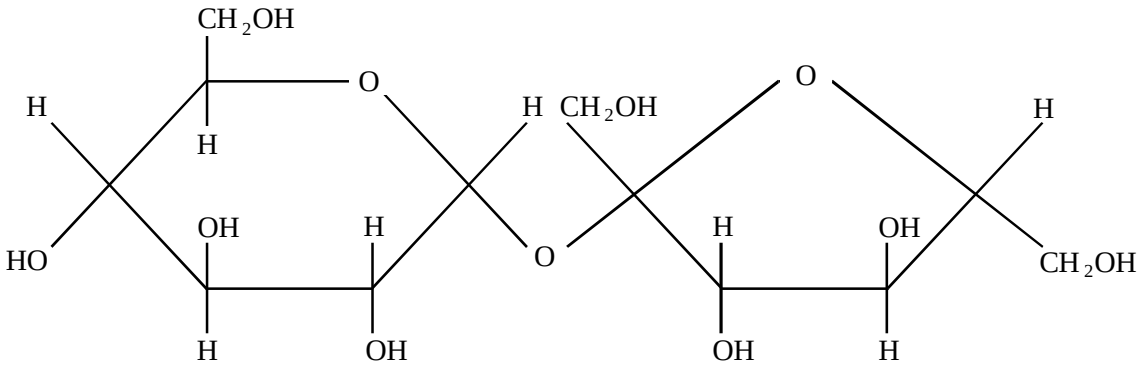
1. Sucrose is a disaccharide. The diagram shows the structure of a molecule of sucrose.



(a) (i) Use the diagram to explain why sucrose is classified as a carbohydrate.

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(1)

(ii) Explain why sucrose will produce a positive result with Benedict's test only after it has been boiled with a dilute acid.

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(2)

(b) Sucrose is sweet-tasting. The receptor molecules in the taste buds on the tongue are proteins. They detect sweet tasting substances only if they have dissolved in the saliva.

(i) Explain how proteins are suited for their roles as receptor molecules.

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(3)

(ii) Explain why glucose and maltose both taste sweet but starch does not.

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(1)

(iii) Saccharin, cyclamates and sucrose are chemically different but they all taste sweet. Suggest why.

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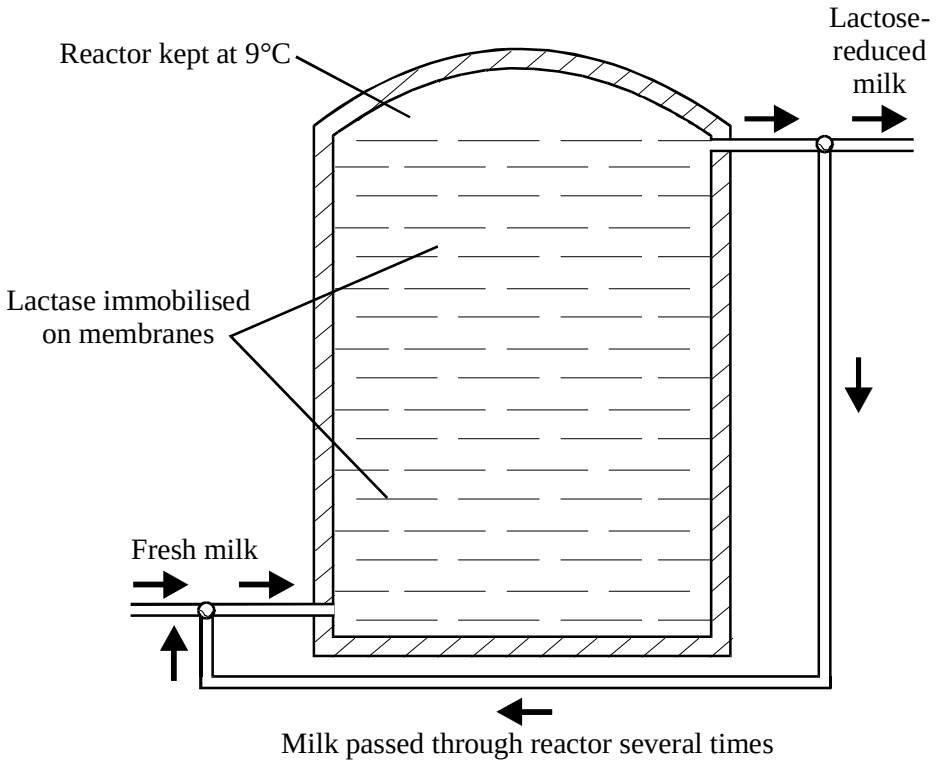
(2)

Lactose is a disaccharide found in milk. Many adults are unable to digest lactose and suffer intestinal problems if they drink milk. Milk can be treated with the enzyme lactase and this reduces the amount of lactose present. The diagram shows an industrial reactor used to produce lactose-reduced milk.



(c) (i) Suggest **one** advantage of immobilising the lactase used in this reaction.

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(1)

(ii) In terms of your knowledge of the way in which enzymes work, explain why it is necessary to pass the milk through the reactor several times to reduce the amount of lactose sufficiently.

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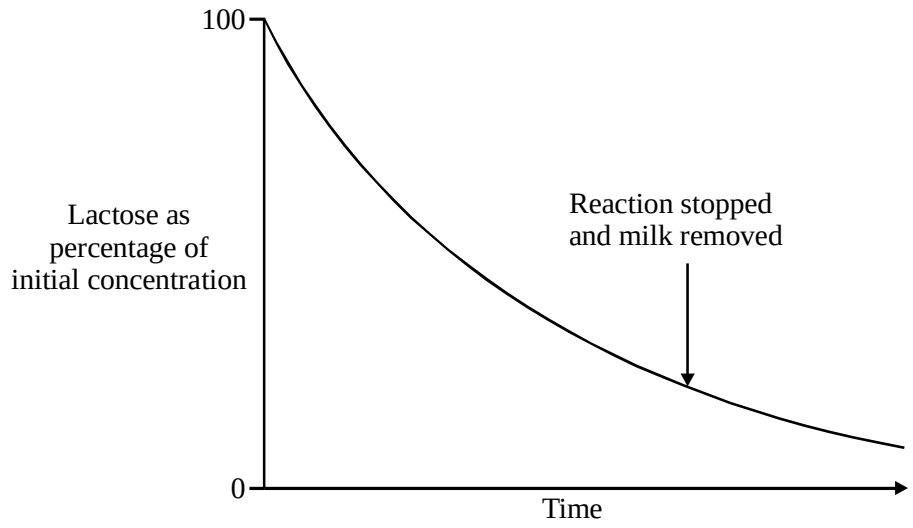
(3)

(d) The graph shows the change in lactose concentration during the course of the reaction.



(i) Explain the change in the rate of reaction with time.

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(2)

(ii) Suggest why the reaction is stopped at the time shown on the graph.

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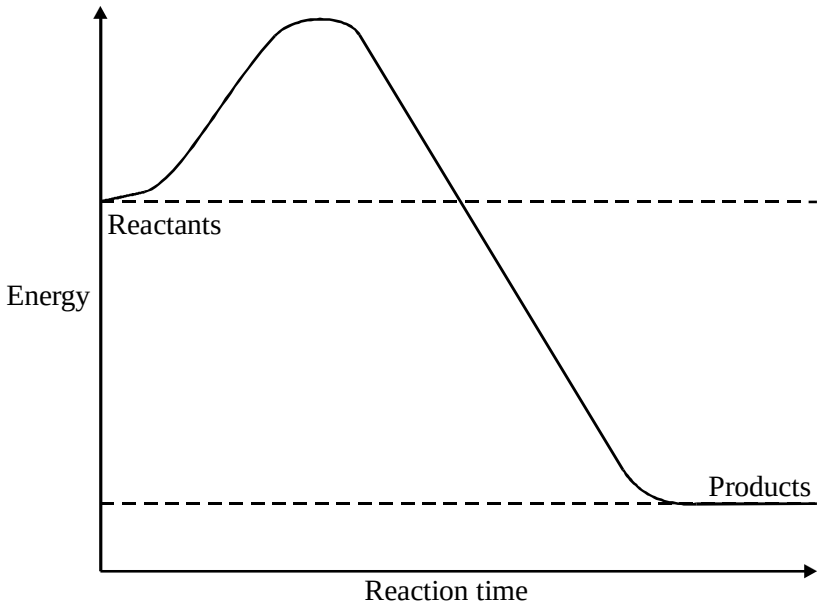
(1)
(Total 16 marks)

2. (a) The graph shows the energy changes which take place during a chemical reaction.



(i) Use the graph to explain what is meant by the term *activation energy.*

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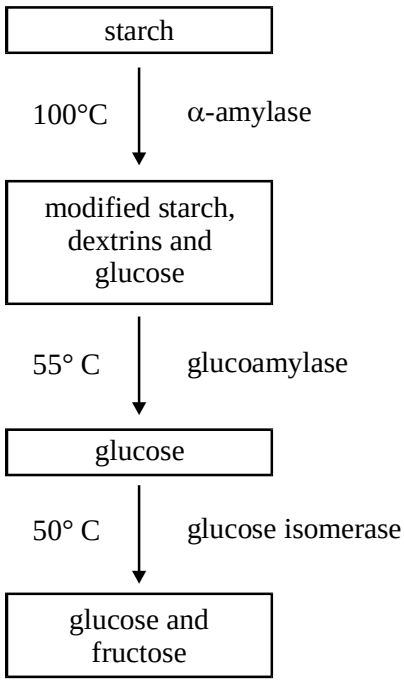
(1)

(ii) Draw a curve on the graph to show the energy changes which would take place if the same chemical reaction were catalysed by an enzyme.

(2)

The flow chart shows the way in which fructose is produced from starch in the food industry.



(b) Describe a biochemical test which could be used to show that reducing sugars were produced in the first stage of this process.

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(2)

(c) Acid could have been used in place of the α-amylase in the first stage of this process. Suggest why:

(i) acid could have been used;

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(1)

(ii) acid was **not** used.

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(1)

(d) In the laboratory, the optimal conditions for bacterial α-amylase are a pH of *7* and a temperature of 80°C.

In terms of your knowledge of the way in which enzymes work, explain why the rate of reaction would change if:

(i) the temperature fell by 10°C;

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(2)

(ii) the pH changed substantially.

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(3)

(Total 12 marks)

3. The *turnover number* of an enzyme is defined as the number of substrate molecules converted to

product by one molecule of enzyme in one minute. In an experiment carried out at 20°C, the turnover number for an enzyme was found to be 2500 at the start of the experiment but dropped to 1000 after 5 minutes.

(a) (i) Suggest why the turnover number decreased after 5 minutes.

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(2)

(ii) How would you expect the turnover number to differ from 2500 at the start of an identical experiment but carried out at 30°C? Explain your answer.

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(2)

(b) Explain why it would be important to have a control in the experiment at 20°C and at 30°C.

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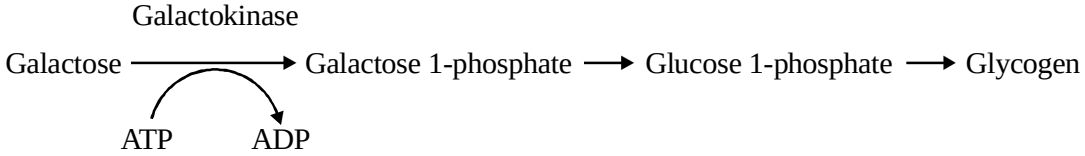
(1)
(Total 5 marks)

4. (a) Galactose is a monosaccharide. The diagram shows the biochemical pathway by which cells convert galactose to glycogen. The enzyme galactokinase catalyses the reaction in which galactose is converted to galactose 1-phosphate.



(i) Why is galactokinase classified as a *transferase*?

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(1)

(ii) Galactokinase is specific to the reaction shown. What features of the enzyme and substrate would contribute to this specificity?

Feature of enzyme

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.....

Feature of substrate

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(2)

(b) Some people who have a deficiency of galactokinase suffer from cataracts. These cataracts result from an increase in the amount of water in the lens of the eye. In the absence of galactokinase, galactose is converted to galacticol. Galacticol is a soluble substance whose molecules are too large to pass through cell membranes. Explain why galacticol causes an increase in the amount of water in the lens of the eye.

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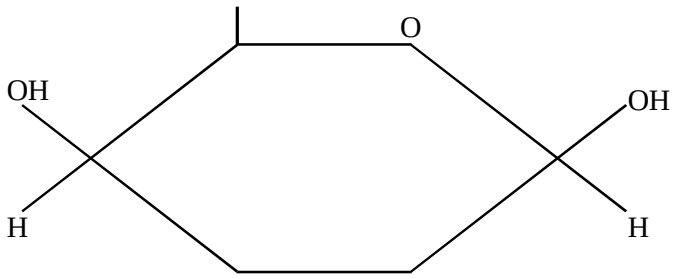
(2)

(c) The diagram shows the structure of a galactose molecule.



(i) Lactose is formed when glucose and galactose are joined by a glycosidic bond. Describe **one** similarity between the formation of the glycosidic bond and the formation of a peptide bond between two amino acids.

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(1)

(ii) Deduce the chemical formula for lactose.

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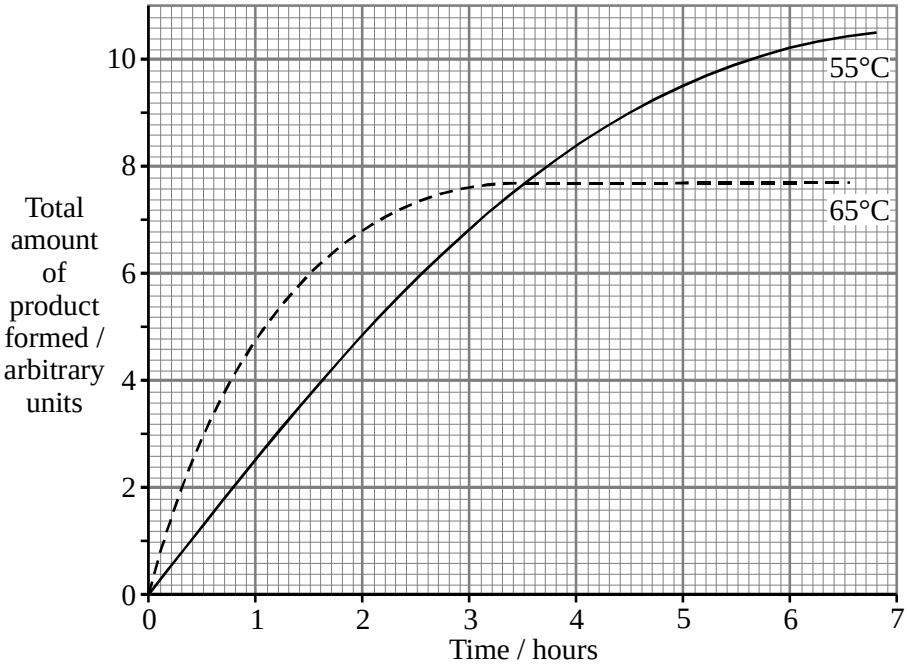
(1)

(d) Galactose is a component of some glycoproteins. These are proteins with carbohydrate units attached and form parts of cell membranes. The carbohydrate units are always found on the outside of the cell surface membrane.

Draw a labelled diagram of the cell surface membrane to show the phospholipids and a transmembrane (intrinsic) glycoprotein molecule.

(3)
(Total 10 marks)

5. The total amount of product formed in an enzyme-controlled reaction was investigated at two different temperatures, 55 °C and 65 °C. The results are shown in the graph.



(a) (i) Explain how you would calculate the rate of the reaction at 55 °C over the first 2 hours of the investigation.

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(1)

(ii) Explain why the initial rate of this reaction was faster at 65 °C than it was at 55 °C.

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(3)

(b) Use your knowledge of enzymes to explain the difference in the two curves between 4 and 6 hours.

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(1)

(c) In this investigation, the enzyme and its substrate were mixed in a buffer solution. What was the purpose of the buffer solution?

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(1)
(Total 6 marks)

6. Meat is the muscle tissue of an animal. When animals are slaughtered, biochemical changes occur in the muscle which result in the meat becoming tough. There are several ways of making the meat tender again. These involve partly breaking down the proteins which make up muscle tissue.

(a) One way is to add a protein-digesting enzyme called papain just before freezing the meat. As the meat is thawed and cooked, this enzyme digests the protein. Use your knowledge of enzymes to explain why:

(i) the rate at which the protein is digested increases as the meat warms up in the early stages of cooking;

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(3)

(ii) protein digestion stops once the meat has been heated to 90 °C.

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(3)

(b) Another way is to leave the meat for 10 days before freezing. Explain how lysosomes in muscle cells make the meat tender before it is frozen.

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(2)
(Total 8 marks)

7. Read the following passage.

Many different processes essential to life depend on proteins. These include enzyme controlled reactions, transport across plasma membranes and the binding of hormones to receptor molecules on their target cells. Every protein molecule has a tertiary structure which gives it a precise three-dimensional shape. The function of the protein depends on this shape, and the shape depends on the pH of the surrounding solution.

Changes in pH affect different proteins in different ways. This is because the amino acid molecules from which they are built have different structures. Some of these amino acids have different charges at different pH values. Unless they have the correct charges, the protein molecule will not have its correct three-dimensional shape.

If hydrogen or hydroxyl ions are added to a solution, its pH will normally change. A buffer solution is one which maintains a constant pH when hydrogen or hydroxyl ions are added to it. Buffers also occur naturally and play an important role in keeping conditions inside living organisms constant.

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

(a) The receptor molecules to which hormones bind are proteins. Glucagon is a hormone.

(i) Use the information in the first paragraph to explain why glucagon will only bind to one particular type of receptor molecule.

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(2)

(ii) Suggest why glucagon is able to bind to liver cells but not to cells in other parts of the body.

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(1)

(b) Explain how the amino acids from which proteins are built (lines 6–7) differ in structure from each other.

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(1)

(c) Amylase is an enzyme, found in saliva, which breaks down starch. It works best at a pH of 8. Explain why amylase does not function in the stomach where the pH is approximately 3.

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(3)

(d) When a suspension of mitochondria is prepared from liver, the tissue is ground in a buffer solution, then centrifuged. Explain why a buffer solution is used.

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(2)

(e) Describe how proteins are arranged in a plasma membrane and the part they play in transporting substances into and out of cells.

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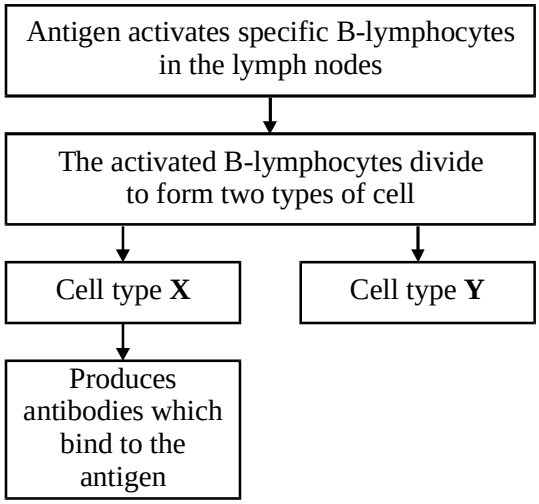
(6)
(Total 15 marks)

8. The flow chart shows some of the stages involved in the immunological response to an antigen.



(a) What is an antigen?

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(1)

(b) Name

(i) Cell type **X** .....

(ii) Cell type **Y** .....

(2)

(c) Explain the importance of cell type **Y** in immunity.

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(2)

(d) Influenza and measles are diseases caused by viruses. The viruses have antigens on their surface. Use your knowledge of antigens and antibodies to suggest why a person may have influenza several times, but usually has measles only once.

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(3)
(Total 8 marks)

9. (a) A protein is formed from 300 amino acids. The diagrams show the primary, secondary and tertiary structures of this protein.

Primary structure. Length = 300 nm

Secondary structure. Length = 45 nm

Tertiary structure. Length = 8.6 nm

(i) Explain what causes the secondary structure to differ in length from the primary structure.

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(1)

(ii) Explain what is meant by the tertiary structure of a protein.

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(1)

(iii) Heating may affect the tertiary structure of a protein. Explain how.

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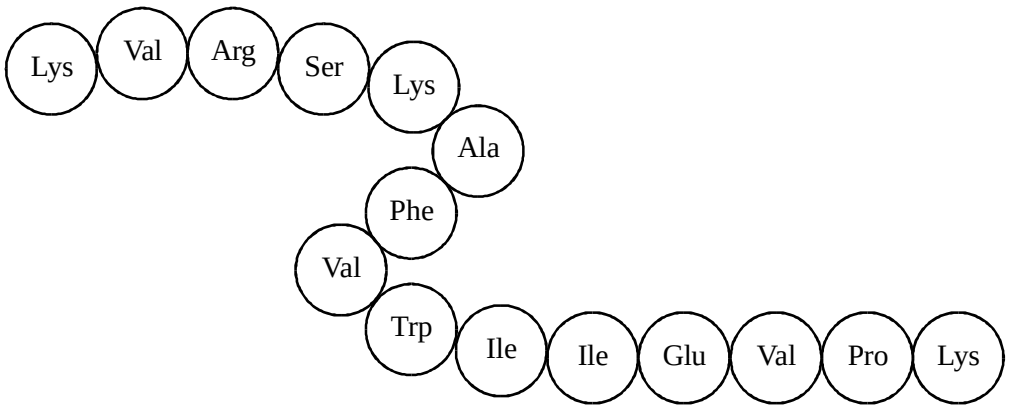
(2)

(b) The first step in investigating the primary structure of a protein is to break it into shorter lengths with enzymes. The table shows some of the enzymes used and the position of the peptide bonds they break.

Enzyme	**Position of peptide bond that enzyme breaks**	
	First amino acid	**Second amino acid**
Trypsin	Lys or Arg	any
Chymotrypsin	Phe, Trp or Tyr	any
V8 protease	Glu	any

The diagram shows a polypeptide chain. The sequence of amino acids should be read from left to right.



(i) How many amino acid fragments will be produced from this polypeptide if it is incubated with a mixture of trypsin and V8 protease?

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(1)

(ii) Explain why trypsin and chymotrypsin break peptide bonds between different amino acids.

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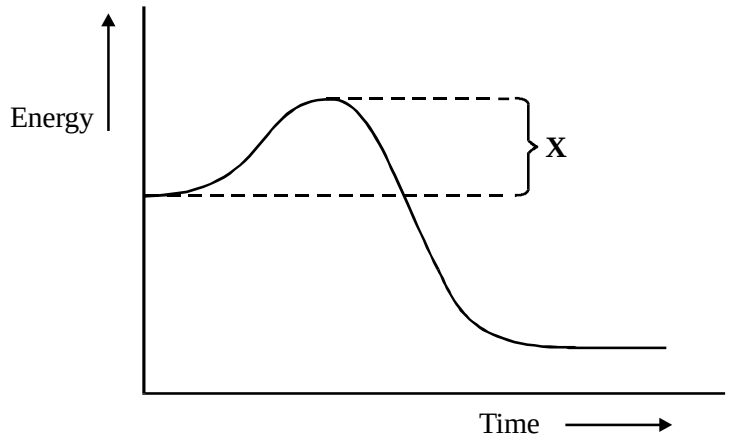
(3)
(Total 8 marks)

10.(a) When heated, hydrogen peroxide breaks down to water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The graph shows the energy changes which take place during this reaction.



(i) What is represented by the part of the curve labelled **X**?

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(1)

(ii) This reaction also takes place in many living cells. Here it is catalysed by the enzyme catalase. Sketch a curve on the graph to show the energy changes which take place when the enzyme is present.

(2)

(iii) When the reaction with catalase is carried out in a test-tube, the test-tube feels warm at the end of the reaction. Use the graph to explain why.

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(2)

(b) The turnover number of an enzyme is the number of substrate molecules converted to product per second. The maximum turnover number of catalase is 200 000 molecules per second. Explain why the turnover number falls as the temperature gets lower.

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(2)
(Total 7 marks)

11. Lactose is a sugar which is found in milk. It can spoil milk products such as ice cream by producing an unpleasant sandy texture. Lactase is an enzyme which is used in making ice cream. It breaks down lactose to glucose and galactose. When ice cream is made, lactase is added to milk and left for about a day at 5 °C. The reaction is very slow.

(a) Use your knowledge of enzymes to explain why the rate of this reaction is very slow at 5 °C.

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(3)

(b) Adult cats are unable to digest lactose. Lactase is used to reduce the amount of lactose in milk for cats. The milk is heated to sterilise it. It is then cooled and the lactase added before packaging. Explain why lactase is added after cooling the milk rather than before heating it.

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(2)
(Total 5 marks)

12. (a) An enzyme was dissolved in water. A biuret test was carried out on the solution. Describe and explain the result you would expect.

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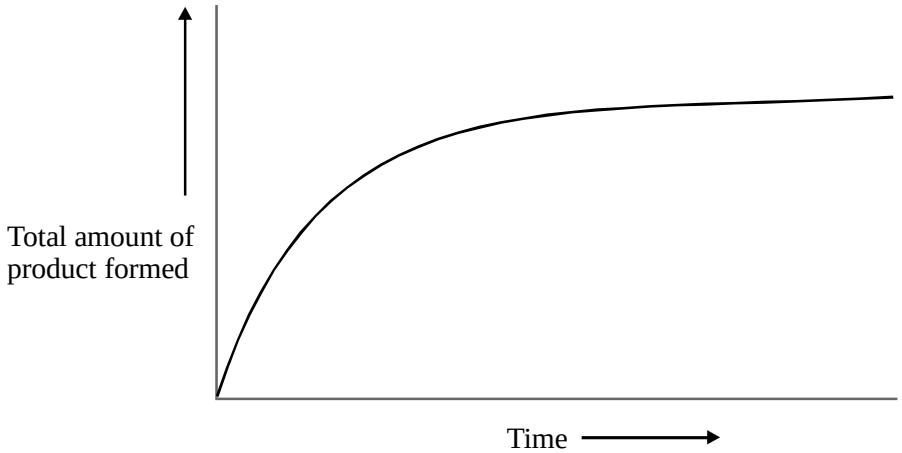
(2)

(b) The graph shows the total amount of product formed during an enzyme-controlled reaction.



(i) Describe and explain what happened to the total amount of substrate present as the reaction progressed.

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(1)

(ii) Use your knowledge of how an enzyme works to explain why the rate of reaction decreased with time.

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(2)

(iii) This reaction was carried out at a temperature of 30°C. Sketch a curve on the graph to show the total amount of product formed at 20°C.

(2)

(c) Catalase is an enzyme which breaks down hydrogen peroxide to produce water and oxygen. The effect of substrate concentration on the rate of this reaction was investigated. Explain why the initial rate of reaction was measured at each substrate concentration.

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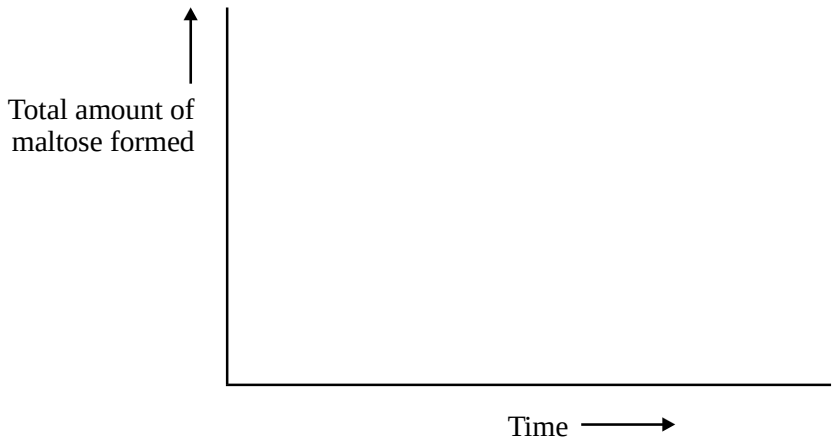
(2)
(Total 9 marks)

13. (a) Amylase is an enzyme which hydrolyses starch to maltose. Some amylase and starch were mixed and the mixture incubated at 37°C until the reaction was complete.

(i) Sketch a curve on the axes below to show the progress of this reaction.



(1)

(ii) Explain why the rate of the reaction decreases as the reaction progresses.

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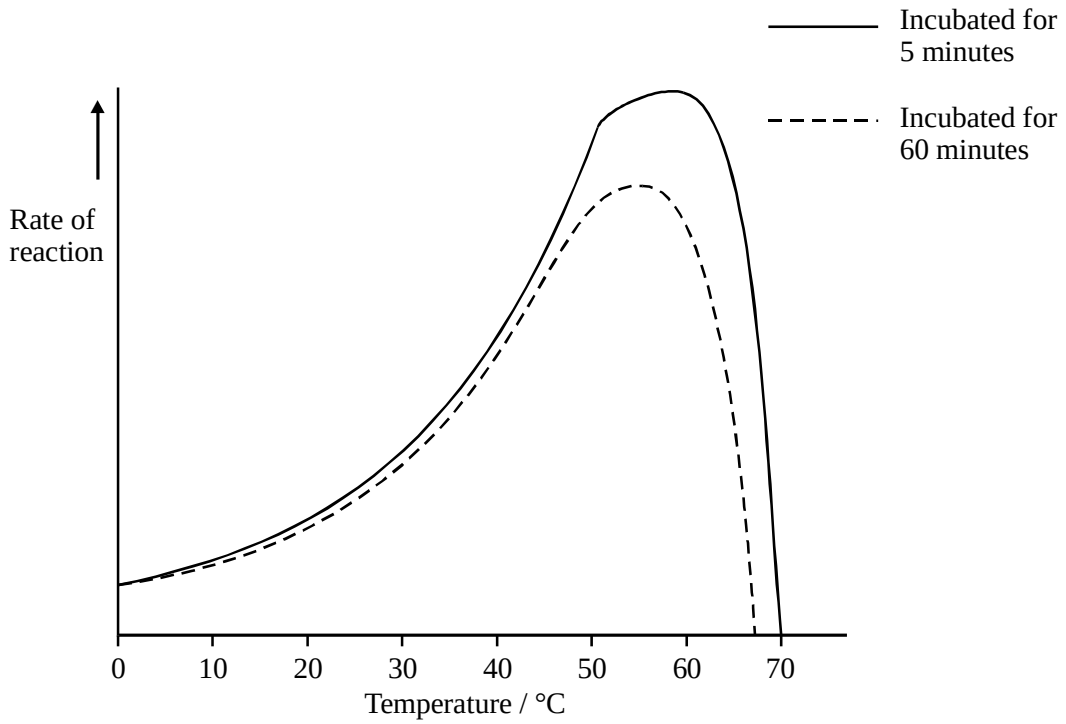
(2)

The effect of temperature on the rate of reaction of an enzyme was investigated. A test tube containing the enzyme and a test tube containing the substrate were incubated separately at each of the temperatures being investigated. After 5 minutes, they were mixed and the rate of reaction was determined. The experiment was repeated but, this time, the enzyme and the substrate were left for 60 minutes before they were mixed. The results of the investigation are shown in the graph.



(b) The enzyme solution used in this investigation was made by dissolving a known mass of enzyme in a buffer solution. Explain why a buffer solution was used.

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(1)

(c) (i) Use the graph to describe how incubation time affects the rate of the reaction.

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(2)

(ii) The maximum rate of reaction with an incubation time of 60 minutes is less than the maximum rate of reaction with an incubation time of 5 minutes. Explain why.

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(3)

(d) Explain how inhibitors affect the rate of enzyme-controlled reactions.

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(6)

(Total 15 marks)

14. Read the following passage.

Job's Tears is a cereal plant which grows in the tropics. An unusual protein has been found in its grains. This protein is unusual because it has two functions. It acts as both an enzyme inhibitor and as an enzyme. As an inhibitor, the protein reduces the activity of starch-digesting enzymes. The protein acts as an enzyme by breaking down chitin, a polysaccharide found in the walls of many fungi, to its monomers. Because of the resulting more negative water potential in the cytoplasm of the fungus, this effectively leads to "death by osmosis" of any fungus attacking the grain.

Our knowledge of the relationship between protein structure and function has led to the development of the new technology of protein engineering. This involves changing the amino acid sequence of a protein and altering its tertiary structure. Altering the tertiary structure changes the protein's properties. So far, we have been unable to produce a protein with more than one function such as that found in Job's Tears. We have had success, though, in making some enzymes more stable and less prone to heat denaturation. We have done this by substituting amino acids and allowing the formation of additional chemical bonds.

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

(a) (i) The protein found in Job's Tears breaks down chitin (line 4). What type of chemical reaction is involved in breaking down chitin?

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(1)

(ii) Breakdown of chitin leads to "death by osmosis" of fungi attacking the grain (lines 6 - 7). Explain how.

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(2)

(iii) This protein does not break down the cell walls of the Job's Tears plant. Explain why.

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(1)

(b) Explain what is meant by the tertiary structure of a protein (line 10).

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(1)

(c) (i) Explain how heating an enzyme leads to it being denatured.

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(2)

(ii) How can protein engineering make enzymes more stable and less prone to heat denaturation (line 13)?

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(2)

(d) Describe how the sequence of amino acids in part of the protein from Job's Tears could enable this protein to act as an enzyme inhibitor.

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(6)
(Total 15 marks)

15. Catalase is an enzyme. It catalyses the breakdown of hydrogen peroxide in the reaction:

$$\underset{\text{hydrogen peroxide}}{2H_2O_2} \rightarrow \underset{\text{water}}{2H_2O} + \underset{\text{oxygen}}{O_2}$$

In an investigation, samples of different substances were added to hydrogen peroxide in a series of test tubes. The rate of reaction was measured by recording the rate at which bubbles of oxygen were produced. A scale going from 0 for no bubbles to 5 for the maximum rate of bubbling was used to measure this. The results are shown in the table.

Tube	Substance added	Rate at which bubbles of oxygen were produced
A	Piece of liver	4
B	Ground liver and sand	5
C	Sand	0
D	Piece of cooled, boiled liver	0

(a) Explain the difference between the rate at which bubbles were produced in.

(i) tubes **A** and **B**;

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(2)

(ii) tubes **A** and **D**.

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(3)

(b) Explain the purpose of tube **C**.

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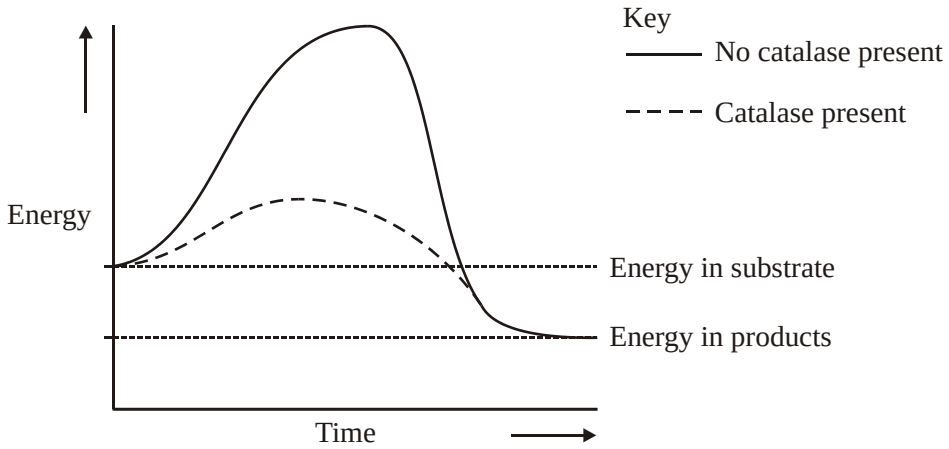
(1)

(c) The graph shows the energy changes which take place during the reaction in which hydrogen peroxide is converted to water and oxygen.



Use the graph to explain why

(i) hydrogen peroxide breaks down at a lower temperature when catalase is present than when it is not present;

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(1)

(ii) test tubes **A** and **B** became warmer when the reaction was taking place.

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(2)

(Total 9 marks)

16. (a) Starch and protein are biologically important polymers.

(i) Explain what is meant by a polymer.

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.....

(1)

(ii) Give **one** example of a biologically important polymer other than starch or protein.

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(1)

(b) In an investigation, the enzyme amylase was mixed in a test tube with a buffer solution and a suspension of starch. The amylase broke down the starch to maltose. When all the starch had been broken down, a sample was removed from the test tube and tested with biuret reagent.

(i) Explain why a buffer solution was added to the amylase-starch mixture.

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(2)

(ii) What colour would you expect the sample to go when tested with biuret reagent?

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(1)

(iii) Give an explanation for your answer to part (ii)

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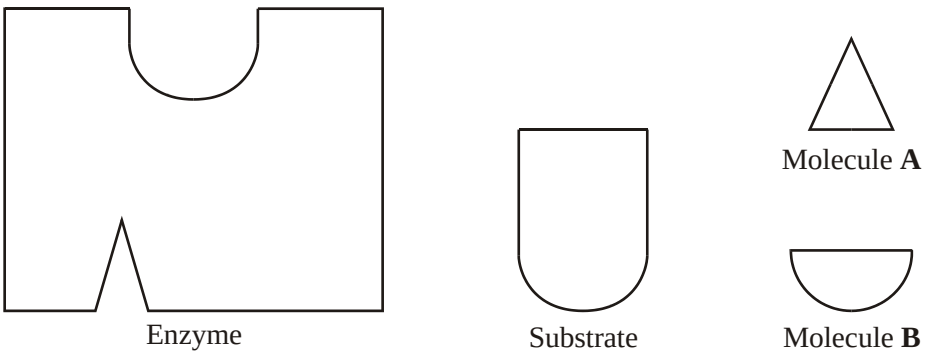
(2)
(Total 7 marks)

17. (a) The diagrams represent an enzyme, its substrate and two other molecules, **A** and **B**.



The addition of a non-competitive inhibitor will prevent the formation of an enzyme-substrate complex. Draw a labelled diagram based on relevant molecules selected from the diagram above to explain how this occurs.

(2)

(b) A decrease in temperature decreases the kinetic energy of molecules in a solution. Explain how a decrease in temperature decreases the rate of an enzyme-controlled reaction.

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(2)

(c) Urea breaks hydrogen bonds. Explain how the addition of urea would affect the rate of an enzyme-controlled reaction.

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(3)
(Total 7 marks)

18. Uric acid is produced in the body. One of the reactions involved in the production of uric acid is catalysed by xanthine oxidase.

$$\text{xanthine} \xrightarrow[\text{oxidase}]{\text{xanthine}} \text{uric acid}$$

(a) A sample of xanthine oxidase was tested by mixing with biuret reagent. Describe and explain the result of this test.

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(2)

(b) Explain why xanthine oxidase is able to catalyse this reaction but it is not able to catalyse other reactions.

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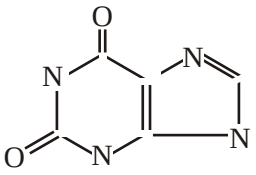
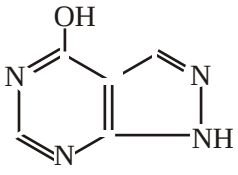
(2)

(c) Gout is a painful condition caused by uric acid crystals in the joints. It is often treated with a drug that inhibits xanthine oxidase. The diagram shows a molecule of xanthine and a molecule of this drug.

Xanthine



Drug used to treat gout



Use the diagram to explain why this drug is effective in the treatment of gout.

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(3)

(Total 7 marks)

19. Some enymes digest protein. They hydrolyse the peptide bonds between amino acids. The extent to which a protein is digested is called the degree of hydrolysis (DH). The DH value may be calculated from the equation:

$$\text{DH} = \frac{100 \times \text{Number of peptide bonds hydrolysed}}{\text{Total number of peptide bonds present}}$$

(a) (i) A protein molecule contains 151 amino acids. What is the total number of peptide bonds in this molecule?

.....

(1)

(ii) A molecule of this protein is digested. The DH value of the digested protein is 18. Calculate the number of peptide bonds that have been hydrolysed.

Answer .....

(1)

(b) What would be the DH value of a protein if it were completely hydrolysed to amino acids? Explain how you arrived at your answer.

DH value .....

Explanation .....

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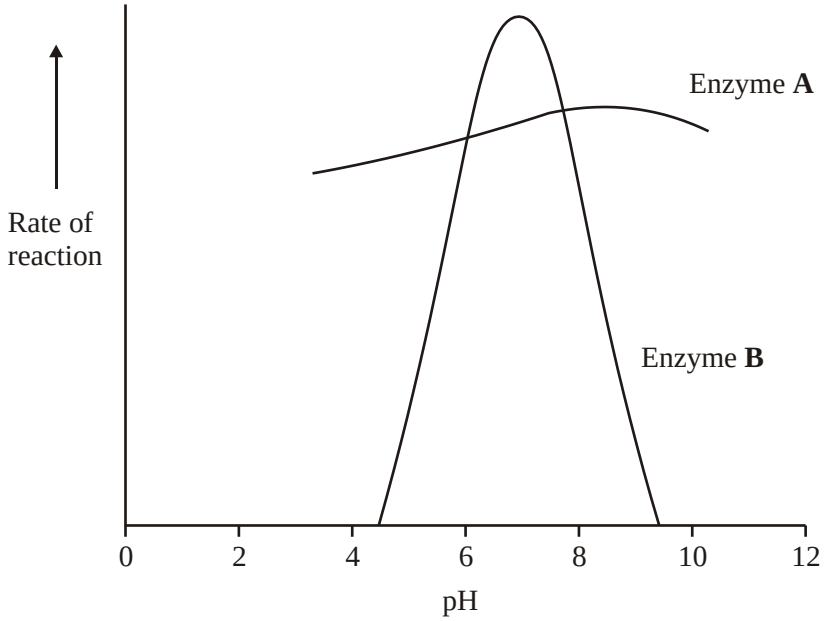
(2)

Enzymes **A** and **B** digest protein. The graph shows the effect of pH on the rates of reaction of these enzymes.



(c) Pepsin is a protein-digesting enzyme found in the stomach. It has an optimum pH of 2 and is fully denatured at pH 6. Sketch a curve on the graph to show the effect of pH on the rate of reaction of pepsin.

(1)

(d) Explain why the rate of reaction of enzyme **B** is low at pH 5.

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(3)

(e) Enzyme **A** is present in some washing powders used for cleaning clothes. Use the graph to suggest why enzyme **A** would be of more use in washing clothes than enzyme **B**.

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(1)

(f) Use your knowledge of protein structure to explain why enzymes are specific and may be affected by non-competitive inhibitors.

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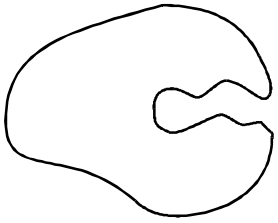
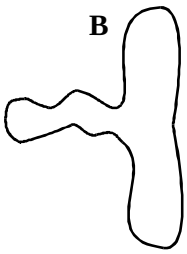
(6)
(Total 15 marks)

20. (a) Diagram **A** shows an enzyme, and **B** is the substrate of this enzyme.

A



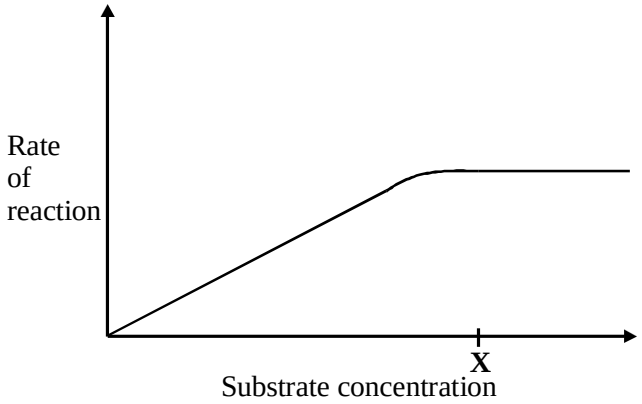
B



By drawing on this diagram, show how a competitive inhibitor would affect the activity of the enzyme.

(2)

(b)



The graph shows the effect of changing substrate concentration on the rate of an enzyme controlled reaction. Explain why increasing substrate concentration above the value shown as **X** fails to increase the rate of the reaction further.

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(2)

(c) Explain how adding excess substrate could overcome the effect of a competitive inhibitor.

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(1)

(d) Explain what happens to an enzyme molecule when it is denatured by high temperature.

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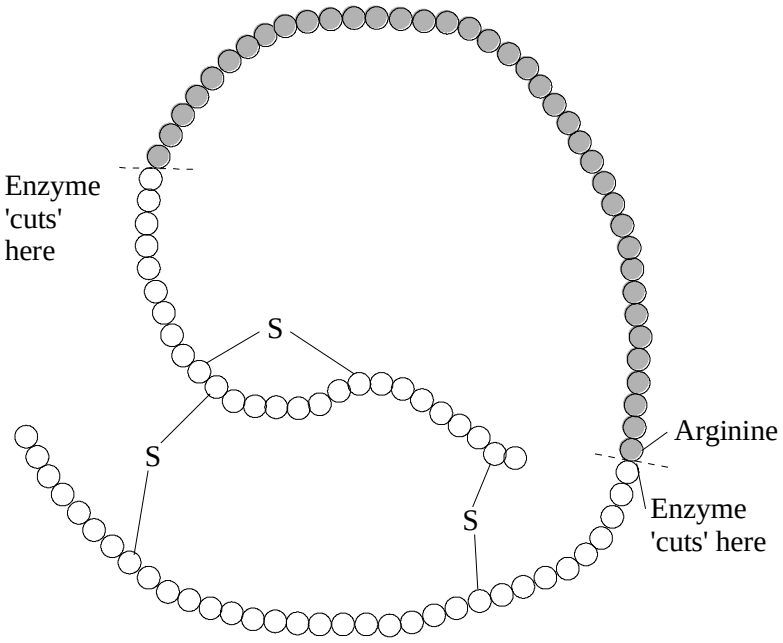
(3)
(Total 8 marks)

21. Insulin is a protein. It is made in the cells of the pancreas from a larger molecule called pro-insulin. An enzyme breaks the pro-insulin into insulin and a short polypeptide. This is shown in the diagram.



(a) Name the type of monomer which forms insulin.

.....

(1)

(b) Describe the result you would expect if the enzyme were tested with biuret reagent.

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(1)

(c) If the amino acid arginine is replaced by glycine in a molecule of pro-insulin, insulin will not be produced. Explain why the enzyme will no longer break down pro-insulin.

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(3)
(Total 5 marks)

22. (a) Glucose molecules can be joined by condensation top form a variety of polymers.

Describe how the condensation reaction can be catalysed by an enzyme.

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(4)

(b) Temperature has a marked effect on blood pH. At 37 °C blood plasma has a pH of 7.4 but at a temperature of 25 °C, the pH is 6.9.
In some surgical procedures the body is cooled by 10 °C. Other than the direct effect that lowering the temperature will have, explain how this cooling will affect the reactions taking place in the body.

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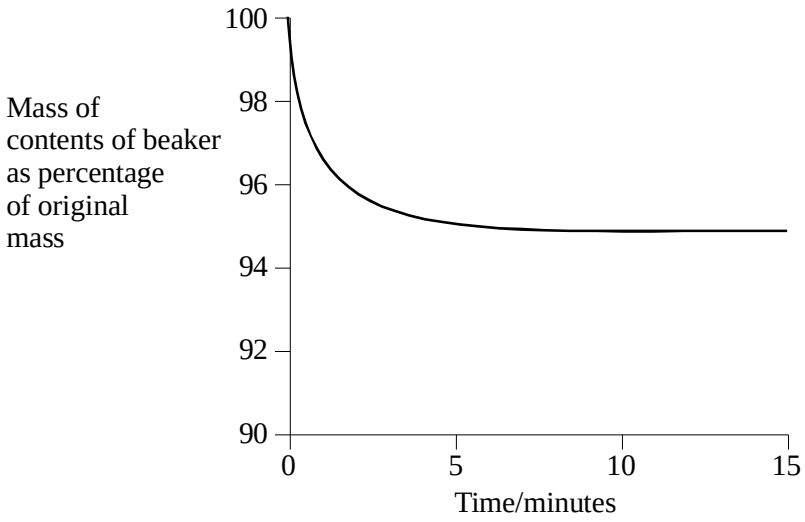
(5)
(Total 9 marks)

23. Catalase is an enzyme which catalyses the breakdown of hydrogen peroxide to water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Potato tubers are a source of catalase.

In an investigation into the reaction between catalase and hydrogen peroxide, 20 identical discs of potato, each 4 mm thick, were put in a beaker of hydrogen peroxide. The mass of the contents of the beaker was recorded over a 15-minute period. The results are shown in the graph.



(a) (i) Explain the change in mass of the contents of the beaker.

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(1)

(ii) Use your knowledge of enzyme action to explain why the rate of reaction changed.

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(2)

(b) A second experiment was carried out. It was identical to that described above except that 40 discs of potato, each 2 mm thick, were put in the hydrogen peroxide in the beaker. Sketch on the graph a curve to show the resulting change in mass.

(2)

(c) In order to show that an enzyme in the potato is responsible for the breakdown of the hydrogen peroxide, a control is necessary. It was suggested that this control should consist of a beaker of hydrogen peroxide with nothing else added. Explain why this would **not** be the best control.

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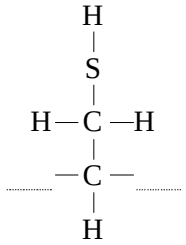
(1)
(Total 6 marks)

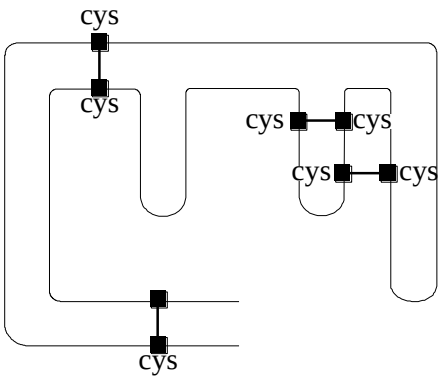
24. Lysozyme is an enzyme found in tears. It helps to protect the eyes by breaking down the cell walls of bacteria. A molecule of lysozyme consists of a single polypeptide chain made from 129 amino acid molecules. The amino acid, cysteine (cys), occurs at eight places in the chain.

(a) The R group in cysteine is CH_2SH·
Complete the diagram to show the structural formula of a cysteine molecule.



(2)

(b) The sulphur atoms form bonds between each other, so the cysteine monomers link together in pairs. As a result, the polypeptide chain folds, as shown in the diagram.



Explain how this folding helps the lysozyme molecule to work as an enzyme.

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(3)

(c) Lysozyme breaks down bacterial cell walls but does not affect the walls of plant cells. Explain why.

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(2)
(Total 7marks)

25. (a) Starch molecules do not break down in boiling water. In the body starch is digested by amylase.

(i) Name the product of the digestion of starch by amylase.

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(1)

(ii) Explain how amylase makes it possible for starch to be digested at body temperature.

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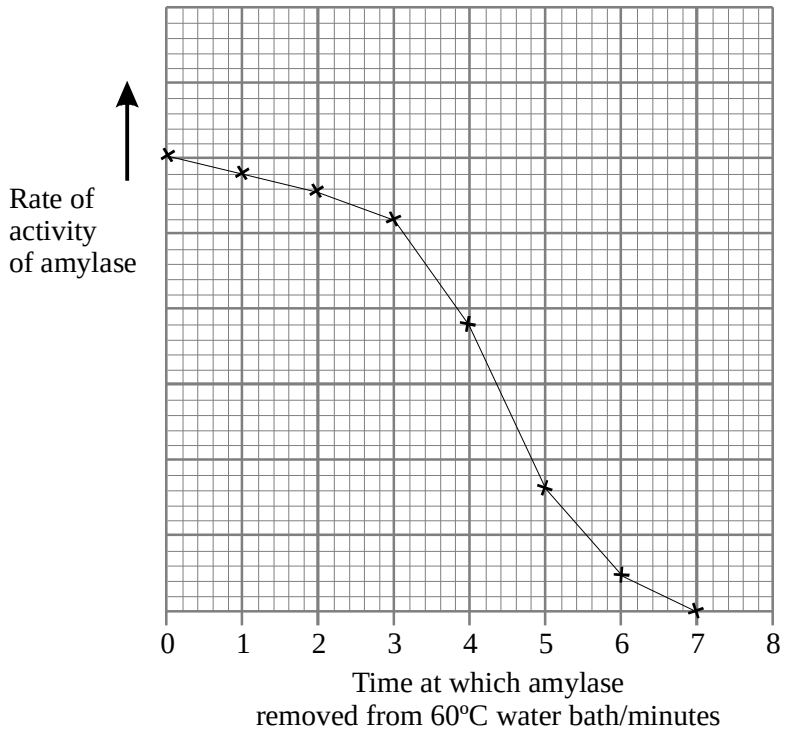
(3)

(b) In an investigation, a sample of amylase was placed in a water bath at 60°C. Each minute, a small amount of the amylase was removed and mixed with starch solution at 35°C. The rate of activity of the amylase was measured. The results are shown in the graph.



Use your knowledge of enzymes to explain why the activity of the amalyse decreased.

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(4)
(Total 8 marks)

26. Cyanide is a poison. It combines non-competitively with an enzyme found in mitochondria. This enzyme, called cytochrome oxidase, is essential for ATP production in respiration. ATP is the substance that transfers energy for use in other processes in the cell.

(a) Use your knowledge of enzymes to explain how cyanide stops the activity of cytochrome oxidase.

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(2)

(b) It has been suggested that it might be possible to use cyanide to kill cancer cells. Cassava plants make a substance called linamarin and also an enzyme that breaks down linamarin to release cyanide. The idea is to use an antibody that attaches only to the cell surface membrane of cancer cells. The enzyme from the cassava plants would be combined with this antibody. Linamarin would then be injected into the person with cancer,

(i) Suggest what type of substance would cause the antibody to attach only to cancer cells.

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(1)

(ii) Explain how this method would kill the cancer cells, but not other cells.

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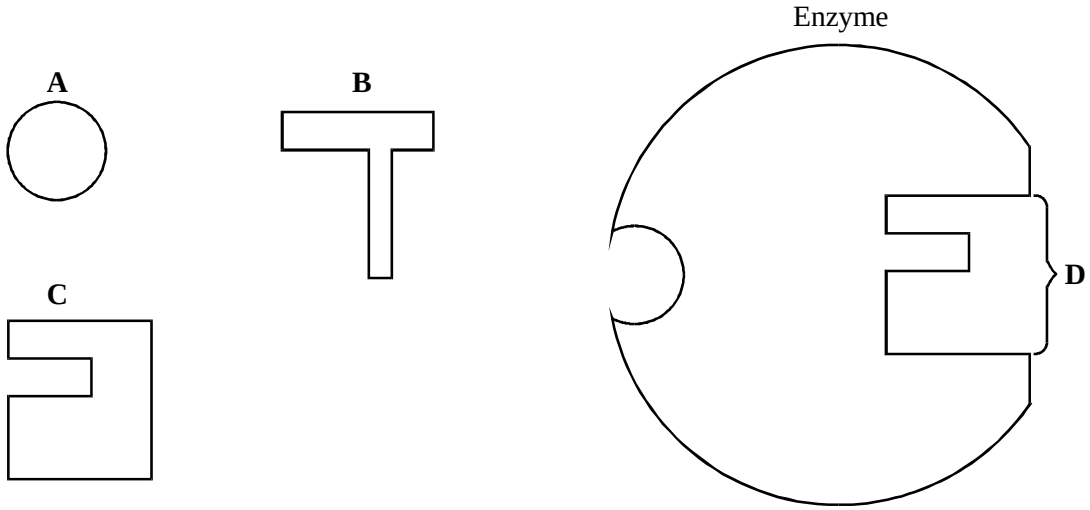
(3)

(Total 6 marks)

27. The diagrams represent an enzyme and three molecules that could combine with it.



(a) Name the part of the enzyme labelled **D**.

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(1)

(b) Explain how substrate **C** is broken down by the enzyme.

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(4)

(c) Molecules **A** and **B** inhibit the enzyme in different ways.
Explain how each molecule inhibits the enzyme.

Molecule **A** .....

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Molecule **B** .....

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(4)

(d) A student carried out an investigation using amylase from a saprophytic fungus. Six wells (holes) of the same size were cut in a starch agar plate. Each well was filled with the same concentration and volume of amylase solution. An equal volume of buffer solution was added to produce a different pH in each well. The plates were incubated at 25°C for 4 hours and then covered with iodine solution. It was observed that there were clear rings around each well. The width of these clear rings is shown in the table.

pH	**Width of clear ring / mm**
4	1
5	2
6	6
7	11
8	9
9	3

(i) What conclusion can be drawn from the results?

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(1)

(ii) Use an appropriate method to estimate the maximum rate of reaction that was observed in this investigation. Show your working.

Maximum rate of reaction .....

(2)
(Total 12 marks)

28. (a) Describe and explain how an increase in temperature affects the rate of an enzyme controlled reaction.

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(6)

(b) (i) Use your knowledge of the tertiary structure of enzymes to explain how a non competitive inhibitor could reduce the rate of an enzyme controlled reaction.

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(4)

(ii) Alcohol dehydrogenase is an enzyme found in the liver. It normally breaks down ethanol (C_2H_5OH) into less harmful products. About 50 deaths each year occur following ingestion of a compound called ethylene glycol ($C_2H_4(OH)_2$) which is found in antifreeze. This compound is not lethal, but it is broken down by alcohol dehydrogenase into highly toxic oxalic acid. Giving a large dose of ethanol as quickly as possible can treat ethylene glycol poisoning. Use your knowledge of enzyme activity to suggest how this treatment may counteract the effects of ethylene glycol poisoning.

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(4)
(Total 14 marks)

29. (a) Many reactions take place in living cells at temperatures far lower than those required for the same reactions in a laboratory. Explain how enzymes enable this to happen.

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(3)

An amylase enzyme converts starch to maltose syrup which is used in the brewing industry.

(b) Describe a biochemical test to identify

(i) starch;

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(2)

(ii) a reducing sugar such as maltose.

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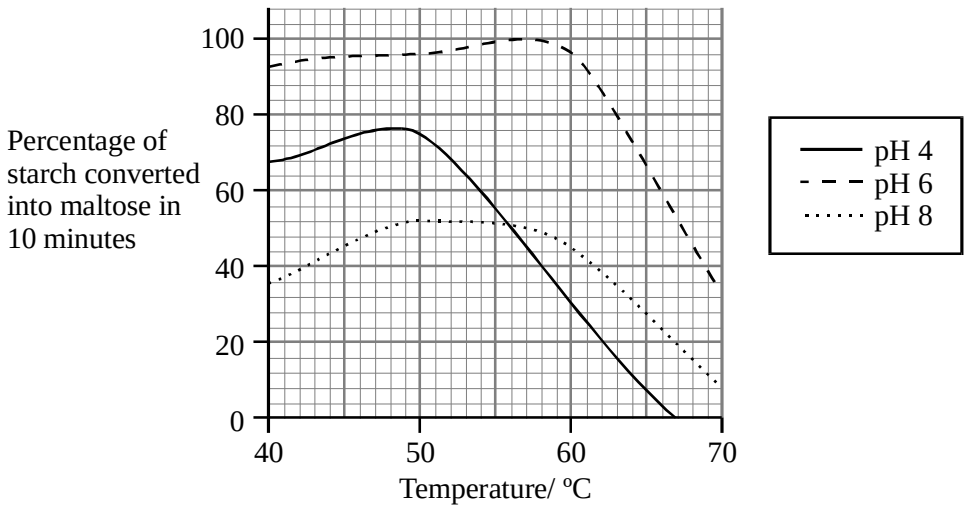
(2)

(c) The graph shows the results of tests to determine the optimum temperature for the activity of this amylase.



(i) Complete the table for the optimum temperature for the activity of amylase at each pH value.

	pH		
	4	**6**	**8**
Optimum temperature / ºC			

(1)

(ii) Describe and explain the effect of temperature on the rate of reaction of this enzyme at pH 4.

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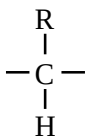
(6)
(Total 14 marks)

30. (a) Complete the structural formula of the amino acid molecule.



(2)

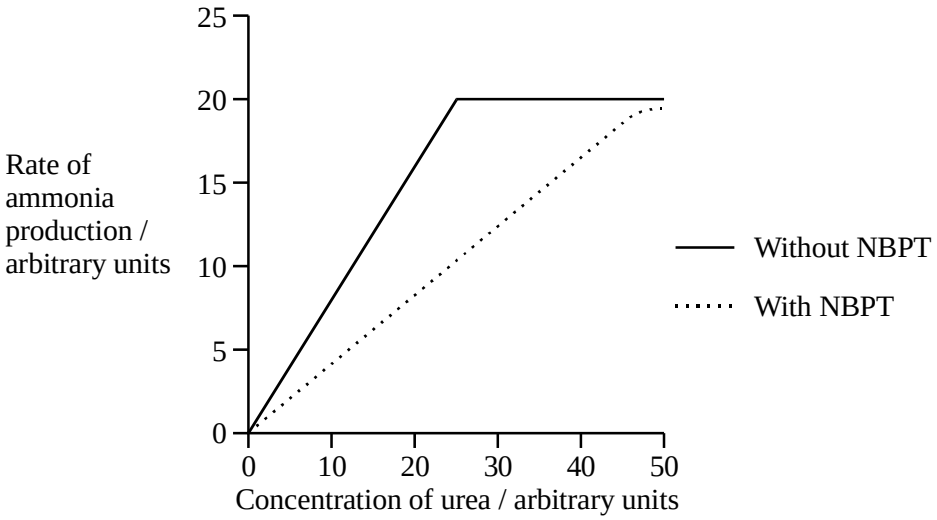
(b) In mammals, amino acids are broken down and urea is formed.

Urea from animal waste is often used as a natural fertiliser. Soil bacteria secrete an enzyme called urease that breaks down urea into ammonia and carbon dioxide. Some of this ammonia is released into the atmosphere.

$$\text{urea} + \text{water} \rightarrow \text{carbon dioxide} + \text{ammonia}$$

Scientists have studied this reaction because it results in the loss of fertiliser. They have produced a substance called NBPT which is added to urea fertiliser.

NBPT is an enzyme inhibitor which affects the action of the urease produced by soil bacteria. The graph shows the results of an experiment in which a standard amount of urease and of the enzyme inhibitor NBPT were added to different concentrations of urea solution.



Describe and explain the effect on the rate of the reaction of increasing the urea concentration

(i) without NBPT present;

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(ii) with NBPT present.

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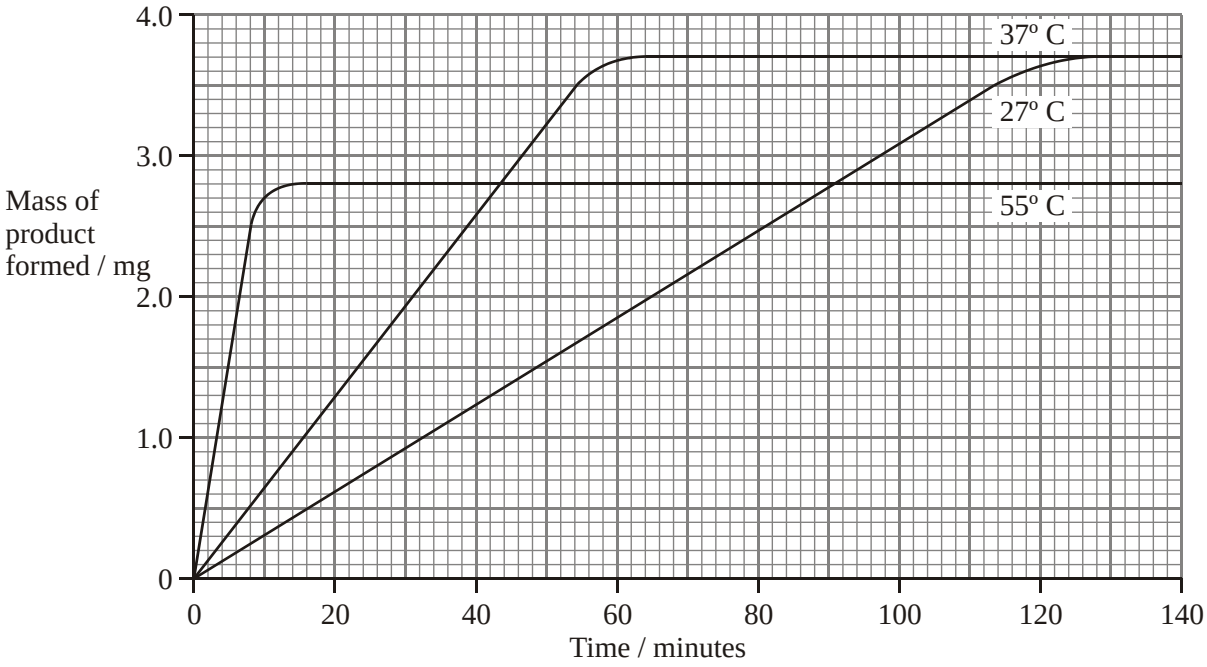
(6)
(Total 8 marks)

31. A student carried out an investigation into the mass of product formed in an enzyme-controlled reaction at three different temperatures. Only the temperature was different for each experiment. The results are shown in the graph.



(a) Use your knowledge of enzymes to explain

(i) why the initial rate of reaction was highest at 55 °C;

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(2)

(ii) the shape of the curve for 55 °C after 20 minutes.

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(3)

(b) Explain why the curves for 27 °C and 37 °C level out at the same value.

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(2)
(Total 7 marks)

32. Lactose is a disaccharide sugar which can be broken down by the enzyme lactase into two monosaccharides, glucose and galactose.

$$\text{lactose + water} \xrightarrow{\text{lactase}} \text{glucose + galactose}$$

(a) The formula for galactose is $C_6H_{12}O_6$. What is the formula for lactose?

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(2)

(b) A solution containing the enzyme lactase was added to a lactose solution. The solution was incubated at 40 °C for one hour. Sample **A** was removed from the tube before incubation. Sample **B** was removed after one hour.

(i) Describe a chemical test you could carry out on sample **A** to show that lactose is a reducing sugar.

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(2)

(ii) This chemical test was carried out on samples **A** and **B**. All experimental variables were the same in the testing of the two samples. Both tubes were left for ten minutes to allow the precipitate to settle. The diagram shows the result.

A **B**

Is galactose a reducing sugar? ……

Explain how the results in the diagram support your answer.

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(2)
(Total 6 marks)

33. (a) Explain how the shape of an enzyme molecule is related to its function.

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(3)

(b) Bacteria produce enzymes which cause food to decay. Explain how vinegar, which is acidic, can prevent the action of bacterial enzymes in some preserved foods.

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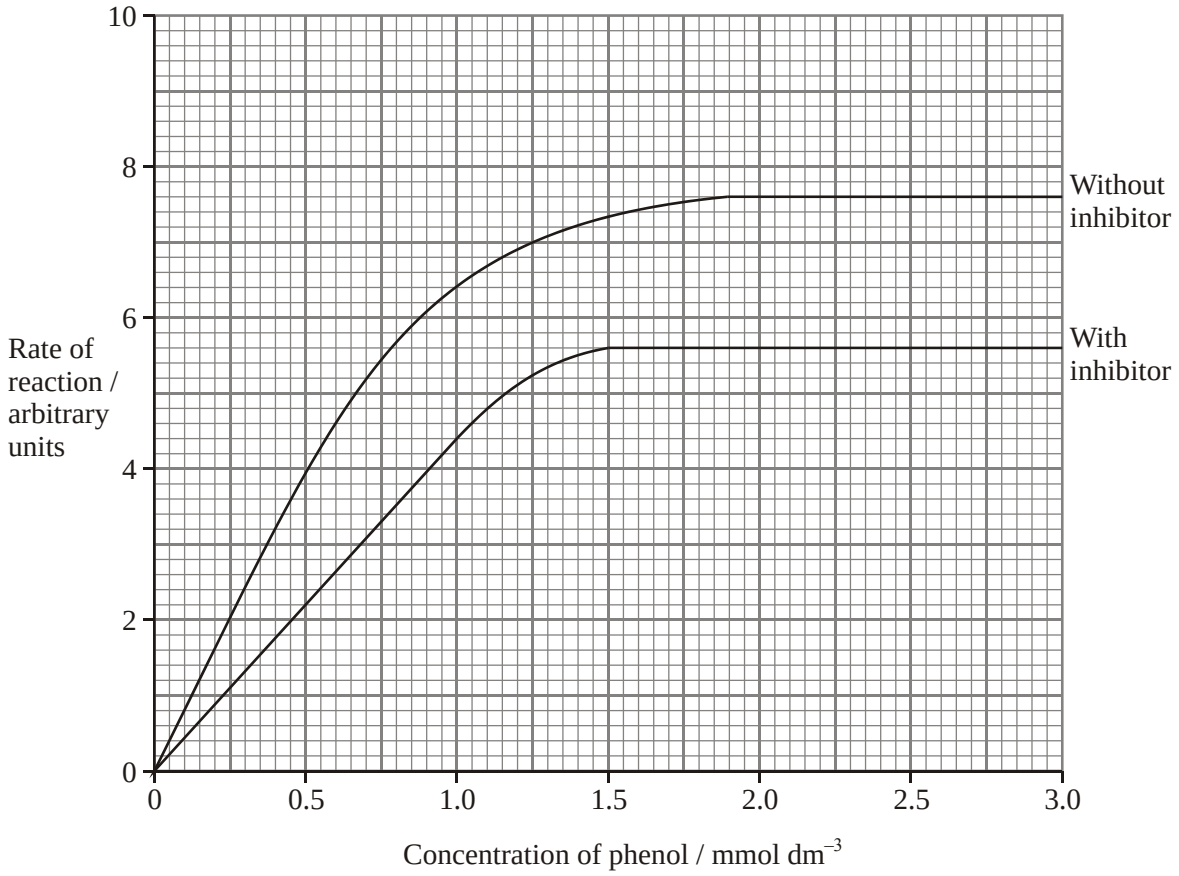
(3)
(Total 6 marks)

34. In an investigation, the rate at which phenol was broken down by the enzyme phenol oxidase was measured in solutions with different concentrations of phenol. The experiment was then repeated with a non-competitive inhibitor added to the phenol solutions. The graph shows the results.



(a) Explain why an increase in concentration of phenol solution from 2.0 to 2.5 mmol dm^{-3} has no effect on the rate of the reaction without inhibitor.

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(2)

(b) Explain the effect of the non-competitive inhibitor.

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(2)

(c) Calculate the percentage decrease in the maximum rate of the reaction when the inhibitor was added. Show your working.

Percentage decrease .....

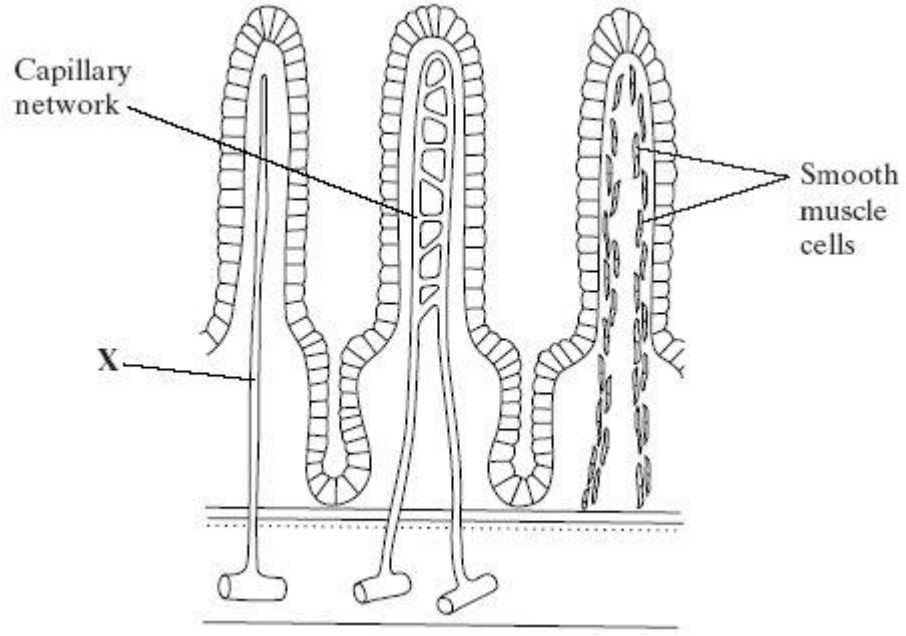
(2)

(d) Draw a curve on the graph to show the results expected if a competitive inhibitor instead of a non-competitive inhibitor had been used.

(1)

(Total 7 marks)

35. The diagram shows different structures present in the wall of part of the ileum.



(i) Describe the function of part **X**.

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(1)

(ii) Suggest an advantage of having muscle cells in the villi.

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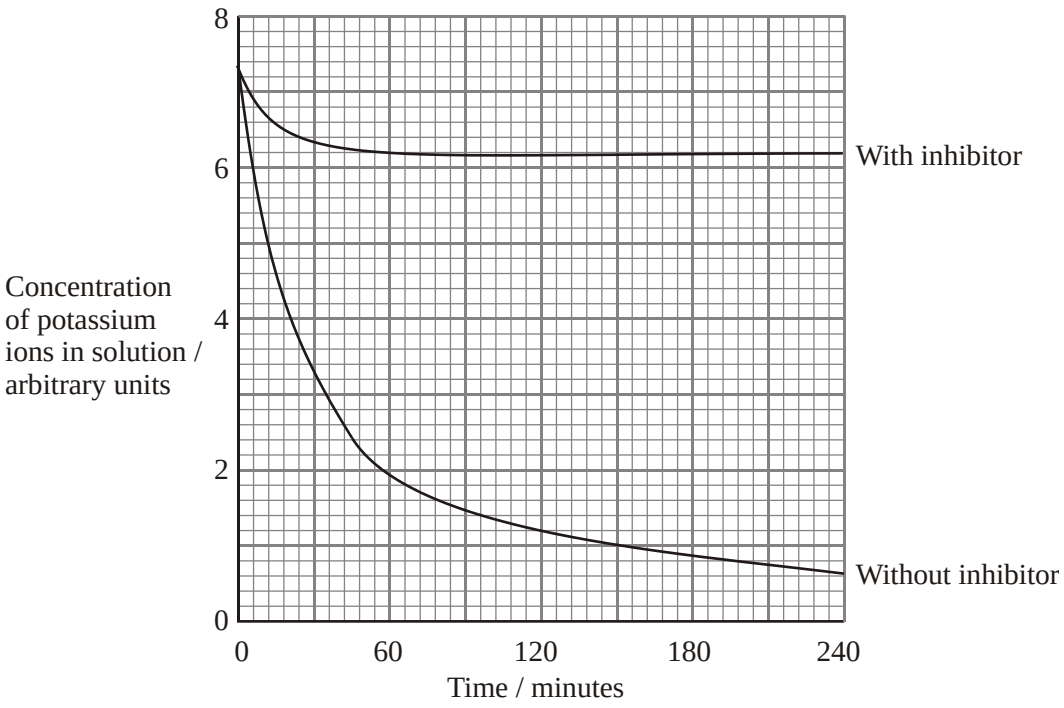
(2)

(Total 3 marks)

36. 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

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(2)

(ii) Without inhibitor

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(1)

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

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(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.

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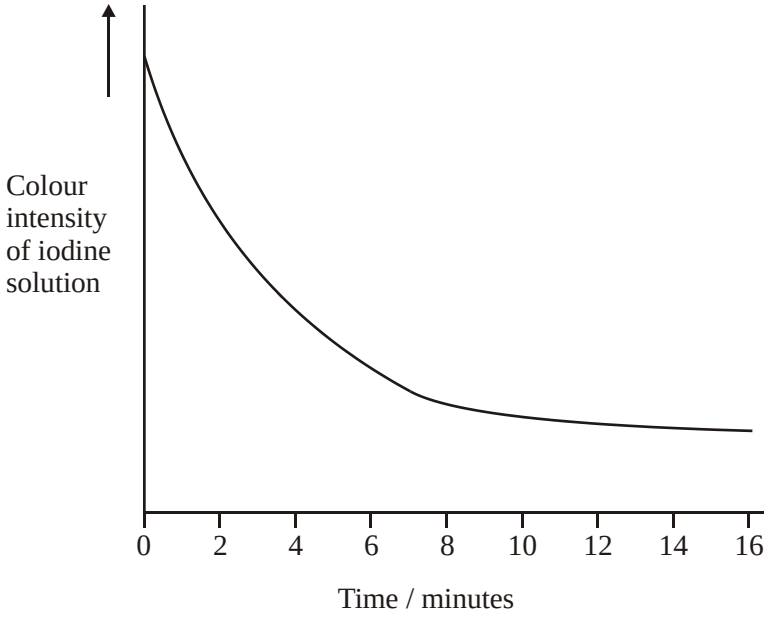
(2)
(Total 7 marks)

37. In an investigation into carbohydrase activity, the contents from part of the gut of a small animal were collected. The contents were added to starch solution at pH 7 and kept in a water bath at 25°C. At one-minute intervals, samples were removed and added to different test tubes containing dilute iodine solution. The colour intensity of each sample was determined. The graph shows the results.



(a) Explain the change in colour intensity.

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(2)

(b) Draw clearly labelled curves on the graph to show the expected result if the experiment was repeated

(i) at 35 °C;

(ii) at pH 2.

(2)

(c) Explain how

(i) raising the temperature to 35 °C affects carbohydrase activity;

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(ii) decreasing the pH affects carbohydrase activity.

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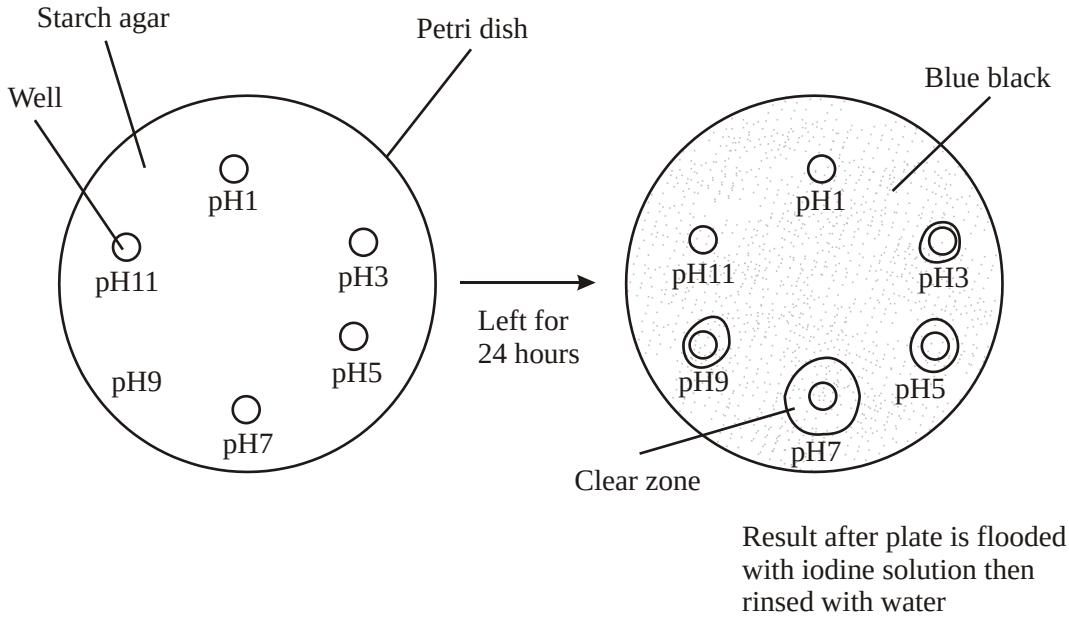
(7)
(Total 11 marks)

38. Amylase is an enzyme that breaks down starch. A student investigated the effect of pH on amylase activity by using a starch agar plate. Six circular wells were cut into the agar plate. Each well contained the same concentration and volume of amylase, and a buffer solution of different pH. The agar plate was then left for 24 hours. The diagram shows the results



Result after plate is flooded with iodine solution then rinsed with water

(a) Describe how the student could have used these results to compare the activity of the enzyme at different pH values.

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(2)

(b) The student concluded that the optimum pH for amylase activity was 7. This conclusion may not be valid. Explain why.

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(1)

(c) Using your knowledge of enzyme structure, explain the result obtained at pH 11.

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(2)

(d) Describe a control that would be necessary for this investigation.

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(2)
(Total 7 marks)

39. (a) Sucrose, maltose and lactose are disaccharides.

(i) Sucrase is an enzyme. It hydrolyses sucrose during digestion. Name the products of this reaction.

..... and .....

(2)

(ii) Sucrase does **not** hydrolyse lactose. Use your knowledge of the way in which enzymes work to explain why.

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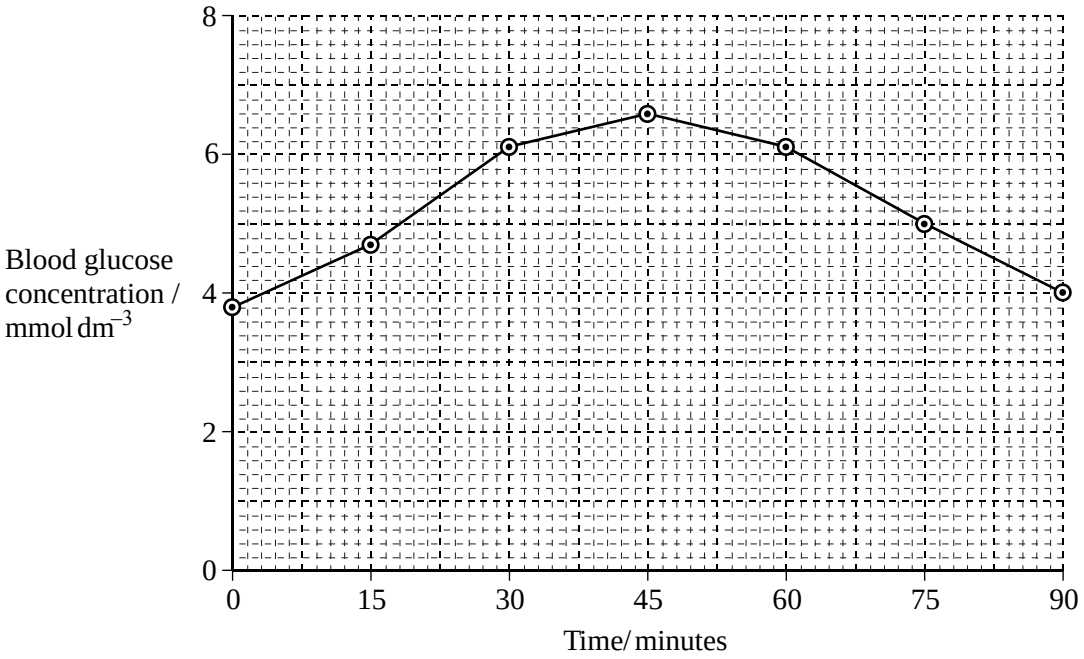
(2)

(b) A woman was given a solution of sucrose to drink. Her blood glucose concentration was measured over the next 90 minutes. The results are shown on the graph.



(i) Describe how the woman's blood glucose concentration changed in the period shown in the graph.

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(2)

(ii) Explain the results shown on the graph.

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(2)

(iii) This woman was lactose intolerant.

On the graph, sketch a curve to show what would happen to her blood glucose concentration if she had been given a solution of lactose to drink instead of a sucrose solution.

(1)
(Total 9 marks)

40. A glucose biosensor is an instrument used to measure glucose concentration. It contains an enzyme called glucose oxidase.

(a) A glucose biosensor detects only glucose. Use your knowledge of the way in which enzymes work to explain why.

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(3)

(b) It is better to use a biosensor than the Benedict's test to measure the concentration of glucose in a sample of blood. Suggest **two** reasons why.

1 .....

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2 .....

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(2)

(c) (i) Diabetes mellitus is a disease that can lead to an increase in blood glucose concentration. Some diabetics need insulin injections. Insulin is a protein so it cannot be taken orally. Suggest why insulin cannot be taken orally.

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(1)

(ii) A drug company produced a new type of insulin. Scientists from the company carried out a trial in which they gave this new type of insulin to rats. They reported that the results of this trial on rats were positive. A newspaper stated that diabetics would benefit from this new drug. Suggest **two** reasons why this statement should be viewed with caution.

1 .....

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2 .....

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(2)

(Total 8 marks)