EXAM PAPERS PRACTICE

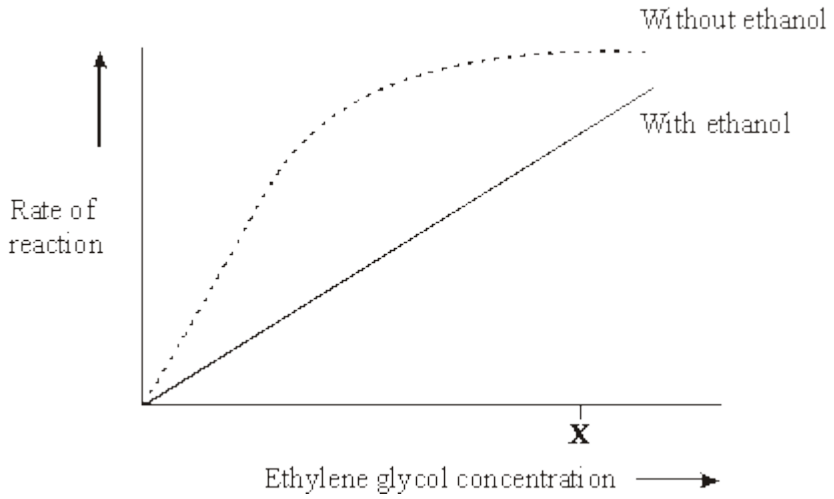
Proteins and enzymes 1

Level: CIE AS 9700
Subject: Biology
Exam Board: Suitable for all boards
Topic: Proteins and enzymes 1
Type: Questionnaire

To be used by all students preparing for CIE AS Biology 9700 foundation or higher tier but also suitable for students of other boards.

1 Ethylene glycol is a substance used in car anti-freeze. If it is accidentally swallowed it enters the liver cells where it is converted to poisonous oxalic acid. Ethanol inhibits the production of oxalic acid and can be used to treat patients who have swallowed anti-freeze.

In an investigation, the rate of reaction of an enzyme that makes oxalic acid was measured with and without ethanol present. The graph shows the results.



(i) Increasing the concentration of ethylene glycol above **X** without ethanol present does not increase the rate of the reaction. Explain why.

(2)

(ii) Use the information in the graph to explain how ethanol prevents oxalic acid production.

(2)

(Total 4 marks)

2 Yarrow is a herbaceous plant which grows in California at altitudes from 1500 m to 3000 m. The mean height of the stems of plants growing at 3000 m is smaller than that of plants growing at 1500 m.

S (a) The higher the altitude, the lower the mean temperature. Explain how the lower temperature at high altitude reduces the growth of plants.

(4)

S (b) The relative contribution of environmental and genetic factors on the growth of the plants was investigated. Samples of young plants were taken and grown outdoors in prepared plots at altitudes of 1500 m and 3000 m.

Altitude at which young plants were collected / m	Mean maximum height of stems of plants / cm	
	Grown at 1500 m	Grown at 3000 m
1500	80.4	35.3
3000	31.5	24.7

Describe the evidence from the table that the variation in height is

(i) partly genetically determined;

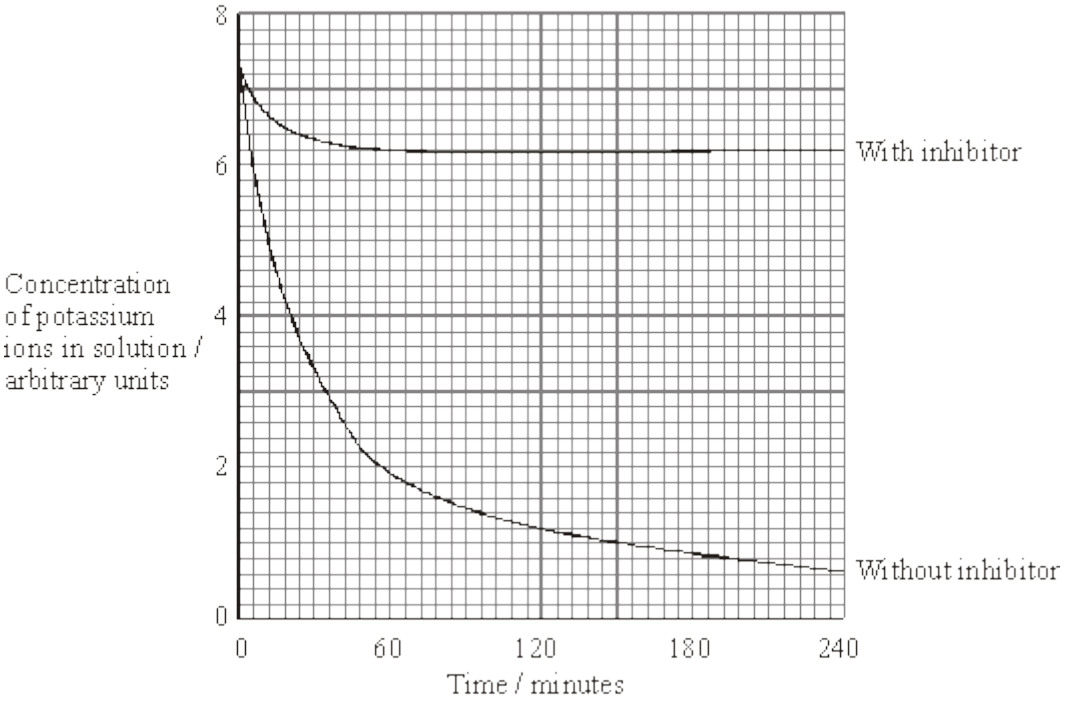
(1)

(ii) partly environmentally determined.

(1)

(Total 6 marks)

3 Two samples of the roots of pea plants were placed in solutions containing potassium ions. An inhibitor to prevent respiration was added to one solution. The concentrations of potassium ions in the two solutions were measured at regular intervals. The graph shows the results.



(a) Explain the decrease in the concentrations of potassium ions in the two solutions between 0 and 30 minutes.

(i) With inhibitor

_____

_____

_____

_____

(2)

(ii) Without inhibitor

_____

_____

(1)

(b) Explain why there is no further decrease in the concentration of potassium ions in the solution with the inhibitor after 60 minutes.

(2)

(c) The substance malonate is an inhibitor of respiration. It has a structure very similar to the substrate of an enzyme that catalyses one of the reactions of respiration. Explain how malonate inhibits respiration.

(2)

(Total 7 marks)

4 (a) *Clostridium difficile* is a bacterium that is present in the gut of up to 3% of healthy adults and 66% of healthy infants.

(i) *C. difficile* rarely causes problems, either in healthy adults or in infants. This is because its numbers are kept low by competition with harmless bacteria that normally live in the intestine.

Use this information to explain why some patients treated with antibiotics can be affected by *C. difficile*.

_____

_____

_____

_____

_____

(2)

(ii) Suggest why older people are more likely to be affected by *C. difficile*.

_____

_____

_____

(1)

(b) The antibiotic methicillin inhibits the enzyme transpeptidase. This enzyme is used by some bacteria to join monomers together during cell wall formation. Methicillin has a similar structure to these monomers. Use this information to explain how methicillin inhibits the enzyme transpeptidase.

_____

_____

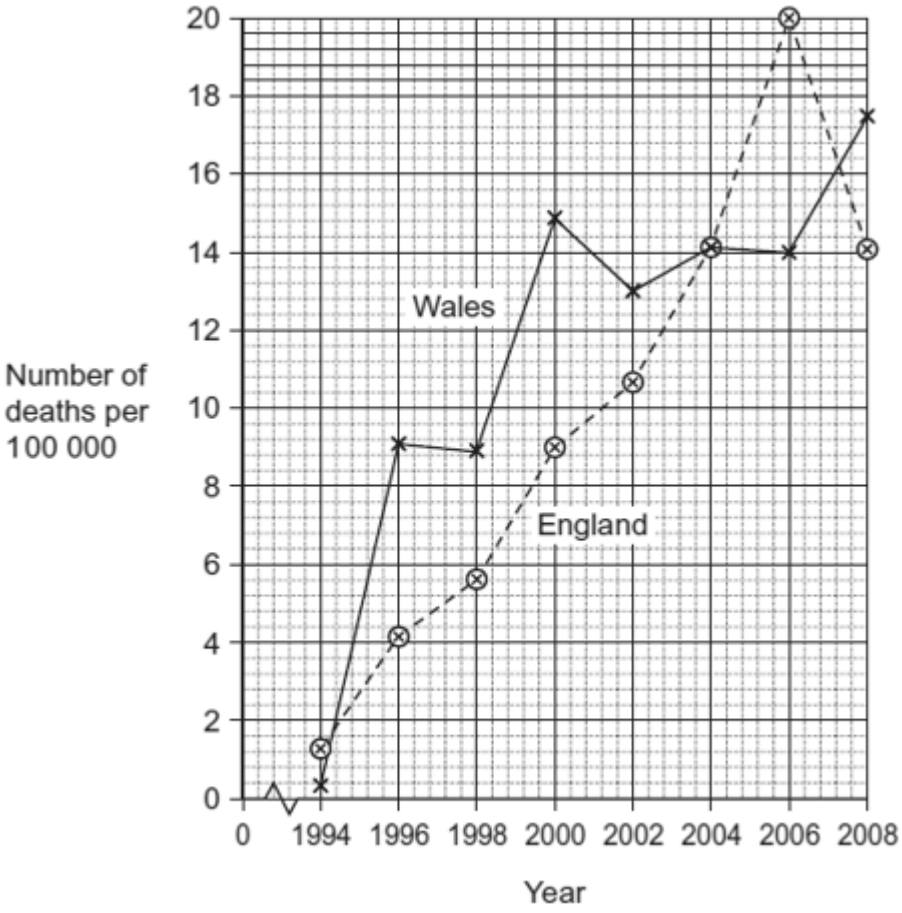
_____

_____

_____

(2)

(c) MRSA is a variety of *Staphylococcus aureus*. It is difficult to treat infections caused by this bacterium because it is resistant to methicillin and to some other antibiotics. As a result, some patients who are already very ill may die if they become infected with MRSA. The graph shows the number of deaths in England and Wales between 1994 and 2008 caused by MRSA.



(i) It may be difficult to identify MRSA as the actual cause of death. Explain why.

_____

_____

_____

(1)

(ii) Describe the change in the number of deaths caused by MRSA in England in the period shown in the graph.

_____

_____

_____

(1)

(iii) Calculate the percentage increase in the number of deaths caused by MRSA in Wales from 1996 to 2006. Show your working.

Answer _____

(2)

(Total 9 marks)

5 Read the following passage.

During the course of a day, we come into contact with many poisonous substances. These include industrial and household chemicals. The skin acts as a barrier and prevents many of these substances entering and harming the body.

The skin is one of the largest organs in the body. It is composed of several layers of tissue. The outer layer consists of dead cells packed with keratins. Keratins are a group of proteins that differ from each other in their primary structure. Each keratin molecule consists of several polypeptide chains, each individual chain wound into a spiral or helix. The polypeptide chains include many sulphur-containing amino acids and these help to give the keratin molecules their characteristic strength.

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

(a) What is the evidence from the passage that keratin molecules have a quaternary structure?

_____

_____

(1)

(b) Explain how sulphur-containing amino acids help to give keratin molecules their characteristic strength (lines 8–9).

_____

_____

_____

_____

(2)

(c) Explain why differences in primary structure result in keratins with different properties (line 6).

(2)

(d) The skin prevents poisonous substances entering and harming the body (line 3). Explain why these substances are unable to pass through the outer layer of skin cells by active transport.

(3)

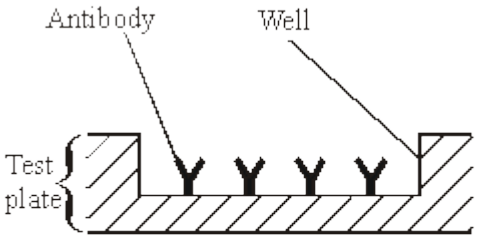
(e) Skin cells may be studied with a transmission electron microscope or an optical microscope. Explain the advantages and limitations of using a transmission electron microscope to study cells.

(6)

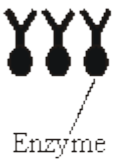
(Total 14 marks)

6 A test has been developed to determine if a person is infected with variant CJD (vCJD), the human form of BSE (mad cow disease). The test detects the protein which causes vCJD in a urine sample.

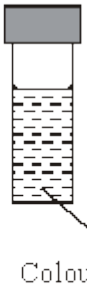
The test kit contains the following components.



A test plate with wells containg antibodies to the protein which causes vCJD

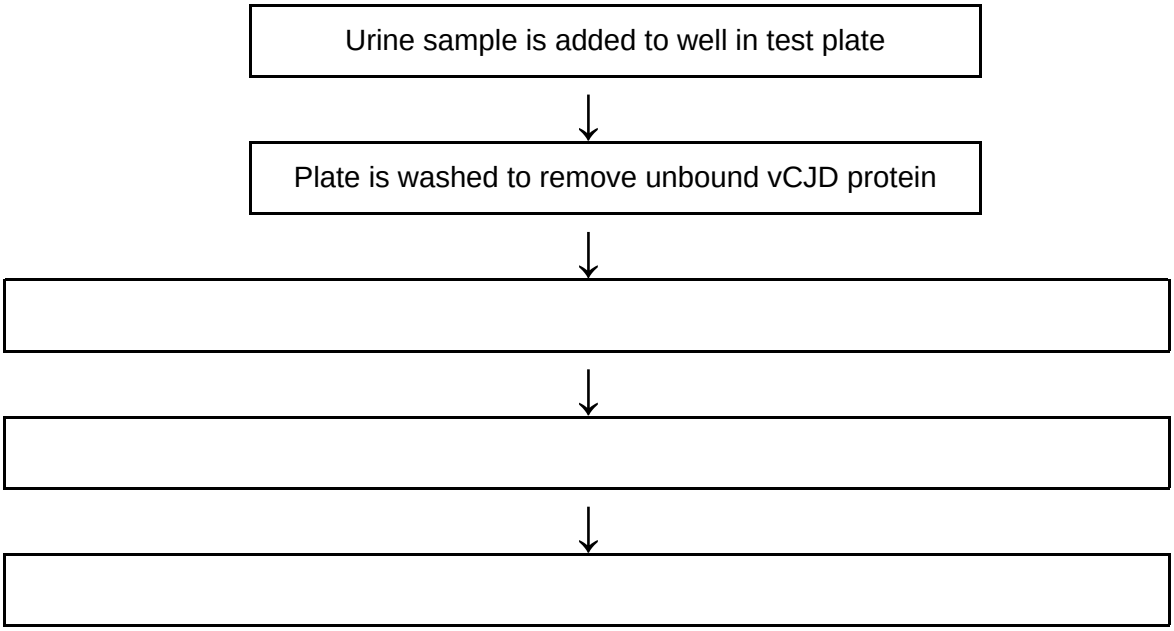


Antibodies to the protein which causes vCJD. These antibodies have an enzyme attached to them



Colourless solution which turns blue if the enzyme is present

(a) Complete the flow chart to describe how this test would be used.



(3)

(b) Explain why this test would detect vCJD, but not other antigens in the urine.

_____

_____

_____

_____

(2)

(Total 5 marks)

7 Read the following passage.

The plasma membrane plays a vital role in microorganisms. It forms a barrier between the cell and its environment, controlling the entry and exit of solutes.
This makes bacteria vulnerable to a range of antiseptics and antibiotics.

When bacteria are treated with antiseptics, the antiseptics bind to the proteins in the membrane and create tiny holes. Bacteria contain potassium ions at a concentration many times that outside the cell. Because of the small size of these ions and their concentration in the cell, the first observable sign of antiseptic damage to the plasma membrane is the leaking of potassium ions from the cell. Some antibiotics damage the plasma membrane in a similar way. One of these is tyrocidin. This is a cyclic polypeptide consisting of a ring of ten amino acids. Tyrocidin and other polypeptide antibiotics are of little use in medicine.

Other antibiotics also increase the rate of potassium movement from cells. It is thought that potassium ions are very important in energy release and protein synthesis, and a loss of potassium ions would lead to cell death. Gramicidin A coils to form a permanent pore passing through the plasma membrane. This pore enables potassium ions to be conducted from the inside of the cell into the surrounding medium. Vanilomycin also facilitates the passage of potassium ions from the cell.
A molecule of vanilomycin forms a complex with a potassium ion and transports it across the membrane. The potassium ion is released on the outside and the vanilomycin is free to return and pick up another potassium ion. Vanilomycin depends on the fluid nature of the plasma membrane in order to function.

Polyene antibiotics have flattened ring-shaped molecules. The two sides of the ring differ from each other. One side consists of an unsaturated carbon chain. This part is strongly hydrophobic and rigid. The opposite side is a flexible, strongly hydrophilic region. It has been shown that polyene antibiotics bind only to sterols. Sterols are lipids found in the membranes of eukaryotes but not in the membranes of prokaryotic organisms. It is thought that several sterol-polyene complexes come together.
The plasma membranes of eukaryotic cells treated with these polyene antibiotics lose the ability to act as selective barriers and small ions and molecules rapidly leak out.

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

(a) By what process do potassium ions normally enter a bacterial cell? Explain the evidence for your answer.

_____

_____

_____

_____

(2)

(b) (i) Draw a peptide bond showing how the COOH group of one amino acid joins to the NH_2 group of another.

(1)

(ii) How many peptide bonds are there in a molecule of tyrocidin (lines 9 - 10)?

_____

(1)

(c) Experiments have shown that vanilomycin is unable to transport potassium ions across a membrane when it is cooled. Gramicidin A continues to facilitate the movement of potassium ions at these low temperatures. Explain these results.

_____

_____

_____

_____

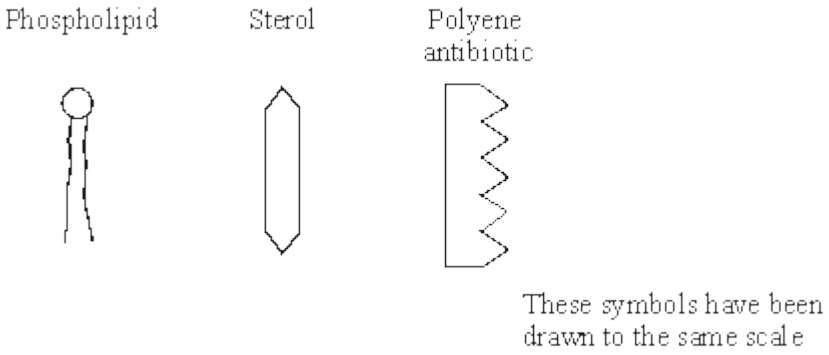
_____

_____

(3)

(d) Draw a simple diagram of one of the phospholipid layers to show how polyene antibiotics allow small ions and molecules to leak rapidly through a plasma membrane. Use the following symbols to represent the different molecules.

Note that the zigzag line on the symbol for the polyene antibiotic represents its hydrophobic region.



(2)

(Total 9 marks)

8 **Essay**

You should write your essay in continuous prose.

Your essay will be marked for its scientific accuracy.

It will also be marked for your selection of relevant material from different parts of the specification and for the quality of your written communication.

The maximum number of marks that can be awarded is

Scientific	16
Breadth of knowledge	3
Relevance	3
Quality of written communication	3

Write an essay on the following topic:

Enzymes and their importance in plants and animals

(Total 25 marks)

9 **Essay**

You should write your essay in continuous prose.

Your essay will be marked for its scientific accuracy.

It will also be marked for your selection of relevant material from different parts of the specification and for the quality of your written communication.

The maximum number of marks that can be awarded is

Scientific	16
Breadth of knowledge	3
Relevance	3
Quality of written communication	3

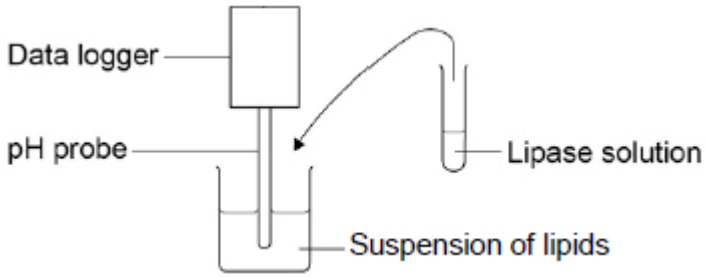
Write an essay on the following topic:

How the structure of proteins is related to their functions.

(Total 25 marks)

10 A student investigated the effect of lipase concentration on the hydrolysis of lipids.

He took a beaker containing a suspension of lipids. He placed a pH probe attached to a data logger into the beaker. After 5 minutes, he added the lipase solution. The data logger recorded the pH. The apparatus used is shown in the diagram below.



(a) The student did **not** add a buffer to the lipase solution.

Explain why.

_____

_____

_____

(1)

(b) Give **two** variables the student would have controlled in this investigation.

1. _____

2. _____

(2)

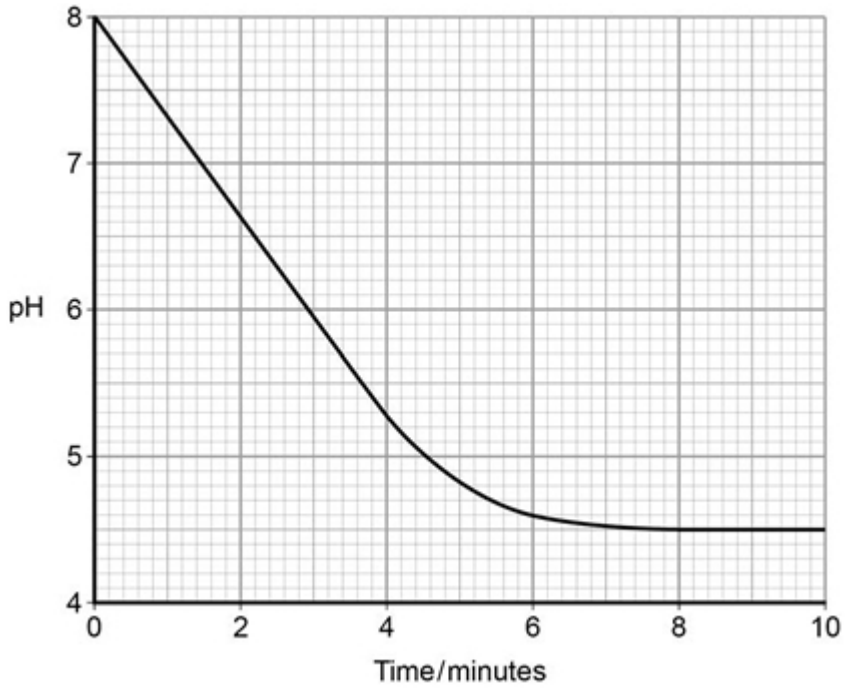
(c) Give the suitable control for this investigation.

_____

_____

(1)

The data logger recorded the pH. The graph below shows what happened after he added the lipase solution.



(d) Draw a tangent on the graph and use it to calculate the rate of change at 5 minutes.

Rate of change at 5 minutes = _____ pH minute^{-1}

(2)

(e) Explain the results shown in the graph.

_____

_____

_____

_____

_____

(2)

(f) The student repeated the experiment with a higher concentration of lipase solution. Describe and explain the results you would expect him to get.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 11 marks)

11 Newborn babies can be fed with breast milk or with formula milk. Both types of milk contain carbohydrates, lipids and proteins.

- Human breast milk also contains a bile-activated lipase. This enzyme is thought to be inactive in milk but activated by bile in the small intestine of the newborn baby.
- Formula milk does not contain a bile-activated lipase.

Scientists investigated the benefits of breast milk compared with formula milk.

(a) The scientists used kittens (newborn cats) as model organisms in their laboratory investigation.

Other than ethical reasons, suggest **two** reasons why they chose to use cats as model organisms.

1. _____

_____

2. _____

_____

(2)

(b) Before starting their experiments, the scientists confirmed that, like human breast milk, cat's milk also contained bile-activated lipase.

To do this, they added bile to cat's milk and monitored the pH of the mixture.

Explain why monitoring the pH of the mixture could show whether the cat's milk contained lipase.

_____

_____

_____

_____

(2)

The scientists then took 18 kittens. Each kitten had been breastfed by its mother for the previous 48 hours.

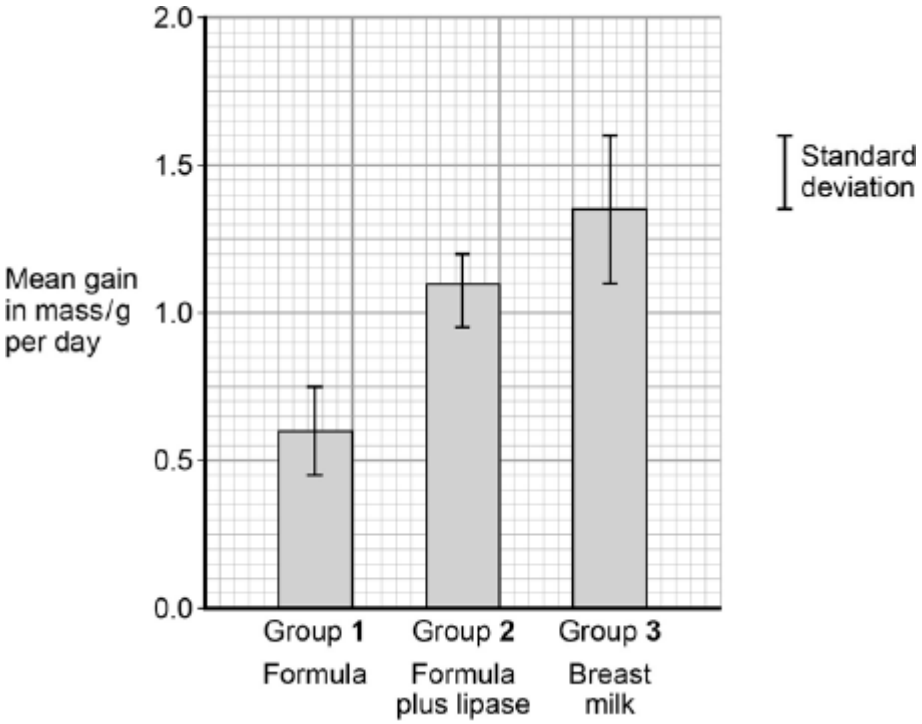
The scientists divided the kittens randomly into three groups of six.

- The kittens in group **1** were fed formula milk.
- The kittens in group **2** were fed formula milk plus a supplement containing bile-activated lipase.
- The kittens in group **3** were fed breast milk taken from their mothers.

Each kitten was fed 2 cm^3 of milk each hour for 5 days.

The scientists weighed the kittens at the start of the investigation and on each day for 5 days.

The figure below shows the scientists' results.



Type of milk given to kittens

(c) What can you conclude from the figure about the importance of bile-activated lipase in breast milk?

(Extra space) _____

_____

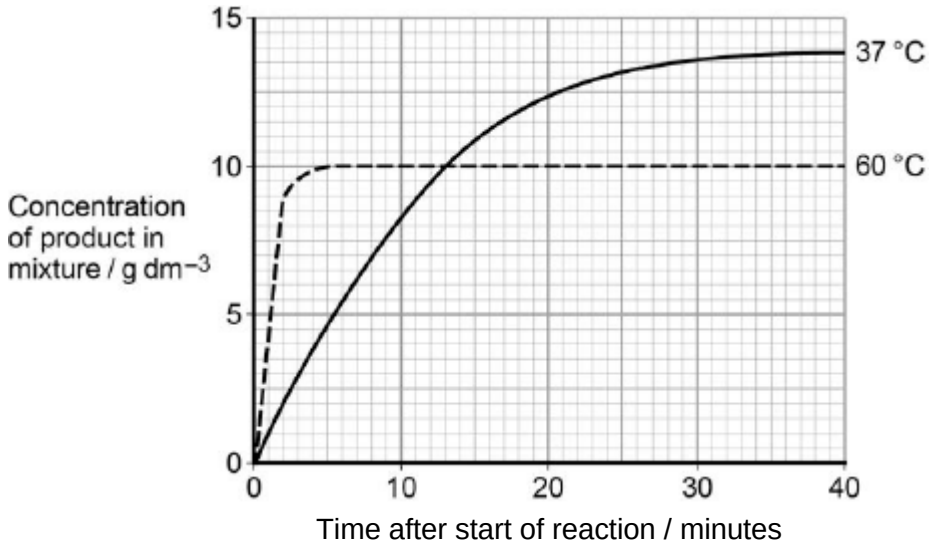
_____

(3)

(Total 7 marks)

12 A technician investigated the effect of temperature on the rate of an enzyme-controlled reaction. At each temperature, he started the reaction using the same concentration of substrate.

The following graph shows his results.



(a) Give **two** other factors the technician would have controlled.

1. _____

2. _____

(1)

(b) Draw a tangent on each curve to find the initial rates of reaction.
Use these values to calculate the ratio of the initial rates of reaction at 60 °C : 37 °C.
Show your working.

Ratio = _____ :1

(2)

(c) Explain the difference in the initial rate of reaction at 60 °C and 37 °C.

(2)

(d) Explain the difference in the rates of reaction at 60 °C and 37 °C between 20 and 40 minutes.

(Extra space)

(4)

(Total 9 marks)

13 A student investigated the effect of chewing on the digestion of starch in cooked wheat.

He devised a laboratory model of starch digestion in the human gut. This is the method he used.

1. Volunteers chewed cooked wheat for a set time. The wheat had been cooked in boiling water.
2. This chewed wheat was mixed with water, hydrochloric acid and a protein-digesting enzyme and left at 37 °C for 30 minutes.
3. A buffer was then added to bring the pH to 6.0 and pancreatic amylase was added. This mixture was then left at 37 °C for 120 minutes.
4. Samples of the mixture were removed at 0, 10, 20, 40, 60 and 120 minutes, and the concentration of reducing sugar in each sample was measured.
5. Control experiments were carried out using cooked wheat that had been chopped up in a blender, not chewed.

(a) What reducing sugar, or sugars, would you expect to be produced during chewing? Give a reason for your answer.

_____

_____

_____

_____

(2)

(b) In this model of digestion in the human gut, what other enzyme is required for the complete digestion of starch?

_____

(1)

(c) What was the purpose of step 2, in which samples were mixed with water, hydrochloric acid and pepsin?

_____

_____

(1)

(d) In the control experiments, cooked wheat was chopped up to copy the effect of chewing.

Suggest a more appropriate control experiment. Explain your suggestion.

_____

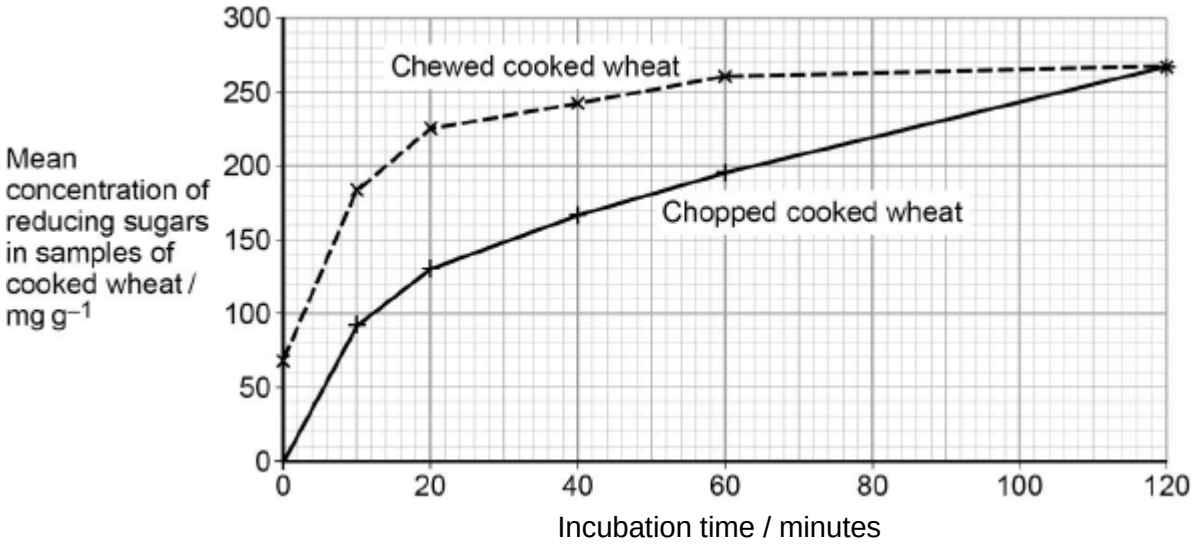
_____

_____

_____

(2)

(e) The figure below shows the student's results.



Explain what these results suggest about the effect of chewing on the digestion of starch in wheat.

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

14 A stomach ulcer is caused by damage to the cells of the stomach lining. People with stomach ulcers often have the bacterium *Helicobacter pylori* in their stomachs.

A group of scientists was interested in trying to determine how infection by *H. pylori* results in the formation of stomach ulcers.

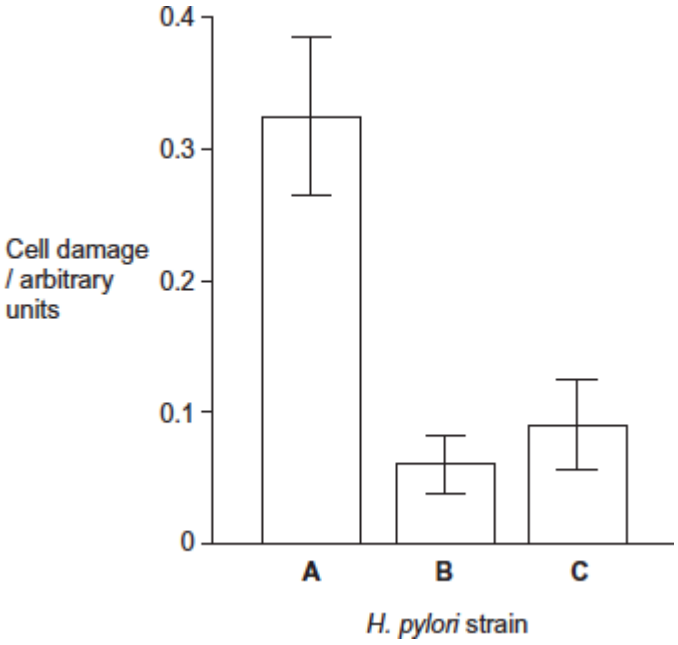
The scientists grew different strains of *H. pylori* in liquid culture.

The table below shows the substances released by each of these strains.

***H. pylori* strain**	**Substances released by the *H. pylori* cells**	
	Toxin	**Enzyme that neutralises acid**
A	✓	✓
B	×	✓
C	✓	×

The scientists centrifuged the cultures of each strain to obtain cell-free liquids. They added each liquid to a culture of human cells. They then recorded the amount of damage to the human cells.

Their results are shown below. The error bars show ± 1 standard deviation.



(a) Describe and explain how centrifuging the culture allowed the scientists to obtain a cell-free liquid.

[Extra space]

(3)

(b) The scientists measured cell damage by measuring the activity of lysosomes.
Give **one** function of lysosomes.

(1)

(c) *H. pylori* cells produce an enzyme that neutralises acid.
Suggest **one** advantage to the *H. pylori* of producing this enzyme.

(2)

(d) What do these data suggest about the damage caused to human cells by the toxin and by the enzyme that neutralises acid?
Explain your answer.

[Extra space]

(3)

(e) The scientists carried out a further investigation. They treated the liquid from **strain A** with a protein-digesting enzyme before adding it to a culture of human cells. No cell damage was recorded.
Suggest why there was no damage to the cells.

[Extra space]

(3)

(Total 12 marks)

15 Cyanide is poisonous. Cyanide binds to cytochrome oxidase, which is an enzyme in the electron transport chain in mitochondria. This stops the movement of electrons to oxygen. As a result, ATP cannot be made via aerobic respiration. If a person or animal is exposed to cyanide, a substance that acts as an antidote can reduce or prevent poisoning. This substance binds to cyanide.

Scientists investigated the effect of cyanide on the rate of respiration of cells in different animal organs and in organs from different animals. They extracted organs from animals that had just been killed. For each animal organ they set up 3 dishes. Each dish contained:

- phosphate solution
- saline (sodium chloride) solution
- cyanide solution of known concentration.

They measured the mean amount of oxygen used by the slices of organs in one hour. Their results are shown in **Table 1**.

Table 1

Trial	Animal organ	Mean amount of oxygen used, in the absence or presence of cyanide, per hour / arbitrary units		
		No cyanide	10^{-4} mol dm^{-3} cyanide	10^{-2} mol dm^{-3} cyanide
A	Sheep liver	2.7	2.5	0.7
B	Sheep kidney	14.1	9.9	1.9
C	Ox liver	1.9	1.5	0.8
D	Rat kidney	20.7	18.8	2.3
E	Rat liver	10.5	10.0	1.9
F	Guinea pig kidney	16.8	14.4	1.9

(a) Suggest how binding of cyanide to cytochrome oxidase affects the enzyme.

[Extra space]

(3)

(b) Suggest how the antidote can reduce poisoning by cyanide.

(1)

(c) **Table 1** shows the scientists' results for different trials. The trials could be put into groups to allow comparisons to be made within each group.

(i) As an example of how trials could be grouped, **Group 1** has been completed in **Table 2** below. Complete **Table 2** to show **three** other possible ways that the scientists' trials could be grouped.

Table 2

Group	Trials allowing comparisons to be made
1	**A** with **B**
2	
3	
4	

(2)

(ii) What is the effect of cyanide on **Group 1** trials in **Table 2**? Use evidence from **Table 1** to support your answer.

_____

_____

_____

_____

_____

_____

(3)

(iii) Calculate the percentage difference in oxygen use for 'rat liver' (**Trial E**) between a cyanide concentration of 10^{-4} and 10^{-2} mol dm^{-3}.

Percentage difference = _____

(2)

(Total 11 marks)

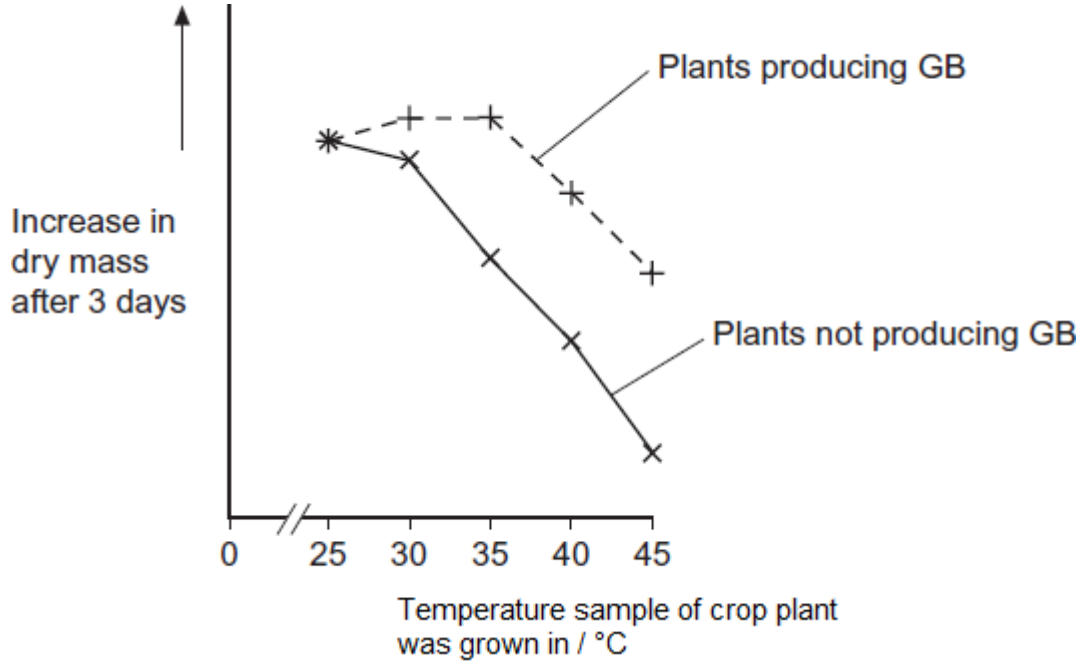
16 Some species of crop plant produce a substance called glycinebetaine (GB).

Scientists transferred the gene for GB into a species of crop plant that does not normally produce GB. These genetically modified plants then produced GB.

The scientists grew large numbers of the same crop plant with and without the gene at different temperatures. After 3 days, they found the increase in dry mass of the plants.

Figure 1 shows their results.

Figure 1



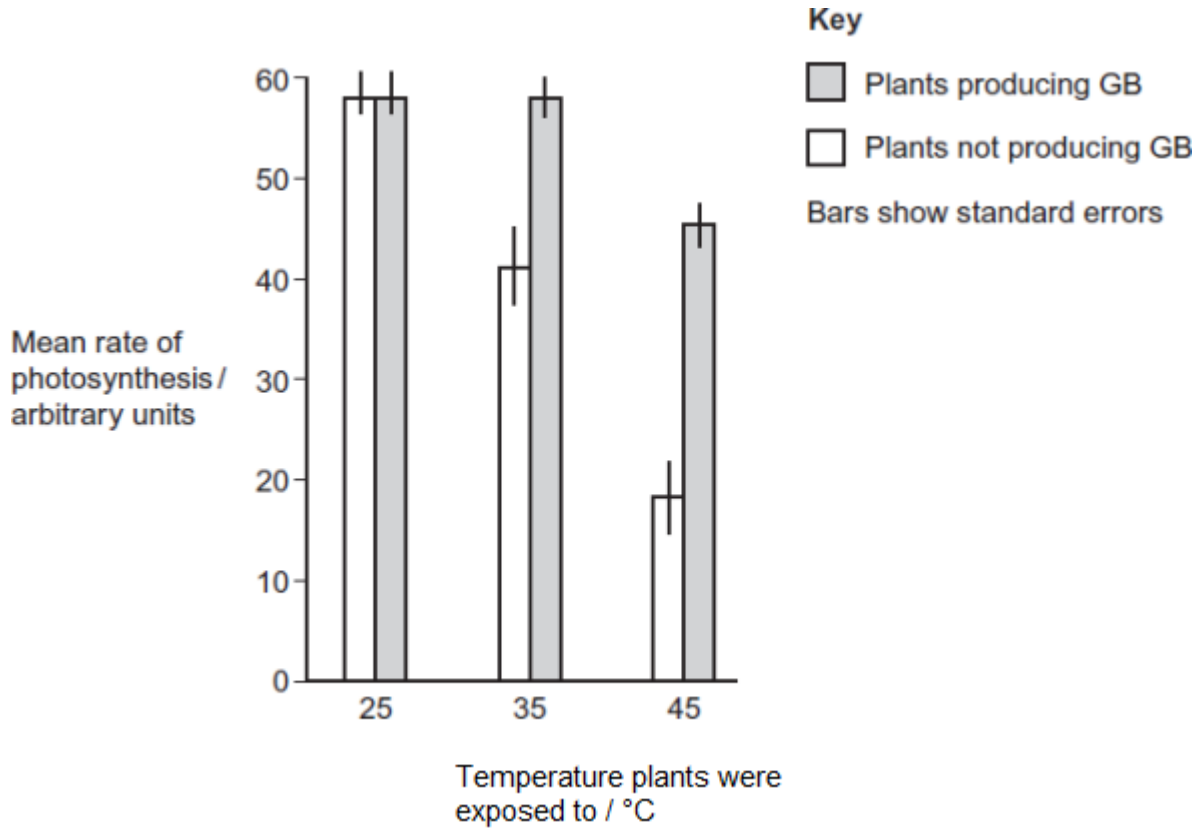
(a) Describe the effect on growth of transferring the gene for GB into this plant.

(2)

(b) The scientists measured the rate of photosynthesis in plants that produce GB and plants that do not produce GB at 25°C, 35°C and 45°C.

Figure 2 shows their results.

Figure 2



(i) The scientists concluded that the production of GB protects photosynthesis from damage by high temperatures.

Use these data to support this conclusion.

_____

_____

_____

(1)

(ii) Use the data from **Figure 2** for plants that do not produce GB to explain the effect of temperature on changes in dry mass of the plants shown in **Figure 1.**

(Extra space)

(4)

Rubisco activase is an enzyme found in chloroplasts. It activates the light-independent reaction of photosynthesis.

The scientists discovered that, as temperature increased from 25°C to 45°C, rubisco activase began attaching to thylakoid membranes in chloroplasts and this stopped it working.

(c) Rubisco activase stops working when it attaches to a thylakoid.

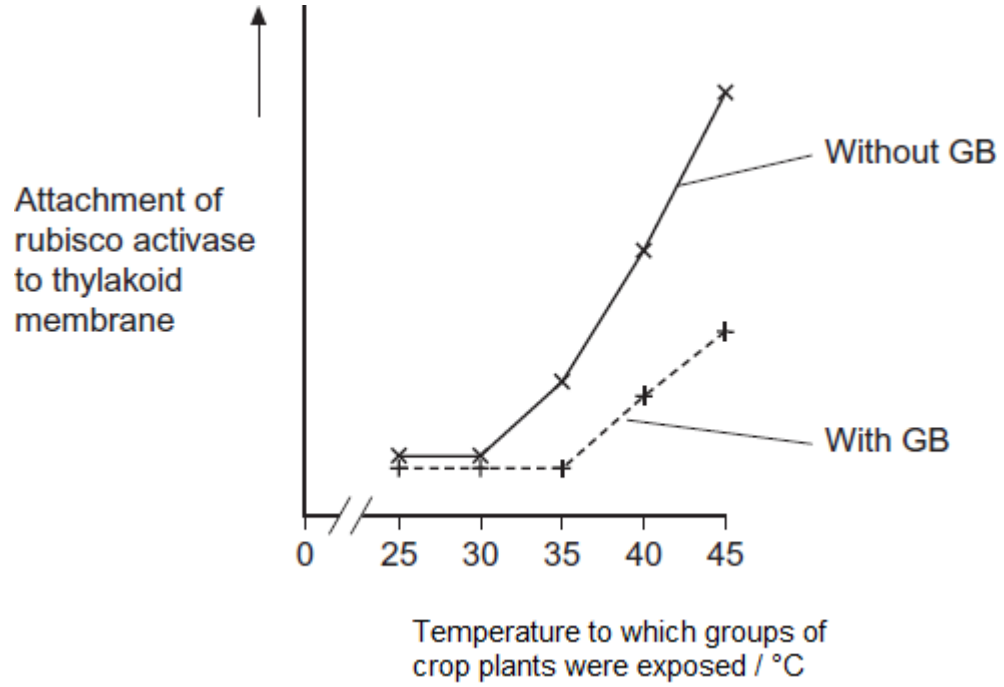
Use your knowledge of protein structure to explain why.

(2)

(d) The scientists investigated the effect of GB on attachment of rubisco activase to thylakoid membranes at different temperatures.

Figure 3 shows their results.

Figure 3



Use information from **Figure 2** and **Figure 3** to suggest how GB protects the crop plant from high temperatures.

(Extra space)

(4)

(e) The scientists' hypothesis at the start of the investigation was that crop plants genetically engineered to produce GB would become more resistant to high environmental temperatures.
The scientists developed this hypothesis on the basis of previous research on crops that are grown in hot climates.

Suggest how the scientists arrived at their hypothesis.

_____

_____

_____

_____

_____

(2)

(Total 15 marks)

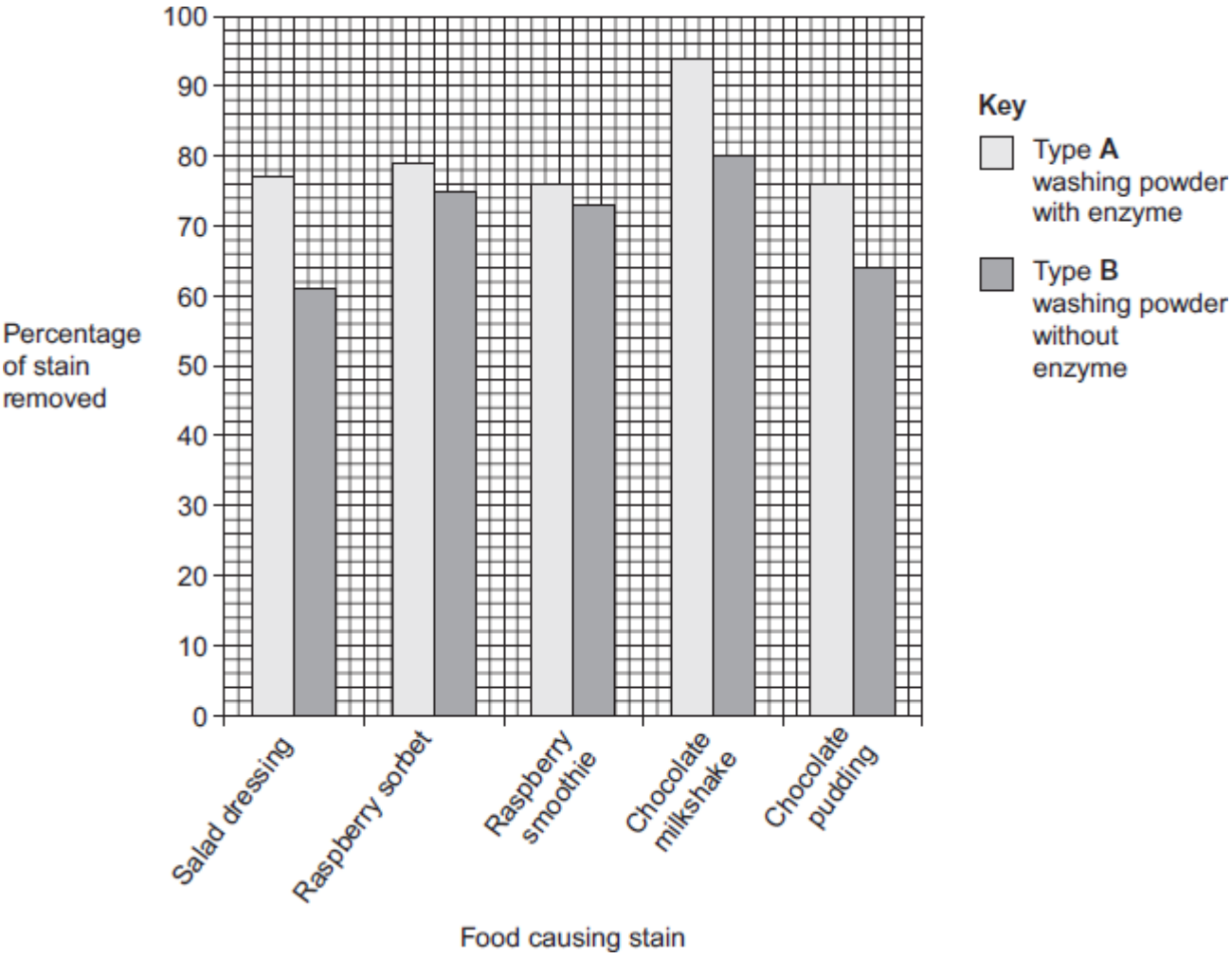
17 Biological washing powders contain enzymes which hydrolyse substances that cause stains on clothes.

A manufacturer tested the ability of two types of the same brand of washing powder to remove different food substances that stain clothes.

- Type **A** contained an enzyme.
- Type **B** was identical to **A** except it did **not** contain the enzyme.

Figure 1 shows the results.

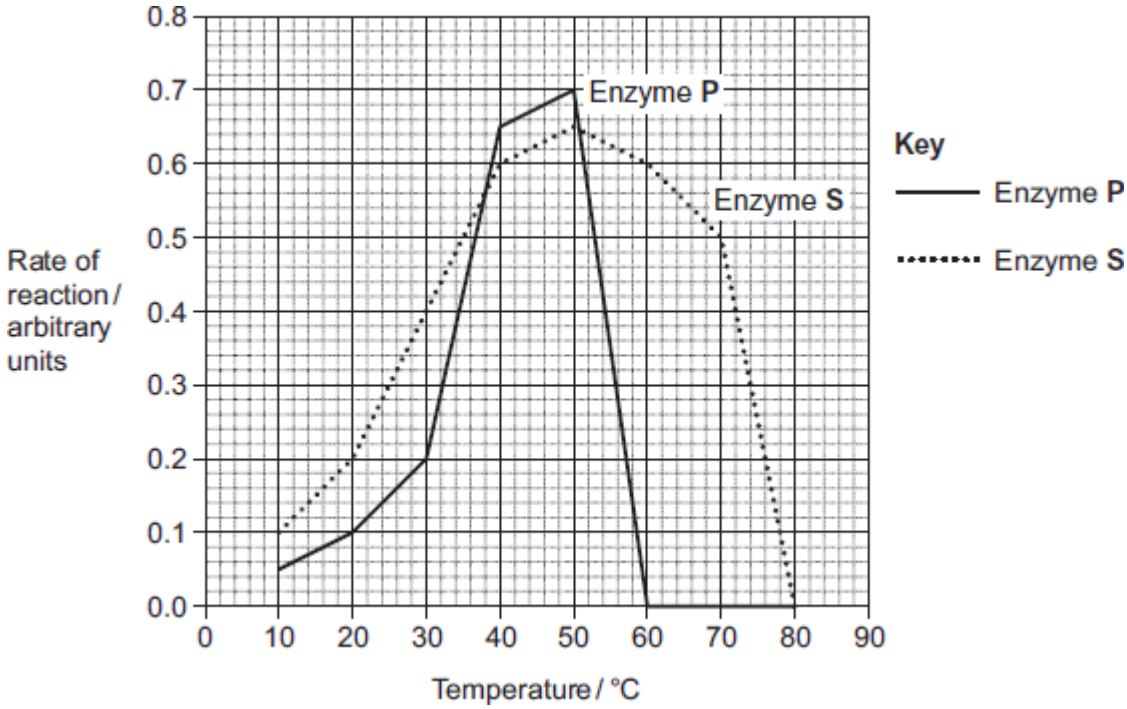
Figure 1



A scientist worked for a company that wanted to develop a biological washing powder that was effective over a range of temperatures. He investigated the effect of temperature on the rates of the reaction catalysed by two enzymes, **P** and **S** used in biological washing powders.

Figure 2 shows his results.

Figure 2



(a) Many of the substances causing the food stains are large, insoluble proteins. Suggest how a biological washing powder removes this type of stain.

(2)

(b) The manufacturer of type **A** and type **B** washing powder claimed that these results showed that biological washing powders are better at removing stains from clothes.

Use the information in **Figure 1** to evaluate this claim.

(Extra space)

(4)

(c) Most customers want a washing powder which removes stains from clothes over a range of temperatures. After obtaining the results shown in **Figure 2**, which enzyme should the scientist recommend for use in a biological powder?

Give reasons for your answer.

(Extra space)

(3)

(d) Biological washing powders often contain a number of different enzymes. This enables them to remove a wider range of stains from clothes.
Explain why a number of enzymes are required to remove a wider range of stains.

(Extra space)

(3)

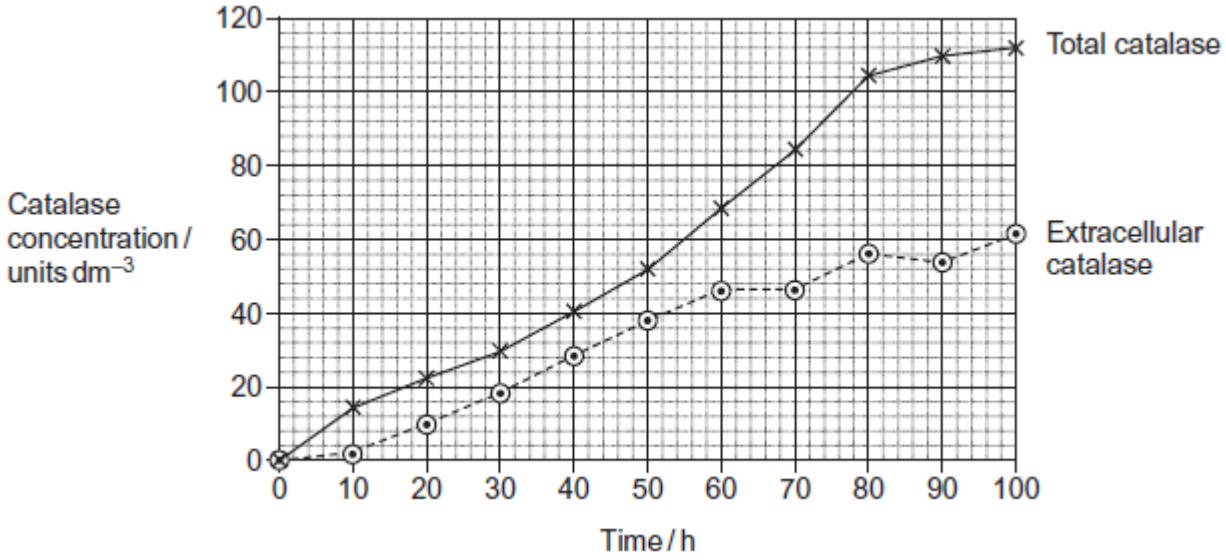
(Total 12 marks)

18 Some of the catalase produced by *Aspergillus niger* is intracellular and some is extracellular. Intracellular enzymes stay inside the cells that produce them. Extracellular enzymes are secreted from the cells that produce them.

Another group of scientists grew a different strain of *A. niger*.

- *A. niger* grows from tiny structures called spores. The scientists kept the spores in an isotonic medium at a low temperature until they needed them.
- They put spores of *A. niger* into a 500 cm^3 flask containing a sterile medium. The medium contained starch.
- They measured the total amount of catalase and the amount of extracellular catalase produced by the fungus over a period of 100 hours.

The graph shows their results.



(a) (i) The scientists kept the spores in an isotonic medium until they were needed. Suggest why it was important that the medium was isotonic.

(2)

(ii) The scientists kept the spores at a low temperature until they were needed. Suggest why.

(1)

(b) Starch is a source of carbon, hydrogen and oxygen for the fungus. Name one other chemical element that must be in the culture medium before *A. niger* can synthesise catalase. Give the reason for your answer.

Chemical element _____

Reason _____

_____

_____

_____

(2)

(c) To get reliable results in this investigation, the medium must be sterile.
Explain why.

_____

_____

_____

_____

_____

(2)

(d) (i) At what time was the concentration of intracellular catalase highest?

_____

(1)

(ii) Between what times was the rate of total catalase production highest?

_____

(1)

(e) Technologists prefer to manufacture extracellular enzymes rather than intracellular enzymes. This is because intracellular enzymes are more expensive to purify than extracellular enzymes. Suggest why intracellular enzymes are more expensive to purify.

_____

_____

_____

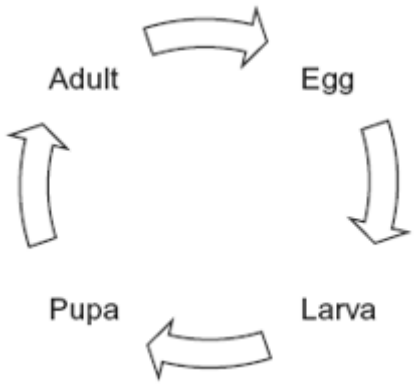
_____

_____

(2)

(Total 11 marks)

19 The diagram shows the life cycle of a fly.



When the larva is fully grown, it changes into a pupa. The pupa does not feed. In the pupa, the tissues that made up the body of the larva are broken down. New adult tissues are formed from substances obtained from these broken-down tissues and from substances that were stored in the body of the larva.

(a) Hydrolysis and condensation are important in the formation of new adult proteins. Explain how.

_____

_____

_____

_____

(2)

(b) Most of the protein stored in the body of a fly larva is a protein called calliphorin. Explain why different adult proteins can be made using calliphorin.

_____

_____

(1)

The table shows the mean concentration of RNA in fly pupae at different ages.

Age of pupa as percentage of total time spent as a pupa	Mean concentration of RNA / µg per pupa
0	20
20	15
40	12
60	17
80	33
100	20

(c) Describe how the concentration of RNA changes during the time spent as a pupa.

(2)

(d) (i) Describe how you would expect the number of lysosomes in a pupa to change with the age of the pupa. Give a reason for your answer.

(2)

(ii) Suggest an explanation for the change in RNA concentration in the first 40% of the time spent as a pupa.

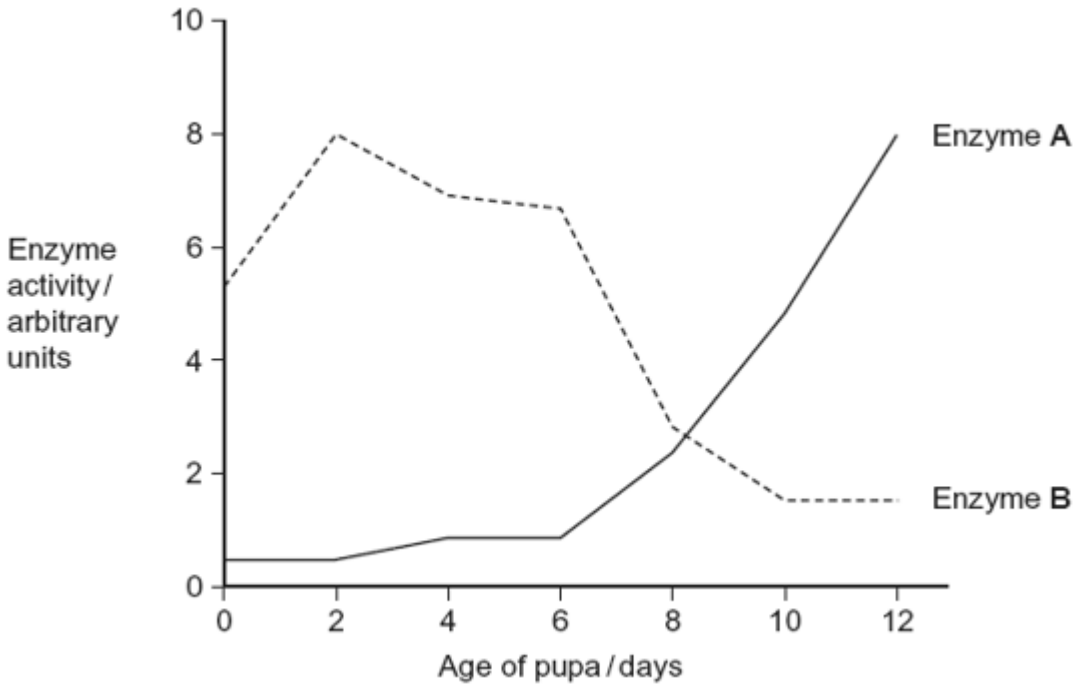
(2)

(e) Suggest an explanation for the change in RNA concentration between 60 and 80% of the time spent as a pupa.

(2)

(f) The graph shows changes in the activity of two respiratory enzymes in a fly pupa.

- Enzyme **A** catalyses a reaction in the Krebs cycle
- Enzyme **B** catalyses the formation of lactate from pyruvate



During the first 6 days as a pupa, the tracheae break down. New tracheae are formed after 6 days. Use this information to explain the change in activity of the two enzymes.

(Extra space)

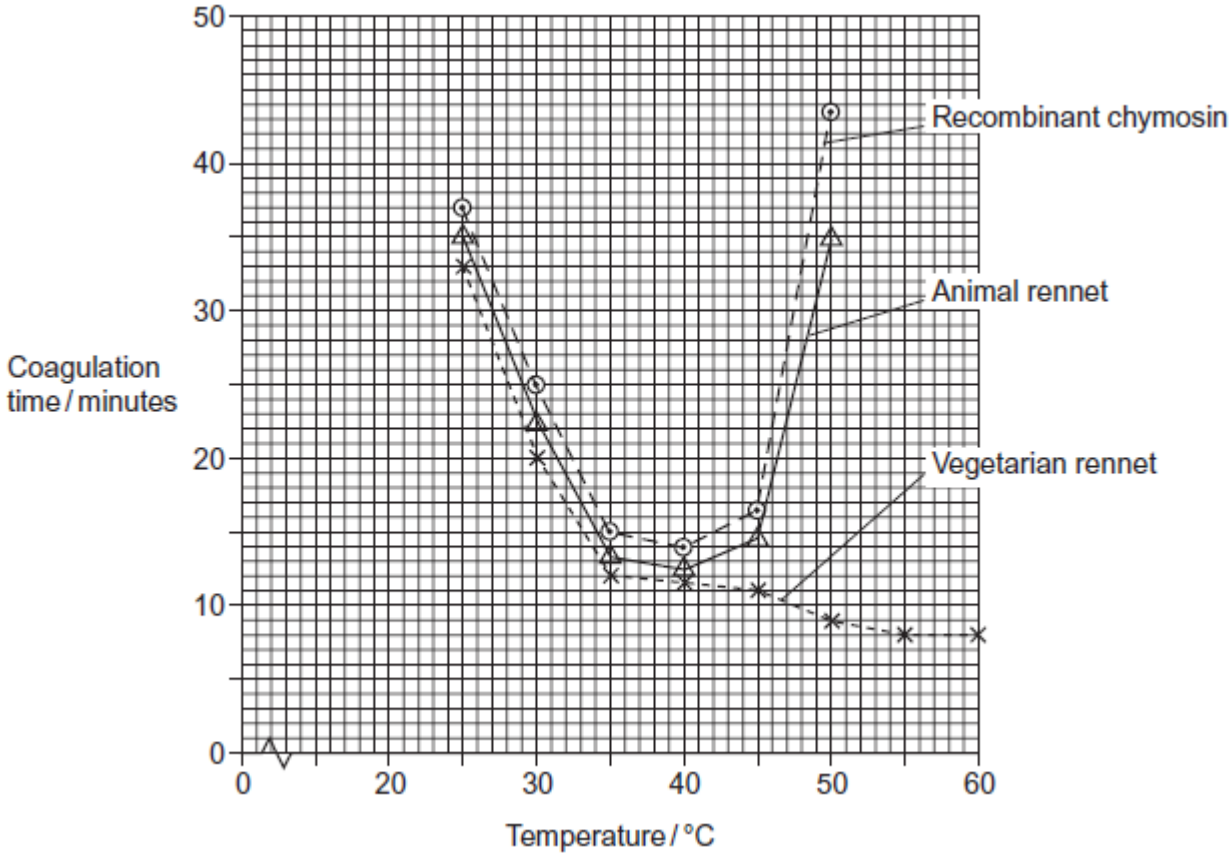
(4)

(Total 15 marks)

20 Different extracts may be added to milk to make cheese. All of these extracts contain chymosin.

- Animal rennet comes from calves and lambs. Rennet from these young animals contains between 80 and 95% chymosin. It also contains between 5 and 20% of another protein-digesting enzyme called pepsin.
- Vegetarian rennet comes from fungi. It contains 100% chymosin.
- Recombinant chymosin comes from bacteria which have had an animal gene for chymosin inserted in them. It contains 100% chymosin.

Scientists investigated the effect of temperature on the time these different extracts took to coagulate milk. Their results are shown below.



(a) Suggest **two** disadvantages of using animal rennet rather than recombinant chymosin as a source of chymosin for making cheese.

1. _____

_____

2. _____

_____

(2)

(b) The shape of the curve for recombinant chymosin is similar to the shape of the curve for animal rennet. Suggest why.

_____

_____

_____

(1)

(c) (i) Describe how the coagulation time for vegetarian rennet is different from that for animal rennet.

_____

_____

_____

(1)

(ii) Calculate the percentage reduction in coagulation time between 45 °C and 60 °C for vegetarian rennet. Show your working.

Answer _____%

(2)

(d) Explain the shape of the curve for animal rennet above 45 °C.

_____

_____

_____

_____

_____

_____

(Extra space)_____

_____

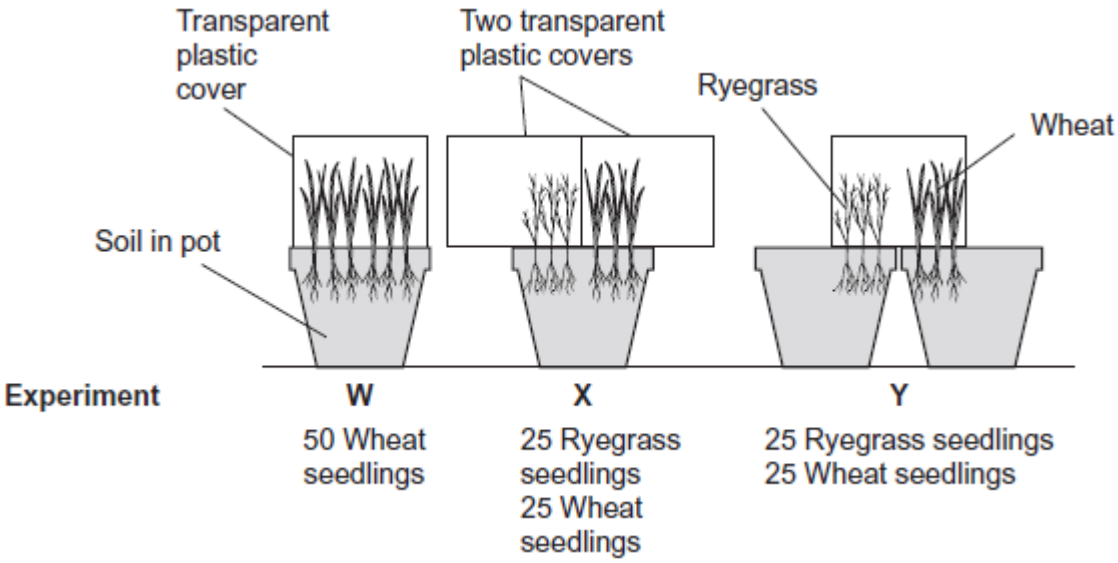
_____

(3)

(Total 9 marks)

21 Wheat is an important cereal crop. Ryegrass is a weed in wheat fields. Wheat and ryegrass belong to the grass family.

Scientists investigated competition between wheat and ryegrass seedlings. They set up three experiments **W, X**, and **Y** as shown in the diagram.



The table shows the mean dry mass of the wheat seedlings as a percentage of their dry mass when grown alone.

	Experiment		
	W	**X**	**Y**
Mean dry mass of wheat seedlings as a percentage of their dry mass when grown alone	100	76	46

(a) Experiment **W** was a control experiment. Explain the purpose of the control experiment in this investigation.

_____

_____

_____

_____

_____

(2)

(b) What can you conclude from this investigation about competition between wheat and ryegrass? Use the data in the table to support your answer.

(Extra space)

(4)

(c) Explain how a decrease in temperature could affect the outcome of this investigation.

(2)

(Total 8 marks)

22 In the early 1980s, before DNA analysis had been developed, scientists investigated the genetic variation of cheetahs living in captivity. They used skin grafts to do this. They carried out skin grafts on anaesthetised animals by

- removing a small piece of skin from one animal. This animal was the recipient.
- replacing the removed skin by a piece of skin taken from another animal. This animal was the donor.
- attaching the new piece of skin with stitches.

A graft may be accepted by the recipient. It will be rejected if the recipient's immune system recognises the antigens on the skin as foreign.

Scientists carried out skin grafts between cheetahs living in captivity and domestic cats. The table shows the data that they obtained.

Recipient of skin graft	Donor of skin graft	Relationship	Time taken for the graft to be rejected / days
Domestic cat 1	Domestic cat 2	Unrelated	13
Cheetah 1	Domestic cat 3	Unrelated	12
Cheetah 1	Cheetah 2	Sisters	No rejection after 52 days
Cheetah 3	Cheetah 4	Unrelated	49
Cheetah 5	Cheetah 6	Unrelated	No rejection after 78 days
Cheetah 7	Cheetah 8	Unrelated	No rejection after 41 days
Cheetah 9	Cheetah 10	Unrelated	No rejection after 24 days
Cheetah 11	Cheetah 12	Unrelated	No rejection after 14 days
Cheetah 13	Cheetah 14	Unrelated	No rejection after 44 days

The scientists also grafted skin from one area to another on the same animal. These grafts were not rejected.

(a) (i) The scientists grafted skin from a domestic cat to a cheetah. Suggest why.

_____

_____

(1)

(ii) They also grafted skin from one area to another on the same animal. Explain why.

_____

_____

(1)

(b) (i) Give **three** conclusions that you can make from the data in the table above about the time taken for rejection.

1. _____

_____

2. _____

_____

3. _____

_____

(3)

(ii) Give **one** reason why these conclusions may **not** be reliable.

_____

_____

(1)

(iii) There are proteins on the skin of cheetahs that act as antigens. What do the data in the table suggest about these cheetah antigens?

_____

_____

(1)

(iv) Antigens are proteins. Explain why a knowledge of antigens can show that animals are genetically similar.

_____

_____

_____

_____

(2)

(Total 9 marks)

23 Lettuce growers investigated the best conditions for germinating lettuce seeds. They soaked lettuce seeds for 8 hours in distilled water at different temperatures. They then germinated some of the seeds at 20°C and some at 35°C. The table shows their results.

Temperature at which seeds were soaked / °C	Percentage of seeds which germinated	
	at 20°C	at 35°C
20	100	89
25	100	43
30	41	1
35	21	0

(a) Use the information above to describe and explain the effect of temperature on lettuce seed germination.

(Extra space)

(3)

(b) Explain why the lettuce growers measured germination as a percentage.

(1)

(Total 4 marks)

24 Doctors compared two tests for lactase deficiency.

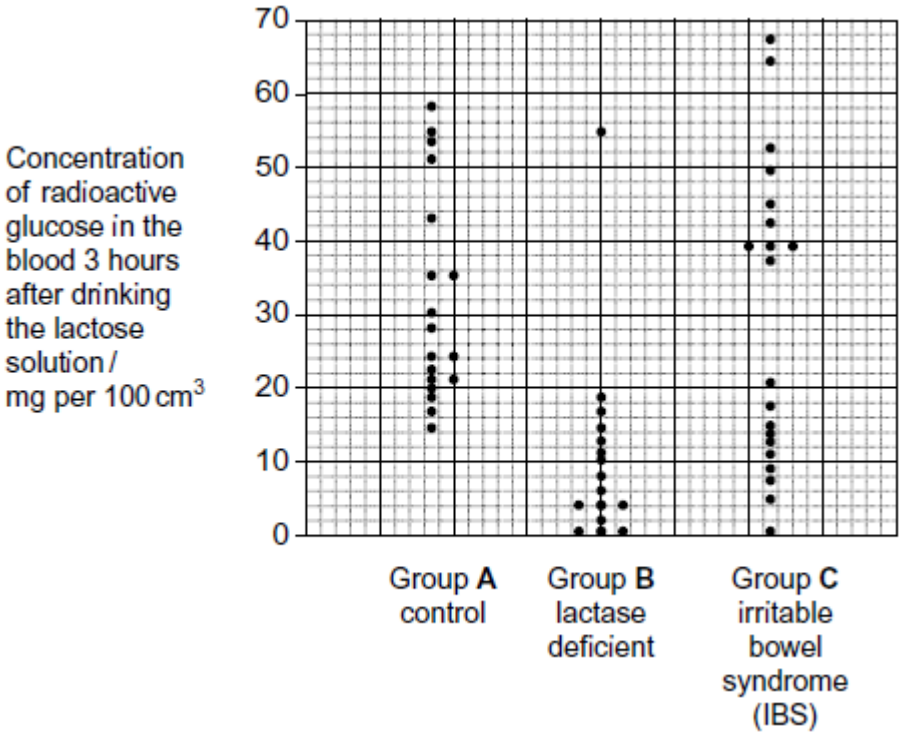
Doctors investigated three groups of people. The people in all three groups were not allowed to eat or drink for 8 hours before the test. They each then drank a solution containing 50 g of lactose made with a radioactive form of carbon called ^{14}C.

- Group **A** were the control group
- Group **B** were lactase deficient
- Group **C** had irritable bowel syndrome (IBS)

Both lactase deficieny and irritable bowel syndrome have similar symptoms.

The lactose tolerance test

The doctors measured the concentration of radioactive glucose in the blood of each person. The figure below shows the results. Each point shows the result for one person 3 hours after drinking the lactose solution.



(a) (i) Give the range of results for the control group (group **A**)

_____

(1)

(ii) Each person in the control group was given 50 g of lactose containing the same amount of radioactive carbon. All the products of lactose digestion were absorbed into their blood. The concentration of glucose was measured in mg per 100 cm^3 of blood.

Explain why the variation in the results may be due to differences in body mass.

(2)

(b) In the test the doctors obtained different results for the three groups.

Would this test be useful to identify people who were lactase deficient? Use the data from all three groups to explain your answer.

(Extra space)

(3)

(Total 6 marks)

25 Doctors compared two tests for lactase deficiency.

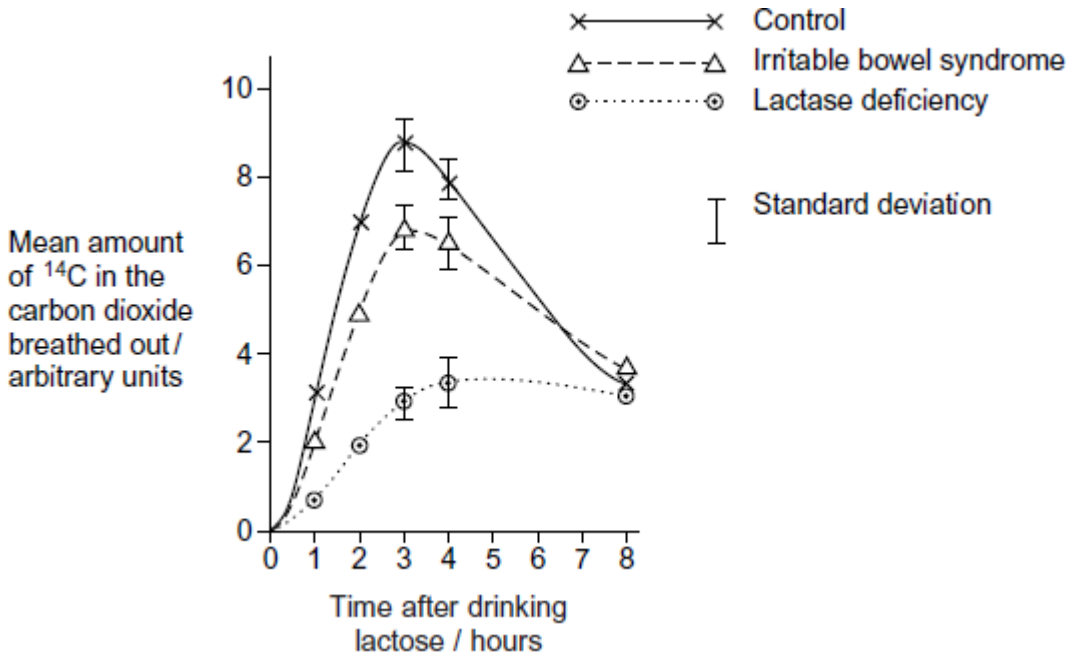
Doctors investigated three groups of people. The people in all three groups were not allowed to eat or drink for 8 hours before the test. They each then drank a solution containing 50 g of lactose made with a radioactive form of carbon called ^{14}C.

- Group **A** were the control group
- Group **B** were lactase deficient
- Group **C** had irritable bowel syndrome (IBS)

Both lactase deficieny and irritable bowel syndrome have similar symptoms.

The carbon dioxide breath test

In this test the doctors measured the amount of ^{14}C in the carbon dioxide breathed out. The doctors took measurements at intervals for 8 hours after each volunteer had drunk the lactose solution. The following figure shows the mean results for each group.



(a) Describe the common trend shown by **all** the curves in the figure.

(1)

(b) Explain why the doctors stopped measuring the amounts of ^{14}C in the carbon dioxide breathed out after 8 hours.

(2)

(c) Carbon dioxide in the breath contained the radioactive form of carbon, ^{14}C. Explain how ^{14}C in carbon dioxide came from ^{14}C in glucose in the blood.

(2)

(d) The doctors concluded that measuring the amount of ^{14}C in the carbon dioxide in the breath after 3 hours was a better way of diagnosing lactase deficiency than the lactose tolerance test. Do you agree with the doctors' conclusion? Give the reasons for your answer.

(2)

(Total 7 marks)

26 Biologists divided new-born rats randomly into four groups.

They fed the rats in each group on a standard diet which only differed in the carbohydrate content. When these rats were adult, the biologists measured the activity of lactase in the digestive system of the rats. The following table shows the mean results for each group.

Diet	Mean lactase activity / μ mol of lactose digested per hour (± standard deviation)
Low sucrose	57.9 (± 14.5)
High sucrose	184.2 (± 30.8)
Low starch	86.9 (± 13.3)
High starch	221.4 (± 25.4)

(a) Give **one** piece of evidence from the table that indicates lactase activity is affected by diet.

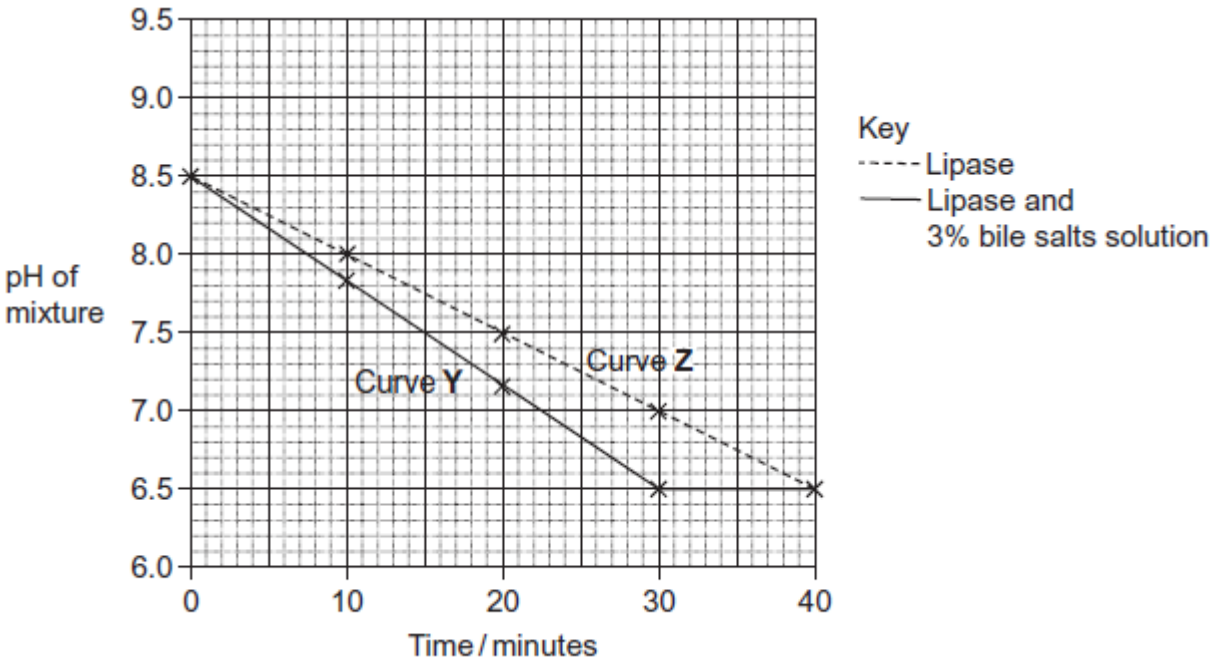
(1)

(b) Some students suggested from these data that increasing starch in the diet was the most effective way to increase lactase activity in lactase deficient people. Is this conclusion valid? Explain your answer.

(2)

(Total 3 marks)

27 Scientists investigated the effect of lipase and a 3% bile salts solution on the digestion of triglycerides. The graph below shows their results.



The scientists also incubated triglycerides with different concentrations of bile salts. After 30 minutes they measured the diameter of the triglyceride droplets. They used the results to calculate the mean radius of the droplets at each concentration. The table below shows their results.

Concentration of bile salts /%	0	1	2	3	4	5
Mean radius of triglyceride droplet / μm	6	5	4	3	2	1

(a) Describe how you would use a microscope to find the mean diameter of triglyceride droplets on a slide.

(Extra space)

(3)

(b) (i) The ratio of mean radius of triglyceride droplets in bile salts at a concentration of 0% to the mean radius in bile salts at a concentration of 3% is 2 : 1.

What is the ratio of their surface areas? Show your working.

You can calculate the surface area of a droplet from the formula

$$A = 4\pi r^2$$

Where A = surface area
r = radius
π = 3.14

(2)

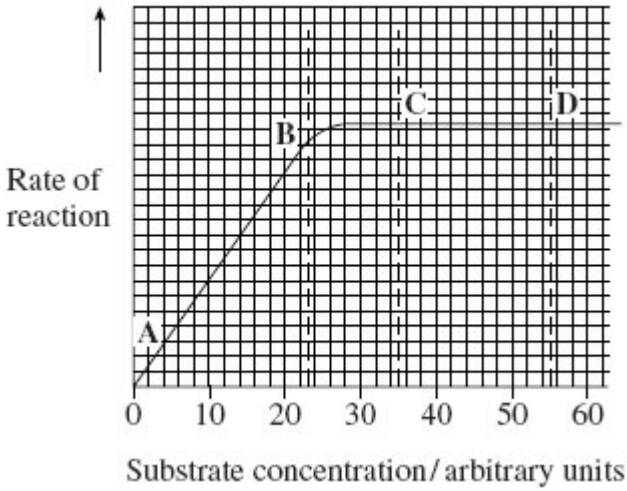
(ii) Use the data in the table to explain the difference between curves **Y** and **Z** in the graph.

(Extra space)

(3)

(Total 8 marks)

28 The graph shows the effect of substrate concentration on the rate of an enzyme-controlled reaction.



(a) (i) Describe what the graph shows about the effect of substrate concentration on the rate of this enzyme-controlled reaction.

(2)

(ii) What limits the rate of this reaction between points **A** and **B**? Give the evidence from the graph for this.

(2)

(iii) Suggest a reason for the shape of the curve between points **C** and **D**.

(1)

(b) Sketch a curve on the graph to show the rate of this reaction in the presence of a competitive inhibitor.

(1)

(c) Methotrexate is a drug used in the treatment of cancer. It is a competitive inhibitor and affects the enzyme folate reductase.

(i) Explain how the drug lowers the rate of reaction controlled by folate reductase.

(2)

(ii) Methotrexate only affects the rate of the reaction controlled by folate reductase.

Explain why this drug does not affect other enzymes.

(1)

(Total 9 marks)

29 Mammals and fish remove nitrogenous waste from their bodies in different forms.

(a) Name **two** polymers present in mammals and fish that contain nitrogen.

1. _____

2. _____

(2)

(b) In a mammal urea is removed from the blood by the kidneys and concentrated in the filtrate.

(i) Describe how urea is removed from the blood.

_____

_____

_____

_____

(2)

(ii) Explain how urea is concentrated in the filtrate.

_____

_____

_____

_____

_____

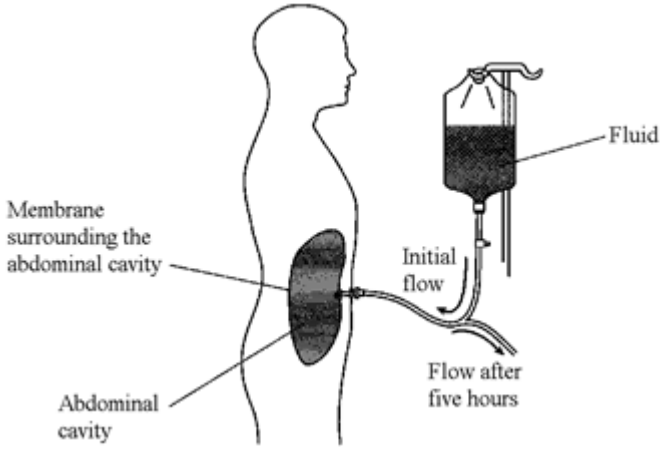
_____

_____

_____

(4)

(c) The diagram shows one way in which a person who has kidney disease can have the condition managed. In the process a fluid is put into the abdominal cavity. Exchange of materials takes place across the membrane that surrounds the abdominal cavity. This removes waste products from the blood. After five hours the fluid is drained out of the cavity and discarded. The cavity is then refilled with fresh fluid.



The table shows the concentration of solutes in the fresh fluid.

Solute	Concentration / mmol dm^{-3}
Sodium ions (Na^+)	132
Chloride ions (Cl^-)	96
Calcium ions (Ca^{2+})	1.25
Magnesium ions (Mg^{2+})	0.25
Glucose	76
Urea	0

(i) By what process does urea enter the fluid in the abdominal cavity from the blood?

_____

(1)

(ii) Explain why the fluid is changed every five hours.

_____

_____

(1)

(iii) Fluid of the composition shown in the table is used instead of distilled water. Explain why.

_____

_____

_____

_____

(2)

(Total 12 marks)

30 When coal is mined by open-cast mining, the top layer of soil is first scraped off and stored in a large heap. Once mining has finished, the area can be reclaimed. Soil from this store is then spread back over the surface.

Some of the bacteria living in the soil store respire aerobically and some respire anaerobically. **Table 1** shows the numbers of aerobic and anaerobic bacteria found at different depths in a soil store.

Depth / cm	**Mean number of bacteria per gram of soil (× 10^7)**			
	Aerobic bacteria		Anaerobic bacteria	
	after 1 month	after 6 months	after 1 month	after 6 months
0	12.0	12.1	0.6	0.8
50	10.4	8.6	0.8	1.3
100	10.1	6.1	0.7	4.1
150	10.0	3.2	0.7	7.9
200	11.6	0.8	0.7	8.4
250	11.9	0.7	0.8	8.8
300	11.0	0.8	0.6	9.1

Table 1

(a) Some of the soil used to determine bacterial numbers was collected from the surface of the soil store. Describe how you would ensure that this soil was collected at random.

_____

_____

_____

_____

(2)

(b) (i) Describe how the numbers of aerobic bacteria after 6 months change with depth.

_____

_____

_____

_____

(2)

(ii) Explain the difference in the numbers of aerobic bacteria at a depth of 300 cm between 1 and 6 months.

_____

_____

_____

_____

(2)

(c) Explain how the changes in bacterial numbers which take place at 150 cm illustrate the process of succession.

_____

_____

_____

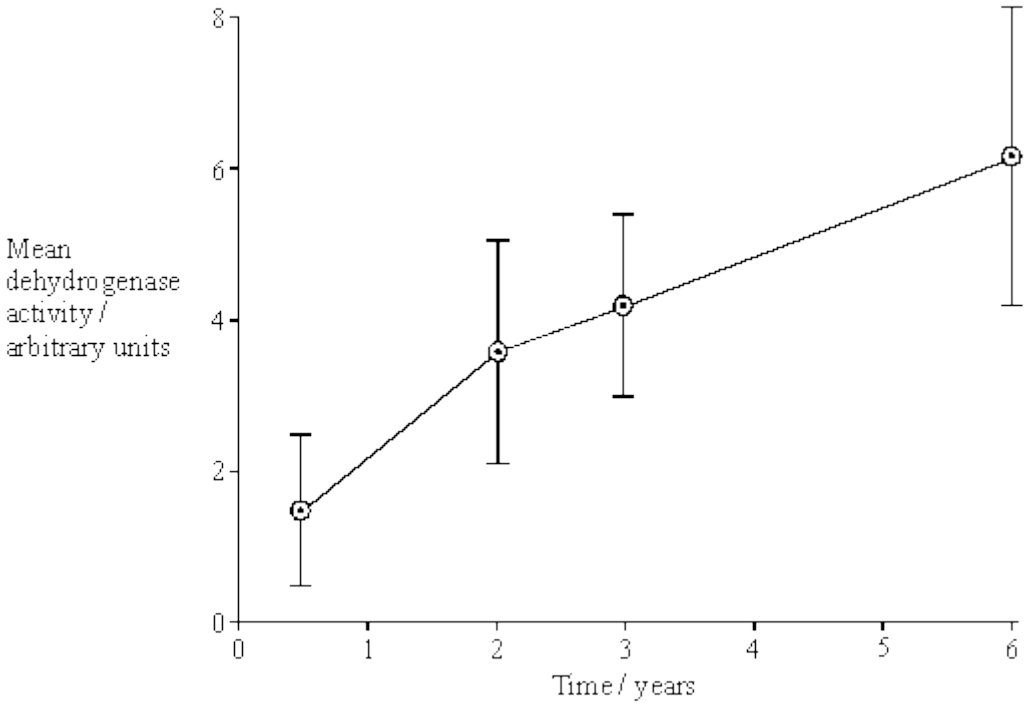
_____

_____

_____

(3)

Dehydrogenase is an enzyme involved in aerobic respiration. Dehydrogenase activity in a soil sample can be used as a measure of the activity of aerobic bacteria. The graph shows the mean dehydrogenase activity of soil samples taken from the same depth in a soil store at different times. The bars on the graph represent two standard errors above and below the mean.



(d) (i) From what depth in the soil store would you expect these soil samples to have been taken? Use information from **Table 1** to explain your answer.

(2)

(ii) How would you expect dehydrogenase activity to vary with depth after 6 months?

Use information from **Table 1** to explain your answer.

(3)

(e) What do the error bars tell you about the difference between the mean dehydrogenase activity at 6 months and 3 years? Explain your answer in terms of probability and chance.

(3)

(f) **Table 2** shows the dehydrogenase activity and the number of aerobic bacteria present in some soil samples.

Dehydrogenase activity / arbitrary units	Number of aerobic bacteria per gram of soil ($\times 10^7$)
13.1	12.0
9.2	8.7
5.5	6.5
3.0	4.6
2.2	2.7
0.4	0.6

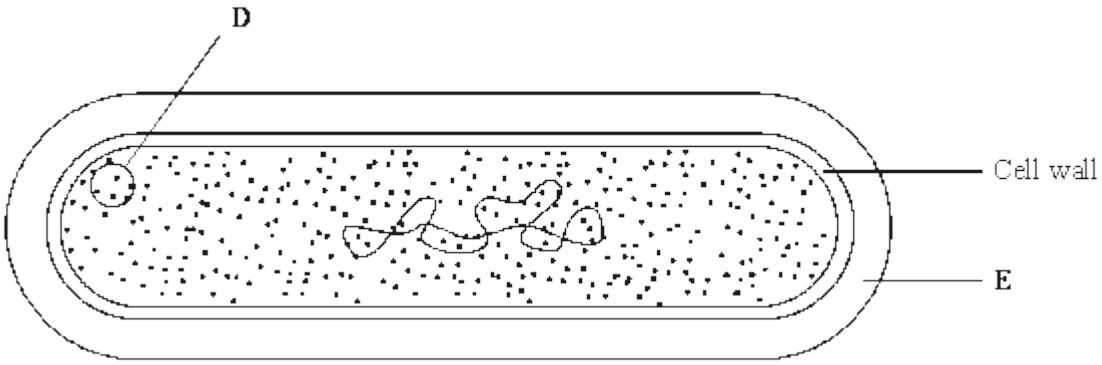
Table 2

A sample of soil was found to have dehydrogenase activity of 8.7 arbitrary units. Explain how you would use the data in **Table 2** to predict the likely number of aerobic bacteria in 1 g of this soil sample.

(3)

(Total 20 marks)

31 (a) The diagram shows a bacterial cell.



(i) Name the parts labelled **D** and **E.**

D _____

E _____

(2)

(ii) Give **one** function of the cell wall.

_____

_____

(1)

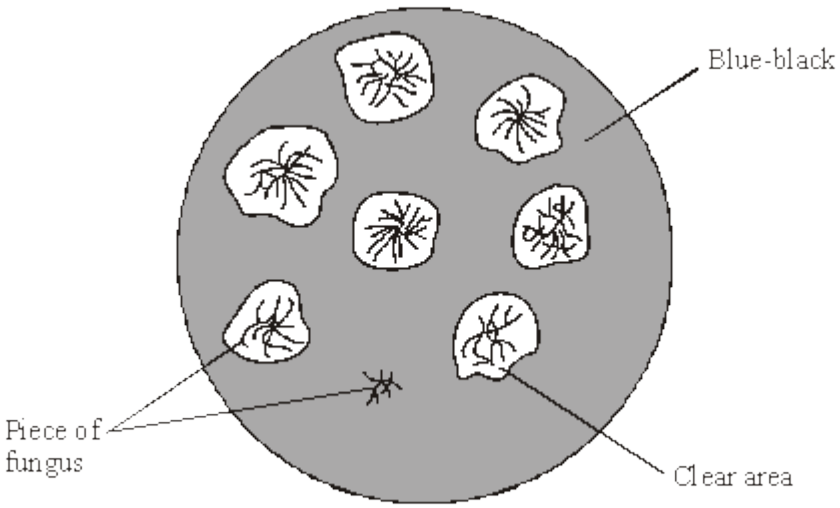
(b) Name **two** structures present in eukaryotic cells that are not present in the cells of prokaryotes.

1. _____

2. _____

(2)

(c) Several small pieces of a saprophytic fungus were placed on a starch agar plate. After 48 hours the iodine solution was poured over the starch agar. The result is shown in the diagram below.



(i) Explain why there is a clear area around most of the pieces of fungus.

_____

_____

_____

_____

(2)

(ii) Suggest why one piece of fungus has no clear area round it.

_____

_____

(1)

(Total 8 marks)

32 Read the following passage.

Alzheimer's disease leads to dementia. This involves small β-amyloid proteins binding together to form structures called plaques in the brain.

Nerve cells in the brain produce a large protein called amyloid-precursor protein that has a complex shape. This protein is the substrate of two different enzymes, α-secretase and β-secretase. These enzymes are normally produced in the brain. One product of the reaction catalysed by β-secretase is a smaller protein that can lead to β-amyloid protein formation. Many people with Alzheimer's disease have mutations that decrease α-secretase production, or increase β-secretase production.

One possible type of drug for treating Alzheimer's disease is a competitive inhibitor of β-secretase. When some of these types of drugs were trialled on patients, the trials had to be stopped because some patients developed serious side effects.

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

(a) Suggest how amyloid-precursor protein can be the substrate of two different enzymes, α-secretase and β-secretase (lines 3–5).

(2)

(b) One product of the reaction catalysed by β-secretase is a smaller protein (lines 6–7).

Describe what happens in the hydrolysis reaction that produces the smaller protein from amyloid-precursor protein.

(2)

(c) Many people with Alzheimer's disease have mutations that decrease α-secretase production, or increase β-secretase production (lines 8–9).

Use the information provided to explain how these mutations can lead to Alzheimer's disease.

(3)

(d) One possible type of drug for treating Alzheimer's disease is a competitive inhibitor of β-secretase (lines 10–11).

Explain how this type of drug could prevent Alzheimer's disease becoming worse.

(2)

(e) When some of these types of drugs were trialled on patients, the trials were stopped because some patients developed serious side effects (lines 11–13).

Using the information provided, suggest why some patients developed serious side effects.

(1)

(Total 10 marks)

33 Read the following passage.

Gluten is a protein found in wheat. When gluten is digested in the small intestine, the products include peptides. Peptides are short chains of amino acids. These peptides cannot be absorbed by facilitated diffusion and leave the gut in faeces

Some people have coeliac disease. The epithelial cells of people with coeliac disease do not absorb the products of digestion very well. In these people, some of the peptides from gluten can pass between the epithelial cells lining the small intestine and enter the intestine wall. Here, the peptides cause an immune response that leads to the destruction of microvilli on the epithelial cells.

Scientists have identified a drug which might help people with coeliac disease. It reduces the movement of peptides between epithelial cells. They have carried out trials of the drug with patients with coeliac disease.

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

(a) Name the type of chemical reaction which produces amino acids from proteins.

_____

(1)

(b) The peptides released when gluten is digested cannot be absorbed by facilitated diffusion (lines 2 – 3). Suggest why.

_____

_____

_____

_____

_____

_____

*(Extra space)*_____

_____

_____

(3)

*(Extra space)*_____

_____

_____

(3)

(c) Explain why the peptides cause an immune response (lines 7 – 8).

_____

_____

_____

(1)

(d) Scientists have carried out trials of a drug to treat coeliac disease (lines 10 – 11). Suggest **two** factors that should be considered before the drug can be used on patients with the disease.

1. _____

_____

2. _____

_____

(2)

(Total 7 marks)

34 Read the following passage.

Aspirin is a very useful drug. One of its uses is to reduce fever and inflammation. Aspirin does this by preventing cells from producing substances called prostaglandins. Prostaglandins are produced by an enzyme-controlled pathway. Aspirin works by inhibiting one of the enzymes in this pathway. Aspirin attaches permanently to a chemical group on one of the monomers that make up the active site of this enzyme.

The enzyme that is involved in the pathway leading to the production of prostaglandins is also involved in the pathway leading to the production of thromboxane. This is a substance that promotes blood clotting. A small daily dose of aspirin may reduce the risk of myocardial infarction (heart attack).

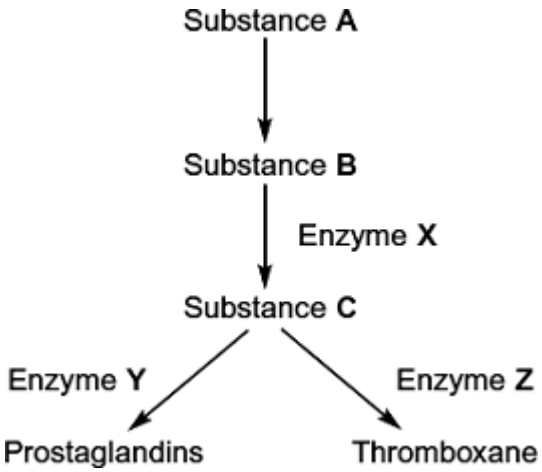
Use information from the passage and your own knowledge to answer the following questions.

(a) Name the monomers that make up the active site of the enzyme (lines 6 – 7).

_____

(1)

(b) The diagram shows the pathways by which prostaglandins and thromboxane are formed.



(i) Aspirin only affects one of the enzymes in this pathway. Use information in lines 5 - 7 to explain why aspirin does **not** affect the other enzymes.

_____

_____

_____

_____

_____

(2)

(ii) Which enzyme, **X**, **Y** or **Z**, is inhibited by aspirin? Explain the evidence from the passage that supports your answer.

Enzyme _____

Explanation _____

_____

_____

(2)

(c) Aspirin is an enzyme inhibitor. Explain how aspirin prevents substrate molecules being converted to product molecules.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)