

1 There are enzymes in biological washing powders. Biological washing powder has to be used at temperatures below 45 °C.

- (a) The enzymes in biological washing powders do **not** work on the stains on clothes at temperatures above 45 °C.

Explain why.

(2)

- (b) Some bacteria, called thermophilic bacteria live in hot springs at temperatures of 80 °C.

Scientists have extracted enzymes from these thermophilic bacteria. These enzymes are being trialled in industrial laundries.

The laundries expect to increase the amount of clothes they can clean by using enzymes from thermophilic bacteria instead of using the biological washing powders the laundries use now.

- (i) The laundries expect to be able to increase the amount of clothes that they can clean each day.

Suggest why.

(2)

- (ii) Using washing powders with enzymes from thermophilic bacteria may be more harmful to the environment than using the biological washing powders that laundries use now.

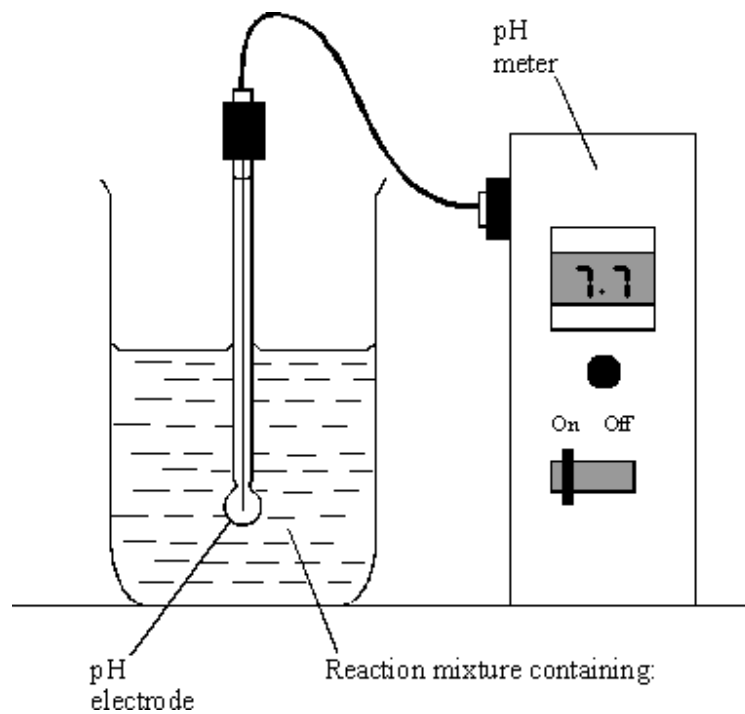
Suggest why.

(2)

(Total 6 marks)

2

The diagram shows the apparatus used to investigate the digestion of milk fat by an enzyme. The reaction mixture contained milk, sodium carbonate solution (an alkali) and the enzyme. In Experiment 1, bile was also added. In Experiment 2, an equal volume of water replaced the bile. In each experiment, the pH was recorded at 2-minute intervals.



Either: **Experiment 1**

milk (contains fat)
sodium carbonate solution
bile
enzyme

or: **Experiment 2**

milk (contains fat)
sodium carbonate solution
water
enzyme

The results of the two experiments are given in the table.

Time in minutes	pH	
	Experiment 1: with bile	Experiment 2: no bile
0	9.0	9.0
2	8.8	9.0
4	8.7	9.0
6	8.1	8.8
8	7.7	8.6
10	7.6	8.2

- (a) Milk fat is a type of lipid. Give the name of an enzyme which catalyses the breakdown of lipids.

(1)

- (b) What was produced in each experiment to cause the fall in pH?

(1)

- (c) (i) For Experiment 1, calculate the average rate of fall in pH per minute, between 4 minutes and 8 minutes. Show clearly how you work out your final answer.

_____pH units per minute

(2)

- (ii) Why was the fall in pH faster when bile was present?

(1)

(Total 5 marks)

3

Bile is produced in the liver, stored in the gall bladder, then released into the small intestine.

(a) Explain how bile affects the digestion of food in the small intestine.

(2)

(b) Bile contains bile pigments and cholesterol.

If the diet contains too much cholesterol, some of it may form 'gallstones' in the bile.

These gallstones may prevent bile from moving out of the gall bladder into the small intestine.

Bilirubin is a yellow-brown bile pigment. This pigment is produced by the liver from haemoglobin released by broken-down red blood cells.

Suggest how gallstones may produce the following symptoms:

(i) very pale faeces

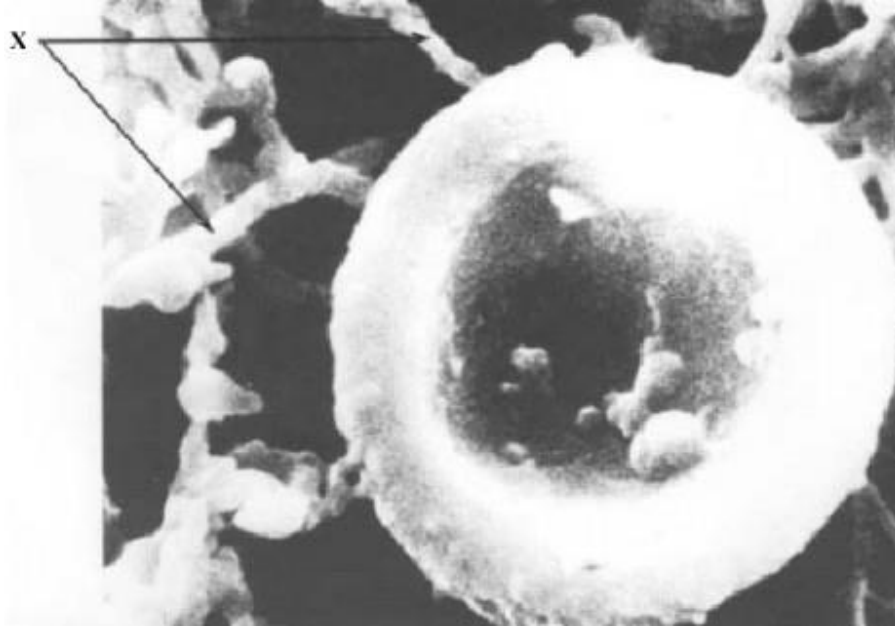
(2)

(ii) jaundice (a yellow tinge to the skin).

(2)

(Total 6 marks)

- 4 The photograph shows a red blood cell in part of a blood clot. The fibres labelled **X** are produced in the early stages of the clotting process.



- (a) Suggest how the fibres labelled **X** help in blood clot formation.

(1)

- (b) The average diameter of a real red blood cell is 0.008 millimetres.
On the photograph, the diameter of the red blood cell is 100 millimetres.

Use the formula to calculate the magnification of the photograph.

$$\text{Diameter on photograph} = \text{Real diameter} \times \text{Magnification}$$

$$\text{Magnification} = \underline{\hspace{2cm}}$$

(2)

- (c) Some blood capillaries have an internal diameter of approximately 0.01 millimetres.
- (i) Use information given in part (b) to explain why only one red blood cell at a time can pass through a capillary.

(1)

(ii) Explain the advantages of red blood cells passing through a capillary one at a time.

(3)

(Total 7 marks)

5

A manufacturer is trying to improve the quality of the biological detergent he produces.

Scientists at his company carried out the following experiments on enzymes:

- Samples of lipase were collected from five different types of bacterium, **A**, **B**, **C**, **D** and **E**.
- The samples were diluted to give the same concentration of lipase.
- Agar jelly containing a lipid was prepared in a dish. This forms a cloudy mixture which becomes clear when the lipid is digested.
- Five small holes were cut into the agar.
- Two drops of lipase solution from bacterium **A** was added to hole **A**.
- This process was repeated for each sample of lipase.

Diagram 1 shows the appearance of the dish.

Diagram 1

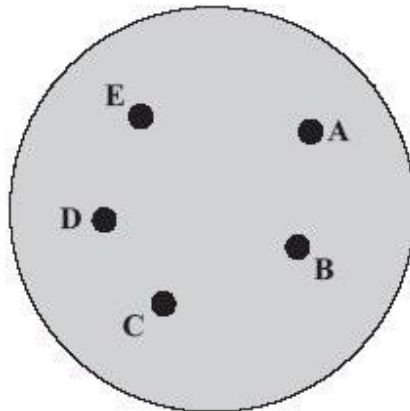
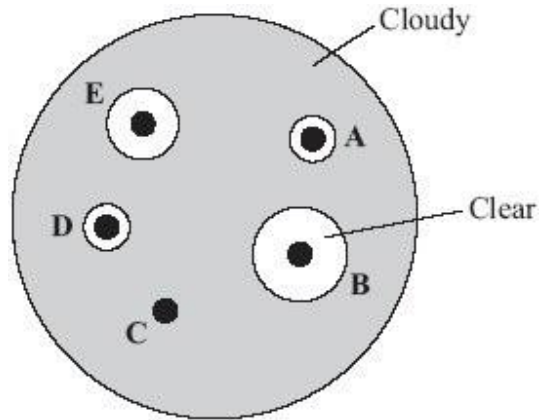


Diagram 2 shows the appearance of the dish 24 hours later.

Diagram 2



- (a) (i) Which type of bacterium, **A**, **B**, **C**, **D** or **E**, produced the most effective lipase in this investigation?

Write your answer, **A**, **B**, **C**, **D** or **E**, in the box.

(1)

- (ii) Explain your answer.

(1)

- (b) The manufacturer plans to add the most effective lipase to the washing powders he produces.

Suggest **two** other factors he should investigate before deciding which lipase is the most effective.

1. _____

2. _____

(2)

- (c) Many biological detergents cannot be used at high temperatures.

Explain why.

(1)

(Total 5 marks)

6 Starch is broken down into sugar by amylase. Amylase is produced in the salivary glands.

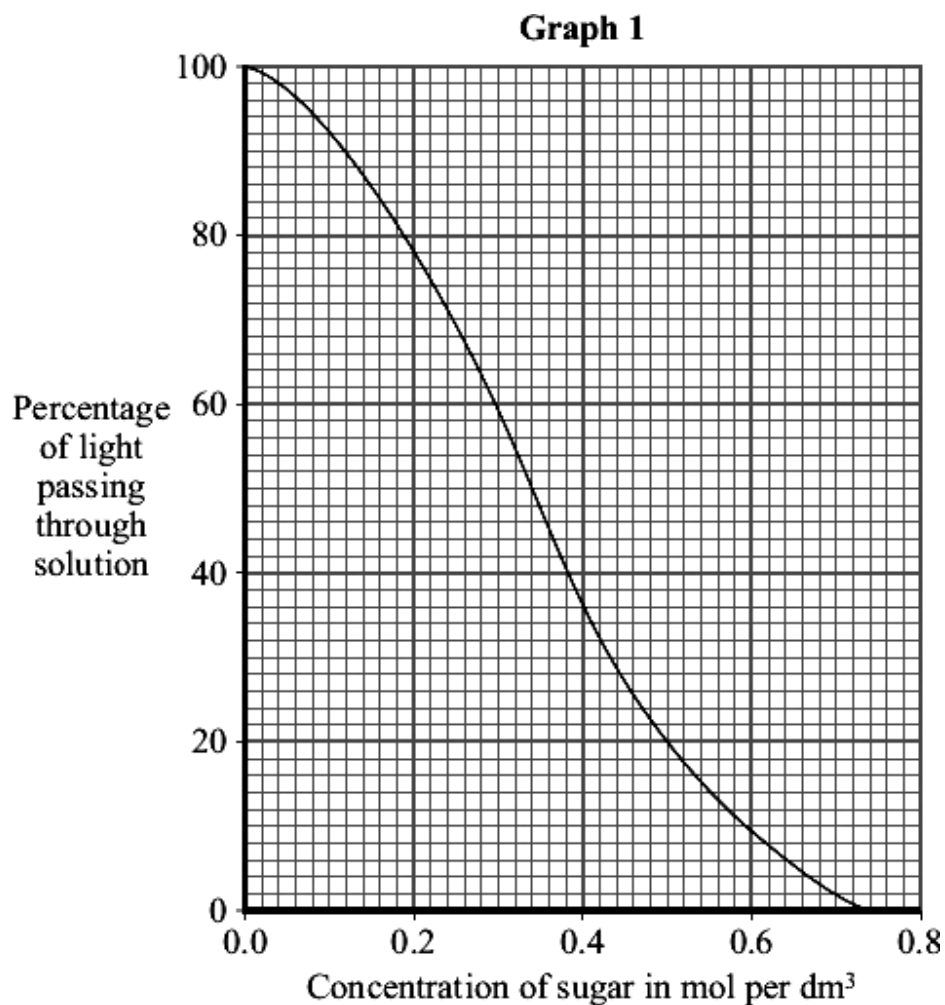
(a) Name **two** other organs in the digestive system which produce amylase.

_____ and _____

(2)

- (b) A colorimeter measures colour intensity by measuring the percentage of light that passes through a solution.

Graph 1 shows the percentage of light passing through sugar solutions of different concentrations to which a test reagent has been added.



Students used a colorimeter to compare the starch-digesting ability of amylase enzymes obtained from two organs, **P** and **Q**.

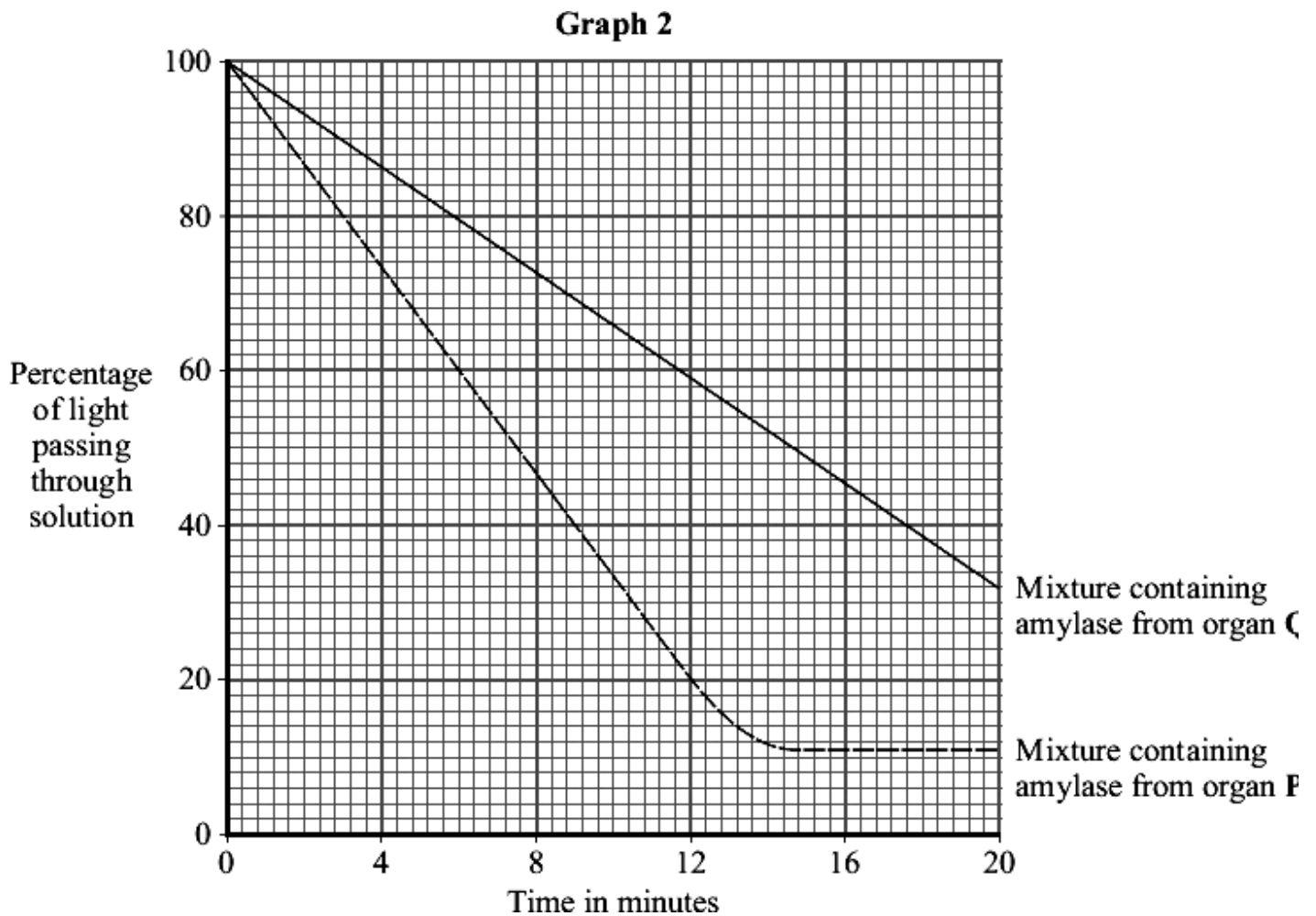
- The students collected 5 cm³ samples of amylase from **P** and **Q** and placed them into a water-bath at 40 °C.
- Two test tubes containing 10 cm³ samples of starch solution were also placed into the water-bath.
- All the tubes were left in the water-bath for 10 minutes.
- Each amylase sample was added to one of the tubes containing the starch solution.
- The test tubes were placed back into the water-bath.
- Every minute, a few drops were taken from each tube, the test reagent was added and the percentage of light passing through this solution was measured in the colorimeter.

The tubes containing amylase samples and starch solution were left in the water-bath for ten minutes before the amylase was added to the starch.

Explain why.

(2)

(c) **Graph 2** shows how the readings from the colorimeter changed over the next 20 minutes.



(i) Use **Graph 1** and **Graph 2** to determine the concentration of sugar in the mixture from organ **Q** after 20 minutes.

Answer _____ mol per dm³

(1)

- (ii) Use your answer to (c)(i) to calculate the rate at which sugar was produced in the mixture containing amylase from organ **Q**.

Show clearly how you work out your answer.

Answer _____ mol per dm³ per minute

(2)

- (iii) Suggest why the amount of light passing through the mixture from organ **P** did not change after 16 minutes.

(1)

- (iv) One of the students suggested that they could have completed their experiment more quickly if the temperature of the water-bath had been set at 80 °C.

This would **not** have been the case.

Explain why.

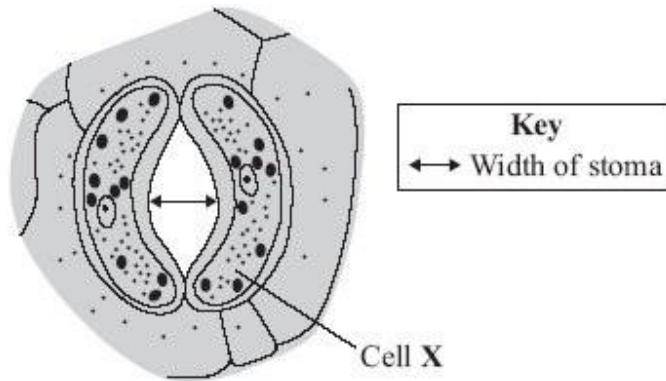
(2)

(Total 10 marks)

7

Plant leaves have many stomata.

The diagram shows a stoma.



(a) Name cell X _____

(1)

(b) The table shows the mean widths of the stomata at different times of the day for two different species of plant.

Species **A** normally grows in hot, dry deserts.

Species **B** grows in the UK.

	Time of day in hours	Mean width of stomata as a percentage of their maximum width	
		Species A	Species B
	0	95	5
Dark	2	86	5
	4	52	6
Light	6	6	40
	8	4	92
	10	2	98
	12	1	100
	14	0	100
	16	1	96
	18	5	54
Dark	20	86	6
	22	93	5
	24	95	5

The data in the table show that species **A** is better adapted than species **B** to living in hot, dry deserts.

Explain how.

(4)

(Total 5 marks)

8 Oxygen is transported round the body by the blood.

Blood leaving the human lung can carry about 250 milligrams of oxygen per litre.
However, only 7 milligrams of oxygen will dissolve in one litre of water at body temperature.

(a) Suggest an explanation for the difference.

(2)

- (b) Blood leaving the skeletal muscles during exercise may contain only 30 milligrams of oxygen per litre.

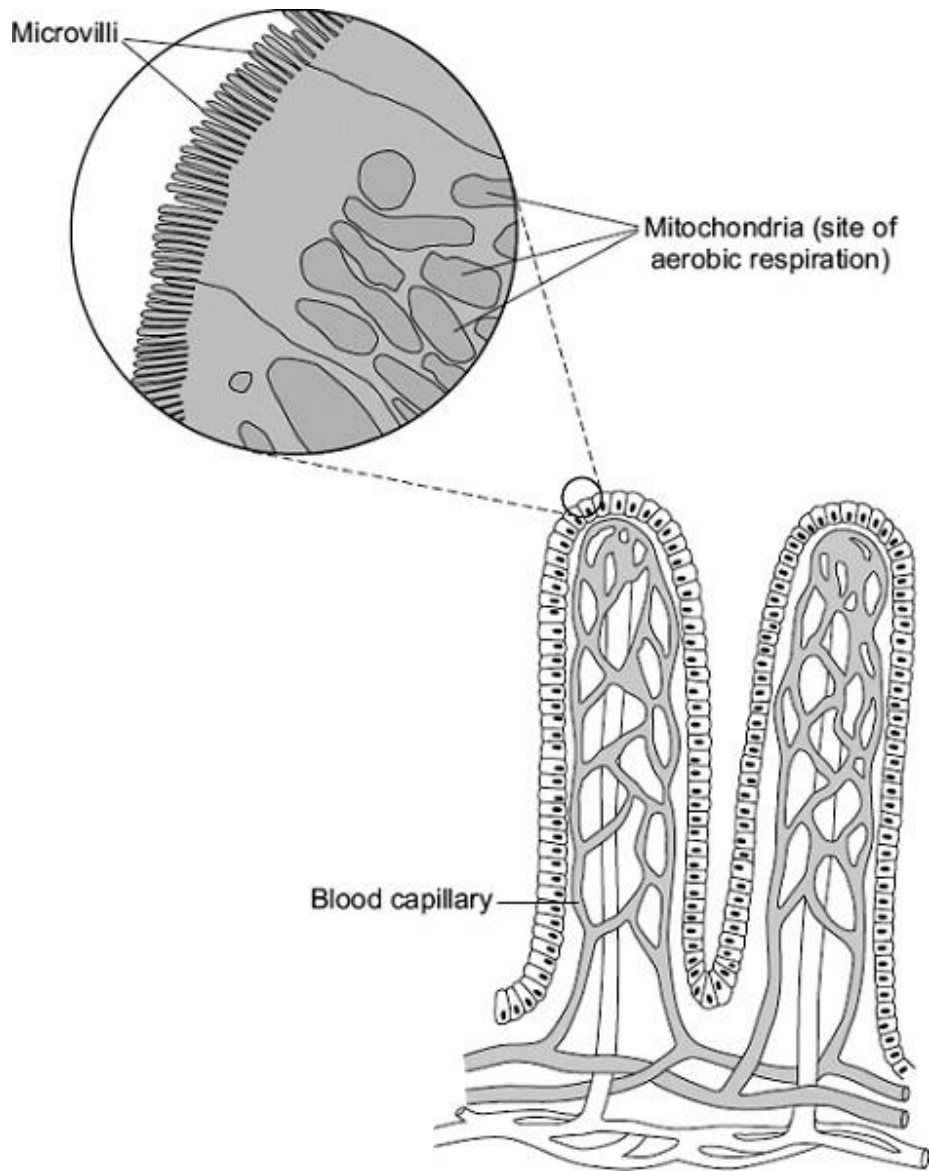
Explain what causes the difference in oxygen concentration between the blood leaving the lungs and the blood leaving the skeletal muscles.

(4)
(Total 6 marks)

9

The villi of the small intestine absorb the products of digestion.

The diagram shows two villi. It also shows parts of some of the surface cells of a villus, as seen with an electron microscope.



Describe and explain how the villi are adapted to maximise the rate of absorption of the products of digestion.

(Total 5 marks)

10

Fresh milk is a mixture of compounds including fat, protein and about 5 % lactose sugar. Lactose must be digested by the enzyme lactase, before the products can be absorbed.

Lactase can be added to fresh milk to pre-digest the lactose. This makes 'lactose-free' milk, which is suitable for people who do not produce enough lactase of their own.

A student investigated the effect of changing pH and temperature on the digestion of lactose in milk.

The results are shown in **Tables 1** and **2**.

Table 1
Effect of pH

pH	Time taken to digest lactose in minutes
4.0	20
5.0	18
6.0	13
7.0	7
8.0	5
9.0	6

Table 2
Effect of temperature

Temperature in °C	Time taken to digest lactose in minutes
30	20
35	14
40	11
45	6
50	12
55	23

(a) The label on a carton of lactose-free milk states:

'Lactase is normally produced in the stomach of mammals.'

The results in **Table 1** show that this statement is unlikely to be true.

Explain how.

(2)

(b) Explain as fully as you can the results shown in **Table 2**.

(3)

(c) Bile is produced in the liver and is released into the small intestine.

Explain how bile helps the digestion of milk.

(2)

(Total 7 marks)

Mark schemes

- 1** (a) shape changed / destroyed (above 45 °C)
accept denatured
accept active site changed
*do **not** accept enzyme killed*

1

(shape) doesn't fit (other molecules / stain)

1

- (b) (i) any **two** from:

- can wash the clothes at higher temperature
- so wash / enzyme action will be quicker
*do **not** accept idea of bacteria working faster*
- enzyme not destroyed at high temperature / 80 °C
accept denaturation or description

2

- (ii) high(er) temperature / 80 °C uses more energy / fuel

1

more pollution / named (eg carbon dioxide / global warming) (from electricity production)

or

increased release of hot water (into the environment)

1

[6]

2

- (a) lipase

1

- (b) fatty acid

ignore glycerol

1

- (c) (i) 0.25 or $\frac{1}{4}$

if correct answer ignore working or lack of working

$$\frac{(8.7 - 7.7)}{4} \text{ for 1 mark}$$

2

- (ii) fats emulsified **or** described re. Small droplets **or** large S.A.
(for enzyme action) **or** fats 'mix' better with water

do not allow breakdown / breakup unqualified

1

[5]

3

- (a) any **two** from:

- neutralises acid / makes conditions alkaline / raises pH
- enzymes (in small intestine) work (more/most effectively)
or stop/prevents enzymes being denatured
- emulsifies fats/lipids **or** description of emulsification
do not accept breakdown unqualified

- larger surface area

2

- (b) (i) bile / bilirubin / pigment / broken down haemoglobin /
substance / cholesterol linked to movement **or** effect

1

does **not** get to the intestine / food / faeces
or cannot leave liver **or** effect not happening (in intestine)

1

- (ii) bilirubin / pigment / broken down haemoglobin
not 'bile' alone

1

(deposited) in skin
*only award if bilirubin / pigment / broken down haemoglobin given
allow carried in the blood*

1

[6]

4

- (a) hold cells together **or** prevent flow of cells **or** trap cells

1

- (b) 12500

if correct answer, ignore working / lack of working

$$\frac{100}{0.008} \text{ for 1 mark}$$

ignore any units

2

(c) (i) size RBC approximately same size capillary **or**
no room for more than one cell **or**
only one can fit **or**
RBC is too big
allow use of numbers
*do **not** accept capillaries are narrow*

1

(ii) more oxygen released (to tissues) **or**
more oxygen taken up (from lungs)

1

and any **two** from:

- slows flow **or** more time available
- shorter distance (for exchange) **or** close to cells / capillary wall
- more surface area exposed

2

[7]

5

(a) (i) B

1

(ii) any **one** from:

- largest area of / most digestion (of lipid)
allow agar / jelly / mixture broken down / digested
*do **not** allow digestion of bacteria / lipase*
*ignore digestion **by** bacteria*
- largest clear area

1

(b) any **two** from:

- effect of pH / pH described
- effect of temperature
- effect on different types of lipid / fat
- cost **or** allergic reactions **or** effect on skin / fabrics / **or**
environment **or** interaction with other chemicals in
powder **or** shelf life

2

(c) enzymes / named enzyme denatured / destroyed
allow active site(of enzyme) altered

1

[5]

6

(a) pancreas
either order

1

small intestine

1

(b) any **two** from:

- to give them time to come to temperature of the water-bath
accept so (they / both) are at the same temperature
- at / near body temperature / best / optimum temperature
- otherwise reaction would take place at a series of different temperatures
or sensible statement about control / fair test

2

(c) (i) 0.42

allow in range 0.42 to 0.425

1

(ii) 0.021

*correct answer with or without working
allow ecf from (c)(i) ie (c)(i) ÷ 20 correctly calculated for **2** marks
if answer incorrect 0.42 ÷ 20 **or** (c)(i) ÷ 20 gains **1** mark*

2

(iii) (all) starch digested / gone / used up / turned to sugar

allow the amount of sugar stays the same / maximum

1

(iv) any **two** from

allow reference to active site once only as alternative to first or second bullet point

- enzyme destroyed / denatured / damaged / shape changed
*do **not** accept killed*
- unable to fit (starch molecule)
- starch can't be digested
enzymes don't work is insufficient

2

[10]

7 (a) guard (cell)

ignore stoma / stomata

1

(b) Species A:

- stomata open in dark / at night **or** close in light / in day 1
- stomata closed during warm(est) period **or** open when cool(er) 1
- heat (energy) / warmth increases evaporation / transpiration
must give explicit link between heat and transpiration 1
- reduces water loss / evaporation / transpiration
ignore photosynthesis
allow converse points for species B 1

[5]

8

(a) blood has red (blood) cells / haemoglobin 1

haemoglobin combines with / carries oxygen
ignore 'mix'
NB Blood can form oxyhaemoglobin = 2 marks 1

(b) blood gains oxygen / becomes oxygenated (in the lungs)
idea of acquiring oxygen must be unambiguous 1

blood loses oxygen to the muscles / cells 1

because muscles are respiring (aerobically) 1

to provide energy (for exercise) 1

[6]

9

D – *many* microvilli (1)

Ex – provide large surface area (1)

five points made

max 3 descriptions

max 3 explanations

D – *many* capillaries / good blood supply (1)

Ex – maintain concentration / diffusion gradient **or** quickly removes food (1)

D – thin wall / one cell thick surface / capillaries near surface (1)

allow villi are thin

ignore villi are one cell thick

Ex – short distance for food to travel (1)

D – *many* mitochondria (1)

Ex – provide energy / ATP for active uptake / transport (1)

[5]

10

(a) stomach is acidic / has low pH

allow any pH below 7

ignore stomach is not alkaline

1

lactase works best / well in alkali / high pH / neutral / non-acidic conditions

allow any pH of 7 and above

accept works slowly in acid conditions

*allow figures from table with a **comparison***

ignore reference to temperature

1

(b) any **three** from

- (below 45(°C)) increase in temperature increases rate / *speed* of reaction
- reference to molecules moving faster / colliding faster / harder / more collisions
- optimum / best at 45(°C)
allow value(s) in range 41 - 49
- high temps / above 45(°C) (rate slows due to) denaturation of enzyme /lactase
*allow synonyms of denaturation but **not** killed*
*denaturation at high **and** low temperature does **not** gain this mark*
ignore body temperature
ignore references to time / pH

3

(c) any **two** from

- acid neutralised **or** conditions made neutral / alkali
accept bile is alkaline
- (allow) emulsification / greater surface area of fat / lipid
allow description of emulsification eg fat is broken down / broken up into droplets
- enzymes (in small intestine) work (more effectively / better)
allow better for enzymes

2

[7]