

## Relative mass

Starch is a type of carbohydrate found in many foods such as pasta, potatoes, bread and rice.



Source: © Shutterstock

When we eat starchy foods, the enzymes in our bodies break the large starch molecules into smaller molecules called simple sugars.

1. One example of a simple sugar is glucose,  $C_6H_{12}O_6$ .

(a) Calculate the relative formula mass of glucose. Use the periodic table to help you.

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Glucose can be used in our bodies to make energy through a process called cellular respiration.

If there is plenty of oxygen, aerobic respiration occurs where glucose reacts with the oxygen to produce carbon dioxide gas and liquid water.

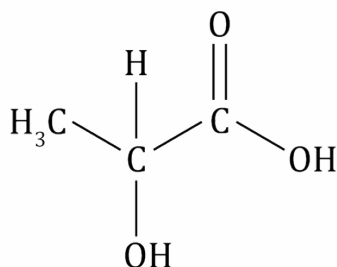
(b) Write the word equation to represent the process of aerobic respiration.

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(c) What is the balanced chemical equation to represent the process of aerobic respiration? Circle the correct answer.

- A  $C_6H_{12}O_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$
- B  $C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + 6H_2O$
- C  $C_6H_{12}O_6 + 12O_2 \rightarrow 6CO_2 + 6H_2O$
- D  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

During high-intensity exercise the body's demand for oxygen is higher. If the body does not have enough oxygen to meet this increased demand, a process called anaerobic respiration happens where the glucose is broken down to produce lactic acid.



lactic acid

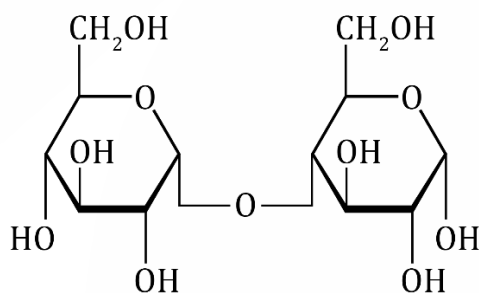
(d) Use the image provided to deduce the chemical formula of lactic acid.

*Hint:* Remember to include any subscript numbers needed to show the number of atoms of the different elements present. For example, in the formula  $\text{H}_2\text{O}$  the subscript number 2 shows that there are two hydrogen atoms present.

(e) Use your answer to calculate the relative formula mass of lactic acid.

*Hint:* Remember to multiply any atomic masses by the number of atoms of that element present in the compound.

2. Starch can be broken down to produce a simple sugar called maltose by enzymes in the mouth and small intestine.



maltose

(a) The chemical formula of maltose is  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ . Calculate the relative formula mass of maltose.

$A_r$  carbon = 12     $A_r$  hydrogen = 1     $A_r$  oxygen = 16

The percentage of an element present in a compound can be determined using the equation:

$$\text{Percentage of element in compound (\%)} = \frac{\text{relative atomic mass of element}}{\text{relative formula mass of compound}} \times 100$$

(b) Use your answer to **part (a)**, along with the equation above, to calculate the percentage of carbon in maltose.

*Hint: Remember to multiply the relative atomic mass by the number of atoms of that element present in the compound.*

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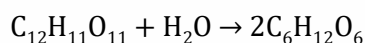
3. Scientists use a measure known as atom economy to assess the efficiency of an industrial process by comparing the relative formula masses of the reactants and products for the reactions used.

(a) Which statement correctly describes atom economy? Circle the correct answer.

- A** A higher atom economy shows the process produces more waste.
- B** Atom economy is a measure of the amount of the reactants used to produce the waste product.
- C** Atom economy is a measure of the amount of the reactants used to produce the useful product.
- D** An atom economy of 100% shows that no desired products have been formed.

Maltose can be broken down, using water and an enzyme called maltase, to make glucose.

The chemical equation for this reaction is:



(b) Use some of the words provided to complete the sentences to state and explain the atom economy of this reaction.

<b>some</b>	<b>50</b>	<b>waste</b>
<b>all</b>	<b>100</b>	<b>desired</b>

The atom economy for this reaction is \_\_\_\_\_%. This is because \_\_\_\_\_ of the atoms of the reactants are used to make the \_\_\_\_\_ product and there is no \_\_\_\_\_ product.

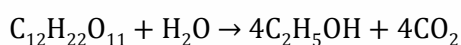
The atom economy of any chemical reaction can be calculated using the equation:

$$\text{Atom economy \%} = \frac{\text{total formula mass of the useful product}}{\text{total formula mass of all reactants}} \times 100$$

Maltose can also be used in a process called fermentation where the maltose reacts with water to produce ethanol,  $\text{C}_2\text{H}_5\text{OH}$ , and carbon dioxide gas.

The ethanol produced can be used as a biofuel to power vehicles such as cars and buses.

The balanced chemical equation for this reaction is:



(c) Calculate the atom economy for the fermentation of maltose to produce ethanol.

Total formula mass of all reactants =

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Formula mass of ethanol =

*Hint: Remember to calculate the formula mass for one molecule of ethanol.*

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Total mass of desired product =

*Hint: Remember to look at the number of molecules of ethanol produced in the balanced equation.*

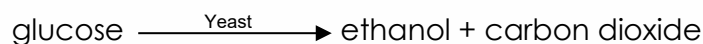
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Atom economy % = ( \_\_\_\_\_ ÷ \_\_\_\_\_ ) × 100

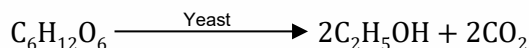
Atom economy = \_\_\_\_\_ %

Another way to produce ethanol is through the fermentation of glucose using yeast, which also produces carbon dioxide.

The word equation for this reaction is:



The balanced chemical equation for the reaction is:



(d) Calculate the atom economy for this process.

*Hint: Follow the steps used in the calculation in **part (c)**.*

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(e) Compare the two methods of producing ethanol and suggest why the use of glucose, rather than maltose, may be the better of the two methods to use for the production of ethanol on a large-scale basis.

*Hint: Consider other reactants needed and the amount of waste product formed as well as the atom economy.*

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Which question(s) did you get wrong? Why?

What will you do next time you're asked a similar question?