Concisely answer all of the following questions **in the space provided**. Budget your time according to the point value of a given problem. If you are unsure of how to solve a problem, be sure to write down any ideas that you have. Partial credit will be given. When in doubt try not to panic, take the logical approach. You have **90 minutes** to complete the exam.

1. An unknown compound has the formula $C_9H_{18}O$. The IR spectrum of the unknown is given below. Using the IR table included in this packet, interpret the labeled peaks (those marked with letter designations) in the spectrum. Write one structure that is consistent with your fragments (12 points).

![IR Spectrum Image]

**A** = $sp^2$ C-H stretch

**B** = $sp^3$ C-H stretch

**C** = C-H stretching vibrations of aldehyde

**D** = $c\equiv$ stretching vibration

**E,F** = C=C stretching vibration of aromatic ring

C$\equiv$H - C-H bending vibration - indication of mono or meta substitution on aromatic
2. An unknown compound having the formula C_{10}H_{12}O_{2} is studied by \(^1\)H NMR and IR spectroscopy. The IR measurements reveal that the compound absorbs strongly at 1710 cm\(^{-1}\). The \(^1\)H NMR spectrum is given below. Fully interpret the given information and propose the structure of the unknown compound. Generous partial credit will be given for structural fragments. (18 points).

\[
\begin{align*}
1710 \text{ cm}^{-1} & \quad \text{IR} = \quad \text{O} \\
\text{C}_{10}\text{H}_{12}\text{O}_{2} & \quad \text{Possible solns} \\
\text{C}_{10}\text{H}_{12}\text{O}_{2} & \\
\frac{10}{2} = 5
\end{align*}
\]

<table>
<thead>
<tr>
<th>\text{Integral}</th>
<th>\text{Splitting}</th>
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</thead>
<tbody>
<tr>
<td>2.0</td>
<td>3</td>
<td>\text{singlet} \quad \text{isolated } \text{CH}_3-O</td>
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<tr>
<td>3.0</td>
<td>2</td>
<td>\text{triplet} \quad \text{likely } \text{CH}_2 \text{-CH}_2 \text{-CH}_2-</td>
</tr>
<tr>
<td>4.2</td>
<td>2</td>
<td>\text{triplet} \quad \text{O-CH}_2- \text{CH}_2-</td>
</tr>
<tr>
<td>7.4</td>
<td>5</td>
<td>\text{singlet} \quad \text{O}</td>
</tr>
</tbody>
</table>
3. An unknown compound X has the formula $C_8H_{14}O_3$. The infrared and $^1H$ NMR spectra of X are given below. Write a reasonable structure for X. So that the maximum of partial credit can be awarded, please show all work on the following page. (20 points).

ONLY SOLUTION

$\text{CH}_3\text{CH}_2\text{O} - \text{CH}_2\text{-CH}_2\text{-CH}_2\text{CH}_2\text{CH}_3$
3. Consider the following reaction:

\[ \text{ } + \text{SO}_2\text{Cl}_2 \xrightarrow{\Delta} \text{CH}_3 \text{CH}_3 \]

\[ \text{CH}_3 \text{C} \equiv \text{N} \equiv \text{N} \text{C} \equiv \text{CH}_3 \]

a) Write all monochlorination products from this reaction. Include all stereoisomers. (8 points)

![Image showing six possible chlorination products]

b) If this product mixture was injected into a GC having a carbowax column, how many peaks would be observed. (6 points)

\[ 6 \text{ see \#'s after each other} \]

Enantiomers would give 1 peak since same physical properties

c) Given the following relative, intrinsic reactivities to free radical chlorination for 3°:2°:1° hydrogens in a typical hydrocarbon, calculate the expected product ratio that should be obtained for the above reaction as analyzed by GC. Report your ratio in percent form. (10 points)

\[ \text{Bad Question data not given} \]

Everyone given Full credit
d) Write a reasonable mechanism (arrow formalism) for the formation of the major monochlorination product in the above reaction. (16 points)

\[
R^- + \overset{\text{N}}{\text{N}} \rightarrow N_2 + \overset{\text{C}}{\text{C}} + \overset{\text{H}}{\text{H}}
\]

\[
R_0 + \overset{\text{O}}{\text{C}} \overset{\text{H}_2}{\text{O}} \rightarrow R - H + \overset{\text{C}}{\text{Cl}} + \overset{\text{H}}{\text{Cl}} \rightarrow \text{SO}_2 + \text{CO}_2
\]

c) Briefly explain the consequences if the above reaction was carried out as follows. (12 points)

1. A 2:1 ratio of alkane to sulfuryl chloride was used in the reaction.
2. Upon completion of the reaction, the reaction was dumped in room temperature ethanol (CH₃CH₂OH)


(1) This is desirable. The XS alkane will increase the statistical likelihood that the reactant will be hit \( R_0 \) increasing mono chlorination (decreasing dichlorination).

(2) \( \overset{\text{CH}_3}{\text{CH}_2-\text{OH}} + \overset{\text{SO}_2\text{Cl}_2}{} \rightarrow \overset{\text{CO}_2-\overset{\text{S}}{\overset{\text{O}}{\text{O}}}}{\overset{\text{C}}{\overset{\text{O}}{\text{H}}}} + \text{2HCl} \)

The above reaction will occur rapidly, yielding heat.

4. Write a complete mechanism for the formation of the major and minor products in the following reaction. 16 points

\[
\overset{\text{Br}}{\text{Br}} + \overset{\text{Br}}{\text{Br}} + \overset{\text{H}_2\text{O}}{\text{H}_2\text{O}} \rightarrow \overset{\text{Br}}{\text{Br}} + \overset{\text{Br}}{\text{Br}} + \overset{\text{H}_2\text{O}}{\text{H}_2\text{O}}
\]

\[
\overset{\text{Br}}{\text{Br}} + \overset{\text{Br}}{\text{Br}} + \overset{\text{H}_2\text{O}}{\text{H}_2\text{O}} \rightarrow \overset{\text{Br}}{\text{Br}} + \overset{\text{Br}}{\text{Br}} + \overset{\text{H}_2\text{O}}{\text{H}_2\text{O}}
\]