總分 100 分，共 7 大題。選擇題務必答案卷內依序作答，在試題內作答者不予計分。

1. For the following descriptions, please show the mechanism and electron flow with arrows.

1-1. The chemical structure of indole is shown below.

\[
\text{Indole}
\]

Indole can function as a Brønsted-Lowry acid in the presence of strong bases (\( \cdot \text{B}^+ \)). Formulate a reaction, showing electron flow with arrows, that demonstrates this reactivity of indole. (3%)

1-2. Indole can also function as a Lewis base in the presence of strong acid. Formulate a reaction, showing electron flow with arrows, that demonstrates this reactivity of indole. (3%)

1-3. Bromohydrins are converted into epoxides when treated with base. Propose a mechanism, using curved arrows to show the electron flow. (4%)

\[
\begin{align*}
\text{HO} - \text{C} & - \text{C} - \text{Br} & \text{NaOH} & \rightarrow \text{Ethanol} \\
\text{CH}_3 & \text{CH}_3 & & \text{O} - \text{C} & - \text{C} - \text{H} \\
& & & \text{CH}_3 & \text{CH}_3
\end{align*}
\]

1-4. Show the product that would be obtained by formation of a bromohydrin from \textit{trans}-2-butene, followed by treatment with base. (4%)

1-5. Please add curved arrows to show the mechanism of each step in the following reaction. (The ion \( \text{OP}_2\text{O}_4^{3-} \) is the diphosphate ion, and "Base" is an unspecified base in the enzyme that catalyzes the reaction.) (6%)

\[
\begin{align*}
\text{Geranyl diphosphate} & \rightarrow \text{Base} & \text{Limonene} \\
& & \text{Limone}
\end{align*}
\]

2. Identify the reagents a–c in the following scheme. (9%)
3. Choose the correct answer:
3-1. When methanol (CH₃OH) acts as a base, its conjugate acid is (2%)
   A) CH₂OH   B) CH₃O⁻   C) CH₄OH   D) CH₃OH₂⁺   E) CH₄O⁺
3-2. Choose the term below which best describes the geometry of acetylene (HCCH). (2%)
   A) trigonal bipyramidal   B) trigonal   C) tetrahedral   D) square planar
   E) linear
3-3. The two structures show below represent (2%)

   A. constitutional isomers
   B. stereoisomers
   C. cis-trans isomers
   D. both B and C
   E. A, B and C

4. α-Terpinene has a formula, C₁₀H₁₆. On hydrogenation over a palladium catalyst, α-terpinene reacts with 2 molar equivalents of H₂ to yield a hydrocarbon, C₁₀H₂₀. On ozonolysis, followed by reduction with zinc and acetic acid, α-terpinene yields two products, glyoxal and 6-methyl-2,5-heptanedione.

   Glyoxal 6-Methyl-2,5-heptanedione

   A. How many degrees of unsaturation does α-terpinene have? (3%)
   B. How many double bonds and how many rings does it have? (3%)
   C. Propose a structure for α-terpinene. (3%)

5. This compound has the molecular formula C₅H₇NO₂. Following are their IR, ¹H NMR and ¹³C NMR spectra. Please solve the chemical structure of this compound. (6%)
6. Predict the major products of the following reactions. (18%)  

(1) \[
\begin{align*}
\text{H}_2\text{N} &\quad \text{Ar} &\quad \text{Cl} \quad \overset{\text{AlCl}_3}{\longrightarrow} \\
\text{NH}_2 &\quad \text{Ar} &\quad \text{Cl}
\end{align*}
\]

(3%)  

(2) \[
\begin{align*}
\text{PhCl} &\quad \overset{\text{OH}}{\longrightarrow} \\
\text{PhCl} &\quad \text{OH}
\end{align*}
\]

(3%)  

(3) \[
\begin{align*}
\text{HO} &\quad \text{CH}_3\text{MgBr} \\
\text{Br} &\quad \text{CH}_3\text{MgBr}
\end{align*}
\]

(3%)  

(4) \[
\begin{align*}
\text{CO} &\quad \overset{\text{1) 2 CH}_3\text{MgBr}}{\longrightarrow} \overset{\text{2) H}_2\text{O}^+}{\longrightarrow} \\
\text{CO} &\quad \text{CO}
\end{align*}
\]

(3%)
7. Predict the reactants, the intermediates and the major products of the following reactions. (32%)

(1) \[ \text{OHC} - \text{CO}_2\text{Me} + A \rightarrow \text{OHC} - \text{CH}_{2}\text{CO}_2\text{Me} \] (3%)

(2) \[ \text{MeO}_2\text{C} - \text{CH} - \text{C} - \text{H} \overset{i-\text{PrNLi}}{\text{THF, } -60^\circ\text{C}} \rightarrow \text{B} \overset{\text{I}}{\rightarrow} \text{C} \] (6%)

(3) \[ \text{O} \overset{\text{LDA}}{\rightarrow} \text{D} \overset{\text{NMe}_2}{\rightarrow} \text{E} \] (6%)

(4) \[ \text{NaOH} \overset{\text{Ethanol}}{\rightarrow} \text{F} \] (3%)

(5) \[ \text{Br} \overset{\text{NH}_3}{\rightarrow} \text{G} \overset{\text{NaBH}_4}{\rightarrow} \] (3%)
6. \[
\text{CONH}_2 \xrightarrow{\text{NaOH, Br}_2, \text{H}_2\text{O}} \text{H}
\]

7. \[
\text{Cl} \quad \text{Cl} \quad \text{Cl} \xrightarrow{\text{NEt}_3} \text{I} \xrightarrow{\text{Cyclopentadiene}} \text{J}
\]

8. \[
\begin{align*}
\text{N}^+ \\
\text{OH} & \quad \xrightarrow{\text{K}} \text{L} \\
\end{align*}
\]

\begin{align*}
&\text{1) Mel} \\
&\text{2) Base}
\end{align*}

(3%)  (4%)  (4%)