Draw the constitutional formula(s) of the major organic product(s) formed in each of the following reactions.

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \xrightarrow{\text{1. Na} \oplus \text{NH}_2} \xrightarrow{\text{2. CH}_3\text{CH}_2\text{I}}
\]
- Compound X was isolated as a derivative of a natural product.

![Chemical structure of X]

**Carbon 4 of X is a stereogenic centre. List the substituents attached to C4 in descending order of priority according to the sequence rules.**

<table>
<thead>
<tr>
<th>highest priority</th>
<th>lowest priority</th>
</tr>
</thead>
</table>

What is the systematic name for compound X? Make sure you include all relevant stereochemical descriptors.

Reduction of X with sodium borohydride (NaBH₄) followed by quenching the reaction with dilute acid gives Y. Give the constitutional formula for Y.

Product Y can be separated into two isomers. Explain.
- Draw the structure(s) of the major organic product(s) formed in each of the following reactions. Give the names of the products where requested.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Reagents</th>
<th>Name(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Structure 1" /></td>
<td>conc. K(\text{OH}) / heat</td>
<td></td>
</tr>
<tr>
<td><img src="image2" alt="Structure 2" /></td>
<td>Cr(_2\text{O}_7)/ H(^+)/H(_2\text{O})</td>
<td></td>
</tr>
<tr>
<td><img src="image3" alt="Structure 3" /></td>
<td>conc. HBr</td>
<td></td>
</tr>
<tr>
<td><img src="image4" alt="Structure 4" /></td>
<td>H(^+)/H(_2\text{O})/ heat</td>
<td></td>
</tr>
</tbody>
</table>

Marks: 6
• Compound **Y** can readily be identified by $^1$H NMR spectroscopy.

On the diagram of **Y**, write the letters a, b, c, *etc.* as necessary to identify each unique hydrogen environment giving rise to a signal in the $^1$H NMR spectrum.

![Diagram of Y](image)

Sketch the $^1$H NMR spectrum of compound **Y**. Label each signal in the spectrum with a, b, c, *etc.* to correspond with your assignments on the diagram of **Y**. Make sure you show the splitting pattern (number of fine lines) you expect to see for each signal. Also write the relative number of hydrogens you expect above each signal.

Compound **Z** is an isomer of **Y**.

![Diagram of Z](image)

What kind of isomers are they?

Compounds **Y** and **Z** can be readily distinguished by instrumental techniques. Suggest how three different techniques can be used to distinguish between the two structures.
Complete the two step mechanism for the reaction given below. Draw intermediate structures, curly arrows and partial charges as appropriate to illustrate the bonding changes that take place.