1. Consider the following theoretical reaction coordinate diagrams, describing the transformation of starting material A into product C via intermediate B. For each reaction coordinate diagram, please answer the following questions:
(a) Is there a possibility that intermediate B may be observable using standard spectroscopic methods, such as NMR spectroscopy?
(b) If there is the possibility that B may be observable, what is the maximum possible energy difference between A and B to allow observation of B by NMR spectroscopy? Please explain your reasoning.

(a) Can B be observed?
(b) Maximum possible energy difference?

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(b) Maximum possible energy difference?
2. The temperature-dependent rates of rearrangement of allyl vinyl ether (eq 1) was studied in the gas phase.

\[
\text{O} \quad \text{O}
\]

(1)

<table>
<thead>
<tr>
<th>Temp (K)</th>
<th>( k ) (s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>469.1</td>
<td>2.875 x 10(^{-3})</td>
</tr>
<tr>
<td>469.4</td>
<td>3.021 x 10(^{-3})</td>
</tr>
<tr>
<td>473.7</td>
<td>3.838 x 10(^{-3})</td>
</tr>
<tr>
<td>427.7</td>
<td>0.120 x 10(^{-3})</td>
</tr>
<tr>
<td>456.7</td>
<td>1.166 x 10(^{-3})</td>
</tr>
<tr>
<td>451.6</td>
<td>0.788 x 10(^{-3})</td>
</tr>
<tr>
<td>440.2</td>
<td>0.341 x 10(^{-3})</td>
</tr>
</tbody>
</table>

a. Provide a depiction of the transition structure for this transformation.

b. Draw a reaction coordinate diagram for this transformation, clearly labeling all intermediates and transition states.

c. Determine \( \Delta H^\ddagger \) and \( \Delta S^\ddagger \) from the data (in kcal/mol and eu, respectively).

d. Explain whether your proposed transition structure is consistent with the experimentally measured value of \( \Delta S^\ddagger \).
3. Which of the following is more stable? Why?

\[ \begin{align*}
\text{H}_2\text{N} & \text{O} \\
\text{OH} & \\
\text{CH}_3 & \\
\text{H}_2\text{N} & \text{O} \\
\text{OH} & \\
\text{CH}_3 & \\
\end{align*} \]

\[ \text{vs.} \]

\[ \begin{align*}
\text{H}_2\text{N} & \text{O} \\
\text{OH} & \\
\text{CH}_3 & \\
\text{H}_2\text{N} & \text{O} \\
\text{OH} & \\
\text{CH}_3 & \\
\end{align*} \]

4. (a) Please draw the lowest energy conformation of these methyl-substituted decalins.

\[ \begin{align*}
\text{Me} & \\
\text{H} & \\
\text{H} & \\
\text{Me} & \\
\text{H} & \\
\end{align*} \]

(b) Please estimate the energy difference between the lowest energy conformations of the diastereomers in part a.
5. *From The Art of Writing Reasonable Organic Reaction Mechanisms, Ch. 5*: Please draw reasonable arrow-pushing mechanisms for the following transformations: