Chapter 11 Review Problems

INSTRUCTIONS:

You do not need to write the question, ONLY WRITE THE PROBLEM NUMBER and ANSWERS/SOLUTIONS.

• For problems that involve calculations, you must show your work to get full credit.
• For multiple choice questions, you can simply write the letter (a, b, c, or d) of the correct response.
• Use the navigation buttons at the bottom of the pages to get hints, check your answers, move to the next problem, or go back to previous pages.

Chapter Review Problems are due at the end of class period on the dates shown in the CHEM 108 Schedule.

• Late submissions will not be accepted unless the student can prove to the instructor that something outside of their control prevented them from turning in the problem set on the due date (see the course syllabus for more details).
11.1) Classify each of the following monosaccharides as either an *aldose* or a *ketose*.

(a) \[
\begin{align*}
\text{HO} & \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} & \quad \text{OH} \quad \text{OH} \quad \text{OH} \quad \text{H} \quad \text{H} \quad \text{H} \\
\end{align*}
\]

(b) \[
\begin{align*}
\text{HO} & \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} & \quad \text{OH} \quad \text{OH} \quad \text{OH} \quad \text{H} \quad \text{H} \\
\end{align*}
\]

(c) \[
\begin{align*}
\text{HO} & \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} & \quad \text{OH} \quad \text{OH} \\
\end{align*}
\]
11.1) Classify each of the following monosaccharides as either an aldose or a ketose.

a) ![Monosaccharide structure](image)

b) ![Monosaccharide structure](image)

c) ![Monosaccharide structure](image)

**HINT:**
Monosaccharides contain either an aldehyde group or a ketone bonding pattern.

- A monosaccharide that contains an *aldehyde group* is called an **aldose**.
- A monosaccharide that contains the *ketone bonding pattern* is called a **ketose**.

**For more help:** See chapter 11 part 1 video or chapter 11 section 2 in the textbook.
11.1) Classify each of the following monosaccharides as either an *aldose* or a *ketose*.

**EXPLANATION:**
Monosaccharides contain either an aldehyde group or a ketone bonding pattern.
- A monosaccharide that contains an *aldehyde group* is called an *aldose*.
- A monosaccharide that contains the *ketone bonding pattern* is called a *ketose*.

*For more details:* See chapter 11 part 1 video or chapter 11 section 2 in the textbook.
11.2) Classify each of the following monosaccharides using the prefix “aldo” for aldoses, or “keto” for ketose, in front of “triose,” “tetrose,” “pentose,” “hexose,” or “heptose.”

a)  \[
\begin{align*}
\text{HO-} & \text{C-} \text{C-} \text{C-} \text{C-} \text{C-} \text{C-} \text{H} \\
\text{H} & \text{OH} \text{ OH} \text{ OH} \text{ OH}
\end{align*}
\]

b)  \[
\begin{align*}
\text{HO-} & \text{C-} \text{C-} \text{C-} \text{C-} \text{C-} \text{H} \\
\text{H} & \text{OH} \text{ OH} \text{ OH}
\end{align*}
\]

c)  \[
\begin{align*}
\text{HO-} & \text{C-} \text{C-} \text{C-} \text{C-} \text{C-} \text{H} \\
\text{H} & \text{OH} \text{ OH}
\end{align*}
\]
11.2) Classify each of the following monosaccharides using the prefix “aldo” for aldoses, or “keto” for ketose, in front of “triose,” “tetrose,” “pentose,” “hexose,” or “heptose.”

HINT: Monosaccharide may be classified by both the number of carbons and whether it is an aldose or a ketose.

- The table on the left is used to classify monosaccharides by the number of carbons they contain.
- A monosaccharide that contains an aldehyde group is called an aldose.
- A monosaccharide that contains the ketone bonding pattern is called a ketose.

<table>
<thead>
<tr>
<th>Number of Carbons</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>triose</td>
</tr>
<tr>
<td>4</td>
<td>tetrose</td>
</tr>
<tr>
<td>5</td>
<td>pentose</td>
</tr>
<tr>
<td>6</td>
<td>hexose</td>
</tr>
<tr>
<td>7</td>
<td>heptose</td>
</tr>
</tbody>
</table>

For more help: See chapter 11 part 1 video or chapter 11 section 2 in the textbook.
11.2) Classify each of the following monosaccharides using the prefix “aldo” for aldoses, or “keto” for ketose, in front of “triose,” “tetrose,” “pentose,” “hexose,” or “heptose.”

EXPLANATION: Monosaccharide may be classified by both the number of carbons and whether it is an aldose or a ketose.

- The table on the left is used to classify monosaccharides by the number of carbons they contain.
- A monosaccharide that contains an aldehyde group is called an aldose.
- A monosaccharide that contains the ketone bonding pattern is called a ketose.

For more details: See chapter 11 part 1 video or chapter 11 section 2 in the textbook.
11.3) Most monosaccharides contain at least one **chiral** carbon. You learned that a chiral carbon is a carbon that is surrounded by **four different groups**. Molecules with just one chiral carbon have a pair of geometric isomers called **enantiomers**. Enantiomers have the same atomic connections, but a different three-dimensional arrangement of atoms, and are nonsuperimposable mirror images of each other. If a molecule has more than one chiral carbon, then it will have more than one pair of enantiomers. The number of stereoisomers that a molecule has can be calculated from the number of chiral carbons. If a monosaccharide has “n” chiral carbons, then it will have $2^n$ stereoisomers.

**QUESTION:** How many stereoisomers are possible for each of the monosaccharides shown below?

a) ![Monosaccharide A](image)

b) ![Monosaccharide B](image)
11.3) Most monosaccharides contain at least one **chiral** carbon. You learned that a chiral carbon is a carbon that is surrounded by **four different groups**. Molecules with just one chiral carbon have a pair of geometric isomers called **enantiomers**. Enantiomers have the same atomic connections, but a different three-dimensional arrangement of atoms, and are nonsuperimposable mirror images of each other. If a molecule has more than one chiral carbon, then it will have more than one pair of enantiomers. The number of stereoisomers that a molecule has can be calculated from the number of chiral carbons. If a monosaccharide has “n” chiral carbons, then it will have $2^n$ stereoisomers.

**QUESTION:** How many stereoisomers are possible for each of the monosaccharides shown below?

**HINT:** Identify the number of chiral carbons, and then calculate the number of stereoisomers. A carbon is chiral if it is surrounded by four different groups; you must consider whether each of the entire groups bonded to the carbon are different from each other.

For more help: See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.3) Most monosaccharides contain at least one **chiral** carbon. You learned that a chiral carbon is a carbon that is surrounded by **four different groups**. Molecules with just one chiral carbon have a pair of geometric isomers called **enantiomers**. Enantiomers have the same atomic connections, but a different three-dimensional arrangement of atoms, and are nonsuperimposable mirror images of each other. If a molecule has more than one chiral carbon, then it will have more than one pair of enantiomers. The number of stereoisomers that a molecule has can be calculated from the number of chiral carbons. If a monosaccharide has “n” chiral carbons, then it will have $2^n$ stereoisomers.

**QUESTION:** How many stereoisomers are possible for each of the monosaccharides shown below?

**EXPLANATION:** Identify the number of chiral carbons, and then calculate the number of stereoisomers. A carbon is chiral if it is surrounded by four different groups; you must consider whether each of the entire groups bonded to the carbon are different from each other. The chiral carbons are highlighted red in the structures below.

**a)**

Because this monosaccharide structure has four chiral carbons, there are $2^4 = (2 \times 2 \times 2 \times 2) = 16$ possible stereoisomers (eight pairs of enantiomers).

**b)**

Because this monosaccharide structure has one chiral carbon, there are $2^1 = 2$ possible stereoisomers (one pair of enantiomers).

**For more details:** See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.4) In previous chapters, we used the wedge and dash system to retain the three dimensional information on a flat surface. For monosaccharides, \textit{Fischer projections} are used for this purpose. The Fischer projection for the one of the two enantiomers of glyceraldehyde is shown on the right. Using \textit{two wedges and two dashes} emanating from the chiral carbon, draw the \textit{wedge and dash representation} of this molecule.
11.4) In previous chapters, we used the wedge and dash system to retain the three dimensional information on a flat surface. For monosaccharides, Fischer projections are used for this purpose. The Fischer projection for the one of the two enantiomers of glyceraldehyde is shown on the right. Using two wedges and two dashes emanating from the chiral carbon, draw the wedge and dash representation of this molecule.
11.4) In previous chapters, we used the wedge and dash system to retain the three-dimensional information on a flat surface. For monosaccharides, **Fischer projections** are used for this purpose. The Fischer projection for the one of the two enantiomers of glyceraldehyde is shown on the right. Using *two wedges and two dashes* emanating from the chiral carbon, draw the *wedge and dash representation* of this molecule.

For more details: See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.5) Draw the enantiomer (mirror image) for each of the monosaccharides shown below.

a)

CH$_2$OH

CHO

HO

H

b)

CHO

H

OH

H

OH

CH$_2$OH

c)

CHO

HO

H

HO

H

OH

CH$_2$OH
11.5) Draw the enantiomer (mirror image) for each of the monosaccharides shown below.

a)

\[
\begin{array}{c}
\text{CHO} \\
\text{HO} \\
\text{CH}_2\text{OH}
\end{array}
\]

b)

\[
\begin{array}{c}
\text{CHO} \\
\text{H} \\
\text{OH} \\
\text{H} \\
\text{OH} \\
\text{CH}_2\text{OH}
\end{array}
\]

c)

\[
\begin{array}{c}
\text{CHO} \\
\text{HO} \\
\text{HO} \\
\text{H} \\
\text{OH} \\
\text{CH}_2\text{OH}
\end{array}
\]

HINT:
A chiral carbon is located wherever lines cross (intersect) in Fischer projections. The hydrogen (H) and the hydroxyl group (OH) positions are reversed on chiral carbons for each particular enantiomer pair. This is the case for all monosaccharide enantiomer pairs.

For more help: See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.5) Draw the enantiomer (mirror image) for each of the monosaccharides shown below.

**EXPLANATION:**
A chiral carbon is located wherever lines cross (intersect) in Fischer projections. The hydrogen (H) and the hydroxyl group (OH) positions are reversed on chiral carbons for each particular enantiomer pair. This is the case for all monosaccharide enantiomer pairs.

For more details: See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.6) An aldotetrose contains two chiral carbons, and therefore there are $2^2 = 4$ aldotetrose stereoisomers. Draw Fischer projections of the four stereoisomers.
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**HINT:**
First draw the Fisher projection’s aldehyde group, two chiral carbons, and non chiral carbon (as shown below) for all four of the stereoisomers. On your first Fischer projection, draw all of the hydroxyl groups on the right side of the chiral carbons and all hydrogens on the left side. Next, draw its mirror image (enantiomer) that has all hydroxyl groups on the left side of the chiral carbons and all hydrogens on the right side. That will give you two of the four stereoisomers. Construct your third Fischer projection by exchanging the positions of a hydroxyl group and a hydrogen that are bonded to the same chiral carbon in order to obtain a structure that differs from your previous ones. Then, draw its mirror image to get your fourth projection.

For more help: See [chapter 11 part 2 video](#) or chapter 11 section 3 in the textbook.
11.6) An aldotetrose contains two chiral carbons, and therefore there are $2^2 = 4$ aldotetrose stereoisomers. Draw Fischer projections of the four stereoisomers.

**EXPLANATION:** First draw the Fisher projection’s aldehyde group, two chiral carbons, and non chiral carbon (as shown below) for all four of the stereoisomers. On the first Fischer projection, all of the hydroxyl groups were (arbitrarily) drawn on the right side of the chiral carbons and all hydrogens on the left side. Next, the mirror image (enantiomer) that has all hydroxyl groups on the left side of the chiral carbons and all hydrogens on the right side. This gives two of the four stereoisomers. The third Fischer projection is constructed by exchanging the positions of a hydroxyl group and a hydrogen that are bonded to the same chiral carbon in order to obtain a structure that differs from the previous ones. Finally, the mirror image of the third projection is drawn to get the fourth projection.

For more details: See [chapter 11 part 2 video](#) or chapter 11 section 3 in the textbook.
11.7) In order to differentiate the two individual monosaccharides of an enantiomer pair, ‘D-’ or ‘L-’ designations are used with the common name. Monosaccharides with the L- designation are sometimes referred to as “L-sugars,” and those with the D- designation are sometimes referred to as “D-sugars.”

Classify each of the eight stereoisomers shown below as either the D-sugar or L-sugar.
11.7) In order to differentiate the two individual monosaccharides of an enantiomer pair, ‘D-’ or ‘L-’ designations are used with the common name. Monosaccharides with the L- designation are sometimes referred to as “L-sugars,” and those with the D- designation are sometimes referred to as “D-sugars.”

Classify each of the eight stereoisomers shown below as either the D-sugar or L-sugar.

In L-sugars, the chiral carbon that is furthest from the top of the Fischer projection has its hydroxyl group on the left. In D-sugars, the chiral carbon that is furthest from the top of the Fischer projection has its hydroxyl group on the right.

For more help: See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.7) In order to differentiate the two individual monosaccharides of an enantiomer pair, ‘D-’ or ‘L-’ designations are used with the common name. Monosaccharides with the L-designation are sometimes referred to as “L-sugars,” and those with the D-designation are sometimes referred to as “D-sugars.”

Classify each of the eight stereoisomers shown below as either the D-sugar or L-sugar.

- In L-sugars, the chiral carbon that is furthest from the top of the Fischer projection has its hydroxyl group on the left.
- In D-sugars, the chiral carbon that is furthest from the top of the Fischer projection has its hydroxyl group on the right.

For more details:
See chapter 11 part 2 video or chapter 11 section 3 in the textbook.
11.8) Draw a Haworth projection for ball and stick representation shown below.
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EXPLANATION:
The side view structures of cyclic monosaccharides are called Haworth projections or Haworth structures. In Haworth projections, the carbon atoms that form the ring are not drawn explicitly, but are implied to occur where lines/bonds meet. Each ring-carbon is bonded to two other ring atoms and two other groups. In the ball and stick representation, the ring carbons are shaded black, groups that are oriented upward relative to the ring-carbons are shaded green. Groups oriented downward from ring-carbons are shaded red.

For more help: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.8) Draw a Haworth projection for ball and stick representation shown below.

EXPLANATION:
The side view structures of cyclic monosaccharides are called Haworth projections or Haworth structures. The carbon atoms that form the ring are not drawn explicitly, but are implied to occur where lines/bonds meet. Each ring-carbon is bonded to two other ring atoms and two other groups. To help you understand the three-dimensional implications of Haworth projections and give clarity to the solution to this particular problem, groups that are oriented upward relative to the ring-carbons are shaded green. Groups oriented downward from ring-carbons are shaded red.

For more details: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.9) Using complete sentences, explain why glucose and many other monosaccharides can be represented by both a cyclic form (as seen in Haworth projections) and a non-cyclic form (as seen in Fischer projections).

**NOTE:** I am *not asking* you to explain what Haworth and Fischer projections are; I am asking *why* these monosaccharides can be represented using a cyclic form and a non-cyclic form.
11.9) Using complete sentences, explain why glucose and many other monosaccharides can be represented by both a cyclic form (as seen in Haworth projections) and a non-cyclic form (as seen in Fischer projections).

**NOTE:** I am *not asking* you to explain what Haworth and Fischer projections are; I am asking *why* these monosaccharides can be represented using a cyclic form and a non-cyclic form.

**For more help:** See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.9) Using complete sentences, explain why glucose and many other monosaccharides can be represented by both a cyclic form (as seen in Haworth projections) and a non-cyclic form (as seen in Fischer projections).

**NOTE:** I am **not asking** you to explain what Haworth and Fischer projections are; I am asking **why** these monosaccharides can be represented using a cyclic form and a non-cyclic form.

**ANSWER:** When monosaccharides that contain five to seven carbons are in aqueous solutions, they can undergo a reversible reaction in which they rearrange their non-cyclic structure to form cyclic structures.

**EXPLANATION:** The open-chain form of an aldose monosaccharide contains both an aldehyde group and at least two hydroxyl groups. The open-chain form of a ketose monosaccharide contains both the ketone bonding pattern and at least two hydroxyl groups. A hemiacetal is formed when a monosaccharide’s hydroxyl group reacts with its carbonyl group. The monosaccharide is “reacting with itself.” The cyclization rearrangement reaction is shown on the right for a D-glucose molecule.

For more details: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.10) Classify each of the molecules shown below as either a pyranose or a furanose.

![Molecules a), b), and c) with their structures shown]

Go back  
Click here for a hint  
Click here to check your answer  
Go to next question
11.10) Classify each of the molecules shown below as either a **pyranose** or a **furanose**.

![Molecules a), b), and c) for classification as pyranose or furanose.](image)

**HINT:**
Cyclic monosaccharides with **five-member rings** (five atoms in the ring structure) are called **furanoses**.
Cyclic monosaccharides with **six-member rings** (six atoms in the ring structure) are called **pyranoses**.

**For more help:** See [chapter 11 part 3 video](link) or chapter 11 section 3 in the textbook.
11.10) Classify each of the molecules shown below as either a **pyranose** or a **furanose**.

EXPLANATION:
Cyclic monosaccharides with **five-member rings** (five atoms in the ring structure) are called **furanoses**. Cyclic monosaccharides with **six-member rings** (six atoms in the ring structure) are called **pyranoses**.

*For more details:* See [chapter 11 part 3 video](#) or chapter 11 section 3 in the textbook.
11.11) 

i) The two enantiomers that can be formed during the cyclization of monosaccharides are called ______________.
   a) conformations  
   b) cis or trans  
   c) sugar twins  
   d) anomers

ii) It is easy to identify the *anomeric carbon* in a Haworth projection of a D-sugar; it is the ring-carbon to the ______________ side of the ring-oxygen.
   a) right-hand  
   b) left-hand

iii) An *α*-anomer has the *OH* on the anomeric carbon oriented ______________ from the ring.
   a) downward  
   b) upward  
   c) in a random direction
11.11)

i) The two enantiomers that can be formed during the cyclization of monosaccharides are called ______________.

**HINT:**
- a) conformations
- b) cis or trans
- c) sugar twins
- d) anomers

ii) It is easy to identify the *anomeric carbon* in a Haworth projection of a D-sugar; it is the ring-carbon to the ______________ side of the ring-oxygen.
   - a) right-hand
   - b) left-hand

iii) An α-anomer has the OH on the anomeric carbon oriented ______________ from the ring.

**HINT:**
- a) downward
- b) upward
- e) in a random direction

**For more help:** See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.11)

i) The two enantiomers that can be formed during the cyclization of monosaccharides are called ______________.
   a) conformations
   b) cis or trans
   c) sugar twins
   d) anomers

ii) It is easy to identify the *anomeric carbon* in a Haworth projection of a D-sugar; it is the ring-carbon to the ______________
   side of the ring-oxygen.
   a) right-hand
   b) left-hand

iii) An α-anomer has the OH on the anomeric carbon oriented ______________ from the ring.
   a) downward
   b) upward
   c) in a random direction

The sugar produced in photosynthesis, and almost all of the other monosaccharides found in plants and animals, are D-sugars. At some point in the history of Earth, nature chose D-sugars. In later chapters of this course, you will only see D-sugars. For more details: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.12) Write the definition of the term “mutarotation.”
11.12) Write the definition of the term “mutarotation.”

**HINT:**

*Mutarotation* is the conversion from __________, to the ___________ form, then to the ___________ (and vice versa).

**For more help:** See [chapter 11 part 3 video](#) or chapter 11 section 3 in the textbook.
11.12) Write the definition of the term “mutarotation.”

**ANSWER:** Mutarotation is the conversion from α-anomer, to the open-chain form, then to the β-anomer (and vice versa).

The mutarotation process is illustrated below for an aldose (D-glucose).

For more details: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.13) Classify each of the molecules shown below as either a $\beta$-anomer or an $\alpha$-anomer.

a)

b)

c)
11.13) Classify each of the molecules shown below as either a \( \beta \)-anomer or an \( \alpha \)-anomer.

HINT:
Although all of the ring-carbons in cyclic monosaccharides are chiral, the only possible change in stereochemistry that may occur in cyclization is that of the \textit{anomeric carbon}. The two enantiomers that can be formed during the cyclization process are called anomers. They are classified, based on the orientation of the hydroxyl group (OH) on the \textit{anomeric carbon}, as the \( \alpha \)-anomer or the \( \beta \)-anomer.

I have included black spheres (●) in order to indicate the position of the \textit{anomeric carbons}.

For more help: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.13) Classify each of the molecules shown below as either a $\beta$-anomer or an $\alpha$-anomer.

I have included black spheres (●) in order to indicate the position of the anomeric carbons.

EXPLANATION:

Although all of the ring-carbons in cyclic monosaccharides are chiral, the only possible change in stereochemistry that may occur in cyclization is that of the anomeric carbon. The two enantiomers that can be formed during the cyclization process are called anomers. They are classified, based on the orientation of the hydroxyl group (OH) on the anomeric carbon, as the $\alpha$-anomer or the $\beta$-anomer.

- The $\alpha$-anomer has the OH on the anomeric carbon oriented downward from the ring.
- The $\beta$-anomer has the OH on the anomeric carbon oriented upward from the ring.

For more details: See chapter 11 part 3 video or chapter 11 section 3 in the textbook.
11.14) Identify each of the molecules shown below as either a monosaccharide, amino sugar, carboxylic acid sugar, alcohol sugar, or a deoxy sugar.

a) ![Molecule a]

b) ![Molecule b]

c) ![Molecule c]

d) ![Molecule d]

e) ![Molecule e]

f) ![Molecule f]

g) ![Molecule g]

h) ![Molecule h]
Identify each of the molecules shown below as either a monosaccharide, amino sugar, carboxylic acid sugar, alcohol sugar, or a deoxy sugar.

For more help: See chapter 11 part 4 video or chapter 11 section 4 in the textbook. 

Click here to check your answer.
11.14) Identify each of the molecules shown below as either a monosaccharide, amino sugar, carboxylic acid sugar, alcohol sugar, or a deoxy sugar.

- **a)** monosaccharide (a polyhydroxyl ketone)
- **b)** carboxylic acid sugar (the carbonyl group (C=O) of a aldose is oxidized to a carboxyl group)
- **c)** deoxy sugar (the cyclic form, a hydroxyl group (-OH) in a monosaccharide is replaced by a hydrogen)
- **d)** deoxy sugar (a hydroxyl group (-OH) in a monosaccharide is replaced by a hydrogen)
- **e)** amino sugar (a hydroxyl group (-OH) in a monosaccharide is replaced by an amino group)
- **f)** monosaccharide (a polyhydroxyl aldehyde)
- **g)** alcohol sugar (the carbonyl group (C=O) of a monosaccharide is reduced to an alcohol)
- **h)** monosaccharide (the cyclic form)

For more details: See chapter 11 part 4 video or chapter 11 section 4 in the textbook.
11.15) Draw the Fischer projection of the monosaccharide derivative that is formed for each of the reactions shown below.

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

\[
\text{O} & \text{C} \text{H} \\
\text{H} & \text{OH} \\
\text{HO} & \text{H} \\
\text{HO} & \text{H} \\
\text{CH}_2\text{OH} \\
\]

\rightleftharpoons \text{[O]} \\

\text{?}

\rightleftharpoons \text{[R]} \\

?
11.15) Draw the Fischer projection of the monosaccharide derivative that is formed for each of the reactions shown below.

**HINT:**
In a carboxylic acid sugars are derived when the aldehyde group (CHO) of a monosaccharide is oxidized to form a carboxyl group (COOH).
- You first learned about the oxidation of aldehydes to carboxylic acids in chapter 10.

**HINT:**
Alcohol sugars, sometimes called “sugar alcohols,” are derived when the carbonyl group (C=O) of a monosaccharide is reduced to a hydroxyl group.
- In chapter 10, you learned how to predict the structure of the alcohol formed in this reaction by adding H₂ “across” the carbonyl group’s double bond.

For more help: See chapter 11 part 4 video or chapter 11 section 4 in the textbook.
11.15) Draw the Fischer projection of the *monosaccharide derivative* that is formed for each of the reactions shown below.

**EXPLANATION:**
In a *carboxylic acid sugars* are derived when the aldehyde group (CHO) of a monosaccharide is **oxidized** to form a carboxyl group (COOH).
- You first learned about the oxidation of aldehydes to carboxylic acids in chapter 10.

**EXPLANATION:**
*Alcohol sugars*, sometimes called “sugar alcohols,” are derived when the carbonyl group (C=O) of a monosaccharide is **reduced** to a hydroxyl group.
- In chapter 10, you learned how to predict the structure of the alcohol formed in this reaction by adding H$_2$ “across” the carbonyl group’s double bond.

*For more details:* See [chapter 11 part 4 video](#) or chapter 11 section 4 in the textbook.
11.16) Draw a Fischer projection of the **2-deoxy sugar** that is derived from the monosaccharide shown below.

![Fischer projection](image)
11.16) Draw a Fischer projection of the **2-deoxy sugar** that is derived from the monosaccharide shown below.

HINT:
A **deoxy sugar** is derived when a hydroxyl group (OH) in a monosaccharide is replaced by a **hydrogen** atom.

- The “2” in **2-deoxy sugar** indicates the carbon position where a hydrogen (H) replaces a hydroxyl group (OH) of the monosaccharide.

For more help: See [chapter 11 part 4 video](#) or chapter 11 section 4 in the textbook.
11.16) Draw a Fischer projection of the **2-deoxysugar** that is derived from the monosaccharide shown below.

**EXPLANATION:**

A **deoxy sugar** is derived when a hydroxyl group (OH) in a monosaccharide is replaced by a **hydrogen** atom.

- The “2” in **2-deoxysugar** indicates the carbon position where a hydrogen (H) replaces a hydroxyl group (OH) of the monosaccharide.

**ANSWER:**

For more details: See [chapter 11 part 4 video](#) or chapter 11 section 4 in the textbook.
11.17) Draw a Fischer projection of the **3-amino sugar** that is derived from the monosaccharide shown below.

\[
\begin{align*}
O & \quad C & \quad H \\
H & \quad OH \\
H & \quad OH \\
HO & \quad H \\
H & \quad OH \\
\text{CH}_2\text{OH}
\end{align*}
\]
11.17) Draw a Fischer projection of the **3-amino sugar** that is derived from the monosaccharide shown below.

**HINT:**

An amino sugar is derived when a hydroxyl group (OH) in a monosaccharide is replaced by an amino group (NH₂).

- The “3” in 3-amino sugar indicates the carbon position where an amino group (NH₂) replaces a hydroxyl group (OH) of the monosaccharide.

**For more help:** See chapter 11 part 4 video or chapter 11 section 4 in the textbook.
11.17) Draw a Fischer projection of the 3-amino sugar that is derived from the monosaccharide shown below.

**EXPLANATION:**

An amino sugar is derived when a hydroxyl group (OH) in a monosaccharide is replaced by an amino group (NH$_2$).

- The “3” in 3-amino sugar indicates the carbon position where an amino group (NH$_2$) replaces a hydroxyl group (OH) of the monosaccharide.

**ANSWER:**

For more details: See chapter 11 part 4 video or chapter 11 section 4 in the textbook.
11.18) Predict whether each of the monosaccharides shown below would give a **positive** or **negative** Benedict’s test.

a) ![Monosaccharide A]

b) **fructose**

![Monosaccharide B]

c) ![Monosaccharide C]
11.18) Predict whether each of the monosaccharides shown below would give a **positive** or **negative** Benedict's test.

**HINT:** Only one ketose gives a positive Benedict’s test.

**For more help:** See [chapter 11 part 4 video](#) or chapter 11 section 4 in the textbook.
11.18) Predict whether each of the monosaccharides shown below would give a positive or negative Benedict’s test.

Except for fructose, ketoses give negative Benedict’s tests.

Although fructose is a ketose (not an aldose), it gives a positive Benedict’s test result. The reason for this is that when fructose is in a hot basic solution, it will undergo either of two rearrangement reactions (shown in your lecture notes), in which it is converted to glucose or mannose. It is actually the glucose and mannose aldoses, not fructose, that are subsequently oxidized to produce a color change in Benedict’s test.

For more details: See chapter 11 part 4 video or chapter 11 section 4 in the textbook.
11.19) 

i) Oligosaccharides are molecules that are made when two to __________ monosaccharides chemically bond to each other.
   a) three  
   b) ten  
   c) twenty

ii) Molecules from particular organic families (such as monosaccharides) are referred to as “__________” when they bond together to form a large molecule.
   a) polymers  
   b) residues  
   c) sugar twins  
   d) anomers

iii) An oligosaccharide that is composed of two monosaccharide residues is called a ____________________.
   a) doublet  
   b) disaccharide  
   c) residue pair

iv) The alpha (α) designation indicates that the bond from the anomeric carbon to the oxygen (O) in the glycosidic bond is oriented ______________ from the ring.
   a) downward  
   b) upward  
   c) in a random direction
11.19)
i) Oligosaccharides are molecules that are made when two to __________ monosaccharides chemically bond to each other.

HINT: 
- a) three
- b) ten
- c) twenty

ii) Molecules from particular organic families (such as monosaccharides) are referred to as “____________” when they bond together to form a large molecule.

HINT: 
- a) polymers
- b) residues
- c) sugar twins
- d) anomers

iii) An oligosaccharide that is composed of two monosaccharide residues is called a _________________.

HINT: 
- a) doublet
- b) disaccharide
- c) residue pair

iv) The alpha (α) designation indicates that the bond from the anomic carbon to the oxygen (O) in the glycosidic bond is oriented ________________ from the ring.

HINT: 
- a) downward
- b) upward
- c) in a random direction

For more help: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
i) Oligosaccharides are molecules that are made when two to ten monosaccharides chemically bond to each other.
   a) three  
   b) ten  
   c) twenty  
   Note that sugars with more than ten monosaccharides chemically bonded to each other are referred to as polysaccharides.

ii) Molecules from particular organic families (such as monosaccharides) are referred to as “____________” when they bond together to form a large molecule.
   a) polymers  
   b) residues  
   c) sugar twins  
   d) anomers

iii) An oligosaccharide that is composed of two monosaccharide residues is called a ____________________.
   a) doublet  
   b) disaccharide  
   c) residue pair  
   Likewise, an oligosaccharide that is composed of three monosaccharide residues is called a trisaccharide.

iv) The alpha (α) designation indicates that the bond from the anomeric carbon to the oxygen (O) in the glycosidic bond is oriented ________________ from the ring.
   a) downward  
   b) upward  
   c) in a random direction  
   Glycosidic bonds are described using alpha (α) or beta (β) designations based on the orientation (stereochemistry) of the glycosidic bond relative to the anomeric carbon. This is done in a manner similar to the α and β designations for cyclic monosaccharides, which was based on the orientation of the hydroxyl group relative to the anomeric carbon.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.20) Draw the structure of the *disaccharide* that is formed when *two* of the monosaccharide shown below are connected by an \(\alpha-(1\rightarrow4)\) glycosidic bond.
11.20) Draw the structure of the **disaccharide** that is formed when **two** of the monosaccharide shown below are connected by an **α-(1→4)** glycosidic bond.

**HINT:**
In order to get a disaccharide with an **α** glycosidic bond, begin with the two monosaccharides in the **α** orientation.

**For more help:** See [chapter 11 part 5 video](#) or chapter 11 section 5 in the textbook.
11.20) Draw the structure of the disaccharide that is formed when two of the monosaccharide shown below are connected by an $\alpha$-(1→4) glycosidic bond.

**EXPLANATION:**
In order to get a disaccharide with an $\alpha$ glycosidic bond, begin with the two monosaccharides in the $\alpha$ orientation.

**Step 1:** An H atom is removed from the hydroxyl group (OH) that is bonded to the anomeric carbon of the left-most residue, and an OH is removed from carbon number 4 in the right-most residue.
- The H and OH that were removed form a water molecule.

**Step 2:** Draw a new bond from the oxygen (O) that remains on the anomeric carbon in the left-most residue to the carbon from which the OH was removed in the right-most residue.
- This new bond is oriented in the same direction as was the bond to OH that was removed.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.21) Draw the structure of the *disaccharide* that is formed when **two** of the monosaccharide shown below are connected by an **α-(1→4)** glycosidic bond.

**NOTE:** This is a different monosaccharide than the one used in the previous problem.
11.21) Draw the structure of the **disaccharide** that is formed when **two** of the monosaccharide shown below are connected by an **α-1→4** glycosidic bond.

**HINT:**
In order to get a disaccharide with an **α** glycosidic bond, begin with the two monosaccharides in the **α** orientation.

Für more help: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.21) Draw the structure of the *disaccharide* that is formed when *two* of the monosaccharide shown below are connected by an \( \alpha-(1\rightarrow4) \) glycosidic bond.

**EXPLANATION:**

In order to get a disaccharide with an \( \alpha \) glycosidic bond, begin with the two monosaccharides in the \( \alpha \) orientation.

**Step 1:** An \( H \) atom is removed from the hydroxyl group (\( OH \)) *that is bonded to the anomeric carbon* of the left-most residue, and an \( OH \) is removed from *carbon number 4* in the right-most residue.
- The \( H \) and \( OH \) that were removed form a water molecule.

**Step 2:** Draw a *new bond from* the oxygen (\( O \)) that remains on the *anomeric carbon* in the left-most residue to the carbon from which the \( OH \) was removed in the right-most residue.
- This *new bond* is oriented in the same direction as *was* the bond to \( OH \) that was removed.

For more details: See [chapter 11 part 5 video](#) or [chapter 11 section 5](#) in the textbook.
11.22) Draw the structure of the **disaccharide** that is formed when **two** of the monosaccharide shown below are connected by a **β-(1→4)** glycosidic bond.
11.22) Draw the structure of the disaccharide that is formed when two of the monosaccharide shown below are connected by a β-(1→4) glycosidic bond.

HINT:
In order to get a disaccharide with a β glycosidic bond, begin with the two monosaccharides in the β orientation.

For more help: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.22) Draw the structure of the disaccharide that is formed when two of the monosaccharide shown below are connected by a β-(1→4) glycosidic bond.

**EXPLANATION:**
In order to get a disaccharide with a β glycosidic bond, begin with the two monosaccharides in the β orientation.

**Step 1:** An H atom is removed from the hydroxyl group (OH) that is bonded to the anomeric carbon of the left-most residue, and an OH is removed from carbon number 4 in the right-most residue.
- The H and OH that were removed form a water molecule.

**Step 2:** Draw a new bond from the oxygen (O) that remains on the anomeric carbon in the left-most residue to the carbon from which the OH was removed in the right-most residue.
- This new bond is oriented in the same direction as was the bond to OH that was removed.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.23) Draw the structure of the **disaccharide** that is formed when **two** of the monosaccharide shown below are connected by an **α-(1→6)** glycosidic bond.
11.23) Draw the structure of the *disaccharide* that is formed when *two* of the monosaccharide shown below are connected by an $\alpha$-($1\rightarrow6$) glycosidic bond.

**HINT:**

In order to get a disaccharide with an $\alpha$ glycosidic bond, begin with the two monosaccharides in the $\alpha$ orientation.

**For more help:** See [chapter 11 part 5 video](#) or chapter 11 section 5 in the textbook.
11.23) Draw the structure of the disaccharide that is formed when two of the monosaccharide shown below are connected by an \( \alpha-(1\rightarrow6) \) glycosidic bond.

**EXPLANATION:**
In order to get a disaccharide with an \( \alpha \) glycosidic bond, begin with the two monosaccharides in the \( \alpha \) orientation.

**Step 1:** An \( H \) atom is removed from the hydroxyl group \((OH)\) that is bonded to the anomeric carbon of the left-most residue, and an \( OH \) is removed from carbon number 6 in the right-most residue.
- The \( H \) and \( OH \) that were removed form a water molecule.

**Step 2:** Draw a *new bond from* the oxygen \((O)\) that remains on the anomeric carbon in the left-most residue to the carbon from which the \( OH \) was removed in the right-most residue.
- This *new bond* is oriented in the same direction as was the bond to \( OH \) that was removed.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.24) The cyclic form of D-glucose (shown on right) is a cyclic hemiacetal. Recall that a hemiacetal is a molecule that contains both an OR group and an OH group that are bonded to the same carbon. Carbons that are bonded to both an OR group and an OH group are called hemiacetal carbons. Carbon number 1 in the cyclic form of D-glucose meets this criterium. The OH that is bonded to carbon number 1 is obvious, but the OR may not be immediately obvious to you. However, note that, beginning at carbon number 1 and moving counter-clockwise, as indicated by the red arrow in the structures shown on the right, the OR bonding pattern is seen.

**QUESTION:** Which of the molecules shown below contain a hemiacetal carbon?

a) 

b) 

c)
11.24) The cyclic form of D-glucose (shown on right) is a **cyclic hemiacetal**. Recall that a *hemiacetal* is a molecule that contains both an \( \text{OR} \) group and an \( \text{OH} \) group that are bonded to the same carbon. Carbons that are bonded to both an \( \text{OR} \) group and an \( \text{OH} \) group are called **hemiacetal carbons**. Carbon number 1 in the cyclic form of D-glucose meets this criterium. The \( \text{OH} \) that is bonded to carbon number 1 is obvious, but the \( \text{OR} \) may not be immediately obvious to you. However, note that, beginning at carbon number 1 and moving counter-clockwise, as indicated by the red arrow in the structures shown on the right, the \( \text{OR} \) bonding pattern is seen.

**QUESTION:** Which of the molecules shown below contain a **hemiacetal carbon**?

**HINT:** Is this a hemiacetal carbon?

For more help: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.24) The cyclic form of D-glucose (shown on right) is a **cyclic hemiacetal**. Recall that a **hemicetal** is a molecule that contains both an OR group and an OH group that are bonded to the same carbon. Carbons that are bonded to both an OR group and an OH group are called **hemicetal carbons**. Carbon number 1 in the cyclic form of D-glucose meets this criterium. The OH that is bonded to carbon number 1 is obvious, but the OR may not be immediately obvious to you. However, note that, beginning at carbon number 1 and moving counter-clockwise, as indicated by the red arrow in the structures shown on the right, the OR bonding pattern is seen.

**QUESTION:** Which of the molecules shown below contain a **hemicetal carbon**?

a) ![hemiacetal carbon](image)

b) ![hemiacetal carbon](image)

c) ![hemiacetal carbon](image)

**ANSWER:** Molecules (a) and (c) contain **hemicetal carbons**.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.25) Can either of the residues in this disaccharide undergo \textit{mutarotation}?
11.25) Can either of the residues in this disaccharide undergo *mutarotation*?

**HINT:**

Oligosaccharides with a residue that contains a hemiacetal anomeric carbon will interconvert (*mutarotate*) between closed anomers and an open-form.

**For more help:** See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.25) Can either of the residues in this disaccharide undergo mutarotation?

Oligosaccharides with a residue that contains a hemiacetal anomeric carbon will interconvert (mutarotate) between closed anomers and an open-form.

Note that the mutarotation does not change the α/β designation of a glycosidic bond.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.26) Determine whether each of the molecules shown below will give positive or negative benedicts tests.

a) 

b) 

c) 

Go back  Click here for a hint  Click here to check your answer  Go to next question
11.26) Determine whether each of the molecules shown below will give **positive** or **negative** benedicts tests.

**HINT:**

Although the cyclic form of this monosaccharide does not have an aldehyde group, its anomeric carbon is a *hemiacetal* which can interconvert to the *aldose open-chain* form as shown below.

**HINT:**

Do these disaccharides contain a *hemiacetal carbon* or are their residues are “locked” in their *cyclic forms*. If the *open-chain form* of an oligosaccharide contains an *aldehyde group*, it will give a positive Benedict’s test.

For more help: See [chapter 11 part 5 video](#) or chapter 11 section 5 in the textbook.
11.26) Determine whether each of the molecules shown below will give positive or negative Benedict's tests.

Although the cyclic form of this monosaccharide does not have an aldehyde group, its anomeric carbon is a hemiacetal which can interconvert to the aldose open-chain form as shown below. The aldose open-chain form is responsible for the positive Benedict’s test.

If the open-chain form of an oligosaccharide contains an aldehyde group, it will give a positive Benedict’s test.

There is not a hemiacetal carbon in this molecule, so both residues are “locked” in their cyclic forms. For this reason, neither rings is able to interconvert to their open-chain forms.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.27)
i) The glycosidic bond that is highlighted **yellow** is a(n) ______________.
   a) β-(1 → 4) glycosidic bond
   b) β-(1 → 6) glycosidic bond
   c) α-(1 → 4) glycosidic bond
   d) α-(1 → 6) glycosidic bond

ii) The glycosidic bond that is highlighted **blue** is a(n) ______________.
   a) β-(1 → 4) glycosidic bond
   b) β-(1 → 6) glycosidic bond
   c) α-(1 → 4) glycosidic bond
   d) α-(1 → 6) glycosidic bond
11.27) 

i) The glycosidic bond that is highlighted yellow is a(n) __________.
   a) $\beta$-(1→4) glycosidic bond
   b) $\beta$-(1→6) glycosidic bond
   c) $\alpha$-(1→4) glycosidic bond
   d) $\alpha$-(1→6) glycosidic bond

ii) The glycosidic bond that is highlighted blue is a(n) ______________.
   a) $\beta$-(1→4) glycosidic bond
   b) $\beta$-(1→6) glycosidic bond
   c) $\alpha$-(1→4) glycosidic bond
   d) $\alpha$-(1→6) glycosidic bond

HINT:

The carbon atoms are now numbered (red font) for you.

- The alpha ($\alpha$) designation indicates that the bond from the anomeric carbon to the oxygen (O) in the glycosidic bond is oriented downward from the ring.
- The beta ($\beta$) designation indicates that the bond from the anomeric carbon to the oxygen (O) in the glycosidic bond is oriented upward from the ring.

For more help: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
11.27)

i) The glycosidic bond that is highlighted yellow is a(n) ________________.
   a) $\beta$-($1 \rightarrow 4$) glycosidic bond
   b) $\beta$-($1 \rightarrow 6$) glycosidic bond
   c) $\alpha$-($1 \rightarrow 4$) glycosidic bond
   d) $\alpha$-($1 \rightarrow 6$) glycosidic bond

   • The alpha ($\alpha$) designation indicates that the bond from the anomeric carbon to the oxygen (O) in the glycosidic bond is oriented downward from the ring.
   • The ($1 \rightarrow 4$) designation indicates that the glycosidic bond originates at carbon 1 (an anomeric carbon) and terminates at carbon 4.

ii) The glycosidic bond that is highlighted blue is a(n) ________________.
   a) $\beta$-($1 \rightarrow 4$) glycosidic bond
   b) $\beta$-($1 \rightarrow 6$) glycosidic bond
   c) $\alpha$-($1 \rightarrow 4$) glycosidic bond
   d) $\alpha$-($1 \rightarrow 6$) glycosidic bond

   • The alpha ($\alpha$) designation indicates that the bond from the anomeric carbon to the oxygen (O) in the glycosidic bond is oriented downward from the ring.
   • The ($1 \rightarrow 6$) designation indicates that the glycosidic bond originates at carbon 1 (an anomeric carbon) and terminates at carbon 6.

For more details: See chapter 11 part 5 video or chapter 11 section 5 in the textbook.
A sweetener is a compound that is added to food in order to impart the sweet taste of sucrose, but with significantly fewer calories. Sweeteners can be classified as “artificial sweeteners” or “natural sweeteners.”

Using one or two complete sentences, explain the difference between “artificial sweeteners” or “natural sweeteners.”
11.28) A sweetener is a compound that is added to food in order to impart the sweet taste of sucrose, but with significantly fewer calories. Sweeteners can be classified as “artificial sweeteners” or “natural sweeteners.”

Using one or two complete sentences, explain the difference between “artificial sweeteners” or “natural sweeteners.”

**HINT:**

*Natural sweeteners* are carbohydrates, ____________ occurring carbohydrate derivatives, or other ____________ occurring non carbohydrate compounds.

*Artificial sweeteners* do not occur in ____________; they are synthesized in ____________ ____________.

**For more help:** See chapter 11 part 6 video or chapter 11 section 5 in the textbook.
A sweetener is a compound that is added to food in order to impart the sweet taste of sucrose, but with significantly fewer calories. Sweeteners can be classified as “artificial sweeteners” or “natural sweeteners.”

Using one or two complete sentences, explain the difference between “artificial sweeteners” or “natural sweeteners.”

**ANSWER** (should be something like this):

*Natural sweeteners* are carbohydrates, naturally occurring carbohydrate derivatives, or other naturally occurring non carbohydrate compounds. *Artificial sweeteners* do not occur in nature; they are synthesized in commercial laboratories.

For more details: See chapter 11 part 6 video or chapter 11 section 5 in the textbook.
11.29)

i) Polysaccharides are composed of more than _____ residues.

a) one
b) two
c) ten
d) nineteen

ii) Homopolysaccharides are composed of ________________ residue(s).

a) only glucose and fructose
b) natural sweetener
c) only one type of
d) more than one type of

iii) Heteropolysaccharides are composed of ________________ residue(s).

a) only glucose
b) artificial sweetener
c) only one type of
d) more than one type of
11.29) 

i) Polysaccharides are composed of *more than _____ residues.*

**HINT:**
- a) one
- b) two
- c) ten
- d) nineteen

ii) Homopolysaccharides are composed of ____________________ residue(s).

**HINT:**
- a) only glucose and fructose
- b) natural sweetener
- c) only one type of
- d) more than one type of

iii) Heteropolysaccharides are composed of _________________ residue(s).

**HINT:**
- a) only glucose
- b) artificial sweetener
- c) only one type of
- d) more than one type of

*For more help:* See *chapter 11 part 7 video* or chapter 11 section 6 in the textbook.
11.29) (a) Polysaccharides are composed of **more than _____** residues.
   
   a) one  
   b) two  
   c) ten  
   d) nineteen

(b) Homopolysaccharides are composed of ____________________ residue(s).
   
   a) only glucose and fructose  
   b) natural sweetener  
   c) **only one type of**  
   d) more than one type of

(c) Heteropolysaccharides are composed of ____________ residue(s).
   
   a) only glucose  
   b) artificial sweetener  
   c) **only one type of**  
   d) more than one type of

For more details: See [chapter 11 part 7 video](#) or chapter 11 section 6 in the textbook.
11.30) Identify the following as properties of **amylose**, **amylopectin**, **both amylose and amylopectin**, or **neither amylose nor amylopectin**.

a) contains $\alpha-(1\to6)$ glycosidic bonds

b) heteropolysaccharide

c) contains glucose residues only

d) contains $\alpha-(1\to4)$ glycosidic bonds

e) contains *only* $\alpha-(1\to4)$ glycosidic bonds

f) does not contain branching points

g) contains $\beta-(1\to6)$ glycosidic bonds

h) more quickly digested (amylose or amylopectin?)
11.30) Identify the following as properties of amylose, amylopectin, both amylose and amylopectin, or neither amylose nor amylopectin.

a) contains $\alpha-(1\rightarrow6)$ glycosidic bonds

b) heteropolysaccharide

c) contains glucose residues only

d) contains $\alpha-(1\rightarrow4)$ glycosidic bonds

e) contains only $\alpha-(1\rightarrow4)$ glycosidic bonds

f) does not contain branching points

g) contains $\beta-(1\rightarrow6)$ glycosidic bonds

h) more quickly digested (amylose or amylopectin?)

Molecules that have a larger number of endpoints are more quickly digested because the digestive enzymes attach to starch molecules at the endpoints. Based on their structures, would you expect amylose or amylopectin to have more endpoints?

**For more help:** See chapter 11 part 7 video or chapter 11 section 6 in the textbook.
11.30) Identify the following as properties of **amylose**, **amylopectin**, **both amylose and amylopectin**, or **neither amylose nor amylopectin**.

a) contains $\alpha$-(1→6) glycosidic bonds  **amylopectin**

b) heteropolysaccharide  **neither amylose nor amylopectin**

c) contains glucose residues only  **both amylose and amylopectin**

d) contains $\alpha$-(1→4) glycosidic bonds  **both amylose and amylopectin**

e) contains only $\alpha$-(1→4) glycosidic bonds  **amylose**

f) does not contain branching points  **amylose**

g) contains $\beta$-(1→6) glycosidic bonds  **neither amylose nor amylopectin**

h) more quickly digested (amylose or amylopectin?)  **amylopectin**

Because of branching, amylopectin molecules have a large number of endpoints. Since the amylase digestive enzymes attach to starch molecules at the endpoints, amylopectin can be digested more quickly than amylose.

**For more details:** See chapter 11 part 7 video or chapter 11 section 6 in the textbook.
11.31) Identify the following as properties of either amylose, cellulose, both amylose and cellulose, or neither amylose nor cellulose.

   a) contains α-(1→6) glycosidic bonds
   b) contains β-(1→6) glycosidic bonds
   c) contains β-(1→4) glycosidic bonds
   d) contains glucose residues only
   e) homopolysaccharide
   f) heteropolysaccharide
   g) has a helical structure
   h) found in plants
   i) can be digested by humans
   j) long and straight molecules that lie next to each other in a side-by-side fashion
11.31) Identify the following as properties of either **amylose**, **cellulose**, **both amylose and cellulose**, or **neither amylose nor cellulose**.

a) contains $\alpha-(1\rightarrow6)$ glycosidic bonds

b) contains $\beta-(1\rightarrow6)$ glycosidic bonds

c) contains $\beta-(1\rightarrow4)$ glycosidic bonds

d) contains glucose residues only

e) homopolysaccharide

f) heteropolysaccharide

g) has a helical structure

h) found in plants

i) can be digested by humans

j) long and straight molecules that lie next to each other in a side-by-side fashion

**HINT:**
Consider the structures of amylose and cellulose.

Use your lecture notes or the textbook to review the information on amylose and cellulose.

**For more help:** See chapter 11 part 7 video or chapter 11 section 6 in the textbook.
11.31) Identify the following as properties of either amylose, cellulose, both amylose and cellulose, or neither amylose nor cellulose.

a) contains α-(1→6) glycosidic bonds neither amylose nor cellulose

b) contains β-(1→6) glycosidic bonds neither amylose nor cellulose

c) contains β-(1→4) glycosidic bonds cellulose

d) contains glucose residues only both amylose and cellulose

e) homopolysaccharide both amylose and cellulose

f) heteropolysaccharide neither amylose nor cellulose

g) has a helical structure amylose

h) found in plants both amylose and cellulose

i) can be digested by humans amylose

j) long and straight molecules that lie next to each other in a side-by-side fashion cellulose

EXPLANATION: Consider the structures of amylose and cellulose.

For more details: See chapter 11 part 7 video or chapter 11 section 6 in the textbook.
11.32) Identify the following as properties of either glycogen, amylopectin, both glycogen and amylopectin, or neither glycogen nor amylopectin.

a) contains $\alpha-(1\rightarrow6)$ glycosidic bonds
b) contains $\beta-(1\rightarrow6)$ glycosidic bonds
c) contains $\beta-(1\rightarrow4)$ glycosidic bonds
d) contains glucose and fructose residues only
e) homopolysaccharide
f) heteropolysaccharide
g) branching occurs less frequently (glycogen or amylopectin)
h) contains helical structures
i) found in plants
11.32) Identify the following as properties of either glycogen, amylopectin, both glycogen and amylopectin, or neither glycogen nor amylopectin.

a) contains $\alpha-(1\rightarrow6)$ glycosidic bonds

b) contains $\beta-(1\rightarrow6)$ glycosidic bonds

c) contains $\beta-(1\rightarrow4)$ glycosidic bonds

d) contains glucose and fructose residues only

e) homopolysaccharide

f) heteropolysaccharide

g) branching occurs less frequently (glycogen or amylopectin)

h) contains helical structures

i) found in plants \hspace{1cm} HINT: Review how plants and animals store excess glucose.

HINT: Consider the structures of glycogen and amylopectin.

For more help: See chapter 11 part 7 video or chapter 11 section 6 in the textbook.
11.32) Identify the following as properties of either glycogen, amylopectin, both glycogen and amylopectin, or neither glycogen nor amylopectin.

a) contains $\alpha-(1\rightarrow6)$ glycosidic bonds  
   both glycogen and amylopectin

b) contains $\beta-(1\rightarrow6)$ glycosidic bonds  
   neither glycogen nor amylopectin

c) contains $\beta-(1\rightarrow4)$ glycosidic bonds  
   neither glycogen nor amylopectin

d) contains glucose and fructose residues only  
   neither glycogen nor amylopectin

e) homopolysaccharide  
   both glycogen and amylopectin

f) heteropolysaccharide  
   neither glycogen nor amylopectin

g) branching occurs less frequently (glycogen or amylopectin)  
   amylopectin

h) contains helical structures  
   both glycogen and amylopectin

i) found in plants  
   amylopectin

Plants store excess glucose as starch (amylose and amylopectin); animals and fungi store excess glucose as glycogen.

EXPLANATION:
Consider the structures of glycogen and amylopectin.

For more details: See chapter 11 part 7 video or chapter 11 section 6 in the textbook.

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This is the last problem.