The structure of D-glucose is shown below. Draw the Fischer projection of L-glucose in the space provided.

D-glucose is in equilibrium with two cyclic pyranose forms. Give the Haworth projection of these two cyclic forms.

Give the products obtained when D-glucose is treated with the following reagents.

methanol / $H^+$  
[Ag(NH$_3$)$_2$]$^+$ / OH$^-$ solution  
1. NaBH$_4$  
2. dilute acid

Draw the Haworth structure of a non-reducing disaccharide, which, on acid hydrolysis, yields D-glucose as the only product.
The structure of D-mannose is shown below. Draw the Fischer projection of L-mannose in the space provided.

L-mannose

D-Mannose is in equilibrium with two cyclic pyranose forms. Give the Haworth projection of these two cyclic forms.

Give the products obtained when D-mannose is treated with the following reagents.

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol / H⁺</td>
<td>1. NaBH₄</td>
</tr>
<tr>
<td>[Ag(NH₃)₂]⁺/OH⁻ solution</td>
<td>2. dilute acid</td>
</tr>
</tbody>
</table>

Draw the Haworth structure of a reducing disaccharide, which, on acid hydrolysis, yields D-mannose as the only product.
An important group of oligosaccharides is the blood group antigens. The blood group antigen of humans with blood group B can be represented by the partial structure below, in which R is a glycoprotein.

The type B blood group antigen can be hydrolysed to galactose (2 mole equiv.), fucose (1 mole equiv.) and a glycoprotein unit.

Specify the fucose unit in the type B blood group antigen as a furanose or a pyranose.

Specify fucose as a hexose, a pentose or a tetrose.

Give the Fischer projections of the open chain form of galactose and fucose.

<table>
<thead>
<tr>
<th>Fischer projection of galactose</th>
<th>Fischer projection of fucose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On your Fischer projection of galactose indicate with an asterisk (*) the carbon atom used in the D/L convention.

Specify the galactose from blood antigen as D-galactose or L-galactose.

Specify the fucose from blood antigen as D-fucose or L-fucose.
Complete the following table.

<table>
<thead>
<tr>
<th>STARTING MATERIAL</th>
<th>REAGENTS/CONDITIONS</th>
<th>CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Structural formula" /></td>
<td>CH₃OH / H⁺ catalyst</td>
<td></td>
</tr>
</tbody>
</table>
A stick representation for the active enantiomer of methadone, an analgesic used as a maintenance drug in the treatment of heroin addiction, is shown below.

Give the molecular formula of methadone.

Methadone contains a stereogenic centre. List the substituents attached to this stereogenic centre in descending order of priority according to the sequence rules.

Highest priority

Lowest priority

What is the stereochemistry at this stereocentre? Write (R) or (S).

List the functional groups present in methadone.

Treatment of methadone with NaBH₄ gives compounds (X) and (Y). Draw the structures of (X) and (Y).

What is the stereochemical relationship between compounds (X) and (Y)?
The nucleic base guanine is drawn below as a keto tautomer. Draw two other tautomers of guanine.

Marks 2