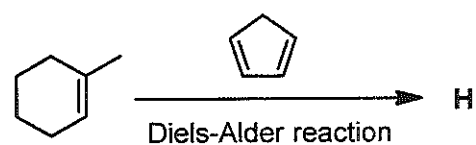
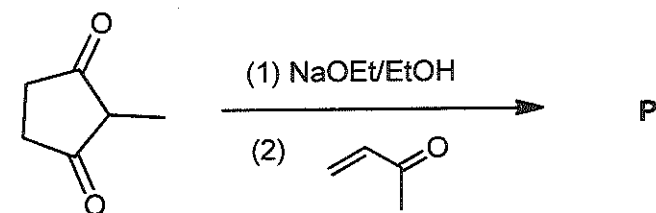
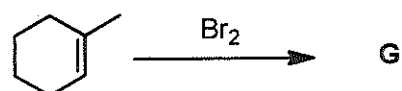
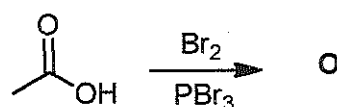
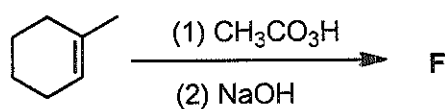
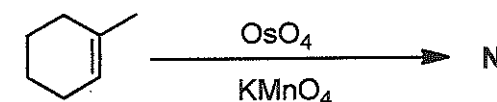
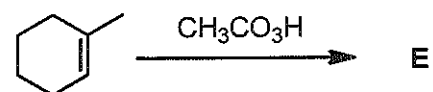
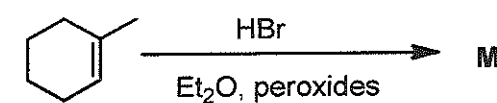
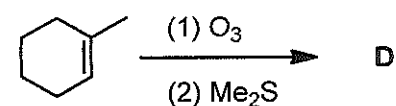
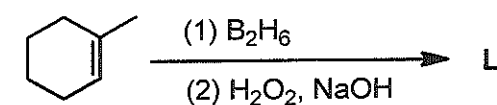
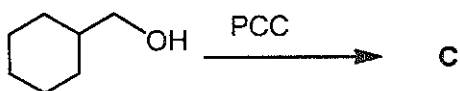
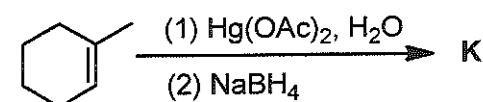
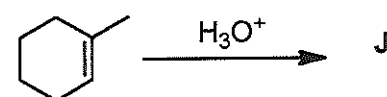
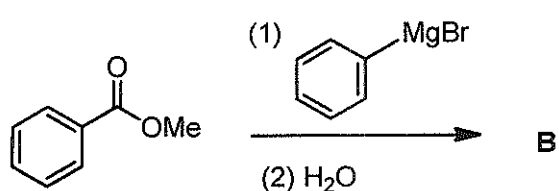
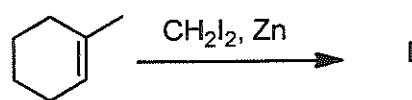
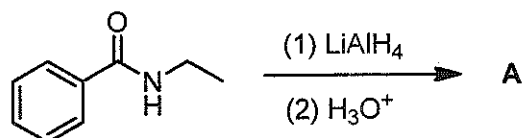
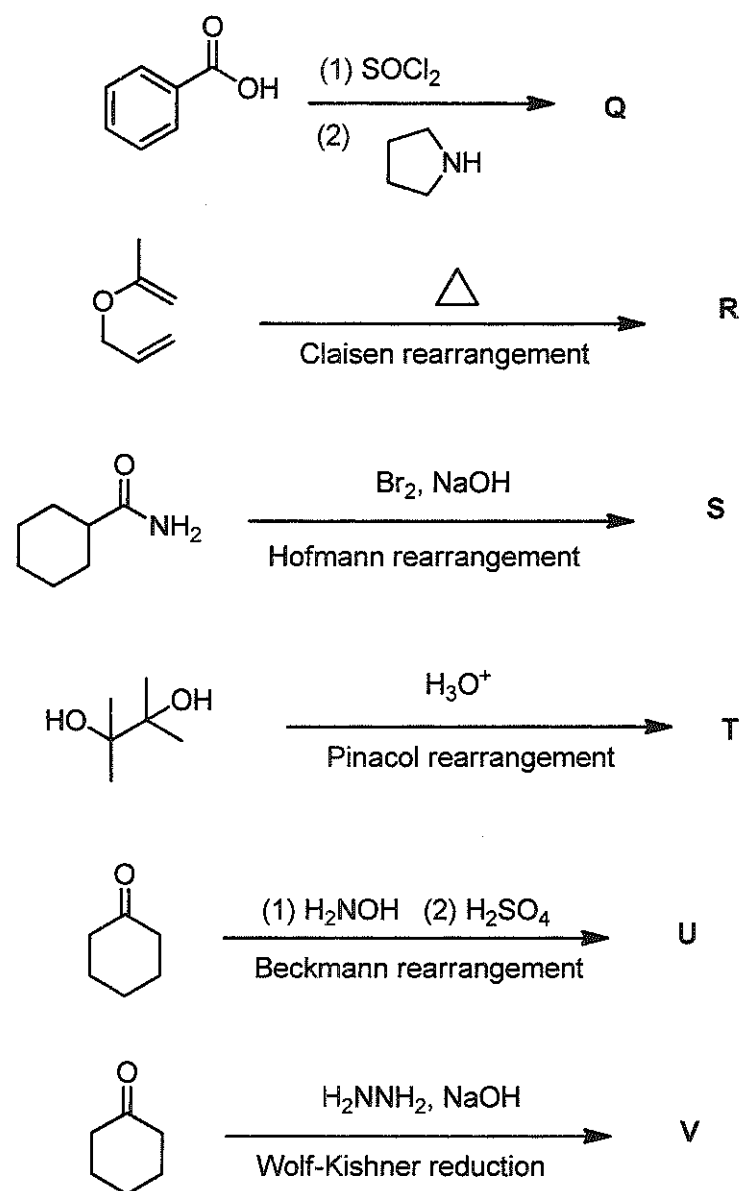


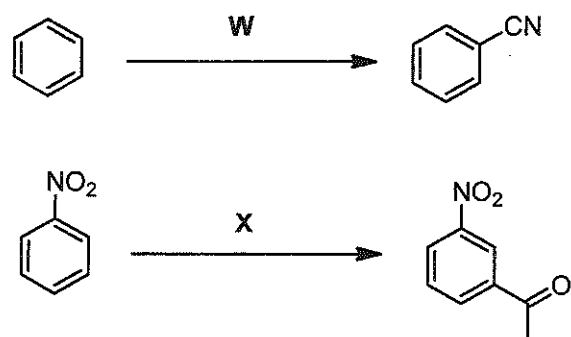
有機化學 (總分 50 分) 每題 2 分.

I. (2 points each) Provide the major product of the following reactions:





II. (2 points each) Suggest a reagent (or reagents for stepwise reactions) that can be used to accomplish the following transformation:



III. (2 points) Deduce the structure of the following compound ( $\text{C}_4\text{H}_8\text{O}_2$ ):

$^1\text{H NMR}$  ( $\text{CDCl}_3$ , 300 MHz):  $\delta$  4.12 (q,  $J = 7.0$  Hz, 2 H), 2.06 (s, 3 H), 1.27 (t,  $J = 7.0$  Hz, 3 H).

$^{13}\text{C NMR}$  ( $\text{CDCl}_3$ , 100 MHz):  $\delta$  170.0, 61.0, 20.7, 14.1

## 無機化學部分 (共五十分)

(15 題綜合題型問題，每題分數如各題標示，無需使用計算機)

- Which of the following statements are true? (多選題，3 分)
  - $C_n(\sigma_v \sigma_v) = C_n(\sigma_v)\sigma_v'$
  - $S_2 \equiv i$  and  $S_1 \equiv \sigma$
  - $iC_2 = \sigma$
  - $D_1 \equiv C_2$
- Select the most favorable Lewis structure for the dicyanamide ion,  $C_2N_3^-$ . (單選題，2 分)
  - $\ddot{C} = N = N = N = \ddot{C}$
  - $\ddot{N} = C = N = C = \ddot{N}$
  - 
  -
- For  $I$  = ionization energy,  $A$  = electron affinity,  $\eta$  = absolute hardness,  $\chi$  = electronegativity,  $E_{HOMO}$  = HOMO energy and  $E_{LUMO}$  = LUMO energy, select the incorrect expressions: (單選題，2 分)
  - $\chi = \frac{A+I}{2}$
  - $E_{HOMO} = -I$
  - $\eta = \frac{A+I}{2}$
  - $E_{LUMO} = -A$
- The metallocene complexes  $MCp_2$  ( $M = V, Cr, Mn, Fe, Co, Ni$ ;  $Cp^-$  = cyclopentadienyl,  $C_5H_5^-$ , a very strong field ligand) are known to adopt an octahedral geometry with a very slight distortion on the  $d\pi$  orbitals. Which of the following metallocene is diamagnetic? (單選題，2 分)
  - $NiCp_2$
  - $CoCp_2^+$
  - $MnCp_2$
  - $CrCp_2$
- The complexes  $[Co(NH_3)_5X]^{2+}$  ( $X = F, Cl, Br, I$ ) have charge transfer to metal bands. Which of these complexes would you expect to have the lowest-energy charge transfer band? (2 分)

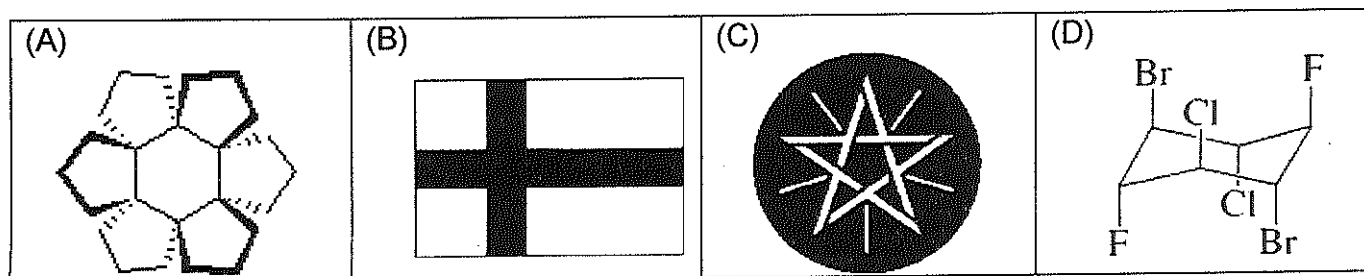
6. Select the best choice in the following questions. (4 分)

- (A) Higher boiling point:  $\text{CH}_3\text{OH}$  and  $\text{CH}_3\text{SH}$   
 (B) Higher melting point: *ortho*- $[\text{C}_6\text{H}_4(\text{OH})(\text{CO}_2\text{H})]$  and *para*- $[\text{C}_6\text{H}_4(\text{OH})(\text{CO}_2\text{H})]$   
 (C) Shortest O—X distance:  $\text{ClO}_3^-$ ,  $\text{BrO}_3^-$ ,  $\text{IO}_3^-$   
 (D) largest O—X—O angle:  $\text{ClO}_3^-$ ,  $\text{BrO}_3^-$ ,  $\text{IO}_3^-$

7. Select the best choice in the following questions. (4 分)

- (A) Smallest radius :  $\text{Y}^{3+}$ ,  $\text{Zr}^{4+}$ ,  $\text{Nb}^{5+}$   
 (B) Greatest volume :  $\text{S}^{2-}$ ,  $\text{Se}^{2-}$ ,  $\text{Te}^{2-}$   
 (C) Lowest ionization energy (IE) : 2nd IE of He, 1st IE of H, and 3rd IE of Li  
 (D) Highest electron affinity : Cl, Br, I

8. Assign the correct **Point Group Symbol** for the following species. (8 分)



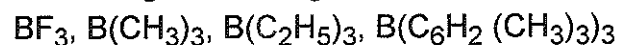
9. The  $4f_z(x^2-y^2)$  orbital has the angular function  $\gamma = A z(x^2-y^2)/r^3$ , where A = constant.

- (A) How many radial nodes does this orbital have? (1 分)  
 (B) How many angular nodes does it have? (1 分)  
 (C) Determine possible values for the  $l$  and  $m_l$  quantum numbers for a 4  $f$  electron. (2 分)

10. (A) List the order of solubility in water:  $\text{PbCl}_2$ ,  $\text{PbBr}_2$ ,  $\text{PbI}_2$ ,  $\text{PbS}$ . (1 分)

(B) List the order of increasing softness:  $\text{Au}^+$ ,  $\text{Cu}^+$ ,  $\text{Li}^+$ ,  $\text{Mn}^{4+}$ ,  $\text{Ti}^{4+}$ ,  $\text{Zr}^{4+}$ . (1 分)

(C) increasing acid strength when reacting with  $\text{NH}_3$ : (1 分)



11. The color associated with each of the following chromium complex or ion was given:

- $[\text{CrCl}_6]^{3+}$  dark green  
 $[\text{Cr}(\text{OH})_6]^{3-}(\text{aq})$  light Green solution  
 $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$  blue violet solution  
 $[\text{Cr}(\text{NH}_3)_6]^{3+}(\text{aq})$  yellow  
 $[\text{Cr}(\text{CO})_6]$  colorless solution  
 $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$  blue solution  
 $\text{Cr}_2\text{O}_7^{2-}$  orange solution

Determine the order of the ligand field strength and the magnitude of crystal field splitting for various Cr oxidation states. (3 分)

12. How many isomers (including both geometric and optical isomers) are possible for the compound  $[\text{Co}(\text{ampy})(\text{NH}_3)_2\text{Cl}_2]^+$ ? (*ampy* = *meta*- $\text{NH}_2\text{CH}_2$ -pyridine) (2 分)

13. (A) Is the reaction  $[\text{Co}(\text{NH}_3)_6]^{3+} + [\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  likely to proceed by an inner-sphere or outer sphere mechanism? (1 分)
- (B) Select the largest reaction rate constant for  $[\text{Co}(\text{NH}_3)_5\text{X}]^{2+} + [\text{Co}(\text{CN})_5]^{3-}$  :  
X = F, OH,  $\text{NH}_3$ , NCS,  $\text{N}_3$ , Cl. (1 分)
- (C) Select the strongest  $\sigma$ -bonding effect:  $\text{H}^-$ ,  $\text{PR}_3$ ,  $\text{CH}_3^-$ , CO,  $\text{I}^-$ ,  $\text{OH}^-$ . (1 分)
14. (A) Select the highest  $\pi$ -bonding effect:  $\text{C}_2\text{H}_4$ ,  $\text{CN}^-$ ,  $\text{NO}_2^-$ ,  $\text{I}^-$ ,  $\text{OH}^-$ . (1 分)
- (B) Select the most coordinatively inert M = Cr(II), Mn(II), Fe(III), Co(III) (1 分)
- (C) Strongest oxidant among  $[(\text{NH}_2\text{C}(\text{=O})\text{C}_5\text{H}_4\text{N})\text{M}(\text{H}_2\text{O})_5]^{3+}$ , when reacting with  $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$ :  
M = Cr, Co, Ru. (1 分)
15. Classify the following configurations as *A*, *E*, or *T* in complexes having *Oh* symmetry. Some of these configurations represent excited states. (5 分).
- (A)  $t_{2g}^4 e_g^2$
- (B)  $t_{2g}^6$
- (C)  $t_{2g}^3 e_g^3$
- (D)  $t_{2g}^5$
- (E)  $e_g$