PART I. 单选题，共二十题 (2 points each)

1. Which of the following species have bond angle of about 109°?
   I. NH₃   II. CO₂   III. H₂O   IV. H₃O⁺   V. O₃
   (A) I, III, IV   (B) II, III, V   (C) I, IV   (D) III, IV, V

2. What are the correct orbital hybridizations for carbon in the following species?
   I. CH₃⁻   II. CH₄   III. CH₅⁺
   a. sp²   b. sp³   c. sp³
   (A) I → a, II → c   (B) II → a, III → b   (C) I → c, III → b   (D) II → c, III → c

3. Which of the following are constitutional isomers of 4-isopropylpentane?
   I. 3-ethyl-2,4,5-trimethylhexane   II. isobutylcyclohexane
   III. 2,2-dimethyl-4-ethylheptane   IV. 4-ethyl-2-methyloctane
   (A) I, IV   (B) II, III   (C) I, II   (D) III, IV

4. What is the percent ionization of acetic acid at pH 2.76 (pKa=4.76)?
   (A) 100%   (B) 50%   (C) 10%   (D) 1%

5. What is a reasonable explanation of the following observation?
   Acetylene is a stronger acid than ethane.
   I. electronegativity   II. resonance   III. hybridization
   (A) I, II   (B) I, III   (C) II, III   (D) I

6. Arrange the following compounds in the order of increasing bond length for the carbon-carbon single bond.
   I. CH₃—CH₃   II. CH≡C—CH₃   III. CH₃—CH=CH₂   IV. CH₂=CH—CH=CH₂
   (A) I, III, II, IV   (B) II, IV, III, I   (C) IV, II, III, I   (D) I, III, IV, II

7. How many pairs of cis-trans isomers are possible for the product from dehydrohalogenation of 3-bromo-hexane?
   (A) 1   (B) 2   (C) 3   (D) 4

8. What is the product from the reaction of butyne with H₂SO₄ and HgSO₄?
   (A) CH₃CH₂COCH₃   (B) CH₃CH—CHCHO
   (C) CH₃CH₂COHCH₂   (D) CH₃CH₂CHCH₂
9. How many different alkenes with the molecular formula C₅H₈Cl are chiral?
   (A) 2 (B) 3 (C) 4 (D) 5

10. Which of the following can be resolved into a pair of enantiomers?
    (A) cis-1,2-dichlorocyclobutane    (B) trans-1,2-dichlorocyclobutane
    (C) cis-1,3-dichlorocyclobutane    (D) trans-1,3-dichlorocyclobutane

11. Which of the following alcohols is most likely to form rearranged products from the reaction with
    HBr?
    (A) (CH₃)₂COHCH₂CH₃    (B) (CH₃)₂CHCHOHCH₃
    (C) (CH₃)₂CHCH₂CH₂OH    (D) (CH₃)₃CH₂OH

12. What are the best conditions for preparing 2-iodohexane from 1-hexene?
    (A) I₂ and heat  (B) HI  (C) HI and peroxides  (D) HIO₄

13. What are the products from the reaction of diisopropyl ether with BBr₃ followed by H₂O?
    (A) CH₃CH₂CH₂Br    (B) CH₂=CHCH₃
    (C) 2 (CH₃)₂CHBr    (D) (CH₃)₂CHBr + (CH₃)₂CHOH

14. The mass spectrum of a compound showed a molecular ion peak at M and another at M+2 in the ratio
    of 3:1. Which of the following heteroatoms does the compound have?
    (A) O (B) Cl (C) Br (D) N

15. Which of the following compounds have an absorption in the UV greater than 200 nm?
    I. 1,2-pentadiene  II. 1,3-pentadiene  III. 1,4-pentadiene
    IV. 2,3-pentadiene  V. 2,4-hexadiene
    (A) II. V (B) I. IV (C) II. III (D) III. IV

16. What is the order of increasing reactivity toward electrophilic aromatic substitution for the following
    compounds?
    I. C₆H₆CH₃    II. C₆H₅Br    III. C₆H₅CH₂Br    IV. C₆H₅CHBr₂
    (A) II. I. IV (B) I. III. IV, II (C) III. IV. I. II (D) II. IV. III. I

17. Which of the combinations of reactions is best for preparation of the following compound C(CH₃OH)₂?
    (A) Wittig/Cannizzarro  (B) Grinard/Clemmensen
    (C) Aldol condensation/Cannizzaro  (D) Baeyer-Villiger
18. Which of the following reaction conditions will convert glucose to 2,3,4,6-tetra-\(O\)-methyl-D-glucose?
   (A) \(\text{CH}_3\text{OH/\text{HCl}}\) → (B) \(\text{CH}_3\text{OH/\text{HCl}}\) → (\(\text{CH}_3\text{)_2\text{SO}_4/\text{NaOH}}\) →
   (C) \(\text{CH}_3\text{)_2\text{SO}_4/\text{NaOH}}\) → (D) \(\text{CH}_3\text{OH/\text{HCl}}\) → (\(\text{CH}_3\text{)_2\text{SO}_4/\text{NaOH}}\) → \(\text{H}_2\text{O/\text{HCl}}\)

19. Ethyl benzoate is reacted with ethyl acetate in a solution of sodium ethoxide. The product is treated with sodium ethoxide and ethyl bromide, followed by reaction with aqueous acid and then heat. What is the most reasonable product from these reactions?
   (A) \(\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{COCH}_3\) → (B) \(\text{C}_6\text{H}_5\text{COCH}_3\text{COOCH}_2\text{CH}_3\)
   (C) \(\text{C}_6\text{H}_5\text{COCH}_3\text{CH}_2\text{CH}_3\) → (D) \(\text{C}_6\text{H}_5\text{CH}_2\text{COCH}_2\text{CH}_3\)

20. A polypeptide has the following proportions of amino acids:
   Gly (1)  Leu (1)  Val (1)  Phe (2)
   Treatment of the pentapeptide with chymotrypsin gave the following fragments:
   Gly-Val  Leu  Phe
   What is the structure of the polypeptide?
   (A) PhePheGlyValLeu (B) GlyValPheLeuPhe
   (C) LeuGlyValPhePhe (D) PheLeuGlyValPhe

PART II. 問答題

1. Starting from (R)-sec-butyl alcohol, and using any optically inactive reagents, show all steps in the synthesis of
   (a) (R)-sec-butyl ethyl ether \((\text{CH}_3\text{CH}_2\text{CH} (\text{CH}_3)\text{OC}_2\text{H}_5)\) (3 points)
   (b) (S)-sec-butyl ethyl ether (3 points)

2. A hydrocarbon, A, adds one mole of hydrogen in the presence of a platinum catalyst to form \(n\)-hexane. When A is oxidized vigorously with \(\text{KMnO}_4\), a single carboxylic acid containing three carbon atoms is isolated. Give the structure and name of A. (3 points)

3. The following reaction is carried out, and the products are separated by careful distillation, recrystallization, or chromatography. For the reaction, tell how many fractions will be collected? Draw a stereochemical formula of the compound or compounds making up each fraction. Tell whether each fraction, as collected, will be optically active or inactive? (3 points)
   
   Racemic \((E)\)-4-methyl-2-hexene \(-\text{Br}_2\) \(\rightarrow\) \(\text{C}_8\text{H}_{12}\)\(\text{Br}_2\)
4. Suggest a mechanism for the conversion of nerol into α-terpineol in the presence of dilute H₂SO₄. (3 points)

\[
\begin{align*}
\text{CH₃} & \quad \text{CH₃} \\
\text{CH} & \quad \text{CH} \\
\text{C} & \quad \text{C} \\
\text{CH₂} & \quad \text{CH₂} \\
\text{CH₃C} & \quad \text{CH₃C} \\
\text{OH} & \quad \text{OH} \\
\text{Nerol (found in bergamot)} & \quad \text{α-Terpineol}
\end{align*}
\]

5. Predict the major products of the following reactions.
(a) [(CH₃)₂NCH=CH₂]+ HI (3 points)
(b) CH₂=CHCF₃ + HBr(AlBr₃) (3 points)
(c) What is the function of AlBr₃ in (b)? Why is it needed here? (2 points)

6. The compound indene, C₆H₈, found in coal tar, rapidly decolorizes Br₂/CCl₄ and dilute KMnO₄. Only one mole of hydrogen is absorbed readily to form indane, C₆H₁₀. More vigorous hydrogenation yields a compound of formula C₆H₁₆. Vigorous oxidation of indene yields phthalic acid. What is the structure of indene? Of indane? (3 points)

7. Making use of any necessary organic or inorganic reagents, outline all steps in the conversion of

\[
\text{(3 points)}
\]

8. Write down the products for the following reactions. (3 points each)
(a) p-CH₂C₆H₄OCH₃+KMnO₄-KOH-heat
(b) C₆H₅OCH₂C₆H₄+Br₂, Fe
(c) cyclo-C₆H₁₁MgBr -CO₂, followed by H₂SO₄
(d)
9. What are A, B, and C? (6 points)
   \[ C_6H_5C(CH_3)_2CH_2COOH + PCl_3 \rightarrow A \]
   \[ A + AlCl_3/CS_2 \rightarrow B \]
   \[ B + N_2H_4, OH, heat, high-boiling solvent \rightarrow C \]

10. What's the product of the following reaction? What's the role of tosyl chloride? (3 points)

   \[
   \begin{align*}
   &\text{CH}_2N\text{CH}_2OH + \text{TsCl} \rightarrow \\
   &\text{CH}_2N\text{CH}_2\text{CH}_2\text{OH}
   \end{align*}
   \]
PART III. 光譜分析

1. Give the structure of the compound Z according to the IR and NMR spectrum. (5 points)
2. Give the structure of the compound SS on the basis of the IR and NMR spectrum. (5 points)