This exam has nine (9) questions. Please check before beginning to make sure no questions are missing. All scratch work must be done on the attached blank pages, which will be collected. Please sign BOTH cover pages.
### Periodic Table of the Elements

<table>
<thead>
<tr>
<th>Period</th>
<th>Group I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
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</table>

**ADVICE:** A picture is worth a thousand words!
1. Predict the major product, **including** stereochemistry where applicable, for each reaction indicated below. You must draw your answer neatly in the box to receive credit. If you believe no reaction will occur you must clearly state so. (55 pts).

a) ![Reaction](image_a)

b) ![Reaction](image_b)

c) ![Reaction](image_c)

d) ![Reaction](image_d)

e) ![Reaction](image_e)
f) \[
\begin{align*}
\text{K}_3\text{MnO}_4 & \
25 \degree \text{C}
\end{align*}
\]

\[
\text{g) } \text{C}_6\text{H}_6 + 1 \text{ eq } \text{C}_4\text{H}_4\text{O}_2
\]

\[
\text{h) }
\begin{align*}
\text{H}_3\text{C} & \\
\text{H} & \\
\text{CH}_3 & \\
\text{H} & \\
\text{CH}_3 &
\end{align*}
\]

\[
\text{1. OsO}_4 \\
\text{2. NaHSO}_3 \\
\text{3. HIO}_4
\]

\[
\text{i) }
\begin{align*}
\text{C}_6\text{H}_6 & \\
\text{CH}_3 &
\end{align*}
\]

\[
\text{1. BH}_3 / \text{THF} \\
\text{2. H}_2\text{O}_2 / \text{HO-}
\]

\[
\text{j) }
\begin{align*}
\text{H} & \\
\text{H} & \\
\text{CH}_3 & \\
\text{CH}_3 &
\end{align*}
\]

\[
\text{CHCl}_3 \\
\text{KOH}
\]

\[
\text{k) }
\begin{align*}
\text{HO} & \\
\text{H} &
\end{align*}
\]

\[
\text{HIO}_4
\]
2. Which of the compounds indicated below would be resolvable into enantiomers at room temperature? Provide a brief explanation for your answer (one sentence plus an accurate drawing will do. Drawings are required for credit). (10 pts).

a) cis-1,2-dihydroxycyclohexane

b) trans-1,2-dimethylcyclohexane

c) cis-1,3-dichlorocyclohexane

d) trans-1,4-diethylcyclohexane

e) 1,1,3-trimethylcyclohexane
3. For each pair of compounds given below, circle the one that will be the more stable. Please show the pertinent interactions as accurately as possible with 3-dimensional drawings (NOTE: Circled compounds not accompanied by drawings will not receive credit). (20 pts).

(a) cis-1,3-dimethylcyclohexane or trans-1,3-dimethylcyclohexane

(b) cis-1-tert-butyl-4-methylcyclohexane or trans-1-tert-butyl-4-methylcyclohexane

(c) cis-1,4-dimethylcyclohexane or cis-1,3-dimethylcyclohexane

(d) trans-1,2-dimethylcyclohexane or trans-1,3-dimethylcyclohexane
4. Provide the most efficient synthesis possible for the compound below beginning with the indicated starting material. Read the question carefully. (15 pts).

2-Iodo-2,4,4-trimethylpentane from 2-methylpropane.

5. [18]-Annulene is an unsaturated hydrocarbon with the structure shown below. Is this compound aromatic? Why or why not? In the space provided fill in the peaks that you would expect this compound to exhibit in its NMR spectrum. Include the total number of peaks expected, their approximate chemical shifts, and their relative integration values. (10 pts).

6. The following pages provide IR and NMR spectra for two unknown compounds whose molecular formulas are given. Provide the structure for these compounds in the boxes provided, and briefly (2-3 words maximum) identify the absorptions in each spectra which helped in making your decision. (30 pts).
C_{10}H_{15}N
C\textsubscript{6}H\textsubscript{12}O\textsubscript{2}
7. When neopentyl alcohol, \((\text{CH}_3)_3\text{CCH}_2\text{OH}\), is heated with acid, it is slowly converted into an 85:15 mixture of two alkenes of formula \(\text{C}_5\text{H}_{10}\). What are these alkenes and how are they formed? Which is the major product and why? (5 pts).

8. Circle the compounds drawn below which would show only a single uncoupled peak in their NMR spectrum. (Achiral solvent; **NOTE:** points will be deducted for incorrectly circled compounds). (10 pts).

9. How can you account for the fact that cis-1,3-hexadiene is much less reactive than trans-1,3-hexadiene in Diels-Alder reactions? This will require **accurate** drawings. (5 pts).