DO NOT OPEN THE EXAM UNTIL INSTRUCTED

Exam 3

Directions:

Please check the exam to be sure there are 8 non-blank pages including the title page. Read all questions and directions carefully before entering answers.

GOOD LUCK
1. Which of the following groups has the highest priority by the Cahn-Ingold-Prelog system?

(a) \( \text{CH}_3\text{CH} \) (b) \( \text{HOCH}_2 \) (c) \( \text{CH}_2=\text{CH} \) (d) \( \text{CH}_3\text{O} \) (e) \( \text{HO} \)

2. Which of the following best describes the pair of compounds shown:

(a) identical (b) constitutional isomers (c) enantiomers (d) diastereomers

3. Which of the following statements is (are) true of S_N1 reactions of alkyl halides in general?

(a) The rate of an S_N1 reaction depends on the concentration of the alkyl halide.
(b) The rate of an S_N1 reaction depends on the concentration of the nucleophile.
(c) S_N1 reactions of alkyl halides are favored by polar-protic solvents.
(d) Answers (a) and (c) only are true.
(e) Answers (a), (b), and (c) are true.

4. What product(s) would you expect to obtain from the following S_N2 reaction?

\[ \text{[cyclic alkane]} + \text{CH}_3\text{O} \rightarrow ? + \text{Br}^- \]

(a) \( \text{H} \quad \text{OCH}_3 \) (b) \( \text{H} \quad \text{OCH}_3 \)

5. Which of the following compounds has a chirality center?

(a) \( \text{Cl} \quad \text{CH}_3 \quad \text{CH}_3 \) (b) \( \text{Cl} \quad \text{Cl} \quad \text{C}_2\text{H}_5 \)

(c) \( \text{Cl} \quad \text{CH}_3 \quad \text{H} \quad \text{Br} \) (d) \( \text{Cl} \quad \text{H} \quad \text{CH}_3 \)
6. Which of the following compounds is never chiral?
   (a) 2,3-dibromobutane  
   (b) 1,3-dibromobutane  
   (c) 1,2-dichlorobutane  
   (d) 1,4-dibromobutane

7. What is the relationship between the following compounds?

   ![Chemical Structures]

   (a) constitutional isomers  
   (b) conformational isomers  
   (c) diastereomers  
   (d) enantiomers

8. Which of the following alkyl halides gives the slowest S\text{\textsubscript{N}2} reaction?

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<table>
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<tbody>
<tr>
<td>(a) CH\text{\textsubscript{3}}CH\text{\textsubscript{2}}Cl</td>
<td>(b) CH\text{\textsubscript{3}}CHCH\text{\textsubscript{2}}Cl</td>
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<tr>
<td>(c) Cl</td>
<td>(d) Cl</td>
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<tr>
<td>CH\text{\textsubscript{3}}C\text{\textsubscript{2}}H\text{\textsubscript{2}}Cl</td>
<td>CH\text{\textsubscript{3}}CHCH\text{\textsubscript{2}}CH\text{\textsubscript{3}}</td>
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<td>(e) CH\text{\textsubscript{3}}CHCH\text{\textsubscript{2}}CH\text{\textsubscript{3}}</td>
<td></td>
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<td>CH\text{\textsubscript{2}}</td>
<td>Cl</td>
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9. Assuming no other changes, what is the effect of doubling only the concentration of the alkyl halide in the following S\text{\textsubscript{N}2} reaction?

   \[
   \text{CH}_3\text{Br} + \text{OH}^- \rightarrow \text{CH}_3\text{OH} + \text{Br}^- 
   \]

   (a) no change  (b) doubles the rate  (c) triples the rate  (d) quadruples the rate  (e) rate is halved

10. Which of the following factors has no effect on the rate of S\text{\textsubscript{N}1} reactions?

   (a) The nature of the alkyl halide  
   (b) The nature of the leaving group  
   (c) The concentration of the alkyl halide  
   (d) The concentration of the nucleophile  
   (e) The value of the rate constant

   Total _____
II. (15) Determine the absolute configuration of all chiral centers in the following molecules.

\[
\begin{align*}
\text{C} & \quad \text{H} \\
\text{Cl} & \quad \text{C} \\
\text{HO} & \quad \text{CH}_3 \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH}_3 \\
\text{H} & \quad \text{Br} \\
\text{H} & \quad \text{OH} \\
\text{CH}_3 & \quad \\
\end{align*}
\]

Draw a wedge and a Fischer projection of 2R,3R-2,3-dibromopentane.

III. (20) Define the following terms:

Enantiomers

Diastereomers

Dextrorotatory

Nucleophile
IV. (15) Provide an explanation for the following observations:

2-chloro-2-methylpropane reacts much more slowly with sodium iodide in acetone than 1-chlorobutane.

2-chloro-2-methylpropane reacts much more rapidly with ethanol (CH₃CH₂OH as solvent) than 1-chlorobutane.

Iodide ion is better nucleophile in polar protic solvents than chloride ion.
V. (20) Answer the questions on any two of the following three pages. Write ‘OMIT’ through the page you wish omitted. Your answers must be clear and complete in order to receive complete credit. A well drawn picture is frequently worth a thousand words.

1. Determine whether the following pairs of molecules are identical, enantiomers or diastereomers.

```
CH₂OH
H─OH
H─OH
CH₃

CH₂OH
H ─ H
HO ─ H
CH₃
```

```
CH₃
H─OH
Br ─ H
CH₃

CH₃
H ─ OH
Br ─ H
CH₃
```

```
CH₃
HO
CH₃

HO
CH₃
```

```
HO
CH₃

CH₃
HO
```

2. For the following pairs of reactions:
   (b) indicate the likely mechanism under the specified conditions
   (c) circle the reaction that is likely to proceed most rapidly
   (d) explain why the reaction you selected would proceed most rapidly

   (A) \[ \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3 \quad \text{Br} \quad \xrightarrow{\text{Na}^+ \cdot \text{C}≡\text{N} \quad \text{acetone}} \quad \text{CH}_3\text{CHCH}_2\text{CH}_2\text{CH}_3 \quad \text{CN} \]

   (B) \[ \text{CH}_3\text{CHCHCH}_3 \quad \text{Br} \quad \xrightarrow{\text{Na}^+ \cdot \text{C}≡\text{N} \quad \text{acetone}} \quad \text{CH}_3\text{CHCHCH}_3 \quad \text{CN} \]

   (C) \[ \text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad \text{Br} \quad \xrightarrow{\text{CH}_3\text{CH}_2\text{OH}} \quad \text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 \quad + \text{HBr} \quad \text{OCH}_2\text{CH}_3 \]

   (D) \[ \text{CH}_3\text{CHCHCH}_3 \quad \text{Br} \quad \xrightarrow{\text{CH}_3\text{CH}_2\text{OH}} \quad \text{CH}_3\text{CH}_2\text{CH}_3 \quad + \text{HBr} \quad \text{OCH}_2\text{CH}_3 \]

Bonus: (2 points) What unusual process is happening in reaction (D)?
3. Circle the most stable species of the following pairs and explain the relative stability.

\[
\begin{align*}
\text{CH}_2=\text{CH} & \quad \text{and} \quad \text{CH}_3\text{CHCH}_3 \\
\text{CH}_2\text{CHCH}_3 & \quad \text{and} \quad \text{CH}_3\text{CHCHCH}_3 \\
\text{CH}_2\text{CHCH}_3 & \quad \text{and} \quad \text{CH}_3\text{CHCH}_3 \\
\text{CH}_2\text{CHCH}_3 & \quad \text{and} \quad \text{CH}_3\text{CHCH}_3
\end{align*}
\]