A. 選擇題 (每題二分)
1. Which molecules are polar?
   \( \text{NH}_3 \) (I); \( \text{CO}_2 \) (II); \( \text{H}_2\text{O} \) (III); \( \text{CH}_4 \) (IV); \( \text{Br}_2\text{V} \).
   (1) I, IV;  (2) I, III;  (3) II, III, IV;  (4) III, IV, V.

2. Using the VSEPR model, predict which atoms have bond angles of about 120°.

   \[
   \begin{array}{cccc}
   \text{I} & \text{II} & \text{III} & \text{IV} \\
   \text{H}_3\text{C} & \text{CH}_3\text{OH} & \text{H}_2\text{C} \equiv \text{CH}_2 & \text{NH}_4\text{Cl} \\
   \uparrow & \uparrow & \uparrow & \uparrow \\
   \end{array}
   \]

   (1) II, IV;  (2) I, IV;  (3) II, III;  (4) I, III.

3. Which statement about resonance structure is false?
   (1) All contribution resonance structures must have the same number of valence electrons.
   (2) All contributing structures must obey the rules of covalent bonding.
   (3) The position of nuclei may change.
   (4) Third period atoms may have up to 12 electrons around them.

4. Arrange the following ions in the order of increasing acidity (weakest to strongest).
   \( \text{H}_2\text{O} \) (I); \( \text{H}_3\text{O}^+ \) (II); \( \text{NH}_4^+ \) (III)
   (1) II, III, I;  (2) I, II, III;  (3) III, II, I;  (4) I, III, II.

5. How many secondary hydrogens are there in the following molecule?

   \[
   \begin{array}{c}
   \text{H}_3\text{C} \quad \text{CHCH}_2\text{CH}_2\text{CH}_3 \\
   \end{array}
   \]

   (1) 1;  (2) 2;  (3) 4;  (4) 9.

6. What is the term for the process of forming ethane from ethane?
   (1) combustion;  (2) fractional distillation;  (3) thermal cracking;  (4) catalytic reforming.

7. Which is the correct structure for vinylcyclobutane?

   \[
   \begin{array}{cccc}
   (1) & (2) & (3) & (4) \\
   \end{array}
   \]

8. Which statement does not describe a transition state?
   (1) Possesses a definite geometry;
   (2) Maximum on the potential energy diagram;
   (3) Structure can be determined experimentally;
   (4) Can not be isolated.
9. Which is the major product from acid catalyzed hydration of 2-methyl-2-pentene?
   (1) 2-methyl-3-pentanol;
   (2) 2-methyl-2-pentanol;
   (3) 4-methyl-2-pentanol;
   (4) 3-methyl-3-pentanol.

10. Which compounds contain stereocenters?
   (I) 2-methylpentane; (II) chlorocyclohexane; (III) 3-methyl-2-butanol; (IV) 2-hydroxyptopanoic acid.
   (1) I, II;
   (2) III, IV;
   (3) I, III;
   (4) II, IV.

11. Which statement about enantiomers is false?
   (1) enantiomers have the same boiling and melting points;
   (2) enantiomers have the same chemical properties;
   (3) enantiomers have same atom connectivity;
   (4) enantiomers have the same three dimensional orientation.

12. Which statements apply to an S_N2 reaction?
   (I) The rate limiting step of the reaction involves the alkyl halide and the nucleophile;
   (II) The order of reactivity is methyl > 1° > 2° > 3°;
   (III) The rate limiting step of the reaction involves only the alkyl halides.
   (IV) There is an intermediate carbocation.
   (1) I, II;
   (2) III, IV;
   (3) I, IV;
   (4) II, IV.

13. Which can’t be used to distinguish phenol from cyclohexanol?
   (1) solubility in water;
   (2) solubility in hydrochloric acid solution;
   (3) solubility in sodium bicarbonate solution;
   (4) solubility in sodium hydroxide solution.

14. The broadening of the stretching vibration peak for alcohols is mainly due to which of the following?
   (1) water contamination;
   (2) a strong dipole moment;
   (3) hydrogen bonding;
   (4) coupling peaks.

15. Which is the splitting pattern for the hydrogen atoms in 2,2-dibromopropane?
   (1) septet;
   (2) quartet;
   (3) doublet;
   (4) singlet.
B. 選擇題 (每題五分)
16. Which functional group is not contained in prostaglandin E₁? (5%)

(1) ketone  (2) tertiary alcohol  (3) carboxylic acid  (4) alkene

17. What structure represents the most stable conformation of cis-1,3-dimethylcyclohexane? (5%)

(1) I  (2) II  (3) III  (4) IV

18. Which alkyl halide would be most reactive in an SN₁ reaction? (5%)

(1) I  (2) II  (3) III  (4) IV

19. Predict the major product. (5%)

(1) I  (2) II  (3) III  (4) No E2 reaction will occur

20. Which alkene is most stable? (5%)

(1) I  (2) II  (3) III  (4) IV
21. What is the product of the following reaction?  (5%)

\[
\begin{align*}
\text{CH}_3 & + \text{HI} \\
\text{I} & \quad \text{II} \\
\text{I} & \quad \text{I} \\
\end{align*}
\]

(1) I  (2) II  (3) III  (4) None of these

22. What product would result from the following reaction?  (5%)

\[
\begin{align*}
\text{C}_7	ext{H}_{12} & + \text{HBr} \quad \text{peroxides} \\
\text{I} & \quad \text{II} \\
\text{I} & \quad \text{Br} \\
\end{align*}
\]

(1) I  (2) II  (3) III  (4) none

23. Which of the following compounds would be the most stable?  (5%)

\[
\begin{align*}
\text{I} & \quad \text{II} \\
\text{III} & \quad \text{IV} \\
\end{align*}
\]

(1) I  (2) II  (3) III  (4) IV

C. Write a reasonable mechanism step-by-step for each of the following reaction. (20%, 5% each)

1. \(\text{CH}_3\text{CO}_2\text{H} + \text{CH}_2\text{N}_2 \rightarrow \text{CH}_3\text{CO}_2\text{CH}_3 + \text{N}_2\)

2. \(\text{CH}_3\text{CH=CH}_2 + \text{HBr}/\text{cat.}\text{(tBuO)}_2, \text{heat} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Br}\)

3. \(\text{CH}_3\text{OCH=CH}_2 + \text{H}^+ / \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CHO} + \text{CH}_3\text{OH}\)

4. \(\text{ArNH}_2 + \text{HNO}_2, \text{H}^+ \rightarrow \text{ArNO}_2\text{H}^+\)
D. Please draw the molecular orbitals indicated by the method of linear combination of atomic orbitals (e.g. HOMO, LUMO) to explain the following reactions. (10 %)

(1) cis, trans-2,4-Hexadiene was heated to give cis-3,4-dimethylcyclobutene. However, it gave trans-3,4-dimethylcyclobutene in the photochemical reaction.

\[
\text{cis, trans-2,4-Hexadiene} \overset{\text{heat}}{\rightarrow} \text{cis-3,4-dimethylcyclobutene} \quad \text{trans-3,4-dimethylcyclobutene} \overset{\text{hv}}{\rightarrow} \text{trans-3,4-dimethylcyclobutene}
\]

(2) [4+2] Cycloaddition of 1,3-butadiene with ethylene easily gives cyclohexene in the thermal reaction.