Carbohydrate (Sugars)

Carbohydrates can be separated into groups

- **Monosaccharides**: these are single sugar units eg glucose, fructose and galactose
- **Disaccharide**s: these are sugars made up of two single sugar units joined together eg maltose, sucrose and lactose
- **Polysaccharides**: these are made up of many monosaccharides joined together into large molecules eg starch, glycogen and cellulose. They are not sugars.

Biological monomers and polymers

A polymer is a large molecule made up of **repeating monomers** eg cellulose (polymer) is made up of many glucose molecules joined together. The glucose molecules are the monomers.

Question

Glucose, fructose, galactose, maltose, sucrose and lactose are all sugars.

Look at the names of these sugars. What do they have in common? **……end in -OSE……**

Hint: This is one way you can recognise sugars

Glucose is a Monosaccharide

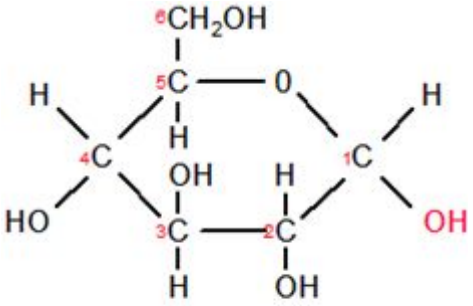
At GCSE you learned that the structure of glucose is $C_6H_{12}O_6$.

Now we are going to look at how these atoms are arranged in a glucose molecule.

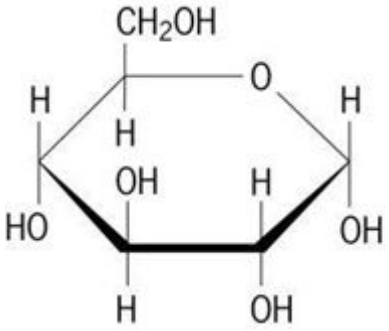
In solution glucose forms a ring structure.

There are two forms of the glucose molecule ∝-glucose and β-glucose (α = alpha, β=beta)

α-glucose



α-glucose



- The structure on the left shows α-glucose with all of its carbon atoms
- The structure on the right shows a simplified version with some of the carbon atoms omitted. The carbons are at the corners. This is an accepted way of drawing glucose.
- On the left hand diagram the carbons are numbered. The allocation of numbers to carbon atoms is always the same

Activity

In the space below copy the structure of α-glucose. Use the simplified version and ignore the thickness of the lines, you can draw them the same thickness.

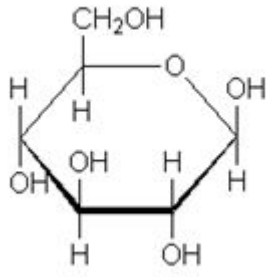
Copy of the right hand diagram with all atoms and groups in the right place

You will need to know this structure and many others and the best way to learn them is to keep copying them out until you can do it without looking at a diagram for help. (Mini whiteboards are great for this!!)

□-glucose

The diagram below shows the structure of □-glucose

In the space next to the diagram copy this structure



Accurate copy with OH and H on carbon 1 opposite orientation to α glucose

Questions (use the diagrams of α and □ glucose)

1. **What is the difference between α and □ glucose? OH is orientated up on carbon 1 not down**
2. **Give the number of the carbon that is affected. Carbon 1**

Additional questions

Glucose is an example of a HEXOSE sugar because it contains 6 carbon atoms in its structure

Suggest how many carbon atoms the following types of sugar contain

- **Pentoses ……5**
- **Trioses ……3**

Notice how the names of molecules can often tell you a lot about the molecules you are studying

Disaccharides

- Di means two
- Saccharide means sugar or molecules made up of sugar units
- So disaccharides are double sugars
- Different combinations of monosaccharides give different disaccharides

Examples

Maltose is a disaccharide made up of **two glucose** molecules joined together

- Glucose + Glucose = Maltose

Similarly

- Glucose + Fructose = Sucrose
- Glucose + Galactose = Lactose

Formation of a disaccharide

- Disaccharides form through **CONDENSATION** reactions
- **WATER** is also a product of condensations reaction
- The bond formed between two monosaccharides to form a disaccharide is a **GLYCOSIDIC BOND**

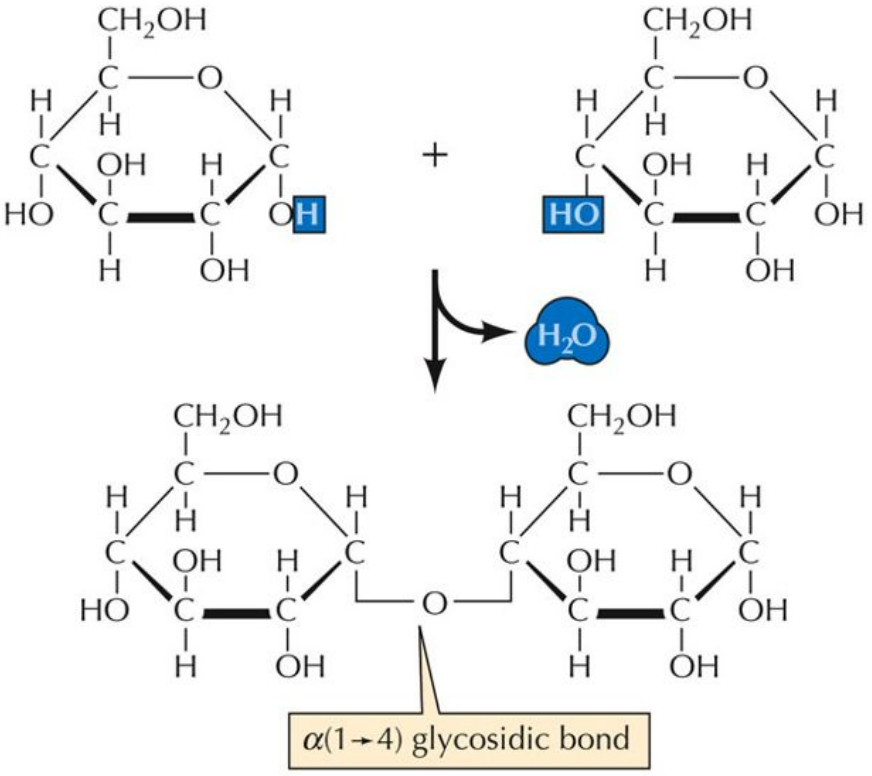
Example

Glucose + Glucose → Maltose + Water

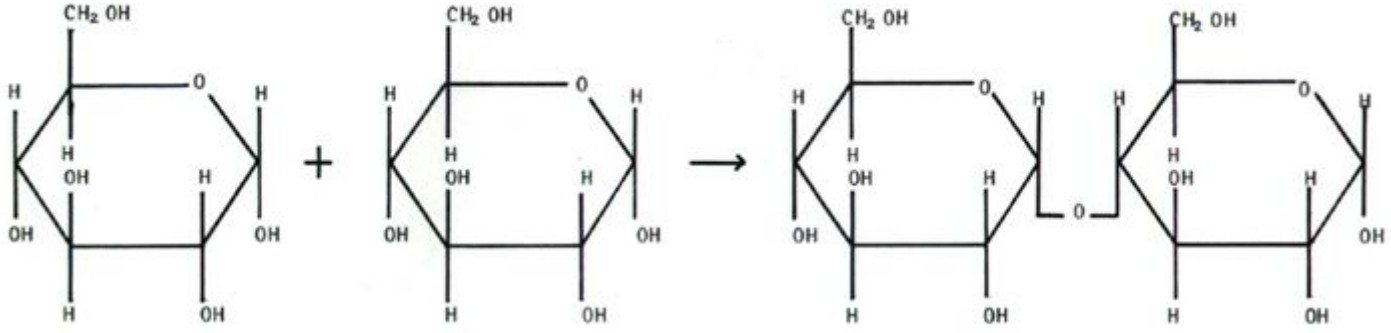
Monosaccharide + Monosaccharide → Disaccharide + Water

See the next page for a detailed diagram

- **Notice that the bond forms through Carbon 1 of the left hand molecule and carbon 4 of the right hand molecule**
- **Water is formed by removal of two hydrogen atoms and one oxygen atom from the two hydroxyl groups (one on each carbon involved)**
- **The remaining oxygen forms part of the glycosidic bond**
- **Since the bond is formed between carbon 1 and carbon 4 this is a 1-4 glycosidic bond**



Another way of representing this condensation reaction is



α Glucose **α Glucose** **Maltose**

Glycosidic bond has the O in it

Activity

On the diagram above add the following labels

- **α Glucose (twice)**
- **Glycosidic bond**
- **Maltose**

Number the carbon atoms on each of the glucose molecules **This starts at the right hand carbon**

Add the molecule that is missing from the diagram on the correct side (name or structure) **water**

See the next page

Hydrolysis of a disaccharide

- Disaccharides are broken down into their constituent monosaccharides by hydrolysis
- A hydrolysis reaction breaks the glycosidic bond and replaces the hydrogen and oxygen atoms removed when the bond was formed

Hydrolysis

Hydro means water

Lysis in biology means to break

So breaking a bond using water

So

Maltose + Water → Glucose + Glucose

Disaccharide + Water → Monosaccharide + Monosaccharide

Activity

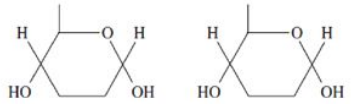
In the space below draw a diagram to represent maltose being hydrolysed into two glucose molecules. Include the structures of the molecules similar to those in previous diagrams

This diagram is the reverse of the one at the end of the previous previous page, but showing water with the maltose on the left hand side of the equation

As a last activity see if you can answer these questions from a past paper

1 **Figure 1** shows two molecules of α glucose.

Figure 1



1 (a) (i) On **Figure 1**, draw a box round the atoms that are removed when a glycosidic bond is formed. *(1 mark)*

1 (a) (ii) Name the chemical reaction involved in the formation of this bond.

.....

(1 mark)

1 (b) Describe how a molecule of β glucose is different from a molecule of α glucose.

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(2 marks)

Answers

Question 1

(a) (i) Box drawn round appropriate H and OH; 1

(ii) Condensation; 1
Accept close versions such as condensing reaction or condensing.

(b) An H atom is at the bottom/an OH is at the top in β glucose;
At the right-hand side of the molecule; 2
Note that this is the lowest acceptable answer. Better candidates might be expected to refer to C^1. Obviously such answers should gain credit. Reject polymerisation.