This exam has five (5) 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>
<th>O</th>
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<tbody>
<tr>
<td>1.</td>
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<td>B</td>
<td>C</td>
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<td>Ra</td>
<td>Ac</td>
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**Lanthanide Series**

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<th>Gd</th>
<th>Tb</th>
<th>Dy</th>
<th>Ho</th>
<th>Er</th>
<th>Tm</th>
<th>Yb</th>
<th>Lu</th>
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**Actinide Series**

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<th>Np</th>
<th>Pu</th>
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<th>Cm</th>
<th>Bk</th>
<th>Cf</th>
<th>Es</th>
<th>Fm</th>
<th>Md</th>
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<th>Lw</th>
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</tbody>
</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. (60 pts).

(a) $\text{1-Methylcyclohexene + BH}_3 / \text{THF, then H}_2\text{O}_2 / \text{HO}^-$.

(b) $\text{trans-2-Butene + Br}_2 / \text{excess LiCl}$.

(c) $\text{3-Methyl-1-butene + Hg(OAc)}_2 / \text{H}_2\text{O, then NaBH}_4$.

(d) $\text{1-Methylcyclohexene + Br}_2 / \text{H}_2\text{O}$.

(e) $\text{3,3-Dimethyl-1-butene + H}_2\text{SO}_4 / \text{H}_2\text{O} / \text{heat}$.
(f) cis-2-Pentene + CHCl₃ / KOH

(g) 3,4-Dimethyl-trans-3-hexene + H₂ / Pd

(h) 1-Methylcyclopentene + KMnO₄ / H₃O⁺.

(i) cis-3-Hexene + O₃, then Zn / H₃O⁺.

(j) 1,3-dimethylcyclopentene + OsO₄, then NaHSO₃.
2. Using CH$_3$CH$_2^+$ as an example, illustrate the difference between hyperconjugation and inductive effects in the stabilization of carbocations. This will require accurate drawings. (10 pts).

Hyperconjugation: stabilization by through-space overlap of C-H sigma bond and vacant p-orbital.

Inductive effect: polarization of sigma bond to alkyl group by adjacent carbocation.

3. (a) Provide a detailed mechanistic analysis for the reaction shown below. Label all intermediate structures (a,b,c etc.), and show all electron flow using the curved arrow convention. (10 pts).

(b) Draw a qualitative reaction energy diagram for this reaction in the template provided below, indicating the relative energy of all reactants, intermediates and products. You need not re-draw structures which are clearly labeled above - use the labels. (5 pts).
4. Muscalure is the sex pheromone of the common house fly. On the basis of the following synthesis, give the structure of muscalure and the structures of the intermediates A and B. (9 pts).

\[ n-C_{13}H_{27}C\equiv CH + Na^+NH_2^- \rightarrow A (C_{15}H_{27}Na) \]

\[ A + n-C_8H_{17}Br \rightarrow B (C_{23}H_{44}) \]

\[ B + H_2, \text{ Lindlar catalyst} \rightarrow \text{muscalure (C}_{23}\text{H}_{46}) \]

\[ A = n-C_{13}H_{27}-C\equiv C-\text{Na}^+ \]

\[ B = n-C_{13}H_{27}-C\equiv C-n-C_8H_{17} \]

\[ \text{muscalure} = \begin{array}{c}
  n-C_{13}H_{27} \\
  n-C_8H_{17}
\end{array} \]

5. Provide the most efficient synthesis possible for each of the following materials from the indicated starting compounds. Read the question carefully. There will be no credit given for preparing the correct product from incorrect starting materials, or for preparing an incorrect product from correct starting materials. Neither synthesis requires more than 4 steps. (16 pts).

(a) 2-Bromo-2-iodobutane from cis-2-butene.

\[ \text{H}_3\text{C} = \text{CH}_3 \quad \text{Br}_2 \quad \text{KOH} \quad \text{HI} \]

(b) trans-1,2-Diethylcyclopropane from 1-butyne plus any alkyl halide.

\[ \text{CH}_3\text{CH}_2-\text{C} \equiv \text{C} \quad \text{NaNH}_2 \quad \text{CH}_3\text{CH}_2-\text{Br} \quad \text{Na} \quad \text{NH}_3 \quad \text{CH}_2\text{I}_2 \quad \text{Zn(Cu)} \]

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

\[ \text{H} \]

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

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

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

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

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

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