

SI Chemistry - Full Discipline Demo

Macromolecules of Life - Sugars and Starches

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best definition.

⚡ Benedict's Reagent	6-carbon sugar	1
⚡ Carbohydrate	The bond holding saccharide units together	2
⚡ Condensation Reaction	A molecule composed of many sugar unit monomers	3
⚡ Glucose	A molecule composed of only one sugar unit	4
⚡ Glycosidic Linkage	A molecule with the chemical formula $C_m(H_2O)_n$.	5
⚡ Hydrolysis	A reaction that breaks glycosidic linkages	6
⚡ IKI Indicator	A reaction that has water as a by-product	7
⚡ Monosaccharide	A reagent used to test for reducing sugars	8
⚡ Polysaccharide	A reagent used to test for starches	9

Correct answers:

- 1 Glucose 2 Glycosidic Linkage 3 Polysaccharide
 4 Monosaccharide 5 Carbohydrate 6 Hydrolysis
 7 Condensation Reaction 8 Benedict's Reagent 9 IKI Indicator

Identify the statements about sugars and starches as true or false.

⚡ Artificial sweeteners are often so intensely sweet that they are diluted with true sugars	
⚡ Glucose and fructose are monosaccharides.	⚡ Sucrose is a polysaccharide.
⚡ The reducing ability of sugars is defined by the presence of an aldehyde (CHO) or ketone (CO) functional group.	
⚡ Zero-calorie sweeteners contain artificial sweeteners that are synthesized by the modification of proteins.	
True	False
1	2

Correct answers:

1

Artificial sweeteners are often so intensely sweet that they are diluted with true sugars

Glucose and fructose are monosaccharides.

The reducing ability of sugars is defined by the presence of an aldehyde (CHO) or ketone (CO) functional group.

2

Sucrose is a polysaccharide.

Zero-calorie sweeteners contain artificial sweeteners that are synthesized by the modification of proteins.

Cellulose, glycogen, and starch are polysaccharides composed of glucose monomers. Polysaccharides can appear linear, branched, or highly branched, as shown in the image below. Label each image with the correct polysaccharide.

Cellulose

Glycogen

Starch

1

2

3

Linear

Branched

Highly Branched

Glucose molecule

Correct answers:

1 Cellulose 2 Starch 3 Glycogen

Exploration

How many carbon atoms does glucose contain?

- ☐ 2
- ☐ 4
- ☐ 5
- ☒ 6



How many monosaccharides combine to form a disaccharide?

- ☒ 2
- ☐ 3
- ☐ 4
- ☐ 1000



Fruit sugar, or fructose, is one type of monosaccharide.

- ☒ True ✓
- ☐ False

Describe the structure of glycogen.

- ☐ Linear
- ☐ Branched
- ☒ Highly branched ✓

Sucralose, an artificial sweetener, is actually considered a sugar because it has a similar chemical formula.

- ☐ True
- ☒ False ✓

Apple cider was tested for both sugar and starch and yielded the following results: an orange color when in the presence of Benedict's reagent and a blue-black color when in the presence of IKI. What macromolecules did the apple cider contain?

- ☐ Starch
- ☐ Reducing sugars
- ☒ Starch and reducing sugars ✓

Exercise 1

Did the table sugar solution test positive or negative for reducing sugars? Explain the science behind your results.

Benedict's reagent changes colors in the presence of reducing sugars and it did not change colors in the presence of table sugar. Table sugar is the disaccharide sucrose, a non-reducing sugar. Sucrose does not have an aldehyde or ketone group.

Do Splenda® and Sweet'N Low® test positive or negative for reducing sugars? List the ingredients found in each of these products. Underline the ingredient that is the artificial sweetener. (Hint: There is only one artificial sweetener in each of the products. Refer to the background as needed.)

Both of the zero calorie sweeteners test positive for reducing sugars. Splenda: Dextrose, Maltodextrin, Sucralose Sweet'NLow: Dextrose, Saccharin, Cream of Tartar, Calcium Silicate

What is the relationship of glucose and dextrose? How does this relationship influence the test results for Splenda® and Sweet'N Low®?

The term "dextrose" is predominantly used in food manufacturing. Dextrose is a type of glucose known as D-glucose. Therefore, zero-calorie sweeteners that contain dextrose actually contain glucose and test positive for reducing sugars. The dextrose is added to reduce the sweetness of the artificial sweeteners.

A common artificial sweetener found in Equal®, NutraSweet®, and many diet sodas is aspartame ($C_{14}H_{18}N_2O_5$). Would a sample of pure aspartame test positive or negative for reducing sugars? (The pure sample does not contain other ingredients, such as dextrose, maltodextrin, or calcium silicate.)

Pure aspartame would test negative for reducing sugars with Benedict's reagent. Aspartame cannot function as a reducing agent; it does not contain the groups normally associated with a positive result (aldehydes and some ketones).

Unlike other sweeteners, Splenda® may be used in cooking because it does not break down at higher temperatures. Many recipes abound that call for Splenda® instead of table sugar. Is a cake baked with Splenda® actually sugar-free? How might this affect a person concerned with blood sugar levels?

Baking a cake with Splenda does add sugar to baking. This may be of concern to people who monitor blood glucose levels.

Data Table 1: Sugar Tests with Benedict's Reagent
(SAMPLE ANSWER BELOW)

Test Tube Number	Substance	Prediction	Final Color	Test Results for Reducing Sugar
1	Distilled Water	Student answers will vary	Blue	Negative
2	Glucose Solution		Orange	Positive
3	Starch Solution		Blue	Negative
4	Table Sugar		Blue	Negative
5	Splenda®		Red-Orange	Positive
6	Sweet'N Low®		Red-brown	Positive
7	Milk		Green	Positive
8	Juice		Orange	Positive
9	Potato		Blue	Negative

Exercise 2

Which sugar substitute tested positive for presence of starch? This sugar substitute contains a starch derived from corn or potatoes. List the ingredient that is the starch.

Splenda, maltodextrin

List three examples of polysaccharides in living organisms. Describe the structural orientations of each.

Cellulose molecules form the cell walls of green plants and have linear chains; starch molecules act as energy stores in green plants and are branched; and glycogen molecules act as energy stores in animals and are highly branched.

When a human consumes starch, the polysaccharides are broken down into simple sugars, which are converted to polysaccharides for storage in the cells. However, simple sugars are used by the cell to perform work. Describe why it is necessary to change the form of the carbohydrate in the body.

Polysaccharides are too large to be transported through the intestinal lining during digestion. They must be broken down into simple sugars, via hydrolysis, so that they may be absorbed by the body. The simple sugars are then condensed and stored as polysaccharides in the cells. Polysaccharides are stored instead of simple sugars to reduce osmotic pressure in the cell. When the cell needs energy to do work, polysaccharides are hydrolyzed and once again become simple sugars that may be converted to energy.

Data Table 2: Starch Tests with IKI Indicator
(SAMPLE ANSWER BELOW)

Test Tube Number	Substance	Prediction	Final Color	Test Results for Starch
1	Distilled Water		Amber	Negative
2	Glucose Solution		Amber	Negative
3	Starch Solution		Blue-Black	Positive
4	Table Sugar		Amber	Negative
5	Splenda [®]		Blue-Black	Positive
6	Sweet'N Low [®]		Amber	Negative
7	Milk		Amber	Negative
8	Juice		Amber	Negative
9	Potato		Blue-Black	Positive

Exercise 3

What type of reaction is the conversion of starch to maltose? Describe what occurs during the reaction.

Starch breaks down via a hydrolysis reaction, whereby water is a reactant and the glycosidic linkages holding together the sugars are broken. This hydrolysis reaction occurs in the presence of the enzyme catalyst α -amylase. Maltose is produced.

Is maltose a reducing sugar or a non-reducing sugar? Support your answer with information in Data Table 3.

Maltose is a reducing sugar. A color change was observed when Benedict's solution was added.

Data Table 3: Conversion of Starch to the Sugar Maltose
(SAMPLE ANSWER BELOW)

Test Tube Number	Substance	Final Color	Test Results for Reducing Sugar	Test Results for Starch
1	Distilled Water	Light Blue	Negative	---
2	Distilled Water	Green-Brown	---	Negative
3	Starch Solution	Amber	Positive	---
4	Starch Solution	Green-Brown (slightly darker than distilled water)	---	Negative

Competency Review

If a carbohydrate has 12 hydrogen atoms, how many oxygen atoms are present in the carbohydrate?

- ☐ 3
- ☒ 6 ✓
- ☐ 9
- ☐ 12

Carbohydrates are the most abundant macromolecule in nature.

- ☒ True ✓
- ☐ False

The bond that holds two monosaccharide molecules together is a ____.

- ☒ glycosidic linkage ✓
- ☐ ionic bond
- ☐ van der Waals force
- ☐ hydrogen bond

Lactose (milk sugar) may be broken down via ____.

- ☐ a dehydration reaction
- ☒ hydrolysis ✓
- ☐ pepsin
- ☐ bile

The tongue perceives ____ to be hundreds of times sweeter than ____.

- ☐ sucrose; some artificial sweeteners
- ☒ some artificial sweeteners; sucrose ✓
- ☐ glucose; fructose
- ☐ starch; sucrose

Sucralose, an artificial sweetener, is actually broken down into a protein to be used by the body during human digestion.

- ☐ True
- ☒ False ✓

Benedict's reagent changes color when ____ reacts with a sugar molecule, and the ion is reduced.

- ☐ iodine
- ☐ sodium
- ☒ copper ✓
- ☐ chlorine

In order to test for reducing sugars with Benedict's reagent, the contents should be placed in cold temperatures, such as an ice bath.

- ☐ True
- ☒ False ✓

IKI indicator changes to a dark blue only when a solution contains reducing sugars.

- ☐ True
- ☒ False ✓

All artificial sweeteners test negative for reducing sugars.

- ☐ True
- ☒ False ✓
-

What type of reaction is the conversion of starch to maltose?

- ☒ hydrolysis reaction ✓
- ☐ dehydration reaction

α -Amylase is a digestive enzyme that breaks down starch into simple sugars.

- ☒ True ✓
- ☐ False

Extension Questions

Benedict's reagent can be used to test the urine of diabetics. What is it testing for and how is that useful for diabetics? (SAMPLE ANSWER BELOW)

Benedict's reagent tests for reducing sugars such as glucose. A diabetic does not properly metabolize the glucose in their body and the excess glucose spills over into the urine. If the urine tests positive with the Benedict's reagent, it means the diabetes is not under control.