1. Give the proper name or structure for each of the following. Name and show any stereochemistry present in these.

   a) \[
   \text{1R,6S}(\text{cis})-6\text{methylcyclohex-3-en-1-ol}
   \]
   
   b) \[
   2,4\text{-diethyl-1-heptanol}
   \]
   
   c) \[
   \text{exo-bicyclo[2.1.1]hex-2-en-5-ol}
   \]
   
   d) \[
   \text{trans-cyclohexene glycol}
   \]
   
   e) \[
   \text{pentaamethylene glycol}
   \]

2. For each set of experimental facts presented below, give reasonable explanations for the observed trends, using the relationships between structure and physical properties.

<table>
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<tr>
<th>Solubility in Water</th>
<th>Boiling Point</th>
<th>Explain Each Separately</th>
</tr>
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<tbody>
<tr>
<td>(8.3 \text{g/100 mL H}_2\text{O})</td>
<td>118°C</td>
<td>157°C</td>
</tr>
<tr>
<td>(26.0 \text{g/100 mL H}_2\text{O})</td>
<td>99.5°C</td>
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   Each of the alcohols can hydrogen bond with water to help it dissolve. The more polar of the three is \(1\)-butanol, which would seem to indicate it should be the one that is most soluble in water. Therefore there must be another explanation. The intermolecular interactions between the \(2^\circ\) and \(3^\circ\) alcohols are less due to smaller surface areas and poorer intermolecular hydrogen bonding. This makes it easier for the water molecules to separate the alcohols. The other reason is that the \(2^\circ\) and \(3^\circ\) alcohols are more compact and disrupt the water molecules less.

   Boiling Point: This is just what one would expect based on intermolecular interactions. The \(1^\circ\) alcohol would have more effective H-bonding, as well as more effective London Dispersion forces (more surface area). We learned earlier that branching reduces boiling point due to a reduction in the dispersion forces. But also here, the hydrogen bonding is made less effective with an increase in the steric size of the alkyl group near the oxygen.

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   Solubility: the number of hydroxyl groups will increase the solubility in water due to increased H-bonding interactions. Butanol has fewer non-polar methylene groups than hexanol making it more soluble.

   Boiling point: both butanol and hexanol are primary alcohols but hexanol has a higher molecular weight, therefore increasing intermolecular London forces and the boiling point. The hexanediol, with the two OH groups, has extra intermolecular interactions, including additional H-bonding, which will raise the boiling point.
3. Provide two different syntheses, using structurally different starting materials, for the following compounds where a Grignard reagent is used in each method.

   a)  
   
   b)  
   
   c)  

4. Provide reagents and conditions to carry out the following transformations. If more than one method is possible, choose the one that is most commonly used for that transformation.

   a)  
   
   b)  
   
   c)  
   
   d)  
   
   e)  
   
   f)  
   
   g)  

...
5. Predict the major organic products expected in the following reactions. Pay particular attention to stereochemistry in your answers. When mixtures are expected, indicate the relative amounts of each.

a) \[ \text{H}_2\text{C} \quad \text{H}_2\text{C} \quad \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{OH} \quad \text{HBr} \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{Br} \]

b) \[ \text{H}_2\text{C} \quad \text{CH}_3 \quad \text{OH} \quad \text{HCl/ZnCl}_2 \rightarrow \downarrow \text{CH}_3 \quad \text{Cl} \]

c) \[ \text{H}_2\text{C} \quad \text{H}_2\text{C} \quad \text{H}_3\text{C} \quad \text{OH} \quad \text{HBr} \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{Br} \quad + \quad \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{Br} \quad + \quad \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{Br} \]

d) \[ \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{OH} \quad \text{PBr}_3 \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{Br} \]

e) \[ \text{H}_2\text{C} \quad \text{H}_2\text{C} \quad \text{OH} \quad \text{1. Ts-Cl/py} \quad \text{2. KO(t-Bu)/HO(t-Bu)} \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{CH}_2 \]

f) \[ \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{OH} \quad \text{1. Ts-Cl/py} \quad \text{2. NaI/acetone} \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{CH}_3 \]

g) \[ \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{CH}_3 \quad \text{1. BH}_3/\text{THF} \quad \text{2. H}_2\text{O}_2/\text{NaOH} \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{CH}_3 \]

h) \[ \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{OH} \quad \text{1. Hg(OAc)}_2/\text{THF/H}_2\text{O} \quad \text{2. NaBH}_4/\text{NaOH} \rightarrow \downarrow \text{H}_3\text{C} \quad \text{H}_3\text{C} \quad \text{CH}_3 \]