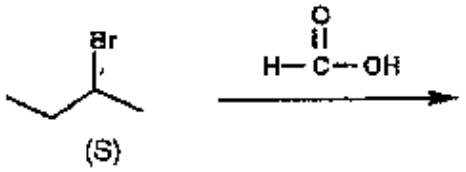


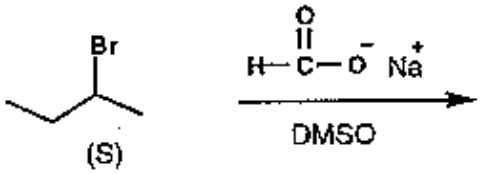
Compound A

5. When *sec*-butylbenzene undergoes **free-radical** bromination, one major product is formed, as follows:

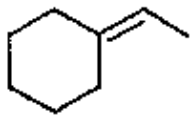
If the starting material is optically active, predict whether the substitution product should also be optically active. (4 pts) Rationalize your answer with a **mechanism (6 pts)** and show the **geometry of the free radical intermediate. (4 pts)**

6. Two substitution reactions of (S)-2-bromobutane are shown below.
Predict the comparative **stereochemical results** of these two reactions.(10 pts)

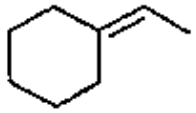
(a) 

(b) 

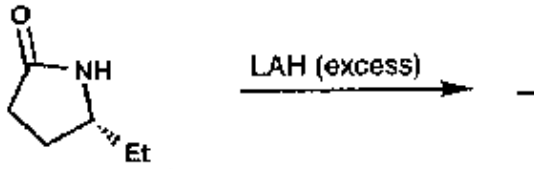
7. Predict **the principal product**(s) of the following reactions and give the structures of the **reactive intermediates for questions (a) and (b) only**.

(a) 

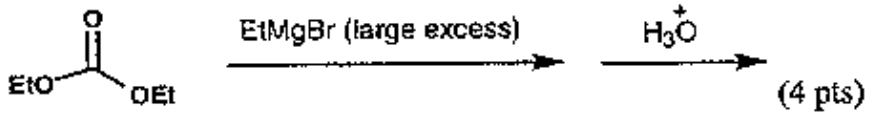
(6 pts)

(b) 

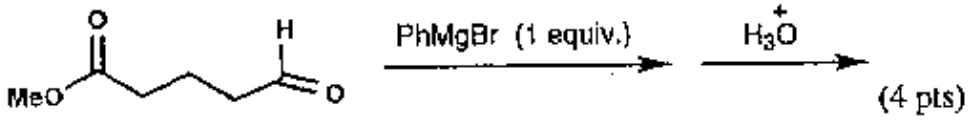
(6 pts)

(c) 

(4 pts)

(d) 

(4 pts)

(e) 

(4 pts)

參考用