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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Biological Molecules (1)

A Level Biology B Topic 1

103 questions · 990 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.
Click any heading or question row below to jump straight to it.
On every question page, click ANSWER in the top-right corner to jump to its mark scheme.
Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

103 questions · 990 marks · grouped by sub-topic, lowest tariff first

SUB-TOPIC 1(a)

CARBOHYDRATES

17 questions in this sub-topic · 149 marks · lowest tariff first

2 Glucose is a monosaccharide that is found in sucrose, amylose and amylopectin.

(a) Sucrose is made from glucose and one other molecule.

Which row of the table gives the name of this molecule and the type of reaction that joins the two molecules together?

(1)

		Name of molecules	Type of reaction
☒	**A**	fructose	condensation
☒	**B**	fructose	hydrolysis
☒	**C**	galactose	condensation
☒	**D**	galactose	hydrolysis

(b) Compare and contrast the structure of amylose and amylopectin.

(3)

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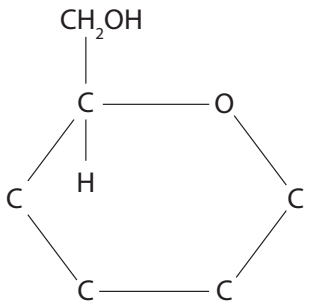
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1 Some carbohydrates are composed of three monosaccharides. These are called trisaccharides.

Raffinose is a trisaccharide composed of glucose, galactose and fructose.

(a) Complete the diagram to show the structure of an **alpha** glucose molecule.

(2)



(b) Name the bond that joins monosaccharides together.

(1)

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(c) The three monosaccharides present in raffinose each have a molecular mass of 180.

The relative atomic mass of the element hydrogen is 1 and the relative atomic mass of the element oxygen is 16.

Calculate the molecular mass of raffinose.

(1)

Answer .....

(Total for Question 1 = 4 marks)

1 Chemical control in plants is brought about by plant growth substances such as auxins.

Auxins cause elongation of cells.

Auxins weaken the bonds between molecules found in cell walls. Molecules found in cell walls include cellulose and hemicellulose.

(a) (i) Which of the following statements about cellulose molecules is correct?

(1)

- ☒ **A** they are branched polymers
- ☒ **B** they contain α-glucose
- ☒ **C** they are bonded to each other by hydrogen bonds
- ☒ **D** they contain 1,6 glycosidic bonds

(ii) The following statements relate to calcium pectate:

1. found in the middle lamella
2. holds cell walls together
3. prevents the movement of water

Which of the following is correct for calcium pectate?

(1)

- ☒ **A** statement 1 and statement 2
- ☒ **B** statement 1 and statement 3
- ☒ **C** statement 2 only
- ☒ **D** statement 3 only

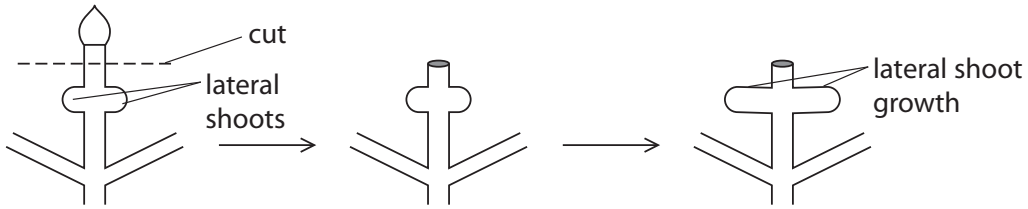
(b) A scientist investigated apical dominance in plants.

In experiment 1, the shoot tips were cut off and the growth of lateral shoots assessed.

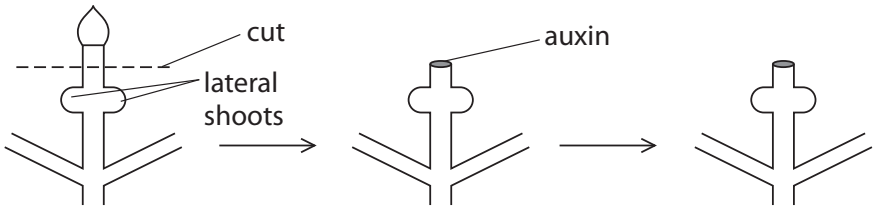
This was repeated in experiment 2, but auxin was placed over the cut end of the tips and the growth of lateral shoots was assessed.

The results are shown in the diagrams.

Experiment 1



Experiment 2



Explain how the interaction between auxins and cytokinins could have produced the results shown in the diagram.

(3)

2 An investigation was carried out to compare the aerobic respiration of different sugars by yeast.

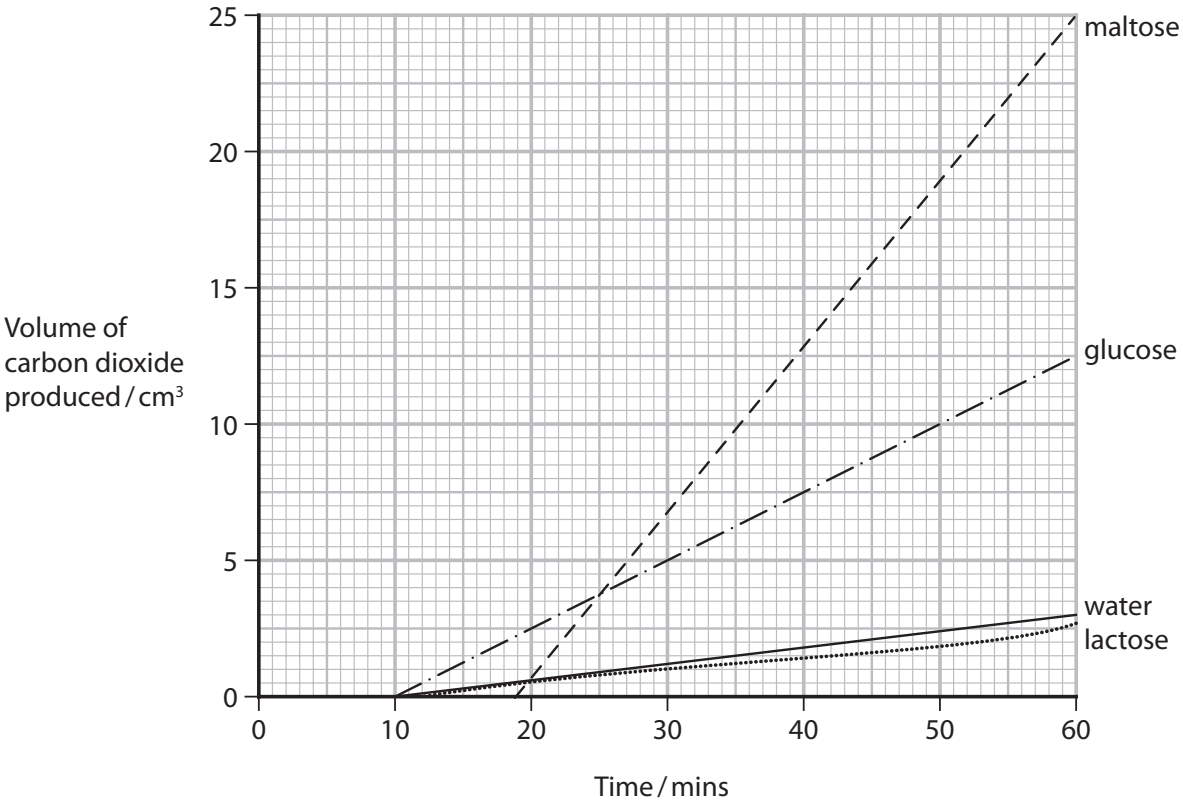
A suspension of yeast was used to produce three cultures, each one with a different sugar.

A control was set up that had a suspension of yeast cultured with water only.

The volume of carbon dioxide produced was measured.

The mass of yeast and the concentration of each sugar were controlled.

The graph shows the results of this investigation.



(a) (i) Give one difference between the structure of glucose and the structure of maltose.

(1)

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(ii) Explain the results for the yeast cultured with glucose and the yeast cultured with maltose.

(2)

(b) Explain the results for the yeast cultured with lactose.

(2)

2 (a) A laboratory technician made a 1 mol dm^{-3} glucose solution and a 1 mol dm^{-3} maltose solution.

In order to do this, the technician calculated the molecular mass of both sugars.

The table shows the molecular mass of the elements present in these sugars.

Element	Molecular mass
carbon	12
hydrogen	1
oxygen	16

(i) Explain why the molecular mass of one glucose molecule is 180.

(2)

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(ii) Calculate the molecular mass of maltose.

(2)

Answer .....

(b) Give **two** differences between the structure of a ribose molecule and the structure of a glucose molecule.

(2)

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2 Bacteria were cultured in two different types of medium.

One medium contained glucose as the energy source and the other contained sucrose.

The same molar concentrations of glucose and sucrose were used.

(a) Which row of the table identifies these sugars?

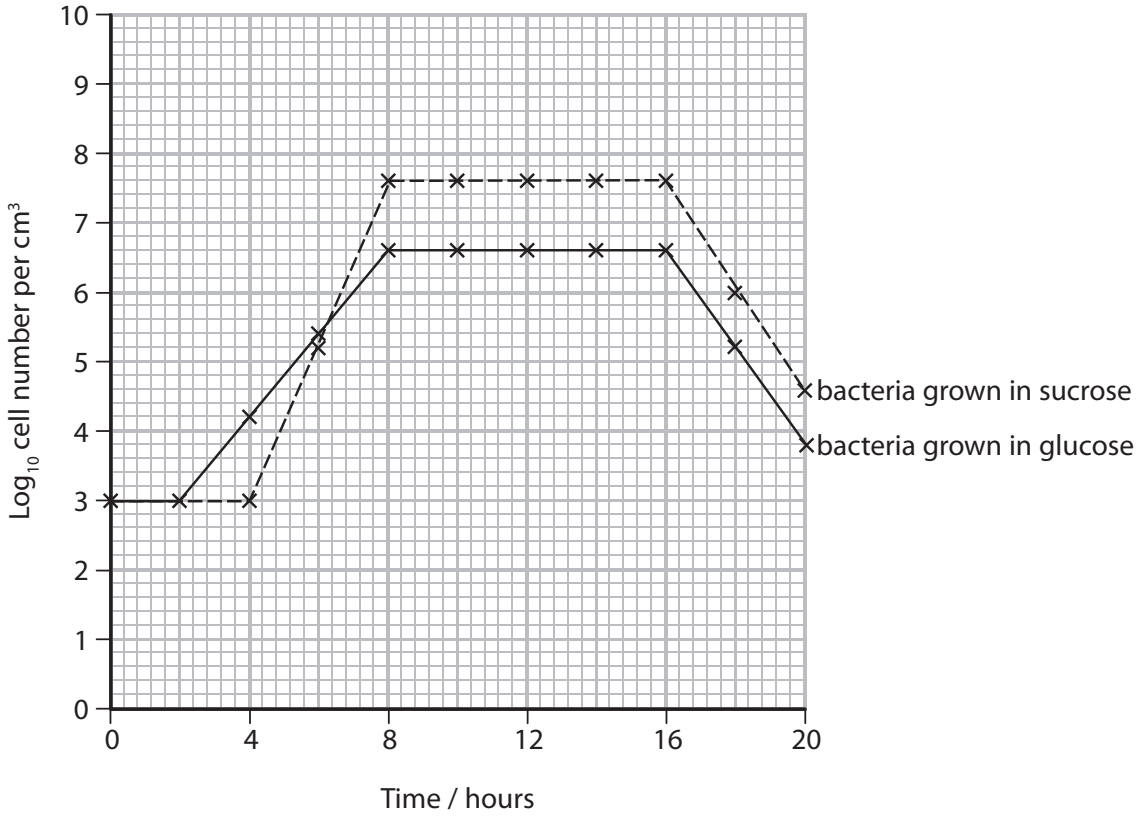
(1)

	Glucose	Sucrose
☒ **A**	monosaccharide	monosaccharide
☒ **B**	monosaccharide	disaccharide
☒ **C**	disaccharide	disaccharide
☒ **D**	disaccharide	monosaccharide

(b) Bacteria were grown in each medium for 20 hours.

Every two hours, the numbers of bacteria were determined using dilution plating and an optical method (turbidity).

The graph shows the results from the dilution plating.



(i) Calculate how many times faster the bacteria in sucrose reproduce than the bacteria in glucose, during the log phase.

(2)

Answer .....

(ii) Analyse the data to explain why the growth curve for sucrose is different from the growth curve for glucose.

(2)

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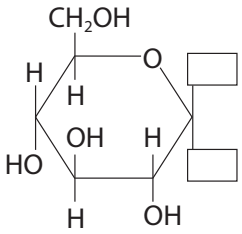
(iii) On the graph, draw a curve to show the number of bacteria grown in glucose as determined by the optical method.

(1)

1 Glucose is a monosaccharide.

(a) Complete the diagram to show the structure of beta-glucose.

(1)



(b) Glucose molecules can be joined to form the polysaccharides starch and cellulose.

Give **three** differences between the structures of starch and cellulose.

(3)

(c) Explain how the properties of starch make it suitable as an energy store in cells.

(2)

7 Only monosaccharides and most disaccharides are reducing sugars.

Reducing sugars produce a red precipitate when heated with blue Benedict's reagent.

(a) Identify the row that shows the correct results after heating three carbohydrates, maltose, amylose and fructose, with Benedict's reagent.

(1)

	maltose	amylose	fructose
☒ **A**	no precipitate	no precipitate	no precipitate
☒ **B**	red precipitate	no precipitate	red precipitate
☒ **C**	red precipitate	red precipitate	no precipitate
☒ **D**	red precipitate	red precipitate	red precipitate

(b) The Benedict's test can be made quantitative and used to determine the concentration of a glucose solution.

The red precipitate formed is removed by filtration. The precipitate is dried and the mass recorded.

The table shows the mass of precipitate formed from a range of glucose concentrations heated with 5 cm^3 of Benedict's reagent.

Glucose concentration / mg cm^{-3}	Mass of precipitate formed / g
0	0.00
2	0.28
4	0.57
6	0.92
8	1.33
10	1.63
12	1.92
14	1.98
16	2.00
18	2.00
20	2.00

(i) Analyse the data to explain the relationship between the glucose concentration and the mass of precipitate formed.

(4)

(ii) When the investigation was repeated, the mean error for each measurement was calculated.

The mean error for each measurement was 0.05 g.

Calculate the percentage error for the mass of precipitate measured at the glucose concentration of 2 mg cm^{-3}.

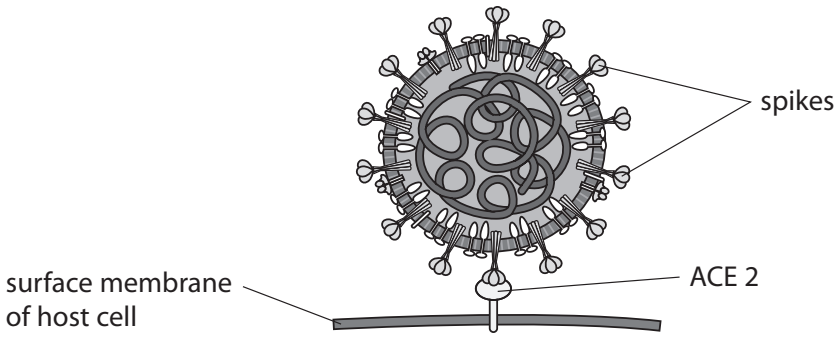
(1)

Answer..... %

(iii) Explain one way in which the mean error in measuring the mass of precipitate could be reduced.

(2)

4 The diagram shows a virus attached to the enzyme ACE 2, on the surface membrane of its host cell.



(a) This virus is classified as an enveloped RNA virus with a helical capsid structure.

Which virus is also classified in the same way?

(1)

- ☒ **A** Ebola
- ☒ **B** human immunodeficiency virus
- ☒ **C** λ (lambda) phage
- ☒ **D** tobacco mosaic virus

(b) The enzyme ACE 2 catalyses the hydrolysis of angiotensin II into angiotensin.

Which of the following describes hydrolysis by ACE 2?

(1)

- ☒ **A** a bond is split to produce angiotensin, using water
- ☒ **B** a bond is split to produce angiotensin, producing water
- ☒ **C** a bond is formed to produce angiotensin, using water
- ☒ **D** a bond is formed to produce angiotensin, producing water

(c) The spikes are proteins with polysaccharide molecules attached.

(i) Compare and contrast the structure of polysaccharides with the primary structure of proteins.

(3)

(ii) Lectins are molecules that bind to polysaccharides.

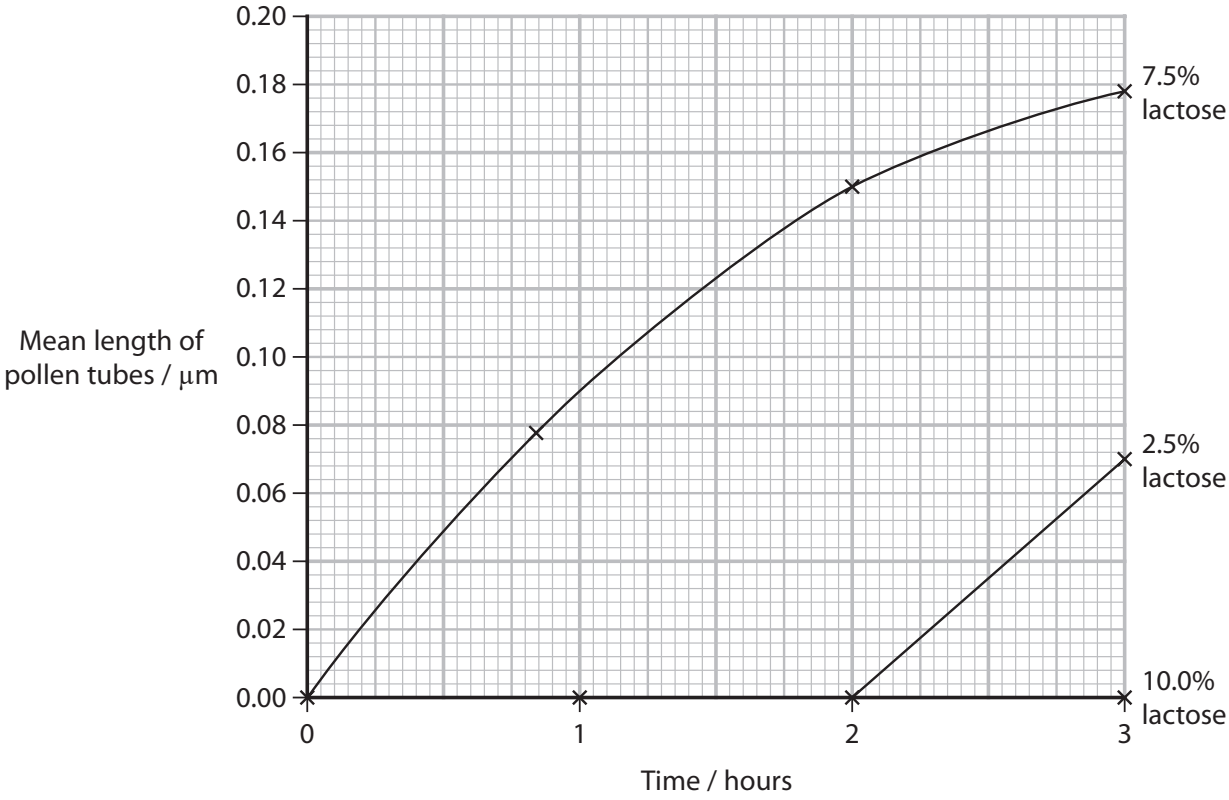
Some lectins bind to the spikes of this virus.

Explain why scientists are hoping that lectins can be used to prevent disease caused by this virus.

(3)

3 The effect of lactose concentration on the growth of pollen tubes was investigated.

The graph shows the results of this investigation.



(a) Describe the structure of lactose.

(2)

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(b) Calculate the rate of growth of the pollen tubes, at 2 hours, for the 7.5 % lactose.

Use a tangent to help you with your calculation.

(2)

Answer ..... µm hour^{-1}

(c) Describe **three** conclusions that can be made from the results of this investigation.

(3)

(d) Give **two** reasons why lactose was an unusual choice of sugar to investigate.

(2)

8 Carbohydrates can be classified as monosaccharides, disaccharides, or polysaccharides.

(a) The table gives some information about polysaccharides.

For each polysaccharide, put **one** cross in the appropriate box, in each row, to show the type of glycosidic bond present.

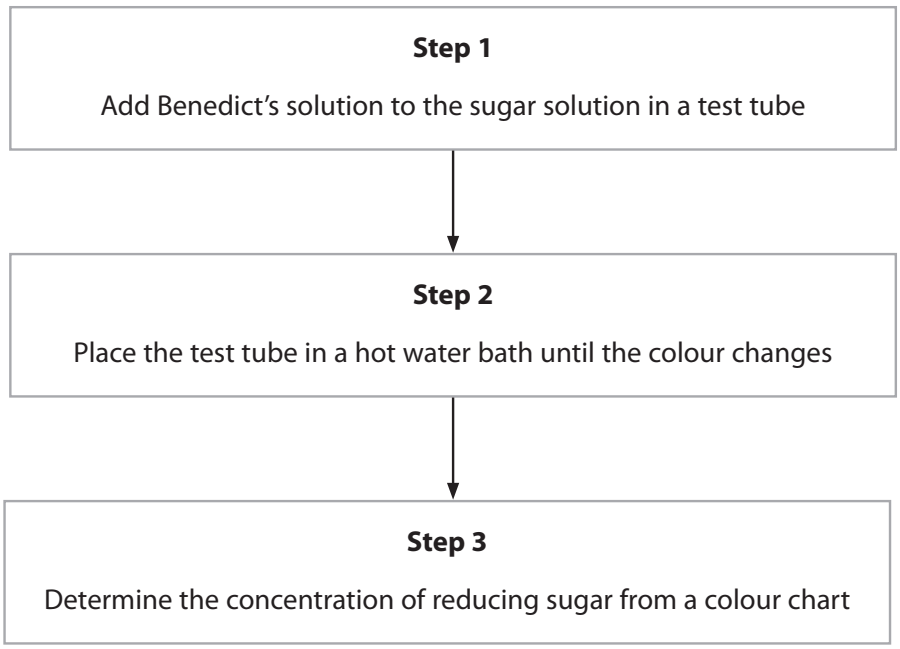
(3)

Polysaccharide	Type of glycosidic bond			
	both 1–4 and 1–6	**1–4 only**	**1–6 only**	**neither 1–4 nor 1–6**
cellulose	☒	☒	☒	☒
glycogen	☒	☒	☒	☒
starch	☒	☒	☒	☒

(b) Monosaccharides and disaccharides are either reducing sugars or non-reducing sugars.

The presence of a reducing sugar, such as glucose, can be identified using the Benedict's test. The method can be used to determine the concentration of the reducing sugar.

The diagram shows the steps involved in the Benedict's test.



The table shows the colour chart.

Colour after heating	blue	green	yellow	orange	red
Concentration of reducing sugar / mg dm^{-3}	0	<1000	1000 to 1500	1500 to 2000	>2000

(i) Describe **two** limitations of using this method for determining the concentration of reducing sugars.

(2)

1 .....

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2 .....

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(ii) This method can be modified to determine the concentration of non-reducing sugars.

Non-reducing sugars, such as sucrose, must be heated in acid before step 1.

A student was given a solution containing both glucose and sucrose.

Devise a method, using the Benedict's test, to determine the concentration of each of these sugars in this solution.

(4)

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8 Fruits consist mainly of sugars, fibre (cellulose) and water.

The sweetness of a fruit depends on the proportion of the different types of sugars that it contains.

The table shows the relative sweetness of five sugars.

Sugar	Relative sweetness
Fructose	1.73
Glucose	0.74
Sucrose	1.00
Maltose	0.32
Galactose	0.32

(a) (i) Which row of the table shows the sugars that are monosaccharides and the sugars that are disaccharides?

(1)

		Monosaccharides	Disaccharides
☒	**A**	fructose and glucose	galactose and maltose
☒	**B**	galactose and glucose	maltose and sucrose
☒	**C**	glucose and maltose	fructose and sucrose
☒	**D**	maltose and sucrose	galactose and glucose

(ii) How are two monosaccharides joined together to form a disaccharide?

(1)

☒ **A** by an ester bond formed during a condensation reaction

☒ **B** by an ester bond formed during a hydrolysis reaction

☒ **C** by a glycosidic bond formed during a condensation reaction

☒ **D** by a glycosidic bond formed during a hydrolysis reaction

(b) The relative sweetness of a sugar solution can be determined by a taste test.

Devise an investigation, that a student could do, to confirm the relative sweetness of the sugars listed in the table.

(3)

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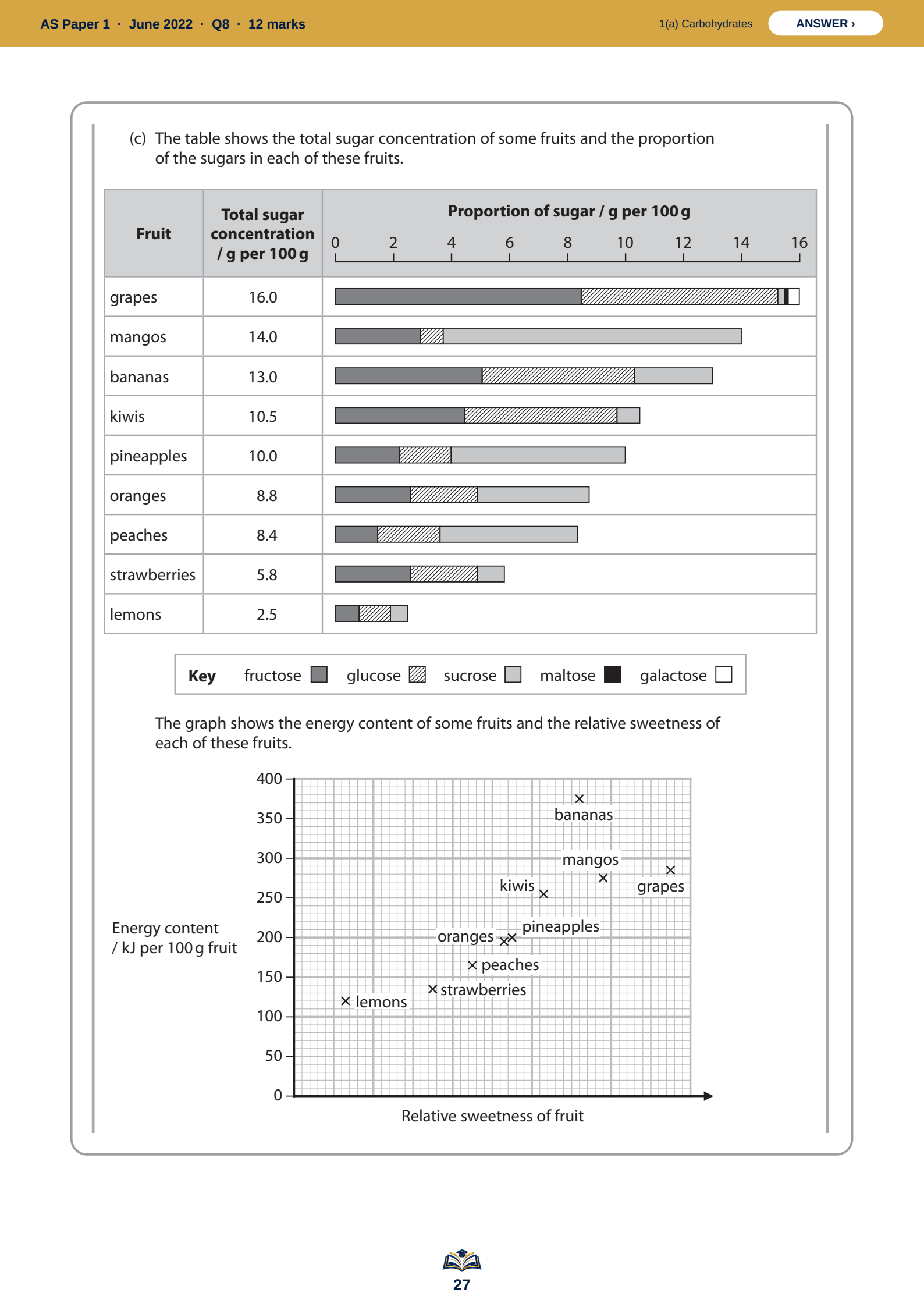
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(c) The table shows the total sugar concentration of some fruits and the proportion of the sugars in each of these fruits.

Fruit	Total sugar concentration / g per 100 g	Proportion of sugar / g per 100 g
grapes	16.0	
mangos	14.0	
bananas	13.0	
kiwis	10.5	
pineapples	10.0	
oranges	8.8	
peaches	8.4	
strawberries	5.8	
lemons	2.5	



Key fructose glucose sucrose maltose galactose

The graph shows the energy content of some fruits and the relative sweetness of each of these fruits.

(i) Determine the ratio of the proportion of sugars in mangos.

(1)

Answer .....

*(ii) Analyse the data to discuss the relationship between the sugar content, the relative sweetness and the energy content of these fruits.

(6)

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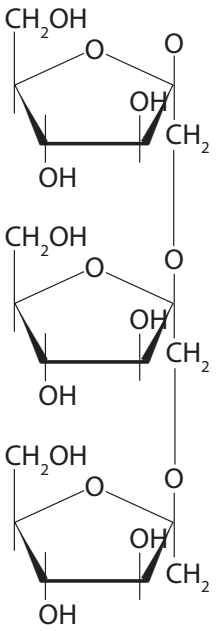
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7 Inulin is a polysaccharide made of fructose that is used as a storage molecule by some plant species.

The diagram shows part of a molecule of inulin.



(a) (i) The inulin molecule in the diagram contains fructose.

Which of these carbohydrates also contain fructose?

(1)

- ☒ **A** lactose, maltose, and sucrose
- ☒ **B** lactose and sucrose
- ☒ **C** maltose and sucrose
- ☒ **D** sucrose

(ii) Which is the name of the chemical bond that joins the monosaccharides in inulin?

(1)

- ☒ **A** ester
- ☒ **B** glycosidic
- ☒ **C** hydrogen
- ☒ **D** peptide

(iii) Fructose has the same molecular formula as glucose.

Which is the molecular formula of a molecule of inulin consisting of four fructose sugars?

(1)

- ☒ **A** $C_{24}H_{42}O_{21}$
- ☒ **B** $C_{24}H_{44}O_{22}$
- ☒ **C** $C_{24}H_{48}O_{21}$
- ☒ **D** $C_{24}H_{48}O_{24}$

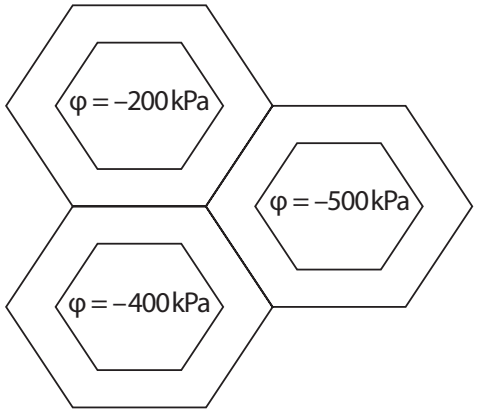
(b) The number of fructose molecules in inulin can vary from 10 to 70.

Inulin with high numbers of fructose molecules is less soluble in water.

(i) The diagram shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1)



(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2)

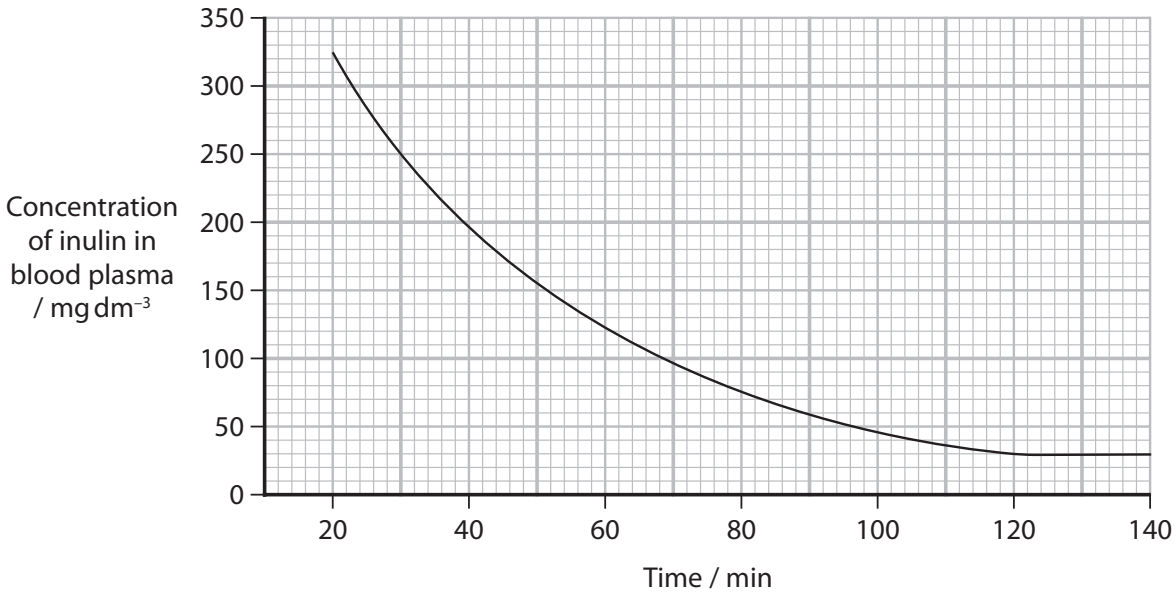
(c) Inulin is used to measure the rate of filtration by the kidneys.

A saline solution containing inulin is injected into the vein of a patient.

The concentration of inulin in the blood plasma is then measured over time.

The rate of filtration is a measure of the maximum rate that inulin is removed from the blood by the kidneys.

The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

Answer .....

(ii) Explain how inulin passes from the blood plasma into the proximal convoluted tubule of a nephron.

(2)

(iii) Explain why all the inulin is released into the urine.

(2)

6 Mitochondria and chloroplasts in eukaryotic cells are thought to have originated millions of years ago by a process called endosymbiosis.

In endosymbiosis, free-living prokaryotic organisms were engulfed by their new host cells.

(a) The table shows the lipid composition of the membranes of these two organelles.

Type of lipid	Percentage of total lipid composition of membranes (%)	
	In mitochondria	In chloroplasts
phosphatidyl A	43	0
phosphatidyl B	35	0
phosphatidyl C	6	1
phosphatidyl D	3	7
phosphatidyl E	13	0
monogalactosyldiacylglycerol F	0	55
digalactosyldiacylglycerol G	0	24
sulfolipid H	0	8

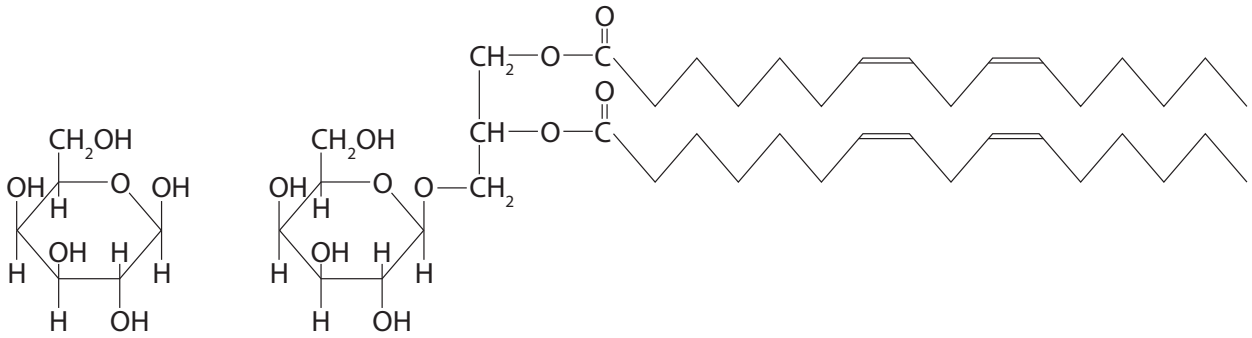
(i) Analyse the data and use your knowledge to explain why these two organelles are thought to have originated from different prokaryotic organisms.

(3)

(ii) Digalactosyldiacylglycerol (DGDG) is synthesised from galactose and monogalactosyldiacylglycerol (MGDG).

The galactose forms a 1,6 glycosidic bond with the MGDG.

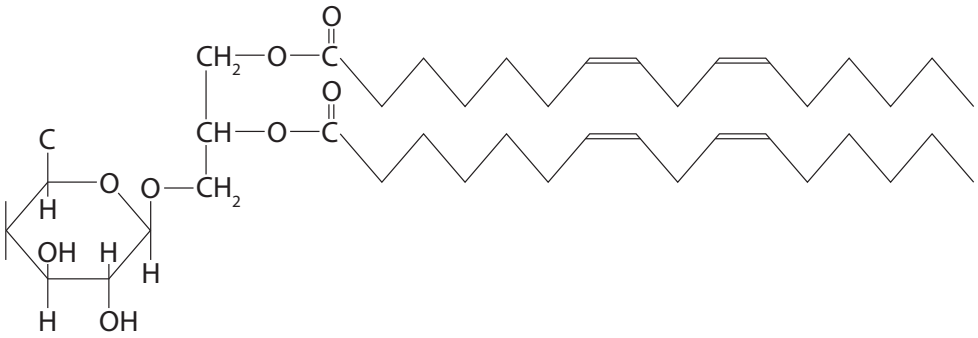
The diagram shows the structure of galactose and MGDG.



galactose MGDG

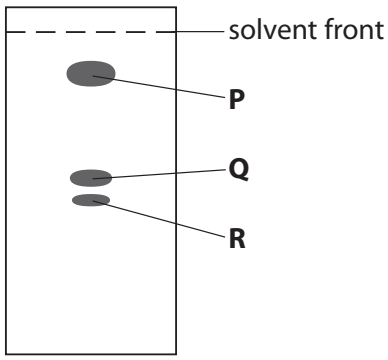
Complete the diagram below to show the structures of the products formed when DGDG is synthesised from galactose and MGDG.

(3)



(iii) Chromatography can be used to separate MGDG, DGDG and sulfolipid extracted from chloroplasts.

The diagram shows the position of these three lipids, **P**, **Q** and **R**, on a chromatogram.



Which row in the table identifies the position of these three lipids in this chromatogram ?

(1)

	Lipid in position P	Lipid in position Q	Lipid in position R
☒ **A**	DGDG	sulfolipid	MGDG
☒ **B**	MGDG	DGDG	sulfolipid
☒ **C**	sulfolipid	DGDG	MGDG
☒ **D**	sulfolipid	MGDG	DGDG

(b) Chloroplasts are thought to be derived from cyanobacteria.

It is estimated that there are 1×10^{10} carbon atoms in one cyanobacterial cell.

Ten photons of light are needed to fix one carbon atom.

(i) Calculate the number of photons of light needed to fix enough carbon to form one cyanobacterial cell.

(1)

(ii) Explain why the value calculated in (b)(i) is likely to be an underestimate.

(2)

(iii) Describe how carbon fixation takes place in chloroplasts.

(3)

8 Skin flora include bacteria that live on the skin.

Different parts of the body have different types of bacteria present.

Skin flora are beneficial as they inhibit the growth of pathogenic bacteria on the skin.

Skin flora compete for nutrients and space or secrete toxic chemicals.

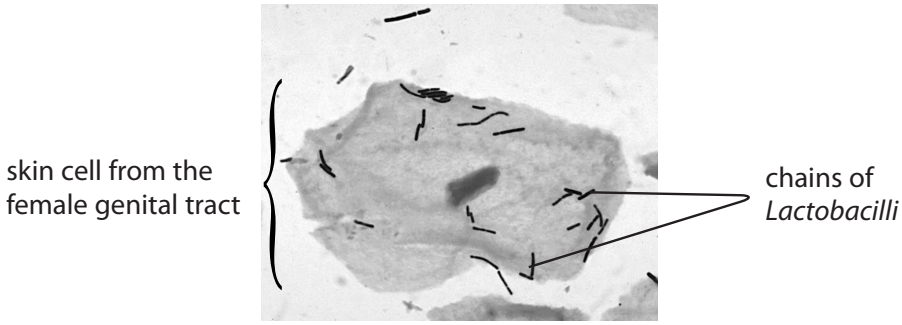
(a) The following are types of bacteria found in the female genital tract:

- *Escherichia coli*
- *Klebsiella* species
- *Lactobacillus* species
- *Staphylococcus* species.

(i) Describe how these types of bacteria present in the female genital tract could be identified.

(4)

(ii) The photograph shows *Lactobacilli* on a skin cell from the female genital tract.



Source: © Janice Carr Content Providers (s): CDC/Dr. Mike Miller

Lactobacilli metabolise glycogen into lactic acid.

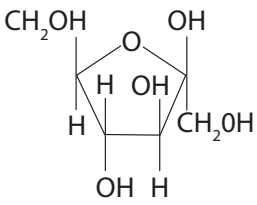
Explain how *Lactobacilli* inhibit the growth of pathogenic bacteria in the female genital tract.

(3)

(b) Sperm cells are released into the female genital tract in seminal fluid.

Seminal fluid contains fructose instead of glucose.

The diagram shows the structure of fructose.



(i) Compare and contrast the structure of fructose with the structure of glucose.

(3)

(ii) Explain the advantages of the presence of fructose in seminal fluid.

(3)

7 Adrenaline is a hormone that stimulates the breakdown of glycogen into glucose.

(a) (i) Which of the following describes this breakdown?

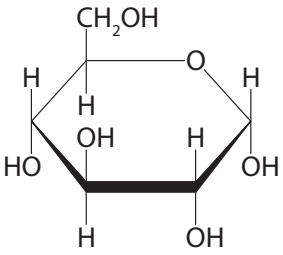
(1)

- ☒ **A** condensation reaction breaking glycosidic bonds
- ☒ **B** condensation reaction breaking phosphodiester bonds
- ☒ **C** hydrolysis reaction breaking glycosidic bonds
- ☒ **D** hydrolysis reaction breaking phosphodiester bonds

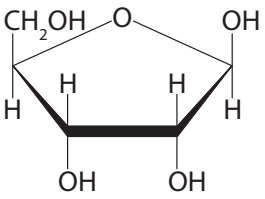
(ii) Which diagram shows the structure of the glucose produced?

(1)

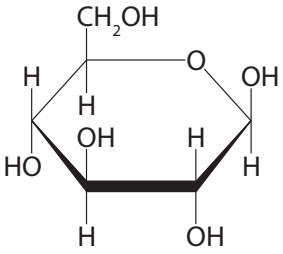
☒ **A**



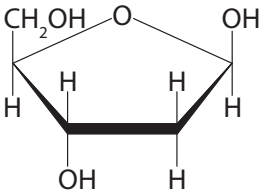
☒ **C**



☒ **B**



☒ **D**



(iii) Explain how the structure of glycogen is related to its function.

(3)

(b) The hormone adrenaline is unable to pass through cell membranes.

When liver and muscle cells are exposed to adrenaline, the enzyme glycogen phosphorylase breaks down glycogen in these cells.

Describe how adrenaline causes liver cells to increase the concentration of glucose in the blood.

(3)

(c) The genetic condition Hers disease is caused by a recessive allele of the glycogen phosphorylase gene.

In an isolated population of 1400 people in the USA, 15 people have Hers disease.

(i) Calculate the number of heterozygous individuals in this population.

Use the Hardy-Weinberg equation

(4)

$$p^2 + 2pq + q^2 = 1$$

Answer .....

(ii) The frequency of Hers disease in most human populations is 1 in 40 000.

Explain why the frequency of Hers disease is higher in the isolated population.

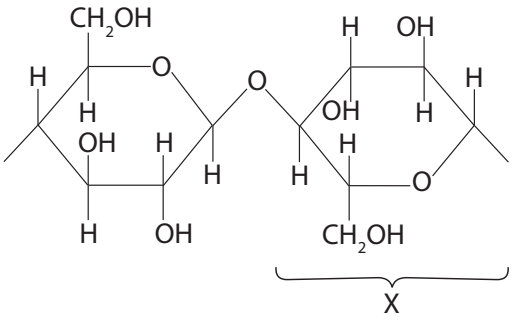
(2)

9 In Kenya, an in-situ conservation project has been set up to make paper from elephant dung.

This project aims to help conserve elephant populations, conserve biodiversity and help local communities.

(a) Paper is produced from cellulose molecules present in elephant dung.

The diagram shows part of a cellulose molecule.



(i) Which of the following is the name of the monomer labelled X on the diagram?

(1)

- ☒ **A** α glucose
- ☒ **B** β glucose
- ☒ **C** α ribose
- ☒ **D** β ribose

(ii) Draw one of the products of the hydrolysis of this part of the cellulose molecule.

(2)

(iii) Explain how the structure of cellulose is adapted for its function in plant cell walls.

(3)

(b) Elephant conservation often involves the setting up of protected areas to stop poaching. Local people are banned from entering these areas.

This method of elephant conservation sometimes causes conflict with local people, as elephants can trample and eat crops in nearby farmland. Farmers sometimes burn areas of grassland and forest to stop elephants destroying their farmland.

The new paper conservation project encourages local people to make paper from elephant dung they collect from the conservation area. The paper they make is sold at a high price.

Conservationists measured the effect of the new paper project on the index of diversity of the area over two years. They also measured the effect of a protected conservation area where local people were banned from entering on the index of diversity. The results are shown in the table.

Area	Index of diversity	
	At start of project	After two years
Conservation area with paper project	2.8	3.6
Conservation area where local people are banned from entering	2.4	2.2

(i) State why calculating an index of diversity is a better measure of biodiversity than counting the number of different species.

(1)

(ii) Give two advantages of in-situ conservation of elephants compared with ex-situ conservation of elephants.

(2)

(iii) Explain the effect of the new paper project on biodiversity compared with the protected area where local people were banned.

(4)

(c) Describe the limitations of CITES in the conservation of organisms such as elephants.

(2)

SUB-TOPIC 1(b)

LIPIDS

12 questions in this sub-topic · 118 marks · lowest tariff first

2 Triglycerides, found in living organisms, have different melting points.

Two factors that affect the melting point of a triglyceride are:

1. the length of the fatty acid chains
2. whether the fatty acid chains are saturated or unsaturated.

(a) A triglyceride is made from the components glycerol and fatty acids.

(i) How many of the following statements about triglycerides are correct?

(1)

- a glycerol molecule is joined to each fatty acid by an ester bond
- an unsaturated fatty acid has at least one double bond between two carbon atoms
- all triglycerides have three fatty acids joined to a glycerol

☒ **A** none

☒ **B** one

☒ **C** two

☒ **D** three

(ii) The table shows the relative atomic mass of the elements present in a triglyceride.

Element	Relative atomic mass
carbon	12
hydrogen	1
oxygen	16

How much lower is the molecular mass of this triglyceride molecule, after it has been made from its components, compared with the sum of its component molecules?

(1)

☒ **A** 18

☒ **B** 33

☒ **C** 54

☒ **D** 99

(b) (i) Stearic acid and arachidic acid are both fatty acids.

Arachidic acid has two more carbon atoms than stearic acid.

The melting point of stearic acid is 69 °C and the melting point of arachidic acid is 76 °C.

Calculate the percentage increase in the melting point, resulting from the presence of two more carbon atoms.

Give your answer to two decimal places.

(1)

Answer ..... %

(ii) Devise a method to investigate how the length of the fatty acids and the degree of saturation of the fatty acids affect the melting point of triglycerides.

(3)

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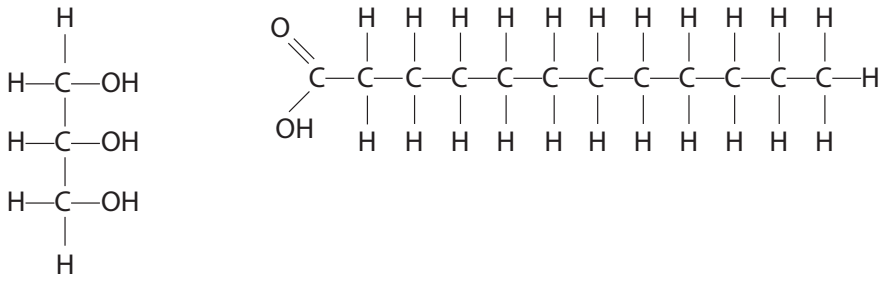
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4 Glycerol molecules and fatty acid molecules are used in the synthesis of cell membranes.

The diagram shows a molecule of glycerol and a molecule of a fatty acid.

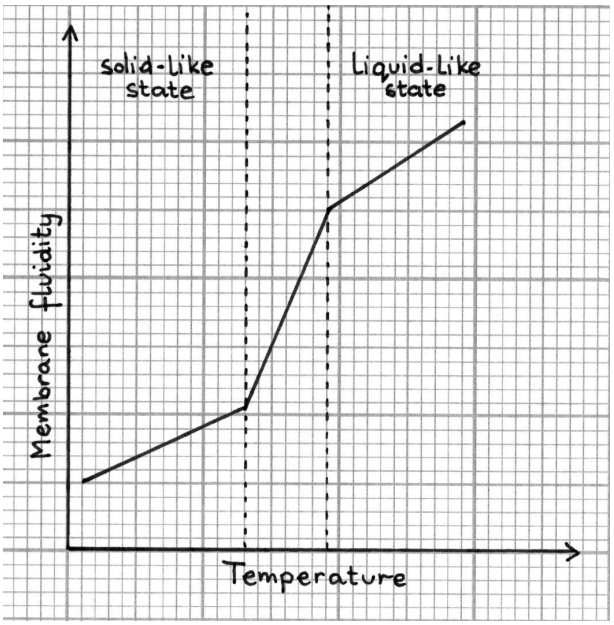


(a) Which of the following describes the reaction when these two molecules are joined together?

(1)

- ☒ **A** condensation reaction forming an ester bond
- ☒ **B** condensation reaction forming a glycosidic bond
- ☒ **C** hydrolysis reaction forming an ester bond
- ☒ **D** hydrolysis reaction forming a glycosidic bond

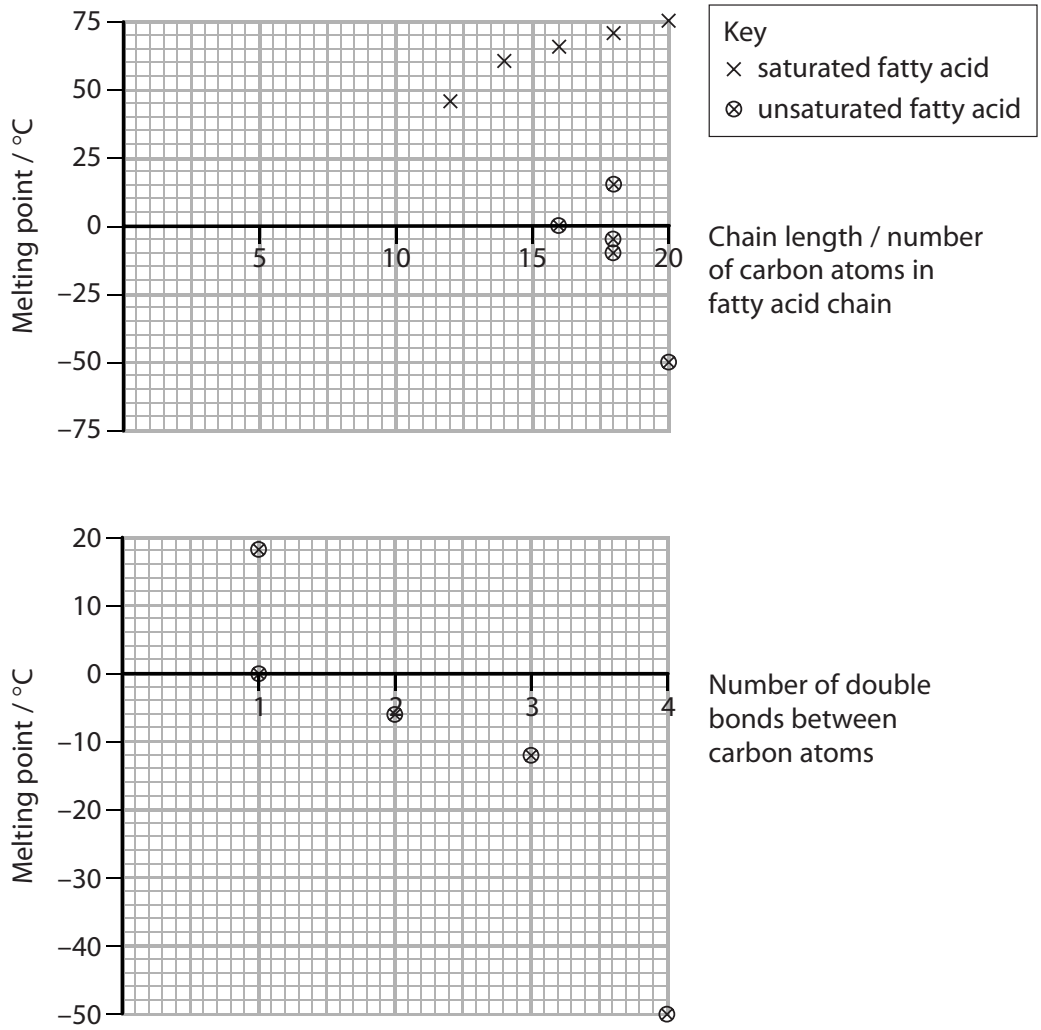
(b) This graph was sketched by a student to show how membrane fluidity changes with temperature.



(i) Describe the relationship between membrane fluidity and temperature as shown by this graph.

(2)

(ii) The student found two graphs about the structure of lipids and their melting points.



The student stated that membrane fluidity depends on the fatty acids present.

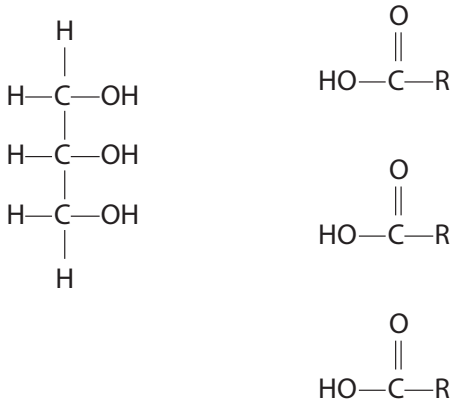
Analyse the data in these two graphs and the sketched graph to comment on this statement.

(4)

(Total for Question 4 = 7 marks)

3 Fats and oils are lipids synthesised from glycerol and fatty acids.

(a) The diagram shows the structures of glycerol and three fatty acids.



(i) Draw the **triglyceride** that would be produced from these molecules.

(1)

(ii) Which type of reaction produces the triglyceride from these molecules?

(1)

- ☒ **A** condensation, releasing water
- ☒ **B** condensation, using water
- ☒ **C** hydrolysis, releasing water
- ☒ **D** hydrolysis, using water

(b) The table shows the fatty acid composition of three lipids: almond oil, cocoa butter, and flaxseed oil. These lipids are eaten by humans.

Lipid	Percentage of each fatty acid present (%)				
	Palmitic acid $C_{16}H_{32}O_2$	**Stearic acid $C_{18}H_{36}O_2$**	**Oleic acid $C_{18}H_{34}O_2$**	**Linoleic acid $C_{18}H_{32}O_2$**	**Linolenic acid $C_{18}H_{30}O_2$**
Almond oil	8	1	77	14	0
Cocoa butter	30	36	30	4	0
Flaxseed oil	2	2	18	20	58

(i) Calculate the mass of oleic acid present in 25 g of almond oil.

Give your answer to **two significant figures**.

(1)

Answer ..... g

(ii) Give **one** similarity and **one** difference between the structure of a **saturated** fatty acid and an **unsaturated** fatty acid.

(2)

Similarity

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.....

.....

Difference

.....

.....

.....

(iii) Analyse the data to comment on which of these lipids are healthier to eat.

(3)

4 Most human cells use carbohydrate as a source of energy.

(a) Explain why glycogen releases energy more slowly than glucose.

(2)

(b) When human cells have used up carbohydrate, they will use lipid and then protein as a source of energy.

The table shows the water content and energy content of three food sources.

Food source	Water content / arbitrary units	Energy content in dry matter / kJ g^{-1}	Energy content in wet matter / kJ g^{-1}	Total energy stored / kJ
Carbohydrate	2 to 3	16.8	4.2 to 6.3	3528
Triglyceride	0	37.8	37.8	567 000
Protein	2 to 3	16.8	4.2 to 6.3	100 800

(i) Explain why the water content of triglyceride is different from the water content of carbohydrate and protein.

(3)

(ii) Using the information in the table, explain why triglycerides are a good energy store.

(2)

(iii) Explain why the **'total energy stored'** column in this table is of limited use in drawing conclusions about the energy content of these food sources.

(2)

3 Milk from cows contains a number of different types of lipid.

Lipids are made of glycerol and fatty acids.

(a) A triglyceride is one type of lipid.

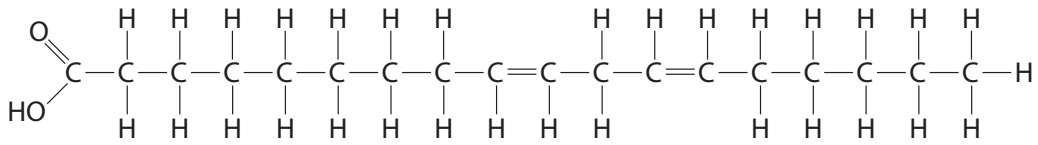
Which row of the table describes a triglyceride?

(1)

		Number of molecules		Name of bond joining molecules
		Glycerol	Fatty acid	
☒	**A**	1	3	glycosidic
☒	**B**	1	3	ester
☒	**C**	3	1	glycosidic
☒	**D**	3	1	ester

(b) Fatty acids are either saturated or unsaturated.

The diagram shows the structure of an unsaturated fatty acid.



Which row of the table shows the differences between this fatty acid and a saturated fatty acid with the same number of carbons?

(1)

		Number of double bonds in the saturated fatty acid	Number of hydrogen atoms in the saturated fatty acid
☒	**A**	0	35
☒	**B**	0	36
☒	**C**	1	35
☒	**D**	1	36

(c) The table shows the composition of some of the different types of lipid in milk from cows.

Type of lipid	Composition of lipids in milk from cows (%)
monoacylglycerols	0.027
diacylglycerols	0.360
triacyglycerols	97.500
free fatty acids	0.027
phospholipids	0.600

Which row of the table shows the types of lipids that are the median and mode for this set of data?

(1)

		Median	Mode
☒	**A**	diacylglycerols	monoacylglycerols
☒	**B**	diacylglycerols	triacylglycerols
☒	**C**	monoacylglycerols	diacylglycerols
☒	**D**	monoacylglycerols	triacylglycerols

(d) Phospholipids have a different structure from other lipids, such as triglycerides.

Give one difference in the properties of phospholipids and triglycerides.

(1)

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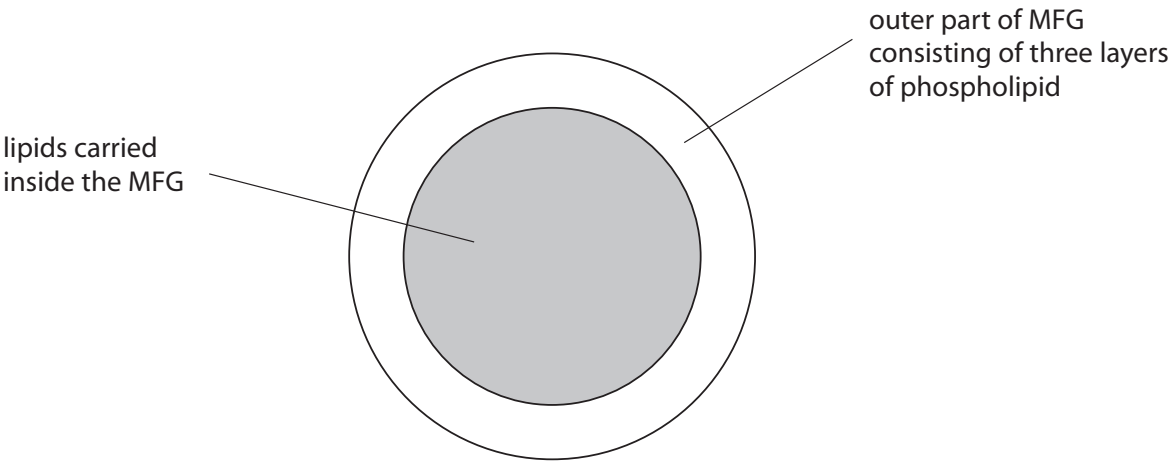
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(e) Milk from cows also contains a solution of proteins, lactose and mineral ions.

The lipids in milk are carried inside milk fat globules (MFG).

The diagram shows an MFG.

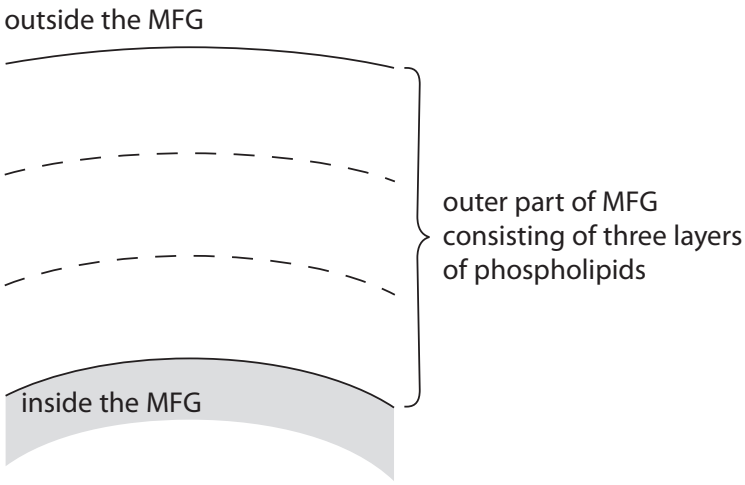


(i) Complete the diagram to show how nine phospholipid molecules would be arranged in the outer part of an MFG.

Use this shape to draw each phospholipid:



(2)



(ii) Explain the structure of an MFG.

(3)

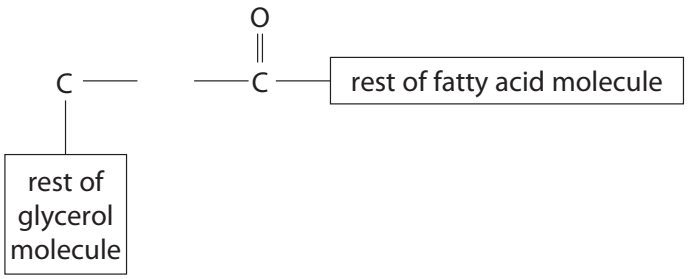
3 The structure of a lipid relates to its role in living organisms.

(a) Triglycerides are lipids.

(i) The diagram shows part of a glycerol molecule and part of a fatty acid.

Complete the diagram to show the ester bond joining the fatty acid to the glycerol molecule.

(1)



(ii) The table shows the relative atomic mass of some elements.

Element	Relative atomic mass
carbon	12
hydrogen	1
nitrogen	14
oxygen	16

A triglyceride is made from a glycerol molecule and three fatty acids.

The molecular mass of the glycerol is 92 and the total molecular mass of the three fatty acids is 362.

Which is the molecular mass of this triglyceride?

(1)

☒ **A** 400

☒ **B** 436

☒ **C** 448

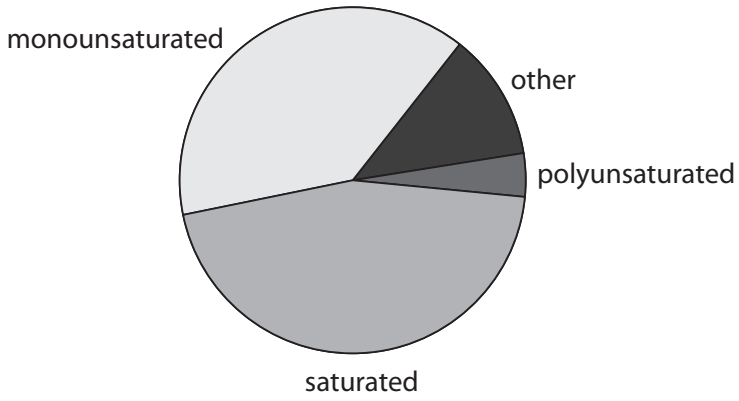
☒ **D** 454

(b) The type of lipid in the diet of a person can affect their risk of developing atherosclerosis.

The table shows the percentage content of different lipids in some products used to cook food.

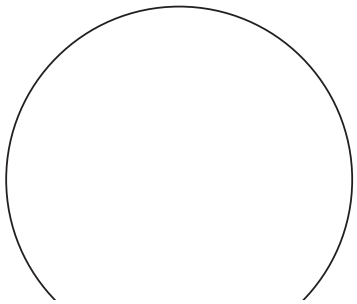
Product	Source of product	Saturated lipids	Monounsaturated lipids	Polyunsaturated lipids		Other lipids
				Omega-6	Omega-3	
Beef fat	animal	45	39	3	1	12
Butter	animal	52	24	2	1	21
Rapeseed oil	plant	7	59	20	9	5
Safflower oil	plant	10	15	75	0	0

(i) The pie chart shows the approximate ratio of the lipids in beef fat.



Complete the pie chart to show the approximate ratio of the lipids in safflower oil.

(1)



(ii) Calculate the difference in mass of polyunsaturated lipid in 500 g of safflower oil and 500 g of beef fat.

(2)

Answer ..... g

(iii) Explain why cooking food using plant products rather than animal products could lower the risk of developing atherosclerosis.

(2)

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(c) Cell membranes contain lipids that have a phosphate group attached to the glycerol, instead of one of the fatty acids.

Explain the importance of the phosphate group in these lipids.

(2)

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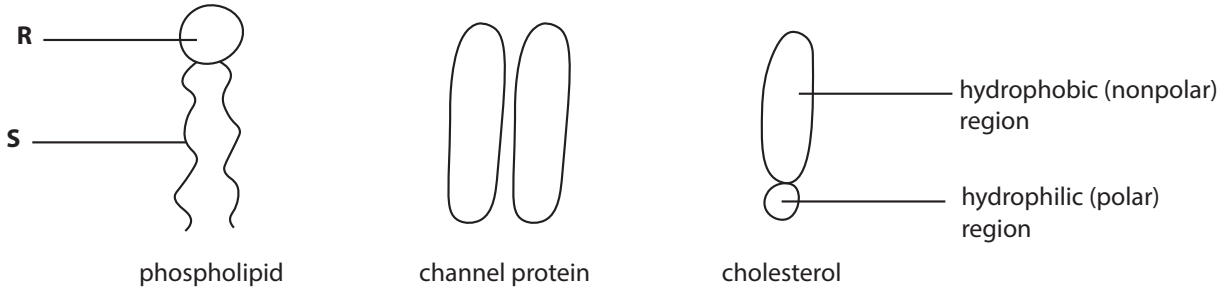
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4 The permeability of the cell surface membrane to a particular molecule depends on a number of factors, including the properties of the membrane and the properties of the molecule moving through it.

(a) The diagram shows some of the components of the cell surface membrane.



phospholipid channel protein cholesterol

(i) Which row in the table describes parts R and S of the phospholipid?

(1)

		Part R	Part S
☒	**A**	hydrophilic fatty acid	hydrophobic phosphate
☒	**B**	hydrophilic phosphate	hydrophobic fatty acid
☒	**C**	hydrophobic fatty acid	hydrophilic phosphate
☒	**D**	hydrophobic phosphate	hydrophilic fatty acid

(ii) Draw part of a cell surface membrane that has twelve phospholipids, one channel protein and one cholesterol molecule.

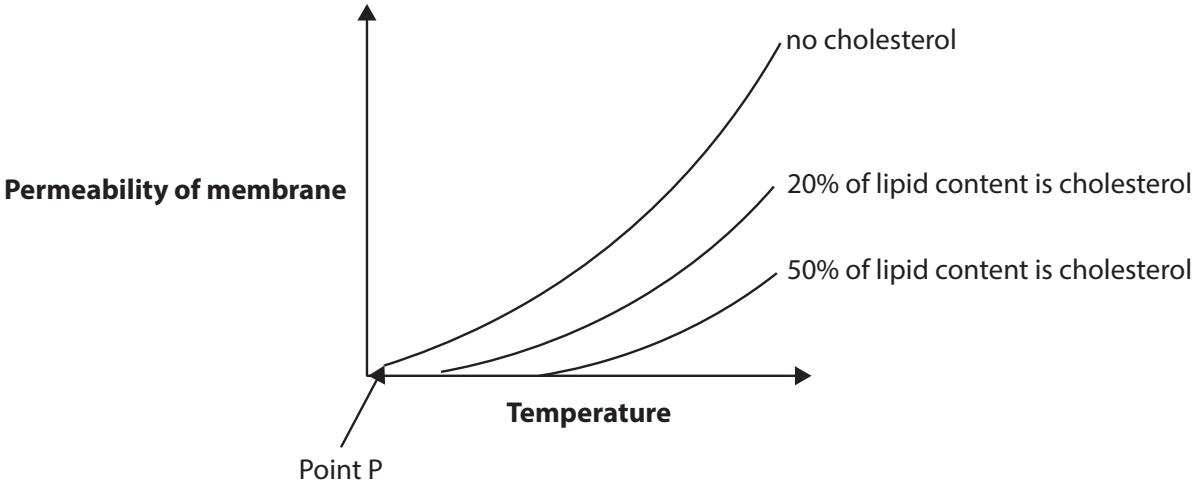
Use the components shown in the diagram.

(2)

(iii) Describe the role of channel proteins in cell transport.

(2)

(b) The graph shows the effect on the permeability of membranes of temperature and the proportion of cholesterol in the membrane.



(i) Analyse the data to give **two** conclusions that can be made from this graph.

(2)

(ii) Explain the effect of temperature on membrane permeability at point P.

(2)

6 The lipid content of the cell membranes of prokaryotic organisms changes in response to changes in the environmental temperature.

(a) Phospholipids form a bilayer in the cell membranes of bacteria.

Describe the structure of a phospholipid.

(2)

(b) The cell membranes of most organisms belonging to the domain Archaea are lipid monolayers.

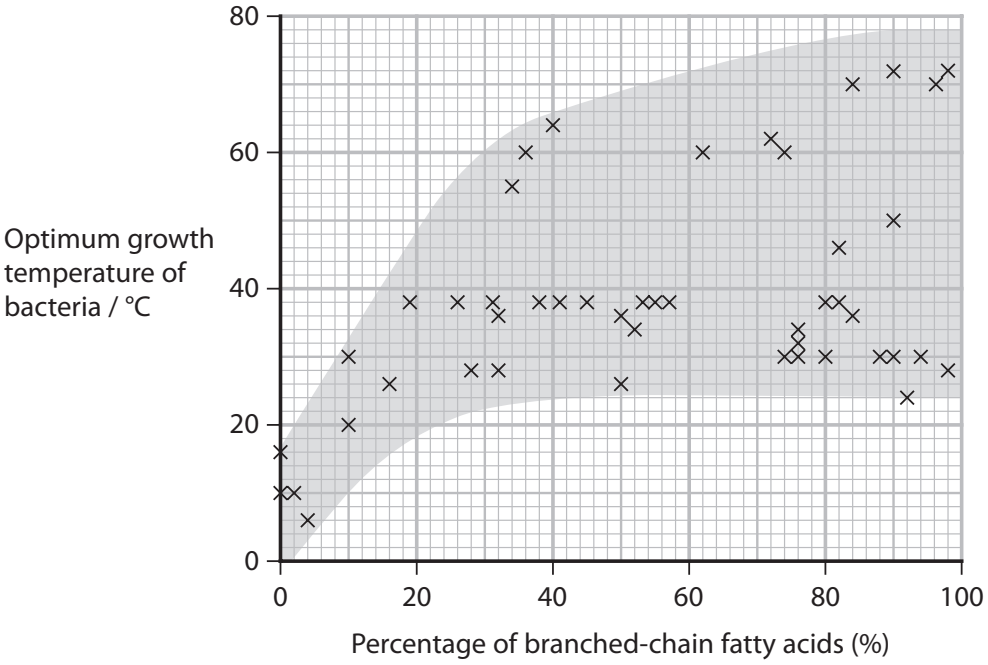
The lipid that forms this monolayer is a bipolar lipid.

Explain why a bipolar lipid is a suitable molecule to form the cell membrane.

(2)

(c) The percentage of branched-chain fatty acids in membranes of bacteria that have different optimum growth temperatures was investigated.

The graph shows the results of this investigation.



(i) Calculate the mean percentage of branched-chain fatty acids in bacteria whose optimum growth temperature is $<20\,°C$.

(1)

Answer ..... %

(ii) Analyse the data to describe **two** conclusions that can be drawn from this investigation.

(2)

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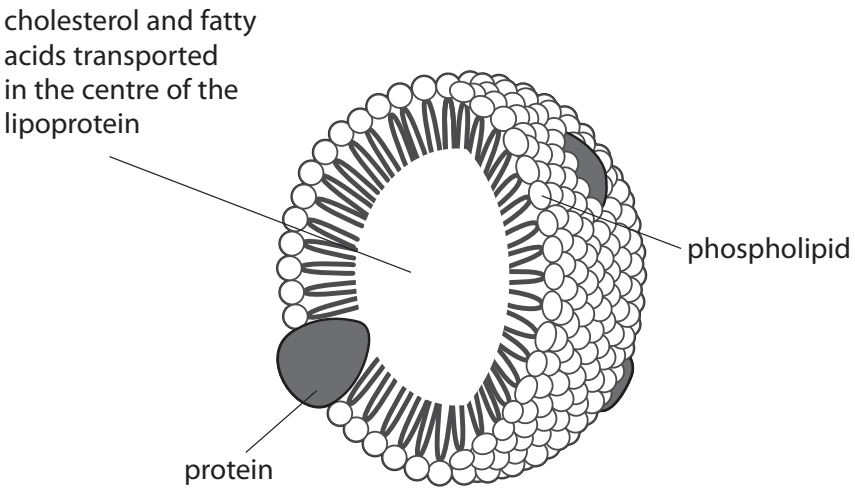
(d) A change in temperature can affect the permeability and fluidity of the membrane.

Explain why it is important that the lipid composition of the membrane of prokaryotic organisms changes if the temperature changes.

(3)

7 High density and low density lipoproteins are spherical structures that transport cholesterol and fatty acids in the bloodstream.

The diagram shows a lipoprotein.



(a) Explain why the properties of lipoproteins enable cholesterol and fatty acids to be transported in the bloodstream.

(3)

(b) The table shows some information about two types of lipoprotein, high density lipoprotein (HDL) and low density lipoprotein (LDL).

Information about lipoproteins	HDL	LDL
density range / g cm^{-3}	1.063 to 1.210	1.019 to 1.063
typical diameter / nm	8	22
typical volume / nm^3	268	
percentage of protein (%)	50	20

(i) Complete the table to show the volume of a typical LDL using the formula:

$$\frac{4}{3}\pi r^3 \quad \text{where } \pi = 3.14$$

(2)

(ii) Analyse the information to explain why LDLs have a lower density range than HDLs.

(2)

(iii) Explain why raised levels of LDLs may increase the risk of heart disease.

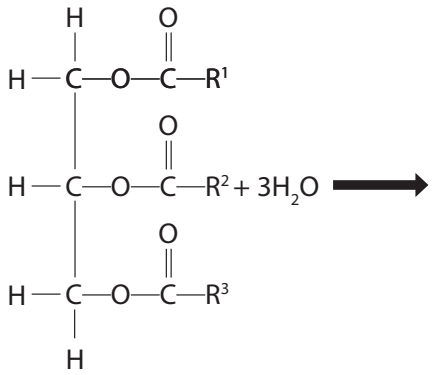
(4)

5 Palm plants and cocoa plants are used to produce lipids for the food industry.

Palm oil is produced from palm plants. Cocoa butter is produced from cocoa plants.

(a) Palm oil and cocoa butter are made of triglycerides composed of different fatty acids.

The diagram shows a triglyceride.



Complete the diagram to show the products of hydrolysis of this triglyceride.

(2)

(b) The fatty acid compositions of palm oil and cocoa butter are shown in the table.

Fatty acid	Chemical formula of fatty acid	Percentage of fatty acid found in palm oil and cocoa butter (%)	
		Palm oil	Cocoa butter
palmitic acid	$C_{16}H_{32}O_2$	45	27
oleic acid	$C_{18}H_{34}O_2$	40	31
linoleic acid	$C_{18}H_{32}O_2$	10	3
myristic acid	$C_{14}H_{28}O_2$	1	1
stearic acid	$C_{18}H_{36}O_2$	4	38

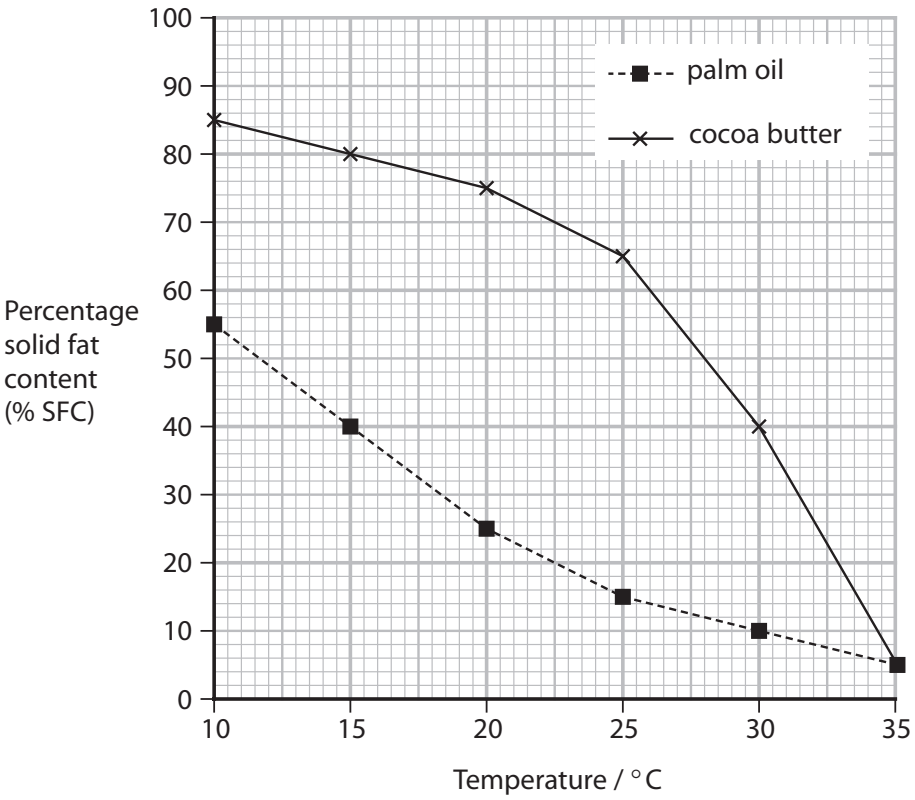
(i) How many of the named fatty acids shown in the table are saturated?

(1)

- ☒ **A** 1
- ☒ **B** 2
- ☒ **C** 3
- ☒ **D** 4

(ii) The percentage solid fat content (% SFC) is a measure of how much of a lipid is solid at different temperatures.

The graph shows the effect of temperature on the % SFC for palm oil and for cocoa butter.



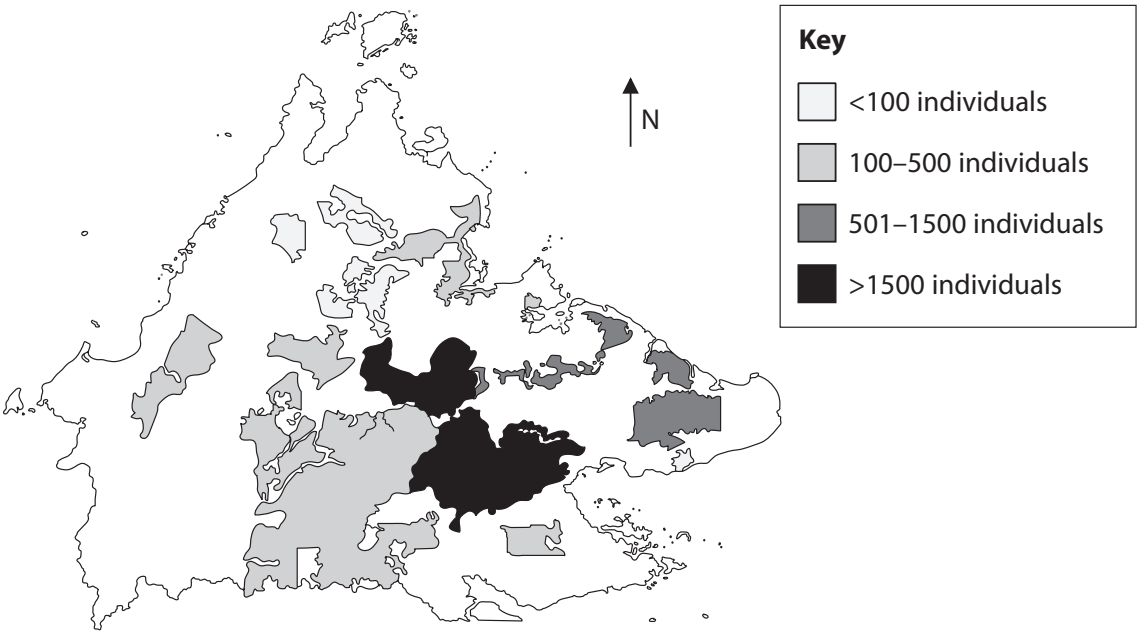
Comment on the effect of temperature on the % SFC of palm oil and of cocoa butter.

(4)

(c) Some forests in Borneo have been cleared to grow these plants.

Orangutans used to live in forests throughout this island but now they are found in small areas of forest.

The map shows the distribution of orangutans in parts of Borneo.



(i) Explain why in areas with low populations of orangutans, many of the orangutans have deformities and health problems.

(2)

(ii) The Malaysian government is paying local people to create and maintain 'land-bridges' of forest to link areas of forest together.

Explain why these payments will help to develop palm oil production and support conservation of orangutans.

(3)

(iii) State how treaties such as CITES help conserve orangutans.

(1)

(Total for Question 5 = 13 marks)

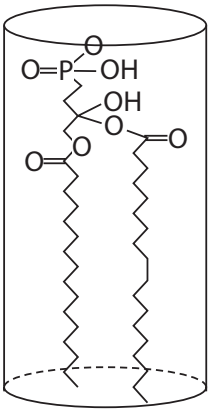
9 The membranes of cells and organelles contain many types of lipids.

(a) Phospholipids are one type of lipid found in cell membranes.

(i) Explain the role of phospholipids in the cell membrane.

(3)

(ii) The diagram shows a phospholipid drawn inside a cylinder.



The cross-sectional area of this cylinder is 0.3 nm^2.

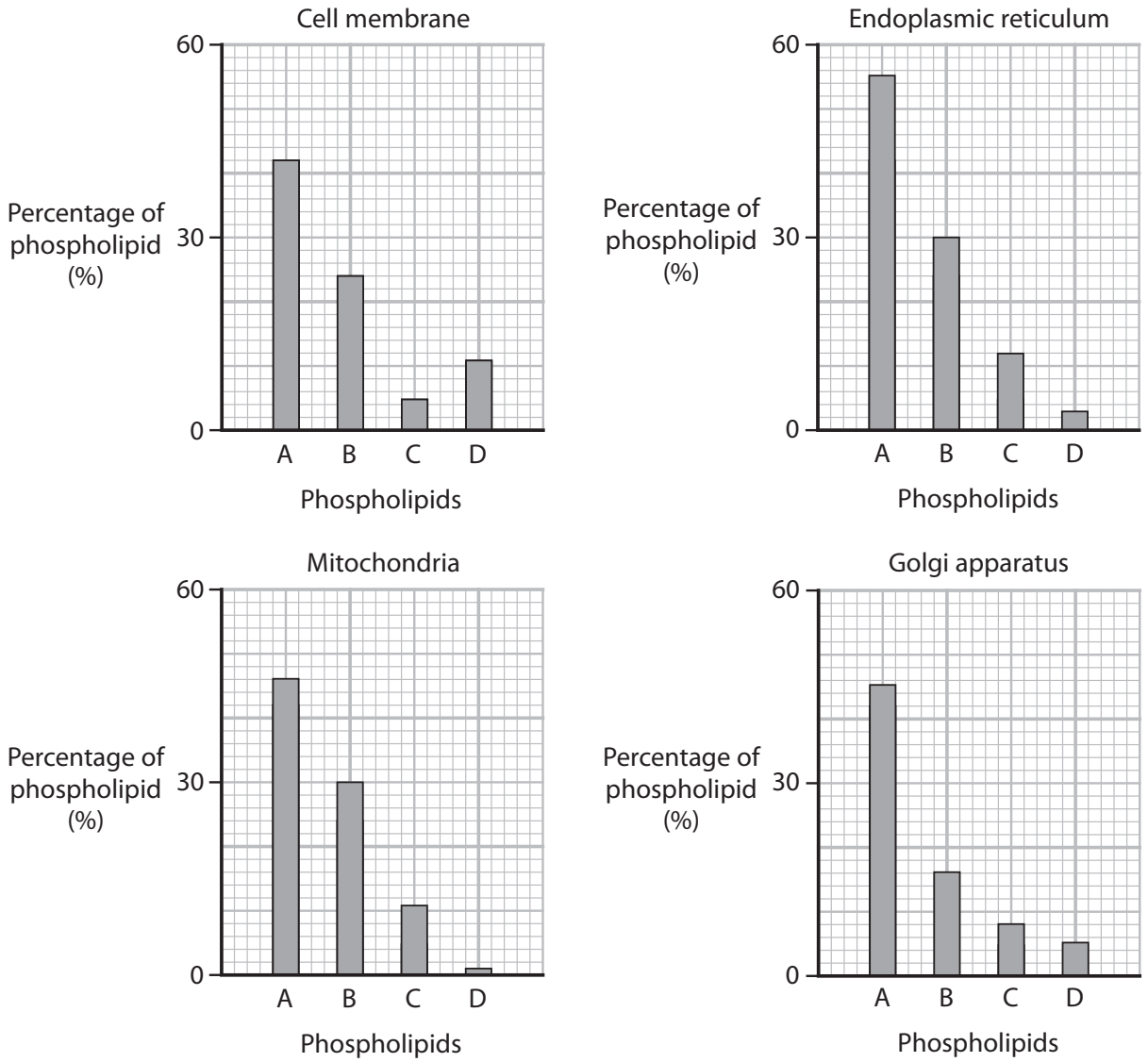
Calculate the number of phospholipid molecules in 1 μm^2 of a phospholipid bilayer.

Give your answer in standard form.

(3)

Answer .....

(b) The graphs show the percentage of four types of phospholipid, A, B, C and D, in the cell membrane and in the membranes of endoplasmic reticulum, mitochondria and Golgi apparatus.



(i) Describe how the structure of one type of phospholipid can be different from the structure of another type of phospholipid.

(2)

(ii) Compare and contrast the phospholipid content of these membranes.

(3)

(iii) The scientists who produced the data did not expect the phospholipid content in the membranes of the endoplasmic reticulum and the Golgi apparatus to be different.

Explain why these scientists did not expect there to be a difference in the phospholipid content in the membranes of these two organelles.

(2)

7 The image shows a bowhead whale.



(Source: © Panther Media GmbH/Alamy Stock Photo)

These marine mammals have a thick layer of blubber beneath their skin that acts as an energy store and an insulator.

Blubber is composed of fat cells and fibrous tissue.

(a) The lipids in blubber contain mostly unsaturated fatty acids.

(i) Describe **two** differences between the structure of an unsaturated fatty acid and a saturated fatty acid.

(2)

(ii) Explain why lipids are used for energy storage and insulation.

(3)

(b) The effect of seasonal feeding and age on the blubber of bowhead whales was investigated.

Samples were removed from three layers in the blubber and analysed for the:

- mean number of fat cells
- mean area of the sample of blubber occupied by fat cells
- mean area of fibrous tissue.

(i) Describe how a light microscope can be used to determine the area of one fat cell.

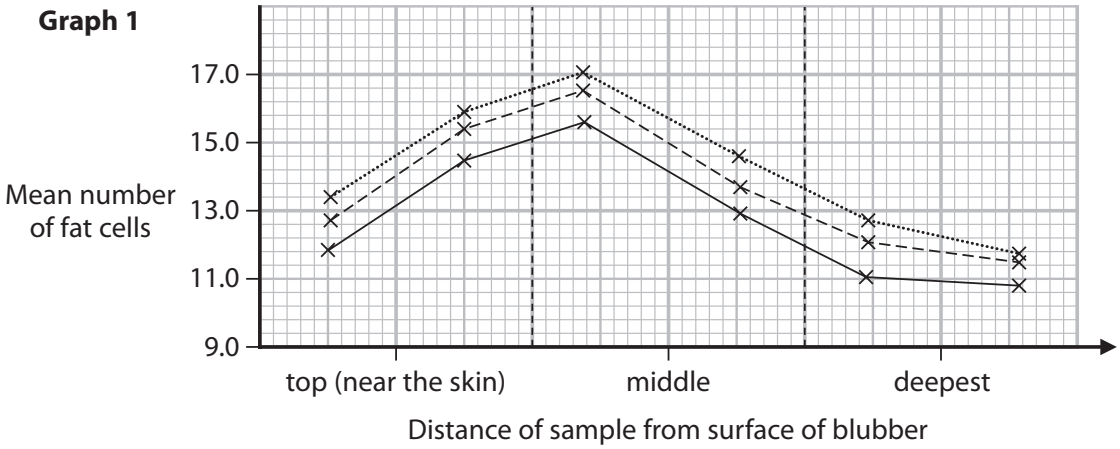
Assume that a fat cell is circular in shape.

(3)

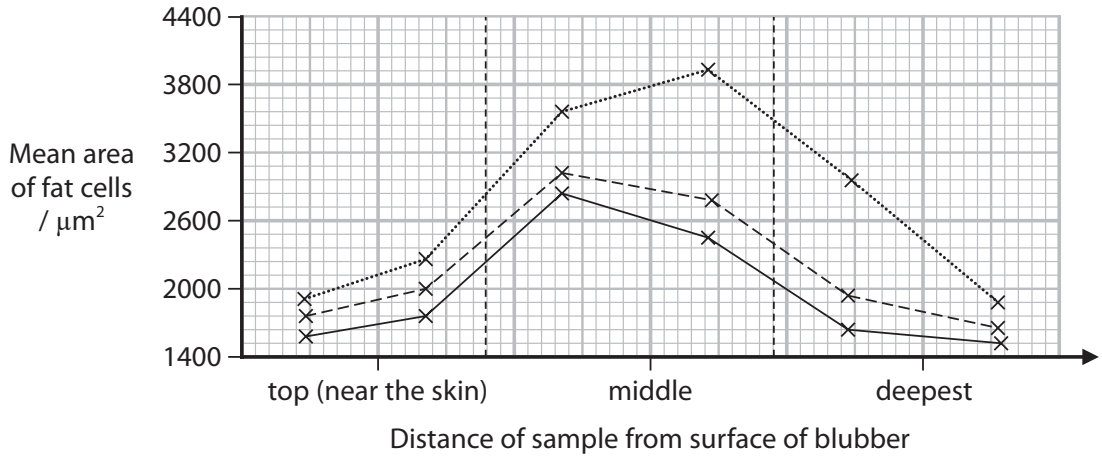
*(ii) The graphs show the results of this investigation.

Key:	..... young whales feeding from mother	– – – – adult whales feeding	——— adult whales after a winter of fasting

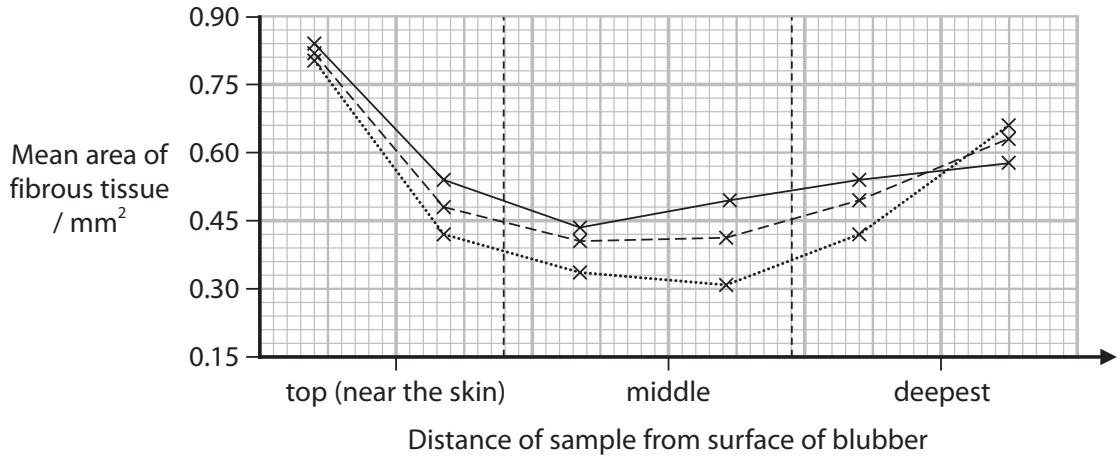
Graph 1



Graph 2



Graph 3



Analyse the data to explain the results of this investigation.

(6)

SUB-TOPIC 1(c)

PROTEINS

16 questions in this sub-topic · 154 marks · lowest tariff first

3 Leeches are parasites that feed by sucking blood. When they bite, they secrete saliva into the wound. The saliva contains a globular protein called hirudin.

(a) Explain why this protein is soluble in water.

(3)

(b) Hirudin is an inhibitor that forms hydrogen bonds with an enzyme.

Explain how hirudin would inhibit the activity of the enzyme.

(3)

1 The photographs show a black cat and a Siamese cat.



© Tim Macpherson, Cultura/Science photo library



© BSIP Laurent/Gluck/Science photo library

The pigment melanin causes the fur to turn black.
This pigment is produced by tyrosinase, an enzyme coded by the TYR gene.

tyrosine $\xrightarrow{\text{tyrosinase}}$ melanin

(a) (i) The diagram shows part of the DNA for the TYR gene.

A	C	C	C	C	A	A	G	G	C	T	C

Complete the diagram to show the messenger RNA produced by the transcription of this DNA.

(1)

(ii) Some amino acids have more than one codon.

Which term describes this property of the genetic code?

(1)

- ☒ **A** degenerate
- ☒ **B** non-overlapping
- ☒ **C** triplet code
- ☒ **D** universal

(b) Siamese cats have a mutation in their TYR gene.
This changes the secondary and tertiary structures of tyrosinase.

(i) Which of the following shows the type of bonding involved in both the secondary and tertiary structures of a protein?

(1)

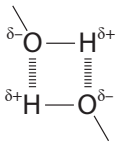
- ☒ **A** hydrogen only
- ☒ **B** hydrogen and ionic
- ☒ **C** ionic and disulfide
- ☒ **D** ionic only

(ii) Explain why the cooler regions of a Siamese cat have dark coloured fur and the warmer regions have lighter coloured fur.

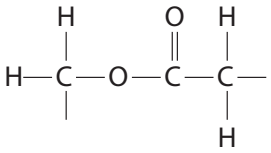
(3)

1 Carbohydrates and proteins are important biological molecules.

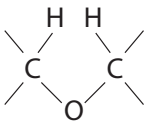
(a) The diagrams show some of the bonds found in biological molecules.



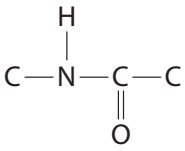
V



W



X



Y



Z

(i) Which one of the letters shows a bond that joins glucose molecules together in a disaccharide?

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(ii) Which letters show bonds that hold together the tertiary structure of a protein?

(1)

- ☒ **A** V and X
- ☒ **B** V and Z
- ☒ **C** W and Y
- ☒ **D** W and Z

(iii) Which letter shows a bond that holds together cellulose molecules within a cellulose microfibril?

(1)

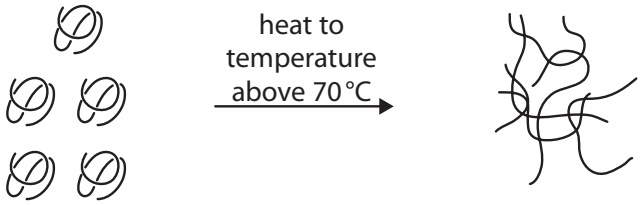
- ☒ **A** V
- ☒ **B** W
- ☒ **C** X
- ☒ **D** Y

(b) Raw egg white is a liquid containing dissolved ovalbumin, a globular protein.

Ovalbumin has some amino acids with polar R-groups and some amino acids with non-polar R-groups.

If raw egg white is heated to a temperature above 70 °C, it irreversibly changes into a solid.

The diagram shows how the structure of ovalbumin changes when heated.



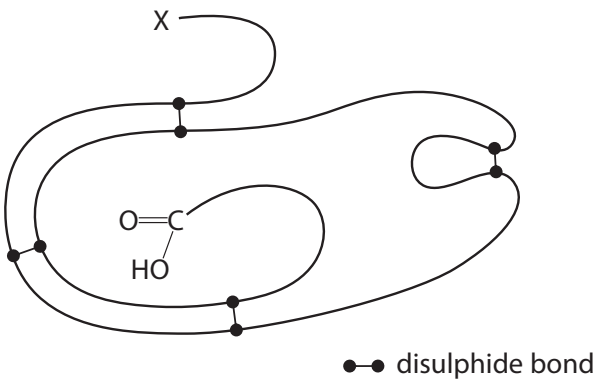
ovalbumin in raw egg white

ovalbumin in solid egg white

Explain why heating ovalbumin to temperatures above 70 °C causes egg white to change from a liquid into a solid.

(3)

3 The diagram shows the tertiary structure of a molecule of the enzyme RNase.



(a) (i) Which chemical group is found at position X?

(1)

- ☒ **A** amino
- ☒ **B** carboxyl
- ☒ **C** hydroxyl
- ☒ **D** nitrate

(ii) Give the meaning of the term tertiary structure of a protein.

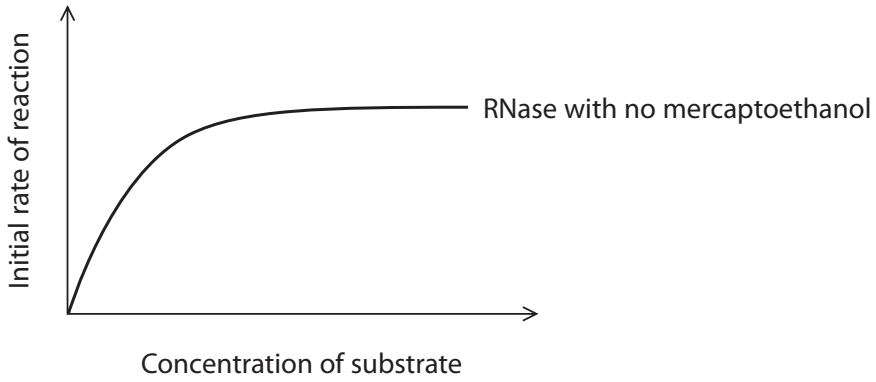
(2)

(b) The chemical mercaptoethanol breaks disulfide bonds.

The graph shows the initial rate of reaction of RNase with no added mercaptoethanol.

Sketch a line on the graph to show the effect of a low concentration of mercaptoethanol on the activity of RNase.

(1)

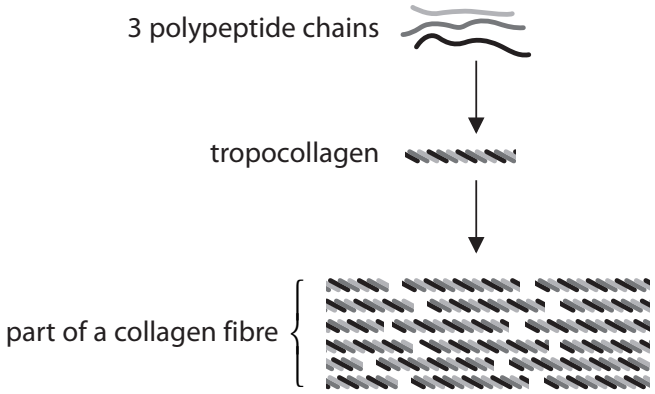


(c) Analyse the information to explain the effect of adding mercaptoethanol on the activity of RNase.

(3)

7 Collagen is a structural protein found in connective tissue.

(a) The diagram shows the components of a typical collagen fibre.



(i) Explain the significance of repeating sequences of amino acids in the formation of tropocollagen.

(2)

(ii) Which of the following bonds holds the 3 polypeptide chains together in the tropocollagen?

(1)

☒ **A** ester

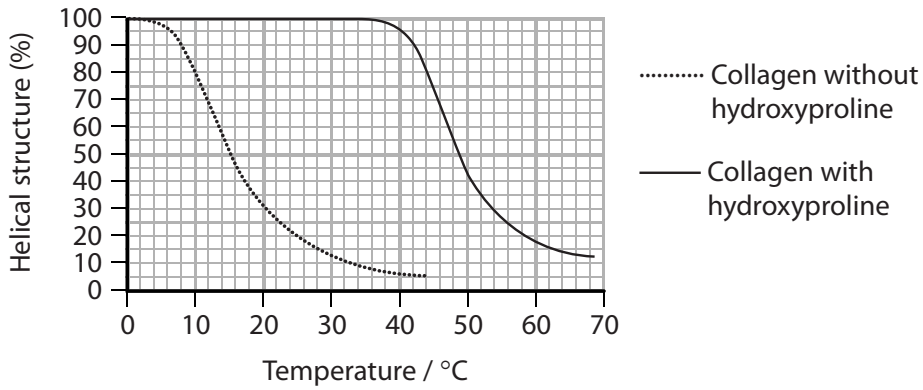
☒ **B** glycosidic

☒ **C** hydrogen

☒ **D** peptide

(b) Hydroxyproline and proline are components of collagen.

The graph shows the effect of temperature on the helical structure of collagen with hydroxyproline and collagen without hydroxyproline.



(i) Analyse the data to explain the importance of hydroxyproline in the structure of collagen.

(2)

(ii) The table shows information about the skin collagen of three animals and the body temperature of each animal.

Animal	Percentage of proline and hydroxyproline in skin collagen (%)	Body temperature / °C
Calf	23.2	37
Shark	19.1	24 to 28
Cod	15.5	10 to 14

The thermal stability of collagen is described by its shrinkage temperature (T_s). This is the temperature at which 50% of the helical structure is lost.

Analyse the data in the graph and the table to comment on the stability of collagen in these animals.

(4)

5 Cattle with bovine spongiform encephalopathy (BSE) have microscopic holes in their brain tissue.

This disease involves the misfolding of proteins which then form clumps.

Clumps of misfolded proteins can be seen with an electron microscope.

(a) BSE is diagnosed by examination of brain tissue.

(i) Explain why the clumps of misfolded proteins can be seen with an electron microscope, but not with a light microscope.

(2)

(ii) Explain why stains are used when preparing tissue for examination using a light microscope.

(2)

(b) The misfolded proteins have a changed secondary structure. Therefore they cannot be digested by some protease enzymes.

(i) Describe what is meant by the secondary structure of a protein.

(2)

(ii) Explain why the misfolded protein cannot be digested by some protease enzymes.

(3)

8 There are three different types of haemoglobin in the blood of an adult human. Each haemoglobin molecule is composed of four polypeptide chains.

(a) The table shows information about these types of haemoglobin.

Type of haemoglobin	Percentage present in the blood (%)	Types of polypeptide chain present
HbA_1	96	2α and 2β
HbA_2	3	2α and 2δ
HbF	1	2α and 2γ

Calculate the ratio of polypeptide chains present in the blood of an adult human.

(3)

Answer .....

(b) The β, δ and γ polypeptide chains have similar amino acid sequences.

The table shows the sequence of nine amino acids in a part of each of these polypeptide chains.

Type of polypeptide chain	Sequence of amino acids
β	- phe - ala - thr - leu - ser - glu - leu - his - cys -
δ	- phe - ser - gln - leu - ser - glu - leu - his - cys -
γ	- phe - ala - gln - leu - ser - glu - leu - his - cys -

The β, δ and γ polypeptide chains are coded for by three different genes.

Compare and contrast the sequence of bases in the DNA coding for each of these parts of the three polypeptide chains.

(4)

(c) Hereditary persistence of fetal haemoglobin (HPFH) is a condition that results from mutations in the genes coding for the β and δ polypeptide chains.

People with this condition produce HbF only.

The table shows the percentage saturation with oxygen, at different partial pressures, for HbF and HbA.

Partial pressure of oxygen / kPa	Percentage saturation of HbF with oxygen (%)	Percentage saturation of HbA with oxygen (%)
5.3	79	74
8.0	92	88
10.7	97	95
13.3	100	99

(i) State what is meant by the term **gene mutation**.

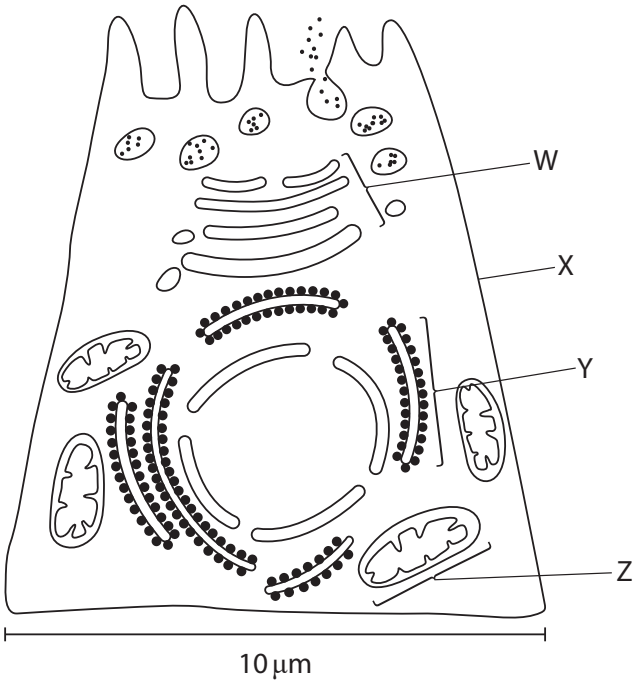
(1)

(ii) With reference to the table, explain why people with HPFH are usually unaware that they have this condition.

(2)

6 Some of the cells in the pancreas secrete proteins.

The diagram represents a pancreatic cell.



(a) (i) The structure labelled **Y** represents the

(1)

- ☒ **A** centrioles
- ☒ **B** Golgi apparatus
- ☒ **C** rough endoplasmic reticulum
- ☒ **D** smooth endoplasmic reticulum

(ii) The structure also found in a prokaryotic cell is labelled

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(iii) Calculate the magnification of this cell.

(2)

Answer.....

(iv) Explain why these pancreatic cells contain large numbers of organelle **Z**.

(3)

.....

.....

.....

.....

.....

(b) The secreted proteins are made from amino acids.

Two amino acids join together to form a dipeptide.

Draw a diagram to show the structure of a dipeptide.

(3)

4 Mitochondria can be extracted from liver cells.

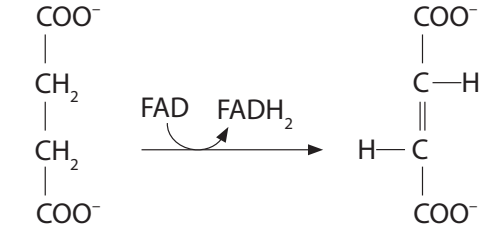
In order to monitor the purification of a sample of mitochondria, a protein concentration : enzyme activity ratio can be determined.

(a) Describe the structure of a globular protein.

(2)

(b) The enzyme used to monitor the purification of mitochondria is succinate dehydrogenase.

This enzyme is involved in the Krebs cycle and converts succinate into fumarate in this reaction.



Succinate Fumarate

(i) When succinate is converted into fumarate, succinate is

(1)

- ☒ **A** hydrolysed
- ☒ **B** oxidised
- ☒ **C** phosphorylated
- ☒ **D** reduced

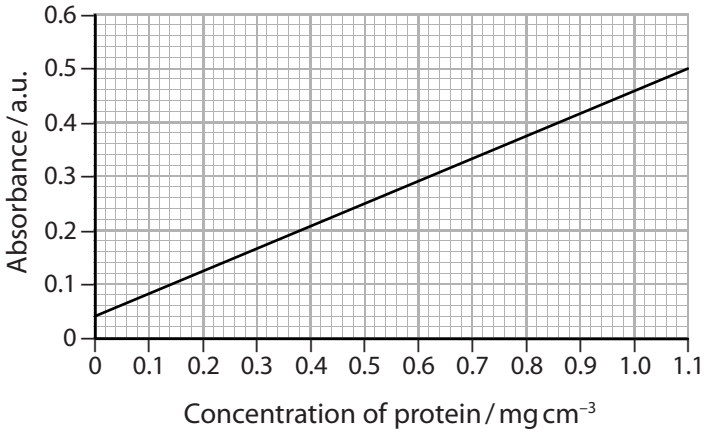
(ii) Explain the role of the Krebs cycle.

(4)

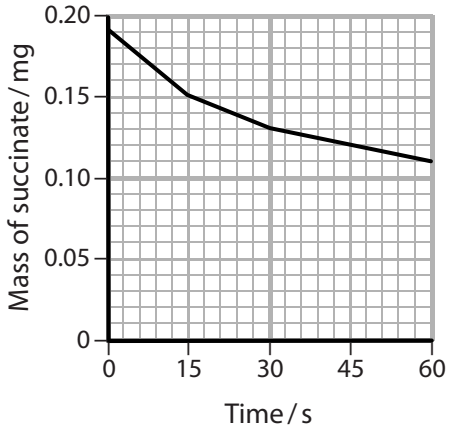
(c) Protein concentrations can be determined by using a calibration curve, shown in graph 1.

The initial rate of activity of succinate dehydrogenase, from a sample of mitochondria, can be determined using graph 2.

Graph 1



Graph 2



(i) This sample of mitochondria had an absorbance of 0.28 when the protein concentration was measured.

Determine the protein concentration of this sample of mitochondria.

(1)

Answer .....

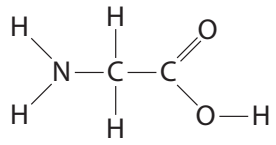
(ii) Determine the initial rate of enzyme activity to obtain the protein : enzyme activity ratio for this sample of mitochondria.

(2)

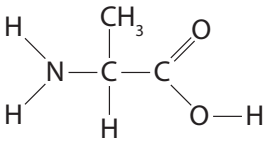
Ratio .....

(Total for Question 4 = 10 marks)

3 The diagram shows two amino acids found in the primary sequence of collagen.



glycine



alanine

(a) (i) Which is the R-group for alanine?

(1)

- ☒ **A** CH_3
- ☒ **B** COOH
- ☒ **C** H
- ☒ **D** NH_2

(ii) Draw the products of a condensation reaction between glycine and alanine.

(2)

(iii) Describe the structure of collagen.

(3)

(b) Ehlers-Danlos syndrome is a human condition caused by a mutation in a collagen gene.

This causes changes to the elasticity and strength of arteries.

Mice were genetically modified to have this mutation.

The elastic constant and force required to break arteries from genetically modified mice and unmodified mice were measured.

The elastic constant is calculated by using the formula:

$$\text{elastic constant} = \frac{\text{force applied}}{\text{increase in length of artery}}$$

The results are shown in the table.

Artery	Elastic constant / N mm^{-1}	Force required to break artery / N
unmodified mice	0.26	2.0
genetically modified mice	0.12	1.6

(i) Calculate the force required to produce an increase in length of 0.5 cm for an artery taken from an unmodified mouse.

(1)

Answer .....

(ii) People with Ehlers-Danlos syndrome are at risk of developing aneurysms.

An aneurysm is an area of artery wall that weakens and can burst.

Explain why people with Ehlers-Danlos syndrome have a high risk of aneurysms.

(3)

.....

.....

.....

.....

.....

7 Peptide hormones and steroid hormones are synthesised by endocrine glands.

Peptide hormones are transported dissolved in blood plasma. They bind to specific receptor molecules on the cell surface membranes of their target organs.

(a) Explain how the primary structure of a peptide hormone determines its properties.

(4)

(b) Some peptide hormones are nonapeptides.

The table shows the amino acid sequences of three types of nonapeptide: A, B and C.

Type	Position of amino acid in the nonapeptide								
	1	2	3	4	5	6	7	8	9
A	cys	tyr	ile	gln	asn	cys	pro	arg	gly
B	cys	tyr	phe	gln	asn	cys	pro	arg	gly
C	cys	tyr	phe	gln	asn	cys	pro	lys	gly

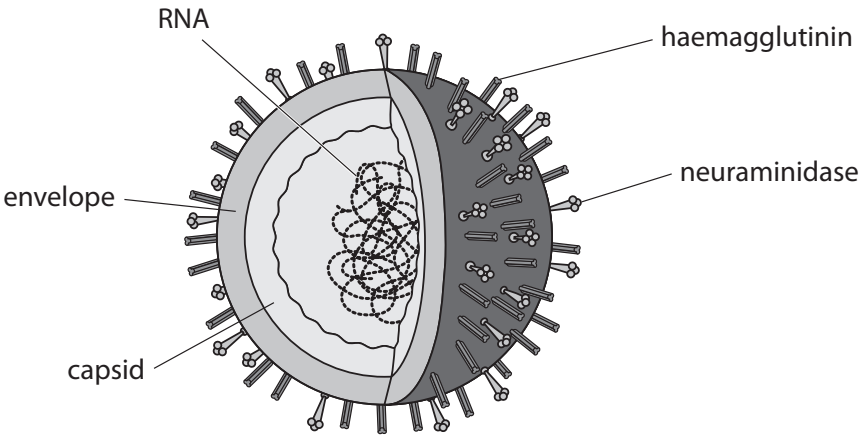
(i) Compare and contrast the amino acid sequence of these three nonapeptides.

(3)

(ii) Explain why the DNA base sequences coding for these three nonapeptides are more variable than their amino acid sequences.

(3)

6 The diagram shows the structure of the influenza virus.



(a) The influenza virus has a helical capsid.

Which virus also has a helical capsid and an envelope?

(1)

- ☒ **A** Ebola
- ☒ **B** human immunodeficiency virus
- ☒ **C** λ (lambda) phage
- ☒ **D** tobacco mosaic virus

(b) Neuraminidase is an enzyme.

Describe the structure of an enzyme.

(3)

*(c) The host cells of the influenza virus are the cells lining the airways. These cells are coated in mucus.

Neuraminidase and haemagglutinin are glycoproteins present in the envelope of the influenza virus.

Neuraminidase and haemagglutinin are important in the lytic cycle of this virus.

Neuraminidase breaks bonds between sialic acid groups and other molecules.

Sialic acid is found on glycoproteins present in the cell membrane, mucus and the envelope of the virus.

Haemagglutinin is a glycoprotein that binds to sialic acid groups.

The lytic cycle of the influenza virus includes the following steps:

1 the virus attaches to a cell

2 the virus moves until it attaches to the correct cell surface receptor

3 new virus particles are made inside the host cell

4 new virus particles bud from the host cell

5 new virus particles are attached to the outside of the host cell membrane and to each other

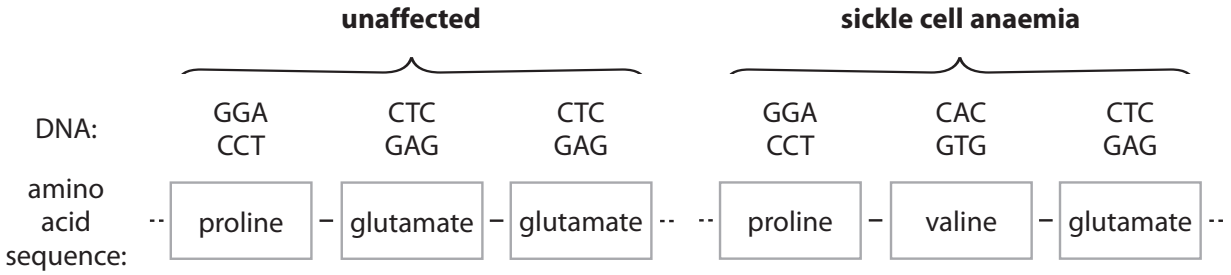
6 new virus particles infect new host cells.

Explain the importance of neuraminidase and haemagglutinin in the spread of infection of the influenza virus in the body.

(6)

4 Sickle cell anaemia is a condition caused by a mutation and a change in the structure of haemoglobin.

The diagram shows the changes that occur in the DNA sequence and the amino acid sequence for this condition.



(a) (i) Which type of bond is used when forming both the secondary structure and tertiary structure of proteins?

(1)

- ☒ **A** disulfide
- ☒ **B** hydrogen
- ☒ **C** ionic
- ☒ **D** peptide

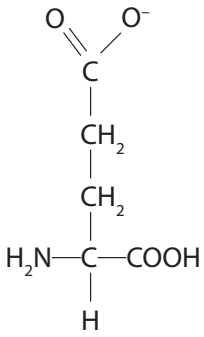
(ii) Which type of mutation has occurred to produce the allele for sickle cell anaemia?

(1)

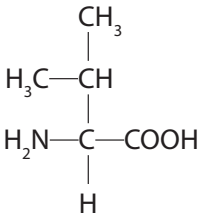
- ☒ **A** insertion
- ☒ **B** deletion
- ☒ **C** substitution
- ☒ **D** translocation

(iii) Glutamate is a charged, polar amino acid. It is located on the outer surface of unaffected haemoglobin molecules.

The diagram shows the structure of the amino acids glutamate and valine.



glutamate



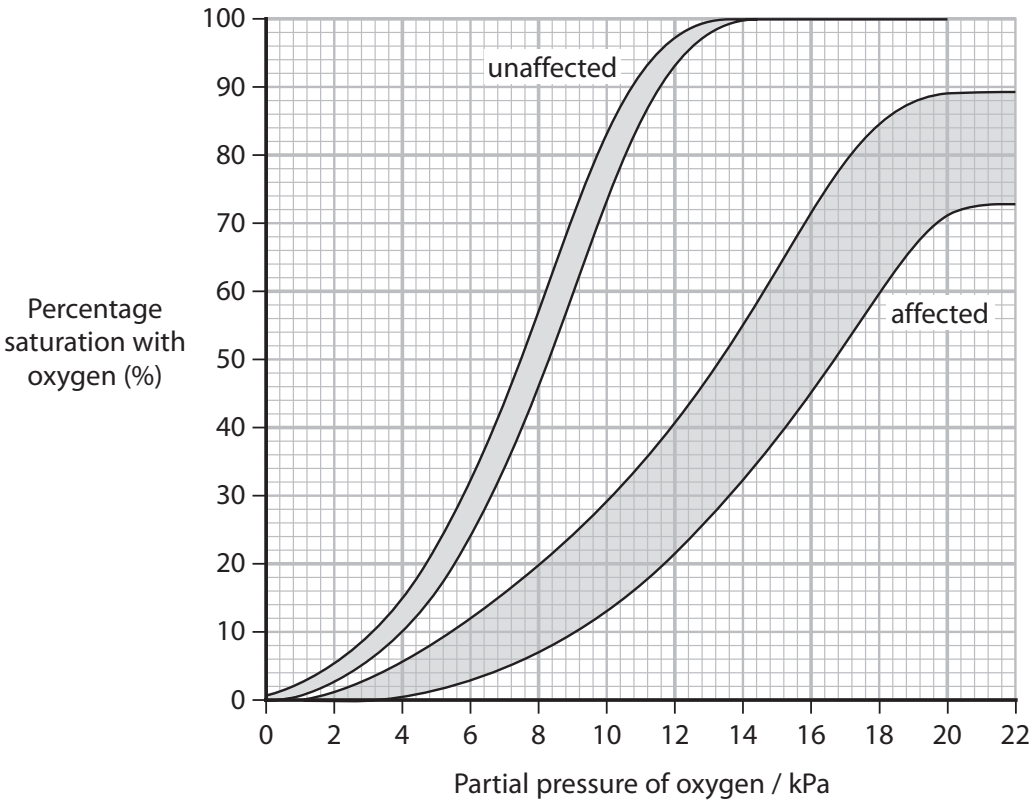
valine

Explain why the mutation in sickle cell anaemia causes haemoglobin molecules to bind together.

(2)

(b) The graph shows the range of oxygen dissociation curves for haemoglobin taken from people who do not have sickle cell anaemia (unaffected) and from people with sickle cell anaemia (affected).

The shaded areas represent the ranges for each blood sample.



(i) Compare and contrast the properties of haemoglobin from these two groups of people.

(2)

(ii) There is only one known allele that causes sickle cell anaemia.

State how the graph suggests that other genes affect the phenotype of people affected by sickle cell anaemia.

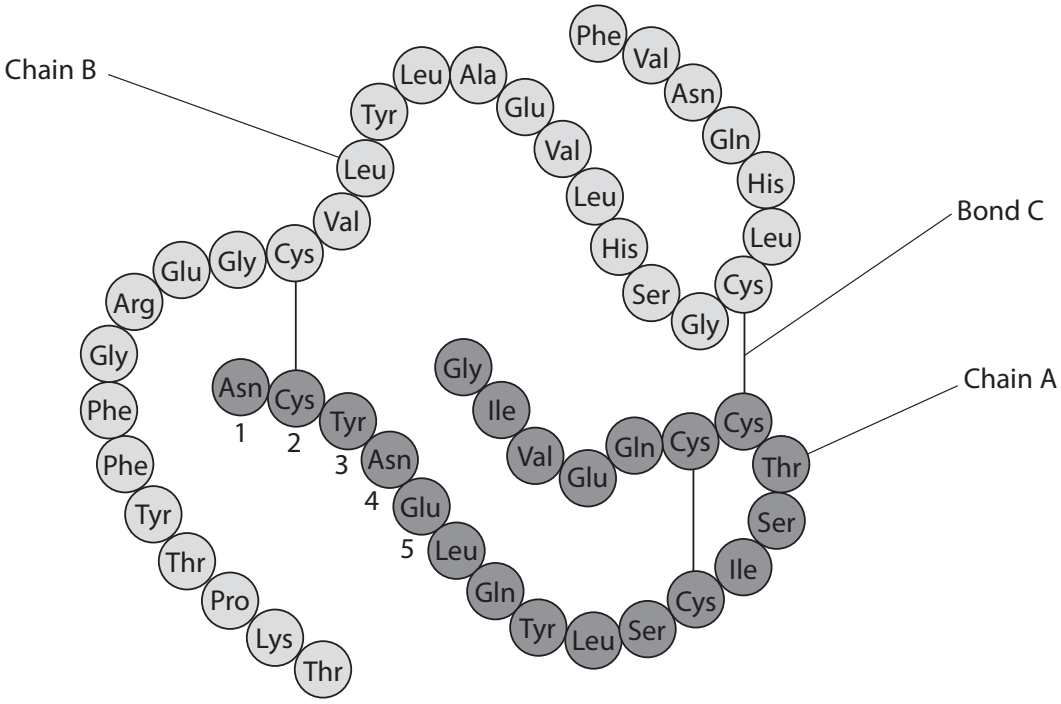
(1)

(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.

(3)

4 Insulin is a protein that is composed of two polypeptide chains, chain A and chain B.

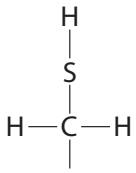
The diagram shows the amino acid sequence of these two polypeptide chains and some of the bonds involved in the folding of this protein.



(a) Cysteine (Cys) is one type of amino acid found in insulin.

The presence of cysteine in insulin is important in determining the structure of this protein.

The R group of cysteine is:



(i) Draw a diagram to show the structure of the amino acid cysteine.

(3)

(ii) Name the covalent bond labelled C in the diagram.

(1)

.....

(b) The table shows the DNA genetic codes on the anti-sense DNA strand (template strand) for amino acids.

Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid
AAA AAG	Lys	CAA CAG	Gln	GAA GAG	Glu	TAC TAT	Tyr
AAC AAT	Asn	CAT CAC	His	GAC GAT	Asn	TCA TCC TCG TCT	Ser
ACA ACC ACG ACT	Thr	CCA CCC CCG CCT	Pro	GCA GCC GCG GCT	Ala	TGG	Try
AGA AGG	Arg	CGA CGC CGG CGT	Arg	GGA GGC GGG GGT	Gly	TGC TGT	Cys
AGC AGT	Ser	CTA CTC CTG CTT	Leu	GTA GTC GTG GTT	Val	TTA TTG	Leu
ATA ATC ATT	Ile					TTC TTT	Phe
ATG	Met						

The genetic codes TAA, TAG and TGA are stop codons.

(i) Complete the diagram to show one base sequence in the antisense DNA strand (template strand) coding for the five amino acids numbered in the diagram of insulin.

(1)

Amino acid number	1	2	3	4	5
Amino acid abbreviation	Asn	Cys	Tyr	Asn	Glu
Base sequence on the antisense DNA strand		TGT			

*(ii) Analyse the information to deduce how gene mutations in the DNA base sequence for Cys (amino acid number 2) could affect the structure of insulin.

(6)

8 During mitosis, microtubules form the spindle.

These microtubules are made of a protein called tubulin.

Individual tubulin molecules are globular with a diameter of 25 nm.

Thousands of tubulin molecules are assembled together to form long, hollow microtubules.

(a) (i) Describe the differences between a fibrous protein and an individual tubulin molecule.

(2)

(ii) A microtubule is 40 μm in length.

Calculate how many times longer this microtubule is than a single tubulin molecule.

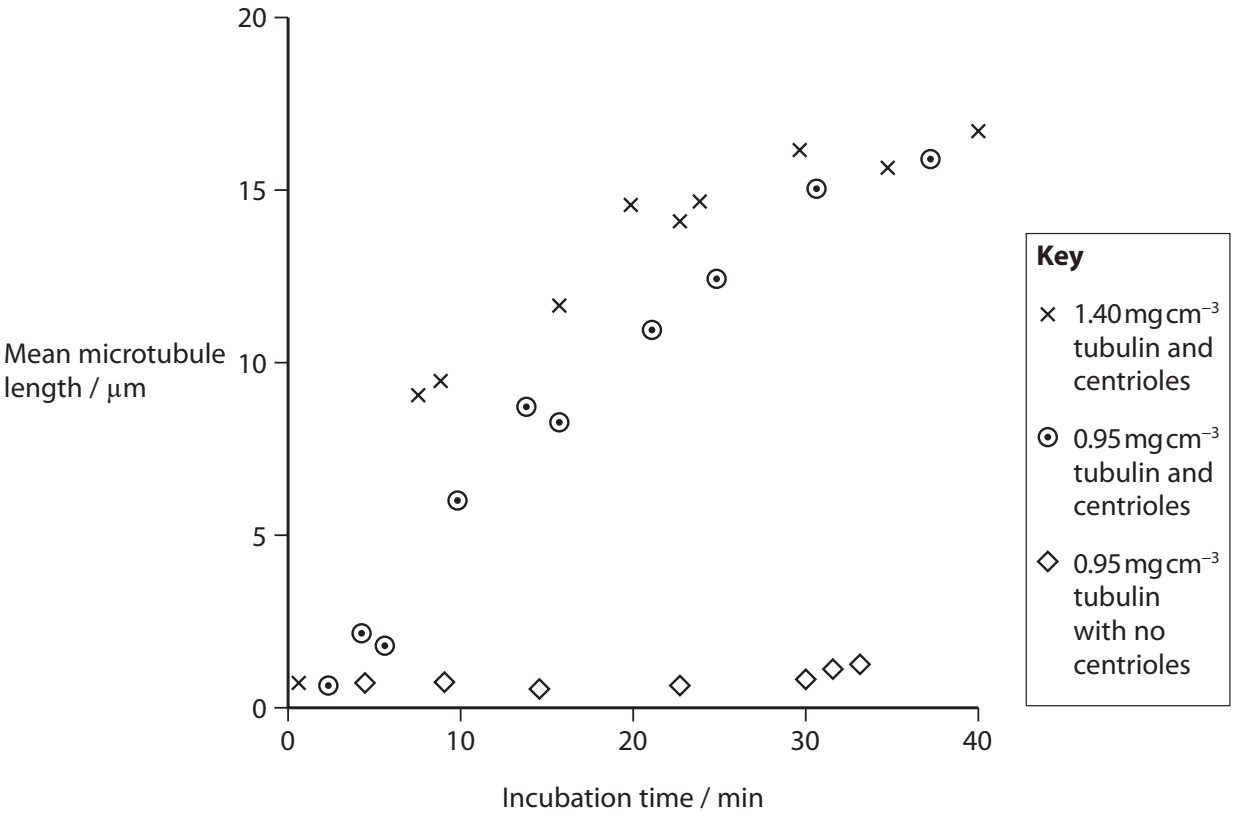
(2)

Answer .....

(b) The involvement of centrioles in spindle formation was investigated using the following method:

- in the first experiment, purified tubulin at a concentration of 1.40 mg cm^{-3} was mixed with centriole fragments
- the mixture was incubated at 35 °C
- every few minutes, the length of any microtubules formed was measured
- in a second experiment, a mixture containing 0.95 mg cm^{-3} tubulin and centriole fragments was used
- in a third experiment, 0.95 mg cm^{-3} tubulin with no centriole fragments present was used
- each of these three experiments was repeated several times.

The graph shows the results of this investigation.



(i) Analyse the data to comment on the relationship between centrioles and tubulin in the production of microtubules.

(4)

(ii) Explain why the centriole fragments and tubulin were each in a buffer solution at 35 °C before being used in these experiments.

(4)

(c) It was observed that for the mixture of 1.40 mg cm^{-3} tubulin with centriole fragments the mean length of microtubules decreased after 40 minutes.

Explain why the microtubule length decreased after 40 minutes.

(2)

9 Doxorubicin (Dox) is a drug used to treat cancer.

(a) Cancer is caused when cells divide uncontrollably.

This drug works in two ways:

- it becomes inserted into the DNA and holds the two strands together.
- it binds to an enzyme that repairs DNA.

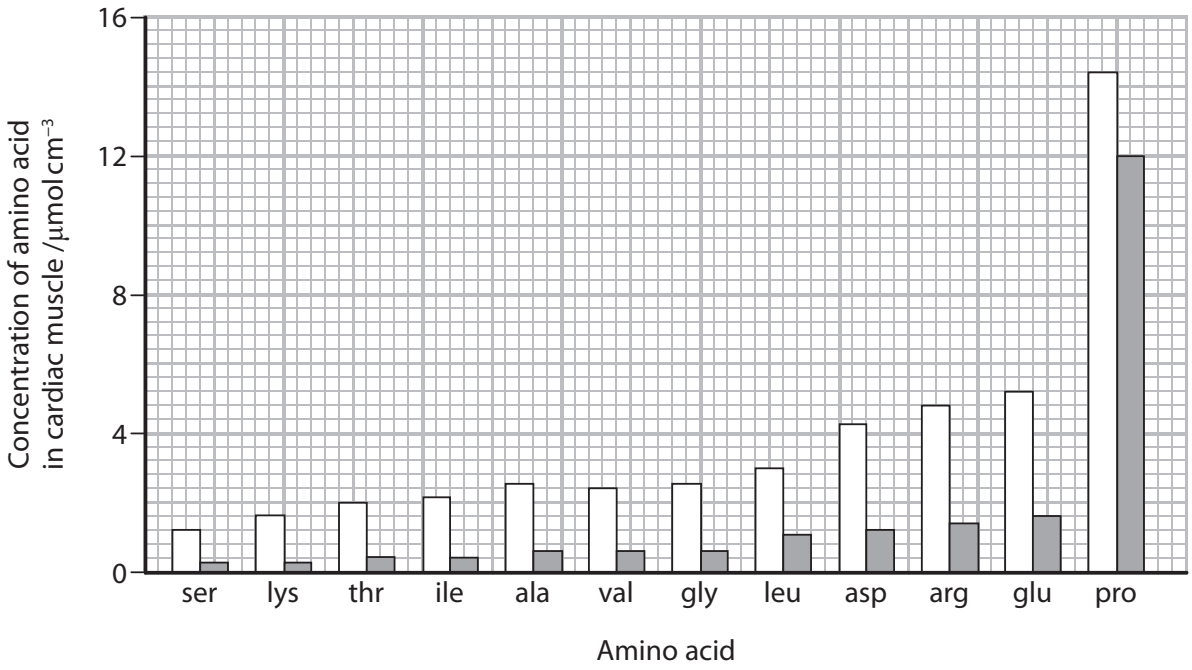
Explain how Dox prevents cancer cells from dividing.

(5)

(b) Weakening of the cardiac muscle is one side effect of using Dox.

The effect of Dox on the concentration of several amino acids in cardiac muscle was investigated.

The graph shows the results of this investigation.



The table shows some non-polar and polar amino acids.

Type	Amino acids
non-polar	ala, gly, ile, leu, pro, val
polar	arg, asp, glu, lys, ser, thr

*(i) Analyse the information to determine the effect of Dox on the concentration of these types of amino acid in cardiac muscle.

(6)

(ii) Explain why a change in the concentration of amino acids results in the weakening of cardiac muscle.

(2)

(iii) Explain how weakening of the cardiac muscle could affect a person.

(3)

SUB-TOPIC 1(d)

ENZYMES

28 questions in this sub-topic · 298 marks · lowest tariff first

1 The venom from some species of snake contains enzymes that affect the blood clotting process.

(a) (i) Which is a correct statement about enzymes?

(1)

- ☒ **A** enzymes decrease the activation energy of metabolic reactions and decrease reaction time
- ☒ **B** enzymes decrease the activation energy of metabolic reactions and increase reaction time
- ☒ **C** enzymes increase the activation energy of metabolic reactions and decrease reaction time
- ☒ **D** enzymes increase the activation energy of metabolic reactions and increase reaction time

(ii) Which components of the blood clotting process are active enzymes?

(1)

- ☒ **A** fibrin and thrombin
- ☒ **B** fibrinogen and thrombin
- ☒ **C** fibrinogen and thromboplastin
- ☒ **D** thrombin and thromboplastin

(b) Factor Xa is a clotting factor present in human blood.

The table shows the effect of different masses of Factor Xa and snake venom on the time taken for blood to clot.

Mass added / μg	Time taken for blood to clot / s	
	Factor Xa added	Snake venom added
0.002	150	104
0.004	44	50
0.020	40	38
0.040	39	37

Describe the effect of snake venom on the time taken for the blood to clot.

(2)

(c) State the role of platelets in the blood clotting process.

(1)

2 Enzymes are catalysts that are sensitive to changes in temperature.

(a) The effect of temperature on the activity of a mammalian enzyme was investigated.

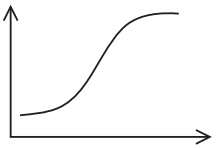
The enzyme was added to a known concentration of the substrate.

The time taken for all of the substrate to be used up was recorded at several temperatures.

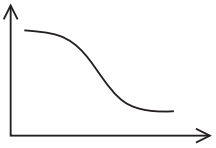
(i) Which graph shows the results of this investigation?

(1)

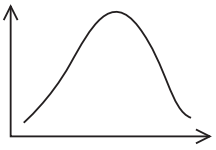
☒ **A**



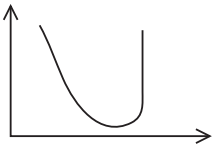
☒ **B**



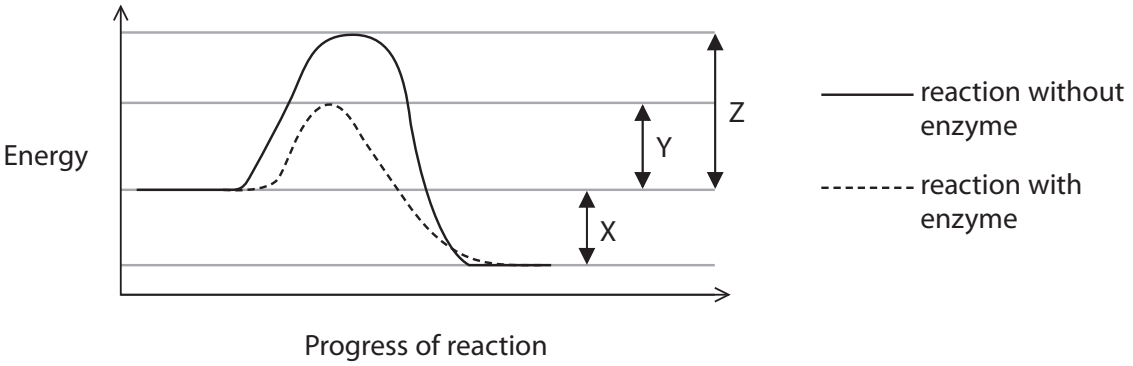
☒ **C**



☒ **D**



(ii) The graph shows the energy changes during a reaction with and without an enzyme.



Which of the following represents the decrease in the activation energy of this reaction?

(1)

- ☒ **A** X
- ☒ **B** X + Y
- ☒ **C** Z
- ☒ **D** Z – Y

(b) Some antibiotics affect the enzymes involved in the growth of bacteria.

(i) Explain why Gram positive bacteria and Gram negative bacteria react differently to some antibiotics.

(3)

(ii) Explain why viruses are not affected by antibiotics.

(2)

2 Living organisms are divided into three domains: Archaea, Bacteria and Eukaryota.

(a) The table shows some characteristics of organisms in the domain Archaea.

Characteristic	Organisms in the domain Archaea
membrane-enclosed nucleus	absent
peptidoglycan in cell wall	absent
ribosomes	70S

Explain why these organisms have **not** been classified in either of the other two domains.

(2)

(b) Some Archaea have the enzyme adenylate kinase (AK).

This enzyme is similar to AK enzymes found in humans.

There are two types of this enzyme in humans, AK1 and AK3.

The table gives some information about these two enzymes.

Enzyme	Location in the cell	Substrate	Role of enzyme
AK1	cytoplasm	adenosine triphosphate (ATP)	transfers phosphate
AK3	mitochondria	guanosine triphosphate (GTP)	transfers phosphate

(i) The tertiary structures of AK1 and AK3 are very similar but not identical.

Analyse the information to deduce why there are two AK enzymes.

(3)

(ii) Some types of Archaea have only one type of AK enzyme.

This enzyme can catalyse both the reactions shown in the table.

The tertiary structure of this enzyme is different from AK1 and AK3.

Explain why Archaea have a different type of AK enzyme.

(2)

2 The egg of a hen contains albumin, a globular protein.

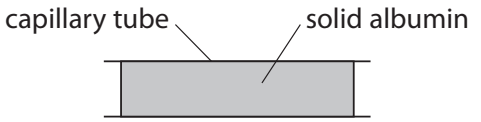
(a) Describe the tertiary structure of a globular protein.

(3)

(b) Pepsin is an enzyme that digests albumin.

Albumin can be put into a 50 mm long capillary tube and then made solid by boiling in water for 10 minutes.

The diagram shows a 50 mm capillary tube containing solid albumin.



Devise an investigation into the effect of pepsin concentration on the digestion of solid albumin.

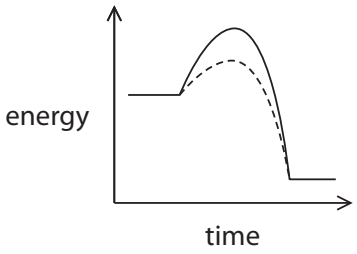
(5)

2 Bromelain is a protease enzyme in pineapple juice.

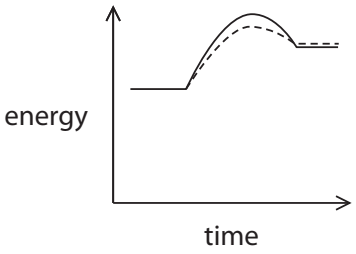
(a) Which graph shows the energy changes that occur in a typical enzyme catalysed reaction?

(1)

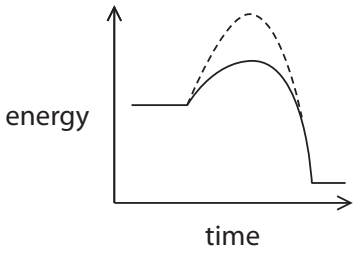
Key:
_____ without enzyme
- - - - - - with enzyme



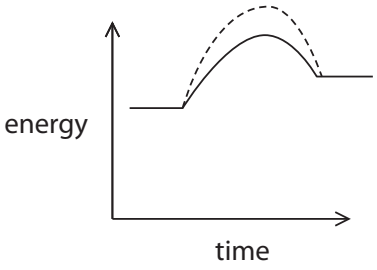
W



X



Y



Z

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

(b) A student investigated the digestion of gelatine protein by pineapple juice.

This is the method used.

Step 1: Make a solid disc of gelatine protein, with a depth of 1 cm, in a Petri dish.

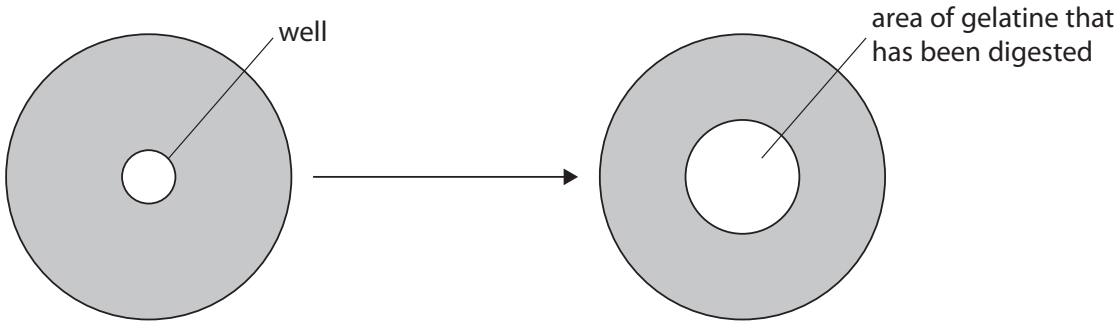
Step 2: Cut out a circular well with a diameter of 2 cm in the centre of the disc.

Step 3: Fill the well with pineapple juice.

Step 4: Incubate the dish for one hour at 37 °C.

Step 5: Measure the diameter of the area that has been digested by the bromelain enzyme.

The diagram shows a gelatine disc before and after incubation with the pineapple juice.



The diameter of the circular area that had been digested after one hour was 6 cm.

Calculate the volume of gelatine that had been digested.

Give your answer, in mm^3, to two significant figures.

Volume of a cylinder = $\pi r^2 l$

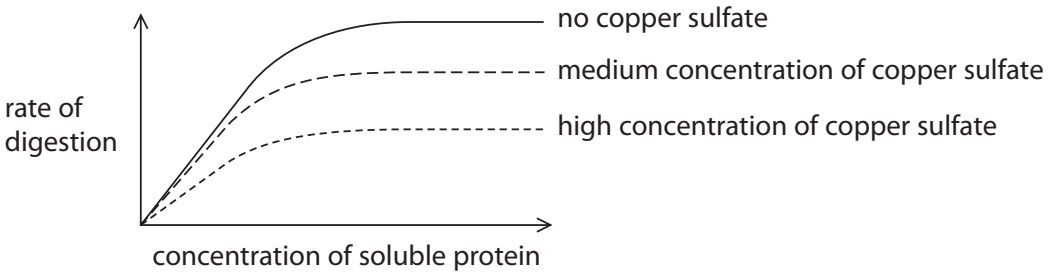
$\pi = 3.14$

(3)

Answer ..... mm^3

(c) Bromelain also digests other proteins.
The student also investigated the effects of changing the concentration of a soluble protein, and the addition of copper sulfate on the rate of digestion of this soluble protein by bromelain.

The results are shown in the graph.



(i) Explain the effect of increasing substrate concentration on the rate of digestion of the soluble protein.

(2)

(ii) Explain the effect of copper sulfate on the rate of digestion of the soluble protein.

(2)

3 The photograph shows an adult mayfly.



(a) *Rhithrogena germanica* is commonly known as the March brown mayfly.

The classification hierarchy for this mayfly is: Animalia
Arthropoda
Insecta
Ephemeropteroidea
Heptageniidae
Rhithrogena germanica

(i) State the genus of this mayfly.

(1)

.....

(ii) This mayfly belongs to the phylum Arthropoda.

Which is the order for this mayfly?

(1)

☒ **A** Animalia

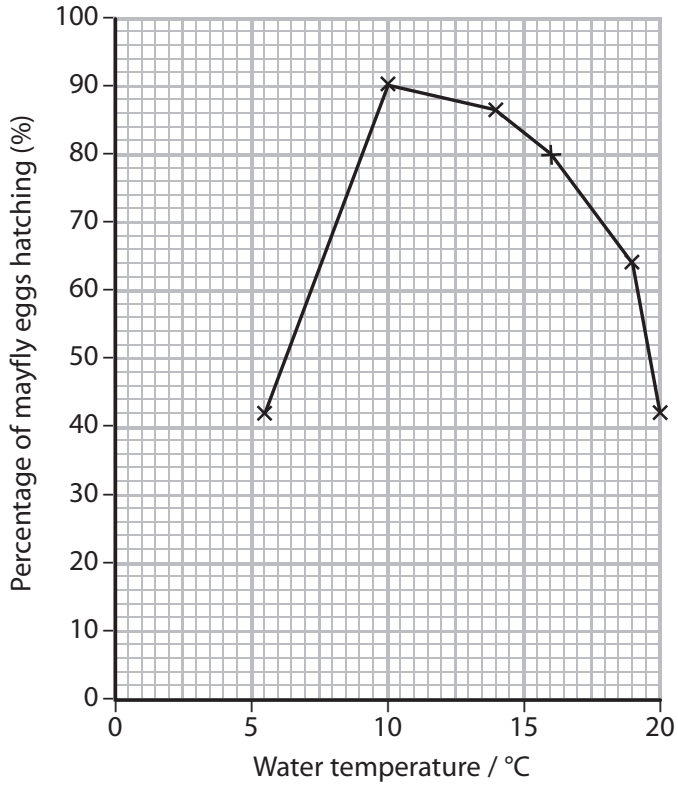
☒ **B** Ephemeropteroidea

☒ **C** Heptageniidae

☒ **D** Insecta

(b) Mayflies lay their eggs in water.

The graph shows the effect of water temperature on the percentage of mayfly eggs that hatch.



Explain the effect of temperature on the percentage of mayfly eggs that hatch.

(4)

(c) Mayfly eggs hatch into immature insects called nymphs. The nymphs live in the water and develop to form adult mayflies.

The photograph shows a mayfly nymph.

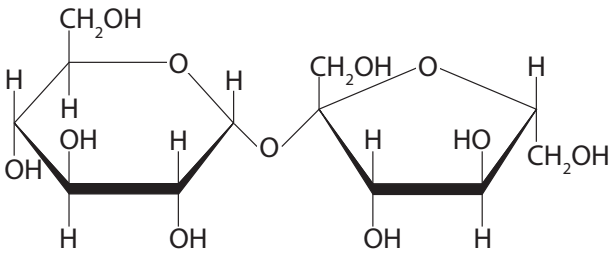


Compare and contrast the structure of the gas exchange system of the mayfly nymph with the adult mayfly.

(3)

2 Enzymes are involved in the breakdown of carbohydrates.

(a) The diagram shows the structure of sucrose.



The enzyme sucrase breaks down sucrose into two monosaccharides.

(i) Which type of reaction does sucrase catalyse?

(1)

- ☒ **A** condensation
- ☒ **B** hydrolysis
- ☒ **C** phosphorylation
- ☒ **D** translocation

(ii) Name the monosaccharides produced from the breakdown of sucrose.

(1)

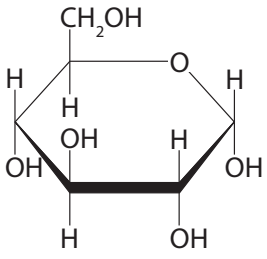
.....

.....

(iii) The diagram shows one of these monosaccharides.

Draw the structure of the other monosaccharide.

(1)



(b) The enzyme amylase breaks down the polysaccharide amylose into maltose.

How many of these statements are true for amylose?

(1)

- It contains 1,6 glycosidic bonds
- It contains 1,4 glycosidic bonds
- It has a helical structure
- It has a branched structure

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

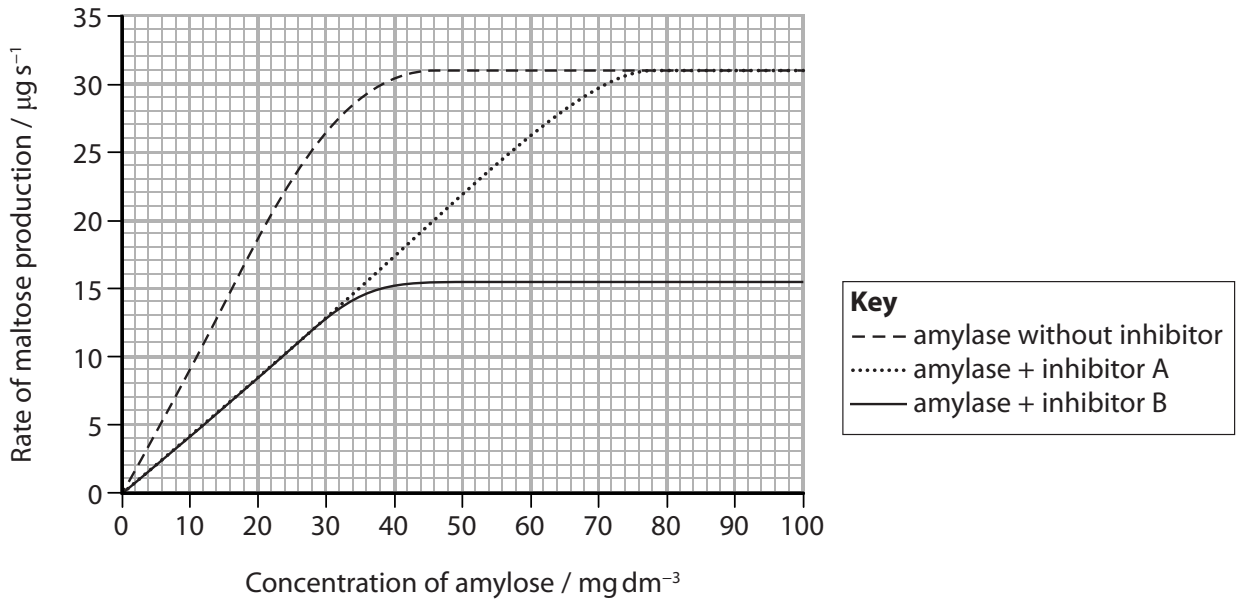
(c) Some plants produce amylase inhibitors.

A student investigated the effects of two inhibitors, A and B, on the activity of amylase.

The same concentration of amylase and the same concentrations of the inhibitors A and B were used.

The rate of maltose production was measured at different concentrations of amylose with each inhibitor and without an inhibitor.

The results are shown in the graph.



(i) Compare and contrast the effects of these two inhibitors on amylase activity.

(2)

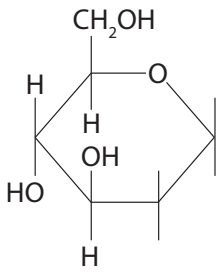
(ii) Explain which of the two inhibitors is non-competitive.

(3)

3 Glucose and fructose are monosaccharides.

(a) Complete the diagram to show the structure of alpha glucose.

(1)



(b) The makers of sweet tasting drinks use the enzyme glucose isomerase to convert glucose into fructose.

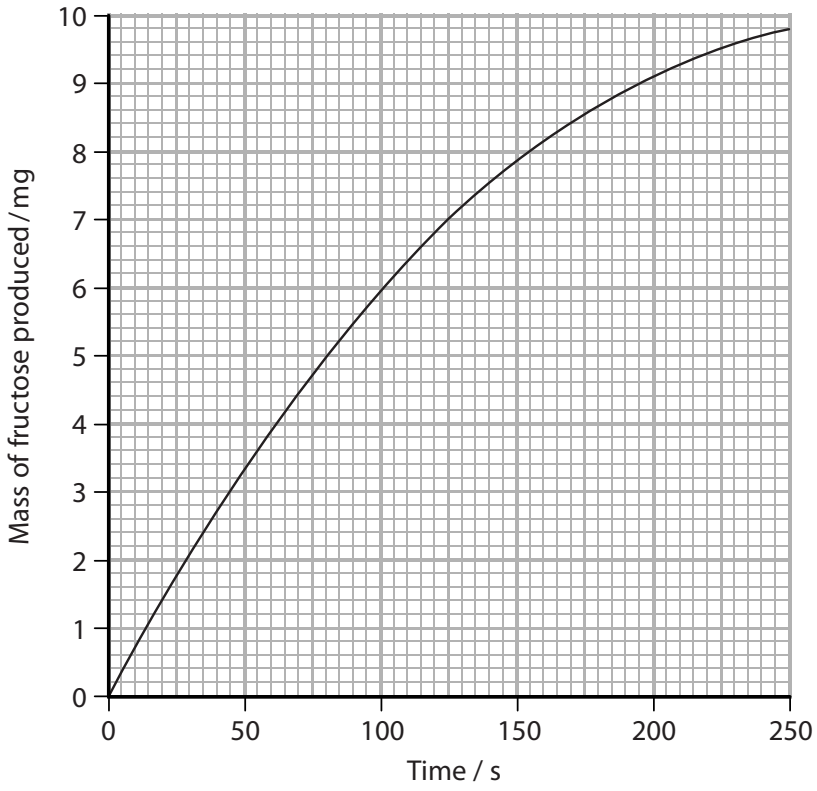
Fructose is a monosaccharide that tastes much sweeter than glucose.

(i) Explain a possible health benefit of converting glucose into fructose for use in sweet tasting drinks.

(2)

(ii) A student investigated the activity of glucose isomerase.

The graph shows the results of this investigation.



Determine the initial rate of the reaction.

(1)

Answer .....

(iii) Cofactors are non-protein molecules that help enzymes to function.

Magnesium ions act as cofactors for some enzymes.

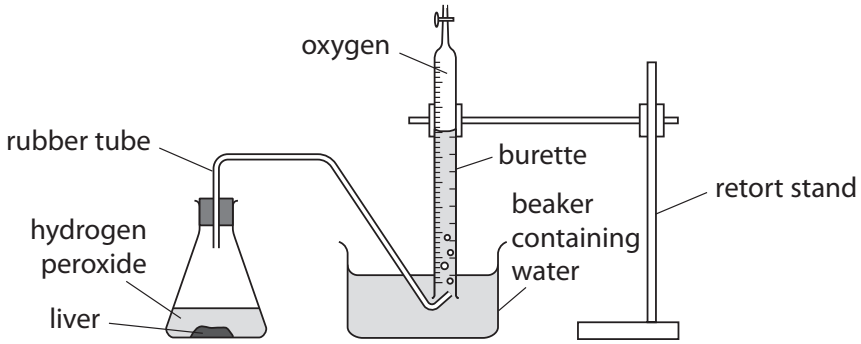
Devise an experiment to investigate the effect of magnesium ions on the initial rate of this reaction.

(5)

5 Liver cells contain an enzyme called catalase.

This enzyme changes hydrogen peroxide in the liver cells into water and oxygen.

A group of students used the apparatus shown to compare the activity of catalase in raw liver tissue and in boiled liver tissue.



The students used the following method.

- a burette filled with water is placed in a beaker containing water
- add hydrogen peroxide to the conical flask
- open the conical flask and drop 0.1g of raw liver into the hydrogen peroxide
- replace the bung on the conical flask
- after 10 seconds pinch the rubber tube to stop any more oxygen entering the burette
- measure the volume of oxygen collected in the burette
- repeat this method for boiled liver

The table shows the results obtained by each student.

Student	Volume of oxygen collected in 10 seconds / cm^3	
	Raw liver	Boiled liver
1	19	0
2	40	0
3	28	0
4	38	0
5	42	0
6	29	0
7	34	0
8	46	0
9	38	0

(a) Explain why no oxygen was produced when boiled liver was added to the hydrogen peroxide.

(3)

(b) Explain why it was important to measure the volume of oxygen in the first 10 seconds.

(2)

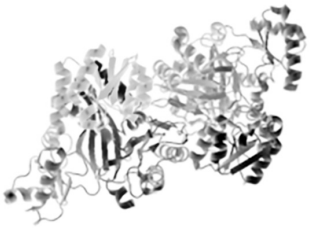
(c) The results for the volume of oxygen collected by each student using raw liver were different.

Give **four** possible improvements to the method used by these students that would reduce the variability of the results.

(4)

6 Acetyl CoA is produced in the link reaction when pyruvate is broken down.

The photograph shows a molecule of the enzyme acetyl CoA carboxylase.



This enzyme is involved in the conversion of acetyl CoA into fatty acids.

The enzyme is activated by citrate.

Citrate does not bind at the active site.

Citrate is produced in the Krebs cycle.

The enzyme is inhibited by long chain fatty acyl CoA molecules.

Fatty acyl CoA molecules have a longer carbon chain than acetyl CoA.

(a) (i) Analyse the information to explain how the activity of the enzyme acetyl CoA carboxylase is controlled.

(5)

(ii) Explain why inhibitors of this enzyme may be useful in treating obesity in humans.

(2)

(b) The enzyme acetyl CoA carboxylase has a different structure in bacteria.

The enzyme in bacteria is made of several polypeptide subunits whereas in humans, the enzyme is one large polypeptide.

Inhibitors of the bacterial enzyme are being developed to treat bacterial infections.

Explain why inhibitors of the bacterial enzyme may be useful when treating bacterial infections.

(2)

5 Fluoride ions reduce anaerobic respiration in yeast by inhibiting the action of the enzyme enolase.

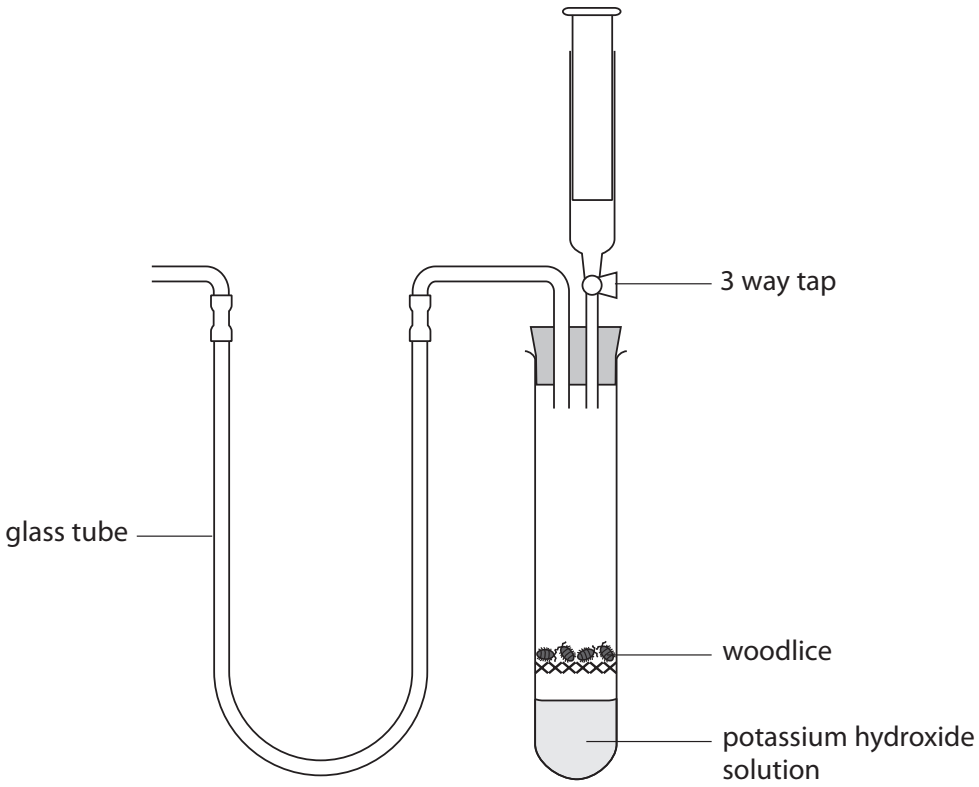
Fluoride ions combine with magnesium ions and phosphate ions to resemble the substrate of enolase.

(a) Name the type of inhibition produced by fluoride ions.

(1)

.....

*(b) The diagram shows some apparatus that can be used to measure the rate of respiration in small animals such as woodlice.



Discuss how you would modify this apparatus and use it to find out if fluoride ions have a significant effect on the rate of anaerobic respiration in yeast.

(9)

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9 Chymosin is an enzyme used to clot milk for the production of cheese.

A farmer investigated the effect of chymosin concentration on the rate of milk clotting.

1 cm^3 of a 0.2% chymosin solution was added to 9 cm^3 milk and the time taken for the milk to clot was recorded. This was repeated using five other concentrations of chymosin.

The results are shown in the table.

Chymosin concentration (%)	Time for milk to clot / min		Mean rate of milk clotting / min^{-1}
	Trial 1	Trial 2	
0.2	7.0	7.5	0.14
0.5	3.5	3.0	
1.0	1.5	1.5	0.67
1.5	1.0	1.5	0.80
2.0	0.8	0.7	1.33
3.0	0.5	0.3	2.50

(a) (i) Calculate the mean rate of milk clotting at a chymosin concentration of 0.5%.

(3)

Answer..... min^{-1}

(ii) Give one reason why the information in the table is insufficient to conclude which concentration of chymosin would be best for cheese production.

(1)

.....

.....

.....

.....

(b) The chymosin used for the investigation costs 3.6p to treat 100 cm^3 of milk.

Calculate how much it would cost to treat 200 dm^3 milk.

(2)

Answer £.....

(c) Devise a valid investigation to compare the effect of chymosin on the clotting time of milk from two different breeds of cattle.

(4)

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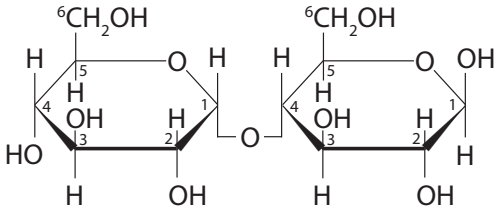
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4 Enzymes are involved in a wide range of metabolic reactions.

(a) The diagram represents the structure of a maltose molecule.



Draw a diagram to show the hydrolysis of maltose.

(3)

(b) Catalase is an enzyme found in potato cells.

It catalyses the breakdown of hydrogen peroxide.

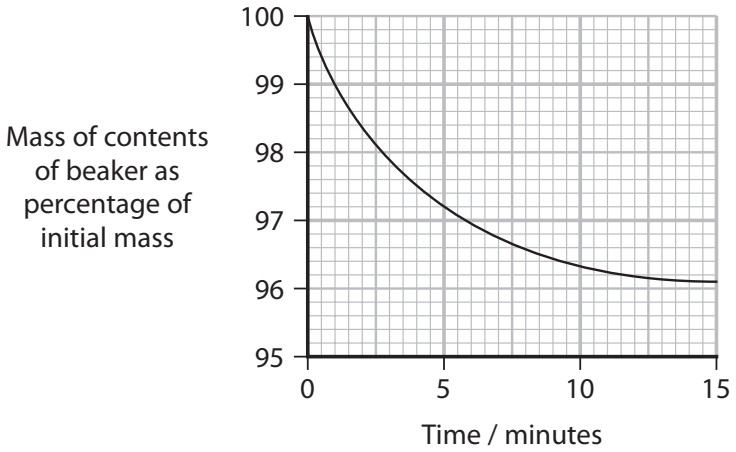
$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water} + \text{oxygen}$$

In an investigation, cylinders of potato were cut with a cork borer.

The cylinders were then sliced into discs with the same thickness and put into a small beaker containing 50 cm^3 of hydrogen peroxide.

The mass of the beaker and its contents was recorded over a period of 15 minutes.

The graph shows the results of the experiment.



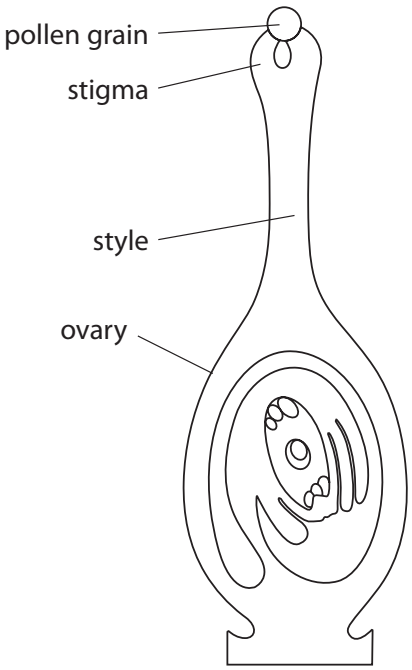
Explain the relationship shown in the graph.

(4)

(c) Explain how a gene mutation can prevent the production of catalase in potato cells.

(3)

5 The diagram illustrates part of a flowering plant when pollination has just taken place.



(a) Describe the role of enzymes in the growth of the pollen tube.

(3)

(b) The styles of some plants secrete RNAase enzymes when pollen from the same flower germinates on the stigma.

Explain how these RNAase enzymes affect the growth of the pollen tube.

(3)

(c) Explain the role of double fertilisation in flowering plants.

(4)

9 Polyphenol oxidase is an enzyme found in many plant cells.

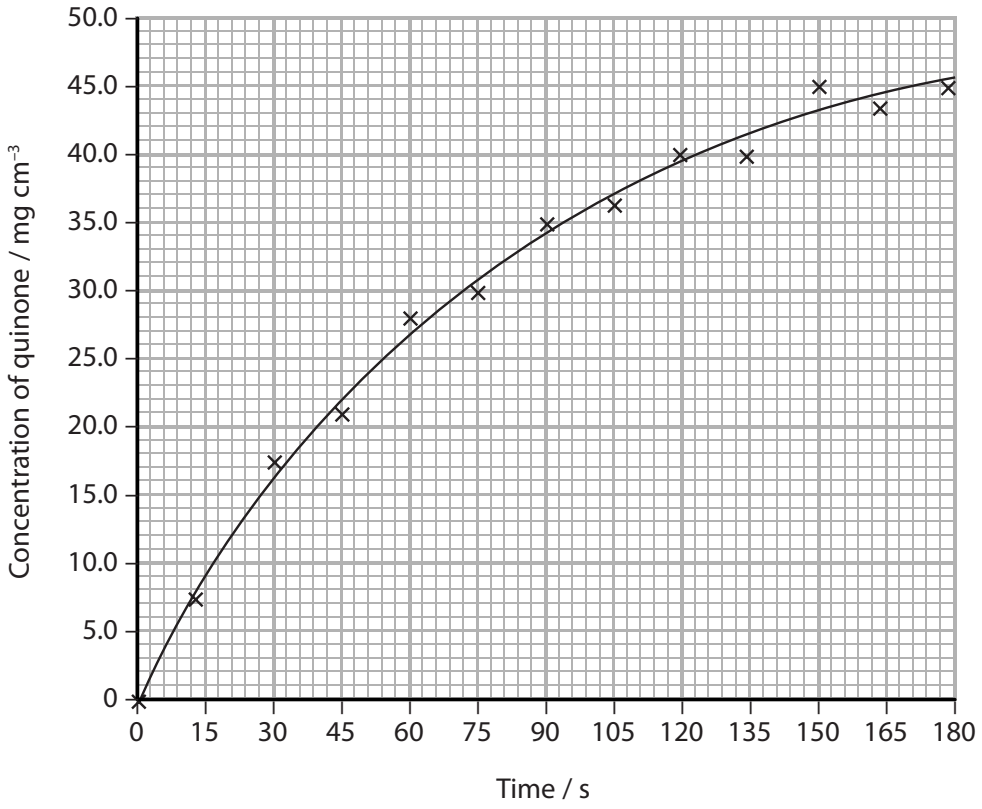
This enzyme catalyses the following reaction

monophenol (colourless) + oxygen ⟶ quinone (brown)

This reaction causes cut fruit to turn brown when exposed to air.

(a) A student carried out an investigation into the rate at which grape juice produced quinone.

The graph shows the results of this investigation.



(i) Calculate the initial rate of this reaction.

(3)

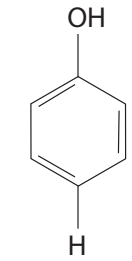
Answer .....

(ii) Explain why adding citric acid to cut fruit reduces the rate at which the fruit turns brown.

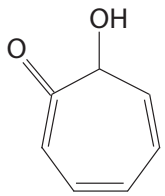
(2)

(iii) The diagram shows the structures of monophenol and a molecule called tropolone.

Tropolone can be added to grape juice to slow the rate at which the juice turns brown.



monophenol



tropolone

Explain how tropolone affects the rate at which the grape juice turns brown.

(2)

(b) Plant breeders have developed a grape variety that produces inactive polyphenol oxidase.

The bonding in this enzyme is changed and this prevents the juice from turning brown.

(i) Which of the following bonds are used to form the tertiary structure of enzymes?

(1)

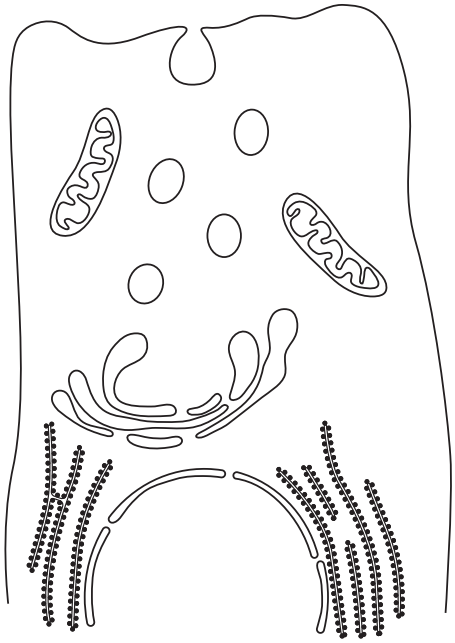
- ☒ **A** hydrogen, glycosidic and ester
- ☒ **B** hydrogen, ionic and disulfide
- ☒ **C** ionic, glycosidic and disulfide
- ☒ **D** ionic, disulfide and ester

(ii) The base sequence of this polyphenol oxidase gene is different in this grape variety.

Explain how this leads to the production of inactive enzyme.

(3)

5 The diagram shows part of a cell from the pancreas that produces enzymes for use in the digestion of food.



(a) State one way in which the structure of a prokaryotic cell would differ from the cell shown in this diagram.

(1)

.....

(b) In an investigation, cells from the pancreas were grown in a culture medium containing radioactive amino acids.

Samples of these cells were taken and the level of radioactivity in three organelles was measured.

The table shows the results of this investigation.

Time after radioactive amino acids were added to the culture medium / min	Level of radioactivity present / arbitrary units		
	Golgi apparatus	Rough endoplasmic reticulum	Vesicles
1	21	120	6
20	52	88	6
40	86	39	8
60	71	23	15
90	50	27	28
120	23	11	51

(i) Using the information in the table, draw arrows on the diagram showing the path of radioactivity through and out of the cell.

(2)

(ii) Comment on the results of this investigation.

(4)

(c) The diagram shows the position of the pancreas and the small intestine.



Lipase and protease enzymes produced by the pancreas are used in the small intestine during digestion.

Pancreatitis is a condition that occurs when the pancreatic duct becomes blocked.

(i) Explain how the contents of the small intestine in a patient with pancreatitis would differ from the contents of the small intestine in a healthy person.

(2)

(ii) Some of the enzymes are produced in an inactive form.

In patients with pancreatitis, these enzymes can become active in the pancreas.

Explain how this activation could affect the pancreas.

(2)

7 The photograph shows sweet red peppers growing on a plant.



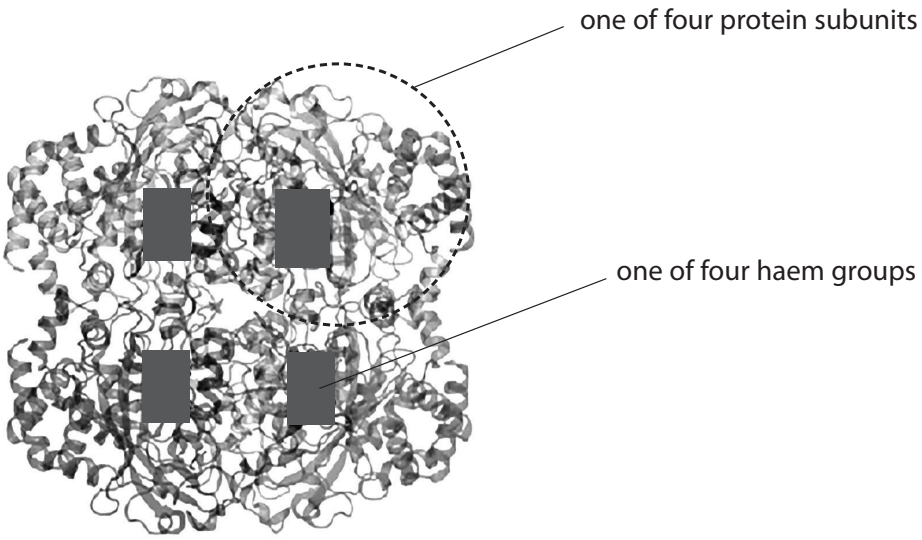
© Janet Horton / Alamy Stock Photo

Unripe sweet red peppers contain the enzyme catalase. As these peppers ripen, the activity of catalase decreases.

The equation summarises the reaction catalysed by catalase.

hydrogen peroxide ⟶ water + oxygen

(a) The diagram shows the structure of catalase.

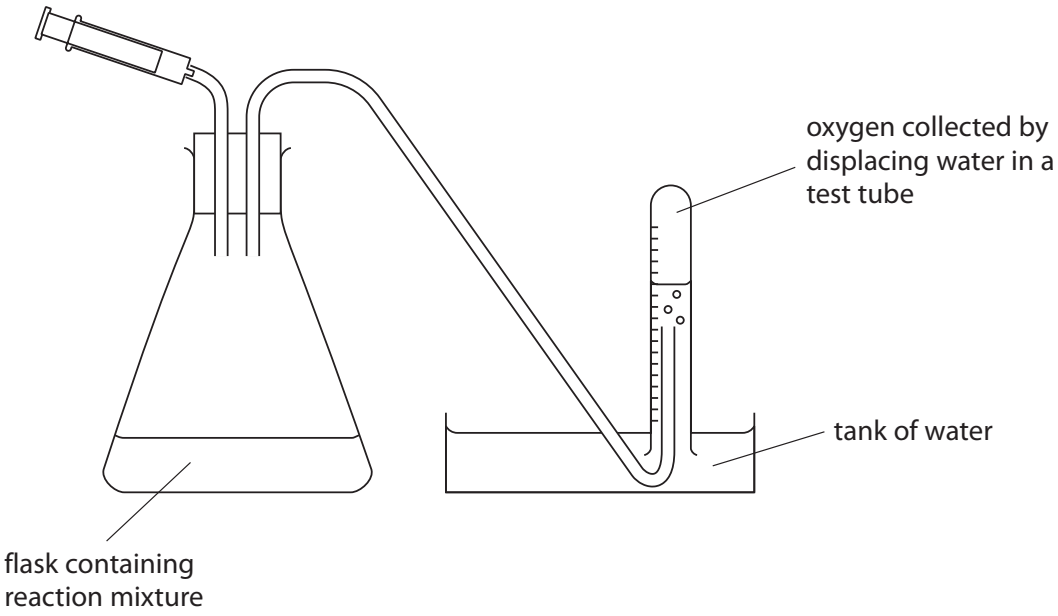


Explain why the enzyme catalase is described as having a tertiary and quaternary structure.

(3)

(b) The activity of catalase can be measured by collecting the oxygen produced during the reaction.

The diagram shows apparatus that can be used to collect the oxygen produced.



(i) When measuring the activity of enzymes, the initial rate of reaction should be measured.

Explain why the initial rate of reaction should be measured.

(2)

*(ii) Devise an investigation, using this apparatus, to show that as sweet red peppers ripen the activity of catalase decreases.

(6)

11 White clover plants provide a rich source of nitrogen for cattle when grown with grass plants in fields.

The photograph shows a clover plant growing in a field of grass.



A student noticed that the grass plants growing near patches of clover were a darker green than other grass plants.

(a) Devise an investigation to show whether the presence of clover plants affects the concentration of the green pigment chlorophyll in grass plants.

(6)

(b) Clover plants have bacteria living in root nodules.

These bacteria convert atmospheric nitrogen (N_2) to ammonia (NH_3) using the enzyme nitrogenase.

(i) State one organic molecule containing nitrogen atoms which is found in plant cells.

(1)

(ii) Nitrogen is a relatively unreactive gas that forms 80% of the atmosphere.

The enzyme nitrogenase catalyses the reaction shown:

$$N_2 + 8H^+ + 16\ ATP \rightarrow 2NH_3 + H_2 + 16\ ADP + 16\ Pi$$

The activation energy for this reaction is very high.

Analyse the information to explain how the enzyme nitrogenase is involved in the energy changes required for this reaction.

(4)

8 Cysteine proteases are enzymes found in fruits such as pineapples.

When a protease enzyme is added to fat-free skimmed milk, the milk turns from cloudy to clear.

(a) Devise an investigation to find the optimum temperature for the activity of the enzyme cysteine protease found in pineapples.

(6)

(b) Cysteine proteases are also found in the predatory bacterium *Bdellovibrio bacteriovorus* (BvB).

These bacteria are harmless to humans but prey on Gram negative bacteria.

(i) Give two differences between Gram negative and Gram positive bacteria.

(2)

(ii) The cell of the predatory BvB is 1μm in length and can swim 100 times its length per second.

Calculate the swimming speed of this bacterial cell in mm s^{-1}.

(2)

Answer .....

(iii) The BvB bacteria have been described as 'living antibiotics'.

Explain why the BvB bacteria might be useful in the future for treating bacterial infections.

(2)

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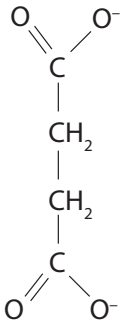
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9 Succinate dehydrogenase is an enzyme found in mitochondria.

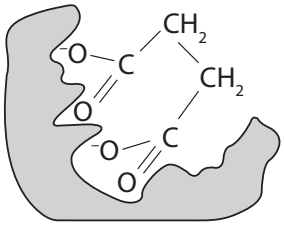
Succinate dehydrogenase converts succinate to fumarate.

The diagrams show the structure of succinate, succinate binding to the active site of succinate dehydrogenase and the structure of fumarate.

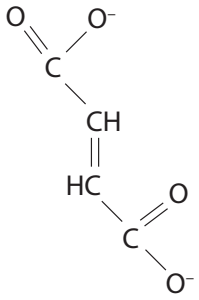
Structure of succinate



Succinate binding to succinate dehydrogenase



Structure of fumarate

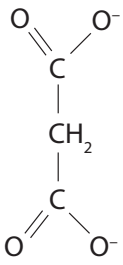


(a) Explain the role of the active site in the conversion of succinate to fumarate.

(3)

(b) The activity of succinate dehydrogenase is inhibited by malonate.

The diagram shows the structure of malonate.

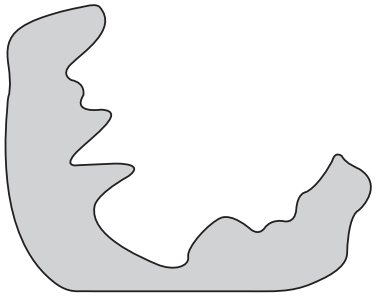


(i) Explain why malonate inhibits the activity of succinate dehydrogenase.

(2)

(ii) On the diagram, draw malonate binding to succinate dehydrogenase.

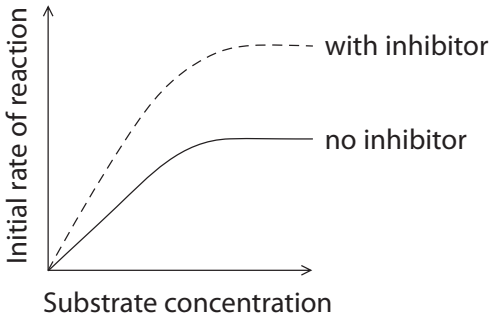
(1)



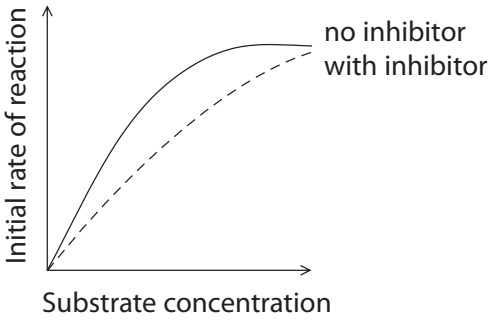
(iii) Which of the following graphs represents the effect of this type of inhibitor?

(1)

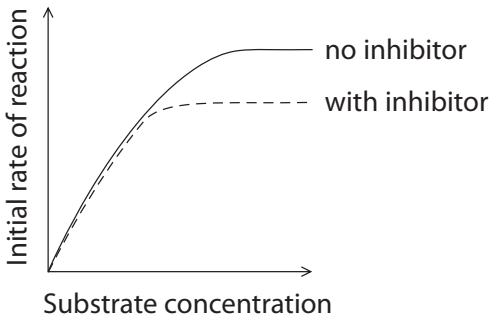
☒ **A**



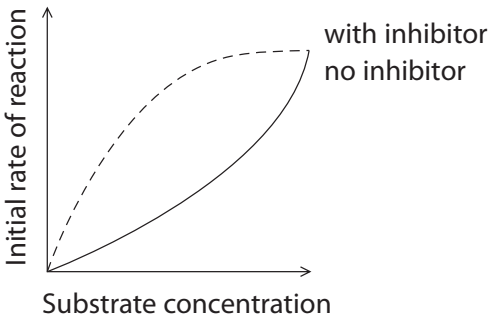
☒ **B**



☒ **C**



☒ **D**



*(c) The rate of reaction of succinate dehydrogenase can be measured using a methylene blue solution.

Methylene blue starts off blue but changes to colourless as succinate is converted to fumarate.

A student investigated the effect of malonate on the rate of reaction of succinate dehydrogenase.

The student used the following steps.

Step 1. Succinate solution was poured into a beaker up to the 25 cm^3 mark.

Step 2. Ten drops of succinate dehydrogenase solution and three drops of methylene blue solution were added.

Step 3. The beaker was left on the bench until the methylene blue became colourless and the time for this change was recorded.

Step 4. Steps 1 to 3 were repeated using two different concentrations of succinate solution.

The whole procedure was repeated with the addition of 15 cm^3 of malonate solution with the succinate solution in **Step 1**.

Criticise the method used in this investigation.

(6)

7 When apples are cut, the enzyme polyphenol oxidase is released from the cells.

This enzyme converts colourless phenols into a brown pigment called melanin.

Citric acid or a protease enzyme can be added to apple slices to prevent this browning.

(a) (i) Explain why the addition of citric acid prevents the browning of apple slices.

(2)

(ii) Explain why the addition of a protease enzyme prevents the browning of apple slices.

(2)

(b) An investigation was carried out into the activity of polyphenol oxidase by measuring the quantity of melanin formed.

An apple was cut into five equal slices and the first slice finely crushed and filtered.

The concentration of melanin in the filtrate was then measured.

The remaining four slices were finely crushed and filtered at 60 second intervals.

The table shows the results of this investigation.

Apple slice	Time / s	Melanin concentration / a.u
1	0	0
2	60	19
3	120	38
4	180	51
5	240	62

(i) Analyse the data to explain the results of this investigation.

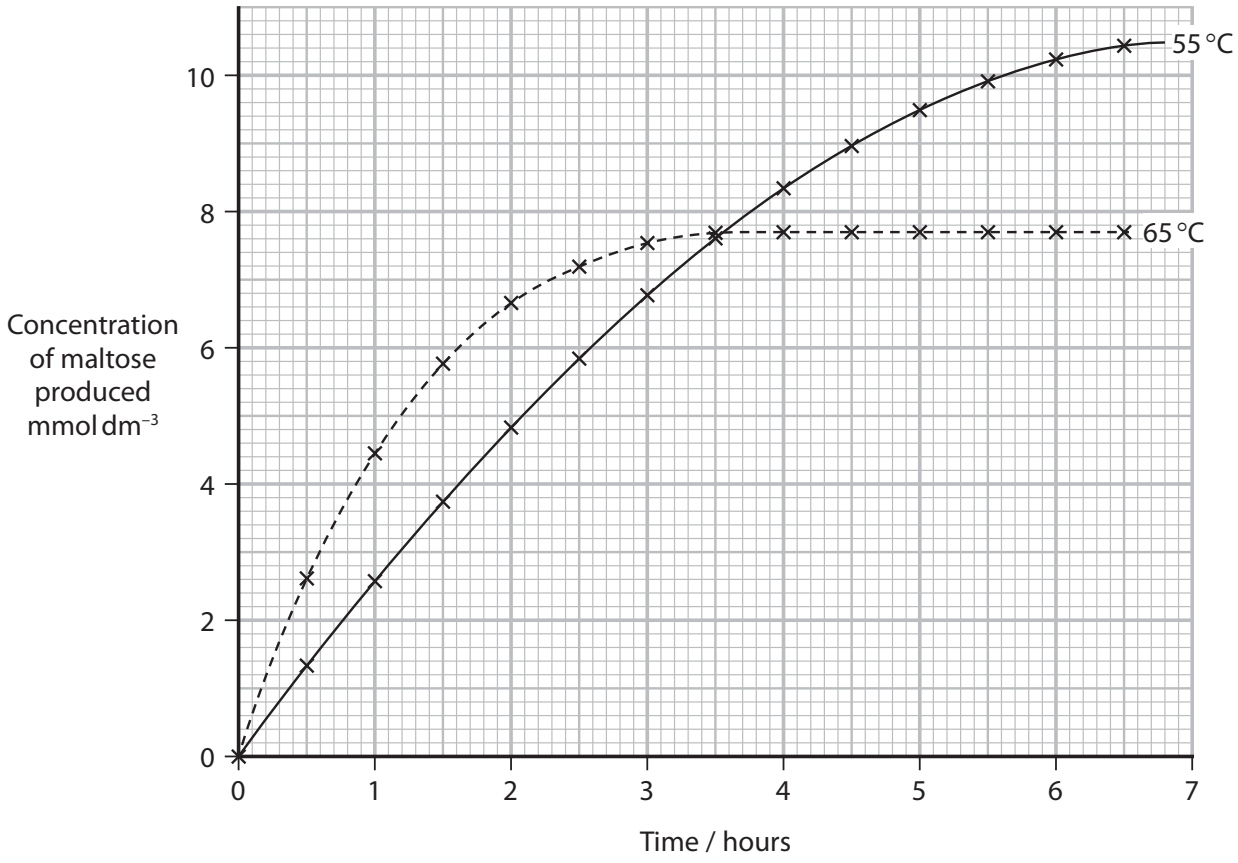
(3)

*(ii) The temperature at which apple slices are stored can affect the activity of the enzyme polyphenol oxidase.

Devise a valid method to investigate the effect of temperature on the browning of apple slices.

(6)

8 The graph shows the results of an experiment investigating the effect of temperature on the hydrolysis of starch using the enzyme amylase.



(a) Calculate the initial rate of reaction at 55 °C in mmol dm^{-3} min^{-1}.

(2)

Answer .....

(b) Explain the difference between the two curves from 4 and 6 hours.

(2)

(c) In this experiment:

- two beakers were prepared containing 1 cm^3 of amylase and 100 cm^3 of starch solution at room temperature
- these beakers were then placed in the water baths at two different temperatures, 55 °C and 65 °C
- every 30 minutes a sample of the mixture was extracted and the concentration of maltose was measured.

(i) Analyse the information to explain why the initial rate of this reaction was faster at 65 °C than it was at 55 °C.

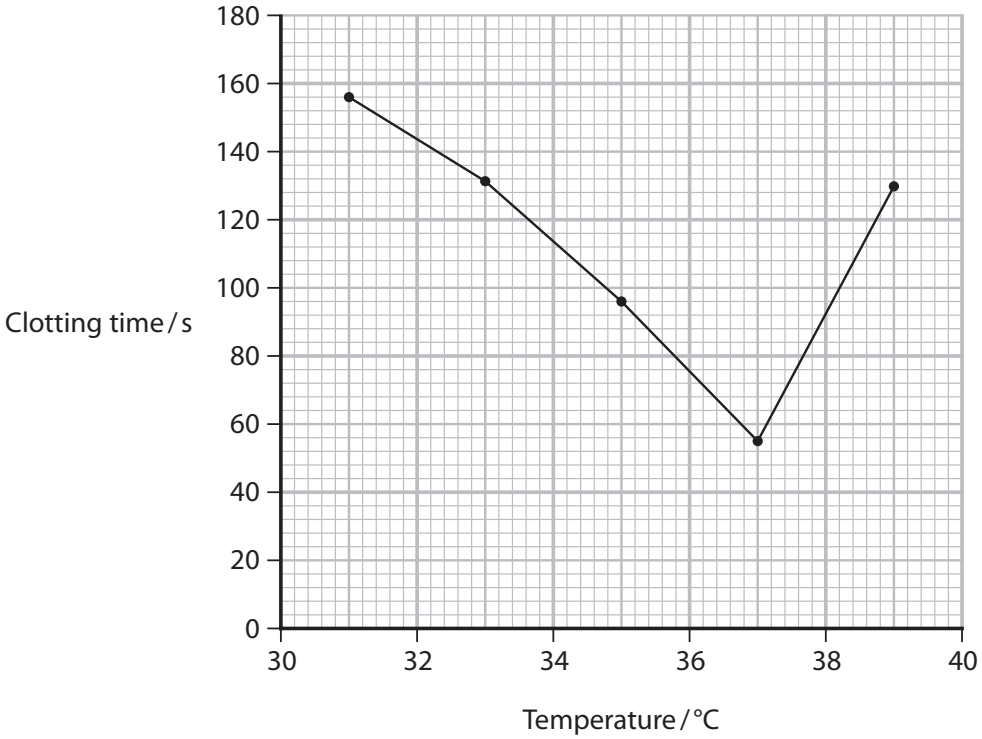
(3)

*(d) Evaluate the method used in this investigation and suggest improvements.

(6)

4 A scientist investigated the effect of temperature on the time it takes for blood to clot.

The graph shows the results of this investigation.



(a) Explain how these results show that enzymes are involved in blood clotting.

(3)

(b) Prothrombin is involved in the blood clotting process.

The *F2* gene codes for the synthesis of prothrombin.

This gene is located from base pair 46 719 191 to base pair 46 739 504 on chromosome 11.

Determine the number of codons in this gene.

(1)

Answer .....

(c) A mutation of the *F2* gene causes thrombophilia, a condition that results in the production of excess prothrombin.

In this gene mutation, guanine is replaced with adenine.

(i) Name this type of mutation.

(1)

.....

(ii) People without this mutation have a 1 in 1000 risk of producing a blood clot in an artery.

The mutation increases this risk by 20 times.

State the probability of producing a blood clot for people with this mutation.

(1)

.....

(iii) Explain why thrombophilia increases the risk of producing a blood clot in an artery.

(3)

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(d) A genetic test can be used to find out if a person has thrombophilia.

The test involves using a restriction endonuclease to obtain genetic material from white blood cells.

This genetic material is then used in the polymerase chain reaction (PCR).

(i) State the role of a restriction endonuclease.

(1)

.....

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(ii) Describe the process of PCR.

(3)

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8 The activity of enzymes is affected by a number of factors.

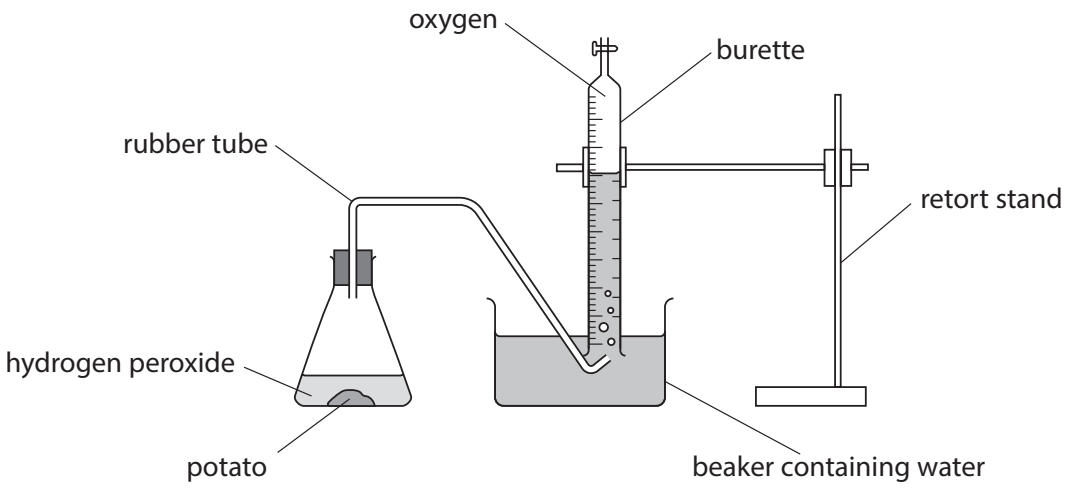
(a) Explain why increasing the temperature of an enzyme-controlled reaction changes the rate of reaction.

(3)

(b) A student investigated the activity of the enzyme catalase in potato.

This enzyme is found in potato cells. It catalyses the conversion of hydrogen peroxide to oxygen and water.

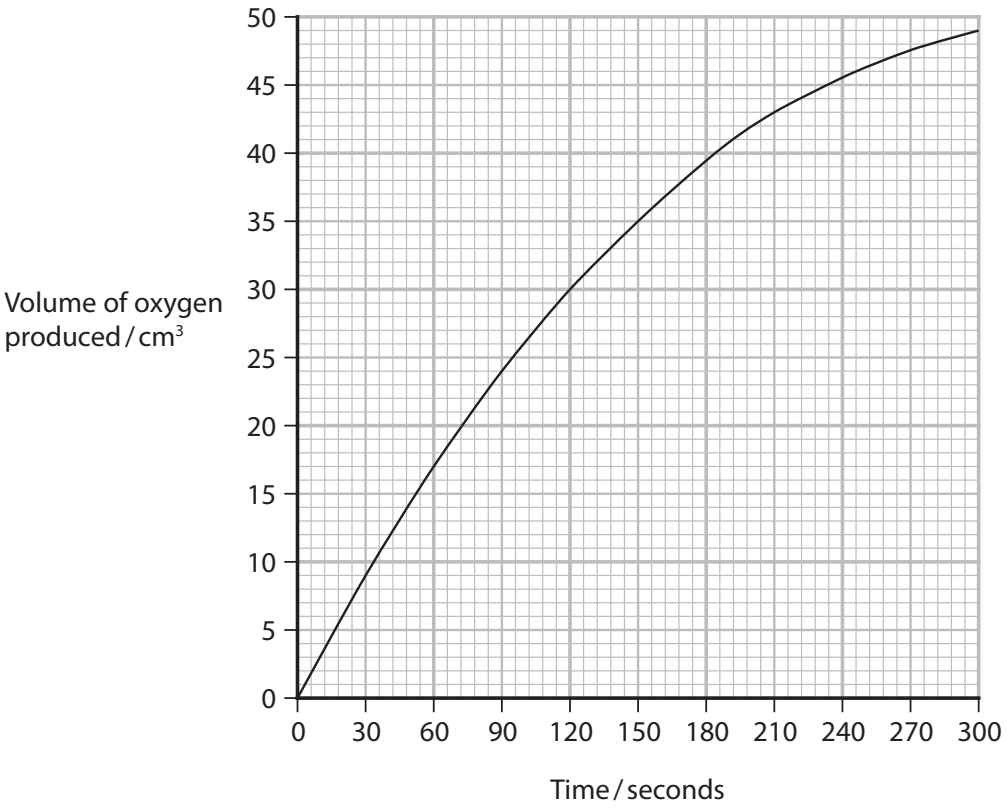
The diagram shows the apparatus used to collect the data.



(i) Describe how two named variables, other than the potato, can be controlled in order to obtain valid results.

(4)

(ii) The graph shows the results of the investigation.



Determine the initial rate of reaction from this graph.

(1)

Answer .....

(iii) Explain why the rate of reaction decreases over time.

(2)

(c) The student used this apparatus to investigate the effect of using increasing numbers of potato cubes on the rate of reaction.

The potato was cut into 1 cm^3 cubes to be used in five trials.

In the first trial, one cube was added to the flask and the volume of oxygen produced in 30 seconds was measured.

The hydrogen peroxide was then replaced.

This was repeated in the other four trials using 2, 3, 4 and 5 cubes of potato.

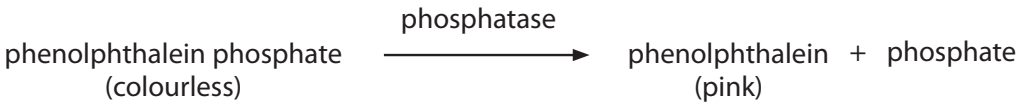
Explain the results you would expect from this investigation.

(3)

7 The activity of enzymes is affected by a number of factors.

(a) A class of students investigated the effect of temperature on the activity of the enzyme phosphatase extracted from mung beans.

This enzyme removes phosphate groups from organic phosphate molecules. The diagram shows the reaction between phosphatase and its substrate, phenolphthalein phosphate.



When they are in alkaline solutions, phenolphthalein phosphate is colourless and phenolphthalein is pink.

The students used the following method.

Step 1 Germinate mung bean seeds, then grind them with water and filter the extract. Use the filtrate as the enzyme extract.

Step 2 Set up 8 tubes, each containing 1 cm^3 of 1% phenolphthalein phosphate, and place in water baths at varying temperatures. Leave for 10 minutes.

Step 3 Add 1 cm^3 of enzyme extract to each tube. Leave in the water baths for 20 minutes.

Step 4 Add 5 cm^3 of 10% sodium carbonate solution (alkaline) to each tube. Place the tubes into an ice bath, which will stop the reaction.

Step 5 Use a colorimeter to measure the absorbance of light for each tube. As the pink colour increases, the absorbance increases.

(i) Describe how you would ensure that the concentration of the enzyme extract was the same for all students carrying out the investigation.

(2)

(ii) Describe how you would ensure that the colorimeter readings were comparable for each of the students.

(2)

(b) The table shows the results obtained in this investigation.

Temperature / °C	10	20	30	40	50	60	70	80
Absorbance of light	0.25	0.33	0.39	0.46	0.53	0.55	0.50	0.33

(i) Explain the effect of temperature on the activity of phosphatase.

(3)

(ii) For enzyme-controlled reactions at temperatures between 0°C and 40°C, a 10°C rise in temperature will double the rate of reaction.

The data collected in this investigation do not show this pattern, suggesting that there may be errors in the method used.

The students repeated the investigation with these four changes:

- adding buffer solution to the phenolphthalein phosphate
- placing separate tubes containing phenolphthalein phosphate and enzyme extract into water baths for 10 minutes before mixing together
- using smaller temperature intervals than 10°C
- stopping the reaction after 5 minutes instead of 20 minutes.

Justify why the students repeated the investigation with these four changes.

(4)

(c) The phosphatase enzyme catalyses the removal of phosphate groups from organic phosphate molecules, releasing phosphate ions.

Give **two** examples of biochemical processes in plant cells requiring phosphate ions.

(2)

10 During respiration, yeast cells break down sugars to produce carbon dioxide and ethanol.

The respiration rate of yeast is affected by several factors. It can be estimated by measuring the rate of production of carbon dioxide gas.

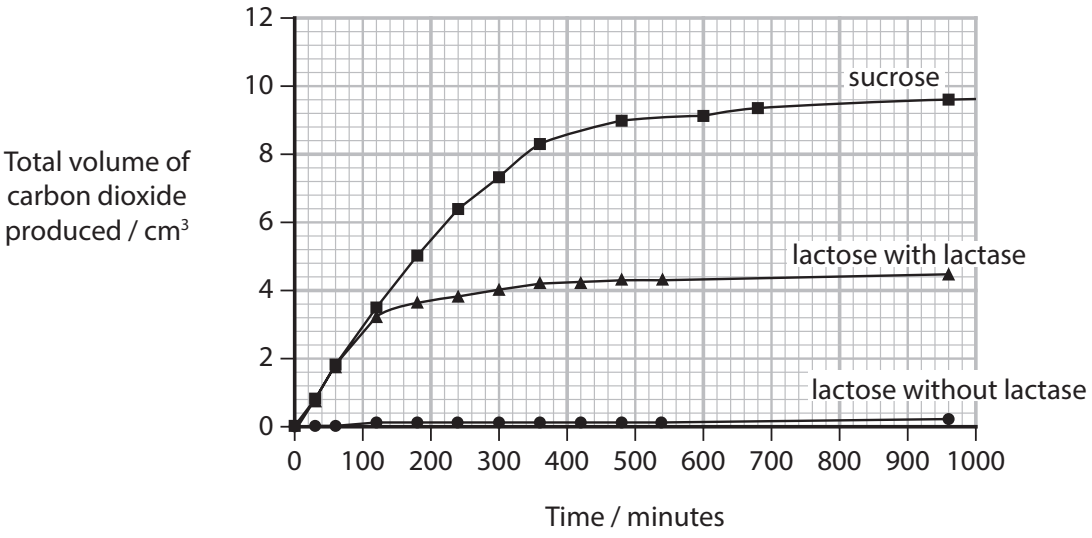
(a) Scientists measured the rate of respiration of yeast using the sugar sucrose as a substrate.

This was repeated using the sugar lactose with and without lactase.

Lactase is an enzyme that hydrolyses lactose.

The same concentrations of both sugars were used and the suspensions were incubated at 30°C.

The graph shows the results.



(i) Calculate the initial rate of respiration of yeast with sucrose.

(1)

Answer ..... $cm^3\ min^{-1}$

(ii) Explain the results for sucrose compared with **lactose without lactase**.

(3)

(iii) Explain the effect of **lactase** on the respiration rate of yeast during the first 400 minutes.

(3)

(b) The experiment with sucrose was repeated at a temperature 10°C lower.

All other variables remained the same.

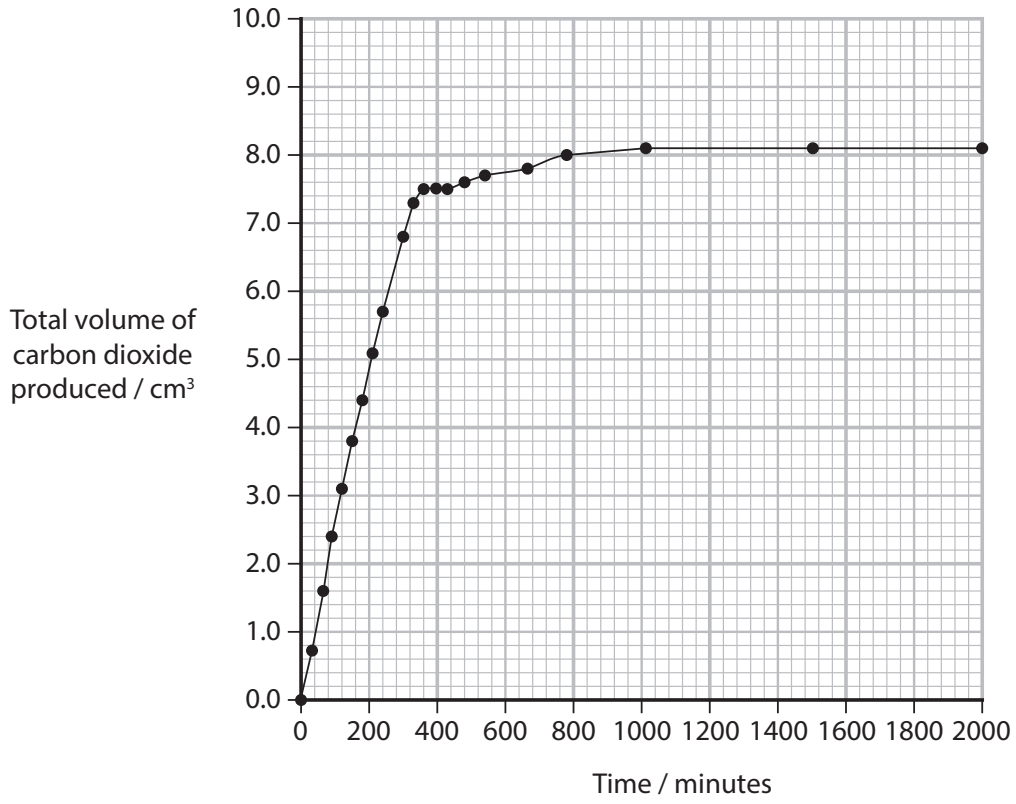
Explain the effect of this temperature change on the rate of respiration of yeast.

(3)

(c) The effect of changing the concentration of yeast on the rate of respiration was also investigated.

Two yeast suspensions were made by adding different masses of yeast to 100 cm^3 of water containing 20 g of sucrose.

The graph shows the results for a suspension containing 7.0 g of yeast.



(i) Sketch a line on this graph to show the expected results for a suspension containing 3.5 g of yeast.

(1)

(ii) Explain the effect of the concentration of yeast on the volume of carbon dioxide produced in this investigation.

(3)

8 Some microorganisms can break down plastics, including polyesters.

Cows are a group of plant-eating mammals that have bacteria living in one of their four stomachs.

These bacteria play a role in the digestion of the plant material consumed by the cow.

Scientists have studied these bacteria to see if they can break down polyesters.

(a) Polyesters account for 15 % of the 25.8 million US tons of plastic waste accumulated in Europe.

Calculate the mass, in kilograms, of polyester in this accumulated plastic waste.

1 US ton = 907.185 kg

(2)

Answer ..... kg

(b) State why scientists think that these bacteria might be able to break down polyesters.

(1)

.....

.....

.....

(c) The bacteria were incubated with polyester at 40 °C in a pH 7 buffer solution.

Explain why these conditions were used.

(2)

.....

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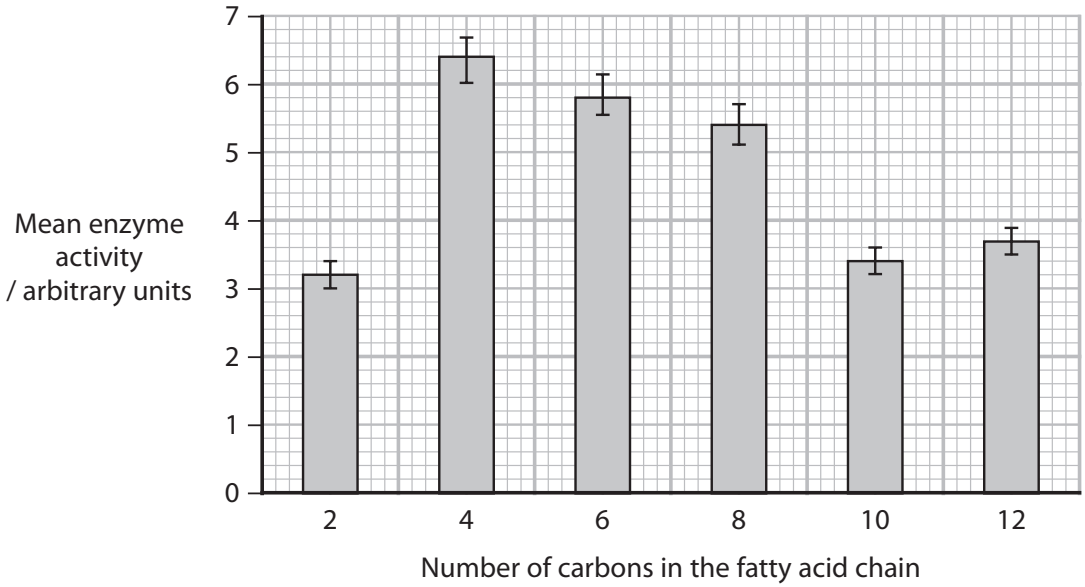
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(d) One study investigated the breakdown of one type of polyester with different fatty acid chain lengths.

The graph shows the mean enzyme activities and standard deviations from this study.



(i) Analyse the data to comment on these results.

(3)

(ii) Devise an experiment to confirm these results.

(5)

(e) In another study, scientists measured the concentration of the breakdown products from two types of polyester, P1 and P2, using bacteria.

The table shows the results of this study.

Breakdown product	Concentration of breakdown products / arbitrary units	
	from P1	from P2
A	38	68
B	30	0
C	5	0
D	0	20
E	0	30

Explain why the scientists thought that the bacteria were producing more than one type of enzyme.

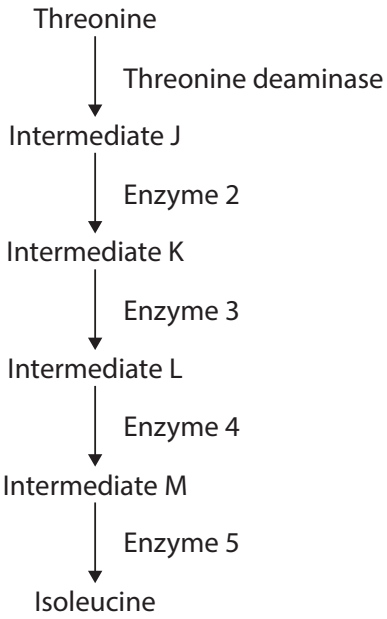
(2)

8 Threonine is an amino acid that can be converted into another amino acid, isoleucine.

This conversion takes five steps.

The first step is catalysed by the enzyme threonine deaminase.

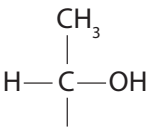
The diagram shows this conversion.



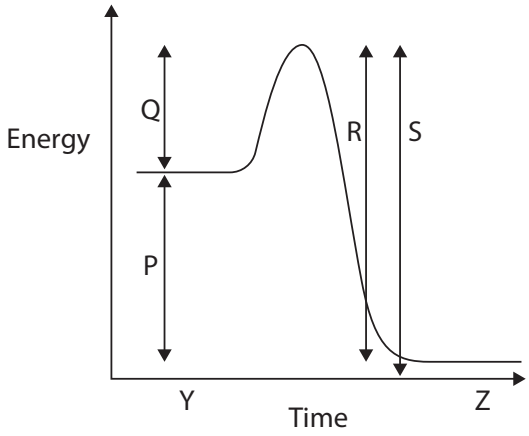
(a) The diagram shows the R group of threonine.

Complete the diagram to show the structure of threonine.

(3)



(b) The graph shows the energy changes during the conversion of threonine to intermediate J, in the presence of threonine deaminase.



(i) Which arrow shows the activation energy for this reaction?

(1)

- ☒ **A** P
- ☒ **B** Q
- ☒ **C** R
- ☒ **D** S

(ii) Which row of the table identifies the molecule present at time Y and the molecule present at time Z on this graph?

(1)

		Time Y	Time Z
☒	**A**	the product threonine	the reactant intermediate J
☒	**B**	the product threonine	the reactant isoleucine
☒	**C**	the reactant threonine	the product intermediate J
☒	**D**	the reactant threonine	the product isoleucine

(iii) Which row of the table shows the change in length of the arrows P and Q on this graph in the absence of the enzyme threonine deaminase?

(1)

		Change in length of arrow	
		P	**Q**
☒	**A**	increase	increase
☒	**B**	increase	no change
☒	**C**	no change	increase
☒	**D**	no change	no change

(c) Explain why the conversion of threonine to isoleucine involves several different enzymes.

(3)

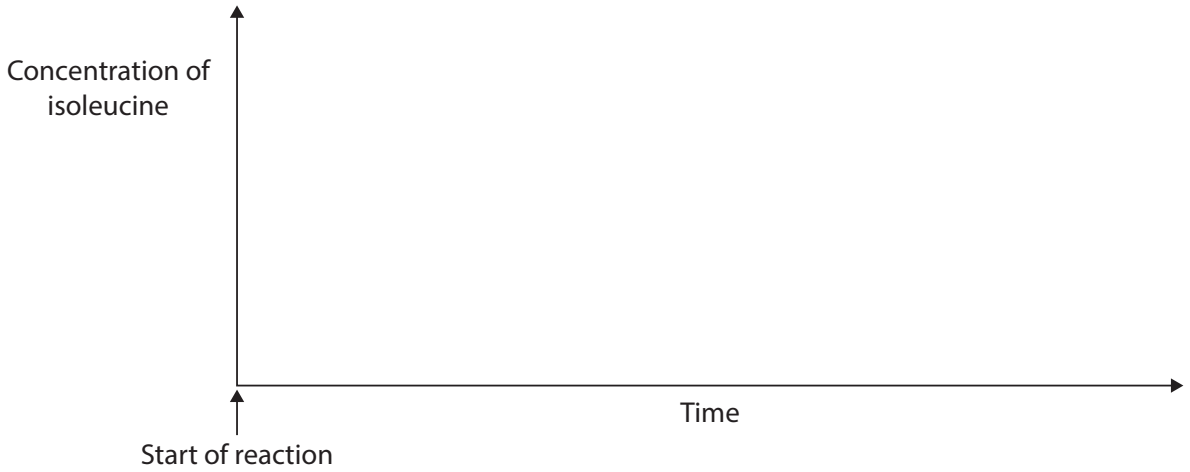
(d) This reaction is affected by end-product inhibition.

(i) Explain how end-product inhibition affects this reaction.

(3)

(ii) Complete the graph to show how the concentration of isoleucine would change as a result of end-product inhibition of threonine deaminase.

(3)



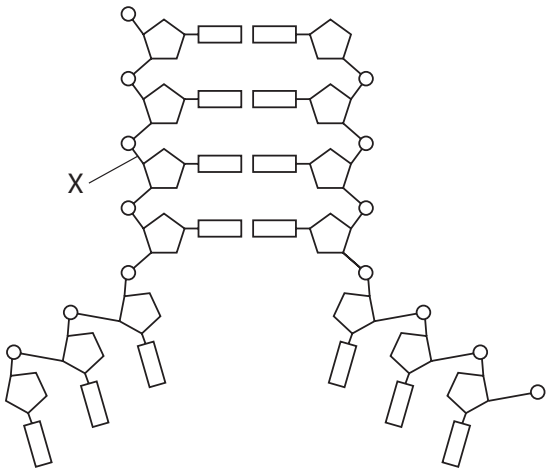
(Total for Question 8 = 15 marks)

SUB-TOPIC 1(e)

NUCLEIC ACIDS AND DNA REPLICATION

12 questions in this sub-topic · 109 marks · lowest tariff first

1 The diagram shows DNA replication.



(a) Which of the following is the name of the bond labelled X on the diagram?

(1)

- ☒ **A** ester
- ☒ **B** glycosidic
- ☒ **C** hydrogen
- ☒ **D** phosphodiester

(b) Describe the roles of three named enzymes involved in DNA replication.

(3)

(c) A section of double-stranded DNA has a total number of 10 000 nucleotides.

Adenine makes up 35% of the nucleotides in this section of double-stranded DNA.

Calculate the total number of cytosine nucleotides found in this section of DNA.

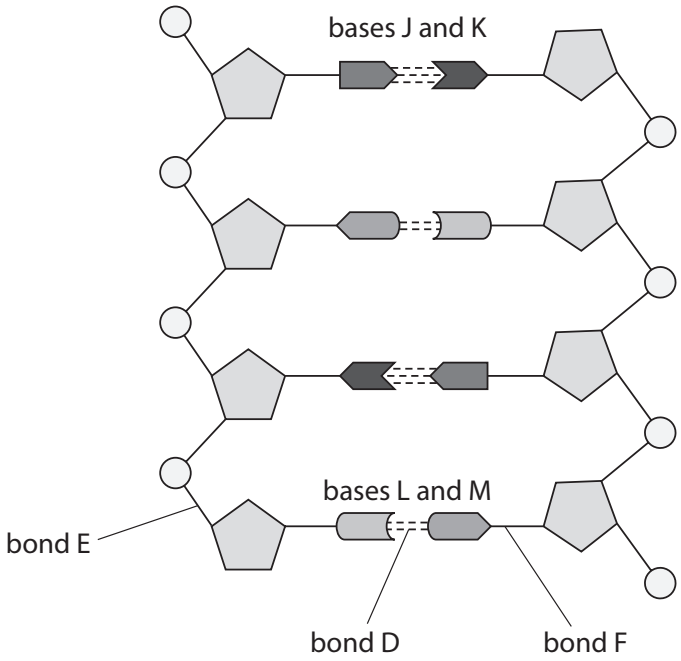
(2)

Answer .....

(Total for Question 1 = 6 marks)

2 During the S phase of the cell cycle, DNA is synthesised by semi-conservative replication.

The diagram shows part of a DNA molecule.



(a) (i) Name the base pairs labelled J and K, L and M.

(2)

J and K .....

L and M .....

(ii) Name the bonds labelled D, E and F.

(2)

Bond D .....

Bond E .....

Bond F .....

(iii) Part of a DNA molecule consists of 840 bases. Of these, 136 are base J.

Calculate the percentage of bases that are M in this DNA molecule.

Give your answer to two decimal places.

(1)

Answer ..... %

(b) State what is meant by the term **semi-conservative replication**.

(1)

.....

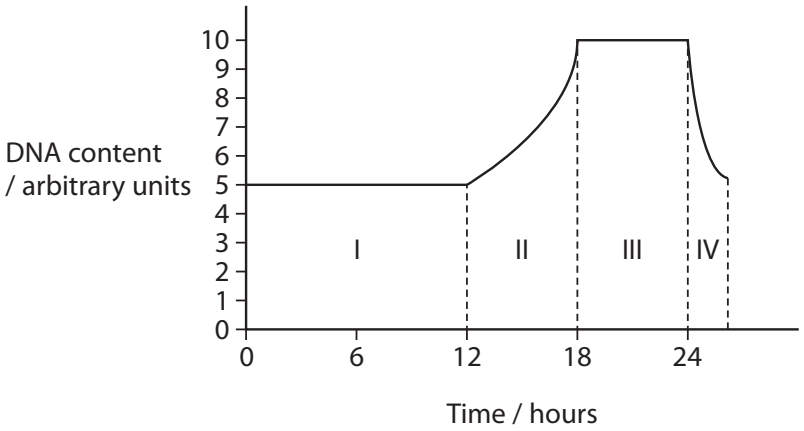
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(Total for Question 2 = 6 marks)

2 The graph shows the DNA content of a cell during four stages, I, II, III and IV, of one cell cycle.



(a) (i) In which stage does DNA replication take place?

(1)

- ☒ **A** stage I
- ☒ **B** stage II
- ☒ **C** stage III
- ☒ **D** stage IV

(ii) Explain the role of the enzyme ligase in DNA replication.

(3)

(b) Describe what is happening during stage IV in the cell cycle.

(3)

1 The nucleic acids, DNA and mRNA, are polymers.

(a) The table shows some components that may be found in a molecule of these nucleic acids.

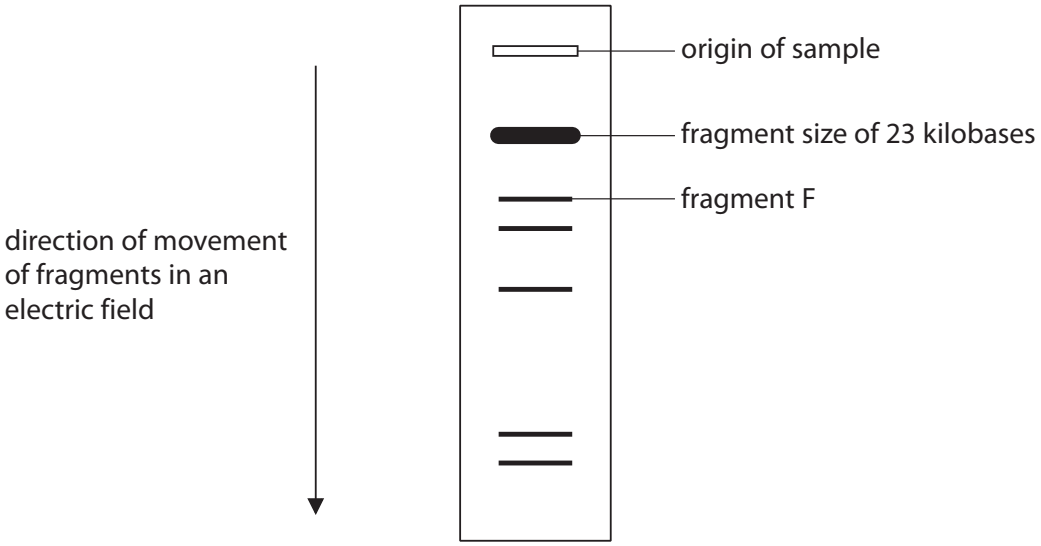
For each component, put **one** cross ☒ in the appropriate box, in each row, to show where these components can be found.

(4)

Component	Component found in a molecule of			
	both DNA and mRNA	DNA but **not** mRNA	mRNA but **not** DNA	neither DNA nor mRNA
Adenine	☒	☒	☒	☒
Hydrogen bonds	☒	☒	☒	☒
Pentose sugar	☒	☒	☒	☒
Uracil	☒	☒	☒	☒

(b) Fragments of DNA can be separated by gel electrophoresis to produce a DNA profile.

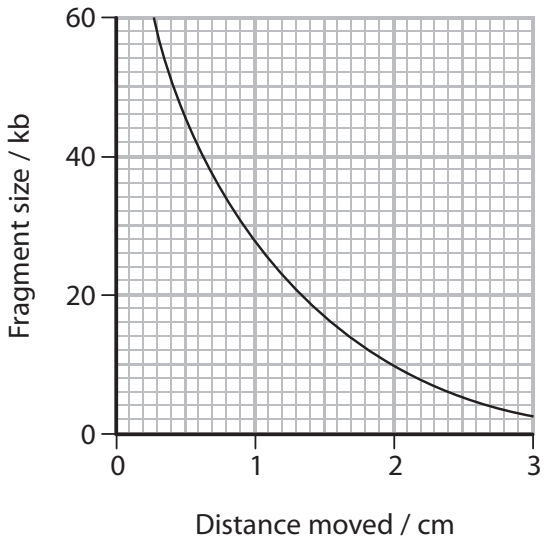
The diagram shows an example of a DNA profile.



(i) Explain why fragments of DNA can be separated by gel electrophoresis.

(2)

(ii) The graph shows the relationship between the distance moved in a gel and the fragment size.



Determine the size of fragment F.

(1)

Answer ..... kb

(Total for Question 1 = 7 marks)

5 Leigh syndrome is a genetic disorder inherited from the mother. The mother carries genes for the disorder in her mitochondrial DNA.

(a) Draw and label a mitochondrion.

(4)

(b) Scientists have developed a technique for producing 'three-parent' babies.

This ensures that a mother with Leigh syndrome will not pass on the genes for this disorder to her baby.

The technique involves:

- removing the nucleus from the ovum of the mother
- removing the nucleus from the ovum of a donor female to produce an enucleated ovum
- inserting the nucleus from the ovum of the mother into the enucleated donor ovum
- fertilising this ovum with the sperm of the father to produce a zygote
- implanting the resulting embryo into the uterus of the mother.

(i) The 'three-parent' baby produced by this technique will inherit mitochondrial DNA from the

(1)

- ☒ **A** donor female
- ☒ **B** donor female and father
- ☒ **C** mother
- ☒ **D** mother and father

(ii) Explain the importance of DNA replication during the development of this zygote into a blastocyst.

(3)

1 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

(3)

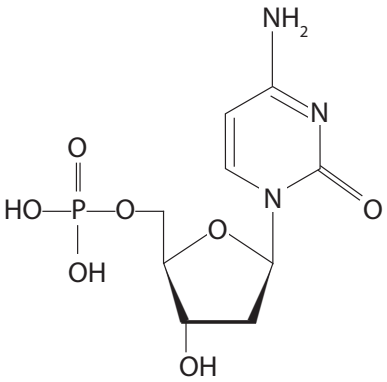
(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

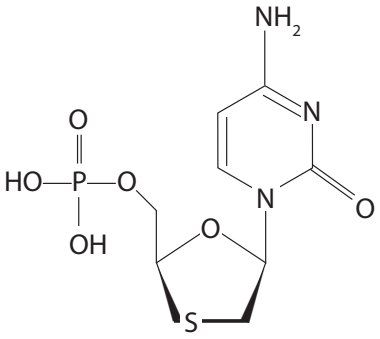
(3)

(ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.

The diagram shows a normal nucleotide and an altered nucleotide.



normal nucleotide



altered nucleotide

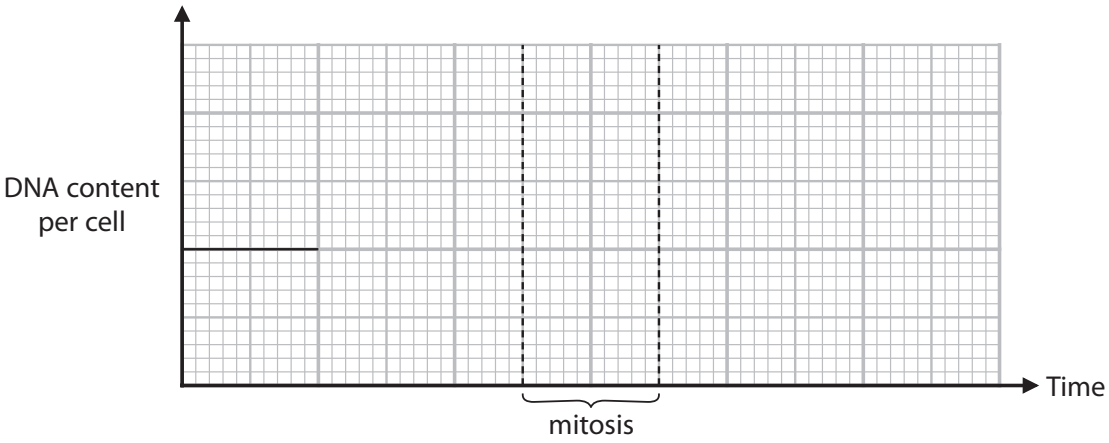
Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2)

7 The synthesis of DNA takes place during the cell cycle.

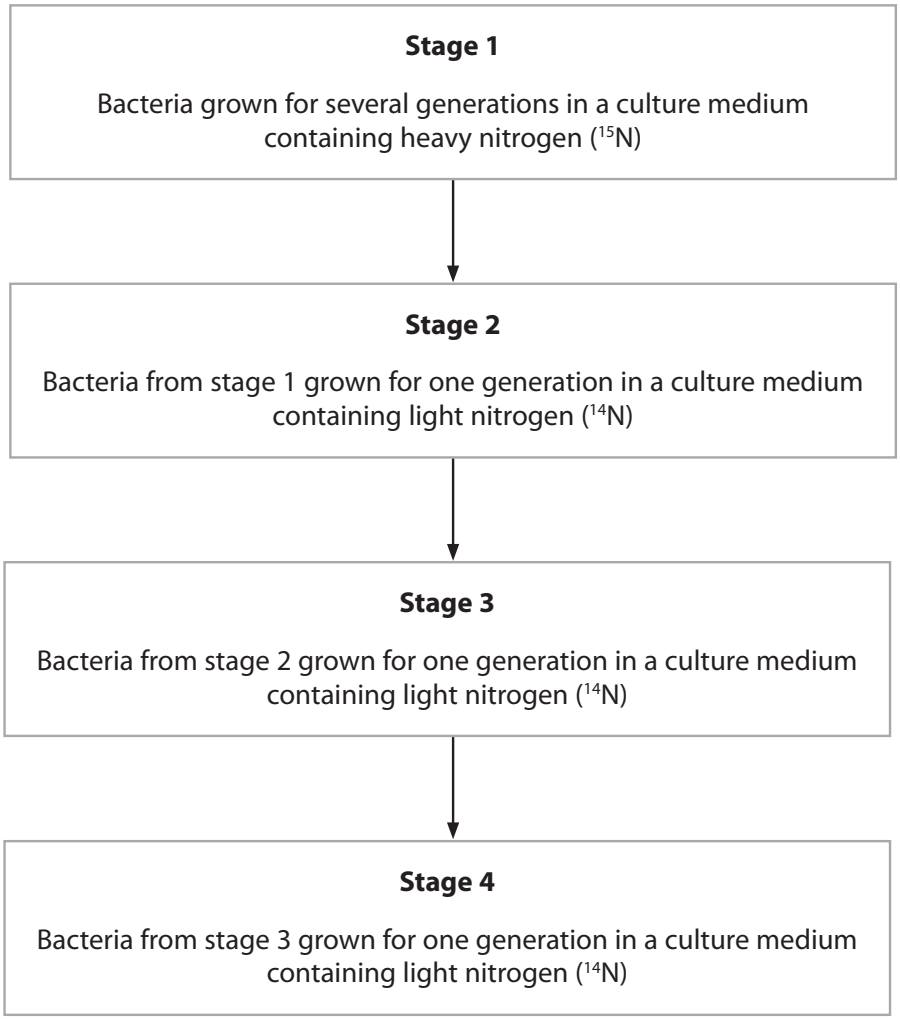
(a) Sketch a graph to show how the DNA content of a cell changes during one cell cycle that includes mitosis.

(3)



*(b) The experiments of Meselson and Stahl contributed to our current understanding of DNA replication.

The diagram shows the stages involved in one experiment.

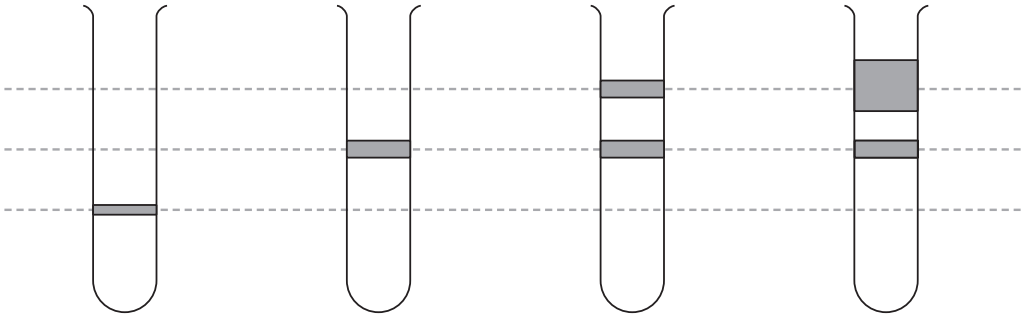


After each stage, a sample of DNA was taken from the bacteria and the DNA molecules separated using a density gradient in a tube.

The heavier DNA molecules form bands lower down the gradient than lighter DNA molecules.

The size of each band is proportional to the percentage of DNA molecules in the sample.

The diagram shows the results of this experiment.



DNA taken after stage 1 | DNA taken after stage 2 | DNA taken after stage 3 | DNA taken after stage 4

Analyse the data to explain the results of this experiment and how it contributed to our current understanding of DNA replication.

(6)

7 *Streptococcus pneumoniae* is a bacterium that causes pneumonia.

(a) When *Streptococcus pneumoniae* is grown on a culture plate, the bacterial cells produce:

- either smooth, shiny colonies (S-strain)
- or rough colonies (R-strain).

The S-strain bacteria produce a smooth capsule but the R-strain bacteria do not.

(i) Explain why the R-strain bacteria are not able to produce the capsule present in the S-strain bacteria.

(2)

(ii) In an investigation, mice were injected with either the S-strain or the R-strain.

The results are shown in the table.

Strain of *Streptococcus pneumoniae* injected into mice	**Injected mice**
S-strain	died
R-strain	lived

The S-strain bacteria were then killed by heating them.

Mice were then injected with either heat killed S-strain bacteria or a mixture of heat killed S-strain bacteria and live R-strain bacteria.

The results are shown in the table.

Strain of *Streptococcus pneumoniae* injected into mice	**Injected mice**
S-strain (heat killed)	lived
S-strain (heat killed) and R-strain (live)	died

Analyse the data to explain why the mice died when they were injected with a mixture of heat killed S-strain and live R-strain bacteria.

(3)

(b) In another investigation, heat killed S-strain bacteria were treated with **one** type of enzyme:

- protein digesting enzymes (proteases)
- RNA-digesting enzymes (RNAases)
- DNA digesting enzymes (DNAases)
- lipid digesting enzymes (lipases).

Each type of enzyme treated S-strain bacteria was then mixed with live R-strain bacteria and injected into mice.

Complete the table to predict whether the mouse lives or dies.

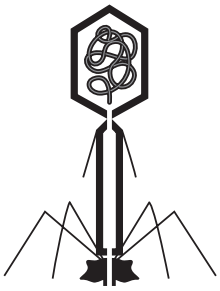
Write **dead** OR **alive** in the spaces in the table.

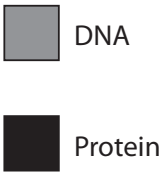
(3)

Enzyme used to treat the heat killed S-strain bacteria	Mouse injected with live R-strain and enzyme treated S-strain [dead or alive]
protease	
RNAase	dead
DNAase	
lipase	

(c) Another investigation used radioactively labelled phages.

Phages are viruses that consist of DNA contained within a protein head.





Phages inject their DNA into a host bacterial cell, but leave the protein heads (called phage ghosts) on the outside of the infected cell.

Two different types of phage were developed by growing the phages in cultures of bacteria in two separate media.

Medium (**A**) contained radioactive phosphorus (^{32}P).

Medium (**B**) contained radioactive sulfur (^{35}S).

Type A phage had DNA that included the ^{32}P.

Type B phage had proteins that included the ^{35}S.

(i) State why radioactive carbon, nitrogen or oxygen were not used in this experiment.

(1)

(ii) Separate cultures of the bacteria *E. coli* were infected with either type A or type B phage.

After infection the empty phage heads (phage ghosts) were separated from the bacterial cells.

Each was tested for radioactivity.

Complete the table to show where radioactivity was present (**Y**) or absent (**N**).

(1)

Phage type (label)	Bacterial cells	Phage ghosts
A (^{32}P)		
B (^{35}S)		

(Total for Question 7 = 10 marks)

5 (a) (i) Which bonds join the nucleotides in a single strand of DNA?

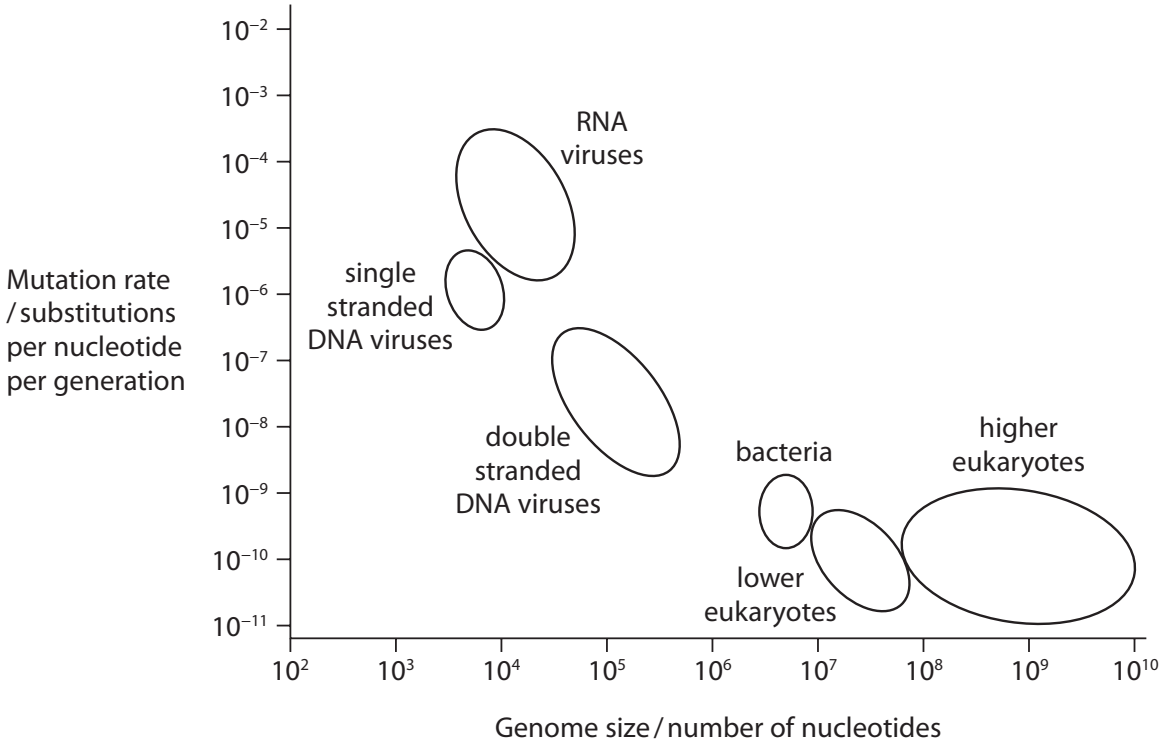
(1)

- ☒ **A** peptide
- ☒ **B** disulfide
- ☒ **C** glycosidic
- ☒ **D** phosphodiester

(ii) Describe how the process of DNA replication produces two identical DNA molecules.

(4)

(b) The graph shows the relationship between genome size and mutation rates of organisms.



(i) Analyse the graph to determine the approximate mutation rate for tobacco mosaic virus (TMV).

(2)

Answer .....

(ii) Comment on the relationship between genome size and mutation rate of the organisms shown in the graph.

(3)

6 During the development of active immunity, macrophages present antigens to T helper cells.

(a) Describe how macrophages present antigens to T helper cells.

(2)

(b) In an investigation into clonal selection, macrophages and T cells were isolated from two strains of guinea pig, strain 2 and strain 13.

The macrophages from each strain of guinea pig were exposed to an antigen and treated with mitomycin.

Mitomycin forms cross links between complementary strands of DNA.

These macrophages were then cultured with T cells from each of the strains of guinea pig for 72 hours.

Radioactive thymidine was included in the culture. This molecule will become incorporated into DNA during DNA replication instead of thymine.

The table shows the results of this investigation.

Source of macrophages	Level of radioactive thymidine incorporated into T cells / a.u.	
	T cells from strain 2 guinea pigs	T cells from strain 13 guinea pigs
strain 2	180	13
strain 13	17	59

(i) Explain why the macrophages were treated with mitomycin.

(3)

(ii) Explain how radioactive thymidine becomes incorporated into the DNA.

(2)

(iii) Analyse the data to explain the results of this investigation.

(4)

9 Aptamers are single-stranded DNA or RNA sequences that fold into specific three-dimensional structures.

Aptamers bind tightly to targets such as proteins and viruses.

(a) Compare and contrast the structure of single-stranded DNA with that of single-stranded RNA.

(3)

(b) Aptamers can be amplified using PCR.

To amplify an RNA aptamer, reverse transcription-PCR (RT-PCR) must be used.

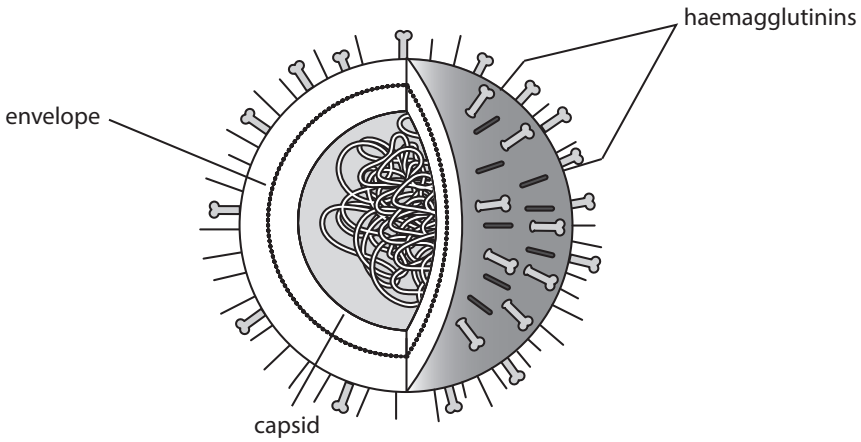
Describe how RT-PCR can be used to amplify RNA aptamers.

(4)

*(c) The diagram shows the structure of the influenza virus.

Haemagglutinin is a glycoprotein that binds to molecules on the cell membranes of the host cells of this virus.

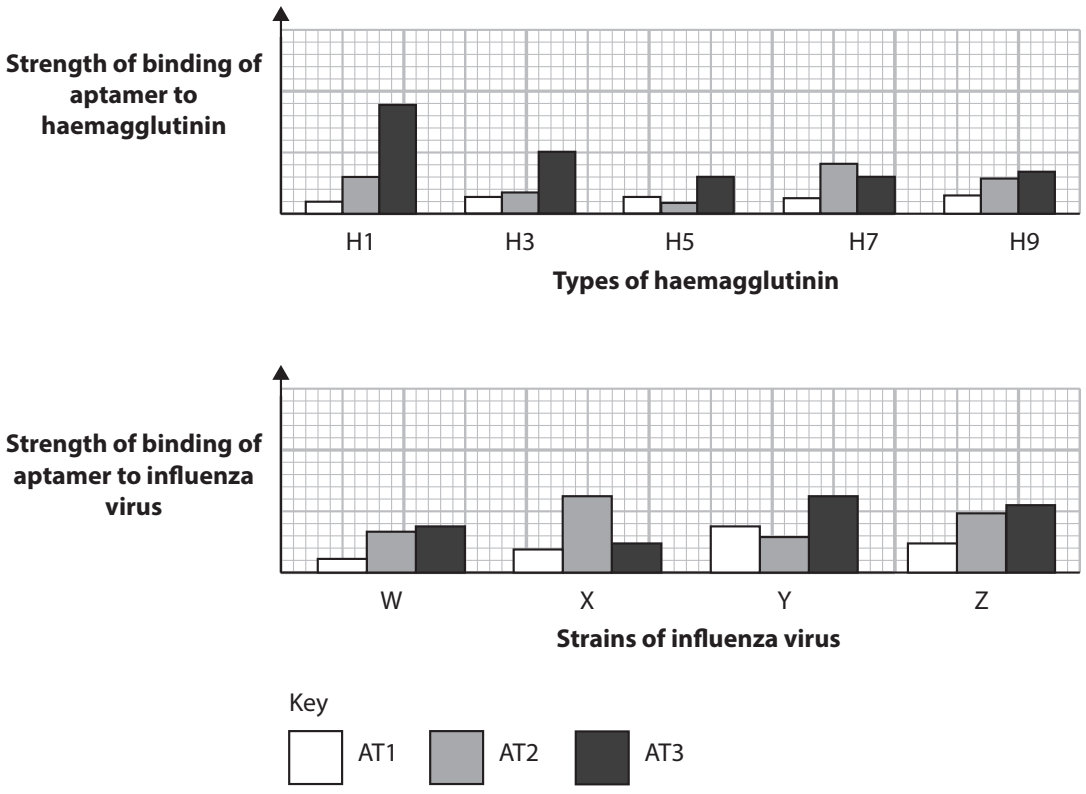
Strains of influenza virus have evolved that have haemagglutinins on their surface, with different antigenic properties.



Aptamers (AT1, AT2 and AT3) have been developed that bind to haemagglutinins (H1, H3, H5, H7 and H9).

The strength of binding of these aptamers to the haemagglutinins and to four strains of influenza virus (W, X, Y and Z) was investigated.

The graphs show the results of this investigation.



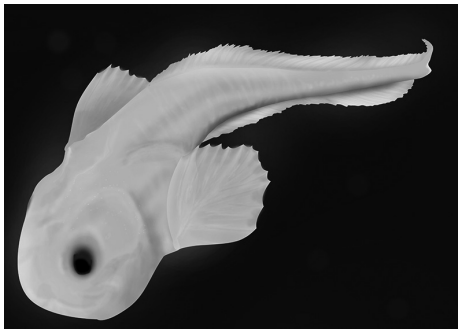
Discuss the advantages and disadvantages of using aptamers to prevent infection with the influenza virus.

(6)

7 The Yap Trench is an area of very deep water in the Pacific Ocean.

In 2017, a new species of fish was caught in the Yap Trench. This was named the Yap hadal snailfish.

The photograph shows a different species of snailfish, the Mariana hadal snailfish.



(Source: © Adisha Pramod/Alamy Stock Photo)

(a) The Yap hadal snailfish was caught in a deep sea trench, at a depth of 7 000 m below sea level.

Hydrostatic pressure increases 100 kPa with every 10 m of depth.

Calculate the hydrostatic pressure at 7 000 m.

Give your answer in standard form.

(1)

Answer ..... kPa

(b) Analysis of the genome of the Yap hadal snailfish and the Mariana hadal snailfish showed that they were closely related.

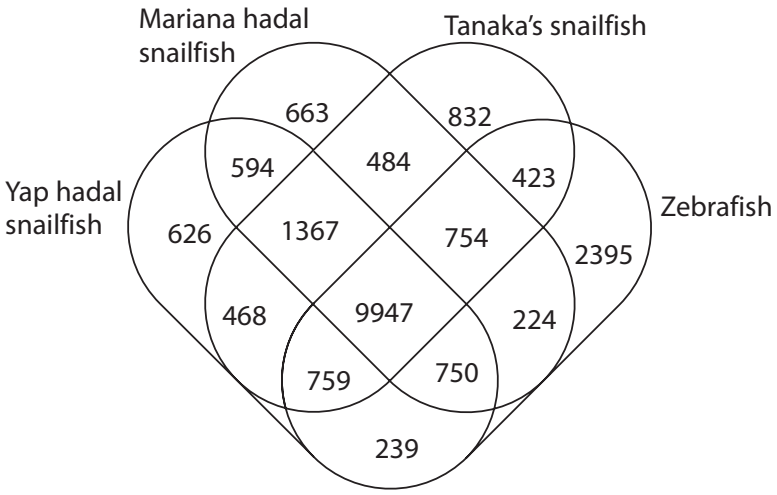
(i) The DNA from the Yap hadal snailfish contained 725 608 564 bases and 204 202 736 of these bases were adenines.

Calculate the number of guanine bases in the DNA of this fish.

(2)

Answer .....

(ii) The Venn diagram shows unique and shared gene families in the genomes of three species of snailfish and a zebrafish.



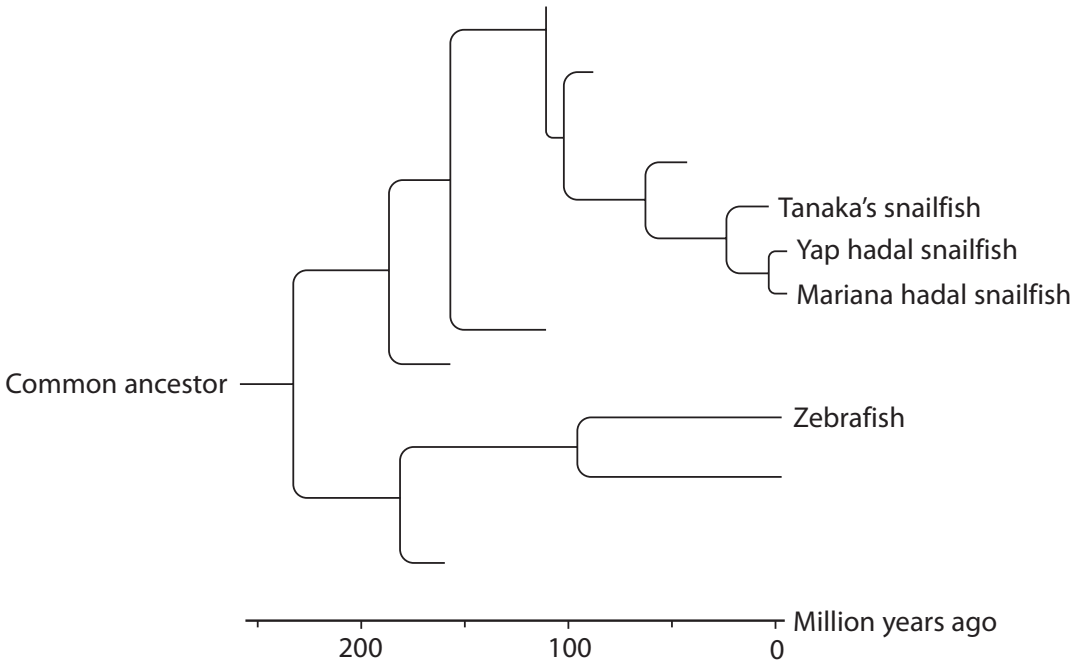
Calculate the percentage of gene families in the Yap hadal snailfish that are shared with the Mariana hadal snailfish.

Give your answer to one decimal place.

(2)

Answer ..... %

(iii) The diagram shows the evolutionary relationship between three species of snailfish and a zebrafish.



Analyse the diagram to describe the evolutionary relationship between these four species of fish.

(3)

*(iv) The Mariana hadal snailfish and the Yap hadal snailfish were caught in separate trenches hundreds of kilometres apart.

Explain how these fish evolved to become separate species.

(6)

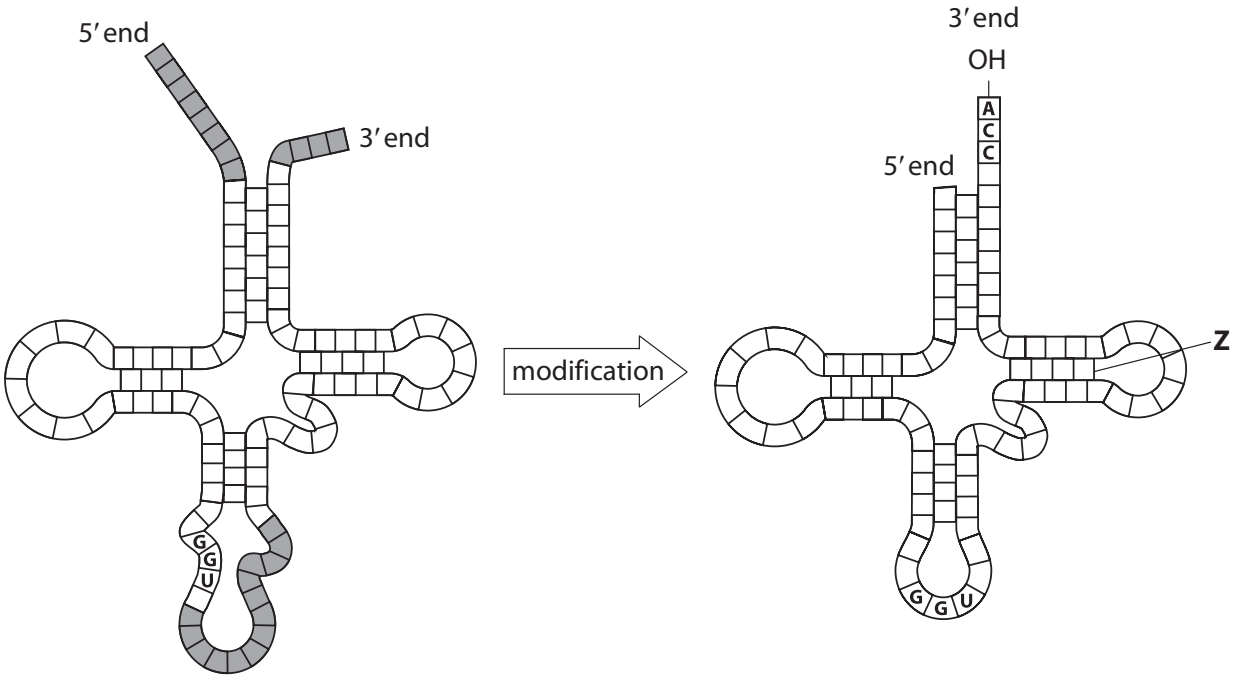
SUB-TOPIC 1(f)

PROTEIN SYNTHESIS AND THE GENETIC CODE

11 questions in this sub-topic · 110 marks · lowest tariff first

2 A molecule of tRNA is made from a precursor molecule that is modified. Modification includes splicing, trimming and attachment of new nucleotides.

The diagram shows a precursor molecule for a tRNA specific for the amino acid proline, and a tRNA molecule specific for the amino acid proline. Some of the bases are shown in each diagram.



precursor molecule

tRNA molecule specific for the amino acid proline

(a) Which bond is labelled **Z**?

(1)

- ☒ **A** glycosidic
- ☒ **B** hydrogen
- ☒ **C** peptide
- ☒ **D** phosphodiester

(b) Describe how this precursor molecule is modified to produce a tRNA molecule specific for the amino acid proline.

(3)

(c) (i) Which of the following base sequences is the mRNA code for proline?

(1)

- ☒ **A** A A T
- ☒ **B** C C A
- ☒ **C** C C T
- ☒ **D** C C U

(ii) Which of the following base sequences is the DNA code for proline?

(1)

- ☒ **A** A C C
- ☒ **B** C C A
- ☒ **C** G G T
- ☒ **D** U G G

(Total for Question 2 = 6 marks)

1 Short sequences of nucleotides are being developed as potential drugs.

They act by binding to selected sites on DNA or RNA molecules and prevent the synthesis of a specific protein associated with a disease.

Two types of drug to treat genetic disorders are:

- antisense drugs, which are RNA nucleotides that bind to mRNA
- triplex drugs, which are DNA nucleotides that bind to DNA forming a three-stranded helix.

(a) (i) The type of bonds that hold the two strands of a DNA molecule together in a double helix are

(1)

☒ **A** glycosidic bonds

☒ **B** hydrogen bonds

☒ **C** phosphodiester bonds

☒ **D** peptide bonds

(ii) Antisense drugs inhibit protein synthesis by interfering with

(1)

☒ **A** protein folding

☒ **B** replication

☒ **C** transcription

☒ **D** translation

(iii) Triplex drugs inhibit protein synthesis by interfering with

(1)

☒ **A** protein folding

☒ **B** replication

☒ **C** transcription

☒ **D** translation

(b) The table shows the sequence of bases in part of an mRNA molecule.

Complete the table to show the base sequence of **each** of the following:

(i) the corresponding coding strand of DNA that produced this mRNA sequence

(1)

(ii) the base sequence of an antisense drug that will bind to this mRNA.

(1)

Base sequence on the DNA coding strand												
Base sequence on mRNA	C	A	U	G	C	A	U	A	U	C	G	G
Base sequence of antisense drug												

(iii) State the number of amino acids that would be coded for by the part of mRNA shown in this table.

(1)

.....

(c) Which of the following statements is true for the total number of bases in a double-stranded DNA molecule?

(1)

☒ **A** $\frac{A+T}{C+G}=1$

☒ **B** $\frac{A}{T}=\frac{C}{G}$

☒ **C** $A \times T = C \times G$

☒ **D** $\frac{A}{C}=\frac{G}{T}$

(Total for Question 1 = 7 marks)

3 In flowering plants, pollen grains grow pollen tubes that are involved in fertilisation, producing a zygote and endosperm.

(a) (i) Which row of the table shows the correct description for these nuclei?

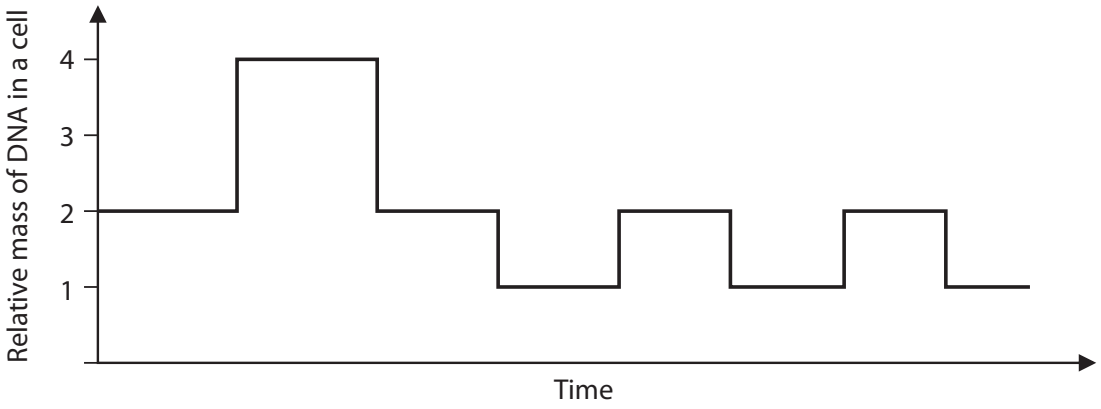
(1)

	Zygote nucleus	Endosperm nucleus	Pollen tube nucleus
☒ **A**	diploid	diploid	haploid
☒ **B**	diploid	triploid	haploid
☒ **C**	diploid	triploid	diploid
☒ **D**	haploid	triploid	diploid

(ii) The production of plant gamete cells involves both mitosis and meiosis.

The graph shows the DNA content of a cell during the production of a pollen grain.

(1)



The order of nuclear divisions shown in the graph is

☒ **A** meiosis, mitosis, mitosis

☒ **B** meiosis, mitosis, meiosis

☒ **C** mitosis, meiosis, meiosis

☒ **D** mitosis, mitosis, meiosis

(b) A scientist investigated the effects of chemical A and chemical B on pollen tube growth.

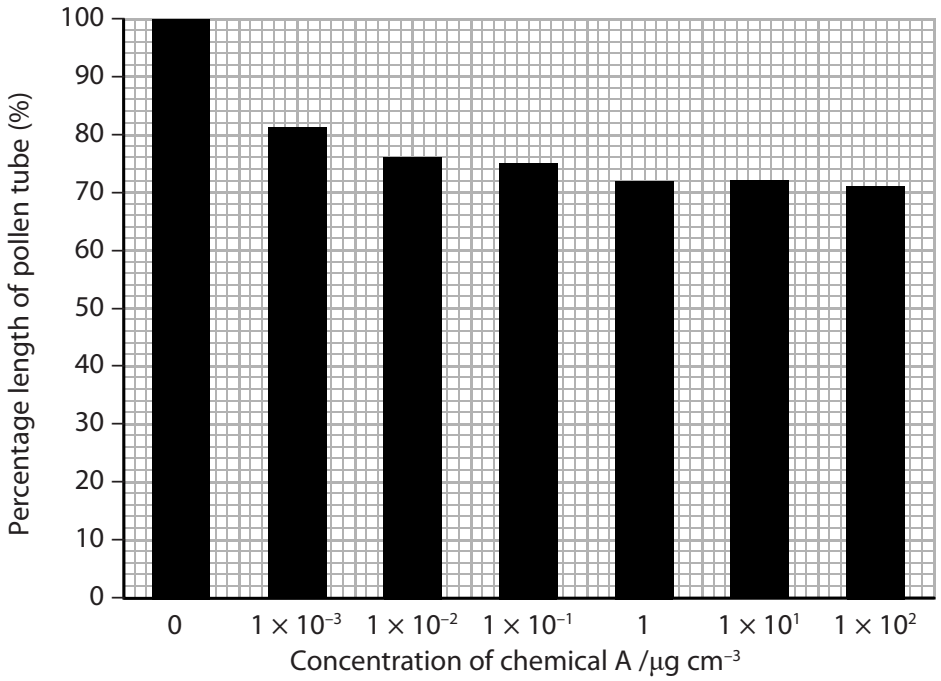
Chemical A prevents transcription.

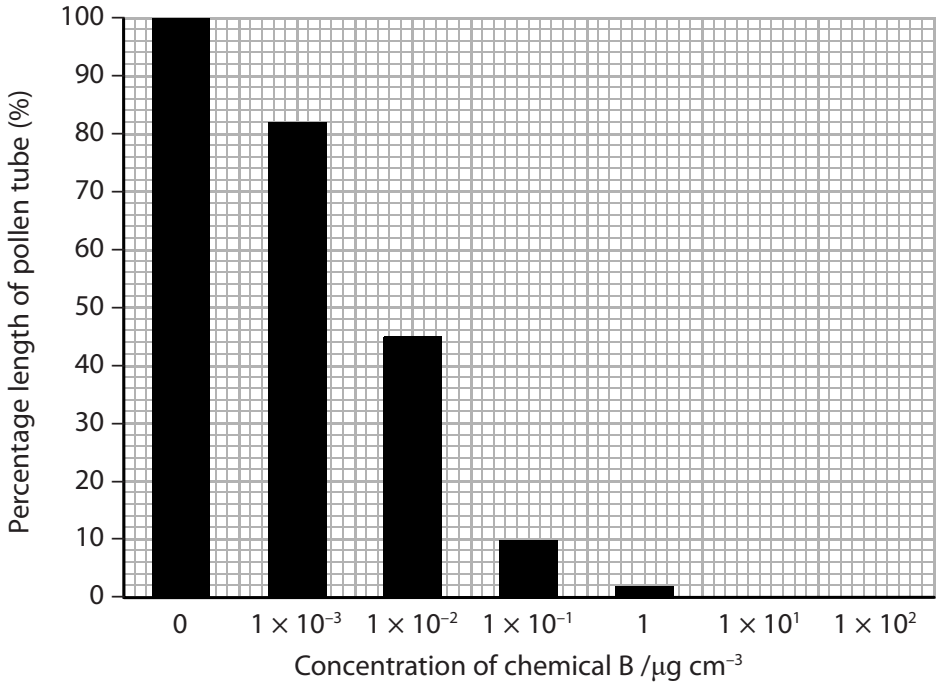
Chemical B prevents translation.

Pollen grains were treated with different concentrations of these two chemicals. The lengths of the pollen tubes they produced were compared with a control group of pollen grains.

The lengths of the pollen tubes were measured and expressed as a percentage of the control group.

The results are shown in the graphs.





(i) The mean length of the pollen tubes in the control group was 7.5 mm.

Calculate the mean length of the pollen tubes after adding 0.010 μg cm^{-3} of chemical A.

(2)

Answer .....

(ii) Analyse the data to comment on the effects of chemical A and chemical B on the roles of transcription and translation in pollen tube growth.

(4)

.....

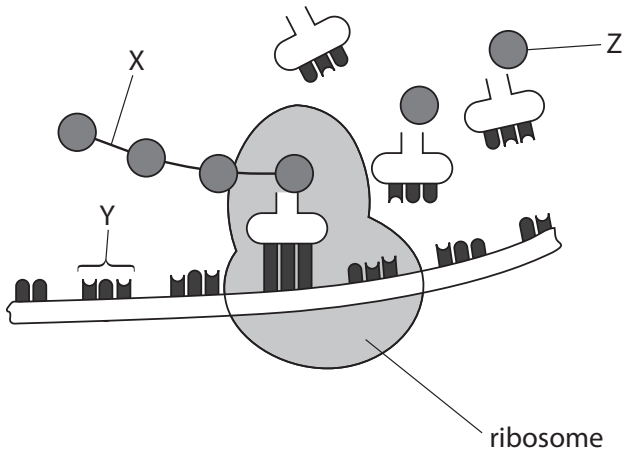
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1 (a) The diagram represents part of protein synthesis.



(i) Name the stage of protein synthesis shown in the diagram.

(1)

.....

(ii) The stage shown in the diagram takes place in the

(1)

- ☒ **A** cytoplasm
- ☒ **B** Golgi apparatus
- ☒ **C** nucleus
- ☒ **D** smooth endoplasmic reticulum

(iii) The part labelled X on the diagram represents

(1)

- ☒ **A** an ester bond
- ☒ **B** a glycosidic bond
- ☒ **C** a hydrogen bond
- ☒ **D** a peptide bond

(iv) The part labelled Y on the diagram represents

(1)

- ☒ **A** an anticodon
- ☒ **B** a base pair
- ☒ **C** a codon
- ☒ **D** a DNA triplet

(v) Name the molecule represented by the part labelled Z on the diagram.

(1)

.....

(b) The table shows the number of bases in the DNA strand used in the synthesis of mRNA.

Complete the table to show the percentage of bases in the mRNA synthesised.

(3)

Bases	Number of bases in the DNA strand	Percentage of bases in the mRNA (%)
Adenine	31 000	23.3
Cytosine	22 000	
Guanine	26 000	
Thymine	24 000	

(Total for Question 1 = 8 marks)

2 Plant growth substances and phytochromes are chemicals that affect the growth of plants.

(a) (i) Which row of the table shows the concentrations required for the fastest growth of lateral buds?

(1)

		Auxin concentration	Cytokinin concentration
☒	**A**	high	high
☒	**B**	high	low
☒	**C**	low	high
☒	**D**	low	low

(ii) Some types of auxin affect the activity of cells in the same way as hormones such as oestrogen affect human cells.

These auxins pass through the cell membrane and affect the synthesis of enzymes.

Explain how these auxins affect the synthesis of enzymes.

(3)

.....

.....

.....

.....

.....

(b) Phytochrome is involved in the germination of seeds.

The effect of red (R) light and far-red (FR) light on the germination of lettuce seeds was investigated.

A scientist exposed five groups of 50 seeds to red light for one minute.

The seeds were planted and the mean number that germinated was calculated.

Another five groups each of 50 seeds were then exposed to red light for one minute, followed by far-red light for four minutes.

These seeds were planted and the mean number that germinated was calculated.

The experiment was repeated with different combinations of red light and far-red light.

The results are shown in the table.

Sequence of red (R) and far-red (FR) light	Mean number of seeds that germinated	Standard deviation (SD)
R	45	±4
R, FR	5	±2
R, FR, R	45	±5
R, FR, R, FR	10	±4
R, FR, R, FR, R	40	±9

Analyse the data to comment on the effect of red (R) and far-red (FR) light on the germination of lettuce seeds.

(4)

5 Some antibiotics work by inhibiting the production of ribosomes in bacteria.

The structure of ribosomes in bacteria is similar to the structure of ribosomes in mitochondria.

(a) (i) Describe the structure of a ribosome.

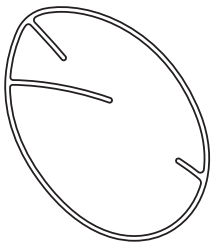
(2)

(ii) Describe the role of ribosomes in protein synthesis.

(2)

(b) These antibiotics can destroy cancer cells in humans.

The diagram shows the membranes of a mitochondrion from a cancer cell treated with these antibiotics.



(i) Give one difference in the membranes of this mitochondrion compared with the membranes of a mitochondrion from an untreated cancer cell.

(1)

(ii) Some cancer cells depend on oxidative phosphorylation for ATP production.

Explain why the antibiotics that inhibit the production of ribosomes prevent oxidative phosphorylation when used to treat cancer cells.

(2)

(iii) Some scientists suggested that inhibiting both glycolysis and mitochondrial respiration may be an effective way of treating cancer cells.

Explain why this suggestion may be an effective way of treating cancer cells.

(2)

7 Scientists investigated the role of ex-situ conservation of plant species on genetic biodiversity.

The scientists investigated the variability of DNA sequences of 30 different genes for a number of species of plants in seed banks and in the wild.

(a) (i) Which row gives correct statements about the genetic code in eukaryotes?

(1)

		Overlapping	Degenerate	Contains introns in genes
☒	**A**	yes	yes	yes
☒	**B**	yes	no	yes
☒	**C**	no	yes	no
☒	**D**	no	yes	yes

(ii) Explain why the DNA sequences of genes are more variable than the sequences of amino acids in the proteins coded for by these genes.

(2)

(iii) Describe how the scientists could use technology to find out whether gene sequences of two species are similar.

(2)

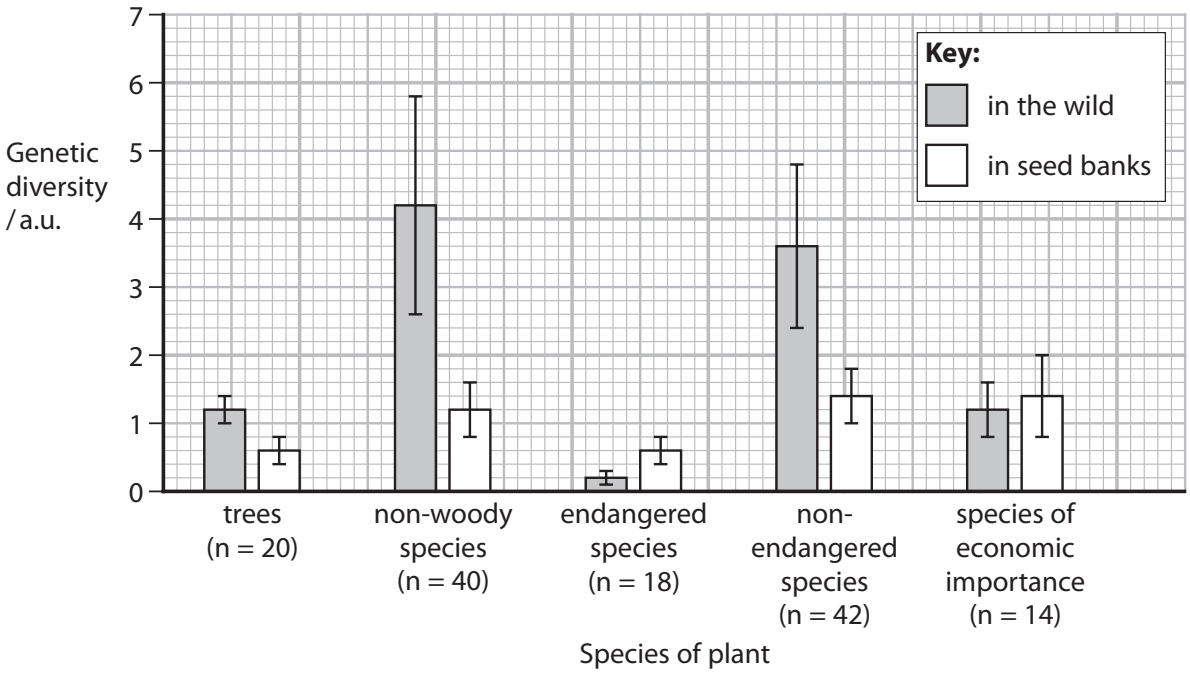
*(b) The scientists measured the mean genetic diversity of species in the wild and the mean genetic diversity of the same species in seed banks.

The species examined included:

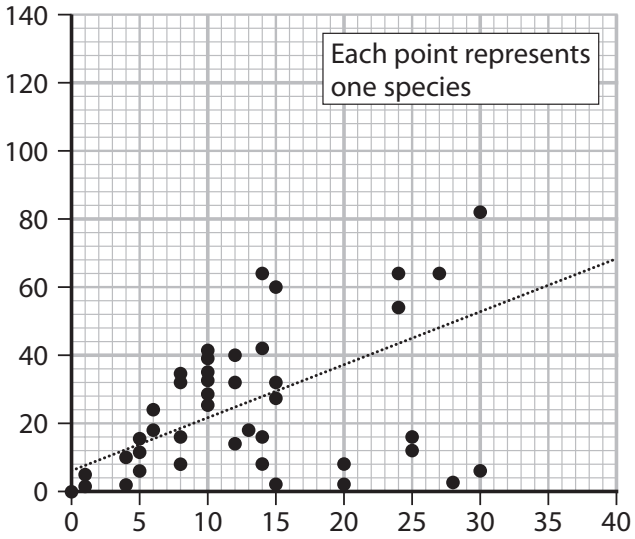
- trees
- non-woody species of plant
- plant species classed as endangered
- plant species classed as not endangered
- plants of economic importance that are harvested by people.

The scientists also measured the mean number of differences in the DNA sequences of the seeds that had been stored for different lengths of time compared with plants in the wild.

The graphs show the results.



Error bars represent +/−1 standard deviation
n = number of different species



Analyse the data to discuss the results of this investigation.

(6)

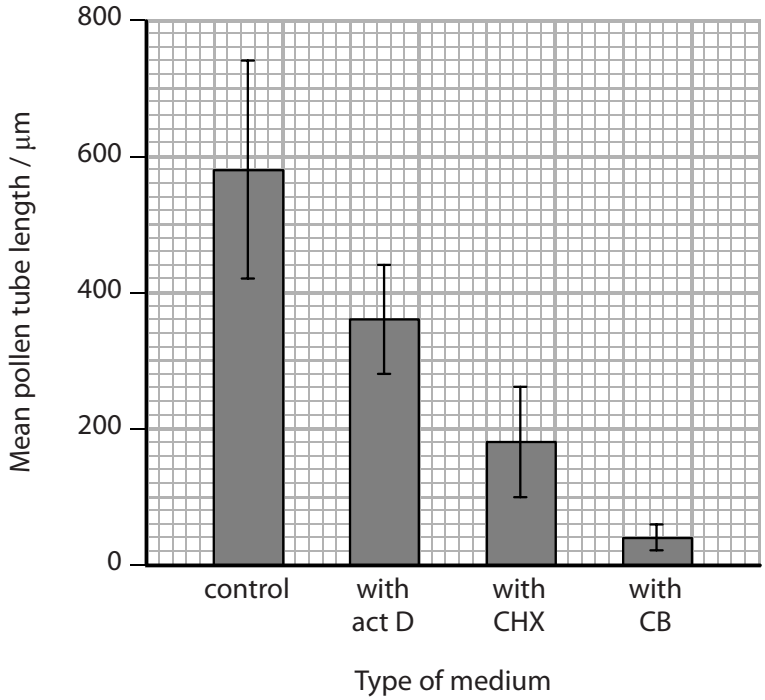
7 A student investigated the effect of three inhibitors on the growth of pollen tubes.

Pollen grains were incubated in a control medium.

In addition, some pollen grains were also incubated in three media, each containing one inhibitor.

The inhibitors used were actinomycin D (act D), cycloheximide (CHX) and cytochalasin B (CB).

The results of this investigation are shown in the graph.



The student made the following conclusions from these results:

Conclusion 1: all three inhibitors affected pollen tube growth

Conclusion 2: pollen grown in CB grew the slowest

Conclusion 3: the control result was the least repeatable

Conclusion 4: more pollen grains germinated in the control group

(a) Analyse the results of this investigation to comment on each of these conclusions.

(4)

(b) (i) Actinomycin D (act D) inhibits transcription.

Explain why pollen tubes could still grow in the presence of act D.

(2)

(ii) Cycloheximide inhibits translation.

Describe the process of translation.

(4)

(iii) Cytochalasin B prevents the addition of monomers in the synthesis of the protein actin.

Describe how monomers are bonded to a polypeptide chain during the synthesis of actin.

(2)

(Total for Question 7 = 12 marks)

5 Eukaryotic cells and prokaryotic cells have similarities and differences in their ultrastructure.

(a) Compare and contrast the ultrastructures of eukaryotic cells and prokaryotic cells.

(4)

(b) Some antibiotics inhibit RNA synthesis and protein synthesis in cells.

Actinomycin D, Rifamycin and α-Amanitin are antibiotics that work by binding to molecules in a cell. This inhibits protein synthesis.

The scientists who developed these antibiotics had to find out which types of cell were affected and which molecule they were binding to.

The table shows the types of cell that these antibiotics affect and the molecule that they bind to.

Antibiotic	Type of cell affected	Molecule that the antibiotic binds to
Actinomycin D	Prokaryotic and eukaryotic	DNA
Rifamycin	Prokaryotic only	RNA polymerase
α-Amanitin	Eukaryotic only	RNA polymerase

(i) Describe the structure of a DNA molecule.

(3)

(ii) Explain the effect of Actinomycin D on protein synthesis.

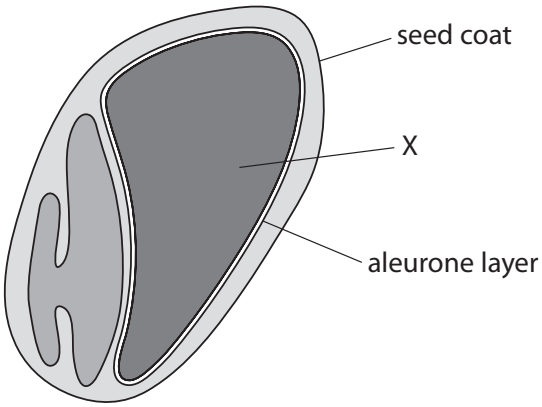
(3)

(iii) Explain the effect of Rifamycin and α-Amanitin on protein synthesis.

(3)

5 Gibberellin stimulates cells in the aleurone layer of cereal grains, such as barley, to produce the enzyme amylase.

The diagram shows the location of the aleurone layer in a barley grain.

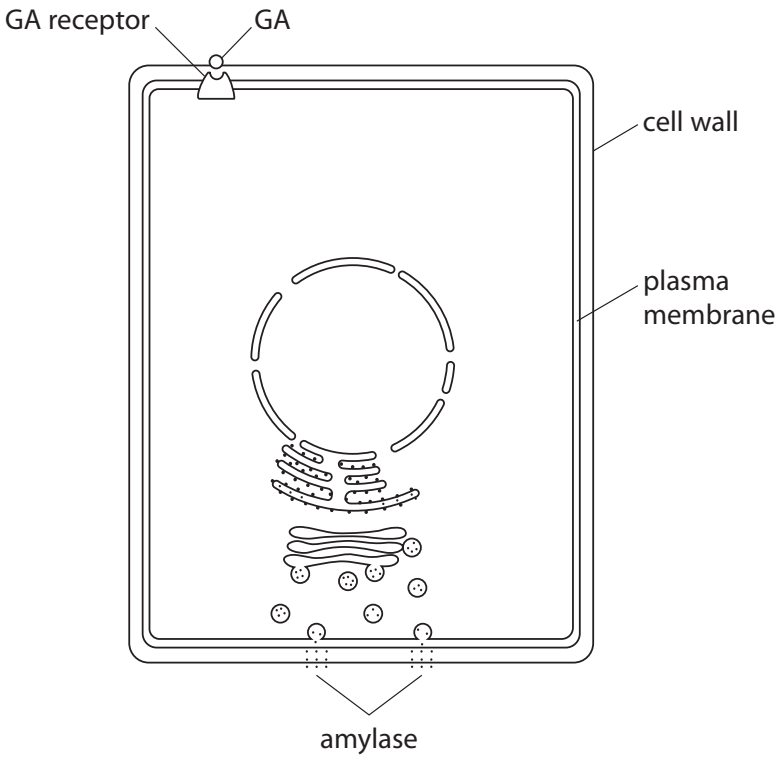


(a) The part labelled X contains triploid cells.

Name the part labelled X.

(1)

(b) The diagram shows a cell from the aleurone layer with some of the structures involved in the production of amylase.



Gibberellin binds to a protein receptor in the cell surface membrane and this stimulates transcription in the nucleus.

(i) Describe the process of transcription in the nucleus of this cell.

(2)

(ii) Describe the processes occurring after transcription that result in the release of amylase from the cell shown in the diagram.

(5)

(c) Global warming may cause sea levels to rise and salty seawater to flood land used for growing crops.

A student read that salt (NaCl) inhibits gibberellin synthesis.

This could affect amylase production in cereal grains.

Devise an investigation to show the effect of salt concentration on amylase production in cereal grains.

(5)

10 Antibiotics can affect bacteria.

The table describes the mode of action of four antibiotics.

Antibiotic	Mode of action
benzylpenicillin	disrupts peptidoglycan structure
streptomycin	binds to 70 S ribosomes
ciprofloxacin	inhibits enzymes involved in prokaryotic DNA replication
rifamycin	inhibits prokaryotic RNA polymerase

(a) (i) Name the antibiotic that affects Gram positive bacteria only.

(1)

.....

(ii) Give one reason why these antibiotics will not affect human cells.

(1)

.....

.....

.....

.....

(b) Explain how rifamycin prevents the growth of bacteria.

(3)

.....

.....

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.....

(c) Mutations in the DNA of bacteria can enable them to be resistant to antibiotics.

(i) A single bacterium can produce 2×10^{10} new cells per day by cell division.

The mean mutation rate in one day is 1 in 10 million new cells produced.

Calculate the mean number of bacteria with mutations that could be produced in one day from a single bacterium.

(2)

Answer .....

(ii) Explain how bacteria may become resistant to streptomycin if a mutation changes the primary structure of a protein.

(3)

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.....

.....

(d) A student compared the effectiveness of these four antibiotics on the growth of bacteria.

Devise a method that the student could use to obtain valid results.

(5)

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.....

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SUB-TOPIC 1(g)

WATER AND INORGANIC IONS

7 questions in this sub-topic · 52 marks · lowest tariff first

2 Mineral ions are needed for plant growth.

A student had a plant that had been kept in the same soil for a long time.

The growth of the plant had slowed down and the leaves were pale green.

The student decided to add fertiliser to the plant and measure the increase in height of the plant.

The student made two predictions:

- the leaves would gradually become greener
- the plant would not start growing until the leaves were greener.

(a) Explain why the student made these predictions.

(3)

(b) The student used a stock fertiliser solution at a concentration of 500 $\mu g\,cm^{-3}$.

Calculate the volumes of stock fertiliser solution and water that had to be mixed together to produce 100 cm^3 of fertiliser solution at a concentration of 50 $\mu g\,cm^{-3}$.

(1)

Volume of stock fertiliser solution ..... cm^3

Volume of water ..... cm^3

(c) When the fertiliser was added to the plant, the height of the plant was 130 cm.

Six weeks after the fertiliser was added, the plant had grown to a height of 155 cm.

Calculate the mean growth rate for this plant, in centimetres per day, in this six-week period.

(1)

Answer ..... cm day^{-1}

(Total for Question 2 = 5 marks)

~~answer, put a line through the box ☒ and then mark your new answer with a cross ☒.~~

1 (a) Plants take up magnesium ions and nitrate ions from the soil. These inorganic ions are dissolved in the water in the soil.

(i) Magnesium ions and nitrate ions are incorporated into molecules made by the plant.

Which row in the table shows the molecules that incorporate these ions?

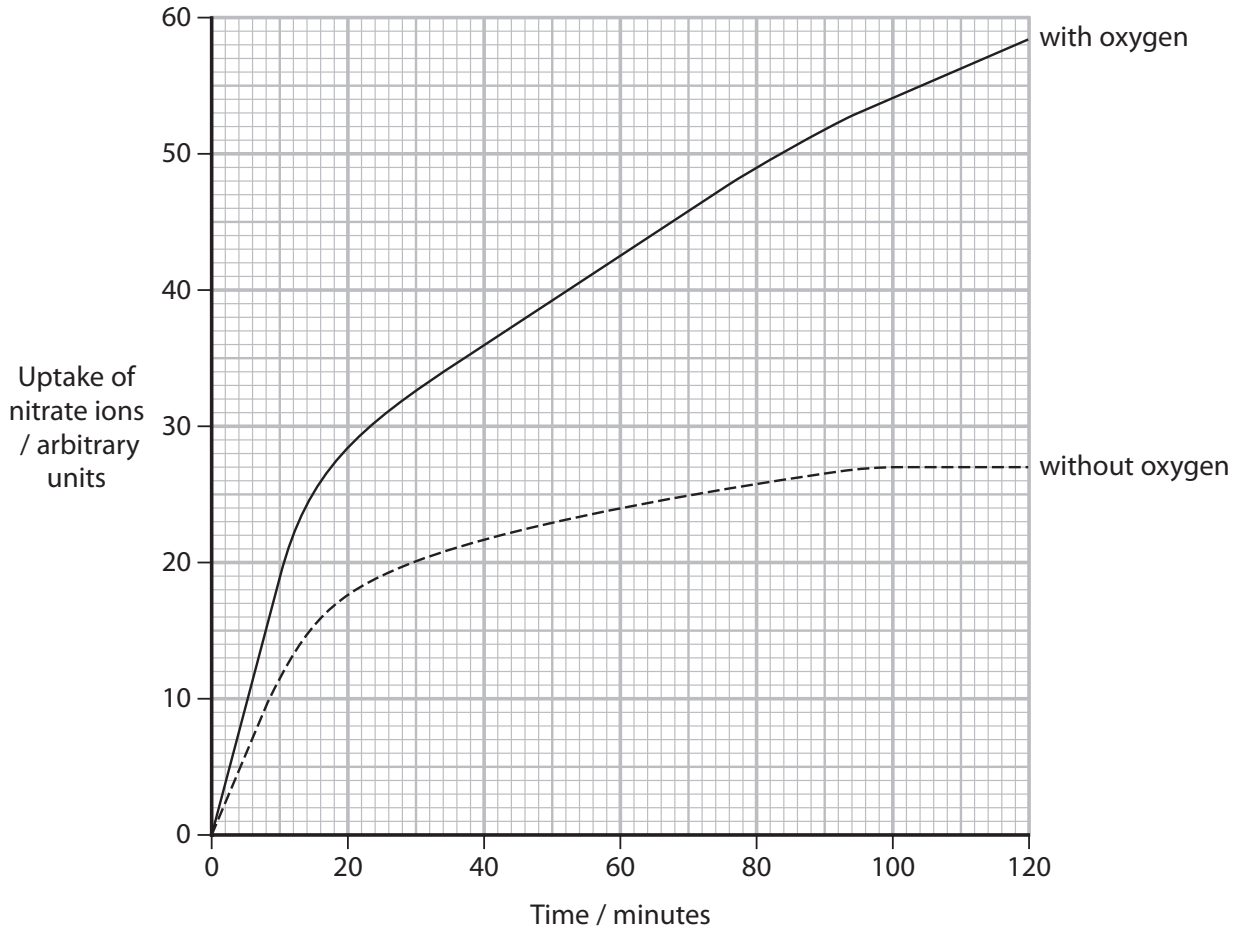
(1)

		amino acids	chlorophyll	nucleotides
☒	**A**	magnesium ions	nitrate ions	magnesium ions
☒	**B**	magnesium ions	nitrate ions	nitrate ions
☒	**C**	nitrate ions	magnesium ions	nitrate ions
☒	**D**	nitrate ions	magnesium ions	magnesium ions

(ii) Explain why these ions dissolve in water.

(2)

(b) The graph shows the uptake of nitrate ions by a plant in the presence and absence of oxygen.



Analyse the data to describe **two** conclusions that can be made about the uptake of nitrate ions by this plant.

(2)

1 .....

.....

.....

2 .....

.....

1 Plants take up inorganic ions from the soil.

These ions include calcium, phosphate and potassium.

(a) (i) Name the molecule that contains calcium ions in the cell walls of a plant.

(1)

.....

(ii) How many of the following statements are correct?

(1)

- phosphate ions are used to make DNA and RNA
- phosphate ions are used in the structure of the cell membrane
- the element potassium is part of a peptide bond

☒ **A** none

☒ **B** one only

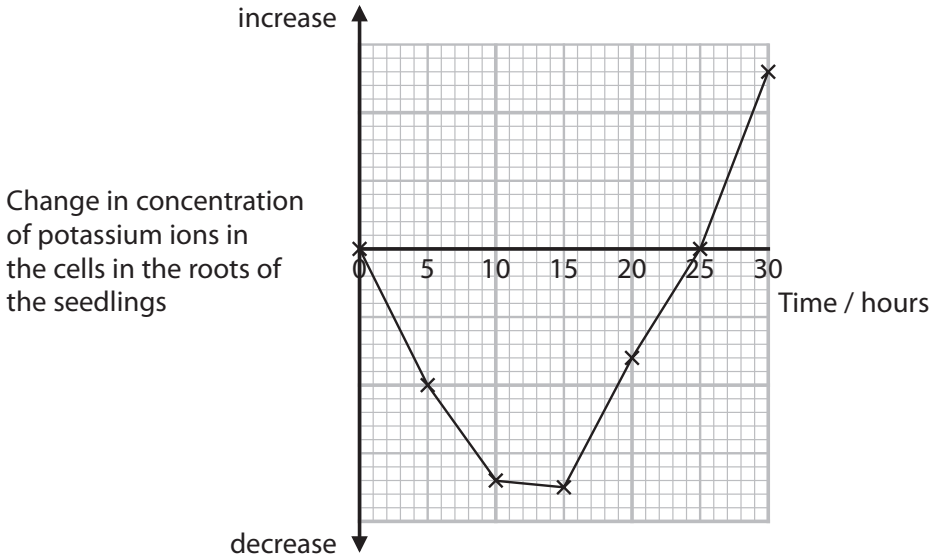
☒ **C** two only

☒ **D** three

(b) The uptake of potassium ions by plant seedlings in anaerobic and aerobic conditions was investigated.

The seedlings were grown in a mineral ion solution containing a low concentration of potassium ions for 30 hours. The conditions were anaerobic for the first 15 hours and aerobic for the second 15 hours.

The graph shows the results of this investigation.



Explain the changes in the concentration of potassium ions in the cells in the roots of the seedlings during this investigation.

(4)

4 Transpiration moves water and mineral ions from the roots to the leaves of plants.

(a) Which box in the table shows the mineral ions needed to make an amino acid and which box shows those needed to make DNA?

(2)

Molecule	Mineral ions needed to make the molecule			
	nitrate ions only	**phosphate ions only**	**both nitrate and phosphate ions**	**neither nitrate nor phosphate ions**
amino acid	☒	☒	☒	☒
DNA	☒	☒	☒	☒

(b) Water enters the root hair cells and moves through the root tissues by the apoplastic and symplastic pathways.

(i) Root hairs have a large surface area that increases the rate of uptake of water.

The surface area of a root hair is rounded up to $3.14 \times 10^5\ \mu m^2$.

Which is the actual surface area of this root hair?

(1)

☒ **A** $31\,460\ \mu m^2$

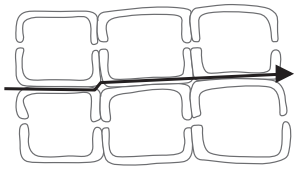
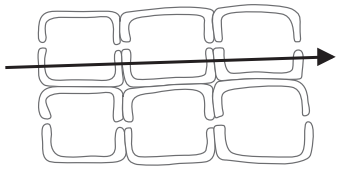
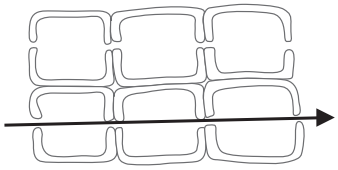
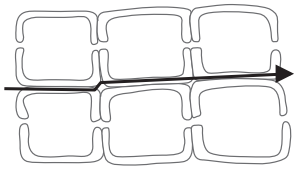
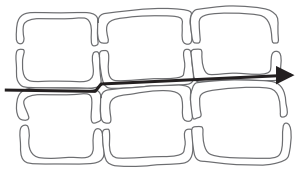
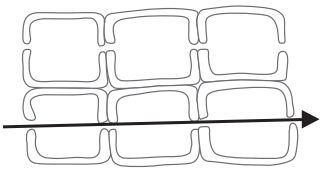
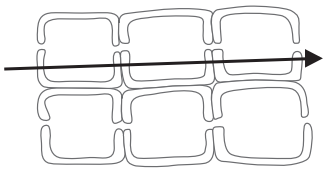
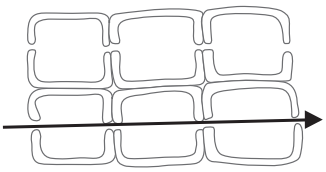
☒ **B** $314\,600\ \mu m^2$

☒ **C** $313\,900\ \mu m^2$

☒ **D** $3\,139\,000\ \mu m^2$

(ii) Which row of the table shows the movement of water through the apoplastic and symplastic pathways?

(1)

	Apoplastic pathway	Symplastic pathway
☒ A		
☒ B		
☒ C		
☒ D		

(iii) Water moves through the root tissue due to a difference in water potential between one cell and the next cell.

Which row of the table describes this movement?

(1)

	Direction of water movement with respect to water potential	Direction of water movement with respect to concentration of solutions
☒ A	higher to lower	concentrated to dilute
☒ B	higher to lower	dilute to concentrated
☒ C	lower to higher	concentrated to dilute
☒ D	lower to higher	dilute to concentrated

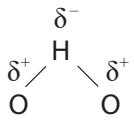
(c) Explain how transpiration depends on the dipole nature of water.

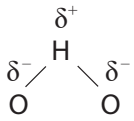
(3)

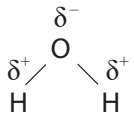
5 The dipole nature of water gives this molecule properties that are important for living organisms.

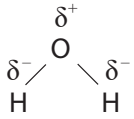
(a) Which diagram shows the dipole nature of water?

(1)

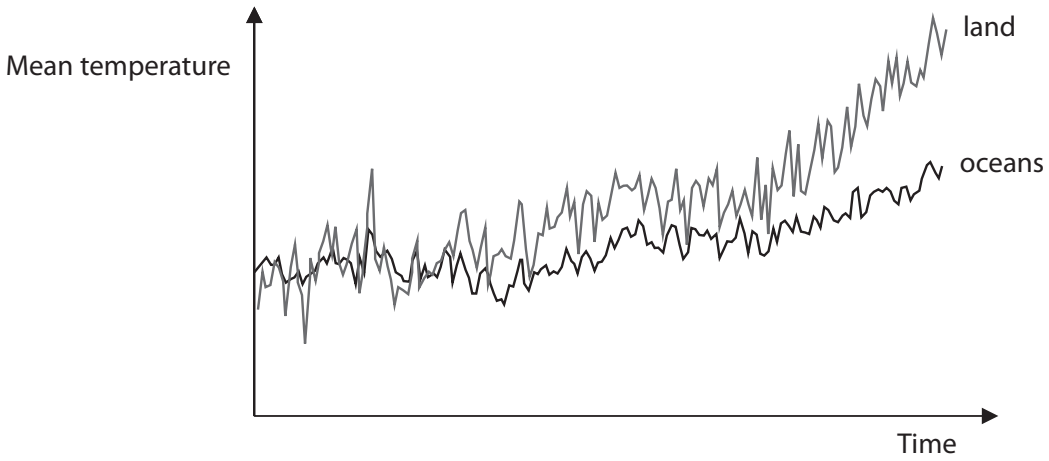
☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(b) The graph shows the mean temperatures of land and oceans over a period of 70 years.



(i) Explain how the dipole nature of water results in the mean temperature change of the oceans, over the 70 years, being less than that of the land.

(2)

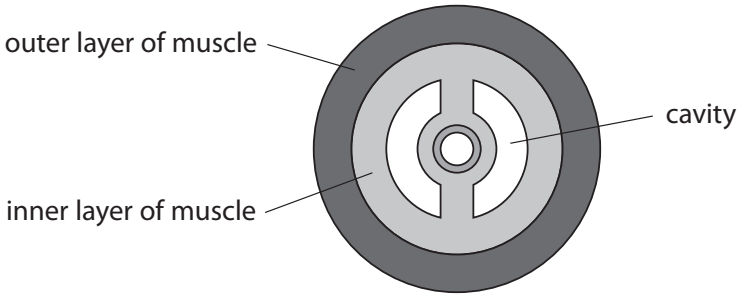
(ii) Explain the importance of this lower change in mean temperature to organisms, such as fish, that live in the oceans.

(2)

(c) Some animals, such as earthworms, have a hydrostatic skeleton.

A hydrostatic skeleton consists of a cavity filled with a water-based fluid, surrounded by two layers of muscle.

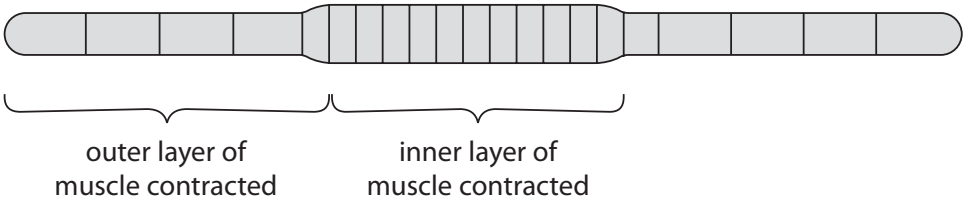
The diagram shows a section through an earthworm.



When the outer layer of muscle contracts in one section of the earthworm, this section becomes longer.

When the inner layer of muscle contracts in one section of the earthworm, this section becomes shorter.

The diagram shows the shape of an earthworm when each layer of muscle contracts.

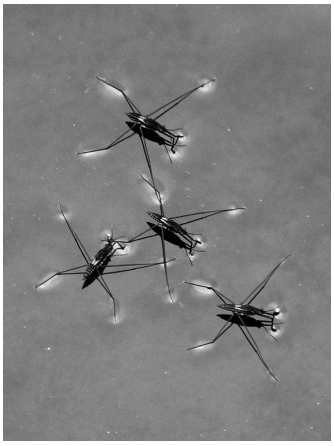


Explain how the dipole nature of water enables the muscle layers to push against the fluid in the cavity and change the shape of the earthworm.

(3)

3 Pond skaters are insects. They can move on the surface of water due to the high surface tension of water.

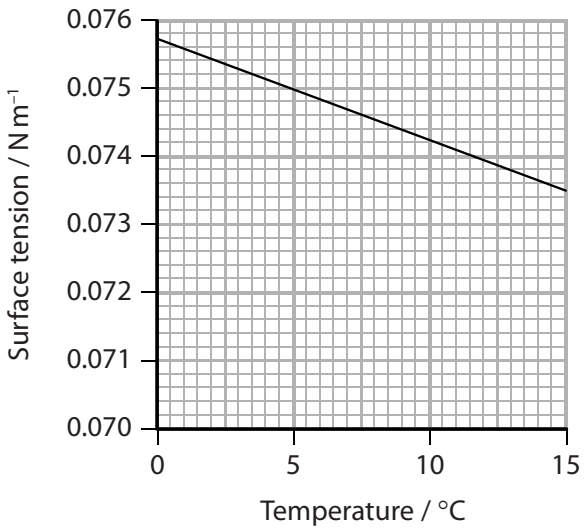
The photograph shows four pond skaters on the surface of water.



(a) Explain how the properties of water molecules result in surface tension.

(3)

(b) The graph shows the effect of temperature on the surface tension of water.



A pond skater has a mass of 0.02 g and has a length of 20 mm in contact with the surface of the water.

The force that this pond skater exerts on the surface of the water can be calculated using the equation:

force in newtons = mass in kilograms × 9.8

(i) Calculate the force exerted by the pond skater for each millimetre length of contact with the surface of the water.

Give your answer in standard form.

(3)

Answer .....

(ii) This pond skater can stay on the surface of water even on a hot day in summer.

Use your calculated value and the graph to explain why this pond skater can stay on the surface of water.

(3)

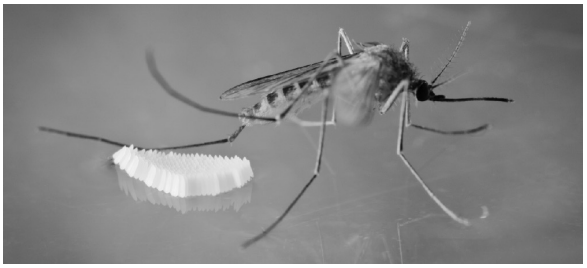
5 Water has a high surface tension.

(a) Explain how the properties of water molecules result in a high surface tension.

(3)

(b) Mosquitoes are insects. They lay their eggs on the surface of water.

The photograph shows a mosquito and eggs on the surface of water.



(Source: © doug4537/Shutterstock)

(i) Analyse the information in the photograph to explain why the mosquito does not sink.

(2)

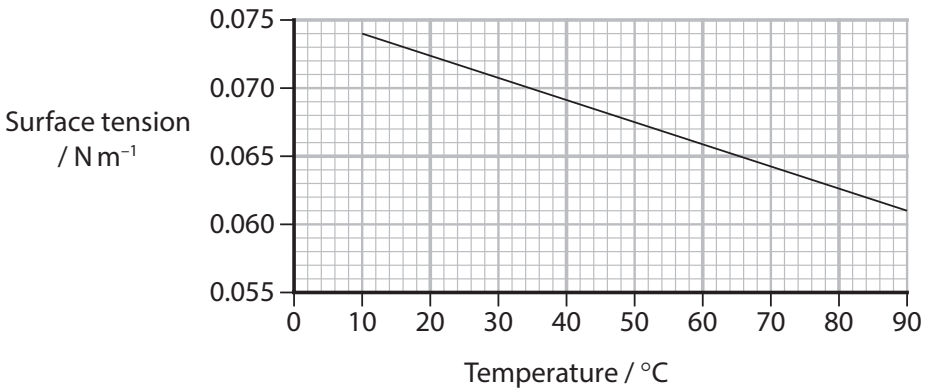
(ii) Kerosene is a mixture of non-polar organic molecules made of carbon and hydrogen.

When kerosene is sprayed on the water, the floating mosquito eggs sink.

Explain why the eggs sink when kerosene is sprayed on the water.

(2)

(c) The graph shows the effect of temperature on the surface tension of water.



(i) Calculate the decrease in surface tension per 1 °C rise in temperature.

Give your answer in standard form, to one decimal place.

(2)

Answer ..... N m⁻¹ per °C

(ii) Explain why a rise in temperature causes a decrease in surface tension.

(2)

MARK SCHEMES

official Pearson Edexcel mark schemes

Question Number	Answer	Additional Guidance	Mark
2(a)	**The only correct answer is A** **B** is incorrect because hydrolysis splits bonds **C** is incorrect because galactose is not a component of sucrose **D** is incorrect because galactose is not a component of sucrose and hydrolysis splits bonds		(1)

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to three of the following: Similarities: • both contain α glucose (1) • both contain glycosidic bonds (1) Differences: • amylose has 1 – 4 (glycosidic) bonds only but amylopectin has both 1 – 4 and 1 – 6 (glycosidic) bonds (1) • amylose is helical but amylopectin is branched (1)	**NB** both contain glucose joined by α glycosidic bonds = 2 marks **ACCEPT:** Coiled/unbranched for amylose	(3)

Question Number	Answer	Additional Guidance	Mark
1(a)	An answer that makes reference to the following: • arrangement of H and OH on C1 shown (1) • rest of molecule correct (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
1(b)	• glycosidic (bond / link) (1)	Ignore 1-4 / 1-6	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(c)	• 504 (1)		**(1)**

Additional Guidance	Mark
	(3)

	Additional Guidance	Ma
onded to each other ules are not branched cules do not contain ules do not contain ycosidic bonds		(3)

	Additional Guidance	Ma
1 and statement 2) does not prevent the e is also found in the te does not		(3)

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	• glucose is a monosaccharide and maltose is {a disaccharide / made of two glucoses / made of two monosaccharides} (1)	**ACCEPT** maltose has a glycosidic bond and glucose does not glucose has 6 carbons and maltose has 12 glucose has the formula $C_6H_{12}O_6$ and maltose $C_{12}H_{22}O_{11}$ **ACCEPT** a labelled diagram	(1)

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An explanation that makes reference to two of the following: • neither sugars respired immediately because the yeast need to {acclimatise / adjust to the conditions} (1) • delay is longer for maltose as {enzymes need to be synthesised / maltose needs to be broken down into glucose} (1) • respiration of maltose is faster (than glucose) as maltose has {twice the number of sugar units / more glucoses / more hydrogens} (1)	**ACCEPT** glycosidic bonds have to be broken **ACCEPT** because maltose contains more energy / maltose is a disaccharide and glucose is a monosaccharide	(2)

Question Number	Answer	Additional Guidance	Mark
2(b)	An explanation that makes reference to the following: • lactose is not {respired / used} as the yeast do not produce {the appropriate enzymes / lactase} (1) • sugars in the cytoplasm are {used / respired} (1)	**ACCEPT** yeast cannot break lactose down **NB** at least one reference to respiration for both marks to be awarded	(2)

	Additional Guidance	Mark
	description e.g. 6 carbons 12 ygen and 6 oxygens	
	both marks for 6x12 + 12x1 + (=180)	(2)

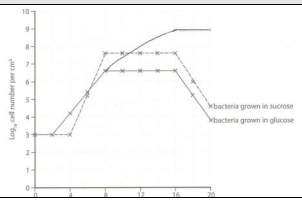
	Additional Guidance	Mark
	mple of calculation + 180 = 360 - 18 = 342	
	rect answer gains full marks with no king	(2)

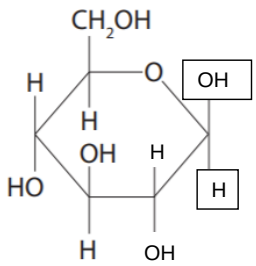
	Additional Guidance	Mark
	ct structures drawn out e has 2 less H **and** 1 less O verse	
	cular mass of ribose is 150 lar mass of glucose is 180	(2)

Question Number	Answer	Additional Guidance	Mark
2(a)	**B** monosaccharide disaccharide	**A** is incorrect because sucrose is a disaccharide **C** is incorrect because glucose is a monosaccharide **D** is incorrect because glucose is a monosaccharide and sucrose is a disaccharide	

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	• values read from graph per unit time and converted back from logs • subtraction of each pair and division done	(7.6=) 39 810 717 and (6.6=) 3 981 072 and (3.0=) 1000 or (4.2=) 15849 15 / 10 / 10.04 **ACCEPT** 1.9 / 1.92 / 2 / 82.5 / 82.54 / 83 for 1 mark if slopes of graph used but no mention of the exponential growth rate constant (*k*)	
	OR • exponential growth rate constant (*k*) calculated and used	**ACCEPT** *k* values calculated (3.820598 / 3.82 and 1.99335548 / 1.99) for 1 mark and *k* sucrose divided by *k* glucose = 1.9 **/** 1.92 / 2 for 2 marks	

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to the following: • (lag phase longer as) {sucrose has to be broken down / enzymes to breakdown sucrose had to be synthesised} (1) • (reproduction faster) because sucrose has more {sugar / monosaccharides / energy} (1)	**ACCEPT** converse for glucose **ACCEPT** sucrase **ACCEPT** sucrose made of glucose and fructose / sucrose is a disaccharide and glucose is a monosaccharide	

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	• a line that continues to go up after 8 hours and then levels off (around) 16 hours without dropping		

Number	Answer	Additional Guidance	Mark
1(a)		Accept HO for OH	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that includes three of the following: • cellulose is made up of beta glucose (monomers) but starch is made up of alpha glucose (monomers) (1) • cellulose contains {unbranched / straight / linear} chains (of glucose) but starch contains branched chains (1) • cellulose contains 1,4 glycosidic bonds but starch contains 1,4 and 1,6 glycosidic bonds (1) • {inverted / flipped} glucose molecules in cellulose but glucose molecules in same orientation in starch (1)	**Piece 2 adjacent sentences only** Accept b / β and a / α Accept cellulose contains one type of molecule but starch contains {two types / amylose and amylopectin} Accept amylose is coiled but cellulose is {not coiled / a straight chain molecule} Accept starch contains 1,6 glycosidic bonds but cellulose does not Accept a diagram	**(3)**

Question Number	Answer	Additional Guidance	Mark
1(c)	An explanation that includes the following: • insoluble (1) • so does not {have an osmotic effect / affect water potential} (1) **or** • {compact / dense / coiled / tightly packed} (1) • so a lot can be stored in a {small / given} space (1) **or** • (amylopectin / starch is) branched (1) • so can be {broken down / hydrolysed} more quickly (1)	**Do not piece** Accept so cannot cross membrane and leave cell Ignore takes up less space unqualified Accept contains many {end branches / terminal glucose molecules} Ignore easy / easier release	**(2)**

(Total for Question 1 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
	An answer that includes the following:		

Number	Answer	Additional Guidance	Mark
7a	B		(1)

Question Number	Answer	Additional Guidance	Mark
7bi	An explanation that makes reference to the following: • as glucose doubles mass of precipitate doubles between 0 and 12 mg cm^{-3} (1) • because all the glucose reacts with the Benedict's reagent (1) • the increase in the mass of precipitate is {non-linear above 12 mg cm^{-3} / stops increasing above 16 mg cm^{-3} } (1) • this is because { all Benedict's reagent used up after 16 mg cm^{-3} / there is an excess of glucose at 16 mg cm^{-3} } (1)	accept there is a linear increase between 0 and 12 mg cm^{-3} accept Benedict's becomes limiting after 12 mg cm^{-3}	(4)

Question Number	Answer	Additional Guidance	Mark
7bii	• Percentage error calculated	0.05 ÷ 0.28 x 100 = 17.9% accept 17.86 / 18	(1)

Question Number	Answer	Additional Guidance	Mark
7biii	An explanation that makes reference to one pair of the following: • repeat measurements more times (1) • to reduce standard deviation (1) • increase drying time (1) • to ensure all water removed (1) • check calibration of balance (1) • to increase accuracy of measurement of mass (1) • rinse all precipitate off filter paper (1) • to ensure all precipitate collected and measured (1)	ALLOW the precipitate should be repeatedly dried and weighed until a constant mass is achieved.	(2)

Question Number	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
4(a)	**The only correct answer is A** ***B*** *is incorrect because human immunodeficiency virus is polyhedral* **C** *is incorrect because λ (lambda) phage is non-enveloped, complex in structure and has DNA* **D** *is incorrect because tobacco mosaic virus does not have an envelope*		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)	**The only correct answer is A** ***B*** *is incorrect because hydrolysis uses water not produces it* **C** *is incorrect because hydrolysis splits bonds not forms them* **D** *is incorrect because hydrolysis splits bonds not forms them*		(1)

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	An answer that makes reference to three of the following, that includes the similarity: **Similarities** • both contain carbon, hydrogen and oxygen (1) **Differences** • polysaccharides are made up of monosaccharides but the primary structures of proteins are made up of amino acids (1) • polysaccharides contain glycosidic bonds but the primary structures of proteins contain peptide bonds (1) • polysaccharides do not contain {nitrogen / sulfur} but primary structures of proteins do contain {nitrogen / sulfur} (1) • polysaccharides may be branched but primary structures of proteins are linear (1)	**DO NOT PIECE TOGETHER** **ACCEPT** glucoses	(3)

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	An explanation that makes reference to the following: • because (if lectins bind to the {spike / polysaccharide) then the virus will not be able to attach to the {ACE 2 / enzyme / (host) cell} (1) • and therefore will not be able to {infect / enter} the cell (1) • new virus particles will not be made (1)	**ACCEPT** {genetic material / RNA} cannot enter cell **ACCEPT** virus cannot replicate lytic cycle will be prevented **DO NOT ACCEPT** latency / lysogenic cycle	(3)

Question Number	Answer	Additional Guidance	Mark
3(a)	A description that makes reference to the following: • glucose and galactose (1) • joined by a (1-4) glycosidic bond (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(b)	• tangent drawn as a straight line touching at 2 hours, on the outside of the curve (1) • rate calculated (1)	**ACCEPT** value between 0.034 and 0.052 to 2 or 3 dps Correct answer gains 2 marks 0.08 / 0.075 gains 1 mark	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	A description that makes reference to the following: • (2.5 % and 7.5 %) lactose stimulates growth of pollen tubes (1) • the effect is dose-dependent / growth depends on the concentration (1) • high concentrations inhibit pollen tube growth (1)	**ACCEPT** pollen tubes can grow in lactose increases pollen tube growth **ACCEPT** pollen tube did not grow in high concentrations 10% was too concentrated for growth	(3)

Question Number	Answer	Additional Guidance	Mark
3(d)	An answer that makes reference to the following: • because sucrose is {produced / secreted / used} by the {stigma / carpel / plant} (1) • because lactose is {found in milk / not {produced by / found in} plants} (1)		(2)

Question Number	Answer	Additional Guidance	Mark
8(a)			(3)

Polysaccharide	Type of glycosidic bond: both 1-4 and 1-6	1-4 only	1-6 only	neither 1-4 nor 1-6
cellulose	☐	X	☐	☐
glycogen	X	☐	☐	☐
starch	X	☐	☐	☐

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	A description that makes reference to the following: • deciding on colours is subjective / people may judge colours differently / hard to distinguish between some colours (1) • the values for the concentration of sugars are ranges / semiquantitative / an { accurate / exact } sugar concentration can not be determined (1)	**Accept** *idea that* 1500 is both yellow and orange **Accept** *idea that* the ranges of concentration are large	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An answer that makes reference to four of the following: • carry out test for reducing sugar (1) • use chart to determine concentration of glucose / sucrose (1) • carry out test for non-reducing sugar on the same volume of solution (1) • heat in (HCl) acid (1) • (then) neutralise (1) • add same { volume/ number of drops } of Benedict's solution (1) • subtract the concentration of glucose from the total concentration to determine sucrose concentration (1)	**Accept** description of test (Benedict's, **plus** heat –) for reducing and non-reducing **Accept** alternative method e.g mass or use of colorimeter **Accept** stated volumes **Accept** hydrolyse sucrose / sugar	(4)

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	**The only correct answer is B** *A is incorrect because galactose is a monosaccharide* *C is incorrect because maltose is a disaccharide* *D is incorrect because the pairs of sugars are the wrong way round*		(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	**The only correct answer is C** *A is incorrect because glycosidic bonds join sugars not ester bonds* *B is incorrect because glycosidic bonds join sugars not ester bonds* *D is incorrect because bonds are formed by condensation reactions*		(1)

Question Number	Answer	Additional Guidance	Mark
8(b)	An answer that makes reference to three of the following: • same concentration of sugar used (1) • (solution of) each sugar should be tasted by same person (1) • sweetness compared with sucrose solution (1) • {water / dried biscuit} should be used between each tasting (1)	**ACCEPT** several people doing the test provided it is clear that they are each tasting all the sugars **ACCEPT** rank sugars in the order of sweetness if no other marks awarded	(3)

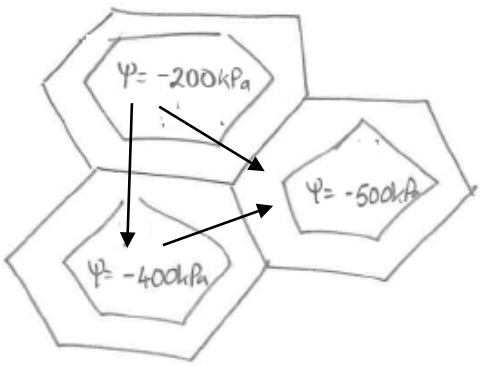
Question Number	Answer	Additional Guidance	Mark
8(c)(i)	• {3 to 4} : 1 : {10 to 13} (1)		(1)

Question Number	Indicative content	
***8(c)(ii)**	**Points made from table:** • statement about fruit and sugar concentration (S) e.g. grapes have the highest concentration lemons have the lowest concentration • comment about grapes being the only fruit to contain maltose and galactose (P) • comment about high sugar concentration and high proportion of fructose or glucose or sucrose (P) **Points made from graph:** • statement about fruit and energy content (S) e.g. bananas have the highest energy content • statement about fruit and relative sweetness (S) e.g. grapes have highest relative sweetness • comment linking energy content to relative sweetness (P) e.g. lemons have the lowest energy content and relative sweetness bananas have the highest energy content but not the highest relative sweetness • comment on the positive correlation between relative sweetness and energy content (P*) **Links made between different sources of information given:** • link between relative sweetness and total sugar concentration (L) e.g. grapes have the highest relative sweetness and total sugar concentration lemons have the lowest relative sweetness and total sugar concentration • positive correlation between relative sweetness and total sugar concentration (L) • positive correlation between energy content and total sugar concentration (L) • with bananas not fitting this pattern (L) • link between relative sweetness and sugar content (L) e.g. grapes have the highest relative sweetness and a high proportion of fructose and glucose mangoes have lower fructose and glucose but have a high relative sweetness because they contain a large proportion of sucrose • bananas must contain other high-energy substances as they have the highest energy content but not the highest sugar content (L)	**Level 1:** 1 mark = 1 point made 2 marks = 2 points made **Level 2:** 3 marks = 3 points made about table and graph that includes either one P or L 4 marks = 3 points made about table and graph that contains at least two P or L **Level 3:** 5 marks = 4 points made about table and graph that contains two Ls 6 marks = 4 points made about table and graph that contains at least three Ls and P*

Question Number	Answer	Mark
7 (a) (i)	The only correct answer is D *A is incorrect as lactose does not contain fructose* *B is incorrect as lactose does not contain fructose* *C is incorrect as maltose does not contain fructose*	**1**

Question Number	Answer	Mark
7 (a) (ii)	The only correct answer is B *A is incorrect as ester bonds are found in lipids* *C is incorrect as hydrogen bonds do not join monosaccharides* *D is incorrect as peptide bonds do not join monosaccharides*	**1**

Question Number	Answer	Mark
7 (a) (iii)	The only correct answer is A *B is incorrect as there should be 21 oxygens* *C is incorrect as there should be 42 hydrogen* *D is incorrect as there are 21 oxygen*	**1**

Question Number	Answer	Additional guidance	Mark
7 (b)(i)	three arrows going in correct directions (1)		**1**

Question Number	Answer	Additional guidance	Mark
7 (b)(ii)	An explanation that makes reference to two of the following. • in **dry** weather {inulin / it} is more soluble / more able to dissolve (1) • so (in dry weather / with less fructose) **water potential** becomes {lower / more negative} (1) • so {in dry weather / with fewer fructose} water moves into {cells / root / plant} / {in dry weather / with fewer fructose} water {is not lost / is retained / stored / is absorbed} (1)	**Allow** insulin **Allow** in **wet** weather {inulin / it} is less soluble / less able to dissolve (1) **Allow** so (in wet weather / with more fructose) **water potential** becomes {higher / less negative} (1) **Allow** {in wet weather / with more fructose} less water {taken in / absorbed} (1)	**2**

Question Number	Answer	Additional guidance	Mark
7 (c)(i)	• correct answer for rate within given range and to two decimal places (1) • mg dm^{-3} min^{-1} / mg dm^{-3} s^{-1} (1)	Example of calculation **Allow** range between (-)7.50 to (-)8.99 (must be two d.p.) **Allow** range between (-)0.12 to (-)0.15 (must be two d.p.) (if in seconds) **Allow** mg dm^{-3} per minute **Allow** mg / dm^3 / min **Allow** mg dm^{-3} / min **Allow** mg dm^{-3} per second **Allow** mg / dm^3 / s **Allow** mg dm^{-3} / s **Allow** any other correct answer using different appropriate units **Correct answer with no working gains full marks.**	**2**

Question Number	Answer	Additional guidance	Mark
7(c)(ii)	An explanation that makes reference to two of the following: 1. ultrafiltration occurs (1) 2. (inulin passes from) glomerulus into Bowman's capsule (1) 3. because inulin is small enough to pass through {basement membrane / pores / fenestrations} (1)	**Allow** (high) hydrostatic pressure moves inulin **Allow** through **gaps** between podocytes **Allow** insulin for inulin	**2**

Question Number	Answer	Additional guidance	Mark
7(c)(iii)	An explanation that makes reference to two of the following: • inulin has no function in humans (1) • inulin is not **reabsorb**ed (1) • because there are no inulin {channels / carriers / pumps} in {proximal convoluted tubule / PCT} (1)	**Allow** insulin for inulin **Allow** inulin is a waste product / is not needed **Allow** absorbed back **into blood** **Allow** first convoluted tubule	**2**

(Total for Question 7 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	An explanation that makes reference to the following: • because different types of lipid are found in the mitochondria and chloroplasts **(1)** • because mitochondria are associated with { respiration / oxidative phosphorylation} whereas chloroplasts are associated with {photosynthesis / light-dependent reactions / photophosphorylation} **(1)** • because mitochondria contain {electron transport proteins / cytochromes / cristae / stalked particles} whereas chloroplasts contain {grana / chlorophyll / photosystems / carotenoids} **(1)**	**Accept** a description of the differences e.g. a lipid high in mitochondria is low in chloroplast, only two of the lipids are found in both organelles **Do not accept** a list of values from the table without some sort of comparison **Accept** any other membrane difference	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	A diagram that shows the following: • a glycosidic bond between C 1 on galactose and C 6 on MGDG **(1)** • rest of molecules complete **(1)** • water molecule **(1)**	ecf if glycosidic bond drawn between C1 and C 4 **Accept** H_20 / water	**(3)**

Question Number	Answer	Mark
6(a)(iii)	**6(a)(iii). The only correct answer is B** ***A*** *is not correct because DGDG is larger than MGDG so will not travel as far and sulfolipid is the smallest quantity so will be the smallest spot* ***C*** *is not correct because DGDG is larger than MGDG so will not travel as far and sulfolipid is the smallest quantity so will be the smallest spot* ***D*** *is not correct because sulfolipid is the smallest quantity so will be the smallest spot*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	1×10^{11}	**Accept** 10^{11} / 100 000 000 000 / 10×10^{10} / any other equivalent ways of expressing this answer	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to two of the following: • because the number of carbon (atoms) in the cell has been under-estimated (1) • because not all the ATP is used in (light-dependent reaction / Calvin cycle / carbon fixation} (1) • because {photons differ in energy / not all wavelengths of light are absorbed by the plant} **(1)**	**Accept** there are more carbons in the cell **Accept** cyclic photophosphorylation is happening **Accept** process is not 100% efficient / some light is reflected / not all photons of light are absorbed	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	A description that makes reference to three of the following: • carbon dioxide diffuses into stroma **(1)** • carbon dioxide binds to {ribulose bisphosphate / RuBP} **(1)** • using {ribulose bisphosphate carboxylase / RUBISCO} **(1)** • resulting in the formation of {(intermediate) 6C compound / GP} **(1)**	**Accept** attaches / joins / reacts / added to **Accept** rubisco	**(3)**

Total for Question 6 = 13 MARKS

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	A description that makes reference to four of the following: • sample taken from the female genital tract (1) • bacteria grown on {selective / indicator} media (1) • bacteria grown on media containing different types of antibiotics (1) • use of {antibodies / DNA profiling} (1) • using {Gram staining / cell shape / colony shape / colony colour} (1)		(4)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	An explanation that makes reference to three of the following: • because they grow on the skin cells preventing pathogenic bacteria from doing so (1) • because they use the glycogen so less {glucose / energy / glycogen} available for the pathogenic bacteria (1) • because they produce lactic acid which inhibits the growth of pathogenic bacteria (1) • because the low pH denatures the enzymes of the pathogenic bacteria (1)	. **ACCEPT** below optimum pH	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An answer that makes reference to three of the following: Similarities • both {are hexoses / have formula of $C_6H_{12}O_6$} (1) • both contain covalent bonds (1) Differences • glucose is a hexagon and fructose is a pentagon (1) • glucose has one CH_2OH and fructose has two (1)	**ACCEPT** have 6 carbons	(3)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: • as a {respiratory substrate / energy source} for the sperm (1) • because movement (through female genital tract) requires ATP (1) • in order to reduce competition for carbohydrates with the {skin / genital tract} {bacteria / cells} (1)	**ACCEPT** provides energy **NB** ATP must be mentioned at least once for both mps to be awarded **ACCEPT** fructose may not be used by skin cells	(3)

	Additional Guidance
:e)} (1)	**DO NOT ACCEPT** in cells **ACCEPT** adenylate cyclase activated
/ protein	**ACCEPT** glycogen phosphorylase is phosphorylated

Answer	Mark
	1

swer	Additional Guidance	Mark
of the following: ic} bonds (1) apid / easy {breakdown / hydrolysis} (1) s not {affect osmosis / leave cells / solute	**DO NOT ACCEPT** beta glucose once	3

wer

four of the following:

cies / type} are kept /
es / varieties} are kept /
y are kept (1)

perature (1)

sture / dry} (1)

xygen} containers (1)

seeds to detect embryo

Answer

olysis reaction breaking

eactions forms glycogen
ot phosphodiester bonds
ot phosphodiester bonds

Additional Guidance	Mark
ACCEPT low genetic diversity / small number of different alleles	**2**

	Additional Guidance	Mark
ving} and	**IGNORE** habitat / area	**1**

	Additional Guidance	Mark
owing:	Example of calculation 15 ÷ 1400 = 0.0107 p = 0.897 q = 0.103 2pq = 2 x 0.897 x 0.103 = 0.185	
a population	0.185 x 1400 = 259 Correct answer with no working gains full marks **ACCEPT** one mark for: q^2 = 0.01 to 0.0107 p = 0.897 to 0.9 **and** q = 0.1 to 0.103 **ACCEPT** 2pq = 0.18 to 0.187 in final answer for **3** marks	**4**

Number	Answer	Additional Guidance	Mark
9(a)(i)	The only correct answer is **B** β glucose *A is incorrect because cellulose does not contain a glucose* *C is incorrect because cellulose does not contain ribose* *D is incorrect because cellulose does not contain ribose*		**(1)**

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	A drawing showing the following: • Correct structure drawn (1) *Hexagonal ring with oxygen in correct place in ring.* *CH_2OH in correct place.* *All OHs apart from Carbon 1 in right places.* *Allow Hydrogens to be just stalks.* • OH groups shown correctly on carbon 1 (1) *pointing in same direction as CH_2OH*	**Do not accept** if water molecule also released / drawn	**(2)**

Question Number	Answer	Additional Guidance	Mark

9(a)(iii)	An explanation that makes reference to three from the following points: • (cellulose molecules are) straight / not helical (1) • (many) hydrogen bonds hold molecules / chains / layers together (1) • (strong) to prevent cell lysis / cells bursting / maintain turgidity / resist (turgor) pressure (1) • (polar nature of glucose) allows water /minerals to diffuse through (1)	**Accept** not coiled **Accept** hydrogen bonds between microfibrils **Accept** other correct functions of strong cell wall	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	• (index of diversity) takes into account populations (of each species) (1)	**Accept** considers abundance / number of each species **Accept** because an area could have many different species but different populations	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An answer that makes reference to two from the following points: • other species are also conserved (in the ecosystem) (1) • animals are not humanised / behaviours are natural / no change to behaviour (1) • less inbreeding occurs (1)	**Accept** converse for *in situ* **Accept** other species are protected / food webs are maintained / maintains biodiversity / maintains links in ecosystem **Accept** more space for animals **Accept** no need to transport animals **Accept** less inbreeding depression / maintain gene pool	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference the following points: • biodiversity has increased (in the paper project area) **more** (than the protected area) (1) • as less / no grassland is burnt / less poaching (1) • (more) niches are available / habitats are not destroyed / elephants transfer plant seeds (1) • local people make money from the paper project / if the elephants are not present, local people lose a source of income (1)	**Accept** biodiversity has increased but {did not increase / went down} in area where people are banned **Accept** grassland burning / poaching still occurs in unprotected area **Accept** converse for protected area **Accept** converse for protected area **Accept** people have a vested interest in the elephants / make a profit	**(4)**

Question Number	Answer	Additional Guidance	Mark
9(c)	A description that makes reference to two of the following points: • not all countries sign the treaty / signing the treaty is voluntary (1) • many species move across national boundaries (1) • monitoring is expensive / some countries are too large to monitor / high financial rewards for {poaching / smuggling} / CITES (only) prevents trade (1)	**Accept** the treaty is not legally binding (within nations) **Accept** some species migrate / have very large ranges **Accept** not all species are classed as endangered **Accept** countries may not be able to monitor within their borders **Accept** some poaching will continue	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	**The only correct answer is D** *A is incorrect because all 3 statements are correct* B is *incorrect because all 3 statements are correct* C is *incorrect because all 3 statements are correct*		(1)

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	**The only correct answer is C** ***A** is incorrect because three molecules of water are lost which is 54, 18 is one molecule* ***B** is incorrect because three molecules of water are lost which is 54, 33 is one molecule with reverse number of H and O atoms* ***D** is incorrect because three molecules of water are lost which is 54, 99 is three molecules with reverse number of H and O atoms*		(1)

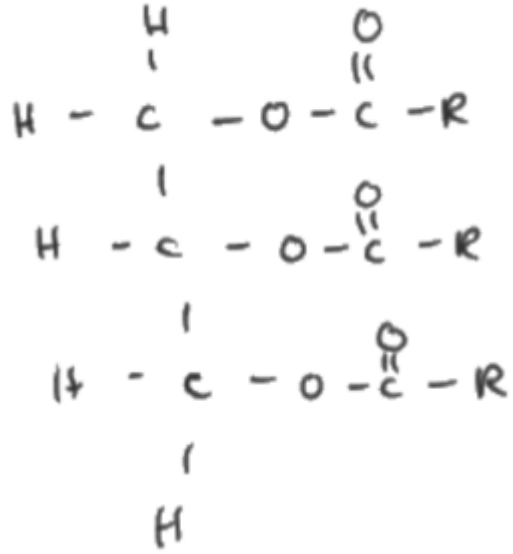
Question Number	Answer	Additional Guidance	Mark
2(b)(i)	• 10.14		(1)

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An answer that makes reference to the following: • heat (solid) samples (of the fatty acids) and measure the temperature at which they melt (1) • use fatty acids of the same chain length but with different {numbers of C C double bonds / degrees of saturation} (1) • use fatty acids of different chain length but the same {number of C C double bonds / saturation} (1) • repeat (for each fatty acid) and calculate the mean (1)	**ACCEPT** cool (liquid) samples (of the fatty acids) and measure the temperature at which they solidify **ACCEPT** average / identify anomalies / do a stats test	(3)

	Additional Guidance	Mark
	Allow converse statements	(4)
point than	Allow fewer carbons in chain	
/er melting	Should be linked to one of the previous mark points	
wers the		
nsaturated ins} would		
but without definite		

	dditional Guidance	M
		(

	dditional Guidance	M
	tive correlation	
	erences to rate, rapid per gradient, dramatic	(

Question Number	Answer	Additional guidance	Mark
3(a)(i)	 (1)		**(1)**

Question Number	Answer	Mark
3(a)(ii)	The only correct answer is A (condensation releasing water) *B is incorrect as water is not used* *C is incorrect as the reaction is not hydrolysis* *D is incorrect as the reaction is not hydrolysis*	**(1)**

Question Number	Answer	Additional guidance	Mark
3(b)(i)	19		**(1)**

Question Number	Answer	Additional guidance	Mark
3(b)(ii)	An answer that makes reference to the following: • both contain COOH / both contain the elements {C, H, O} / both have carbon-hydrogen bonds / C-C bonds / carbon to carbon **single** bonds / same number of oxygens / both have an OH group (1) • saturated fatty acids have {no carbon-carbon double bonds / C=C bonds} / saturated fatty acids have higher proportion of hydrogen atoms / saturated are {straight / not kinked} (1)	**Accept** both have carboxylic acid (groups) **Allow** converse for unsaturated	**(2)**

Question Number	Answer	Additional guidance	Mark
3(b)(iii)	An answer that makes reference to three of the following: • {palmitic / stearic} is saturated / {oleic / linoleic / linolenic} is unsaturated (1) • {almond / flaxseed} has high unsaturated / {cocoa butter} has high saturated / {almond / flaxseed} has less low saturated / {cocoa butter} has low unsaturated (1) • {almond / flaxseed / unsaturated fatty acids} {do not increase CHD / less likely to lead to atherosclerosis / fewer plaque deposits in artery} (1) • {almond / flaxseed / unsaturated fatty acids} has less energy so less obesity (1)	**Accept** palmitic or stearic as equivalent to saturated e.g. {palmitic acid / stearic acid} are high in cocoa butter for **mp 2, 3, 4** **Accept** oleic or linoleic or linolenic for unsaturated fatty acids e.g. oleic acid is high in almond oil for **mp 2, 3, 4** **Accept** converse for saturated / cocoa **Accept** correct ref to LDLs / HDLs **Accept** converse for saturated / cocoa	**(3)**

(Total for Question 3 = 8 marks)

Number	Answer	Additional Guidance	Mark
4(a)	An explanation that makes reference to the following: • glycogen is a {polymer / polysaccharide} **(1)** • therefore glycosidic bonds need to be broken **(1)**	**DO NOT ACCEPT** glucose {is a polysaccharide/ has more glycosidic bonds} **ACCEPT** description of polysaccharide structure **ACCEPT** needs hydrolysis before it can be used in respiration	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An explanation that makes reference to three of the following: • carbohydrates and proteins are {hydrophilic / polar} molecules **(1)** • triglycerides are {hydrophobic / non polar} molecules **(1)** • therefore water will associate with proteins and carbohydrates **(1)** • but be repelled by the triglycerides **(1)**	**ACCEPT** {absorb / bond to} water **ACCEPT** can't bond to water	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An explanation that makes reference to two of the following: • triglycerides store more energy per gram than carbohydrates and proteins in both wet and dry matter **(1)** • because it has a high {carbon / hydrogen} content **(1)** • because it contains no water **(1)**	**ACCEPT** low oxygen content	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(iii)	An explanation that makes reference to the following: • units given for energy only **(1)** • therefore a comparison cannot be made **(1)**	**ACCEPT** no indication of mass	**(2)**

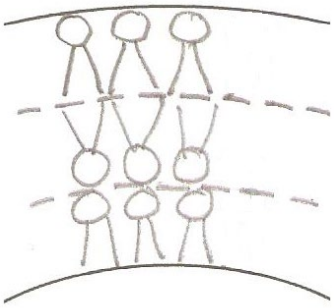
Total for Question 4 = 9 MARKS

3(a)	B		**(1)** **comp**

Question Number	Answer	Additional Guidance	Mark
3(b)	D		**(1)** **comp**

Question Number	Answer	Additional Guidance	Mark
3(c)	A		**(1)** **comp**

Question Number	Answer	Additional Guidance	Mark
3(d)	• phospholipids are polar and triglycerides are non-polar		**(1)** **exp**

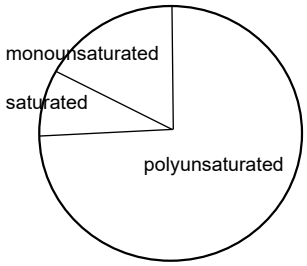
Question Number	Answer	Additional Guidance	Mark
3(e)(i)		All 3 layers drawn correctly = 2 marks 2 layers drawn correctly = 1 mark There should not be gaps between the layers	**(2)** **exp**

Question Number	Answer	Additional Guidance	Mark
3(e)(ii)	An explanation that makes reference to three of the following: • lipids are non-polar so cannot be carried in the solution (1) • non-polar phospholipid tails enclose the lipids (1) • phosphate heads are polar so can interact with the solution (1) • and with each other in two adjoining layers (1)		**(3)** **EXP**

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following:		

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	• an O drawn between the two covalent bonds		(1)

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	**The only correct answer is A** **B** is incorrect because three water molecules (54) have to be subtracted, not one **C** is incorrect because three water molecules 54 have to be subtracted, not six hydrogens **D** is incorrect because three water molecules 54 have to be subtracted		(1)

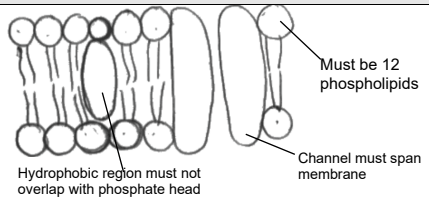
Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• pie chart drawn showing lipid content of safflower oil, labelled	 saturated section less than monounsaturated and polyunsaturated three quarters by eye	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	• percentage of polyunsaturated lipids in 500 g {beef / oil} calculated (1) • 355 (g) (1)	Example of calculation: (3 + 1) × (500 ÷ 100) = 20 75 × (500 ÷ 100) = 375 Correct answer with no working gains full marks	(2)

Question Number	Answer	Additional Guidance	Mark
3(b)(iii)	An explanation that makes reference to the following: • because plant products will contain less {cholesterol / saturated lipids} (than animal products) (1) • therefore there will be less cholesterol (in the blood stream) to {build up / form a plaque / form an atheroma} in an artery (1)	**ACCEPT** converse explanation **ACCEPT** more polyunsaturated lipids	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)	An explanation that makes reference to two of the following: • the phosphate (head) is {polar / hydrophilic} (1) • therefore the phosphate can interact with the aqueous environment (1) • otherwise the lipids {will form a micelle / will not form a bilayer (and not enclose the cytoplasm) (1)	**ACCEPT** dissolve in water in the cytoplasm and environment	(2)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**The only correct answer is B** **A** is incorrect because R is the hydrophilic phosphate and S is the hydrophobic fatty acid **C** is incorrect because R is the hydrophilic phosphate and S is the hydrophobic fatty acid **D** is incorrect because R is the hydrophilic phosphate and S is the hydrophobic fatty acid		(1)

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An answer that makes reference to the following: • 12 phospholipids arranged in a bilayer and channel protein spanning the width of the bilayer (1) • cholesterol drawn showing hydrophilic region {in / adjacent} to phosphate heads and hydrophobic region in amongst fatty acids (1)		(2)

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	A description that makes reference to the following: • to provide a hydrophilic channel (through the bilayer) (1) • for facilitated diffusion (1)	Accept allow movement of {hydrophilic molecules/large/polar/charged molecules/ions}	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An answer that makes reference to the following: • as temperature increases the permeability increases (1) • (presence of cholesterol) decreases permeability / increase in cholesterol decreases permeability (1)	Accept converse – no cholesterol, membrane is more permeable	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An explanation that makes reference to the following: • (Low heat energy of phospholipids) so very little kinetic energy (1) • phospholipids do not move so {molecules not able to/less pass through/ low rate of diffusion} (1)	Accept other terms e.g less fluid eq to do not move	(2)

Question Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to the following: • glycerol attached to two fatty acids (by ester bonds) (1) • and one phosphate attached to glycerol (1)	**ACCEPT** from a labelled diagram **NB** made from one glycerol two fatty acids and one phosphate = 1 mark if neither mark awarded	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to the following: • because the {two polar groups / outside layers} will interact with the aqueous environment (on each side of membrane) (1) • rest of molecule will provide hydrophobic barrier / there will be a hydrophobic layer (inside) (1)	**ACCEPT** form H bonds with water	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	• 1.5 (%)		(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	A description that makes reference to two of the following: • bacteria with higher optimum growth temperatures have a greater percentage of branched chain fatty acids (1) • the greater the percentage of branched chain fatty acids the greater the range of optimum growth temperature (1) • an optimum growth temperature of more than 40°C needs at least 30% of branched chains (1)	**ACCEPT** positive correlation between optimum growth temperature and percentage of branched-chain fatty acids converse **ACCEPT** bacteria with optimum temperature between 20°C and 40°C had the greatest range in percentage of branched-chain fatty acids converse	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)	An explanation that makes reference to the following: • because membranes control {permeability / what can enter and leave the cell} (1) • such as {uptake of nutrients / uptake of oxygen / removal of waste products} (1) • because membranes need to be fluid for {movement / cell division} (1)	**ACCEPT** converse i.e. what would happen if membrane composition did not change **ACCEPT** membranes become more {permeable / leaky} at higher temperatures **ACCEPT** named nutrients / waste products	(3)

Question Number			
7(a)	An explanation that makes reference to the following: • because {cholesterol / fatty acids} are hydrophobic (so cannot be carried in bloodstream) (1) • phospholipid tails are hydrophobic so {cholesterol / fatty acids} can be carried inside lipoprotein (1) • {protein / phospholipid heads} in lipoprotein are hydrophilic (enabling transport in bloodstream) (1)	**ACCEPT** non-polar **ACCEPT** non-polar **ACCEPT** polar	

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• substitution of values into equation • answer given to 3 or 4 sig figs	$4/3 \times \pi \times 11 \times 11 \times 11$ / 5572.453 5570 / 5572 **ACCEPT** 5580 / 5575 for 1 mark	

Question Number	Answer		Mark
7(b)(ii)	An explanation that makes reference to two of the following: • because (in the LDL) there is less protein (contained in a larger volume) (1) • because the protein is denser than the phospholipid (in the LDL) (1) • (the LDL has) {a larger hole in the middle / fewer molecules in relation to its size} (1)	**ACCEPT** converse statements for HDL **ACCEPT** types of protein in HDL are denser than the types in LDL	

Question Number	Answer	Additional Guidance	Mark
7(b)(iii)	An explanation that makes reference to four of the following: • because cholesterol is a risk factor (1) • (because of raised LDLs) more cholesterol in the blood (1)		
	• {cholesterol / plaque / atheroma} builds up in (walls of) artery (1) • reducing the flow of blood to the heart {tissue / cells} (1) • therefore lack of oxygen for (aerobic) respiration (in heart cells) (1)		

Number	Answer	Additional Guidance	Mark
5(a)	An answer that makes reference to the following: • correct structure of glycerol (1) • correct structure of three fatty acids (1)	Max one mark if other molecules e.g. water added to right hand side **Accept** 3 x one fatty acid	2

Question Number	Answer	Additional Guidance	Mark
5 (b)(i)	C 3 *A is incorrect because palmitic, myristic and stearic acid are saturated fats* *B is incorrect because palmitic, myristic and stearic acid are saturated fats*		1
	D is incorrect because palmitic, myristic and stearic acid are saturated fats		

Question Number	Answer	Additional Guidance	Mark
5 (b)(ii)	An answer that makes reference to four from the following: • %SFC for both decreases as temperature increases for both cocoa butter and palm oil / both have 5% SFC at 35 °C (1) • the % SFC of cocoa butter is higher at all temperatures (except 35 °C) (1) • because cocoa butter has higher percentage of / more saturated fat (1) • so fatty acid chains can associate with each other more easily (1) • the % SFC of cocoa butter decreases more steeply above 25 °C / larger decrease after 25°C (1)	**Accept** converse **Accept** converse **Accept** pack more tightly together / has straight chains/rods which pack tightly together higher density of intermolecular contacts/bonds	4

Question Number	Answer	Additional Guidance	Mark
5 (c) (i)	An explanation that makes reference to two from the following: • a genetic bottleneck has occurred (1) • resulting in a smaller gene pool (1) • so the probability of receiving two recessive alleles is higher (1)	**Accept** lower genetic diversity **Accept** inbreeding / higher chance of two organisms have similar alleles	2

Question Number	Answer	Additional Guidance	Mark
5 (c)(ii)	An explanation that makes reference to three from the following: • therefore animals from different populations can move across territories / forest to forest (1) • therefore increasing genetic diversity / widens gene pool / increased allele number (1) • and balances the needs of local people with conservation / retains jobs for local people (1) • local people are more likely to maintain the bridges (1)	**Accept** animals from different forests can move in / more outbreeding	3

Question Number	Answer	Additional Guidance	Mark
5(c)(iii)	An answer that makes reference to one from the following: • {banning export / import trade of species} preventing {poaching / illegal trapping} (1)	**Accept** {countries} sign treaty / agree preventing {poaching / trapping / exports / imports / trade}	**1**

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	An explanation that makes reference to the following: • phosphate heads are {polar / charged / hydrophilic}, so interact with / face the aqueous environment (inside and outside of cell) (1) • fatty acid tails form a {non-polar / hydrophobic } barrier / layer (on inside) (1) • (so control the) movement of { polar/charged / non-lipid soluble / water soluble } molecules into and out of the cell (1)	**Accept** waterproof layer **Accept** (only) allow lipid soluble molecules through	(3)

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	• number of phospholipids in 1 μm^2 calculated (1) • number of phospholipids in bilayer given (1) • answer in standard form (1)	Example of calculation: 1 000 000 ÷ 0.3 = 3 333 333.3333 **1** mark for 1 000 000 ÷ 0.3 / 3 333 333.3333 **Accept** x 2 as ecf from mp 1 3 333 333.3333 × 2 = 6 666 666.7 / 6 666 666.67 **2** marks for 6 666 667 /6 666 666.67 **Accept** answers in standard form as ecf for mp1 or 2 **2** marks for 3.3 x10^6 6.7 × 10^6 with no working out gains 3 marks	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	A description that makes reference to the following: • number of carbons/hydrogens in the fatty acid tail (1) • the number of carbon carbon double bonds (1)	**Accept** length of fatty acid tail /different R group chain **Accept** some are saturated / monounsaturated / polyunsaturated **Accept** different alcohol groups attached to phosphate **Accept** some have only one fatty acid tail and some have more	(2)

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An answer that makes reference to three of the following: **Similarities (max 2)** • all contain all four types of phospholipid (1) • A is the commonest in all four types of membrane (1) • B has the second highest percentage in all four types (1) **Differences (max 2)** • each membrane has a different { ratio/ percentage } of the four types of phospholipid (1) • C has the lowest percentage in the cell membrane and D has the lowest percentage in the other types of membrane (1) • the relative proportions of B, C and D are different in the cell membrane compared with the other three types of membrane (1)	**Accept** D is lowest in all except the cell membrane **Accept** description of the order of the types	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference to the following: • when vesicles containing { proteins / (poly)peptides / lipids / steroids } from the endoplasmic reticulum fuse with the Golgi apparatus (1) • some of the membrane of the Golgi apparatus comes from the endoplasmic reticulum (1)	**Accept** vesicles from ER move to the Golgi apparatus where proteins are modified	(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	A description that makes reference to two of the following: • unsaturated fatty acid has (at least one) carbon carbon double bonds whereas a saturated fatty acid has {no carbon carbon double bonds / has single carbon carbon bonds (only)} (1) • unsaturated fatty acids have fewer hydrogens than saturated fatty acids (for the same number of carbons) (1) • unsaturated fatty acid structure has kinks and saturated does not (1)	**ACCEPT** C C double bonds / C=C bonds **DO NOT ACCEPT** saturated fatty acid has no double bonds **ACCEPT** converse expressed as a ratio	(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	An explanation that makes reference to three of the following: • lipids are used for (energy) storage because they are {insoluble / hydrophobic / non-polar / do not mix with water} (1) • lipids are used for energy storage as they have a high content of hydrogen (1) • lipids are used for insulation as they do not conduct heat (1) • because they are large molecules that are loosely packed (1)	**ACCEPT** poor conductors (of heat)	(3)

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	A description that makes reference to three of the following: • stain the fat cells (1) • use an (eye piece) graticule to measure the {diameter / length} (1) • use a (stage) micrometer to {determine the actual diameter of the cell / calibrate the graticule} (1) • take several measurements and calculate a mean (1) • calculate the area using the formula $A = \pi r^2$ (1)	**ACCEPT** size **DO NOT ACCEPT** area **ACCEPT** $\pi (d \div 2)^2$	(3)

Question Number	Indicative content	
***7(b)(ii)**	**Indicative content:** **Graph 1** • juvenile whales have more fat cells at all depths from skin than adult whales (D) • because they have been fed high quality milk from their mothers (E) • they need a thick layer as they have a larger surface area : volume ratio (E) • and therefore will lose more heat (E) • adult whales have fewer fat cells than young whales (D) • because their diet is not so energy-rich (E) • because the females are feeding their young (E) • fasting whales have the least number of fat cells at all depths (D) • because their fat reserves have been used up over the winter (E) • fat cells present in all layers of skin (D) • to provide a thick insulator layer (E) • because the whales live in cold waters (E) **Graph 2** • juvenile whales have the highest area of fat cells at all depths from skin than adult whales (D) • because they have been fed high quality milk from their mothers (E) • adult whales have smaller area of fat cells than young whales (D) • because their diet is not so energy-rich (E) • because the females are feeding their young (E) • fasting whales have the lowest area of fat cells at all depths (D) • because their fat reserves have been used up over the winter (E) • highest area of fat cells is in intermediate layer for all whales (D) **Graph 3** • juvenile whales have lowest area of fibrous tissue at all depths from skin	**Level 1 : descriptions** 1 mark : results from one graph described 2 marks : results from two graphs described **Level 2 : some explanation** 3 marks : one explanation given 4 marks : two explanations given **Level 3 : detailed explanation** 5 marks : three explanations of data from at least two of the graphs 6 marks : at least one explanation of data from each graph

	than adult whales (D) • fasting whales have the highest fibrous tissue (D) • because fibrous tissue being formed to replace area filled by fat cells (E)	

	Answer	Additional Guidance	Mark

Number	Answer	Additional Guidance	Mark
3a	An explanation that makes reference to three of the following: • this protein is folded so that hydrophilic groups are on the outside (and hydrophobic on the inside) (1) • these exposed R groups are { polar / ionic } (1) • therefore they form hydrogen bonds with water (1) • because water is a polar solvent (1)	accept description of dipolar nature of water / ability to form hydrogen bonds with {charged / polar} molecules	(3)

Question Number	Answer	Additional Guidance	Mark
3b	An explanation that makes reference to the following: • hirudin changes the structure of the enzyme (1) • this results in a change in the active site of the enzyme (1) • which prevents the substrate from binding (1)	accept binds to the active site accept prevents enzyme substrate forming	(3)

Question	Answer	Additional Guidance	Mark

Mark
1

Mark
1

	Additional Guidance	Mark
	ACCEPT converse throughout **ACCEPT** enzyme for tyrosinase for all mark points **ACCEPT** optimum temperature is cool / low	
/		
to		**3**

	Additional Guidance	Mar
		1

Answer	Mar
liscrete reading frames *ses* *n all organisms*	**1**

Answer	Mar
nly *d in the secondary structure* *olved in the secondary structure* *d in the secondary structure*	**1**

Question Number	Answer	Mark
1(a)(i)	The only correct answer is B (X) *A is incorrect as W is not found in a disaccharide* *C is incorrect as Y is not found in disaccharide* *D is incorrect as Z is not found in disaccharide*	**1**

Question Number	Answer	Mark
1(a)(ii)	The only correct answer is B (V and Z) *A is incorrect as X is not found in proteins* *C is incorrect as W is not found in proteins* *D is incorrect as W s not found in proteins*	**1**

Question Number	Answer	Mark
1(a)(iii)	The only correct answer is A (V) *B is incorrect as W is not found in cellulose* *C is incorrect X does not hold molecules together in cellulose* *D is incorrect as Y is not found in cellulose*	**1**

Question Number	Answer	Additional guidance	Mark
1(b)	An explanation that makes reference to three of the following: • in raw egg white ovalbumin {polar /charged} groups are on the outside (1) • because {they associate / bond with water molecules / are hydrophilic} (1) • heating denatures (the ovalbumin) (1) • because {hydrogen bonds / ionic bonds} break (1) • new bonds form between {nonpolar / hydrophobic} groups of ovalbumin molecules (to form a solid) (1)	**Allow** {nonpolar / uncharged} groups on inside **Allow** uncharged {do not associate with water / are hydrophobic} **Allow** tertiary structure changes	**3**

itional Guidance	Mark
ctioning) enzymes available / n of (functioning) enzyme er active (if qualified)	(3)

Additional Guidance	Mark
suitable named bonds involved	(2)

Additional Guidance	Mark
horizontal line showing no reaction	(1)

	Additional
ving:	ACCEPT from 10 to 5 au
(1)	ACCEPT cell elongates / s poles apart / cell membr equator of the cell
(1)	

Answer
vn at the other end of the polypept
e on a side chain or part of the ca
functional group at the nitrogen si

Number	Answer	Additional Guidance	Mark
7(a)(i)	An explanation that makes reference to the following: • glycine is very small so the collagen fibres are very close together **(1)** • so this allows the formation of bonds that hold the polypeptide chains together **(1)**	**ACCEPT** amino acids have small R groups which enables the proteins to be close together	**(2)**

Question Number	Answer	Mark
7(a)(ii)	**7(a)(ii). The only correct answer is C** ***A*** *is not correct because ester bonds are involved in bonding carboxyl and OH groups* ***B*** *is not correct because glycosidic bonds are found in carbohydrates* ***D*** *is not correct because peptide bonds join the amino acids in the individual polypeptide chains, not between the chains as there are no free carboxyl and amino groups along the length of the chain*	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b) (i)	A response that makes reference to the following: • the collagen with hydroxyproline has more helix present than collagen without hydroxyproline (at higher temperatures) **(1)** • therefore hydroxyproline must be responsible for holding the helix together **(1)**	**ACCEPT** collagen without hydroxyproline loses helical structure at lower temperature **ACCEPT** hydroxyproline maintains strength of collagen	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(b) (ii)	A response that makes reference to the following: • the T_s values for collagen with hydroxyproline is 49°C / collagen without hydroxyproline is 15°C **(1)** • therefore presence of hydroxyproline increases the thermal stability of collagen **(1)** • calves will have the most stable collagen **(1)** • which is necessary as calves have the highest body temperature **(1)**	**ACCEPT** prevents helical structure breaking down **ACCEPT** converse **ACCEPT** converse / correlation between the two variables e.g. calf has the highest % of hydroxyproline and highest body temperature	**(4)**

Total for Question 7 = 9 MARKS

Number	Answer	Additional Guidance	Mark
5ai	An explanation that makes reference to two of the following: • a light microscope has limited (useful) magnification (1) • because a light microscope has limited resolution (1) • because the wavelength of visible light is more than a beam of electrons (1)	accept converse for electron microscope	**(2)**

Question Number	Answer	Additional Guidance	Mark
5aii	An explanation that makes reference to the following: • provides greater contrast (1) • because the stain {attaches to / is taken up by} specific {parts / types of}cell (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5bi	A description that makes reference to two of the following: • folding of the {primary structure / polypeptide chain } (1) • into α-helix or β pleated sheet (1) • due to formation of hydrogen bonds (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5bii	An explanation that makes reference to the following: • protease enzymes have an active site specific to certain amino acid sequences (1) • so the misfolded protein will not fit in the active site (of the protease enzyme) (1) • therefore enzyme is unable to hydrolyse peptide bond (1)		**(3)**

Number	Answer	Additional Guidance	Mark
8(a)	• percentage of each polypeptide in each type of haemoglobin **(1)** • total percentage of α chains given **(1)** • ratio calculated **(1)**	Example of calculation HbA_1: α = 48 β = 48 HbA_2: α = 1.5 δ = 1.5 HbF : α = 0.5 γ= 0.5 α = 48 + 1.5 + 0.5 = 50 α : β : δ : γ = 100 : 96 : 3 : 1 Correct answer with no working gains full marks Award 2 marks for 200 :192: 6: 2 OR 50: 48: 1.5 : 0.5	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(b)	A response that makes reference to the following: **Similarities** • there will be {27 bases / 9 triplet codons } in the sequence **(1)** • all three will have the code for { phe / amino acid 1 / amino acids 4-9 / leu, ser, glu, leu, his, cys } **(1)** • β and γ will both code for the same amino acid 2 / δ and γ will both code for the same amino acid 3 **(1)** **Differences** • the sequence of bases in the code for the same amino acid might be different **(1)** • {β and δ will have different sequences for amino acids 2 and 3 / β and γ different for amino acid 3 / δ and γ different for amino acid 2 } **(1)**	**ACCEPT** they have the same number of (DNA) bases **ACCEPT** triplet sequence is the same for … / same codon **ACCEPT** if clear context of bases coding for … in the whole response **ACCEPT** if clear context of bases coding for … in the whole response	**(4)**

Question Number	Answer	Additional Guidance	Mark
8(c)(i)	change in the base sequence or quantity of DNA **(1)**		**(1)**

Question Number	Answer	Additional Guidance	Mark
8(c)(ii)	An explanation that makes reference to the following: • the oxygen-carrying capacity of the haemoglobins are very similar **(1)** • therefore {gas exchange / breathing} will not be affected **(1)**	**ACCEPT** have similar saturation of O_2 **ACCEPT** HbF has better O_2 carrying ability **ACCEPT** have no symptoms, no effect **ACCEPT** oxygen will not limit activity	**(2)**

Total for Question 8 = 10 MARKS

Question Number	Answer	Additional Guidance	Mark
6ai	**C** rough endoplasmic reticulum		**(1)**

Question Number	Answer	Additional Guidance	Mark
6aii	**B** X		**(1)**

Question Number	Answer	Additional Guidance	Mark
6aiii	To check on typeset version of the paper working shown (1) (1)	correct answer	**(2)**

Question Number	Answer	Additional Guidance	Mark
6aiv	An explanation that makes reference to the following: • organelle Z produces ATP (1) • which supplies the energy for the synthesis of proteins (1) • which supplies energy for {modification / transport / secretion} of proteins (1)	 accept enzymes / hormones accept active transport / exocytosis	**(3)**

Question Number	Answer	Additional Guidance	Mark
6b	A diagram that includes the following: • amino group and carboxyl group shown (1) • a carbon attached to H and R on each side of (1) • a peptide bond shown (1)	 accept reasonable example of an R group	**(3)**

Question Number	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
4(a)	A description that makes reference to two of the following: • has a {tertiary structure / three dimensional structure (and quaternary structure)} (1) • held by named bond (1) • hydrophilic on the outside of the molecule (1)	**ACCEPT** hydrophobic R groups in the centre of the structure	**(2)**

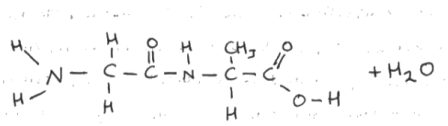
Question Number	Answer	Mark
4(b)(i)	**The only correct answer is B** ***A*** *is not correct because no bonds are being broken* ***C*** *is not correct because no phosphate group is being added* ***D*** *is not correct because if FAD is reduced to* $FADH_2$ *the succinate is being oxidised*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An explanation that makes reference to four of the following: • completely oxidises {pyruvate / acetyl Co A} (1) • to release as much energy as possible (1) • to generate ATP (directly) (1) • to produce {reduced coenzyme / NADH} (1) • so that ATP can be produced {in the ETC / by oxidative phosphorylation} (1)	**ACCEPT** glucose **DO NOT ACCEPT** makes **ACCEPT** $FADH_2$ / FADH / reduced {NAD / NADH} / reduced {FAD / FADH / $FADH_2$}	**(4)**

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	concentration of protein read from graph	0.58 / 0.57 (mg cm^{-3})	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	• initial rate of reaction calculated (1) • ratio calculated (1)	0.00267 / 0.0027 (mg sec^{-1}) / 0.16 (mg min^{-1}) 0.58 : 0.0027 = 214.81 : 1 or 3.63 : 1 21481 : 100 or 363 : 100 0.57 : 0.0027 = 211.11 : 1 or 3.56 : 1 21111 : 100 or 356 :100 **CE applies from both 4(c)(i) and the value for initial rate of reaction**	(2)

3(a)(i)	*B is incorrect because it is the carboxylic acid group* *C is incorrect because it is not the R group* *Dis incorrect because it is the amino group*		**1**

Question Number	Answer	Additional Guidance	Mark
3 (a)(ii)	*An answer that makes reference to:* • correct peptide bond between the amino acids (1) • a water molecule (1)		**2**

Question Number	Answer	Additional Guidance	Mark
3(a)(iii)	*An answer that makes reference to three from:* • three polypeptide chains (1) • that are (left hand) helices joined together (1) • (helices are held together) by hydrogen bonds (1) • many tropocollagen molecules / triple helices joined together (1)	**Allow** repeating sequences of amino acids / every third amino acid is glycine / lots of proline **Allow** triple helix	**3**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• 1.3 N (1)		**1**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to three of the following: • arteries stretch more / (have weaker collagen which means that) less force produces a longer extension (1) • because the elastic constant is lower (1) • and (blood in arteries) has high pressure (1) • and less force is required to break the artery (1)	**Allow** less elasticity in arteries **Allow** arterial blood has high hydrostatic pressure	**3**

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
7(a)	An explanation that makes reference to the following: • (primary structure is) sequence of amino acids that determines the tertiary structure (1) • because the {amino acids / R groups} determine the {type / position} of the bonds (1) • credit named bond (that forms between the R groups) (1) • polar {amino acids / R groups} need to be on the outside of the hormone so that it can dissolve in the (blood) plasma (1) • (part of) the (final structure of) molecule has to be of a specific shape to {be complementary / bind} to the receptor molecules (on the target cells) (1)	**ACCEPT** shape / folding / 3D structure e.g. hydrogen, ionic, disulfide, van der waals **ACCEPT** hydrophillic **ACCEPT** active site in either context of hormone or receptor, unless clearly talking about enzymes	(4)

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	An answer that makes reference to the following: Similarities: • all three types have the same amino acids in positions 1, 2, 4, 5, 6, 7 and 9 (1) Differences: • type A has ile in position 3 whereas types B and C have phe (1) • type C has lys in position 8 whereas types A and B have arg (1)	**ACCEPT** they all have cys, tyr, gln, asn, (cys), pro, gly they all have one amino acid different **ACCEPT** instead of phe **ACCEPT** instead of arg	(3)

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	An explanation that makes reference to the following: • there are more (triplet) codes than there are amino acids (1) • so the code is degenerate (1) • therefore the same amino acids may have a different code (1) • this helps to maintain the same {structure / function} of the {nonapeptide / protein} (1)	**ACCEPT** this helps to prevent a mutation from changing the {structure / function}	(3)

Question Number	Answer	Additional Guidance	Mark
6(a)	**The only correct answer is A** **B** is incorrect because Ebola has a helical capsid and an envelope whereas HIV has a polyhedral capsid **C** is incorrect because Ebola has a helical capsid and an envelope whereas λ (lambda) phage does not have an envelope and has a complex capsid **D** is incorrect because Ebola has a helical capsid and an envelope whereas TMV does not have an envelope		(1)

Question Number	Answer	Additional Guidance	Mark
6(b)	A description that makes reference to two of the following: • globular / 3D / tertiary protein (1) • held together by {hydrogen bonds / disulfide bridges / ionic bonds/hydrophobic (interactions)} (1) • between R groups (1) • has an active site (1)	**Accept** hydrophobic R groups on inside /hydrophilic R groups on outside = mp 2 & 3	(3) EXP

Question Number	Indicative content	
***6(c)**	Indicative content: Lytic Cycle **(L)** • virus attaches/binds to (host) cells • (viral) genetic material / provirus, inserted (into host cell) • viral proteins/capsid made • **genetic material /(viral) RNA**, replicates • new viral particles assembled • cell ruptures/viral particles, released Haemagglutinin **(H)** • binds to sialic acid groups on the {glycoproteins / cell membrane / host cell / mucus} • so that it can infect host cell • needed by new virus particles to attach to more (host) cells Neuraminidase **(N)** • needed to separate virus particles from the {(non-host) cells / membrane} that they attach to • breaks down mucus • cleave the haemagglutinin from the sialic acid group on cell • needed to separate the new virus particles from each other • needed to separate the new virus particles from the host cell membrane (that they have budded out of) • needed to release the new virus particles from mucus • so that they are free to attach to new host cells • so that the infection is spread	**Level 1:** 1 mark = 1 point from L, H or N 2 marks = 2 points from L, H or N **Level 2 :** 3 marks = 3 points from at least two of L, H or N 4 marks = 4 points from at least two of L, H or N **Level 3 :** 5 marks = 5 points from L, H and N 6 marks = 6 points from L, H and N

Question Number	Answer	Mark
4 (a)(i)	The only correct answer is B (hydrogen) *A is incorrect as disulfide bonds do not form secondary structure* *C is incorrect as ionic bonds do not form secondary structure* *D is incorrect as peptide bonds do not form secondary structure*	**1**

Question Number	Answer	Mark
4 (a)(ii)	The only correct answer is C (substitution) *A is incorrect as no bases are deleted* *B is incorrect as no bases are added* *D is incorrect as no chromosome sections are moved*	**1**

Question Number	Answer	Additional guidance	Mark
4(a)(iii)	An explanation that makes reference to two of the following: • {valine / new amino acid} is {non-polar / not charged} (1) • so valine is hydrophobic (1) • so the **haemoglobin** (molecules) are {less soluble in water} / so the **haemoglobin** (molecules) {form fewer hydrogen bonds with water / **haemoglobin** (molecules) associates with {fewer water molecules} (1)	**Allow** glutamate is hydrophilic **Allow** is less able to dissolve in water **Allow** haemoglobin molecules are less able to associate with water	**2**

Question Number	Answer	Additional guidance	Mark
4(b)(i)	An answer that makes reference to two of the following: Similarities (**max 1**) 1. both have {S-shaped / sigmoidal} curve (1) 2. both have cooperative binding (1) Differences (**max 1**) 3. affected haemoglobin has a lower affinity for oxygen (1) 4. affected haemoglobin has {lower saturation of oxygen / never reaches 100 % saturation} (1) 5. there is a wider {variation / range / spread / variability} in affinity (for haemoglobin) from people with sickle cell anaemia (1)	**One similarity and one difference.** **Allow** converse for unaffected	**2**

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	• there is a {wide / large} {variation / range} (1)		**1**

Question Number	Answer	Additional guidance	Mark
4(b)(iii)	An explanation that makes reference to three of the following: • (haemoglobin has a) low(er) **affinity** for oxygen (1) • haemoglobin never becomes fully saturated / less oxygen will {bind to / load on} haemoglobin (1) • so that less oxygen is available for **respiration** (in muscles) / less **aerobic respiration** / more **anaerobic respiration** (1) • so that less **ATP** is produced for **muscle contraction** / more **lactic acid** formation (in muscles) (1)	**Allow** sickle cell haemoglobin needs higher partial pressure of oxygen to saturate **Allow** sickle cell haemoglobin is less saturated with oxygen / carries less oxygen	**3**

(Total for Question 4 = 10 marks)

4(a)(i)	• COOH and NH_2 group shown (1) • cysteine R group and H shown (1) • attached to central C (1)	**ACCEPT** charged groupings	**(3)** **EXP**

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	• disulfide (bond / bridge)	**ACCEPT** disulphide	**(1)** **GRAD**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	AAC / AAT/ GAC/ GAT | TGT | TAC / TAT | AAC / AAT/ GAC/ GAT | GAA / GAG		**(1)** **GRAD**

Question Number	Indicative content
***4(b)(ii)**	**Indicative content:** • substitution mutation may result in no change of amino acid • TGT to TCC • so no effect on structure • substitution may change amino acid • e.g. TGT to TGG • inserting a try instead of Cys • no disulphide bond joining chain A and B together at that point • insertion / deletion will result in {frame shift mutation / change in amino acid sequence} • Cys no longer present in that position • no disulphide bond joining chain A and B together at that point • Cys may be inserted further down the chain so disulfide bond forming elsewhere • chain A will be shorter • change in bonding will affect {tertiary / quaternary} structure of insulin Level 1 : different types of mutation described but no link to insulin amino acids Level 2 : different types of mutation described with a link to insulin amino acids Level 3 : effects of mutations linked to possible changes in structure of insulin

	Additional Guidance	Mark
rence to two of the or no tertiary (1) ole whereas tubulin ater) (1) of long polypeptide) whereas tubulin is e (1)	ACCEPT fibrous proteins have hydrophobic groups on the outside / converse ACCEPT fibrous proteins are {longer / tougher}	**(2)**

	Additional Guidance	Mark
(1) (1)	<u>Example of calculation</u> • 40 μm = 40000 nm / 25 nm = 0.025 μm ACCEPT correct standard form • 40000/ 25 = 1600 correct answer gains both marks	**(2)**

Additional Guidance	Mark
ACCEPT greater concentration of tubulin produces onger microtubules	**(4)**

Mark	nal Guidance
(4)	equilibration onding between {tubulin d centrioles}

Mark	e
(2)	forming and ached at

Question Number	Answer	Additional Guidance	Mark
9(a)	An explanation that makes reference to five of the following: • DNA synthesis is needed for {mitosis / cell division} (1) • Dox prevents {DNA synthesis / DNA strands separating / promotors binding} (1) • because the strands are not available (for nucleotides to align) (1) • Dox prevents {transcription / transcription factors from binding} (1) • so no proteins synthesised (1) • repair enzyme will not be able to remove the drug (1)	**ACCEPT** without DNA synthesis the cell will remain in interphase **ACCEPT** mRNA cannot be made **ACCEPT** {cell cycle stops / cells destroyed} if damaged DNA is not repaired	

Question Number	Indicative content
***9(b)(i)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>Indicative content</u> • Dox decreases the concentration of (all) amino acids shown • largest actual decrease is glu and asp (3.6 μmol cm^{-3}) • smallest actual decrease is ser (0.9 μmol cm^{-3})) • relative decrease is least for pro (16.67%) • relative decrease is greatest for asp (85.71%) • data not available for all amino acids • polar and non-polar amino acids are affected • polar amino acids affected most (total 14.4 μmol cm^{-3} compared to total 11.7 μmol cm^{-3} / mean 2.4 μmol cm^{-3} compared to mean 1.95 μmol cm^{-3}) • effect on non-polar amino acids is within a {narrower range for actual decrease / wider range for percentage decrease}

	Level 1 : comments on overall effect of Dox 1 mark = level 1 comment only 2 marks = level 1 comment backed up with figures / level 2 comment but no figures given **Level 2 : comments on effect of Dox on polar and non-polar amino acids** 3 marks = level 2 comment only / level 1 comment with a level 2 calculation (= actual decrease in concentration) 4 marks = level 2 comment backed up with a level 2 calculation **Level 3 : comments about amino acids within the group of polar / non-polar amino acids** 5 marks = level 3 comment / level 2 comment with a level 3 calculation (= percentage decrease in calculation) 6 marks = comment backed up with a level 3 calculation	
Level 0	Marks	No awardable content
Level 1	1-2	An **answer** may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The **answer** will contain basic information with some attempt to describe the data shown in the graph
Level 2	3-4	An **answer** will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The **answer** shows some linkages and lines of scientific reasoning with some structure between the graph and the different types of amino acids
Level 3	5-6	An **answer** is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The **answer** shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that makes reference to the following: • a decrease in some amino acids may mean that {certain proteins cannot be formed / less protein made} (1) • if these proteins are involved in heart muscle structure then it will be weaker (1) • these proteins may affect heart muscle function (1)	**ACCEPT** named example e.g. actin, myosin, collagen **ACCEPT** named example e.g. collagen, haemoglobin, myoglobin, cytochromes	

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference to the following: • heart will not be able to pump as well (1) • so less {oxygenated blood / oxygen} will be delivered to the {cells / tissues / organs / named example} (1) • example of a consequence of this (1)	**ACCEPT** less carbon dioxide removed / lowers blood pH **e.g.** less aerobic respiration, build-up of lactic acid / fatigue / breathlessness	

Question Number	Answer	Mark
1(a)(i)	**The only correct answer is A** ***B*** *is not correct because enzymes decrease reaction time* ***C*** *is not correct because enzymes decrease activation energy* ***D*** *is not correct because enzymes decrease activation energy and decrease reaction time*	**(1)**

Question Number	Answer	Mark
1(a)(ii)	**The only correct answer is D** ***A*** *is not correct because fibrin is not an enzyme* ***B*** *is not correct because fibrinogen is not an enzyme* ***C*** *is not correct because fibrinogen is not an enzyme*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)	A description that makes reference to two of the following: • {increasing mass / more} (snake venom) decreases clotting time (1) • {small mass / 0.002 µg} of snake venom has a shorter clotting time (than Xa) (1) • {larger masses / 0.004 µg and over / 0.02 and 0.04} has little effect on clotting time (1)	**ACCEPT** clotting time is faster converse **ACCEPT** takes less time / faster rate **ACCEPT** 0.004 µg has slight increase and 0.02 µg and 0.04 µg has slight decrease	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(c)	form a {plug / mesh / scab / barrier / thrombus} to seal the {blood vessel / wound} / release {clotting factors / thromboplastin}	**ACCEPT** to stop bleeding / to prevent {infection / microorganisms entering} **DO NOT ACCEPT** prothrombin / thrombin / fibrinogen / fibrin	**(1)**

Number	Answer	Additional Guidance	Mark
2ai	D		(1)

Question Number	Answer	Additional Guidance	Mark
2aii	D Z-Y		(1)

Question Number	Answer	Additional Guidance	Mark
2bi	An explanation that makes reference to the following: • Gram positive bacteria have a thick layer of peptidoglycan in their cell wall (1) • some antibiotics inhibit (enzymes involved in) the formation of peptidoglycan so are effective against Gram positive bacteria (1) • some antibiotics are not able to cross the peptidoglycan layer so they are {more / only} effective against Gram negative bacteria (1)	accept converse, accept reference to teichoic acid	(3)

Question Number	Answer	Additional Guidance	Mark
2bii	An explanation that makes reference to the following: • because viruses are not living cells (1) • because viruses do not have a cell wall (1)	accept antibiotics usually target {cell walls / cell membranes / replication / translation / metabolism }	(2)

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
2(a)	An explanation that makes reference to the following: • not Bacteria as Archaea do not have a peptidoglycan cell wall (1) • not Eukaryota as these organisms {have 70S ribosomes / do not have a nucleus} (1)	**IGNORE** refs to gram negative and gram positive bacteria prokaryotes **DO NOT ACCEPT** if wrong reason given as well **ACCEPT** do not have 80S ribosome **IGNORE** refs to other membrane-bound organelles **DO NOT ACCEPT** if wrong reason given as well	(2)

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	An answer that makes reference to three of the following: • (two enzymes) because enzymes found in different locations (1) • pH is different / their substrates are found in different locations (1) • (two enzymes) because their substrates are different (1) • therefore their <u>active site</u> will be different {shape / structure} (1) • {similar structure / both are AK enzymes / both are kinases} because both {are transferring phosphate / have similar roles (1)	**IGNORE** incorrect explanations of what the enzymes are doing with ATP and GTP **ACCEPT** enzymes cannot move between mitochondria and cytoplasm **ACCEPT** ATP in cytoplasm and GTP in mitochondria **ACCEPT** because one uses ATP and the other uses GTP	(3)

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to two of the following: • Archaea {do not have mitochondria / only have cytoplasm} so do not need two enzymes (1) • {pH / temperature} of Archaea different to human's (1) • Archaea's enzymes need to be able to {bind / fit} to {two substrates / both ATP and GTP} (1) • {genetic code / (DNA) base sequence} is different **OR** different primary structure (1)	**ACCEPT** need to form ESCs with different substrates **NB** ref to induced-fit may access this point provided in the context of substrate	(2)

2 (a)	A description that makes reference to three of the following: • (folded into) {spherical / rounded / 3D} shape (1) • {polar / hydrophilic} {R groups / amino acids} on outside (1) • {non polar / hydrophobic} {R groups / amino acids} on inside (1) • ionic / hydrogen / disulfide bonds (1)	Accept disulfide bridges	**(3)**

Question Number	Answer	Additional Guidance	Mark
2 (b)	An answer that makes reference to five of the following: • (put albumin tubes into a) range of at least five pepsin concentrations (1) • control {temperature using water bath / pH using buffer} (1) • use same {concentration / source / mass / length / volume} of albumin (1) • leave for {same / stated} time or measure at regular time intervals (1) • measure {length of albumin remaining / mass of albumin} (at end of investigation) (1) • {use several capillary tubes / repeat} and {calculate mean / calculate SD / identify anomalies} (1) • control tube with no enzyme (for comparison) (1)	Time how long it takes for albumin to disappear = 2 marks Accept measure absorbance using a colorimeter	**(5)**

Question Number	Answer	Mark
2(a)	The only correct answer is A *B is incorrect as the graph shows an endothermic reaction* *C is incorrect as the enzyme has increased activation energy* *D is incorrect as the graph shows a endothermic reaction*	**1**

Question Number	Answer	Additional guidance	Mark
2 (b)	• 3^2 x pi x 1 and 1^2 x pi x 1 • 28.26 – 3.14 = 25.12 25.12 x 1000 = 25120 = 25000	• 25 000 **or** 2.5 x 10^4 = **3 marks** • 25 120 = **2 marks** (**Allow** range up to 25133) • 28260 (**Allow** up to 28274.33…) **OR** 3140 (**Allow** up to 3141.59…) **OR** 28000 **OR** 3100 **OR** 28.26 (**Allow** up to 28.274…) **and** 3.14 (**Allow** up to 3.1415…), **OR** 25.12 (**Allow** up to 25.1327…= (**1 mark)** **correct answer gains all three marks**	**3**

Question Number	Answer	Additional guidance	Mark
2 (c)(i)	An explanation that makes reference to two of the following: • rate increases then levels off (1) • increases as {higher chance of enzyme – substrate collisions / enzyme is in excess / there are unoccupied active sites / substrate concentration is the limiting factor} (1) • rate levels off when {active sites are occupied / all (enzymes) have formed E-S complexes / enzyme concentration is limiting} (1)	**Allow** more enzyme-substrates complexes can form (when rate increases) **Allow** all enzymes occupied / full **Allow** bromelain for enzyme	**2**

Question Number	Answer	Additional guidance	Mark
2 (c)(ii)	An explanation that makes reference to two of the following: • copper (sulfate) is an (non competitive) inhibitor (1) • binds to the enzyme and changes {shape / structure} of active site (1) • so that substrate does not bind / E/S complexes can not form (so rate falls) (1)	**Do not accept** if competitive inhibitor **Allow** changes enzyme shape / binds to allosteric site / changes tertiary structure	**2**

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	*Rhithrogena*	DO NOT ACCEPT *Rhithrogena germanica*	**(1)**

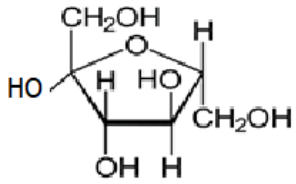
Question Number	Answer	Mark
3(a)(ii)	**The only correct answer is B** ***A*** *is not correct because Animalia is the kingdom* ***C*** *is not correct because Heptageniidae is the family* ***D*** *is not correct because Insecta is the class*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to four of the following: • as temperature increases up to 10°C hatching increases and then decreases (1) • enzyme activity affects {hatching / development / growth} (1) • (below 10°C) increase in temperature increases {kinetic energy / enzyme-substrate complexes / successful collisions between enzyme} (1) • (above10°C) temperature too high denatures enzymes (1) • higher temperature results in less dissolved oxygen available (1)	Piece together **ACCEPT** converse **DO NOT ACCEPT** starts to denature **ACCEPT** shape of active site changed	**(4)**

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to three of the following: **Similarities:** • large surface area (1) • thin exchange surface / small diffusion distances (1) **Differences:** • nymphs have gills and adults have trachea / spiracles (1) • the nymph has external system and the adult has internal system (1)	**DO NOT PIECE TOGETHER** **ACCEPT** both have tracheoles if not awarded as a difference **ACCEPT** tracheoles if not awarded as a similarity **ACCEPT** gills on the outside and {spiracles / trachea / tracheoles} are on the inside	**(3)**

Number	Answer	Mark
2(a)(i)	**The only correct answer is B** ***A*** *is not correct because condensation joins monomers* ***C*** *is not correct because phosphorylation adds phosphate* ***D*** *is not correct because translocation does not break down sucrose*	**(1)**

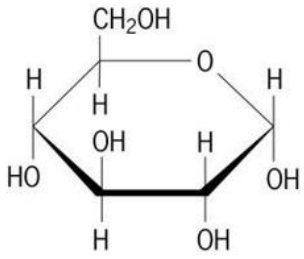
Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	• glucose and fructose	Reject beta glucose	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)(iii)		**ACCEPT** HO or OH **ACCEPT** correct variations of fructose **ACCEPT** C's in ring **ACCEPT** line with nothing as H	**(1)**

Question Number	Answer	Mark
2(b)	**The only correct answer is B** ***A*** *is not correct because amylose has a helical and contains 1,4 glycosidic bonds* ***C*** *is not correct because amylose is not branched and does not contain 1,6 glycosidic bonds* ***D*** *is not correct because* amylose is not branched and does not contain 1,6 glycosidic bonds	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(c)(i)	An answer that makes reference to the following: One from: • (increase in) rates are same up to 30 to 32 (mg dm^{-3}) / at 13 (µg s^{-1}) (1) • both reduce rate up to 30 to 32 (mg dm^{-3}) / at 13 (µg s^{-1}) (1) Then: • B stops increasing but A continues to increase (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
2(c)(ii)	An explanation that makes reference to the following • inhibitor B because reaction does not reach rate without inhibitor (1) • because it binds to {enzyme / allosteric site} (1) • changes {active site} (1)	**ACCEPT** levels off / plateaus / stays the same / does not maximum rate **DO NOT ACCEPT** binds to active site	**(3)**

Number	Answer	Additional Guidance	Mark
3(a)	• correct structure of alpha glucose		(1)

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	An answer that makes reference to two of the following: • less needed for same sweet effect (1) • therefore less {energy / calorie} intake (1) • therefore less risk of appropriate named health benefit (1)	**e.g.** reduced obesity / (type 2) diabetes / tooth decay / heart disease / atherosclerosis / high blood pressure / CVD / CHD	(2)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	• 0.066 to 0.074	**DO NOT ACCEPT** 0.06°	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)(iii)	An answer that makes reference to the following: • with and without magnesium ions (1) • use same {volume / stated cm^3 / concentration} of isomerase enzyme (1) • use excess {glucose / substrate} (1) • control {temperature / pH} (1) • repeat to {calculate mean / calculate average / standard deviation / standard error / recognise anomalies} (1)	**ACCEPT** same mass **DO NOT ACCEPT** if in list	(5)

Answer	Mark
to three of the following: structure} (1) ulfide} bonds are broken (1) 1) s / attaches} to {substrate / hydrogen peroxide} / es (1)	(3)

Answer	Mark
:o the following: 1) is in excess / not limiting / decreases / becomes limiting (1)	(2)

	Mark
	(4)

Number	Answer	Additional Guidance	Mark
6(a)(i)	An explanation that makes reference to the following: • citrate binds to another site on the enzyme, activating the enzyme (1) • so that the structure of the enzyme is changed (1) • so that active site binds more effectively to the substrate (1) • an increase in fatty acyl CoA molecules inhibits the substrate binding to the active site (1) • due to competitive inhibition (1)	Accept citrate and fatty acyl CoA molecules act together to regulate the activity of the enzyme	**(5)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	An explanation that makes reference to two of the following: • fewer fatty acids will be made (1) • so that less fat is stored (1) • because the enzyme is being inhibited despite being activated by citrate (1)	Allow (less fat stored so) fat reserves used	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to two of the following: • an inhibitor of the bacterial enzyme may not affect the human one (1) • description of effect of treatment eg fatty acids not made so {less respiration / bacteria die} (1) • so that there will be fewer side effects if used as a treatment for infections (1)	Allow enzymes are specific Allow is an effective antibiotic	**(2)**

Indicative content	Answer
according to candidates' deployment of knowledge and understanding of the material in and skills outlined in the generic mark scheme.	es reference to five of th
elow is not prescriptive and candidates are not required to include all the material which is dditional content included in the response must be scientific and relevant.	ons are moved out of the
east	ermeable to water (1)
ydroxide / remove gauze	
to tubing	
st / glucose mixture / use boiled glucose solution	on / low(er) water poten
	s a counter-current mul
asure the carbon dioxide released	re permeable to water (1
ions of fluoride / plus and minus fluoride	s out (of the collecting c
lt	
ast / mass of yeast / volume of mixture / temperature	
atise with the three-way tap open	
finish before measuring rate of reaction	

Answer
is
ne / distance divided by time
n tube diameter
tion against fluoride concentration
ulate standard deviation

ble content
tes isolated elements of biological knowledge and understanding to the given context with comments made. ements related to consequences are made with limited linkage to a range of scientific ideas, techniques and procedures. sion will contain basic information with some attempt made to link knowledge and ing to the given context. **to 3 ideas with no analysis** **dlice means Level 1 max**
tes adequate knowledge and understanding by selecting and applying some relevant acts/concepts. ces are discussed which are occasionally supported through linkage to a range of scientific esses, techniques and procedures. sion shows some linkages and lines of scientific reasoning with some structure. **m 4 to 6 ideas including at least 1 analysis** **iate method eg. yeast and photosynthesis / aerobic respiration / Benedict's / OH means Level 2 and maximum of 5 marks**
tes comprehensive knowledge and understanding by selecting and applying relevant of biological facts/concepts. ces are discussed which are supported throughout by sustained linkage to a range of eas, processes, techniques or procedures. sion shows a well-developed and sustained line of scientific reasoning which is clear and uctured. **r more ideas including at least 2 analysis** **o statistical analysis**

Number	Answer	Additional Guidance	Mark
9a	• mean calculated (1) • mean rate calculated (1) • expressed as appropriate significant figures	3.25 min 0.3077 min^{-1} 0.31 min^{-1} accept ECF	**(3)**

Question Number	Answer	Additional Guidance	Mark
9aii	An answer that includes one of the following reasons • there is no information about the effect of other variables e.g. temperature, type of milk used (1) • there is no consideration about the time needed for a useful yield of cheese (1)		**(1)**

Question Number	Answer	Additional Guidance	Mark
9b	• interconvert dm^3 and cm^3 (1) • cost calculated (1)	200 dm^3 = 200000 cm^3 or 100 cm^3 = 0.1 dm^3 3.6 x 2000 = £72	**(2)**

Question Number	Answer	Additional Guidance	Mark
9 c	A method that includes at least four of the following features: • source of milk identified as the independent variable with at least one control considered e.g. volume(1) • time for clotting identified as the dependent variable with some detail about how to determine the end point (1) • identification of at least one other variable with description on how to control it (1) • discussion of what effect the variable would have if it was not controlled. (1) • description of how to increase the validity or reliability of results	 e.g. enzyme {volume / concentration / source}, temperature, pH, stirring. method e.g. use of a thermostatically controlled water bath, pH buffer, etc e.g. what effect would changing temperature have on enzyme activity. e.g. repeats for each milk type, consideration about how to deal with anomalous results.	**(6)**

Question Number	Answer	Additional Guidance	Mark
4(a)	A diagram showing the following: • two glucose molecules (1) • correct H and OH groups on each glucose (1) • water clear as substrate not product (1)	**Accept** two molecules of α-glucose	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that includes four of the following: • mass of contents of the beaker reduce over time (1) • because oxygen is released (1) • the rate of decrease in mass is non-linear / loss of mass reduces over time (1) • because the substrate is used up / lower substrate concentration (1) • resulting in fewer collisions between the active site and the substrate (1)	**Allow** oxygen is a gas (NOT gas has no mass) **Allow** Rate of reaction decreases **Allow** fewer enzyme substrate complexes	**(4)**

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to the following: • change in the sequence of DNA (1) • results in {missing / different} {amino acid / codon} (1) • results in {different / missing / shorter} {protein / enzyme} (1)	**Allow** description e.g. frameshift, deletion **Allow** change to {start / stop} codons; different {amino acid sequence / primary structure}	**(3)**

Number	Answer	Additional Guidance	Mark
5(a)	A description that includes: • enzymes {hydrolyse / digest} the tissue (of the style) (1) • provides {nutrients / energy /ATP} for pollen tube growth (1) • clears path for pollen tube growth / allows pollen tube to enter ovule (1)	**Allow** enzymes {regulate the production of growth hormones / extend the cytoskeleton / are involved in aerobic respiration / produce new cell membranes} **Allow** provides cell structures needed for growth	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that includes: • enzymes {hydrolyse / digest} the (m)RNA (1) • this prevents {translation / protein synthesis / enzyme synthesis} (1) • which prevents {digestion of style / pollen tube growth / pollen tube reaching ovule / prevents self-pollination} (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An explanation that includes four of the following: • one (male nucleus) fuses with two polar nuclei (1) • which produces a triploid (endosperm) nucleus (1) • which therefore, provides nutrients (for germination) (1) • one (male nucleus) fuses with the female gamete nucleus (1) • which produces the diploid zygote (1)	**Allow** pollen/egg/ova/fertilises	**(4)**

	Additional Guidance	Mark
) two of the structure} changes onic bonds / affects nger fits / binds (1)	**Accept** {shape / structure} of monophenol changes so it no longer fits active site **Accept** because H^+ ions / bind to monophenol **Accept** E/S complexes do not form	**(2)**

	Additional Guidance	Mark
o two the following: ucture} to ibitor / binds in the enol / enzyme reasing the {rate of enzyme activity}(1)		**(2)**

	Additional Guidance	Ma
	Accept a straight line that must through or between 19.0 mg cm^{-3} or 24.0 mg cm^{-3} at 30 s. **TE** for mark points 2 and 3 from wrong tangent **TE** for mark point 3 for correct gradient calculation with no tangent (y ÷ x) Example of calculation: 21.0 / 30 = 0.70 mg $cm^{-3} s^{-1}$ (accept range of between 0.63 mg $cm^3 s^{-1}$ to 0.80 mg $cm^3 s^{-1}$) Correct answer with no working gains full marks	(3

er	Additional Guidance	Mark
lrogen, ionic and disulfide) c and ester bonds are not c bonds are not tertiary nds are not tertiary		(1)

er	Additional Guidance	Mark
ce to three of the acids / primary ups (1) y / quaternary} tary to monophenol / } so {monophenol te complexes cannot	**Accept** insertion of a stop codon leads to shorter polypeptide (1) **Accept** different hydrogen bonds / disulfide bonds / ionic bonds **Accept** correct references to α-helix and β-sheet **Accept** references to substrate for monophenol	(3)

Mark	
	(1)

nal Guidance
e named organelle e.g lope / mitochondria / Golgi aller ribosomes / cell wall /

Mark	
	(2)

nal Guidance

Mark	
	(4)

Additional Guidance
converse

Additional Guidance	Mark
ACCEPT prevents enzymes going to the small intestine ACCEPT more {undigested food / protein / starch / polysaccharides} ACCEPT lower concentration of { amino acids / sugars / glucose }	EXP

Additional Guidance	Mark
ACCEPT pancreatic duct damaged ACCEPT digests insulin (in the pancreas)	(2)

7(a)	• enzymes are made of polypeptide chains with bonds between (R groups) to form a 3D tertiary structure (1) • catalase has four subunits so has quaternary structure (1) • because proteins with {non-protein / haem} groups have quaternary structure (1)	**ACCEPT** are (semi) soluble so fold into a {3D shape / globular structure} in water **ACCEPT** more than one polypeptide chain	**(3)** **EXP**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	An explanation that makes reference to two of the following: • because as soon as the reaction starts the substrate is {broken down / decreasing} (1) • so the substrate concentration is no longer controlled (1) • substrate concentration should not limit the rate of reaction (1)		**(2)** **EXP**

Question Number	Indicative content
***7(b)(ii)**	**Indicative content:** • {pieces / extract} of red peppers used • peppers at various stages of ripeness tested • red pepper added to flask containing hydrogen peroxide • volume of oxygen collected recorded at regular (short) time intervals • temperature controlled using water bath • pH controlled using a buffer • same {volume / concentration} of hydrogen peroxide • same {type / size} of red pepper used • investigation repeated with different red peppers at each stage of ripeness • graph plotted of volume of oxygen collected against time (for each pepper) • tangent drawn to work out initial rate of reaction • cm^3 per minute • graph plotted of initial rate against ripeness of red pepper Level 1 : method described to measure activity of catalase in red peppers Level 2 : method includes using red peppers at varying degrees of ripeness with a consideration of controlling other variables for valid data Level 3 : method includes a description of how to measure initial rate of reaction

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to two of the following:		

Number	Answer	Additional Guidance	Mark
11(a)	An explanation that makes reference to six of the following: • grass taken from in or near clover and from an area without clover (1) • standardised mass of grass plants collected (1) • use of known volume of (named) solvent to extract pigment from (known mass of) grass (1) • absorbance measured in colorimeter (1) • red filter used to measure absorbance of green chlorophyll (1) • colorimeter zeroed with solvent (1) • replicates taken and means calculated (1) • t test used to look for significant difference (1) • other relevant factor monitored (1)	Allow lab-based experiment where grass is grown with and without clover Allow use of {sand / pestle and mortar/ food mixer} to grind up grass Allow extract filtered Allow details of chromatography if carried out as an alternative with area or intensity of green spots measured Allow compare standard deviation	**(6)**

Number	Answer	Additional Guidance	Mark
8(a)	An answer that makes reference to six of the following: • make extract of pineapple juice (1) • same {volume of skimmed milk / volume of pineapple juice extract} (1) • {use colorimeter to measure changes in absorbance with time / beaker over a black cross and time to disappear} (1) • calculation of initial rate (1) • at a range of temperatures using a water bath (1) • pH controlled using buffer (1) • plot graph of initial rate against temperature (1)	Allow other appropriate methods Allow use colorimeter to measure transmission Allow measure absorbance every 30s Allow 10 – 80°C (must be at least 5 temps)	**(6)**

Question Number	Answer	Additional Guidance	Mark
8 (b)(i)	An answer that makes reference to two of the following: • Gram positive bacteria have more peptidoglycan than Gram negative bacteria (1) • Gram positive stains {purple / blue} (with Gram stain), but Gram negative do not stain {purple / blue} (with Gram stain) (1) • Gram positive contains {teichoic acid / lots of murein} but Gram negative do not (1) • Gram positive have no {periplasmic space / outer membrane} but Gram negative do (1)	Allow Gram positive have a thicker cell wall than Gram negative Allow Gram positive stains {purple / blue} (with Gram stain), but Gram negative stain red (with Gram stain) Allow Gram positive have low {lipid / phospholipid} content but Gram negative have high {lipid / phospholipid} content	**(2)**

Question Number	Answer	Additional Guidance	Mark
8 (b)(ii)	An answer that makes reference to the following: • conversion of micrometres to mm (1) • calculation of speed (1)	Example calculation 1µm = 0.001 mm 0.001 x 100 = 0.1 (mm s^{-1}) Correct answer with no working gains full marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An explanation that makes reference to two of the following: • BvB can kill gram negative bacteria (1) • without side effects for humans (1) • therefore could be useful when treating resistant bacterial infections (1)	Allow bacteria cannot become resistant to BvB	**(2)**

Indicative content
rding to candidates' deployment of knowledge and understanding of the material in kills outlined in the generic mark scheme.
is not prescriptive and candidates are not required to include all the material which is nal content included in the response must be scientific and relevant.
s not controlled / volume not controlled eg beaker
to measure volumes of succinate / 15 cm^3 of water should have been added to the without inhibitor
ıte of reaction because of collisions between substrate and enzyme active site
d
the temperature constant
ed or rate of reaction changes with kinetic energy
site and therefore rate of reaction
uld have been measured
e adding the dehydrogenase / use colorimeter
ill fall with time therefore rate will be lower
bjective
ne quantitative data
malonate was used
s of malonate should have been used
on can be identified

Guidance	Mark
d two must be $-O^-$ in s the succinate =O then $-O^-$ then n on page 28)	**(1)**

Guidance	Mark
	(1)

	Additional Guidance	Mar
ng: (1)	Allow complementary in shape / interaction of R groups and substrate / conformational change / induced fit	
(1)	Allow forms an {enzyme substrate complex / stable intermediate compound}	
ond formed (1)		**(3)**

	Additional Guidance	Mar
ng: oth ends of (1)		
/ act as a (1)		**(2)**

uccinate used succinate should have been used be drawn onto the graph
eated
average / deal with anomalies / statistical analysis}
nt
ed elements of biological knowledge and understanding to the given context with nts made.
elated to consequences are made with limited linkage to a range of scientific ideas es and procedures.
uate knowledge and understanding by selecting and applying some relevant epts.
iscussed which are occasionally supported through linkage to a range of scientific chniques and procedures.
rehensive knowledge and understanding by selecting and applying relevant ical facts/concepts.
iscussed which are supported throughout by sustained linkage to a range of esses, techniques or procedures.
ct validity identified OR two suggestions made on how to improve the validity [e.g. two random points from indicative contents met] made on how to improve the validity related to specific issues identified ontent] ade on how to improve the validity related to specific issues identified with some provement} on the data obtained [e.g. at least two triplets with some additional

ative content	ce	Mark
ent of knowledge and understanding of the material in relation to :. ates are not required to include all the material which is indicated ust be scientific and relevant. ariable ace area, variety, source }, pH d and how the temperature will be controlled ed pH buffer, etc ontrolled nts made e.g. 120 seconds linked to the data already obtained as not controlled. E.g. what effect would changing mass of apple data nelanin		**(3)**

Additional Guidance	Mark
ver pH changes {structure/shape} of the active site} n't form enzyme-substrate complex / nding of the substrate to the enzyme	**(2)**

Additional Guidance	Mark
fects on substrate or product reaks down / hydrolyses} the enzyme e enzyme digests protein	**(2)**

ntent
f how the investigation should be carried out may be attempted but with limited tation and/or evaluation of the scientific information. Generalised comments made. will contain basic information with some attempt made to link knowledge and the given context.
f how the investigation should be carried will be given with occasional evidence of tation and/or evaluation of the scientific information, including some consideration of the data obtained shows some linkages and lines of scientific reasoning with some structure.
f how the investigation should be carried out is given which is supported throughout the analysis, interpretation and/or evaluation of the scientific information, including the value of the results and additional data that may be required. shows a well-developed and sustained line of scientific reasoning which is clear, ically structured.

endent variables have been identified and some attempt has been made to control other

ent and at least two control variables have been clearly specified and most have clear
l/controlled.

ent and at least two control variables have been clearly specified and most have clear
l/controlled. Clear reference and use has been made of the existing technique and data
·ement of melanin concentration. Understanding may be shown through some
significant and/or limitations on determining end points, etc

Number	Answer	Additional Guidance	Mark
8(a)	A calculation that shows: • An initial gradient line drawn / a relevant early value read off graph (1) • Gradient measured / divide amount of product produced by time taken (1)	<u>Example of calculation</u> • (2.5 - 2.6) after 1 hour / (1.3-1.4) after 30min • 2.6 ÷ 60 = 0.043 (mmol dm^{-3} min^{-1}) **Allow** answers between 0.041-0.047 correct answer gets both marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)	An explanation that makes reference to the following: • the enzyme may have denatured at 65 °C / the enzyme's active site may have changed shape at 65 °C (1) • because {hydrogen bonds / bonding} has been disrupted (1)	**Allow** converse	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(c)	An analysis that makes reference to three of the following: • higher temperatures mean molecules have more kinetic energy (1) • therefore there is a greater chance of a collision between the enzyme and substrate (1) • therefore more chance of an enzyme-substrate complex being formed (1) • reaction mixture {is warming up / has not reached equilibration / not hot enough to denature enzyme yet } (1)		**(3)**

Question Number	Indicative content
8 (d)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • temperature not controlled at the start • allow time for equilibration in the water bath before mixing and starting the reaction • rate of reaction changes while the mixture warms up • Only two temperatures tested • Use a wider range of temperatures • It would help identify the temperature at which the enzyme is denatured • pH not controlled • use a buffer • pH affects shape of active site and therefore rate of reaction • separate experiments not repeated • repetition of each experiment • so you can {calculate a mean average / deal with anomalies / statistical analysis} • values and reactants, products not specified • specific e.g. how product measured etc • Volume of mixture removed not mentioned • Removal of mixture may alter concentrations in reaction mixture • Enzyme may continue to hydrolyse starch while measuring maltose concentration • Same volume of amylase and starch used • Initial concentrations the same • Comment on timings e.g. the same sampling used for both / more frequent sampling could take place
	• The same sampling time will mean there will be the same reduction of volume in each mixture

Level	Marks	
0	0	No awardable content
1	1-2	An explanation of how the investigation should be carried out may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4	An explanation of how the investigation should be carried will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information, including some consideration of the limitations of the data obtained The explanation shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An explanation of how the investigation should be carried out is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information, including consideration of the value of the results and additional data that may be required. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.

Additional Guidance

Level 1 response = two issues that could {reduce / help} validity identified OR two suggestions made on how to improve the validity which are not related to any issues identified [e.g. two random points from indicative contents met]

Level 2 response = at least two suggestions made on how to improve the validity related to specific issues identified [e.g. at least two pairs from the indicative content]

Level 3 response = a range of suggestions made on how to improve the validity related to specific issues identified with some appreciation on the impact of the {issue / improvement} on the data obtained [e.g. at least two triplets with some additional indicative content]

4 (a)	An explanation that makes reference to the following: • clotting takes longer at low temperature due to {low kinetic energy / fewer enzyme-substrate collisions} (1) • clotting time is least at {body/optimum} temperature (1) • (clotting takes longer) at {temperatures above 37°C / high temperatures} (because) enzymes are denatured (1)	Accept clotting takes less time as temperature increases because {kinetic energy increases / more enzyme-substrate collisions}	**(3)**

Question Number	Answer	Additional Guidance	Mark
4 (b)	6771		**(1)**

Question Number	Answer	Additional Guidance	Mark
4 (c)(i)	substitution	Accept point mutation	**(1)**
Question Number	**Answer**	**Additional Guidance**	**Mark**
4 (c)(ii)	1 in 50	Accept other correct probabilities e.g. 2% or 0.02	**(1)**

Question Number	Answer	Additional Guidance	Mark
4 (c)(iii)	An explanation that makes reference to the following: • (excess prothrombin means) more thrombin (1) • therefore increased {conversion / catalysis} of fibrinogen to fibrin (1) • fibrin {is insoluble / traps blood cells / forms mesh / forms net} (1)	Accept if there is more fibrin it is more likely to clot	**(3)**

Question Number	Answer	Additional Guidance	Mark
4 (d)(i)	cut DNA to produce {short sections of DNA / short tandem repeats / mini satellites} (1)	Accept cut DNA into fragments / cut DNA to give sticky ends	**(1)**

Question Number	Answer	Additional Guidance	Mark
4 (d)(ii)	A description that makes reference to three of the following: • use (DNA) primers / nucleotides (1) • use {high temperature / 95 °C} for 30 seconds (to separate DNA strands) (1) • use {lower temperature / 55 °C} for 20 seconds (to bind primers) (1) • heat to 72°C with polymerase (to replicate DNA) (1) • repeat process (to obtain many copies of DNA) (1)		**(3)**

Number	Answer	Additional Guidance	Mark
8(a)	An explanation that contains three of the following: • higher **kinetic** energy so more enzyme-substrate complexes formed (1) • at very high temperatures the rate decreases due to **denaturation** (1) • because of bond changes in the enzyme altering the **active site** (1) • so substrate no longer fits **active site** (and rate of product formation decreases)	Accept higher kinetic energy increases number / rate of collisions (between enzyme and substrate) Accept at temperatures above the optimum the rate decreases due to denaturation Accept changes to tertiary structure change the shape of the active site Accept bonds break in the enzyme altering the active site Do not accept peptide bonds Accept substrate no longer complementary to active site	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	A description including two of the following variables with suitable methods of control: • appropriate named variable (1) • description of how the variable is controlled (1) • appropriate named second variable (1) • description of how second variable is controlled (1)	eg • volume of hydrogen peroxide / accept stated volume - measuring cylinder / syringe / pipette (to measure same volume) • concentration of hydrogen peroxide / accept stated concentration – dilute / make up solution to same % concentration / use of stock solution • temperature / accept stated temperature - flask in **thermostatically controlled** waterbath / accept descriptions • pH / accept stated pH – buffer (in flask)	**(4)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	Initial rate of reaction calculated (1)	Answer uses **seconds** 0.33 cm^3 s^{-1} **Accept:** values in range: 0.28 to 0.35 cm^3 s^{-1} **Accept:** cm^3 /s ; cm^3 per second Answer uses **minutes** 19.8 cm^3 min^{-1} **Accept:** values in range 16.8 to 21.0 cm^3min^{-1} **Accept**: cm^3 /min ; cm^3 per min	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An explanation including the following • {hydrogen peroxide / substrate / reactant} is {converted to products / used up} (1)	Accept {hydrogen peroxide / substrate / reactant} becomes a limiting factor Accept concentration of {hydrogen peroxide / substrate / reactant} decreases	
	• so less substrate to collide with the enzyme (1)	Accept less substrate so fewer enzyme-substrate complexes form	**(2)**

Question Number	**Answer**	**Additional Guidance**	**Mark**
8(c)	An explanation including the following • (as more potato is added) more oxygen is produced because more {enzyme is / active sites are} present (1) • (as more potato is added) increase in volume of oxygen is expected as surface area increases (1) • (as more cubes are added) {volume of oxygen produced / graph / rate of reaction} may level off as substrate {is not in excess / is used up} (1)	Accept rate of reaction would increase because there is more enzyme available Accept increased rate of reaction is expected as surface area increases Accept at a higher number of cubes, concentration of hydrogen peroxide may be a limiting factor	**(3)**

Total for Question 8 = 13 marks

Number	Answer	Additional Guidance	Mark
7(a)(i)	A description that contains two of the following: • use {same / stated} mass of mung bean seeds (1) • use {same / stated} volume of water (1) • {same / standardised} germination conditions (1)	Allow weight for mass Ignore age / variety of beans Accept control of stated germination conditions eg temperature, light intensity, time If no other mark awarded accept make a single batch / stock solution to give to all students for 1 mark only	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	A description that includes two of the following: • zero the colorimeter with (distilled) water (1) • use an appropriate (green) filter (1) • ensure that cuvettes {are not scratched / have no fingerprints on them} (1)	Accept calibrate / reset for zeroing colorimeter Accept use of phenolphthalein phosphate Ignore reference solution Accept use same filter / fix the wavelength	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	An explanation that includes three of the following: • (between 10 - 60°C / up to 60°C) as temperature increases activity of phosphatase increases (1) • as molecules have more kinetic energy (1) • so collisions between enzyme and substrate {are more likely to occur / occur more frequently} (1) • the optimum temperature is **<u>between 51 - 69°C</u>** (1) • {above optimum temperature / above stated temperature (60 - 80°C)} {<u>enzyme activity / rate of reaction</u>} decreases, as the active site {begins to change / changes} shape (1)	Accept converse in context of temp decreasing for mp1, 2 and 3 Ignore effect of temperature on absorbance of light Accept rate of reaction increases Accept enzymes / substrates /particles have more KE Accept enzyme-substrate complexes are more likely to form Accept more E-S complexes formed per unit time Accept above {optimum temperature / above stated temperature 60 - 80°C)} {<u>the enzyme activity / rate of reaction</u>} decreases, as enzyme {begins to be / is} denatured Ignore high temperature	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	An answer that includes the four of the following: • (add buffer to each tube of phenolphthalein phosphate) because pH may affect the {rate of reaction / enzyme activity} (1) • (place separate tubes containing phenolphthalein phosphate and enzyme into water baths before mixing together) so they {can come up to temperature / are at the same temperature} (1) • (use smaller temperature intervals than 10°C) so that the optimum temperature can be identified more precisely (1) • (stop the reaction before 20 minutes) so that an initial rate can be calculated (1)	Accept (extremes of) pH can denature enzyme / accept description of denaturation Accept reference to equilibration Accept ref to enzyme reaching required temperature Accept more accurately Ignore identified more easily Accept so that concentration of {reactants / substrates} is not limiting / so end product inhibition does not occur **Do not allow** concentration of enzyme decreases / enzymes used up Ignore refs to enzyme being denatured	**(4)**

Question Number	Answer	Additional Guidance	Mark
7(c)	An answer that includes the following: • one example given (1) • second example given (1)	e.g. synthesis of ATP synthesis of nucleotides / nucleic acids / named nucleic acid synthesis of phospholipids regeneration of ribulose bisphosphate phosphorylation of glucose (in glycolysis) synthesis of NADP Ignore photosynthesis / respiration / translation / protein synthesis / carbon fixation /	**(2)**

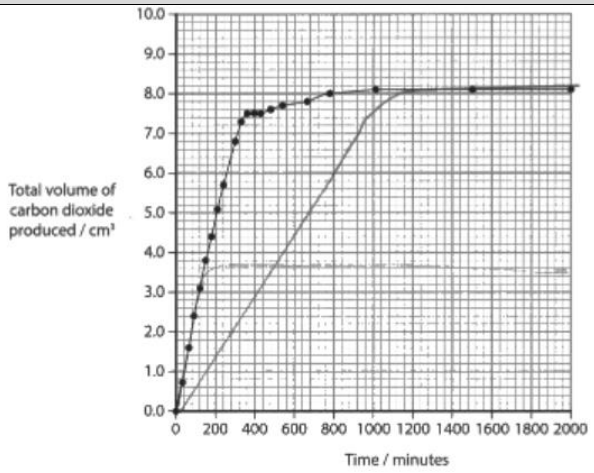
Total for Question 7 = 13 marks

Number	Answer	Additional Guidance	Mark
10(a)(i)	An answer that includes the following • correct rate of respiration (1)	0.03 (cm^3 min^{-1}) accept 0.028 – 0.032	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	An explanation that includes the following: • (yeast) can use sucrose to produce carbon dioxide (1) • (yeast) cannot use lactose, so no respiration (1) • because lactose cannot be broken down (1) • {respiration stops / volume of carbon dioxide remains constant} because all {sucrose / substrate} has been used up (1)	Accept (yeast) can use sucrose to respire Accept line levels off because all {sucrose / substrate} {has been used up / is a limiting factor}	**(3)**

Question Number	Answer	Additional Guidance	Mark
10(a)(iii)	An explanation that includes the following: • lactase breaks down lactose to give glucose and galactose (1) • yeast can use one of these (sugars) as a respiratory substrate (1) • because volume of CO_2 is approx. half of that {expected / produced by sucrose} (1) • rate of respiration at 400 minutes is close to zero as all {glucose / substrate} has been used up (1)	Accept yeast can respire using glucose /one of these sugars Accept yeast cannot use one of them / galactose to respire Accept because the volume of CO_2 has levelled out as all the {glucose / substrate} has been used up	**(3)**

Question Number	Answer	Additional Guidance	Mark
10(b)	An explanation that includes three of the following: • at lower temperature, there will be less kinetic energy, so respiration **rate** is lower (1) • because fewer enzyme-substrate collisions <u>per unit time</u> (1) • respiration will continue until all of the {sucrose / substrate} is used up (1) • so that {the same volume (of CO_2) is produced / (eventually) rate of respiration will reach zero} (1)	Accept at lower temperature, there will be less kinetic energy, so less CO_2 produced per unit time Accept less ES complexes per unit time Accept less frequent / likely collisions Do not accept no ES collisions Do not accept in context of enzyme denatured (at a lower temperature) it will take longer for the {rate of respiration to reach zero / same volume of CO_2 to be produced}	**(3)**

Question Number	Answer	Additional Guidance	Mark
10(c)(i)	An answer that includes the following: • line drawn to the right of existing line ie slower initial rate and reaching same final value (1)		(1)

Question Number	Answer	Additional Guidance	Mark
10(c)(ii)	An explanation that includes three of the following: • (7g yeast / high concentration) more yeast cells present, so {carbon dioxide is produced faster / more carbon dioxide produced (at start) (1) • (more yeast cells present), so more enzymes to {hydrolyse sucrose / carry out respiration} (1) • final volume of CO_2 produced is the same for 7g and 3.5g yeast (1) • because {mass / concentration} of {sucrose / substrate} is the same for both (1) • line levels off sooner for 7.0g because sucrose is used up more quickly} (1) • 3.5g yeast will produce half the rate of reaction compared to 7.0g yeast (1)	**All marking points must be comparative** Accept converse for 3.5g yeast for all points Accept more enzymes (for more yeast) Accept more yeast cells so higher respiration rate Accept line levels off sooner for 7.0g because rate of respiration is faster Accept it takes twice as long for the line to plateau (with 3.5g yeast)	(3)

(Total for Question 10 = 14 marks

Question Number			
8(a)	• mass of plastic in kg calculated (1) • mass of polyester calculated (kg) (1) **OR** • 15 % of 25.8 million calculated (1) • mass of polyester calculated (kg) (1)	Example of calculation: 23 405 373 000 / 23 405.373 million 3.5×10^9 / 3.51×10^9 / 3 510 805 950 3.87 million / 3 870 000 3.5×10^9 / 3.51×10^9 / 3 510 805 950 Correct answer = 2 marks Correct answer but incorrectly expressed in standard form or too many dps = 1 mark Correct figures but wrong order of magnitude = 1 mark	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)	• bacteria {produce enzymes / can digest plant material} (1)		(1)

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that makes reference to two of the following: • because this is the {pH / temperature} of the cow's stomach (1) • therefore the optimum {pH / temperature} of the <u>enzymes</u> (1) • buffer used to keep pH constant (1)	**ACCEPT** optimum conditions {pH / temperature} that the enzymes work fastest at	(2)

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	An answer that makes reference to three of the following: • no correlation (between mean enzyme activity and the number of carbons in the fatty acid chain) (1) • {optimum / best} number (appears to be) 4 carbons (1) • but could be {6 / between 4 and 6} as the range bars overlap (1) • small standard deviations indicating that variability within data sets is low (1)	**ACCEPT** not proportional **ACCEPT** least activity with 2 carbons **ACCEPT** but could be 10 as error bars overlap	(3)

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	An answer that makes reference to five of the following: • use (polyesters with) fatty acid chains {of varying lengths / containing either 2, 4, 6, 8, 10 or 12 carbons} (1) • initial rate of reaction measured (1) • credit method for monitoring reaction (1) • experiment carried out at 40°C in (thermostatically-controlled) waterbath (1) • credit named control variable (1) • experiment repeated several times to calculate mean and {range bars / standard deviation} (1)	e.g. colorimeter / absorbance / transmission / pH change / mass change e.g. enzyme {volume / concentration}, same temperature if mp 4 not awarded, substrate {volume / concentration}, pH	(5)

Question Number	Answer	Additional Guidance	Mark
8(e)	An explanation that makes reference to two the following: • because there were two different types of polyester and enzymes are specific (1) • because the two polyesters produced different {products / concentration of products} • and therefore there must be different bonds that need breaking (1)	**ACCEPT** description / examples	(2)

Question Number	Answer	Additional Guidance	Mark
8(a)	An answer that makes reference to the following: • COOH and NH_2 shown (1) • H shown (1) • all attached to central carbon (1)	ACCEPT $-NH_3^+$ and $-COO^-$	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	**The only correct answer is B** *A is incorrect because the activation energy is the energy between that of the substrates and the highest energy* *C is incorrect because the activation energy is the energy between that of the substrates and the highest energy* *D is incorrect because the activation energy is the energy between that of the substrates and the highest energy*		**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	**The only correct answer is C** *A is incorrect because the reactant is threonine and the product is intermediate J* *B is incorrect because the reactant is threonine and the product is intermediate J* *D is incorrect because the reactant is threonine and the product is intermediate J*		**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	**The only correct answer is C** *A is incorrect because the energy of the reactants does not change but more activation energy would be needed* *B is incorrect because the energy of the reactants does not change but more activation energy would be needed* *D is incorrect because the energy of the reactants does not change but more activation energy would be needed*		**(1)**

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that makes reference to the following: • because threonine is not converted directly to isoleucine / it is not a one step process / (conversion) is part of a metabolic pathway (1) • each intermediate has a different (3D) shape (1) • and therefore, active site of (one) enzyme is not complementary to all substrates (1)	ACCEPT all (substrates) cannot fit into the active site of the same enzyme	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	An explanation that makes reference to three of the following: • above a certain concentration, {isoleucine /final product} binds to {threonine deaminase / enzyme } (1) • at an allosteric site / site other than active site (1) • causing a conformational change (of protein / enzyme) • the (3D) shape of the active site, changes / is different 1) • so it cannot bind to threonine (1)	ACCEPT description of it binding elsewhere on enzyme A active site deforms A threonine/substrate, can no longer fit A no, enzyme-substrate / ES, complexes form	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	An answer that makes reference to the following: • a line starting at zero and sloping up (1) • a line that overall stays flat (1) • but there are oscillations /AW (1)	ACCEPT slight decrease	**(3)**

1(a)	**D** phosphodiester *A is incorrect as this bond is found in lipids* *B is incorrect as this bond is found in carbohydrates* *C is incorrect as this bond pair bonds nucleotides*		**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)	A description that makes reference to the following points: • {DNA polymerase} {joins the sugar phosphate backbone (between nucleotides) / forms phosphodiester bonds / joins adjacent nucleotides} (1) • DNA {ligase} {joins fragments of DNA / short pieces of DNA / Okazaki fragments} (1) • DNA {helicase} {breaks hydrogen bonds / unzips double helix / separates strands} (1)	**Accept** {RNA primase} makes {RNA to start replication of DNA}	**(3)**

Question Number	Answer	Additional Guidance	Mark
1 (c)	A calculation that makes reference to the following points: • correct calculation of percentage cytosine (1) • correct calculation of number of nucleotides (1)	15 % cytosine 15 % of 10 000 = **1500** Correct answer with no working gains full marks **One mark** for 15 %	**(2)**

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	• J and K : cytosine and guanine (1) • L and M : adenine and thymine (1)	1 mark = correct pairings but wrong way round OR 1 mark for letters (C-G and A-T) the correct way round	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	• D = hydrogen (bond) E = phosphodiester (bond) F = covalent (bond)	All three correct = 2 marks 1 or 2 correct = 1 mark **ACCEPT** covalent **ACCEPT** N-glycosidic bond	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(iii)	• 33.81 (%) (1)		**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)	• (two) DNA molecules are made that consist of one, original / old (parent) strand and one new strand (1)		**(1)**

	Mark
	(1)

s not increases

a.u.

Additional Guidance	Mark
ACCEPT join Okazaki fragments / joins fragments produced from copying the lagging strand / needed for working in 3' to 5' direction	(3)
ACCEPT between (mono) nucleotides	

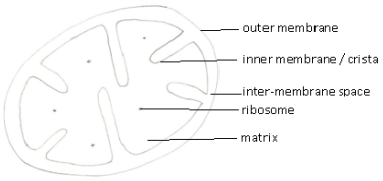
Guidance	Mark
spindle fibres push rane contracts at	(3)

	Mark
ide chain	(1)
rboxyl group at the	
de of an amino acid	

Question Number	Answer	Additional Guidance	Mark
1(a)	<table><tr><th rowspan="2">Component</th><th colspan="4">Component found in a molecule of</th></tr><tr><td>both DNA and mRNA</td><td>DNA but **not** mRNA</td><td>mRNA but **not** DNA</td><td>neither DNA nor mRNA</td></tr><tr><td>Adenine</td><td>X</td><td>☐</td><td>☐</td><td>☐</td></tr><tr><td>Hydrogen bonds</td><td>☐</td><td>X</td><td>☐</td><td>☐</td></tr><tr><td>Pentose sugar</td><td>X</td><td>☐</td><td>☐</td><td>☐</td></tr><tr><td>Uracil</td><td>☐</td><td>☐</td><td>X</td><td>☐</td></tr></table>		

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	An explanation that makes reference to two of the following: • {DNA / fragments} {are negatively charged / have a phosphate group} (1) • therefore the {DNA / fragments} move {when a potential difference is applied / towards the positive electrode} (1) • {smaller / lighter} fragments move further / {larger / heavier} fragments move shorter distance (1)	**ACCEPT** current / charge / voltage / electric field towards (positive) anode **ACCEPT** small fragments faster / larger fragments slower	

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	7 / 7.0 / 8 / 8.0 / 9 / 9.0 (kb)		

Question Number	Answer	Additional Guidance	Mark
5(a)	A drawing that shows the following: Drawing marks : • 2 membranes drawn (1) • (continuous) inner membrane (of two) folded (1) Label marks : Any **two** from • {inner membrane / crista} and outer membrane (1) • inter-membrane space (1) • matrix (1) • ribosome (1)		**(4)**

Question Number	Answer	Mark
5(b)(i)	**The only correct answer is A** ***B*** *is not correct because the father's mitochondria do not enter the ovum on fertilisation* ***C*** *is not correct because only the nucleus was used from the mother* ***D*** *is not correct because only the nucleus was used from the mother and the father's mitochondria do not enter the ovum on fertilisation*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to three of the following: • zygote divides by mitosis (several times to form blastocyst) (1) • to make identical copies of the {DNA (molecules) / chromatids} (1) • so that all cells (in the blastocyst) {will be diploid / have two copies of each chromosome} (1) • so that when the mitochondria divide they will have a copy of the DNA (1)	**ACCEPT** genetically-identical (daughter) cells / same genetic information **ACCEPT** correct number of chromosome / 46 chromosomes / 23 pairs **ACCEPT** mitochondrial DNA divides	**(3)**

Question Number	Answer	Additional guidance	Mark
1(a)	A description that makes reference to the following: • (rough endoplasmic reticulum) performs {polypeptide synthesis / translation / protein synthesis} (1) • (Golgi apparatus) {modifies proteins / glycosylates proteins / adds carbohydrates to proteins / packages proteins / forms quaternary structure of proteins / produces lysosomes / modifies lipids / forms glycolipids} (1) • (mitochondria) {makes ATP / performs respiration} (1)	**Allow** makes proteins **Allow** forms {primary / secondary / tertiary structure} **Do not accept** forms quaternary structure **Do not accept** forms cell walls **Do not accept** anaerobic respiration	**3**

Question Number	Answer	Additional guidance	Mark
1 (b)(i)	A description that makes reference to three of the following: • (DNA) helicase {breaks hydrogen bonds / separates strands / unzips the two strands / unzips the DNA} (1) • complementary {nucleotides / bases} pair up (1) • (DNA) polymerase forms {phosphodiester bonds / forms sugar-phosphate backbone} (between nucleotides bound to strand) (1) • (DNA) ligase {joins (Okazaki) fragments} (1)	**Allow** adenine pairs with thymine **and** cytosine pairs with guanine **Allow** A,T,C,G for names **Do not accept** polymerase forms hydrogen bonds **Allow** joins breaks in DNA strands	**3**

Question Number	Answer	Additional guidance	Mark
1(b)(ii)	An explanation that makes reference to two of the following: • altered form {has a missing OH group / has sulfur instead of carbon}(1) • so phosphodiester bonds cannot form (between neighbouring / adjacent nucleotides) (1) • (and) **sugar phosphate backbone** cannot form (1)	**Allow** S instead of C-OH **Do not accept** S instead of OH	**2**

(Total for Question 1 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following: • a {vertical / upward sloping} line that shows the DNA content increasing (before mitosis) **and** a {vertical / downward sloping} line that shows the DNA content decreasing (after/towards end of mitosis) (1) • a horizontal line extending across all of mitosis (1) • DNA doubles after replication and returns to same level indicated at start (halves) (1)		(3)

Question Number	Indicative content	
***7(b)**	Indicative content: DNA replication **(D)** • reference to semi-conservative replication • helicase {separates the DNA strands / break hydrogen bonds between DNA strands} • each DNA strand acts as a template • bases complementary base pair with the exposed bases (on template strands) • DNA polymerase joins together (adjacent) DNA nucleotides • each new molecule (of DNA) has one old strand and one new strand • number of molecules doubles each time so total width of bands doubles each time Stage 1 **(S1)** • bases contain {heavy nitrogen / 15 N } • only one band near bottom of tube, as all the DNA has {heavy nitrogen / ^{15}N } Stage 2 **(S2)** • DNA replication occurs using the { light nitrogen / ^{14}N } • new strands will contain light nitrogen / ^{14}N } • only one band as all new molecules / DNA have one heavy and one light strand • band higher up in the tube as it is lighter than the {original / stage 1} DNA Stage 3 **(S3)** • new strands will contain { light nitrogen / ^{14}N } • (two bands because) {original / stage 1 / heavy nitrogen / ^{15}N strands} will bind with lighter strands to form {medium weight DNA molecules / band in same position as stage 2 } • (two bands because) light strands from stage 2 molecules will bind with new light strands to form lightest molecules, so will be higher up the tube • bands of equal widths as equal number of light and heavy strands in stage 2 DNA	**Level 1:** 1 mark = 2 details from D, S1, S2, S3 or S4 2 marks = 3 details from D, S1, S2, S3 or S4 **Level 2:** 3 marks = 4 details from **two** of D, S1, S2 S3 or S4 4 marks = 4 details from **three** of D, S1, S2 S3 or S4 **Level 3:** 5 marks = 5 details from **four** of D, S1, S2 S3 or S4 6 marks = 5 details from **all** of D, S1, S2 S3 and S4

	Stage 4 **(S4)** • all new strands contain { light nitrogen / ^{14}N } • (two bands because) {original / stage 1 / heavy nitrogen / ^{15}N strands} will bind with lighter strands to form {medium weight DNA molecules / band in same position as stage 2 / band in same position as the last stage} • (two bands because) light strands from stage 2 molecules will bind with new light strands to form lightest molecules, so will be { higher up the tube / in same position as the last stage } • more light strands in stage 3 DNA that heavy strands so the width of band for lightest DNA will be wider • in a ratio of 3 : 1	

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	An explanation that makes reference to the following: • gene {not present / mutated} in R-strain (1) • so that the {enzymes / proteins} needed for synthesising capsule are not present (1)		(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	An explanation that makes reference to the following: • R-strain {picked up something from / transformed by} the dead S-strain (1) • therefore, R-strain now has the genes for {enzymes / proteins} needed for synthesising capsule (1) • therefore, R-strain now has a capsule / R-strain now virulent (1)		(3)

Question Number	Answer	Additional Guidance	Mark
7(b)			(3)

Enzyme used to treat the heat killed S-strain bacteria	Mouse infected with live R-strain and treated S-strain [Dead or Alive]
protease	dead (1)
DNAase	alive (1)
lipase	dead (1)

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	carbon, oxygen and nitrogen are found in both DNA and protein (1)		(1)

Question Number	Answer	Additional Guidance	Mark
7(c) (ii)			(1)

Phage type (label)	Bacterial cells	Phage ghosts
A (^{32}P)	Y	N
B (^{35}S)	N	Y

Number	Answer	Additional Guidance	Mark
5(a)(i)	D phosphodiester *A is incorrect because peptide bonds are found in proteins* *B is incorrect because disulfide bonds are found in proteins* *C is incorrect because glycosidic bonds are found in carbohydrates*		1

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	A description that makes reference to four of: • hydrogen bonds between nucleotides broken by DNA helicase (1) • complementary nucleotides bind (1) • because {hydrogen bonds} will only form between cytosine and guanine and adenine and thymine (1) • phosphodiester bonds are formed by DNA polymerase (1) • (the leading strand is synthesised continuously but lagging strand required) DNA ligase to join fragments (on lagging strand) (1)	**Allow** unzipped by helicase	4

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	*An answer that makes reference to:* • correct indication of selection of RNA virus (for TMV) (1) • correct use of graph to identify intercept between 0.000001 and 0.0005 (1)	**Allow** correct use of standard form e.g. 10^{-4} **Allow** ecf for correct use of y axis with wrong selection of virus type correct answer gets both marks	2

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	*An answer that makes reference to three from:* • as genome size increases, mutation rate decreases (1) • RNA / ss DNA /ss nucleic acid has a higher mutation than ds DNA (1) • because it is single stranded template so does not produce copies with complementary bases / is less stable (1) • viruses have a higher mutation rate than bacteria / eukaryotes (1)	**Allow** converse / allow correlation **Allow** eukaryotes have lowest mutation rates **Allow** RNA viruses have highest mutation rates	3

Question Number	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to the following: • antigen on {surface / membrane} of macrophage (1) • binding of antigen to {CD4 / receptor} on T helper cell (1)	ACCEPT antigen on MHC on macrophage	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An explanation that makes reference to the following: • to prevent DNA {replication / unwinding / unzipping} (1) • so that macrophages could not {divide / carry out mitosis} (1) • so that any division could be attributed to the T cells only / radioactive thymidine incorporated into T cells only (1)	**ACCEPT** separating **ACCEPT** number of macrophages remains constant **ACCEPT** no thymidine incorporated into the macrophage	(3)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to two of the following: • {complementary to / binds to / forms H bonds with} adenine (on the DNA) (1) • forming phosphodiester bonds (with adjacent nucleotides) (1)	**ACCEPT** formation of a sugar-phosphate backbone	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	An explanation that makes reference to four of the following: • most (radioactive) thymidine incorporated into T cells that were the same strain as the macrophages (1) • because these cells are dividing more (1) • because {the (MHC and CD4) receptors bind together better / antigen presentation improved} (1) • due to genetic compatibility (1) • strain 2 {macrophages are better antigen presenters / T cell proliferate faster than strain 13} (1)	**ACCEPT** converse throughout **ACCEPT** more T cells if antigen is presented by macrophages from same {strain / number} guinea pig description **ACCEPT** faster mitosis **ACCEPT** better recognition **ACCEPT** self-antigens **ACCEPT** antigen presentation is more effective	(4)

Question Number	Answer	Additional Guidance	Mark
9(a)	An answer that makes reference to three of the following: Similarities: • both consist of {(mono) nucleotides / adenine, guanine and cytosine} (1) • both contain phosphodiester bonds (1) Differences: • DNA has thymine whereas RNA has uracil (1) • DNA has deoxyribose whereas RNA has ribose (1)	DO NOT ACCEPT A,G,C **DO NOT ACCEPT** hydrogen bonds DO NOT ACCEPT T and U	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)	A description that makes reference to four of the following: • use of reverse transcriptase to synthesise a DNA copy of the RNA strand (1) • details of the molecules needed in the PCR process (1) • details of the PCR process (1) • repeated cycles (1) • {use of RNA polymerase / transcription} of DNA to make RNA (1)	Reverse transcription to convert RNA aptamer to DNA e.g. primers, buffers, DNA mononucleotides, DNA polymerase (2 of these) e.g. temperature cycles (high to break bonds, lower to synthesise DNA)	(4)

Question Number	Indicative content	
***9(c)**	Indicative content: Graph 1: AT3 has the highest strength of binding of all with H1 AT1 binds the least except for H5 AT2 binds most to H7/least to H5 AT3 binds the most for all types apart from H7 All Aptamers bind to each haemagglutinin Graph 2: All Aptamers bind to all strains AT3 is binds strongest to W and Y and Z AT 2 binds strongest to X AT1 binds least to apart from Y Viral infections: • viruses attach to host cells • by attachment sites binding to receptor molecules • influenza uses haemagglutinin to bind to host cells Advantages of aptamers: • aptamer binding to haemagglutinin prevents attachment of influenza to host cell • virus cannot enter host cell and replicate • therefore viral infection will not spread • aptamers can bind to different strains of influenza and prevent infection by a range of strains • offering greater protection • aptamers can bind to a different types of haemagglutinin and therefore should prevent infection by a range of strains • offering greater protection • could bind to other {strains / haemagglutinins} that may result from mutations in the virus • offering further protection against new strains	**Level 1** 1 mark = any two comments 2 marks = 3 descriptions **or** 1 description and 2 adv/disadv **or** 2 descriptions and 1 adv/disadv **Level 2 :** **Minimum 3 descriptions +** 3 marks = 1 advantage / disadvantage 4 marks = 2 advantages / disadvantages **Level 3** **Minimum 3 descriptions +** 5 marks = 3 statements that include at least one advantage and one disadvantage 6 marks = 4 statements that include at least one advantage

	Disadvantages of aptamers: • virus may mutate and aptamer may not be able to bind • not part of the immune system • not in immunological memory • so protection could be short-lived • new treatment so {long term / side effects} not known • no details on how long they last in the body • as they bind to a range of haemagglutinins they may bind to other molecules/cells • reference to lack of error bars and therefore cannot determine significance of results	and one disadvantage

	Marks	AO2 discuss
0	0	No awardable content
1	1-2	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Additional Guidance	Mark
7(a)	• 7×10^4	**ACCEPT** 7.0×10^4	(1)

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• number of guanine and cytosine bases given as 317 203 092 **OR** number of thymine bases given as 204 202 736 **OR** number of adenine and thymine bases given as 408 405 472 • number of guanine bases calculated as 158 601 546	Correct answer with no working get 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	• one set of correct figures {selected / calculated} for Yap hadal snailfish (1) • 85.8 (%) (1) **OR** • one set of correct figures {selected / calculated} for Mariana hadal snailfish (1) • 85.6 (%) (1)	14 750 / 12 685 / 2 092 *85.816949152542372881355932203 39* 14 783 / 12 658 / 2 125 *85.625380504633700872623959954001* 1 mark if {incorrect rounding / too many dps given in answer} ECF correct % for correct numbers {used / added up} from diagram wrongly	(2)

Question Number	Answer	Additional Guidance	Mark
7(b)(iii)	A description that makes reference to three of the following: • All four fish {share the same (original) common ancestor / came from the same species} (1) • Yap hadal and Mariana snailfish are <u>most closely-related</u> / the zebrafish is the <u>least closely-related</u> (1) • Yap hadal and Mariana snailfish evolved from the same {species / common ancestor} (1) • The common ancestor of the {Yap hadal snailfish / Mariana snailfish} {evolved from / had} the same common ancestor as the Tanaka's snailfish (1) • Zebrafish are the <u>most distantly-related</u> because they diverged from the others {about 240 million years ago / the longest time ago} (1)	**NB IGNORE** years given unless contradictory **ACCEPT** had the most recent common ancestor Tanaka's snailfish is <u>closer-related</u> to the zebrafish than the other snailfish as they have the closest common ancestor **ACCEPT** evolved from the same species **ACCEPT** the three snailfish are <u>more closely related</u> as they share a (more) recent common ancestor	(3)

Question Number	Indicative content
*7(b)(iv)	**Indicative content:** **Aspect 1 : Isolation** • common ancestor lived in same area • example of allopatric speciation • because in different trenches • geographical barrier • which is shallower water **Aspect 2 : Selection pressures** • conditions in two areas were different • e.g. temperature, food, predators • therefore different selection pressures / description of **Aspect 3 : Natural selection story** • two species evolved from the common ancestor they shared • mutations occurred (in DNA) • some giving rise to advantageous alleles • new phenotypes enabling survival • example of phenotype described • survivors reproduced and passed down their alleles • increase in allele frequencies **Aspect 4 : Decrease in gene flow** • gene flow reduced between two populations • no longer interbreed together • over time became two separate species as they cannot interbreed to produce fertile offspring • as would have become reproductively isolated • because {did not recognise mating behaviour / incompatible genitalia} **Aspect 5 : Epigenetics** • epigenetic modification occurred • different genes became permanently switched off in the two species • these changes were inherited

Level 1

1 mark = any relevant comment

2 marks = demonstration of **some** understanding of **1** aspect

Level 2

3 marks = Good understanding of **1** aspect + **1** other aspect mentioned

4 marks = Good understanding of **2** aspects + **1** other mentioned

Level 3

5 marks = Good understanding of **2** aspects + **2** others mentioned

6 marks = Good understanding of **3** aspects + **1** other aspect mentioned which includes some specific detail relating to question scenario

Question Number	Answer	Mark
2(a)	**The only correct answer is B** ***A*** *is not correct because glycosidic bonds join monosaccharides together* ***C*** *is not correct because peptide bonds join amino acids together* ***D*** *is not correct because phosphodiester bonds join adjacent mononucleotides together*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)	A description that makes reference to the following: • removal of the {shaded nucleotides / introns} (1) • attachment of ACC (and OH) (1) • joining with phosphodiester bonds (1)	**ACCEPT** shaded {parts / areas} **ACCEPT** adding {acceptor stem / amino acid binding site}	**(3)**

Question Number	Answer	Mark
2(c)(i)	**The only correct answer is B** ***A*** *is not correct because G binds to C and U to A* ***C*** *is not correct because G binds to C and U to A* ***D*** *is not correct because G binds to C and U to A*	**(1)**

Question Number	Answer	Mark
2(c)(ii)	**The only correct answer is C** ***A*** *is not correct because C binds to G and A binds to T on DNA* ***B*** *is not correct because C binds to G and A binds to T on DNA* ***D*** *is not correct because C binds to G and A binds to T on DNA*	**(1)**

Question Number	Answer	Mark
1 a i	**The only correct answer is B** ***A*** *is not correct because glycosidic bonds are in carbohydrates* ***C*** *is not correct because phosphodiester bonds are between the phosphate and base forming the backbone of the DNA molecule* ***D*** *is not correct because peptide bonds are in proteins*	**(1)**

Question Number	Answer	Mark
1 a ii	**The only correct answer is D** ***A*** *is not correct because proteins fold with bonds between amino acids and not with mRNA* ***B*** *is not correct because replication does not involve mRNA* ***C*** *is not correct because transcription forms mRNA from a DNA template*	**(1)**

Question Number	Answer	Mark
1 a iii	**The only correct answer is C** ***A*** *is not correct because proteins fold with bonds between amino acids and not with DNA* ***B*** *is not correct because replication is not involved in protein synthesis* ***D*** *is not correct because translation does not involve DNA*	**(1)**

Question Number	Answer	Mark
1(b)(i)	GTACGTATAGCC	**(1)**

Question Number	Answer	Mark
1(b)(ii)	GUACGUAUAGCC	**(1)**

Question Number	Answer	Mark
1(b)(iii)	4	**(1)**

Question Number	Answer	Mark
1(c)	**The only correct answer is B** ***A*** *is not correct because A + T will not equal C +G* ***C*** *is not correct because* A × T will not equal C × G ***D*** *is not correct because A/C will not equal T/G*	**(1)**

	Additional Guidance	Mark
ving:		
ffect /	**Accept** converse for chemical B / stopping translation	
growth ncreases	**Accept** correct mathematical comparison e.g. overall chemical A causes a 29% drop and chemical B causes a 100 % drop **Accept** transcription occurred before chemical A added	
proteins /	**Accept** pollen tube cannot grow without synthesis of new proteins	**(4)**

nal Guidance	Mark
ation:	
m = 5.7 mm	
ding from graph A ains full marks	
= maximum 1	**(2)**

r	Additional Guidance	M
id , triploid, haploid)		
perm nucleus is not diploid		
tube nucleus is not diploid		
e nucleus is not haploid but s is not diploid but haploid		

r	Additional Guidance	M
osis, mitosis, mitosis)		
division is not meiosis but the same		
ivision is not mitosis as the and third divisions are both the same and does not		
uclear division halves the vision does not halve the		(

Ma	(1

Ma	(1

Answer	Mark
ıe tRNA *ımplementary bases joined by hydrogen bonds* *uld be found on a DNA molecule in the nucleus*	**(1)**

	Additional Guidance	Mark
		(1)

	Additional Guidance	Mark
	[NB. penalise just once for inappropriate decimal places] ACCEPT 25 ACCEPT 21 ACCEPT 0	**(3)**

	Additional Guidance	Mark
		(1)

Answer	Mark
not occur in the Golgi apparatus *t translation takes place in the nucleus* *oplasmic reticulum does not have any ribosomes for translation*	**(1)**

Answer	Mark
n lipids *are in carbohydrates* *are bonds in the secondary not primary structure of the protein*	**(1)**

Number	Answer	Additional Guidance	Mark
2 (a)(i)	The only correct answer is: **C** low auxin, high cytokinin *A is incorrect as high auxin inhibits lateral shoots* *B is incorrect as high auxin inhibits lateral shoots* *D is incorrect as low cytokinin inhibits lateral shoots*		**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An explanation that makes reference to three of the following points: • auxin binds with {receptor / transcription factor} (inside cell / in cytoplasm / in nucleus) (1) • transcription factor becomes active / is activated (1) • transcription factor binds to {DNA / promoter} (1) • switches on / causes {transcription / production of RNA} (1)	**Accept** forms auxin-receptor complex **Accept** forms hormone-receptor complex **Do not accept** if receptor on cell membrane **Accept** transcription factor changes shape **Accept** auxin-receptor complex becomes a transcription factor **Accept** auxin-receptor complex binds to DNA / promoter (1)	**(3)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to four of the following points: • **more** seeds germinate when last colour is red (1) • number of exposures to light makes no difference (1) • significant difference when last colours are different as standard deviations do not overlap (1) • red light converts P_R into P_{FR} / far red light converts P_{FR} into P_R (1) • {P_{FR} stimulates/ P_R inhibits} {germination / gibberellin release / activation of amylase / abscisic acid}	**Allow** converse for FR light **Accept** no significant difference when last colours are same as standard deviations overlap (1) **Accept** P725 or P730 for P_{FR} / P665 or P660 for P_R **Accept** high P_{FR} : low P_R ratio stimulates germination	**(4)**

Question Number	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	An answer that makes reference to the following: • composed of protein and RNA (1) • (arranged in) two {(sub) units / parts} (1)	**ACCEPT** large and small subunit / 60S and 40S subunit / 50S and 30S subunit	(2)

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An answer that makes reference to two of the following: • translation (1) • to hold the tRNA on the mRNA (1) • whilst peptide bonds form to join (adjacent) amino acids together (1)		(2)

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	• {fewer / smaller} cristae / less folding of the inner membrane / reduced surface area of inner membrane		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to two of the following: • (fewer cristae / lower surface area) therefore reduced electron transport chain (1) • because ribosomes prevented from synthesising {enzymes / ATPase / electron transport molecules} (1) • credit reason linked to protein not made (1)	e.g. no enzymes to catalyse steps in Krebs cycle, no ATPase channels for {protons to pass through / phosphorylation of ADP}, no ETC so no redox reactions **ACCEPT** less intermembrane space for accumulation of protons = 1 mark	(2)

Question Number	Answer	Additional Guidance	Mark
5(b)(iii)	An explanation that makes reference to the following: • no ATP will be produced (if both inhibited / glycolysis inhibited) (1) • therefore no {energy / ATP} for metabolic process / named metabolic processes / cell division} (1)		(2)

Question Number	Answer	Mark
7(a)(i)	The only correct answer is D (no yes yes) *A is incorrect as the genetic code is not overlapping* *B is incorrect as the genetic code is not overlapping* *C is incorrect as eukaryotes do have introns*	**1**

Question Number	Answer	Additional guidance	Mark
7(a)(ii)	An explanation that makes reference to two of the following: • because most amino acids have more than one triplet / code is degenerate (1) • (genes contain) introns / non-coding DNA (1) • changing amino acid sequences affects {secondary structure / tertiary structure / quaternary structure / bonding / protein structure} (1)	**Allow** codon for triplet **Allow** converse	**2**

Question Number	Answer	Additional guidance	Mark
7 (a)(iii)	A description that makes reference to the following: • **DNA** sequencing (1) • use gel electrophoresis (1) • comparing DNA band patterns / use bioinformatics to compare sequences in databases (1)	**Allow** Sangar sequencing **Allow** description of gel electrophoresis **Allow** fragments for bands **Allow** DNA hybridisation between two species	**2**

Question Number	Indicative content
7 *(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions (D)** • more diversity in wild for trees / non-woody species / non-endangered species / most species have higher diversity in wild / converse for seedbank • more diversity in seedbanks for endangered species / species of economic interest / converse for wild • non-woody species and non-endangered species have high variability / wide standard deviations • endangered species / trees how lower variability / lower standard deviations • the age in seed banks increases, the number of differences increases **Explanations (E)** • less breeding in seed banks / reproduction in wild increases variation • less gene flow in seed bank / more genetic drift occurs in wild • in wild more meiosis / crossing over / independent assortment / mutation / random breeding (to generate variation) • in the wild there is more selection pressure / natural selection • trees are slower growing / live longer, so less diversity • non-woody species have high reproduction rate so increased number of genetic changes • (for most) having fewer seeds stored means lower diversity • for endangered species there is inbreeding / genetic bottleneck / small gene pool (so lower diversity) • non-endangered species have high diversity due to higher numbers of each species / more breeding **Validity of data and conservation role (V)** • correct comment on whether differences are significant or not linked to overlapping error bars • (there is a correlation between genetic differences of seeds with age) but many outliers / less data for longer times • different group sizes so difficult to make (valid) comparisons / some groups have low numbers / low sample size (reduces validity) • shows need to keep rebreeding plants in seed banks to maintain diversity

	• show seedbanks play role in maintaining genetic diversity for conservation of endangered species (as more diversity in the seedbank) • no idea which dot is which species in scatter graph

Level	Marks	
0	**0**	**No awardable content**
1	1-2 (1-3)	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. **One mark: any one comment from D, E, or V** **Two marks: any two comments from D, E, or V**
2	3-4 (4-6)	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. **Three marks: any three from two of D, E, or V** **Four marks: any four from two of D, E, or V**
3	5-6 (7-9)	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **Five marks: any five from D, E and V** **Six marks: any six from D, E, and V and must relate to both graphs**

	Additional Guidance	Mark
e following:		
(1)		
(1)	Reject amino acid**s**	
(1)	Allow {complementary base pairing / hydrogen bonds} between tRNA and mRNA	
(1)		
(1)		
		(4)

	Additional Guidance	Mark
following:		
(1)		
(1)	Allow amine and carboxylic acid and formulae	
(1)		
	Allow release of a water molecule	**(2)**

	Additional Guidance	Mar
llowing:	Allow the use of the term 'valid' Allow error bar, confidence limits or standard deviations for range bar	
ht of the columns for e control column (1)	Allow conclusion one not justified because there is an overlap between act D and control range bar	
en about time (1)		
as the range bar is nge bar is shorter in (1)		
e is no information s used / numbers of (1)		
		(4)

	Additional Guidance	Mar
he following:		
pollen grain (1)	Allow some mRNA can still be made e.g. if act D was a competitive inhibitor or transcription not completely inhibited	
sis} can take place (1)	Allow pollen tubes may already have the proteins they need for growth	
		(2)

Number	Answer	Additional Guidance	Mark
5(a)	An answer that makes reference to the following: **Similarities** • cytoplasm **(1)** • cell membrane **(1)** • ribosomes **(1)** **Differences** • eukaryotic cells contain {Membrane-bound organelles / named example e.g. mitochondria }, prokaryotic cells do not **(1)** • eukaryotic cells have 80S ribosomes, prokaryotic cells have 70S ribosomes **(1)** • eukaryotic cells have {a nucleus / nuclear envelope }, prokaryotic cells {have a nucleoid / do not have a nucleus} **(1)** • some eukaryotic cells have a cellulose cell wall and prokaryotic cells have a {murein / peptidoglycan} cell wall **(1)**	Max of 3 marks if only differences given **ACCEPT** eukaryotic cells have larger ribosomes **ACCEPT** as comparison: prokaryotes have free-floating genetic material (in the cytoplasm)	**(4)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	A description that makes reference to three of the following: • composed of nucleotides / nucleotides described **(1)** • nucleotides held together by phosphodiester bonds **(1)** • complementary base pairs held together by hydrogen bonds **(1)** • two {sugar phosphate backbones / polynucleotide chains / DNA strands} that form a double helix **(1)**	**ACCEPT** description e.g. between named base pairs	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to the following: • the DNA strands will not be able to separate / no template strand will be available **(1)** • leading to inhibition of {transcription / mRNA synthesis / RNA polymerase binding to DNA} **(1)** • DNA of both cell types are the same (structure) so both cell types affected **(1)**	**ACCEPT** DNA can't be unzipped	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(iii)	An explanation that makes reference to the following: • will inhibit {transcription / mRNA synthesis} **(1)** • because the RNA polymerase {will be inhibited / will not be able to bind to the DNA} **(1)** • each antibiotic affects different cell types because the (structure of) RNA polymerases are different **(1)**	**ACCEPT** cannot catalyse the reaction, prevent enzyme-substrate complex formation	**(3)**

Total for Question 5 = 13 MARKS

5(a)	endosperm		**(1)**

Question Number	Answer	Additional guidance	Mark
5(b)(i)	A description that makes reference to two the following: • DNA strands separate (1) • antisense strand used as template (for mRNA) (1) • RNA polymerase synthesises mRNA (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
5(b)(ii)	A description that makes reference to five of the following: • mRNA leaves through nuclear pores (1) • {translation occurs at / mRNA travels to} ribosomes / rough endoplasmic reticulum (1) • codons (on mRNA) pair with anticodons on tRNA / tRNA brings amino acid (to the ribosome) (1) • peptide bonds form between amino acids (1) • amylase enters Golgi and is {modified / processed} / amylase {is packaged into vesicles / travels in vesicles} (1) • exocytosis releases {amylase / protein} (1)	Accept protein for amylase Accept description for exocytosis	**(5)**

Question Number	Answer	Additional guidance	Mark
5(c)	An answer that makes reference to five of the following: • (soak grains in) range of at least five salt concentrations (1) • use {surface sterilised seeds / sterile agar / sterile Petri dishes} (1) • {wash / cut} grains and place onto starch agar (1) • leave for 24-48 hours (1) • add iodine (solution) (1) • measure {diameter/area} of clear zone (1)	Accept wash grains with bleach Accept leave {washed / cut} seed in starchy solution If alternative method used (grain in starch solution), accept use a colorimeter to measure absorbance	**(5)**

Number	Answer	Additional Guidance	Mark
10(a)(i)	• benzylpenicillin		(1)

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	An answer that makes reference to one of the following: • human cells are {eukaryotic / lack cell wall / lack peptidoglycan} (1) • human cells have different {ribosomes / enzymes} (1)	**ACCEPT** these antibiotics only affect prokaryotes	(1)

Question Number	Answer	Additional Guidance	Mark
10(b)	An explanation that makes reference to the following: • {binds to / changes shape of} the {enzyme / active site / RNA polymerase} (1) • therefore {transcription / mRNA synthesis} prevented (1) • no {proteins / polypeptides / enzymes} can be made (1)		(3)

Question Number	Answer	Additional Guidance	Mark
10(c)(i)	• multiplication (1) • division (1)	2×10^{10} divisions per day x 10^{-7} mutations per division / $2 \times 10^{10} = 20\,000\,000\,000$ $\div 10\,000\,000 / = 2\,000 / 2 \times 10^{3}$ Correct answer gains full marks, with no working shown ALLOW one mark for $20\,000\,000\,000 / \div 10\,000\,000 / 10 \times 10^{6} / 1 \times 10^{7}$	(2)

Question Number	Answer	Additional Guidance	Mark
10(c)(ii)	An explanation that makes reference to three of the following: • different {R groups / disulphide bonds / hydrogen bonds / ionic bonds} (1) • therefore different secondary / tertiary structure (1) • therefore different shaped ribosome (1) • therefore streptomycin cannot bind (to ribosome) (1)		(3)

Question Number	Answer	Additional Guidance	Mark
10(d)	An answer that makes reference to five of the following points: • same species of bacteria (1) • same {concentration / volume} of antibiotic (1) • use {agar / broth / culture medium} (1) • incubate between 20 ^{0}C and 25 ^{0}C for stated time (1) • measure {zone of inhibition / turbidity} (1) • use of described aseptic technique (1)	**DO NOT ACCEPT** less than 24 hours **e.g.** use of Bunsen burner / flame loop / swab bench	(5)

2(a)	• magnesium ions needed for chlorophyll (1) • nitrate needed for {protein / amino acids} (1) • (leaves gradually become greener) because it takes a while for chlorophyll to be made (1) • (delay in plant growth) because plant needs to photosynthesise before plant can grow (1)	**ACCEPT** greener because chlorophyl is made **ACCEPT** photosynthesis / protein synthesis needed for growth	**(3)** **EXP**

Question Number	Answer	Additional Guidance	Mark
2(b)	• 10 cm^3 fertiliser + 90 cm^3 water		**(1)** **GRAD**

Question Number	Answer	Additional Guidance	Mark
2(c)	• 0.6 (cm day^{-1})	**ACCEPT** 0.595 Do not accept 0.59	**(1)** **CLER**

Question Number	Answer	Additional Guidance	Mark
1(a)(i)	**The only correct answer is** C **A** is incorrect because magnesium ions are not incorporated into amino acids or nucleotides **B** is incorrect because magnesium ions are not incorporated into amino acids **D** is incorrect because magnesium ions are not incorporated into nucleotides		(1)

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	An explanation that makes reference to the following: • because water is {(di)polar } (solvent) (1) • ions form charged attractions / electrostatic attractions (with it) (1)	**ACCEPT** charged / hydrophilic **ACCEPT** form hydrogen bonds	(2)

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that makes reference to the following: • more nitrate ions are taken up in the presence of oxygen (1) • nitrate ions are taken up faster in the presence of oxygen (1) • Nitrates are taken up by (diffusion and) active transport in presence of oxygen/ nitrates only taken up by diffusion without oxygen present (1)	ACCEPT converse	(2)

Question Number			
1(a)(i)	• (calcium) pectate (1)	**IGNORE** middle lamella **DO NOT ACCEPT** any other molecule	(1)

Question Number	Answer	Mark
1(a)(ii)	**The only correct answer is C** ***A*** *is incorrect because statements 1 and 2 are correct and statement 3 is incorrect* ***B*** *is incorrect because statements 1 and 2 are correct and statement 3 is incorrect* ***D*** *is incorrect because statements 1 and 2 are correct and statement 3 is incorrect*	(1)

Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that makes reference to four of the following: • (decrease in concentration) due to K^+ {leaving (cell) / being used in synthesis of correct named molecule} **AND** (increase in concentration) due to K^+ being taken up (by cell) (1) • ions decrease {by (facilitated) diffusion / move down a concentration gradient} (1) • ions taken up by active transport (1) • (in aerobic conditions) oxygen available for aerobic respiration (1) • aerobic respiration generates (more) {ATP / energy} (1)	**PIECE TOGETHER** **ACCEPT** active transport cannot take place in anaerobic conditions **ACCEPT** converse **ACCEPT** converse	(4)

Question Number	Answer	Additional Guidance	Mark
4(a)	<table><tr><th rowspan="2">Molecule</th><th colspan="4">Mineral ions used</th></tr><tr><th>nitrate ions only</th><th>phosphate ions only</th><th>both nitrate and phosphate ions</th><th>neither nitrate nor phosphate ions</th></tr><tr><td>amino acid</td><td>X</td><td>☐</td><td>☐</td><td>☐</td></tr><tr><td>DNA</td><td>☐</td><td>☐</td><td>X</td><td>☐</td></tr></table>		(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	**The only correct answer is C** **A** is incorrect because 31 460 would be rounded up to 3.15×10^4 **B** is incorrect because 314 600 would be rounded up to 3.15×10^5 **D** is incorrect because 3 139 000 would be rounded up to 3.14×10^6		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	**The only correct answer is C** **A** is incorrect because symplast pathway does not go through cell walls **B** is incorrect because it shows the pathways the wrong way round **D** is incorrect because it shows apoplastic going through the cytoplasm		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)(iii)	**The only correct answer is B** *A is incorrect because water moves from a dilute solution to a more concentrated one* *B is incorrect because water moves from a high water potential to a lower one* *D is incorrect because water moves from a high water potential to a lower one*		(1)

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to the three of the following: • water has a (small) positively charged {hydrogen / end} and a (small) negatively charged {oxygen / end} (1) • therefore hydrogen bonds form (between water molecules) (1) • therefore water moved due to {cohesion / cohesive forces} (between water molecules) (1) • (because of) {adhesion / adhesive forces} between water and xylem (1)	**ACCEPT** cohesive properties **ACCEPT** adhesive properties water moves due to adhesive and cohesive forces = 1 mark if no other mark awarded	(3)

Question Number	Answer	Additional Guidance	Mark
5(a)	**The only correct answer is C** *A is incorrect because water is H_2O* *B is incorrect because water is H_2O* *D is incorrect because the H has the slightly positive charge and O has the slightly negative charge*		(1)

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An explanation that makes reference to two of the following: • because water forms (many) hydrogen bonds (1) • (which gives it a) high specific heat capacity (1) • so the temperature of the water rises less than the temperature of the land for the same input of energy (1)	**ACCEPT** H bonds / strong cohesive forces / very cohesive **ACCEPT** a lot of energy needed to raise temperature of water **NB** a lot of energy needed to break the H bonds to raise temperature of water = 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to the following: • because the (body) temperature of a fish {fluctuates with {external / water / ocean} temperature / cannot be regulated} (1) • need appropriate (body) temperature for {enzyme activity / metabolism} (1) • if temperature increased there would be less oxygen (dissolved) in the water for the fish (1)	**ACCEPT** organisms for fish throughout **ACCEPT** cold-blooded / poikilothermic helps keep fish' temperature constant **ACCEPT** temperature change could denature enzymes **ACCEPT** constant temperature maintains levels of prey for the fish	(2)

Question Number	Answer	Additional Guidance	Mark
5(c)	An explanation that makes reference to three of the following: • because water molecules are tightly bonded together (1) • by hydrogen bonds (1) • so water is incompressible (1) • shape of body changes because {pressure increases / volume does not increase} (1)	**ACCEPT** water molecules are close together / strong cohesive forces **DO NOT ACCEPT** adhesive forces **ACCEPT** so the water molecules cannot be pushed closer together	(3)

swer	Additional Guidance	Mark
(1)	Example of calculation 0.00002 x 9.8 = 0.000196	
y 50 (1)	0.000196 ÷ 20 = 0.0000098 (Nmm^{-1}) 0.000196 x 20 = 0.0098 (Nm^{-1}) Allow ECF from calculation of force	
ndard form with (1)	Correct answer with units scores all 3 marks 9.8 x 10^{-6} Nmm^{-1} 9.8 x 10^{-3} Nm^{-1} Allow 9.8 x 10^{-6} N Correct answer but incorrect units or no units scores 2 marks	**(3)**

Additional Guidance	Mar
dipolar description hydrogen slightly 'e and oxygen slightly negative hydrogen positive or oxygen ve	
RE adhesion	
description e.g. at air water ıce more hydrogen bonding is into ater	**(3)**

wer	Additional Guidance	Mark
e to the following:		
0 ($N\,m^{-1}$) (1)	Allow figure between 0.070 and 0.074 for interpretation of warm day	
kerted by the pond (1)	Consequential error from part (i)	
(than 15°C) the surface eater (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
5(a)	An explanation that makes reference to three of the following: • because water molecules are (di) polar (1) • due to even distribution of charge (1) • and therefore form hydrogen bonds between water molecules (1) • which are (high) cohesive forces (1) • only form between molecules to side and below, not with air • resulting in an {inward / downward} force (at the surface) (1)	ACCEPT H bonds between O^- and H^+ for mp1 & 3 ACCEPT cause cohesion ACCEPT (water) molecules pulled closer together	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An explanation that makes reference to two of the following: • the weight of the insect is spread out over a large area /insect has hairs on its legs, to {distribute weight / exert less downward, pressure / force} (1) • so the force of the mosquito is, less than the cohesive forces (of the water) / insufficient to break the H bonds (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to the following: • eggs sink because kerosene reduces surface tension (1) • by reducing the {number of hydrogen bonds that can form / cohesive forces} (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5(c)(i)	An answer that makes reference to two of the following: • two points read from the graph and divided by the temperature difference (1) • answer given in standard form to one dp (1)	1 mark for: 0.0001625 OR 0.0001666 Correct answer: 1.6×10^{-4} or 1.7×10^{-4} = 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(c)(ii)	An explanation that makes reference to two of the following: • water molecules {have more kinetic energy / vibrate more /move faster} (1) • reducing / breaking, the {hydrogen bonds / intermolecular attraction / cohesive forces} (1)		**(2)**