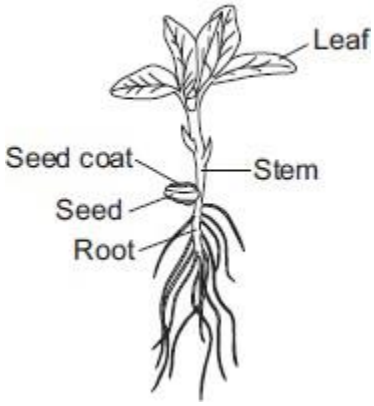
1 Catalase is an enzyme found in many different tissues in plants and animals. It speeds up the rate of the following reaction.

$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water + oxygen}$$

Figure 1 shows a 25-day-old broad bean seedling.

Figure 1



Some students investigated whether different parts of bean seedlings contained different amounts of catalase.

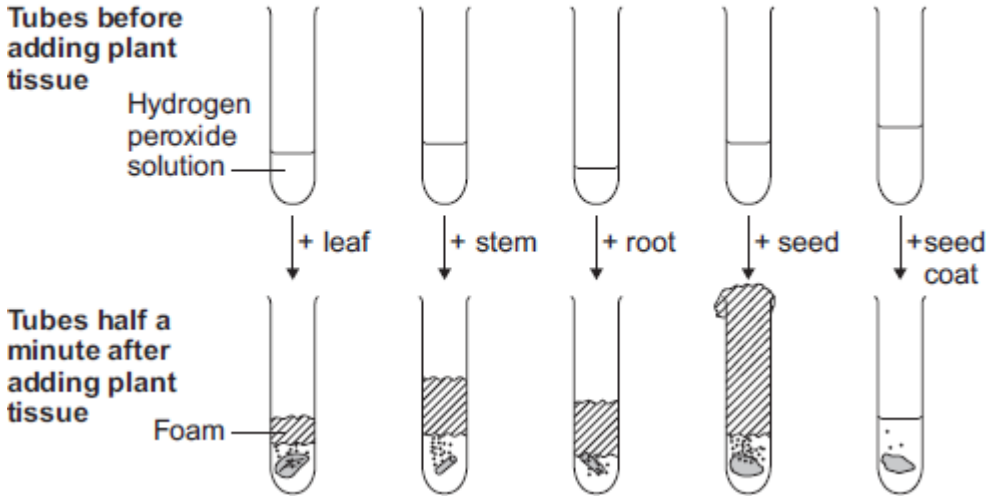
The students:

- put hydrogen peroxide into five test tubes
- added a different part of a bean seedling to each tube
- recorded the results after half a minute.

If there was catalase in part of the seedling, oxygen gas was given off.
When oxygen gas is given off, foam is produced in the tubes.

Figure 2 shows the results.

Figure 2



The students made the following conclusions:

- most parts of a bean seedling contain catalase
- the seed contains a lot of catalase
- stems and roots have quite a lot of catalase
- the leaves have a little bit of catalase
- the seed coat has hardly any catalase.

The students' teacher said that the students needed to improve their investigation in order to make valid conclusions.

(a) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Describe how you would carry out an investigation to compare the amounts of catalase in different parts of bean seedlings.

You should include details of how you would make sure your results give a valid comparison of the amounts of catalase.

(6)

(b) Scientists investigated the effect of pH on the activity of the enzyme catalase in a fungus.

The table below shows the scientists' results.

pH	Enzyme activity in arbitrary units					
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Mean**
3.0	0	0	0	0	0	0
4.0	6	5	8	4	7	6
5.0	38	65	41	42	39	
5.5	80	86	82	84	88	84
6.0	100	99	96	103	102	100
6.5	94	92	90	93	91	92
7.0	61	63	61	62	63	62
8.0	22	22	21	24	21	22

(i) Calculate the mean enzyme activity at pH 5.0.

_____

_____

Mean =_____arbitrary units

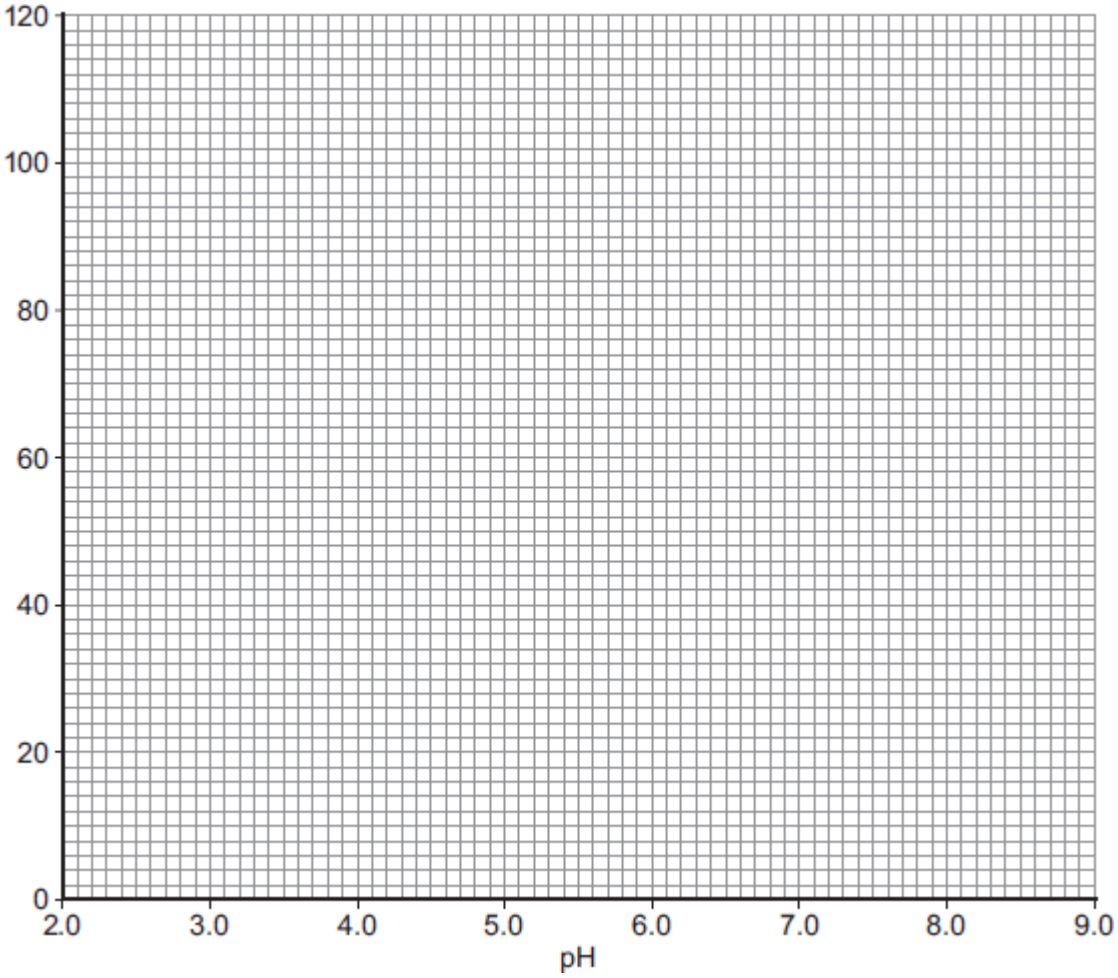
(2)

(ii) On the graph paper in **Figure 3**, draw a graph to show the scientists' results.

Remember to:

- add a label to the vertical axis
- plot the mean values of enzyme activity
- draw a line of best fit.

Figure 3



(4)

(iii) At what pH does the enzyme work best?

_____

(1)

(iv) Predict the activity of the enzyme at pH 9.0.

_____arbitrary units

(1)

(v) Suggest why the enzyme's activity at pH 3.0 is zero.

_____

_____

(1)

(Total 15 marks)

2 (a) High-fructose corn syrup (HFCS) is used instead of sucrose as a sweetener in many types of food.

Table 1 shows the relative sweetness of different types of sugar.

Table 1

Sugar	**Relative sweetness**
Fructose	173
Glucose	74
Lactose	16
Sucrose	100

(i) One of the sugars was used as a 'standard' measure of sweetness.

The sweetness of all the other sugars was compared with this.

Which sugar was used as the standard of sweetness?

_____

(1)

(ii) Fructose is used instead of sucrose in many types of food.

Suggest why.

Use information from **Table 1** in your answer.

_____

_____

_____

_____

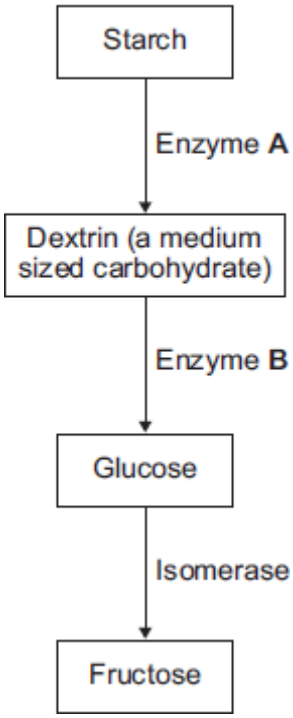
_____

_____

(3)

(b) **Diagram 1** shows the main stages in the industrial production of fructose for use in HFCS.

Diagram 1



(i) **A** and **B** are two enzymes that digest carbohydrates.

What general name do scientists give to enzymes like **A** and **B**?

Tick (✓) **one** box.

carbohydrases ☐

lipases ☐

proteases ☐

(1)

(ii) The enzymes in **Diagram 1** come from bacteria that live in hot springs.

The enzymes work best at a temperature of 60 °C.

What would happen to most enzymes at a temperature of 60 °C?

_____

_____

(1)

(iii) It is an advantage to carry out these reactions in the industrial production of HFCS at 60 °C.

Suggest why.

_____

_____

_____

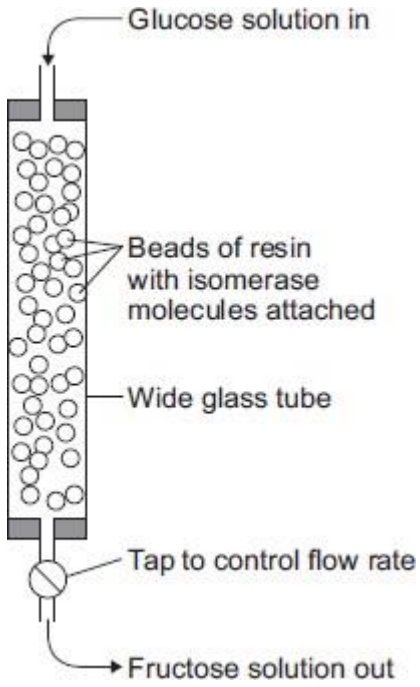
_____

(2)

Isomerase is used in an immobilised form in the production of HFCS. Isomerase molecules are immobilised by attaching them to beads made of resin in a glass tube.

Diagram 2 shows how immobilised isomerase is used.

Diagram 2



(c) An alternative to using immobilised isomerase is to mix isomerase solution with glucose solution in a large container.

Suggest **two** advantages of using immobilised isomerase, rather than isomerase solution, in the production of HFCS for use in human foods.

1. _____

_____

2. _____

_____

(2)

(d) **Table 2** shows some differences between the industrial production of HFCS from glucose using:

- isomerase solution
- immobilised isomerase.

Table 2

	Isomerase solution	**Immobilised isomerase**
Reaction container volume in m^3	1100	15
Time taken for reaction in hours	20	0.5
Temperature in °C	65	60
Number of product refining stages	4	1
Total production cost in £ per tonne	500	5

Explain how factors given in **Table 2** help to lower production costs when using the immobilised enzyme.

(3)

(e) **Table 3** gives information about the half-life of isomerase in the two processes.

The **half-life** of the enzyme is the time it takes for the enzyme's activity to fall to half its starting value.

The **active life** of the enzyme is the time for which it can be used before it is thrown away.

Table 3

	Isomerase solution	**Immobilised isomerase**
Half-life of enzyme in hours	30	1500
Active life of enzyme in half-lives	0.7	3

(i) Using the information from **Table 3**, we can calculate that the active life, in hours, of isomerase solution is 21 hours.

Calculate the active life, in hours, of **immobilised isomerase**.

_____

_____

Active life of immobilised isomerase = _____ hours

(2)

(ii) A high active life of isomerase is important in lowering the production costs of HFCS.

Explain why.

_____

_____

_____

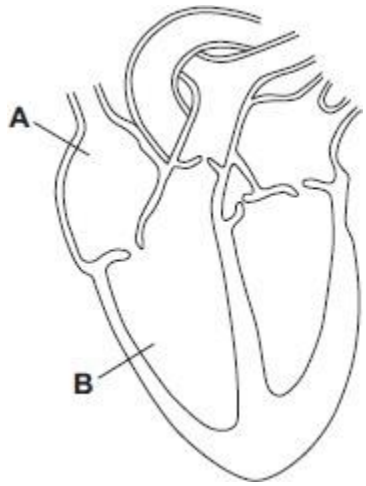
_____

(2)

(Total 17 marks)

3 **Diagram 1** shows a section through the heart.

Diagram 1



(a) Use words from the box to name the structures labelled **A** and **B** on **Diagram 1**.

aorta	**atrium**	**pulmonary artery**	**ventricle**

A _____

B _____

(2)

(b) The tissue in the wall of the heart contracts.

(i) What type of tissue is this?

Tick (✓) **one** box.

muscular ☐

glandular ☐

epithelial ☐

(1)

(ii) What does the heart do when this tissue contracts?

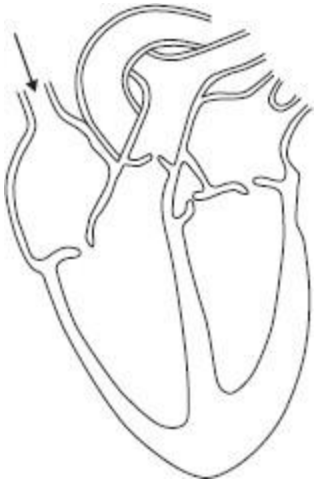
_____

_____

(1)

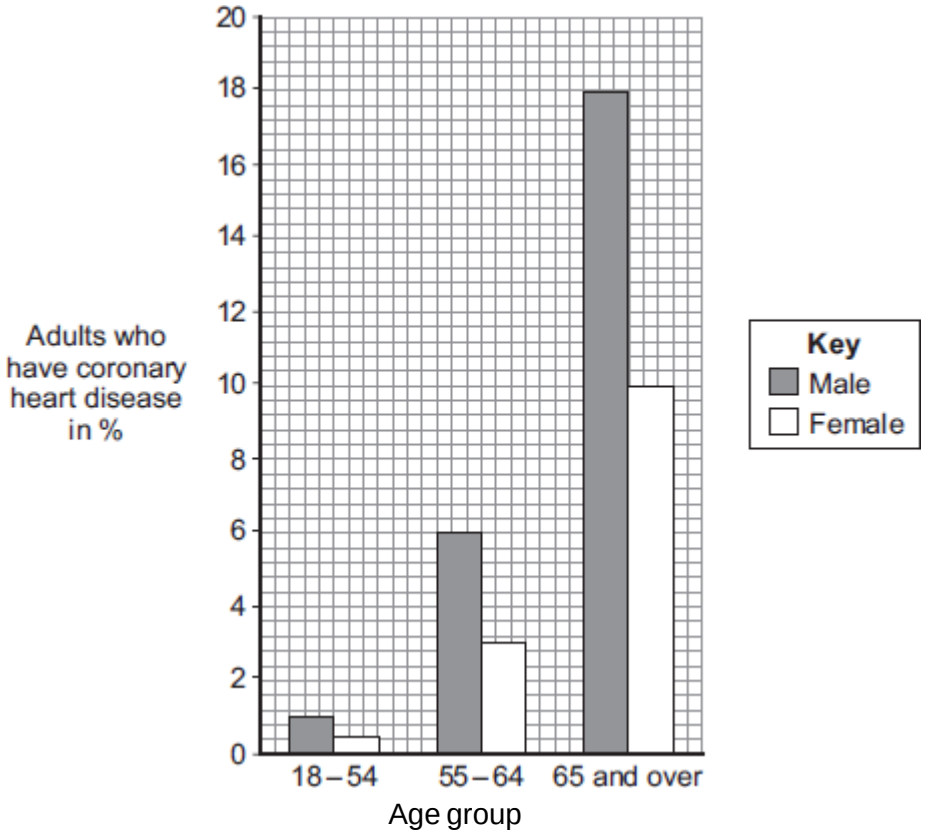
(c) Draw arrows on **Diagram 2** to complete the route taken by deoxygenated blood through the heart.

Diagram 2



(2)

(d) The graph shows the percentage (%) of adults in the UK who have coronary heart disease.



(i) Look at the graph.

Which group of people is **most** at risk of having coronary heart disease in the UK?

_____

(2)

(ii) Explain what happens to the heart in coronary heart disease.

_____

_____

_____

_____

_____

_____

(3)

(Total 11 marks)

4 Lipase is an enzyme that digests fat.

(a) (i) Complete the equation to show the digestion of fat.

Use the correct answer from the box.

glucose	**glycerol**	**glycogen**

fat $\xrightarrow{\text{lipase}}$ fatty acids + _____

(1)

(ii) Name **one** organ that makes lipase.

_____

(1)

(b) Some students investigated the effect of bile on the digestion of fat by lipase.

The students:

1 mixed milk and bile in a beaker
2 put the pH sensor of a pH meter into the beaker
3 added lipase solution
4 recorded the pH at 2-minute intervals
5 repeated steps 1 to 4, but used water instead of bile.

Suggest **two** variables that the students should have controlled in this investigation.

1. _____

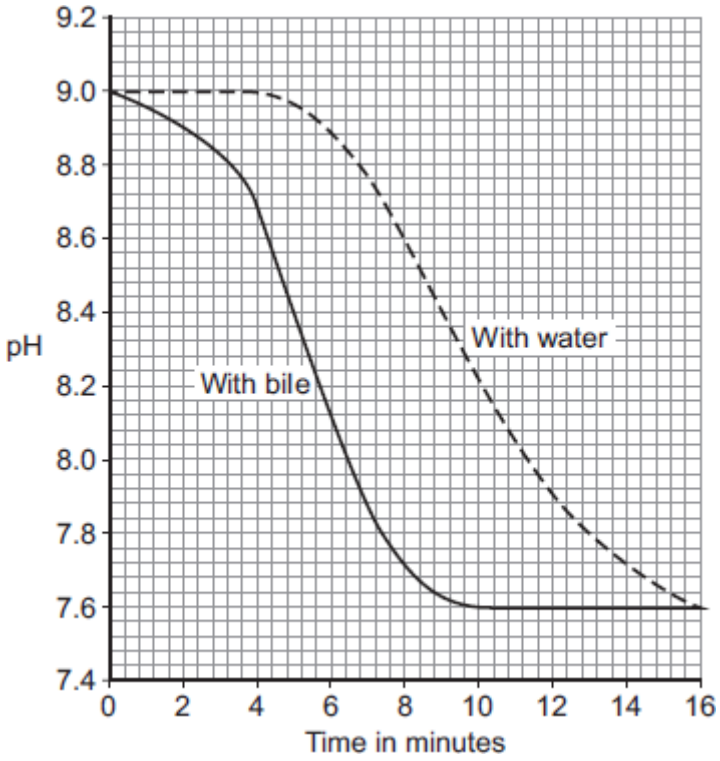
_____

2. _____

_____

(2)

(c) The graph shows the students' results.



(i) Why did the pH decrease in both investigations?

_____

_____

(1)

(ii) Bile helps lipase to digest fat.

What evidence is there in the graph to support this conclusion?

_____

_____

(1)

(iii) Suggest **one** reason why the contents of both beakers had the same pH at the end of the investigations.

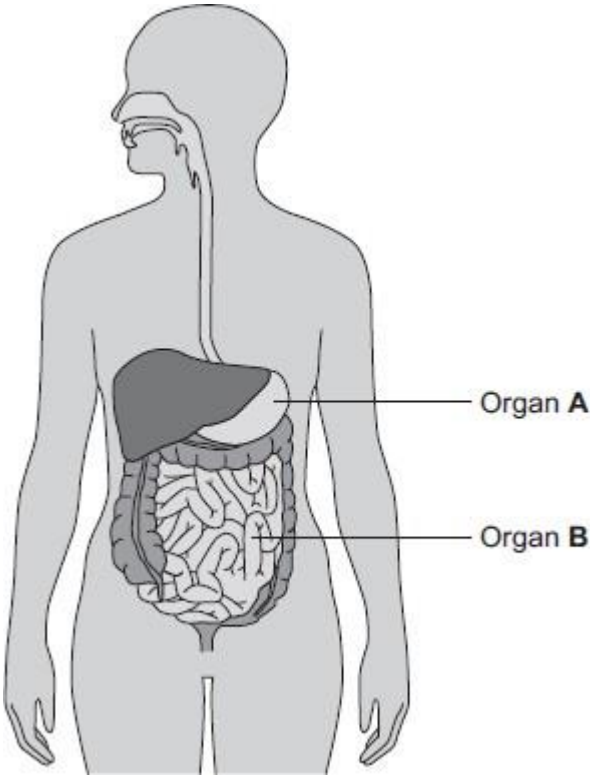
_____

_____

(1)

(Total 7 marks)

5 The diagram below shows the human digestive system.



(a) (i) What is Organ **A**?

Draw a ring around the correct answer.

gall bladder **liver** **stomach**

(1)

(ii) What is Organ **B**?

Draw a ring around the correct answer.

large intestine **pancreas** **small intestine**

(1)

(b) Digestive enzymes are made by different organs in the digestive system.

Complete the table below putting a tick (✓) or cross (✕) in the boxes.

The first row has been done for you.

		Organ producing enzyme			
		salivary glands	**stomach**	**pancreas**	**small intestine**
Enzyme	**amylase**	✓	✕	✓	✓
	lipase				
	protease				

(2)

(c) The stomach also makes hydrochloric acid.

How does the acid help digestion?

_____

_____

(1)

(d) Draw **one** line from each digestive enzyme to the correct breakdown product.

Digestive enzyme	**Breakdown products**
Amylase breaks down starch into……	**amino acids.**
Lipase breaks down fats into…	**bases.**
Protease breaks down proteins into…	**fatty acids and glycerol.**
	sugars.

(3)

(Total 8 marks)

1 (a) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1−2 marks)
The method described is weak and could not be used to collect valid results, however does show some understanding of the sequence of an investigation.

Level 2 (3−4 marks)
The method described could be followed and would enable some valid results to be collected, but lacks detail.

Level 3 (5−6 marks)
The method described could be easily followed and would enable valid results to be collected.

Examples of the points made in the response:
- bean seedlings of same age
- cut material from same part of each organ (for repeats) e.g. top 1 cm of stem / a whole cotyledon / seed
- equal mass of each organ

  accept weight for mass
- grind / homogenise
- in equal amounts of water / buffer
- equal volumes of hydrogen peroxide solution
- equal concentrations of hydrogen peroxide solution
- same temperature
- temperature maintained in water bath
- quantitative measure of gas production eg height of foam in mm / collect gas in graduated syringe in cm^3
- for same time period
- repetitions (3+ times)
- calculate mean for each.

6

(b) (i) correct answer: 40

1 *mark for 45 as the anomalous result has been included in the calculation*

or

1 *mark for* $\frac{(38 + 41 + 42 + 39)}{4}$

or $\frac{160}{4}$

2

(ii) vertical axis correctly labelled:
'Enzyme activity in arbitrary units'

allow ecf from (b)(i)

1

points plotted correctly ±1 mm

*deduct **1** mark for each incorrect plot*

2

suitable line of best fit

not feathery, not point to point

1

(iii) 6.0 / 6

allow ± 0.1

if 6.0 not given, allow correct for candidate's graph ± 0.1

1

(iv) in range 0 to 14 units

allow correct for candidate's graph

1

(v) enzyme denatured / enzyme (active site) shape changed

allow substrate no longer fits (active site)

ignore reference to temperature

do not allow enzyme dies

1

[15]

2 (a) (i) sucrose

1

(ii) fructose is sweeter than sucrose

1

can use less fructose (for same sweetness)

1

cheaper / can use in slimming food

allow 'less calories '

accept 'better for diabetics'

1

(b) (i) carbohydrases

1

(ii) denatured / shape changed

ignore 'inactivated'

allow 'enzyme / shape destroyed'

1

(iii) faster reaction

1

so more product made / product made in shorter time

allow '60 °C will kill microorganisms'

1

(c) any **two** from:

- enzyme can be re-used / not wasted
- constant-flow system
- can be automated
- product (= food) not contaminated by enzyme / enzyme may give allergic reaction / no need to separate P from E

allow 'people do not want to eat enzymes'

2

(d) any **three** from:

- volume is smaller so costs less to heat / to maintain temperature / to build
- temperature is cooler so costs less to heat / to maintain temperature / loses less heat to surroundings
- reaction time is shorter so reduces running costs (re. heating / stirring) or can make more product in time
- 1-stage product refining c.f. 4 stages, leading to reduced labour / time cost

need to qualify each point with respect to how it lowers costs

3

(e) (i) 4500

*correct answer = **2** marks*

*allow **1** mark for: 1500 x 3*

2

(ii) enzyme used for longer / less enzyme needed

1

less money spent <u>on enzyme</u>

1

[17]

3 (a) A - atrium

ignore references to right / left

1

B - ventricle

1

(b) (i) muscular

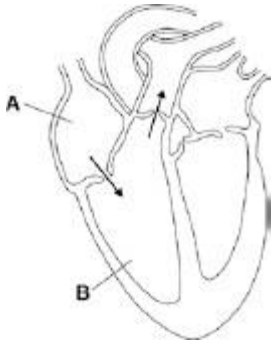
1

(ii) push blood

accept pump / force

1

(c)



arrows approx as indicated

1

arrow(s) showing flow from A to B
from B out / up / to artery

1

(d) (i) male

1

65 and over

1

(ii) fatty deposits / material in (coronary) arteries

allow correct points made about heart attacks

1

narrows / blocks / reduces flow

1

decreases oxygen supply (to heart muscle)

1

[11]

4 (a) (i) glycerol

1

(ii) pancreas / <u>small</u> intestine

accept duodenum / ileum

ignore intestine unqualified

1

(b) any **two** from:

- type of milk
- volume / amount of milk
- vol. bile equals vol. water
- volume of lipase
- concentration of lipase
- temperature

ignore time interval

ignore solution unqualified

*do **not** allow pH*

ignore starting pH

ignore volume / amount of bile / water

ignore concentration of bile

accept amount of lipase if neither volume nor concentration given

2

(c) (i) <u>fatty</u> acid (production)

1

(ii) fast<u>er</u> reaction / digestion (with bile)
or
pH decreases fast<u>er</u> (with bile)
or
takes less time (with bile)
or
steeper fall / line (with bile)

allow use of data

ignore easier

1

(iii) all fat / milk digested
or
same amount of fatty acids present
or
(lower pH) denatures the enzyme / lipase

allow all reactants used up

ignore reference to neutralisation

allow enzyme won't work at low pH

*do **not** allow enzyme killed*

1

[7]

5 (a) (i) stomach

1

(ii) small intestine

1

(b)

	salivary glands	stomach	pancreas	small intestine
amylase	✓	×	✓	✓
lipase	×	×	✓	✓
protease	×	✓	✓	✓

1 *mark per correct row*

or

if no correct row max ***1*** *mark for any one correct column*

2

(c) enzyme / protease / pepsin most effective in acid conditions / low pH

accept optimum / correct pH

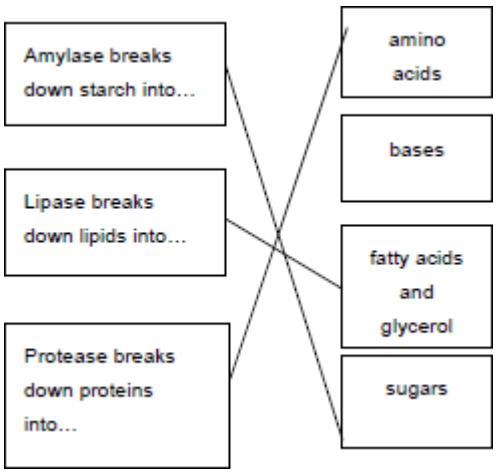
do not accept ref to incorrectly named enzymes

ignore killing bacteria

ignore acid breaks down food

1

(d)



3

[8]