1. Circle the letter of the correct IUPAC name: (3 pts total)

   - a. 2-Chloro-3-methylhexanol
   - b. 5-Chloro-4-methyl-2-hexanol
   - c. 3-Methyl-2-chloro-5-hexanol
   - d. 2-Hydroxy-4-methylhexylicloride

   - a. 2-Ethyl-3-bromo-4-methylpentane
   - b. 2-Hydroxy-5-bromopentane
   - c. 5-Bromo-2-pentanol
   - d. 2-Hydroxy-4-methylhexylchloride

   - a. 8-Chloro-4-t-butyl-4,7-dimethylnonane
   - b. 6-t-Butyl-2-chloro-3,6-dimethylnonane
   - c. 2-Chloro-3,6,7-trimethyl-6-propyloctane
   - d. 6-sec-Butyl-2-chloro-3,6-dimethyloctane

   **3-Brorno-2,4-dimethylhexane**

2. Rank the following in order of INCREASING boiling point:

   - a. CH₃CH₂CH₃
   - b. CH₃CH₂CH₂OH
   - c. CH₃CHCH₃
   - d. CH₂CHCH₂CH₂OH

   \[ A < C < B < D \]

3. Which IS TRUE of APROTIC solvents? Circle the letter of all that apply.

   a. They solvate anions strongly
   b. They are polar
   c. They solvate cations strongly
   d. They speed up SN2 reactions

4. Locate the position of all the following features THAT APPLY by placing the letter on the diagram:

   - A. Products
   - B. Transition state
   - C. Intermediate
   - D. Reactants
   - E. Activation energy
   - F. heats of combustion

5. The energy diagram in question 4 would be that for which reaction: 

   a. The reaction of methane and Cl₂
   b. The reaction of methyl bromide and sodium hydroxide
   c. The reaction of t-buty alcohol and HCl
   d. None of these reactions
6. A Stevens student wanted to prepare methanol as part of his senior thesis. He was stuck on whether to use chlorination of methane or iodination of methane followed by an SN2 reaction with sodium hydroxide.

A. \[ \text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3	ext{Cl} + \text{HCl} \] 
B. \[ \text{CH}_4 + \text{I}_2 \rightarrow \text{CH}_3	ext{I} + \text{HI} \] 
C. \[ \text{CH}_3X + \text{OH}^- \rightarrow \text{CH}_3\text{OH} + X^- \] 

Help him out by answering the following three questions:

1). What is the \(\Delta H\) for reactions A and B? in Kcal/mol (don't forget the sign!).

\[ \text{A } -24.5 \text{ kcal/mol} \quad \text{B } +13 \text{ kcal/mol} \]

2). Which reaction (A or B) seems energetically more feasible \[ \underline{A} \]

3). Is reaction C feasible for both Cl and I? \[ \underline{Y} \text{ or } \underline{N} \]

4). What advice would you give him with respect to the relative proportions of \(X_2\) and methane?

\[ \underline{X_2} \text{ will be a chain reaction and there will be two } \underline{4} \text{ radicals for each methyl radical. (need half as much } \underline{X_2} \text{ as methane)} \]

7. The following kinetic data were collected for a reaction of the type: \( \text{A } + \text{ B } \rightarrow \text{ C } \)

<table>
<thead>
<tr>
<th>Trial</th>
<th>[A]</th>
<th>[B]</th>
<th>Rate (mol/l-sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2.0</td>
</tr>
</tbody>
</table>

(6pts total)

1). The reaction is:
   a. First order in both A and B and second order overall.
   b. First order in A, 0 order in B and second order overall
   c. 0 order in A, first order in B and first order overall.
   d. First order in A, 0 order in B and first order overall.

2) The rate equation for the reaction is:

\[ \text{Rate} = \frac{a \cdot k \cdot [A] \cdot [B]}{b \cdot k \cdot [A] \cdot [B] \cdot c \cdot k \cdot [A] \cdot d \cdot k \cdot [B]} \]

   e. either c. or b.

3) Of the reactions we have studied this data fits:
   a. Free radical chlorination \[ \underline{b} \]
   b. Nucleophilic subst. by SN1
   c. Nucleophilic subst. by SN2
8. How would you synthesize the following compound starting with optically pure (R) or (S) 2-butanol?

\[
\text{CH}_3\text{CH}_2\text{Br}
\]

a. 1. (R)-2-Butanol + TsCl  2. NaCN/DMSO  

b. 1. (S)-2-Butanol + TsCl  2. NaCN/DMSO

c. 1. (S)-2-Butanol + HBr (heat)  2. NaCN/DMSO  
d. (R)-2-Butanol + NaCN/DMSO

9. Monobromination of ethylcyclohexane gives one product in good yield. Which is it? (circle letter)

1) a. b. c. d.  

2) If chlorine is substituted for bromine what would you expect?

a. The same result  b. Three products in the ratio of 6:3:1  
c. Four products in the ratio of 50:25:15:10  d. Four products in the ratio of 4:3:2:1

10. A series of nucleophilic displacements of the type: RCl + X⁻ → CH₃OH → RX + Cl⁻ (18 pts) were carried out on each of the alkyl chlorides, A-F, shown below. The characteristics of the reactions are described. Select the most likely compound to fit the reaction. (Assume X⁻ is a fairly strong nucleophile.)

SN1

---

1. The reaction followed 2nd order kinetics; product was 100% opt. active with RETENTION of configuration.
2. The reaction was first order and gave mostly RACEMIZATION with some inversion.
3. The reaction was second order; the product was 100% active with INVERSION of configuration.
4. The reaction was second order; neither the reactant nor the product were optically active.
5. The reaction was first order with RETENTION of configuration.
6. The reaction was second order and gave three stereoisomers.

- Reaction 1 involved compound E  - Reaction 2 involved compound C
- Reaction 3 involved compound B  - Reaction 4 involved compound D
- Reaction 5 involved compound A  - Reaction 6 involved compound F
11. Which of the following is the key intermediate in the chlorination reaction shown?

\[
cyclopentane + \text{Cl}_2 \xrightarrow{\text{light}} \text{chlorocyclopentane}
\]

a. \[
\text{H}
\]

b. \[
\text{H}
\]

c. \[
\text{Cl}^-
\]

d. \[
\text{Cl}
\]

12. The MOST STABLE carbocation is:

a. \[
\text{CH}_3
\]

b. \[
\text{CH}_3
\]

c. \[
\text{CH}_3
\]

d. \[
\text{CH}_2^+
\]

13. A solution of pure \((S)-2\)-iodobutane \([\alpha]\) \(+15.90^\circ\) in acetone is allowed to react with radioactive \(^{131}\text{I}\) until 1.0% of the iodobutane contains radioactive iodide. The specific rotation, \([\alpha]\), of the recovered iodide is \(+15.58^\circ\).

1. The percentages of \((R)\) and \((S)\) in the product mixture are:
   a. 99% \((R)\), 1% \((S)\)  
   b. 99% \((S)\), 1% \((R)\)  
   c. 98% \((S)\), 2% \((R)\)  
   d. Can't tell without more data

2. The rate of iodine exchange is:
   a. \(1/2\) as fast as the loss in activity  
   b. Twice as fast as the loss of activity  
   c. Equal to the loss in activity

3. The likely mechanism for this reaction is:
   a. SN^1  
   b. Free radical  
   c. SN^2  
   d. E^2

14. J. W. Frankenfeld, the well known SIT researcher has recently found three hitherto unknown elements in the atmosphere of the planet Venus. Existing as their anions, these new substances have been designated \(A^-\), \(B^+\), and \(C^-\). Their atomic masses have been determined as: \(A=5\) Vmu (Venus mass units) \(B=10\) Vmu and \(C=21\) Vmu. Dr. Frankenfeld plans to use them as nucleophiles in the \(SN^2\) reaction: \(\text{CH}_3\text{Br} + A^- \rightarrow \text{CH}_3A^- + \text{Br}^-\) Predict their order of reactivity (slowest first)

   A) In methanol: \(A < B < C\)

   B) In the gas phase: \(C < B < A\)

15. The INCREASING order of stability (least first) of carbocations is: \(B\)

   For free radicals it is: \(B\)  

   The ease of formation of radicals is in the order: \(B\)

a. \(1^0 < 2^0 < \text{methyl} < 3^0\)

b. methyl \(< 1^0 < 2^0 < 3^0\)

c. \(3^0 < 2^0 < 1^0 < \text{methyl}\)

d. methyl \(< 2^0 < 1^0 < 3^0\)
18. The carbocation: \( \text{CH}_3\text{CHCHCH}_3^+ \) will rearrange to which carbocation during an SN\(^1\) reaction?

- \( \text{b. CH}_3\text{CH}_2\text{CH}_2\text{CH}_3^+ \)
- \( \text{c. CH}_3\text{CHCHCH}_3^+ \)
- \( \text{d. No rearrangement is expected} \)

19. This species represents the transition state for the:

- \( \text{a. Reaction of 1-propanol with HBr} \)
- \( \text{b. Reaction of 1-bromopropane with OH}^- \)
- \( \text{c. Reaction of propanol with PBr}_3 \)
- \( \text{d. Reaction of 1-bromopropanol with heat} \)

20. Which compound will react slowest with OH\(^-\) in a typical SN\(^2\) reaction? (circle letter)

- \( \text{a. CH}_3\text{Cl} \)
- \( \text{b. CH}_3\text{CHCH}_2\text{CH}_3 \)
- \( \text{c. CH}_3\text{CHCHCH}_3 \)

21. Show the major products for the following reactions: (12 pts total)

a. \( \text{CH}_2\text{CHCH}_3 + \text{KOH/ethanol} \rightarrow \text{CH}_3\text{CH} = \text{CH}_2 \)

b. \( \text{CH}_2\text{CHCH}_2\text{OH} + \text{HBr} \rightarrow \text{CH}_3\text{CH} = \text{CH}_2\text{Br} \)

c. \( \text{CH}_3\text{COSO}_2\text{C}_6\text{H}_5 + \text{Br}_2 \rightarrow \text{CH}_3\text{CH} = \text{CH}_2\text{Br} \) (R)

(Show stereochemistry)

d. \( \text{CH}_3\text{CHCHCH}_3 + \text{PBr}_3 \rightarrow \text{CH}_3\text{CH} = \text{CHCH}_3 \)

e. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} + \text{NaI} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{I} \)

g. \( \text{CH}_3\text{CH}_2\text{CH}_2\text{I} + \text{Mg} \rightarrow \text{CH}_3\text{CH} = \text{CHCH}_2\text{MgI} \)

(\( \text{RX} \rightarrow \text{RX} = \text{MgI} \rightarrow \text{CH}_3\text{CH} = \text{CHCH}_2\text{MgI} \))