# 1.12 The Digestive System and Enzymes: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** Bile is produced and stored before it is released into the small intestine.

**(a)** Name the organ that produces bile. **(1)**

**(b)** Name the organ that stores bile before it is released. **(1)**

**(c)** State one function of bile in digestion. **(1)**

**(Total for Question 1 is 3 marks)**


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**2** Lactase is an enzyme that catalyses the breakdown of lactose (a sugar found in milk) into glucose and galactose in the small intestine. People with lactose intolerance produce very little or no lactase.

**(a)** Predict what happens to undigested lactose in a lactose-intolerant person after they drink milk. **(1)**

**(b)** Tom, a food scientist, develops a milk-based drink with lactase enzyme already added to it before it is sold, to make it suitable for lactose-intolerant people. Suggest why adding lactase directly to the drink allows lactose-intolerant people to digest the lactose it contains. **(2)**

**(c)** Tom tests the new drink by measuring the concentration of lactose remaining over time after adding a fixed amount of lactase, at 37°C. State two variables, other than temperature, that should be controlled between repeat tests to make the comparison valid. **(2)**

**(Total for Question 2 is 5 marks)**

**3** Explain how this meal is digested as it passes through the digestive system, referring to mechanical digestion, chemical digestion (naming enzymes and the products they produce) and the role of bile.

**(Total for Question 3 is 6 marks)**


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**4** Enzymes are described as being 'specific' to their substrate.

**(a)** Using the lock and key model, explain what is meant by an enzyme being 'specific'. **(2)**

**(b)** A student mixes protease enzyme with a starch solution. Use the lock and key model to explain why no reaction takes place. **(2)**

**(Total for Question 4 is 4 marks)**

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**5** Table 1 shows how the rate of reaction of amylase changes with pH, obtained by mixing amylase with starch solution at a fixed temperature using buffer solutions of different pH.

pH: 2, 4, 6, 7, 8, 10
Relative rate of reaction (arbitrary units): 0, 3, 8, 10, 6, 1

**(a)** Identify the optimum pH for amylase shown by the data in Table 1. **(1)**

**(b)** Describe the pattern shown by the data in Table 1 as pH increases from 2 to 10. **(2)**

**(c)** Explain, in terms of enzyme structure, why the rate of reaction is zero at pH 2. **(2)**

**(Total for Question 5 is 5 marks)**


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# Mark scheme · 1.12 The Digestive System and Enzymes: 30-minute Pack

## Question 1

(a) liver **B1**

**(a) Answer: Liver.**

(b) gall bladder **B1**

**(b) Answer: Gall bladder.**

(c) any one of: neutralises the acid from the stomach, producing an alkaline pH suitable for enzymes in the small intestine; OR emulsifies fats/lipids into smaller droplets, increasing the surface area for lipase to act on, oe **B1**

**(c) Answer: E.g. neutralises stomach acid to give an alkaline pH suited to the small intestine's enzymes; or emulsifies fats, increasing the surface area for lipase.**

## Question 2

(a) the lactose is not broken down/absorbed in the small intestine and passes into the large intestine, where gut bacteria act on it, causing digestive discomfort (e.g. bloating, wind, diarrhoea), oe **B1**

**(a) Answer: It is not digested or absorbed, and passes into the large intestine, where gut bacteria act on it, causing digestive discomfort.**

(b) the lactase added to the drink can catalyse the breakdown of the lactose in the drink itself, independently of the person's own (lacking) lactase, oe **B1**

(b) so the lactose is already broken down into glucose and galactose before/as the drink is consumed, which the person can absorb normally without needing their own lactase, oe **B1**

**(b) Answer: The added lactase breaks down the lactose in the drink itself, so it is already converted to glucose and galactose, which the person can absorb without needing their own lactase.**

(c) one correct variable to control, from: volume of milk/drink used; concentration/amount of lactase enzyme added; starting concentration of lactose in the drink; pH of the drink, oe **B1**

(c) a second, different correct variable from the same list (any two from the list, max 2 marks; do not credit the same variable twice) **B1**

**(c) Answer: Any two from: volume of drink used; concentration of lactase added; starting lactose concentration; pH of the drink.**

## Question 3

**Level 3** A detailed and logically structured explanation that clearly links mechanical digestion, the action of amylase, protease and lipase (with correct substrates and products), and the role of bile in emulsifying fat and neutralising stomach acid, to show how the meal is broken down into small, soluble molecules. **5-6**

**Level 2** The answer describes some relevant features of both mechanical and chemical digestion, naming at least two digestive enzymes and referring to bile, but the explanation of how these processes work together may be incomplete or not fully logically ordered. **3-4**

**Level 1** The answer includes simple, isolated statements about digestion, for example naming that food is broken down or naming one enzyme, with little or no reference to mechanical digestion, specific enzyme products, or the role of bile, and the answer is not well linked. **1-2**

**Level 0** No relevant content. **0**

**Indicative content:**

- Mechanical digestion (chewing in the mouth and churning in the stomach) breaks food into smaller pieces, increasing the surface area for enzymes to act on.
- Amylase (produced by the salivary glands and pancreas, acting in the mouth and small intestine) catalyses the breakdown of starch into sugars such as maltose and glucose.
- Protease (e.g. pepsin, produced in the stomach; also produced by the pancreas and small intestine) catalyses the breakdown of protein into amino acids.
- Lipase (produced by the pancreas, acting in the small intestine) catalyses the breakdown of lipids into fatty acids and glycerol.
- The stomach produces hydrochloric acid, which gives the acidic pH needed for pepsin to work and helps kill harmful bacteria in food.
- Bile is produced in the liver and stored in the gall bladder before being released into the small intestine.
- Bile neutralises the acidic mixture arriving from the stomach, producing an alkaline pH suited to the enzymes of the small intestine.
- Bile emulsifies lipids into smaller droplets, increasing the surface area available for lipase to act on and speeding up fat digestion.
- Each digestive enzyme is specific because the shape of its active site is complementary only to its particular substrate (the lock and key model).
- Sugars and amino acids are absorbed into blood capillaries in the villi of the small intestine. Most dietary lipids enter lacteals and pass through the lymph before reaching the blood.


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## Question 4

(a) the enzyme's active site has a shape that is complementary to (fits) only one particular substrate, oe **B1**

(a) the substrate binds to (fits into) the active site, forming an enzyme-substrate complex, allowing the reaction to take place, oe **B1**

**(a) Answer: An enzyme's active site has a shape complementary to only one substrate; that substrate fits into (binds to) the active site, forming an enzyme-substrate complex.**

(b) protease's active site shape is complementary to protein molecules, not to starch, oe **B1**

(b) the starch molecule's shape does not fit the protease's active site, so no enzyme-substrate complex can form and the reaction cannot take place, oe **B1**

**(b) Answer: Protease's active site is complementary to protein, not starch, so starch does not fit the active site; no enzyme-substrate complex forms and no reaction occurs.**

## Question 5

(a) pH 7 cao **B1**

**(a) Answer: pH 7.**

(b) the rate of reaction increases as pH increases from 2 up to a peak at pH 7, oe **B1**

(b) the rate of reaction then decreases as pH increases further, from pH 7 to pH 10, oe **B1**

**(b) Answer: The rate increases from pH 2 to a peak at pH 7, then decreases from pH 7 to pH 10.**

(c) a pH this far from the optimum breaks the bonds holding the enzyme's tertiary structure together, changing the shape of its active site (the enzyme is denatured), oe **B1**

(c) the substrate (starch) can no longer bind to/fit the active site, so no enzyme-substrate complexes form and the rate of reaction is zero, oe **B1**

**(c) Answer: At pH 2 the enzyme is denatured (its active site shape is changed), so starch can no longer bind to the active site and the rate of reaction is zero.**


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