# 國立清華大學 105 學年度碩士班考試入學試題

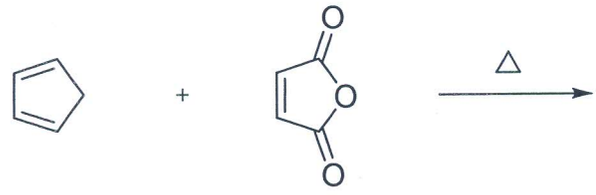
系所班組別：生命科學院乙組、醫學生物科技學程

考試科目（代碼）：有機化學(0502、0706)

　　*請在【答案卷】作答

**Part 1 簡答題**

1. Please predict the product of the following reaction. **(6%)**

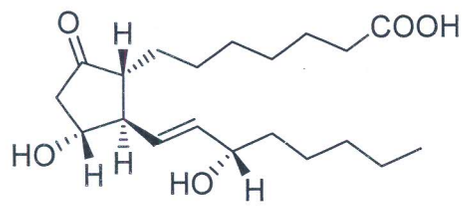



A　endo-adduct

B　exo-adduct

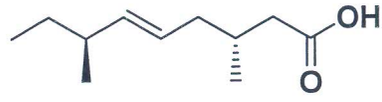
2. Please label each stereocenter with * and its **R** or **S** configuration. **(6%)**

(a)

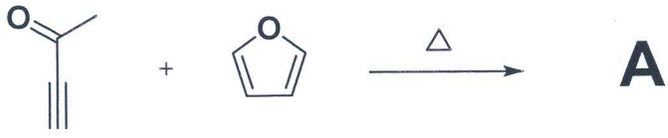


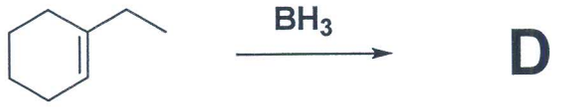

Prostaglandin $E_1$

(b)




3. Please predict the product of the following reaction. **(3 % each)**





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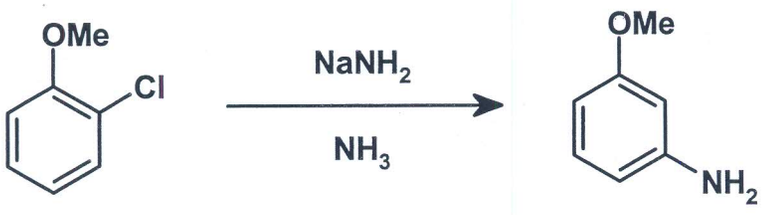
4. Cyclopentanone reacts with ethane-1,2-diol ($HOCH_2CH_2OH$) in the presence of acid to form a compound A, $C_7H_{12}O_2$. **(9 %)**

(a) Give a structure for A.

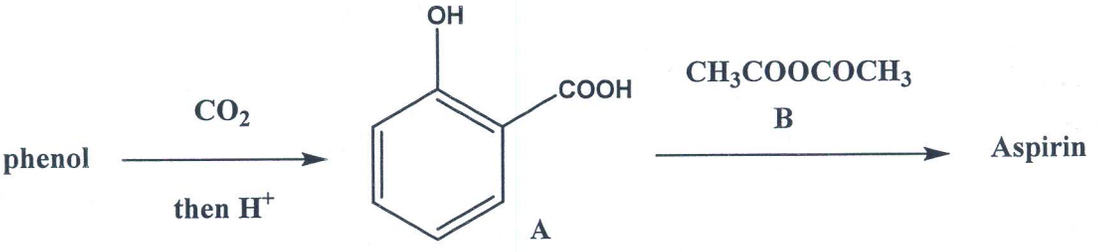
(b) Explain the role of the acid.

(c) Provide a mechanism for the reaction.

5. Please provide the product and mechanism of the following reaction. **(5%)**




6. The following questions relate to the synthesis of aspirin, which is shown below. **(15 %)**




(a) Draw the skeletal structure of phenol.

(b) Give the IUPAC name for compound A.

(c) Draw the skeletal structure for compound B.

(d) Given that the IUPAC name of aspirin is 2-ethanoyloxybenzoic acid, draw the skeletal structure of aspirin.

(e) Draw the skeletal structure of *p*-ethanoyloxybenzoic acid.

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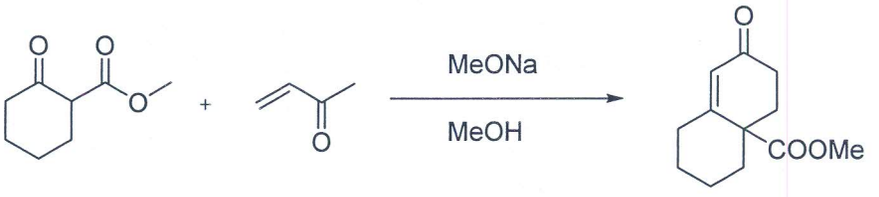
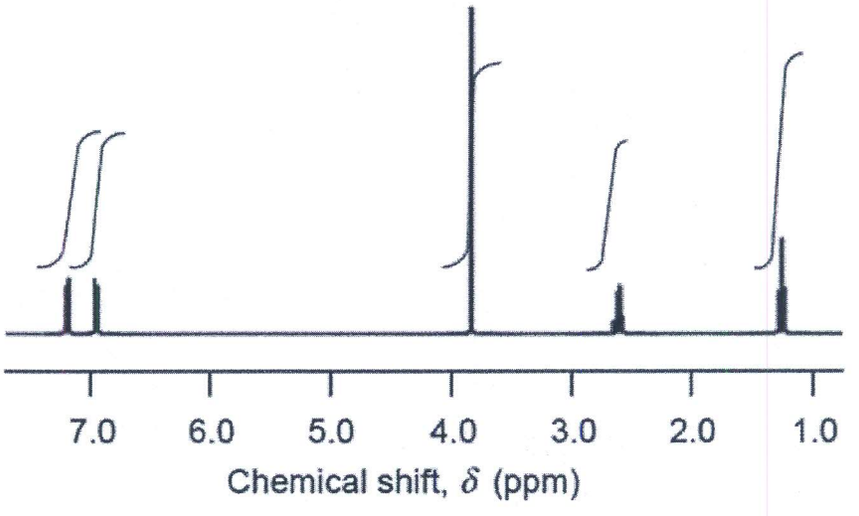
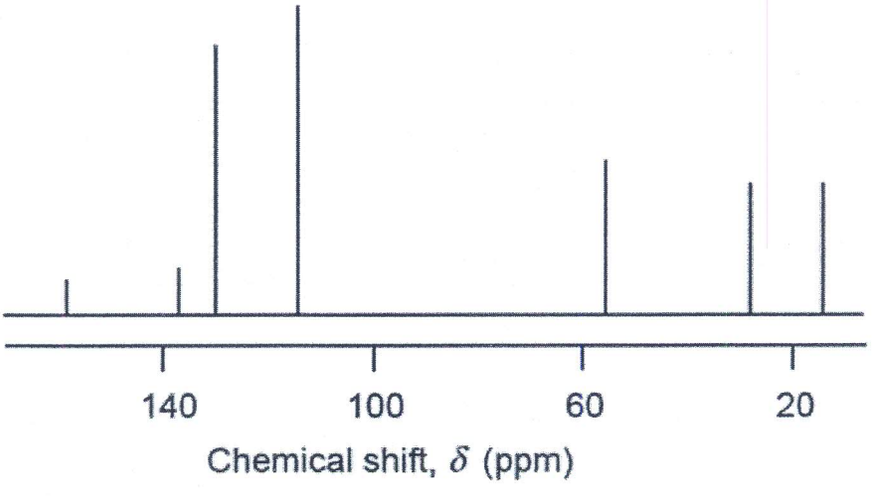
7. Please propose a mechanism of the following reaction. **(5 %)**




8. The $^{1}H$ and $^{13}C$ NMR spectra of a compound with the molecular formula $C_9H_{12}O$ are shown below. Use the spectra to propose a structure for this compound: **(6 %)**



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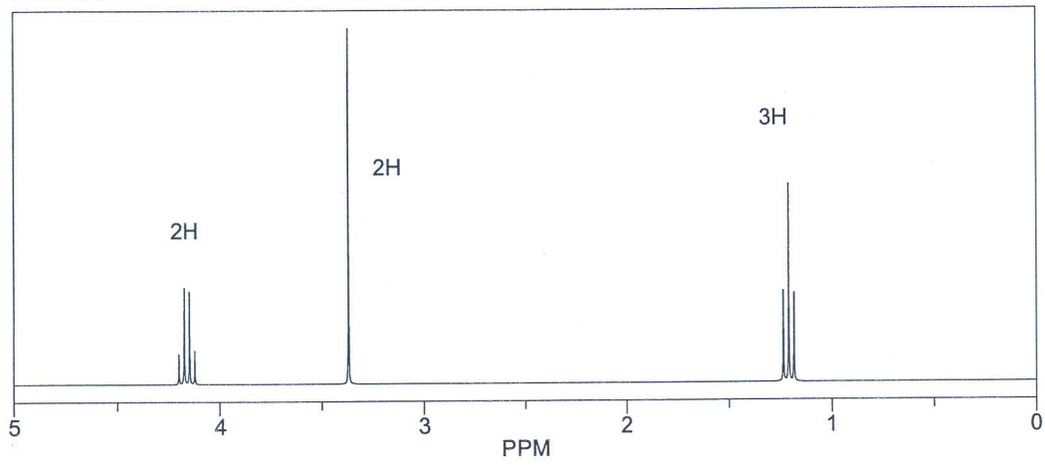
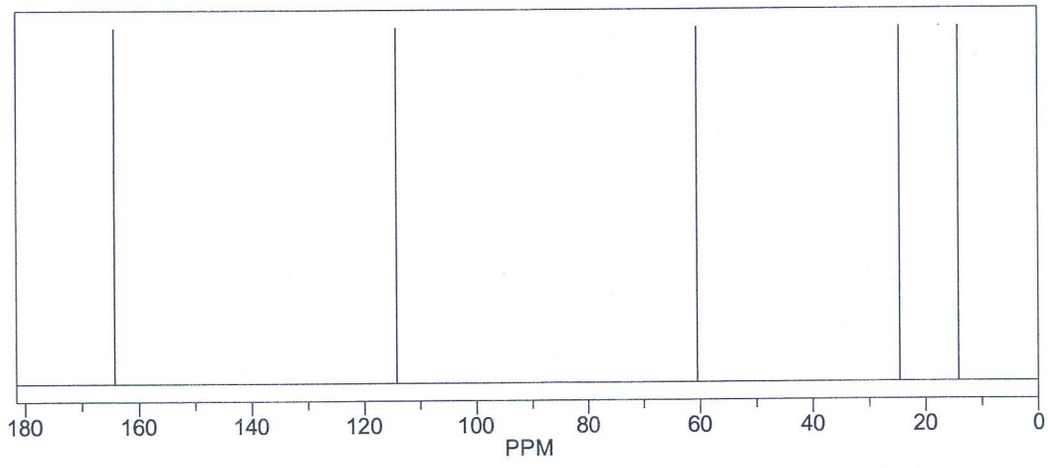
9. This compound has the molecular formula $C_5H_7NO_2$. Following are the $^1H$ NMR, $^{13}C$ NMR and IR spectra. **(6%)**

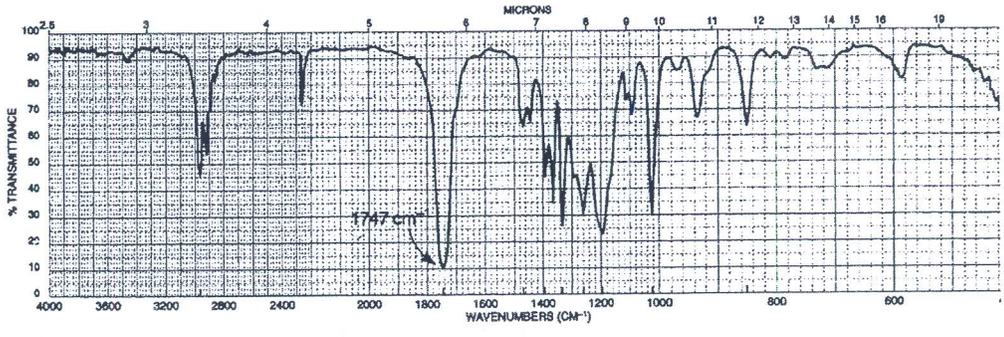
$^1H$ NMR




$^{13}C$ NMR




IR



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**Part 2 單選題**：Please select 1 answer from each of the following questions (**30%, 1.5% each**)

1. Which of the following substances has a Lewis structure containing non-neutral atoms with charges?
   (A) Acetamide　(B) Cyclopropane　(C) Ethylene oxide　(D) Nitromethane

2. Aspirin is known to be composed of 60.0% carbon, 4.4% hydrogen, and 35.6% oxygen with a molecular weight of 180. What is its molecular formula?
   (A) $C_6H_{12}O_6$　(B) $C_7H_{16}O_5$　(C) $C_8H_4O_5$　(D) $C_9H_{10}O_4$

3. 11.64 g compound **J** is burned in the presence of oxygen to give 34.2 g carbon dioxide and 21 g water. What is empirical formula for compound **J**?
   (A) $CH_4$　(B) $C_2H_6$　(C) $C_3H_8$　(D) $C_4H_{10}$

4. Based on NMR data, which of the following compounds has *t*-butyl group in structure?
   (A) $C_3H_3Cl_5$ triplet, δ 4.52, 1H; doublet δ 6.07, 2H
   (B) $C_{10}H_{14}$ singlet, δ 1.30, 9H; singlet, δ 7.28, 5H
   (C) $C_{10}H_{13}Cl$ singlet, δ 1.57, 6H; singlet, δ 3.02; singlet, δ 7.27, 5H
   (D) $C_3H_5Cl_3$ singlet, δ 2.20, 3H; singlet, δ 4.02, 2H

5. How many pairs of eclipsed hydrogens are present in planar cyclobutane?
   (A) 4　(B) 6　(C) 8　(D) 10

6. Among 1-chloropentane, 1-chloro-2-methylpentane, 2-chloropentane, and 2-chloro-2-methylpentane how many structures have a chiral center?
   (A) 1　(B) 2　(C) 3　(D) 4

7. The blood of lobsters contains a blue copper porphyrin complex. The structure of $Cu^{2+}$ pigment of octamethylporphyrin contains 2 primary amines. What charge does the complex have?
   (A) 0　(B) 1　(C) 2　(D) 3

8. An unknown compound **K** rapidly decolorized a solution of bromine in $CCl_4$. When **K** is subjected to ozonolysis, the products are butanone and propanol. What might be the structure of **K**?

**I**. *cis*-2-methyl-3-hexene　　**II**. *cis*-3-methyl-3-hexene

**III**. *trans*-2-methyl-3-hexene　　**IV**. *trans*-3-methyl-3-hexene

(A) I, II　　(B) I, III　　(C) II, IV　　(D) III, IV

9. Acetylene has an acid ionization constant ($K_A$) of $\sim 10^{22}$. Calculate the concentration of acetylide ion expected to be present in a 14 M solution of potassium hydroxide that is 0.01 M in acetylene.

(A) $1.4 \times 10^{-7}$　　(B) $1.4 \times 10^{-8}$　　(C) $1.4 \times 10^{-9}$　　(D) $1.4 \times 10^{-10}$

10. Arrange the following in increasing order of reactivity toward ring nitration.

**I**. benzene　　**II**. toluene　　**III**. *p*-xylene　　**IV**. *m*-xylene

(A) I, II, III, IV　(B) I, II, IV, III　　(C) II, III, IV, I　　(D) III, IV, II, I

11. Which of the following chemical pairs may be distinguished by chromic anhydride test?

(A) benzene and toluene

(B) bromobenzene and bromocyclohexane

(C) bromobenzene and 3-bromo-1-hexene

(D) ethylbenzene and benzyl alcohol

12. Ethyl chloride (0.1 M) reacts with potassium iodide (0.1 M) in acetone solution at 60 °C to give ethyl iodide and potassium chloride at a rate of $5.44 \times 10^{-7}$ mole/liter/sec. If the reaction proceeds by an $S_N2$ mechanism, what is the rate of the reaction at 0.01 M of both reactants?

(A) $5.44 \times 10^{-7}$　　(B) $5.44 \times 10^{-8}$　　(C) $5.44 \times 10^{-9}$　　(D) $5.44 \times 10^{-10}$

13. Optically pure 2-bromooctane has a specific rotation of -34.6° and optically pure 2-octanol has a specific rotation of -9.9°. Under $S_N1$ conditions 2-bromo octane of specific rotation -20.8° is found to yield 2-octanol of specific rotation + 3.96°. What is the percentage of racemization accompanying the reaction?
(A) 1/2　(B) 1/3　(C) 2/3　(D) 1/4

14. HCN has p$K_a$ = 9.21; acetic acid has p$K_a$ = 4.76. $\Delta G° = -2.3\ RT \log K_a$ (in which 2.3 RT = 1.36) What is $\Delta G°$ for the following reaction (Kcal/mole)?

$$HCN + CH_3CO_2^- \rightarrow CN^- + CH_3CO_2H$$

(A) 1.36　(B) 4.45　(C) 4.60　(D) 6.05

15. Arrange in increasing order of reactivity of the following halides with aqueous alcoholic silver nitrates.
**I**. $C_6H_5CH_2Br$　**II**. $CH_3C_6H_4Br$　**III**. $CH_3Br$　**IV**. $(C_6H_5)_2CHBr$
(A) II, III, I, IV　(B) IV, II, I, III　(C) II, I, IV, II　(D) IV, III, II, I

16. An aromatic dibromide $C_7H_6Br_2$ reacts with aqueous sodium hydroxide. Only 1 bromo group is lost to give the product $C_7H_7BrO$. When the dibromide is converted to a Grignard reagent and then hydrolyzed, the product is toluene. What is the relationship between 2 substituents containing Br?
(A) *ortho*　(B) *meta*　(C) *para*　(D) all of above

17. Compound **L**, $C_5H_{10}$, decolors a solution of $Br_2$ in carbon tetrachloride. When **L** is dissolved in cold, concentrated sulfuric acid and then heated with water, **M**, $C_5H_{12}O$ is formed. **M** reacts with chromic acid $H_2Cr_2O_7$ to give **N**, $C_5H_{10}O$. Both **M** and **N** give positive iodoform tests. The reaction mixture of the iodoform test also produces isobutyric acid $(CH_3)_2CHCOOH$. What is the structure of **N**?
(A) $CH_3(CH_2)_3CHO$　(B) $(CH_3)_2CHCOCH_3$
(C) $(CH_3CH_2)_2CO$　(D) $(CH_3)_3CCHO$

18. Arrange the following compounds in increasing order of basicity.

**I**. ethylamine　　**II**, 2-aminoethanol　　**III**. 3-amino-1-propanol

(A) I, II, III　　(B) I, III, II　　(C) II, III, I　　(D) III, I, II

19. How many stereoisomers do you expect in methylethyl-*s*-butylsulfonium bromides?

(A) 1　　(B) 2　　(C) 3　　(D) 4

20. Which of the following phenol derivatives has the strongest acidity?

(A) 2,4-dichloro　　(B) 2,5-dichloro　　(C) 2,6-dichloro　　(D) 3,5-dichloro