Unit 1

Biology and Disease

The Digestive System

Practice Exam Questions

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

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

..... and .....

(2 marks)

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

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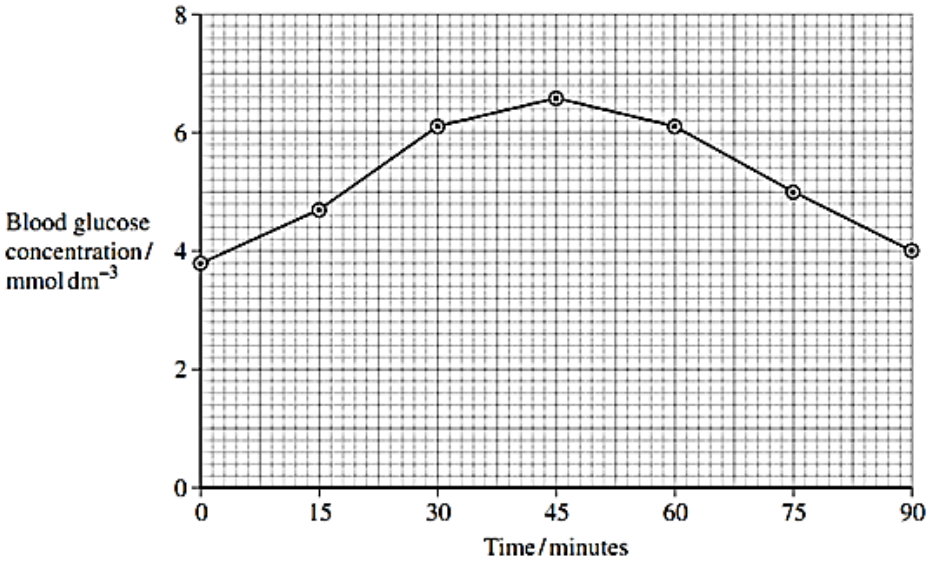
(2 marks)

1 (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.



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

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(2 marks)

(b) (ii) Explain the results shown on the graph.

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(2 marks)

(b) (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 mark)*

2 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 marks)

(Extra space).....

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(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 marks)

(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 mark)

(c) (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 marks)

Areas outside the box will not be scanned for marking

3 (a) Describe the role of the enzymes of the digestive system in the complete breakdown of starch.

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(5 marks)

(b)

Some people cannot digest lactose when they are adult. They could digest lactose when they were children.

Use your knowledge of water potential to explain why these adults get diarrhoea when they drink milk.

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(2 marks)

4

(a) *Induced fit* and *lock and key* are two models used to explain the action of enzymes.

(a) (i) Describe the *induced fit* model of enzyme action.

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(2 marks)

(a) (ii) Describe **one** way that the *lock and key* model is different from the *induced fit* model.

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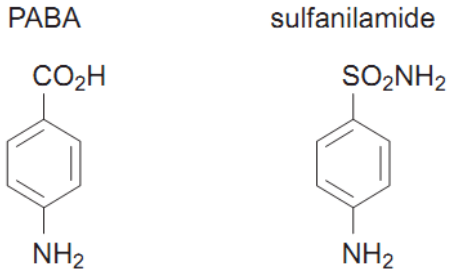
(1 mark)

(b) Folic acid is a substance required by bacteria for cell growth. Bacteria produce folic acid by the following reaction.

The diagram shows the structure of a molecule of PABA. It also shows the structure of a molecule of a drug called sulfanilamide, which can be used to treat bacterial infections. Sulfanilamide prevents bacteria producing folic acid.



Use the diagram and your knowledge of enzymes to explain how sulfanilamide prevents bacteria producing folic acid.

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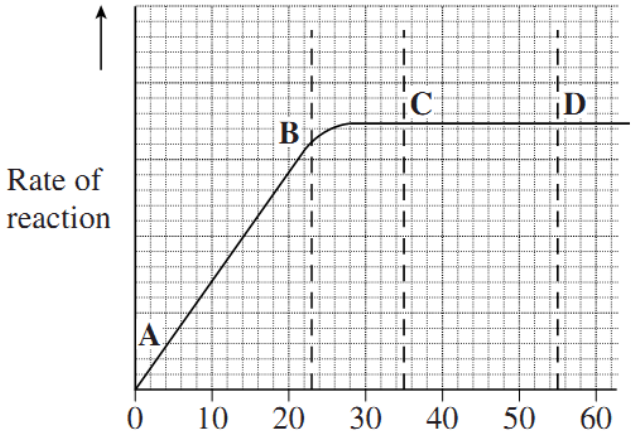
(3 marks)

5

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.

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(2 marks)

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

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(2 marks)

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

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(1 mark)

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

(1 mark)

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

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

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(2 marks)

(c) (ii) Methotrexate only affects the rate of the reaction controlled by folate reductase. Explain why this drug does not affect other enzymes.

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(1 mark)

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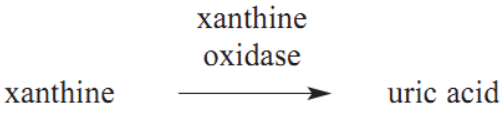
Uric acid is produced in the body. One of the reactions involved in the production of uric acid is catalysed by xanthine oxidase.



(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 marks)

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

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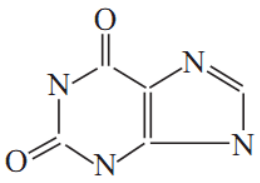
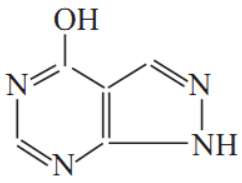
(2 marks)

(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 marks)

7

Hydrogen peroxide breaks down slowly at room temperature to produce oxygen and water.

$$2H_2O_2 \longrightarrow 2\ H_2O + O_2$$

Catalase is an enzyme that catalyses this reaction.

(a) Explain why adding catalase to hydrogen peroxide makes the reaction go faster.

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(2 marks)

(b) Students investigated the effect of substrate concentration on the rate of reaction of catalase. They used sand to grind a potato. This broke open the potato cells. The mixture of potato and sand was used as a source of catalase. The students measured the amount of oxygen produced to find the rate of reaction.

(i) Suggest a suitable control for this investigation and explain why it was necessary.

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(2 marks)

(ii) The temperature was kept constant with a water bath. Give **one** reason why allowing the temperature to fluctuate would lead to unreliable results.

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(1 mark)

8

The equation shows the breakdown of lactose by the enzyme lactase.

$$\text{lactose} + \text{water} \xrightarrow{\text{lactase}} \text{galactose} + \text{monosaccharide } \mathbf{X}$$

(a) (i) Name the type of reaction catalysed by the enzyme lactase.

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(1 mark)

(a) (ii) Name monosaccharide **X**.

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(1 mark)

(b) (i) Describe how you would use a biochemical test to show that a reducing sugar is present.

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(2 marks)

(b) (ii) Lactose, galactose and monosaccharide **X** are all reducing sugars.
After the lactose has been broken down there is a higher concentration of reducing sugar. Explain why.

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(1 mark)

(c) A high concentration of galactose slows down the breakdown of lactose by lactase.
Use your knowledge of competitive inhibition to suggest why.

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(2 marks)

(d) People who are lactose intolerant are **not** able to produce the enzyme lactase.
Explain why these people get diarrhoea when they drink milk containing lactose.

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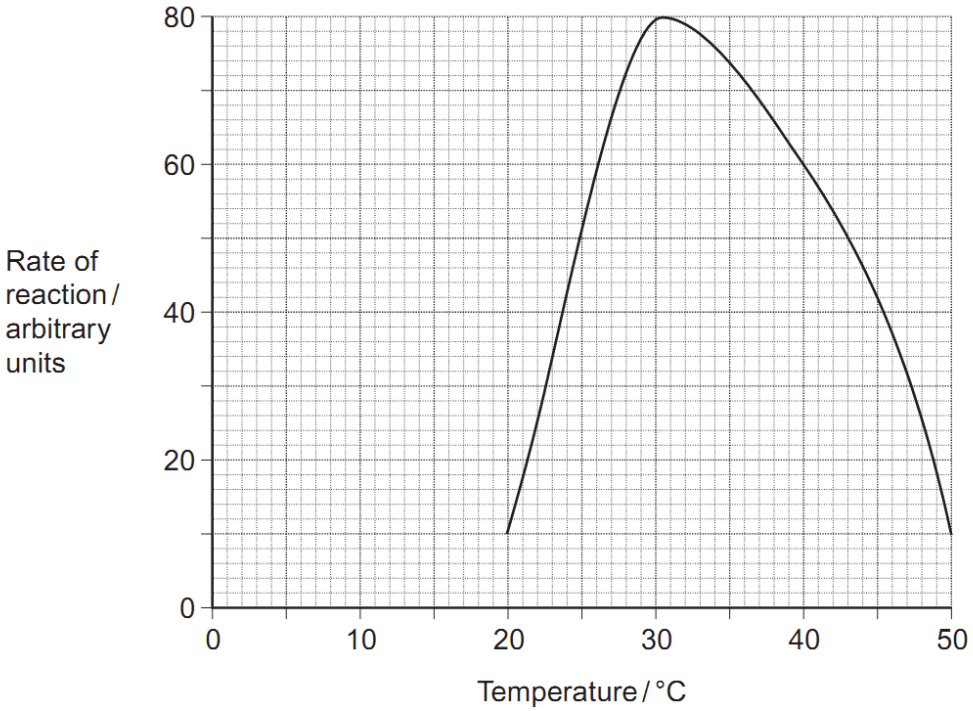
(2 marks)

[Total 9 marks]

A protease is an enzyme that digests protein. The graph shows how the activity of a protease varies with temperature.



(a) (i) Describe what the graph shows about the effect of temperature on the rate of reaction.

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(1 mark)

(a) (ii) Explain the shape of the curve between 30 °C and 50 °C.

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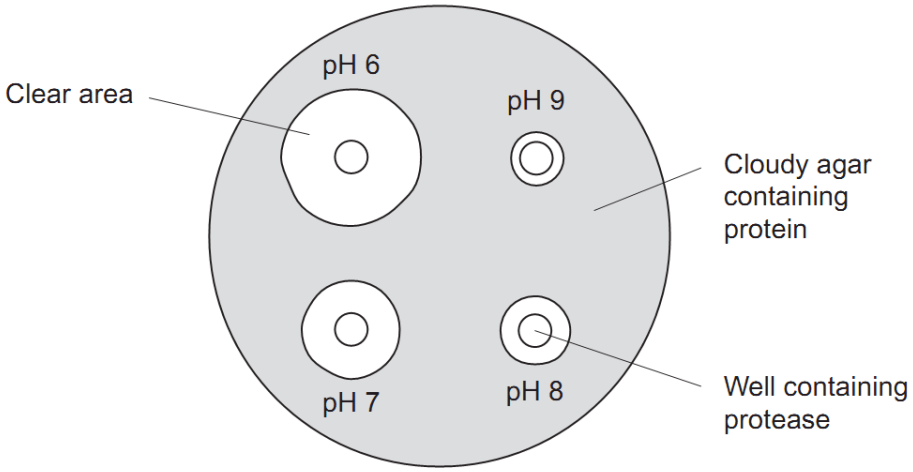
(3 marks)

(b) Students investigated the effect of pH on the activity of the protease.

- The students used agar plates containing protein. The protein made the agar cloudy.
- They made four wells of equal size in the agar of each plate.
- They added a drop of protease solution to each of the wells. The protease solution in each well was at a different pH.
- The students incubated the agar plates for 4 hours at a constant temperature.

The diagram shows the agar plates after they were incubated and the pH of the protease solution in each well.



(b) (i) How should the students make sure that the pH of the protease solution did **not** change?

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(1 mark)

(b) (ii) Use the graph to suggest a suitable temperature for incubating the agar plates. Explain your answer.

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(1 mark)

(b) (iii) Use the diagram to describe the effect of pH on the activity of this protease.

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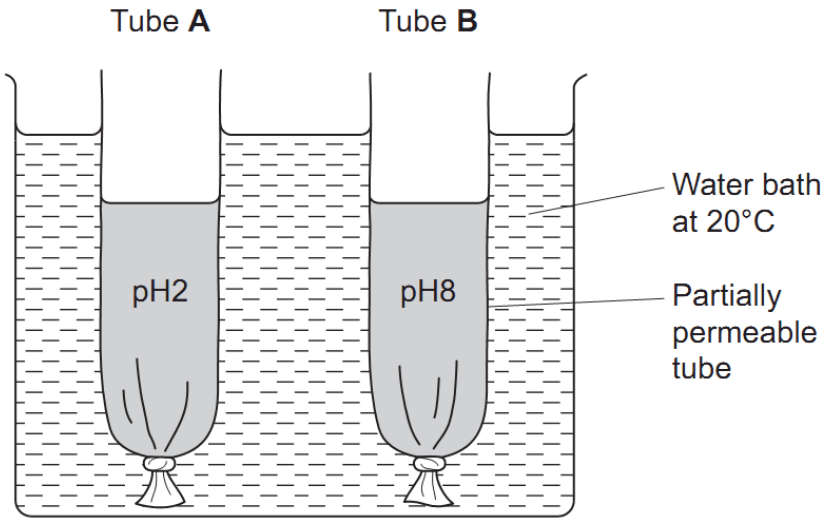
(1 mark)

Total 7 marks

10 A student investigated the effect of pH on the activity of the enzyme amylase.
She set up the apparatus shown in the diagram.



The tubes were made from Visking tubing. Visking tubing is partially permeable.
She added an equal volume of amylase solution and starch to each tube.

- She added a buffer solution at pH2 to tube **A**.
- She added an equal volume of buffer solution at pH8 to tube **B**.

After 30 minutes, she measured the height of the solutions in both tubes.
She then tested the solutions in tubes **A** and **B** for the presence of reducing sugars.

(a) Describe how the student would show that reducing sugars were present in a solution.

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(3 marks)

(b) After 30 minutes, the solution in tube **B** was higher than the solution in tube **A**.

(b) (i) Explain why the solution in tube **B** was higher.

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(3 marks)

(Extra space) .....

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(b) (ii) The student concluded from her investigation that the optimum pH of amylase was pH8. Is this conclusion valid? Explain your answer

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(1 mark)

11 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).

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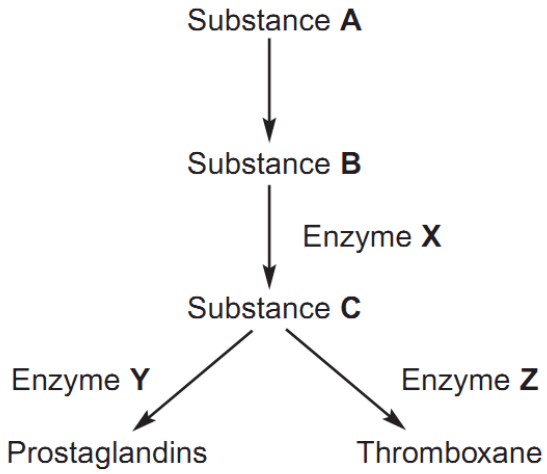
(1 mark)

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



(b) (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.

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(2 marks)

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

Enzyme .....

Explanation .....

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(2 marks)

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

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(2 marks)

(d) Aspirin may reduce the risk of myocardial infarction (lines 8 – 12). Explain how.

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(3 marks)

Digestion and Enzymes
Answers & Markscheme

1.

Part	Sub Part	Marking Guidance	Mark	Comments
(a)	(i)	Glucose; Fructose;	2	Any order.
(a)	(ii)	Lactose has a different shape/structure; Does not fit/bind to active site of enzyme/sucrase; OR Active site of enzyme/sucrase has a specific shape/structure; Does not fit/bind to lactose;	2	Only allow a second mark if reference is made to the active site. Max 1 mark if active site is described as being on the substrate. Do not accept same shape.
(b)	(i)	Rose and fell; Peak at 45 (minutes) / concentration of 6.6 (mmol dm^{-3});	2	
(b)	(ii)	Glucose (produced by digestion) is absorbed / enters blood; Decrease as used up/stored;	2	
(b)	(iii)	Curve roughly parallel to the x-axis or falling, starting from approximately the same point;	1	

2.

Part	Sub Part	Marking Guidance	Mark	Comments
(a)		Enzyme/active site has a (specific) tertiary structure; Only glucose has correct shape / is complementary / will bind/fit; To active site; (Forming) enzyme-substrate complex;	3 max	**Q** Allow second mark if candidate refers to correct shape or complementary in terms of the enzyme. Do not allow 'same' shape **Q** Do not allow third mark if active site is described as being on substrate.
(b)		(Only detects glucose whereas) Benedict's detects (all) reducing sugars/named examples; Provides a reading / is quantitative / Benedict's only provides a colour / doesn't measure concentration / is qualitative/semi-quantitative; Is more sensitive / detects low concentration; Red colour/colour of blood masks result; Can monitor blood glucose concentration continuously;	2 max	**Q** Do not credit quicker/more accurate unless qualified. **Q** Allow Benedict's detects monosaccharides for first mark point.
(c)	(i)	Broken down by enzymes / digested / denatured (by pH) too large to be absorbed;	1	

2 continued

(c)	(ii)	Study not carried out on humans / only carried out on rats; Long-term/side effects not known; Scientists have vested interest; Study should be repeated / further studies / sample size not known;	2 max	

3.

Part	Sub Part	Marking Guidance	Mark	Comments
(a)		Amylase; (Starch) to maltose: Maltase; Maltose to glucose; Hydrolysis; (Of) glycosidic bond;	5 max	**Q** Do not penalise incorrect site for digestion or incorrect site of enzyme production.

(b)		Low(er) <u>water potential</u> in lumen / intestine / gut; Water enters lumen / leaves (body) cells / by <u>osmosis</u>;	2	Accept: hypertonic instead of low(er) water potential Neutral: water does not leave lumen by osmosis **Q** Water potential must be in the correct context

4.

(a)(i)	Active site / enzyme not complementary; Active site changes (shape) / is flexible; (Change in enzyme allows) substrate to fit / E-S complex to form;	2 max	Active site becomes complementary / wraps around substrate = 2 marks For mark point 2. allow 'binding site' but not 'enzyme' For mark point 2. can only have enzyme changes (shape) if active site has been mentioned earlier Final mark point must have context Reject: active site on substrate for second marking point only Accept: diagrams only if suitably labelled or annotated
(a)(ii)	Active site does not change (shape) / is fixed (shape) / is rigid / does not wrap around substrate / (already) fits the substrate / is complementary (before binding);	1	Assume that 'it' refers to lock and key
(b)	Similar structure / shape (to PABA) / both complementary; Competes for / binds to active site / competitive inhibitor; Less PABA binds / less E-S complexes; ***OR*** Specific reference to different structure / shape (to PABA) using the diagram; Binds to position other than active site / binds to allosteric site / binds to inhibitor site / non-competitive inhibitor; Changes the active site so substrate cannot bind / less PABA binds / less E-S complexes;	3 max	**Q** Reject: same structure / shape Note: competitive inhibitor binds to active site = 1 mark (same mark point) Assume that 'it' refers to sulfanilamide Accept: PABA / substrate cannot bind Neutral: less product produced as in question stem Neutral: different structure / shape to PABA Reject: active site on substrate for second marking point only

5.

Part	Sub Part	Marking Guidance	Mark	Comments
(a)	(i)	Increases then plateaus / constant / steady / rate does not change; Correct reference. to 27/28 units; e.g. increases up to / plateaus at 27/28	2	Neutral: 'peaks' / 'reaches a maximum' / 'stops increasing' / 'no effect' instead of 'plateaus' Reject: rate decreases / reaction stops
(a)	(ii)	Substrate concentration / amount of substrate; As substrate concentration increases, rate increases / positive correlation (between rate and substrate concentration);	2	
(a)	(iii)	All active sites occupied / saturated / enzyme limiting (rate of reaction) / maximum number of E-S complexes;	1	Reject: enzymes used up Reject: substrate limits rate of reaction Neutral: substrate no longer limits the reaction Neutral: reference to temperature
(b)		Curve is lower and plateaus at a higher substrate concentration (it must also start at zero);	1	Accept: curve lower and joins existing curve at final point (with no plateau) Reject: if curve plateaus before original Reject: if curve plateaus lower than original
(c)	(i)	Methotrexate / drug is a similar shape / structure to substrate; Binds to / fits / is complementary to active site; Less substrate binds / less enzyme-substrate complexes formed;	2 max	**Q** Reject: same structure / shape **Q** Reject: reacts with active site Accept: substrate cannot bind / enzyme-substrate complex not formed
(c)	(ii)	Methotrexate / drug is only similar shape to specific substrate / only fits this active site; ***OR*** Methotrexate / drug is a different shape to other substrates / will not fit other active sites;	1	Assume that 'it' refers to the drug

6

(a) Lilac/purple/mauve/violet;
Xanthine oxidase is a protein; 2
Reject pink or blue as the resulting colour with biuret.

(b) Substrate has specific shape;
Allows binding/fitting/forms ES complex with active site;
Or
Active site has specific shape;
Allows binding/fitting/forms ES complex with substrate; 2
Accept structure ≡ shape

(c) Xanthine similar shape to drug;
Drug fits active site/competes for active site/is a competitive inhibitor;
Less/no uric acid formed; 3

Total 7

7

(a) Lowers activation energy (of reaction);
More molecules able to react;
By splitting the reaction into stages;
Allows E-S complex to be formed;
Provide a surface/place for reaction; 2 max

(b) (i) Sand + (boiled potato) + hydrogen peroxide/substrate;
To show that the enzyme produced the reaction / sand had no effect /
see if sand has an effect; 2

(ii) High temperature denatures / temperature affects rate of reaction /
volume of gas affected by heat / only one variable; 1

Total 5

8.

8(a)(i)	Hydrolysis;	1	Accept phonetic spelling. Ignore reaction.
(a)(ii)	(Alpha) glucose;	1	Accept α glucose. Reject β glucose / beta glucose
(b)(i)	Add Benedict's (reagent) and heat / warm; Red/orange/yellow/green (colour);	2	Reject Add HCl Accept brown, reject other colours
(b)(ii)	2 products / 2 sugars produced;	1	Look for idea of **two** Accept named monosaccharides produced. "More" insufficient for mark Neutral if incorrect products named Neutral "lactose is a polysaccharide" Neutral "lactose is not a reducing sugar" Neutral: Reference to surface area.
(c)	1. Galactose is a similar shape / structure to lactose/both complementary; 2. (Inhibitor / Galactose) fits into / enters / binds with active site (of enzyme); 3. Prevents/less substrate fitting into / binding with (active site) / fewer or no E-S complexes;	2 max	1. **Q** Reject: Same shape / structure 2. Accept blocks active site Look for principles: 1 Shape 2 Binding to active site 3 Consequence
(d)	Low / decreased water potential (in gut); Water enters gut / lumen / leaves cells by osmosis;	2	Neutral ref to concentrations Accept ψ for water potential

Question	Marking Guidance	Mark	Additional Guidance
9 (a)(i)	Increase to 30°C/31°C and then decreases / optimum or max rate at 30°C/31°C;	1	Accept: peak at 30°C/31°C
(a)(ii)	1. Enzyme denatured / hydrogen bonds/bonds holding tertiary structure broken / tertiary structure changed; 2. Change in shape of active site (of enzymes); 3. Substrate / protein no longer fits / binds (into active site) / few or no ES complexes; 4. More enzyme (molecules) denatured as temperature increased;	3 max	1. Reject: Peptide bonds broken Denatures active site = 2 marks for mp 1 and 2 2. **Q** Only allow second point if active site is used correctly Accept: active site no longer complementary 3. Accept: Substrate cannot bind to enzyme
(b)(i)	Use buffer / test pH (at end/ at intervals);	1	Accept a method of measuring pH. Reject litmus.
(b)(ii)	(30°C/31°C)Maximum rate / optimum temperature;	1	Accept other valid answers e.g. temp below 30°C as enzyme not denatured.
(b)(iii)	Works best at pH 6 / at higher pH activity decreases;	1	Accept converse Insufficient: pH 6 had largest clear area

Question	Marking Guidelines	Mark	Comments
10 (a)	1. Add Benedict's; 2. Heat; 3. Red/orange/yellow/green (shows reducing sugar present);	3	Hydrolyse with acid negates mp1 2. Accept warm, but not an unqualified reference to water bath 3. Accept brown
(b)(i)	1. Starch hydrolysed / broken down / glucose/maltose produced; 2. Lower water potential; 3. Water enters by osmosis;	3	1. Neutral: Sugar produced
(b)(ii)	Only 2 pHs studied/ more pHs need to be tested;	1	Accept: different amylase may have a different optimum pH

Question	Marking Guidelines	Mark	Comments
11(a)	Amino acid / amino acids ;	1	If anything else is given as well do not award mark.
(b)(i)	1. Affects one monomer/amino acid; 2. Not found in all active sites;	2	i.e. What is affected i.e. Where it is found. 2. Must relate to active site. Enzyme is insufficient.
(b)(ii)	1. **X**; 2. Enzyme in both pathways;	2	2 Award independently
(c)	1. Occupies/blocks/binds to active site; 2. Substrate will not fit / does not bind / no longer complementary to / enzyme-substrate complex not formed;	2	i.e. What it does in terms of the active site. 1. Ignore references to change in shape and shape of aspirin molecule. Ignore reference to competitive inhibitor i.e. Consequence required
(d)	1. Prevents/reduces formation of thromboxane; 2. Blood clots do not form / less likely to form; 3. (Do not block) coronary arteries / vessels; 4. Heart muscle/wall gets oxygen;	3 max	1. Must prevent/reduce production. 2. Accept converse from this point onwards 4. Reference to heart must be qualified.