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Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL AS BIOLOGY (9610)

Unit 1 The Diversity of Living Organisms

Monday 4 January 2021

07:00 GMT

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided.
Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

For Examiner's Use

Question	Mark
1	
2	
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TOTAL	



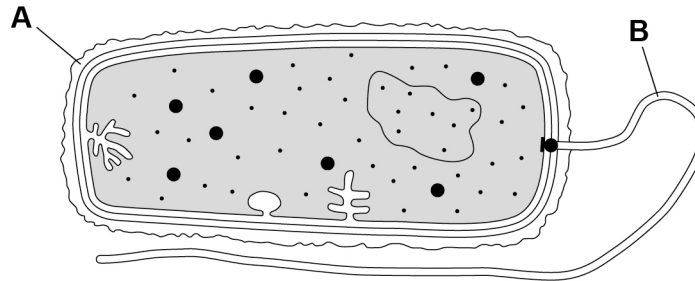
J A N 2 1 B L O 1 0 1

Answer **all** questions in the spaces provided.

0 1

Figure 1 shows the structure of a bacterial cell.

Figure 1



0 1 . 1

Name the structures labelled **A** and **B** in **Figure 1**.

[2 marks]

Structure **A** (Slime) capsule

Structure **B** Flagellum

0 1 . 2

Name **one** structure found in a bacterial cell that is **also** found in a eukaryotic cell.

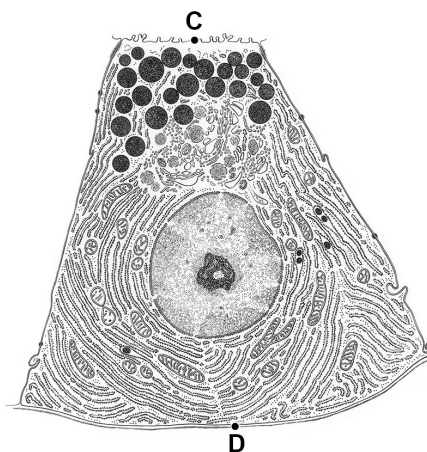
[1 mark]

Ribosomes

Figure 2 shows a drawing of a cell from the pancreas.

The magnification of the cell is x8000

Figure 2



0 1 . 3 Calculate the actual length of the cell shown in **Figure 2** from **C** to **D**.

Give your answer in μm .

[2 marks]

Measured length C to D = 51 mm = 51 000 μm

Actual length = image $\div$ magnification = 51 000 $\div$ 8000

= 6.375 μm

Actual length **C** to **D** = 6.4 μm

0 1 . 4 An electron microscope was used for viewing the cell shown in **Figure 2**.

Give **two** reasons for using an electron microscope instead of a light microscope.

[2 marks]

Reason 1 An electron microscope has a greater magnification.

Reason 2 It has a greater (higher) resolution, so organelles such as ribosomes, cristae and the endoplasmic reticulum are visible.

The pancreas produces enzymes and hormones.

0 1 . 5 Complete the table by stating **one** function for each organelle in a cell from the pancreas.

[3 marks]

Organelle	Function
Mitochondria	<i>(Aerobic) respiration, producing ATP</i>
Rough endoplasmic reticulum	<i>Making proteins by joining amino acids (to form the enzymes and hormones)</i>
Golgi apparatus	<i>Modifies and packages enzymes/hormones into vesicles to be released from the cell</i>

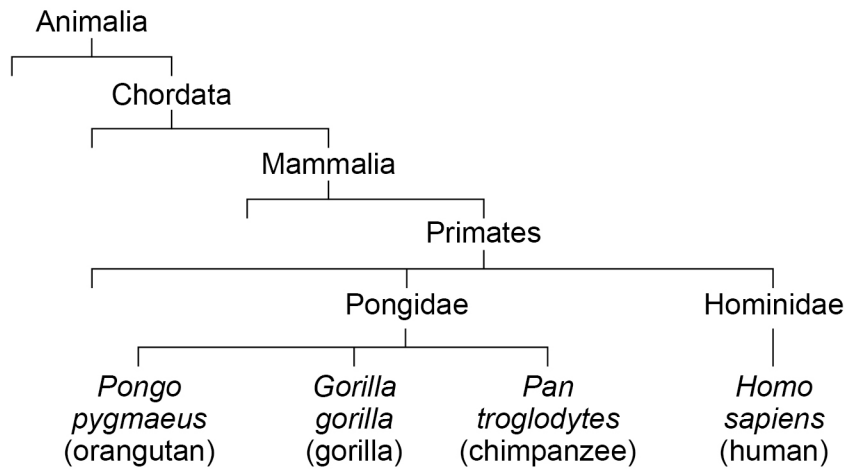


0 2

Figure 3 shows the classification of some primates.

The classification uses groups called taxa. The taxa are organised into a hierarchy.

Figure 3



0 2 . 1

Define hierarchy.

[2 marks]

*Smaller groups are placed within larger groups,
with no overlap between groups.*

Use **Figure 3** to answer Questions **02.2** and **02.3**.

0 2 . 2

State the class these primates are in.

[1 mark]

Mammalia (mammals)

0 2 . 3

State the genus of the chimpanzee.

[1 mark]

Pan



Question 2 continues on the next page

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Scientists discovered the body of an ape-like animal, **Species X**, frozen in ice in Siberia.

The scientists extracted a protein called albumin from the blood of **Species X**.

There are differences in the amino acid sequence of albumin in different species of animal.

The scientists used the principles of immunology to compare different albumins from different species:

- the scientists inject albumin from **Species X** into a rabbit
- the rabbit's white blood cells produce antibodies specific to the **Species X** albumin
- the antibodies cause the albumin molecules to clump together and form a precipitate.

Figure 4 shows the procedure the scientists used.

Figure 4

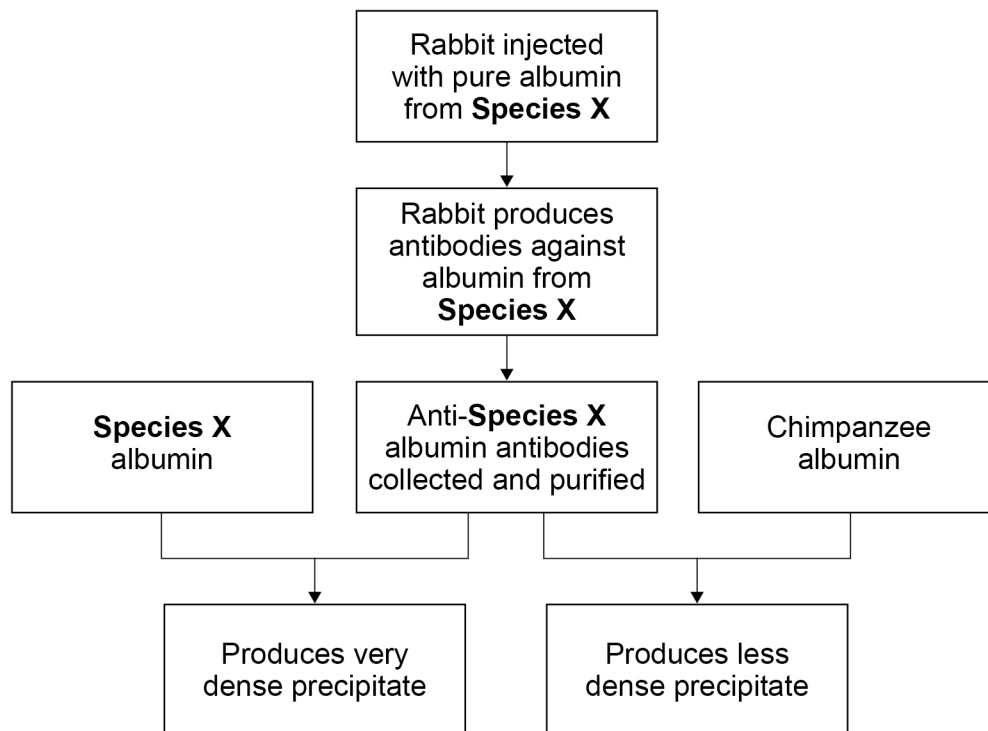


Table 1 shows the scientists' results.

Table 1

Species tested against anti- Species X albumin antibodies	Density of precipitate as percentage of the amount of precipitate with Species X albumin
Species X	100
Chimpanzee	95
Gorilla	95
Orangutan	85



0 2 . 4

Explain why the chimpanzee albumin produces a less dense precipitate than the **Species X** albumin when added to the anti-**Species X** albumin antibodies.

[2 marks]

Chimpanzee albumin has a different sequence of amino acids, so it has a different shape (structure) to Species X albumin.

The anti-Species X albumin antibodies are specific (complementary) to Species X albumin, so less binding occurs with chimpanzee albumin and less precipitate forms.

0 2 . 5

Give **two** conclusions the scientists could make from the results in **Table 1** about the taxonomic relationships between **Species X** and the other primates.

[2 marks]

1 *Species X is most closely related to the chimpanzee and the gorilla, which are equally related to Species X.*

2 *Species X is least closely related to the orangutan.*

Question 2 continues on the next page

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Another method scientists use to confirm taxonomic relationships is to compare amino acid sequences for important proteins such as haemoglobin.

Table 2 shows a comparison of the positions of five amino acids in the haemoglobin of the four species from **Table 1** (on page 6).

Table 2

Species	α chain		β chain		
	Position 11	Position 23	Position 87	Position 104	Position 115
Species X	Ala	Glu	Thr	Arg	Pro
Chimpanzee	Ala	Glu	Thr	Arg	Pro
Gorilla	Ala	Asn	Thr	Lys	Pro
Orangutan	Thr	Asn	Lys	Arg	Gln

0 2 . 6 Complete **Table 3** to show the number of amino acids in the same positions in the four species.

Use information from **Table 2**.

[1 mark]

Table 3

	Species X	Chimpanzee	Gorilla	Orangutan
Species X		5	3	1
Chimpanzee			3	1
Gorilla				1
Orangutan				



0 2 . 7

The scientists conclude that the comparison of amino acid positions supports the results of the immunological study shown in **Table 1** (on page 6).

Give evidence for and against the scientists' conclusion.

[2 marks]

Evidence for the scientists' conclusion. *Species X and the chimpanzee have the most amino acids in common (5), and Species X and the orangutan have the fewest in common (1).*

Evidence against the scientists' conclusion. *The gorilla has fewer amino acids in common with Species X (3) than the chimpanzee, but it gave the same percentage of precipitate (95%) as the chimpanzee in the immunology test.*

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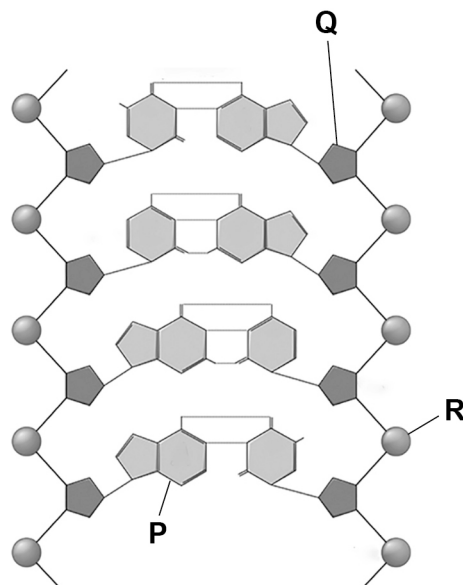
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0 3

Figure 5 shows part of a DNA molecule.

Figure 5



0 3 . 1

Name the structures labelled **P**, **Q** and **R** in **Figure 5**.

[3 marks]

Structure **P** (Nitrogenous / nitrogen-containing) baseStructure **Q** Deoxyribose (pentose sugar)Structure **R** Phosphate (group)

0 3 . 2

Describe **two** differences between a molecule of DNA and a molecule of mRNA.

[2 marks]

Difference 1 mRNA contains ribose, but DNA contains deoxyribose.

Difference 2 mRNA contains uracil, but DNA contains thymine. (mRNA is also single-stranded and shorter, but DNA is double-stranded.)



0 3 . 3

Describe the role of tRNA in the process of translation.

[3 marks]

Each tRNA molecule carries a specific amino acid (attached to its amino acid binding site).

The anticodon on the tRNA is complementary to, and binds to, the codon on the mRNA (at the ribosome).

This brings two amino acids next to each other, allowing the ribosome to link the amino acids together by peptide bonds.

Figure 6 shows the sequence of bases in a section of DNA that codes for a polypeptide containing seven amino acids.

Figure 6

TACAAGGTCGTCTTTGTCAAG

Hydrolysis of the polypeptide produced the four different amino acids shown in **Table 4**.

Table 4

Amino acid	Number present
Phe	2
Met	1
Lys	1
Gln	3

0 3 . 4

Give the amino acid sequence in the polypeptide.

Use the base sequence shown in **Figure 6**.

Write your answer in **Table 5**.

[2 marks]**Table 5**

Met	<i>Phe</i>	<i>Gln</i>	<i>Gln</i>	<i>Lys</i>	<i>Gln</i>	<i>Phe</i>
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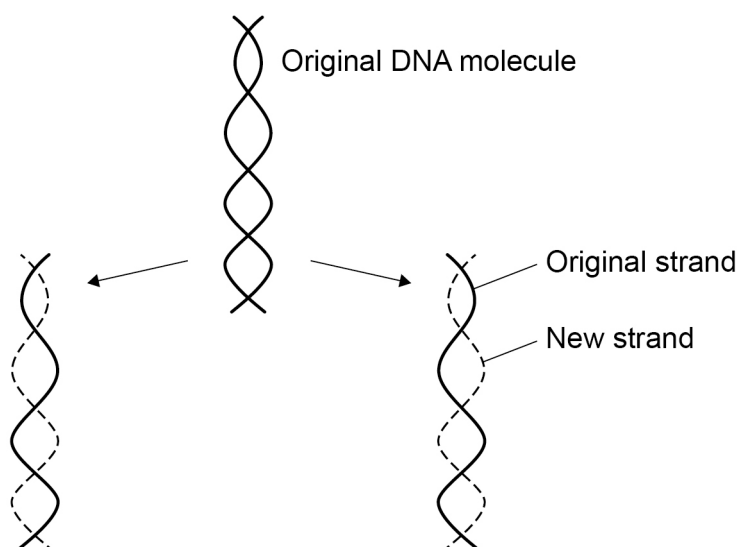
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0 4

Figure 7 shows the process of DNA replication.

Figure 7



0 4 . 1

Explain why the process of DNA replication is described as semi-conservative.

[2 marks]

*Each new DNA molecule retains one original (parental) strand,
because the original strand acts as a template and the new strand is
formed by complementary base pairing.*

Bacteria must have a supply of nitrogen to make the bases used for DNA replication.

In an investigation into DNA replication:

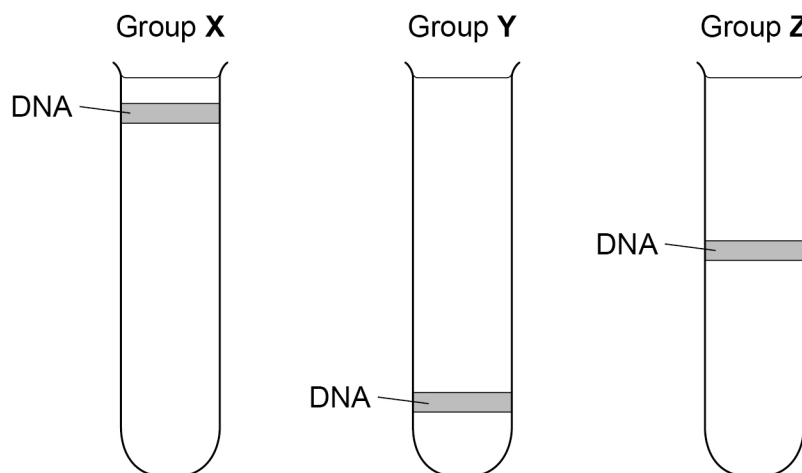
- a group of bacteria (group **X**) was grown for many cell divisions with a supply of nitrogen, ^{14}N .
- a second group of bacteria (group **Y**) was grown for many cell divisions with a supply of 'heavy' nitrogen, ^{15}N .
- some of the bacteria grown with the ^{15}N were then removed, given ^{14}N and allowed to divide **once** (group **Z**).

DNA was isolated from each group of bacteria and centrifuged.



Figure 8 shows the DNA bands formed in the centrifuge tubes.

Figure 8



0 4 . 2

Describe how the DNA is isolated from the bacteria.

[2 marks]

Break open the bacterial cells, e.g. by grinding in a homogeniser (or by sonication).

Spin the contents of the cells at high speed in an (ultra)centrifuge so the DNA separates out.

0 4 . 3

What do the tubes from group X and group Y show about the density of DNA found in the two different groups of bacteria?

[1 mark]

DNA from group Y (grown with ^{15}N) is more dense than DNA from group X (grown with ^{14}N).

Turn over ►



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Explain the position of the DNA band formed from the bacteria in group Z.

[2 marks]

The band is in the middle (intermediate density) because each DNA molecule has one ^{15}N strand and one ^{14}N strand.

The original template strand contains ^{15}N and the new strand contains ^{14}N , as replication is semi-conservative.

7



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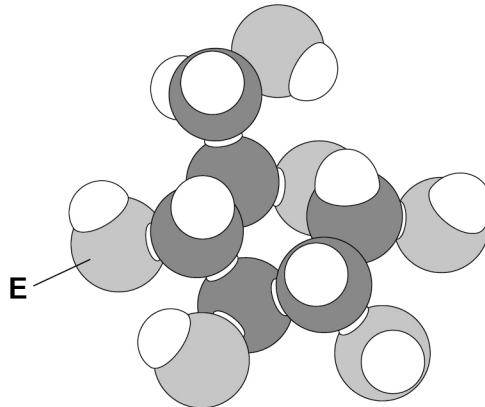


0 5

Scientists use physical 3D models to represent biological molecules.

Figure 9 shows a model of an α -glucose molecule.

Figure 9



0 5 . 1

Name the element represented by **E** in **Figure 9**.

[1 mark]

Element **E** = Oxygen

0 5 . 2

α -glucose and β -glucose are known as **isomers**.

Define **isomer**.

[1 mark]

Molecules with the same chemical (molecular) formula but a different structural formula (atoms arranged differently).

0 5 . 3

α -glucose can form 1,4 and 1,6 glycosidic bonds.

Name **one** polysaccharide that contains 1,4 and 1,6 glycosidic bonds.

[1 mark]

Glycogen



In **Figure 9** the shape representing:

- oxygen has a mass of 6 g
- hydrogen has a mass of 2 g
- carbon has a mass of 5 g

Assume the bonds between the molecules have a mass of zero.

0 5 . 4

The model of an α -glucose molecule has a mass of 90 g

Show how this number is obtained.

[2 marks]

The formula of α -glucose is $C_6H_{12}O_6$

(6 carbons, 12 hydrogens and 6 oxygens)

Mass = $(6 \times 5) + (12 \times 2) + (6 \times 6)$

= $30 + 24 + 36 = 90$ g

0 5 . 5

Calculate the mass of a model of a maltose molecule.

[2 marks]

Two α -glucose models = $2 \times 90 = 180$ g

A condensation reaction removes one water molecule (H_2O):

$(2 \times 2) + 6 = 10$ g, so maltose ($C_{12}H_{22}O_{11}$) = $180 - 10$

Mass of a model of maltose = 170 g

Question 5 continues on the next page

Turn over ►



Glycine is an amino acid.

The R-group of glycine is a hydrogen atom.

Glycine contains an element that is not found in α -glucose.

In a model of glycine, the shape representing this element has a mass of 6.5 g

0 5 . 6

Name the additional element needed to make a molecule of glycine.

[1 mark]

Nitrogen

0 5 . 7

Calculate the mass of the model of a glycine molecule.

[2 marks]

Glycine = $\text{NH}_2\text{CH}_2\text{COOH}$, formula $\text{C}_2\text{H}_5\text{NO}_2$

(2 carbons, 5 hydrogens, 2 oxygens and 1 nitrogen)

Mass = $(2 \times 5) + (5 \times 2) + (2 \times 6) + (1 \times 6.5)$

= $10 + 10 + 12 + 6.5$

Mass of the model of a glycine molecule = 38.5 g

10



0 6

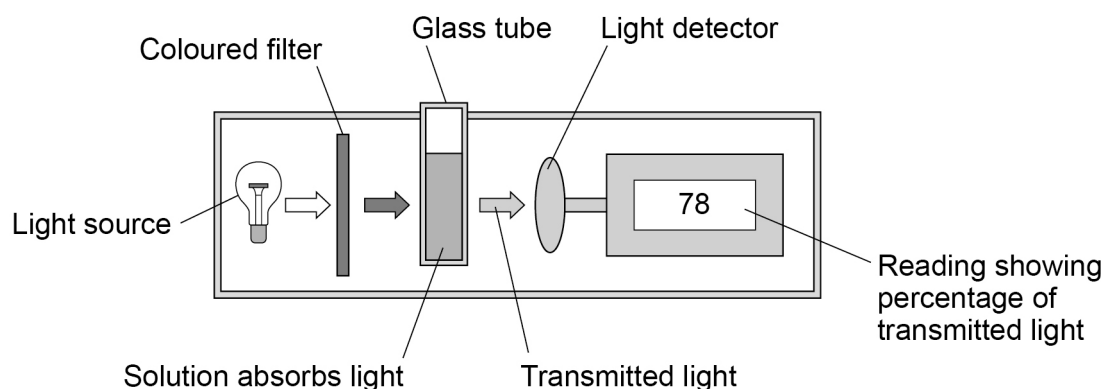
Casein is a protein found in milk. It can be hydrolysed by the protease enzyme, trypsin.

Casein forms a cloudy suspension and can be hydrolysed by trypsin to form a clear solution.

The clearer a solution is, the more light can pass through the solution. This means that the progress of the hydrolysis of casein can be monitored using a colorimeter.

Figure 10 shows a colorimeter.

Figure 10



Students investigate the effect of the concentration of casein on the rate of hydrolysis using trypsin.

The students:

1. make 10 cm^3 of a 0.8% trypsin solution
2. make a suspension of casein of concentration 0.1 g dm^{-3}
3. mix 2 cm^3 of the casein suspension with 1 cm^3 of the trypsin solution in a glass tube
4. put the glass tube into the colorimeter and set the percentage transmission to zero
5. measure the percentage transmission at 1-minute intervals for 8 minutes
6. wash out the glass tube with distilled water and dry it thoroughly
7. repeat steps 2 to 6 using concentrations of casein from 0.2 g dm^{-3} to 0.5 g dm^{-3}

0 6 . 1

Name a piece of laboratory apparatus that the students could use for measuring the volume of the solutions precisely.

[1 mark]

(Graduated) pipette (or burette / syringe)

Question 6 continues on the next page

Turn over ►



06.2

Suggest why the students wash the glass tube with distilled water and why they dry it thoroughly between each set of readings.

[2 marks]

Washing *To remove residue (contamination) from previous solutions.*

Drying *To avoid diluting the next mixture.*

06.3

The students are not able to keep the temperature constant during the experiment. Name **the other variable** the students do not control.

Describe how this variable could be controlled.

[2 marks]

Name of variable *pH*

How this variable is controlled *Use a buffer solution (of a set pH) in each mixture.*

This method uses a colorimeter to monitor the progress of the reaction.

An alternative method can be used to obtain data for this experiment. An 'X' is drawn on the outside of the glass tube. The students look through the solution and time how long it takes before the 'X' can be seen.

06.4

Explain the limitations of this method.

[2 marks]

It is less accurate because it is subjective: it is difficult to judge the end point when the X can first be seen,

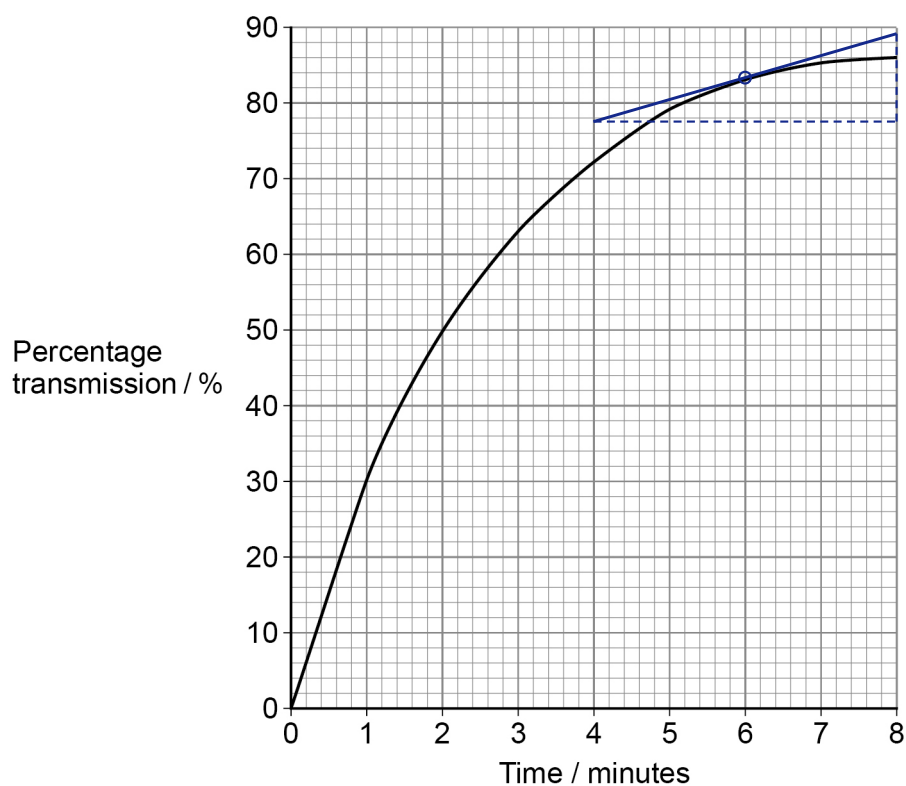
and different individuals perceive the X at different times.

If the casein is not fully hydrolysed by the end of the experiment, the X may never be seen.



Figure 11 shows the data the students obtain for the hydrolysis of casein using trypsin, at a casein concentration of 0.2 g dm^{-3}

Figure 11



0 6 . 5 Calculate the rate of hydrolysis **at** 6 minutes.

[2 marks]

$$\begin{aligned} \text{Gradient of tangent at 6 minutes} &= (89.1 - 77.5) \div (8 - 4) \\ &= 11.6 \div 4 = 2.9 \end{aligned}$$

Rate of hydrolysis = 2.9 percentage transmission min^{-1}

Question 6 continues on the next page

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The rate of hydrolysis at 6 minutes is lower than the initial rate of reaction.

Explain why.

[2 marks]

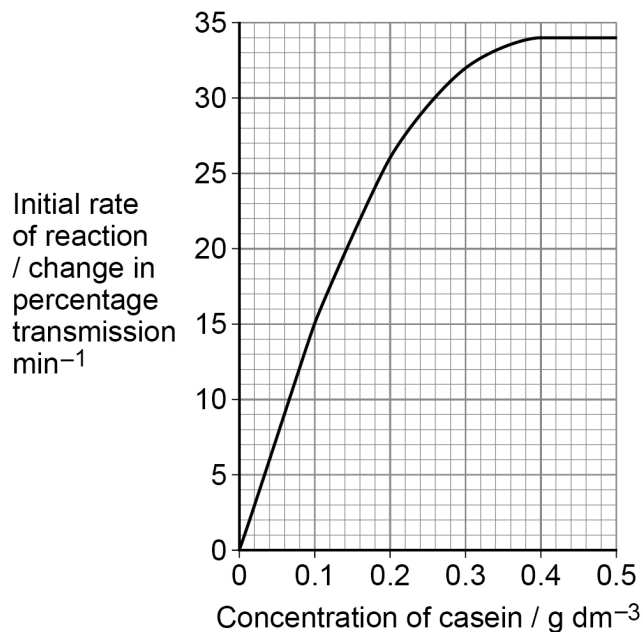
At 6 minutes there is a lower concentration of substrate (casein molecules) than at the start, as much has already been hydrolysed, so there is less chance of casein binding to (entering) the active site of trypsin, so fewer enzyme-substrate complexes form.



The students calculate the initial rate of reaction for each of the concentrations of casein.

Figure 12 shows the results.

Figure 12



0 6 . 7

Describe the results, using data from **Figure 12**.

[2 marks]

As the concentration of casein increases, the initial rate increases, then it plateaus (stays constant).

The rate stays constant at $34 \text{ \% min}^{-1}$ from 0.4 g dm^{-3} of casein upwards.

Question 6 continues on the next page

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0 6 . 8

Using information from **Figure 12**, explain what limits the rate of reaction:

- at 0.1 g dm^{-3} of casein
- at 0.5 g dm^{-3} of casein.

[3 marks]

At 0.1 g dm^{-3} of casein *Substrate (casein) concentration limits the rate, as increasing the substrate concentration increases the rate, so more enzyme-substrate complexes form.*

At 0.5 g dm^{-3} of casein *Enzyme (trypsin) concentration limits the rate, as all the active sites are occupied (saturated), so the maximum number of enzyme-substrate complexes has formed.*

0 6 . 9

The experiment is repeated using milk instead of casein solution. Although all of the casein has been hydrolysed, the liquid is still not completely clear.

Suggest why.

[1 mark]

Milk contains substances that are not protein (e.g. fat), so they are not digested by trypsin.

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0 7

Read the following passage.

Olestra is an artificially manufactured chemical that can be used as a fat substitute in foods. Olestra is made from sucrose and fatty acid chains. Ester bonds join the sucrose to the fatty acid chains. Olestra contains from 6 to 8 fatty acid chains, and these chains can be of different lengths. The different numbers and lengths of fatty acid chains allows the manufacturers to create products with different melting points. **Figure 13** shows a molecule of Olestra containing 8 fatty acid chains.

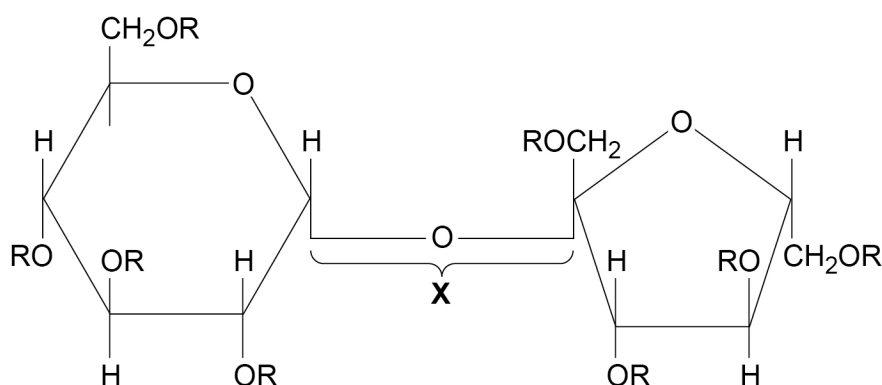
Olestra is not able to move through the walls of the intestine and enter the bloodstream. This means that although Olestra has the same taste as fat, the Olestra passes through the gastrointestinal tract undigested and doesn't contribute calories or nutrients to the diet.

Vitamins are required in the diet for many body functions. Some lipid soluble vitamins dissolve in Olestra. This has resulted in Olestra being banned from sale in the European Union and Canada.

Use information from the passage and your own knowledge to answer the questions.

Figure 13 shows a molecule of Olestra. **R** represents a fatty acid chain.

Figure 13



0 7 . 1

Olestra contains sucrose.

Describe the structure of sucrose.

[2 marks]

Sucrose is a disaccharide made of an α -glucose molecule and a fructose molecule joined together by a (1,2) glycosidic bond.

0 7 . 2

Name the type of reaction that forms the bonds between the sucrose and the fatty acid molecules in Olestra.

[1 mark]

Condensation (esterification)

0 7 . 3

Olestra contains from 6 to 8 fatty acid chains (lines 3–4).

Give the number of molecules of water that would be needed to hydrolyse one molecule of Olestra containing 8 fatty acid chains into separate fatty acids and monosaccharides.

[1 mark]

9

0 7 . 4

The length of the fatty acid chains in Olestra may vary.

State another possible way that the fatty acids may be different from each other.

[1 mark]

They may be saturated or unsaturated (contain C=C double bonds).

0 7 . 5

Suggest why Olestra is **not** able to move through the intestine walls (line 8).

[1 mark]

Olestra is too large (a very large molecule), and there are no transport proteins for it.

Turn over ►



0 7 . 6

Give **one** reason why triglycerides are a better way of storing energy than carbohydrates, in the human body.

[1 mark]

Triglycerides store more energy per gram, as they have a high hydrogen content (low oxygen content).

0 7 . 7

Olestra can be used as a fat substitute in food.

Describe a biochemical test for fat.

Include a positive result for this test.

[2 marks]

Description *Shake (mix) the sample with ethanol, then pour the ethanol into water.*

Positive result *A white (milky) emulsion forms.*

0 7 . 8

Suggest why Olestra has been banned in some countries (lines 12–14).

[1 mark]

Lipid-soluble vitamins dissolve in Olestra and pass out with it, so they cannot be absorbed, causing vitamin deficiency.

10

END OF QUESTIONS



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