B2aD The Digestive System and Enzymes: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The digestive system breaks down food into small molecules that can be absorbed.

(a) Name the enzyme that begins the chemical digestion of starch in the mouth. **(1)**

(b) State the organ where most absorption of small food molecules occurs. **(1)**

(c) Give two functions of the liver in digestion or absorption. **(2)**

(Total for Question 1 is 4 marks)

---

2 Lipase is an enzyme that acts on fats (lipids).

(a) State the product(s) formed when lipase acts on triglyceride fat molecules. **(1)**

(b) Name the substance produced by the liver that helps emulsify fats, increasing their surface area. **(1)**

(Total for Question 2 is 2 marks)

---

3 The gastric juice in the stomach has a low pH because it contains hydrochloric acid.

(a) Calculate the hydrogen ion concentration [H+] in mol/dm3 of gastric juice with pH 2. Show your working. **(2)**

.....

(Total for Question 3 is 2 marks)

4 A student measures the time taken for an amylase solution to break down starch using iodine. The student records the time taken at different temperatures and obtains these results:

Temperature 15 degrees C: 220 s
Temperature 25 degrees C: 130 s
Temperature 35 degrees C: 80 s
Temperature 45 degrees C: 240 s

Use the data to answer the following.

(a) State the temperature at which amylase activity appears to be highest. **(1)**

(b) Explain why the time increases again at 45 degrees C. **(1)**

(Total for Question 4 is 2 marks)

---

5 An experiment measures the initial rate of amylase by recording the time to decolourise iodine-starch. Two trials at 30 degrees C give times 100 s and 105 s. At 40 degrees C the times are 60 s and 58 s. Calculate the mean initial rate as 'starch decolourised per minute' for 30 degrees C and 40 degrees C. Show working.

(a) Calculate mean time for 30 degrees C and convert to decolourisation events per minute (use 1 event per run). **(2)**

.....

(b) Calculate mean time for 40 degrees C and convert to decolourisation events per minute. **(2)**

.....

(Total for Question 5 is 4 marks)

6 A student investigates how changing pH affects pepsin (a protease found in the stomach). The student prepares buffered solutions at pH 1.5, 2.5, 3.5 and 5.5 and measures the time taken for a fixed concentration of pepsin to hydrolyse a standard protein substrate. Results (time to complete hydrolysis): pH 1.5: 90 s; pH 2.5: 40 s; pH 3.5: 70 s; pH 5.5: 200 s.

Use these results to answer the following.

(a) State the pH at which pepsin activity is highest, and give the evidence from the data. **(2)**

(b) Explain why activity falls again at pH 1.5 and at pH 5.5. **(2)**

(Total for Question 6 is 4 marks)

---

7 Required practical style question: A student tests how bile affects the digestion of lipid by lipase. They set up four identical tubes containing the same volume of oil emulsion and the same concentration of lipase. Tube 1: no bile, tube 2: 0.5 cm3 bile, tube 3: 1.0 cm3 bile, tube 4: 2.0 cm3 bile. After 10 minutes at 37 degrees C they measure the decrease in turbidity (arbitrary units): tube1 5 units, tube2 12 units, tube3 20 units, tube4 20 units.

Answer the following about the investigation.

(a) State the relationship between bile volume and decrease in turbidity from these results. **(1)**

(b) Suggest one control variable the student should keep constant and why. **(1)**

(c) Explain why the decrease in turbidity shows a plateau between tubes 3 and 4. **(1)**

(Total for Question 7 is 3 marks)

8 A student measures the mass of a piece of intestine tissue sample before and after being placed in a solution containing protease for 30 minutes. Initial mass 1.20 g, final mass 0.96 g. Calculate the percentage decrease in mass and suggest one biological reason mass decreased.

(a) Calculate the percentage decrease in mass. Show your working. **(3)**

.....

(b) Suggest one biological reason why the tissue mass decreased after protease treatment. **(1)**

(Total for Question 8 is 4 marks)

---

9 Error analysis: A laboratory report states that 'increasing enzyme concentration always increases the rate of reaction'. A student repeats an experiment and finds that after a certain enzyme concentration, the rate no longer increases. Using scientific reasoning, critique the blanket statement and explain why the student's data show a plateau.

(a) Give one clear scientific reason why the statement 'increasing enzyme concentration always increases the rate' is incorrect. **(2)**

(b) Explain how the student's observed plateau supports your critique. **(2)**

(Total for Question 9 is 4 marks)

10 Extended response (6 marks). A new enzyme called protease X is being tested for use in a laundry detergent to remove protein stains at 30 degrees C. Describe and explain the scientific factors the manufacturer must consider when deciding whether protease X is suitable for the detergent. In your answer consider activity, stability and safety, and include any further tests you would recommend.

(Total for Question 10 is 6 marks)

---

11 A sample of saliva contains 0.025 mg of amylase per cm3. A test solution requires 5.0 cm3 saliva. Calculate the mass of amylase added to the test solution in micrograms (microg). Show working and state the final answer with units.

(a) Calculate the mass of amylase in mg in 5.0 cm3 of saliva. Show working. **(2)**

.....

(b) Convert the mass in mg to micrograms (microg). Show working and final answer. **(3)**

.....

(Total for Question 11 is 5 marks)

12 Stretch question: The small intestine has many villi which increase surface area. A student estimates that flattening all villi would reduce the absorptive surface area by 60%. Explain quantitatively how such a reduction in surface area would affect the rate of absorption of a simple sugar, assuming diffusion is the only limiting factor. State any assumptions you make.

(a) Explain quantitatively how a 60% reduction in surface area affects diffusion rate, assuming rate α surface area and all else equal. **(3)**

(b) State one biological assumption made in this quantitative argument. **(1)**

(Total for Question 12 is 4 marks)

Mark scheme · B2aD The Digestive System and Enzymes: Exam Drill

Question 1

- (a) **B1** amylase (salivary amylase) cao
- **(a) Answer: Amylase**
- (b) **B1** small intestine (accept small bowel) cao
- **(b) Answer: Small intestine**
- (c) **B1** produces bile, oe
- (c) **B1** stores and processes nutrients (eg converts glucose to glycogen) or detoxifies substances, oe
- **(c) Answer: Produces bile; stores and processes nutrients (for example converts glucose to glycogen) or detoxifies substances.**

Question 2

- (a) **B1** glycerol and fatty acids cao
- **(a) Answer: Glycerol and fatty acids**
- (b) **B1** bile cao
- **(b) Answer: Bile**

Question 3

- (a) **M1** uses relation $[H+] = 10^{-p}H$ and substitutes pH = 2
- (a) **A1** 0.01 mol/dm3 cao
- **(a) Answer: 0.01 mol/dm3**

Question 4

- (a) **B1** 35 degrees C (shortest time so highest rate) cao
- **(a) Answer: 35 degrees C**
- (b) **B1** enzyme denaturation at higher temperature reduces activity, oe
- **(b) Answer: Because the enzyme is denatured at the higher temperature, reducing its activity.**

Question 5

- (a) **M1** correct mean time for 30 C = (100 + 105)/2 = 102.5 s and converts to per minute: 60 / 102.5
- (a) **A1** 0.585 events per minute (to 3 s.f.) cao
- **(a) Answer: 0.585 per minute**
- (b) **M1** mean time = (60 + 58)/2 = 59 s and rate = 60 / 59
- (b) **A1** 1.02 events per minute (to 3 s.f.) cao
- **(b) Answer: 1.02 per minute**

Question 6

- (a) **B1** pH 2.5
- (a) **B1** evidence: shortest time (40 s) so fastest hydrolysis, oe
- **(a) Answer: pH 2.5, because the time is shortest at 40 s indicating fastest activity.**
- (b) **B1** pH 1.5 is too acidic and pH 5.5 too alkaline relative to optimum so enzyme shape is altered, oe
- (b) **B1** altered active site reduces ability to bind substrate, decreasing rate, oe
- **(b) Answer: Because both pH extremes alter the enzyme's shape and active site so it binds substrate less effectively, reducing activity.**

Question 7

- (a) **B1** increase in bile volume increases the decrease in turbidity up to 1.0 cm3; beyond that no further increase (plateau) cao
- **(a) Answer: Increasing bile increases decrease in turbidity up to 1.0 cm3, after which it plateaus.**
- (b) **B1** temperature (eg keep at 37 degrees C) because enzyme activity is temperature sensitive, oe
- **(b) Answer: Temperature, because enzyme activity changes with temperature.**
- (c) **B1** there is a limiting factor (eg enzyme concentration or substrate amount) so adding more bile does not increase the rate further, oe
- **(c) Answer: Because another factor limits digestion (for example enzyme concentration or substrate availability), so extra bile does not increase the rate.**

Question 8

- (a) **M1** calculates change: 1.20 - 0.96 = 0.24 g and divides by original: 0.24 / 1.20
- (a) **M1** multiplies by 100 or equivalent to find percent
- (a) **A1** 20% decrease cao
- **(a) Answer: 20%**
- (b) **B1** protease broke down proteins in the tissue into soluble amino acids which diffused out, reducing mass, oe
- **(b) Answer: Protease broke down proteins to soluble amino acids that diffused out of the tissue, reducing mass.**

Question 9

- (a) **B1** rate can become limited by substrate concentration so extra enzyme has no substrate to act on, oe
- (a) **B1** other factors such as temperature or pH can limit activity so increasing enzyme alone will not increase rate, oe
- **(a) Answer: Because the reaction can be limited by substrate concentration or by other conditions (temperature or pH), so extra enzyme cannot increase rate beyond a limit.**
- (b) **B1** plateau shows that beyond a certain enzyme concentration another factor is limiting (eg all substrate molecules are already bound), oe
- (b) **B1** this demonstrates the initial blanket statement is not universally true, oe
- **(b) Answer: The plateau shows that beyond a certain enzyme concentration another factor, such as substrate availability, is limiting the rate; this contradicts the blanket statement.**

Question 10

- **Level 3** (5-6): Detailed response that links multiple relevant factors: explains optimum activity at 30 degrees C, pH range in detergents, stability to surfactants and oxidising agents, safety (allergenic potential), and recommends appropriate tests. Uses scientific reasoning and gives examples.
- **Level 2** (3-4): Clear response that describes some factors such as activity at 30 degrees C and basic stability concerns, with some explanation and at least one recommended test.
- **Level 1** (1-2): Simple statements about activity or safety with little or no explanation; limited or no suggestions for tests.
- **Indicative content:**
  - state that enzyme must be active at 30 degrees C and explain how activity is measured (rate of stain removal at that temperature)
  - consider pH of detergent and required pH range for activity; explain that many detergents are alkaline so enzyme must be active and stable at higher pH
  - discuss stability to surfactants, oxidising agents (bleach) and high ionic strength; explain that protease may be inactivated by these components
  - consider thermal stability during manufacturing and storage; explain importance of shelf life
  - consider safety: potential for allergic reactions or degradation products; tests for toxicity and allergenicity
  - recommend lab tests: activity assays at 30 degrees C across pH range, stability tests with detergent ingredients, wash-cycle trials on stained fabrics, and safety testing

Question 11

- (a) **M1** multiplies concentration by volume: 0.025 mg/cm3 x 5.0 cm3
- (a) **A1** 0.125 mg cao
- **(a) Answer: 0.125 mg**
- (b) **M1** knows conversion 1 mg = 1000 microg and multiplies: 0.125 x 1000
- (b) **M1** shows multiplication giving 125
- (b) **A1** 125 microg cao
- **(b) Answer: 125 microg**

Question 12

- (a) **M1** states proportionality: rate is proportional to surface area (rate α area)
- (a) **M1** calculates new area = 40% of original so rate becomes 0.40 x original
- (a) **A1** concludes rate would be 40% of original (ie a 60% decrease) cao
- **(a) Answer: The absorption rate would fall to 40% of its former value (a 60% decrease), assuming diffusion rate is directly proportional to surface area.**
- (b) **B1** assumes diffusion is sole limiting factor and concentration gradient, diffusion distance and transporter density remain constant, oe
- **(b) Answer: Assumes diffusion is the only limiting factor and concentration gradient and diffusion distance stay the same.**