

PEARSON EDEXCEL IAL BIOLOGY • YBI11

BIOLOGY



EXAM QUESTION PACK

UNIT 1: MEMBRANES, PROTEINS, DNA AND GENE EXPRESSION

SCORE

/563

PERCENTAGE

%

STEMUP

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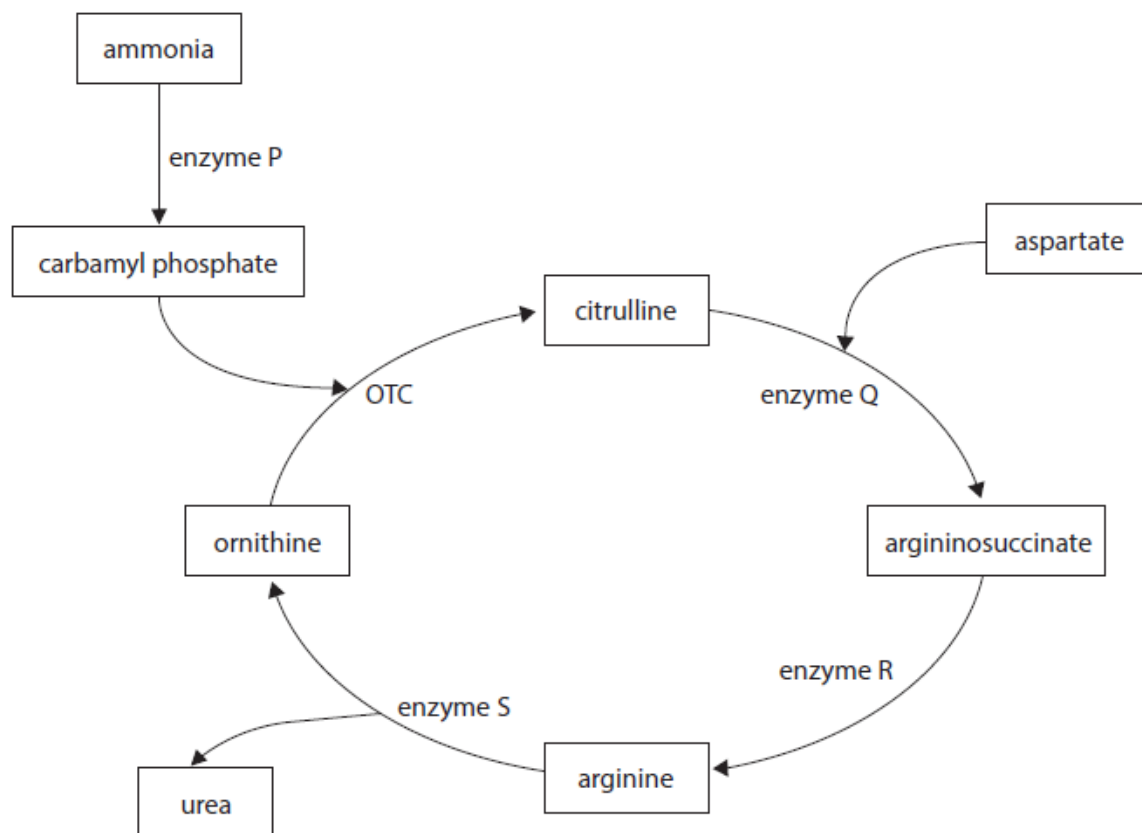
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Q1.

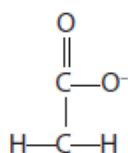
The amino acid aspartate is converted into the amino acid arginine in the urea cycle.

The urea cycle involves several enzymes and takes place in the liver.

The diagram shows part of the urea cycle.



(a) The R group of aspartate is



Draw the structure of the amino acid aspartate.

(3)

(b) Explain why several enzymes are involved in the urea cycle.

(3)

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(c) Ornithine transcarbamylase (OTC) is one enzyme involved in the urea cycle.

Ornithine transcarbamylase deficiency is an inherited genetic disorder.

(i) Suggest how a person can be shown to have this disorder.

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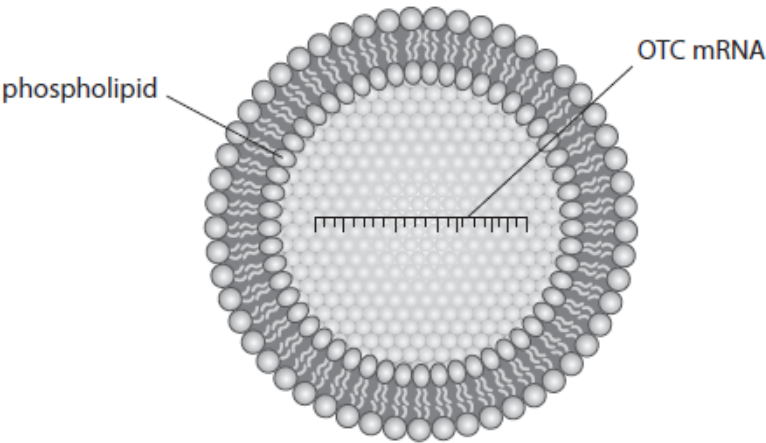
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*(ii) Targeted mRNA therapy is being developed to treat OTC deficiency in mice.

Targeted mRNA therapy involves injecting mice with phospholipid particles containing OTC mRNA.

These particles, shown in the diagram, target liver cells.



The table shows the results of one study using these particles.

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(Total for question = 15 marks)

Q2.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐ .

People with cystic fibrosis produce very thick, sticky mucus.

Cystic fibrosis is caused by mutations in a gene coding for the CFTR protein.

(a) Explain why a mutation in this gene results in the production of very thick, sticky mucus.

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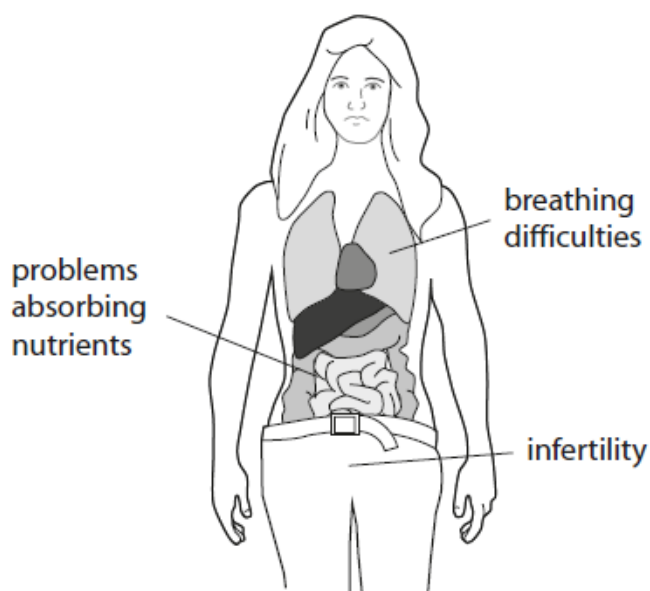
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(b) The diagram shows some health problems associated with cystic fibrosis, in a female.



Explain why very thick, sticky mucus results in these health problems.

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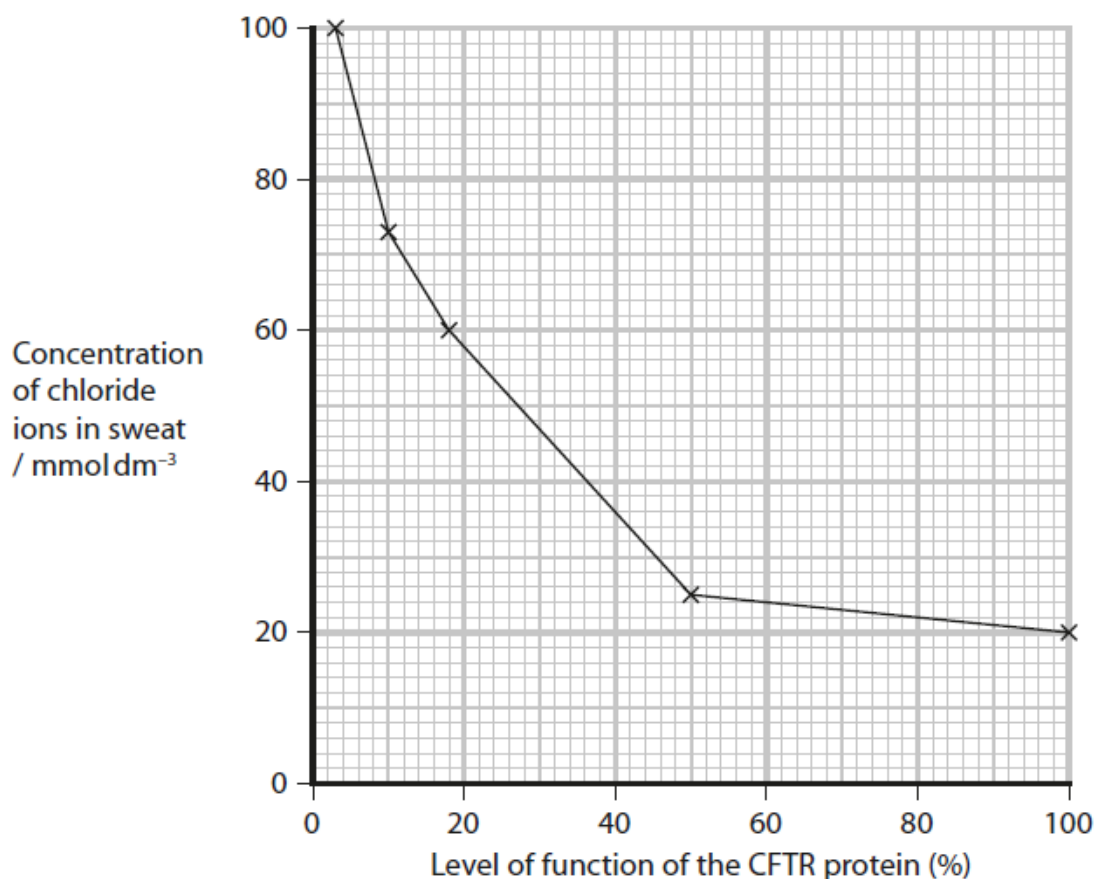
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(c) The graph shows the correlation between the concentration of chloride ions in sweat and the level of function of the CFTR protein.



Individuals diagnosed with cystic fibrosis have a level of function of the CFTR protein of 18% or less.

(i) Which is the change in concentration of chloride ions in the sweat of an individual when the level of function of CFTR protein decreased from 100% to 18%?

(1)

- ☐ **A** 15 mmol dm⁻³
- ☐ **B** 35 mmol dm⁻³
- ☐ **C** 40 mmol dm⁻³
- ☐ **D** 80 mmol dm⁻³

(ii) Cystic fibrosis results from different mutations in the CFTR gene.

Explain how the graph provides evidence that cystic fibrosis results from different mutations in the CFTR gene.

(2)

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(Total for question = 11 marks)

Q3.

A number of diseases are associated with lifestyle risk factors.

Some of these risk factors cause mutations.

(a) Mutations can give rise to cancer.

State the meaning of the term **mutation**.

(1)

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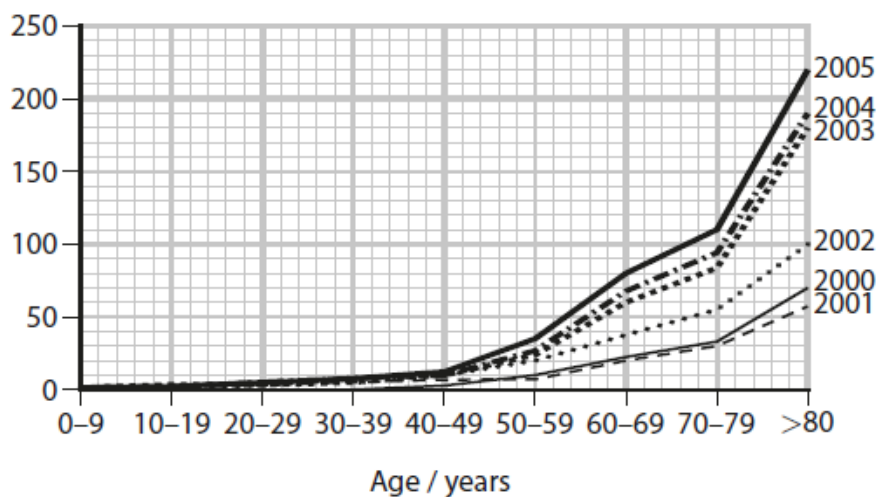
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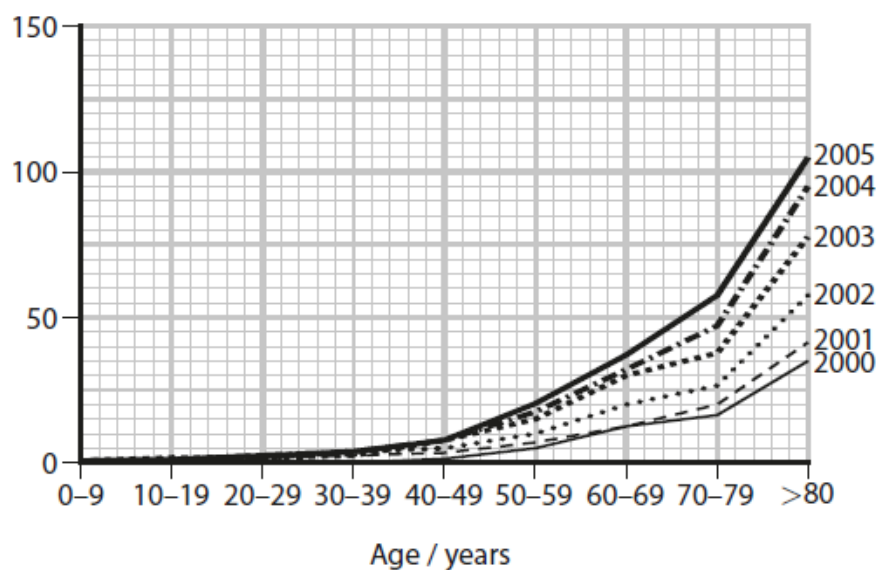
(b) Exposure to ultraviolet light is associated with the development of skin cancer.

The graphs show the incidence of skin cancer in males and females in one country in the Far East, from 2000 to 2005.

Incidence of skin cancer per 100 000 of the male population



Incidence of skin cancer per 100 000 of the female population



(i) The graphs show some correlations.

State the meaning of the term **correlation**.

(1)

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(ii) Describe the correlations shown by these graphs.

(3)

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(iii) Suggest a reason for each of the correlations shown by these graphs.

(3)

*(c) The table shows some information from a study of the incidence of emphysema in smokers and non-smokers.

Information	Males	Females
Number of individuals in the study	25	25
Mean age when diagnosed / years	53.1	54.2
Range of ages when diagnosed / years	32 to 77	34 to 68
Number of smokers	5	6
Number of non-smokers	20	19
Number of smokers with emphysema	1	6
Number of non-smokers with emphysema	0	0

Criticise the design of this study.

(6)

(Total for question = 14 marks)

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

When the blood glucose level of a person without diabetes becomes too high, the liver stores glucose as a polysaccharide.

(1)

- ☐ **A** amylopectin
- ☐ **B** cellulose
- ☐ **C** glycogen
- ☐ **D** starch

(b) Blood glucose levels can become high following the digestion of carbohydrates.

Which of the following can be digested to release glucose?

(1)

- ☐ **A** both fructose and sucrose
- ☐ **B** both fructose and galactose
- ☐ **C** both galactose and lactose
- ☐ **D** both lactose and sucrose

(c) Diabetes is a risk factor for cardiovascular disease.

(i) One estimate is that there are 415 million people with diabetes in the world and that 46% of these people are undiagnosed.

Calculate the number of people who have undiagnosed diabetes.

(1)

Answer

(ii) There are two types of diabetes, Type I and Type II.

The treatment for Type I diabetes is different from the treatment for Type II diabetes, so it is important for a correct diagnosis to be made.

Diagnosis can be difficult, particularly in people aged between 20 and 40 years old.

A genetic screening method is now available for the diagnosis of diabetes.

Explain why doctors are more likely to screen individuals once they develop diabetes than use methods such as prenatal testing.

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(Total for question = 6 marks)

Q5.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

Enzymes are biological catalysts that have an effect on the energy required for a reaction.

(a) State the meaning of the term **biological catalyst**.

(2)

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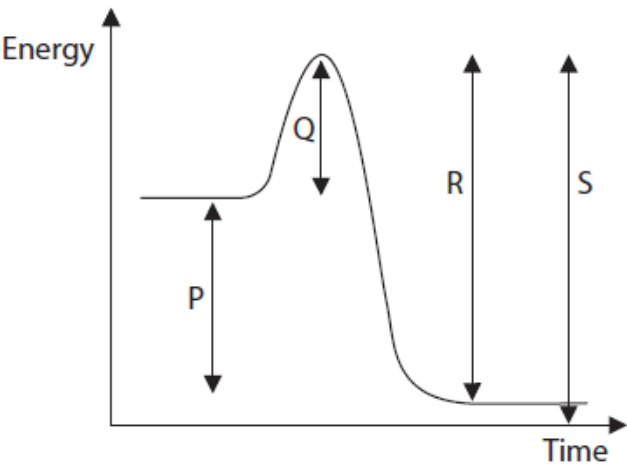
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(b) The graph shows the energy changes during an enzyme catalysed reaction.



Which arrow shows the energy required to start the reaction?

(1)

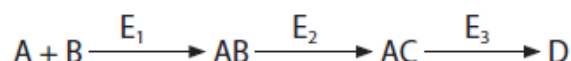
☐ **A** P

☐ **B** Q

☐ **C** R

☐ **D** S

(c) The diagram shows a series of chemical reactions.



Three different enzymes, E_1 , E_2 and E_3 , are involved in these reactions.

Explain why E_1 cannot convert AB into AC or AC into D.

Use the information in the diagram to support your answer.

(3)

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(d) Pectinase is an enzyme that breaks down pectin.

The effect of different combinations of pH and temperature on pectinase activity was investigated.

The volume and concentration of pectinase and pectin were kept the same in all reactions.

The table shows the rate of reaction for each pH and temperature combination tested.

pH	Temperature / °C	Rate of reaction / a.u.
2	5	0
2	30	0
2	60	0
4	5	5
4	30	35
4	60	0
8	5	5
8	30	10
8	60	0

Describe **two** conclusions that can be drawn from these results.

(2)

- 1
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- 2
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(Total for question = 8 marks)

Q6.

Haemophilia A is an inherited genetic disorder.

Haemophilia A results in the blood not being able to clot.

(a) The table gives some information about blood clotting components.

Complete the table by filling in the empty boxes with either the name of the component, the role

of the component or the solubility of the component.

(6)

Name	Role	Solubility
thromboplastin		soluble
.....	catalyses the conversion of fibrinogen into fibrin	
fibrin	1 2	

(b) Haemophilia A is inherited in a similar way to red-green colour blindness.

Explain why more males than females are affected with haemophilia A.

(3)

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(Total for question = 9 marks)

Q7.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Warfarin is a drug used to treat people who have a blood clot.

(a) (i) Read through the following passage about warfarin.

Write on the dotted lines the most appropriate word or words to complete the passage.

(3)

Warfarin is used to treat people with blood clots as it lowers the number of clotting factors in the blood.

One clotting factor in blood is prothrombin.

Prothrombin is converted to the enzyme thrombin by

The of thrombin binds to fibrinogen and as a result a mesh of fibres and is formed.

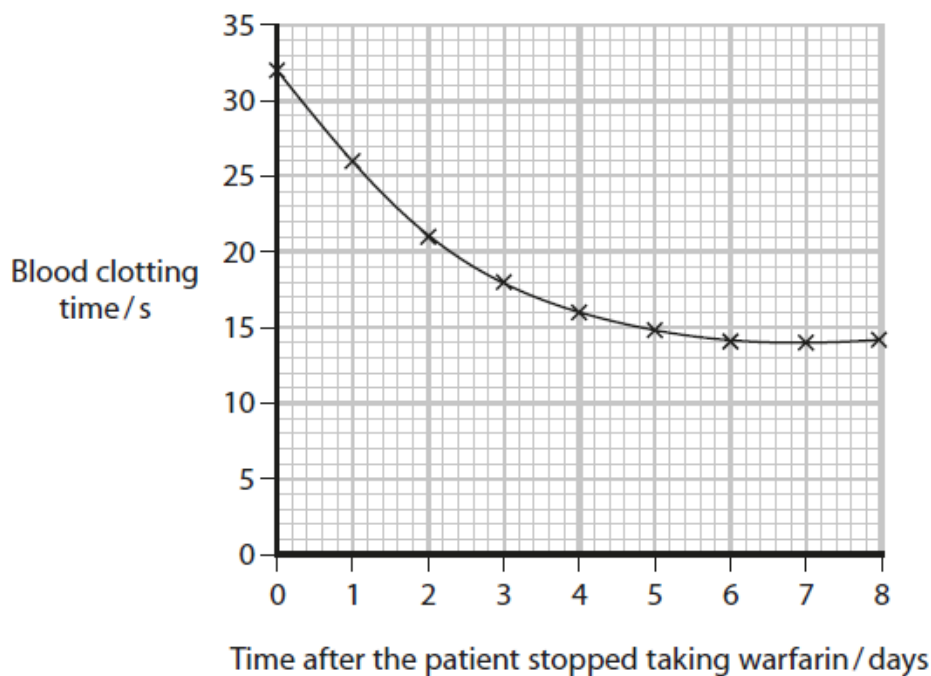
(ii) Which type of drug is warfarin?

(1)

- ☐ **A** an anticoagulant
- ☐ **B** an antihypertensive
- ☐ **C** a platelet inhibitor
- ☐ **D** a statin

(b) The time taken for a blood sample to form a blood clot can be measured. This is called the clotting time.

The graph shows the blood clotting time after a patient has stopped taking warfarin.



Calculate the rate of decrease in the clotting time at two days after stopping taking warfarin.
Use a tangent for your calculation.

(2)

Answer

(Total for question = 6 marks)

Q8.

The structure of blood vessels relates to their function.

(a) Describe how the structure of capillaries relates to their function.

(2)

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(b) Draw a cross-section of an artery to show details of its structure.

Label **two** features of the artery on your diagram.

(3)

(c) Explain why veins need valves along their length.

(2)

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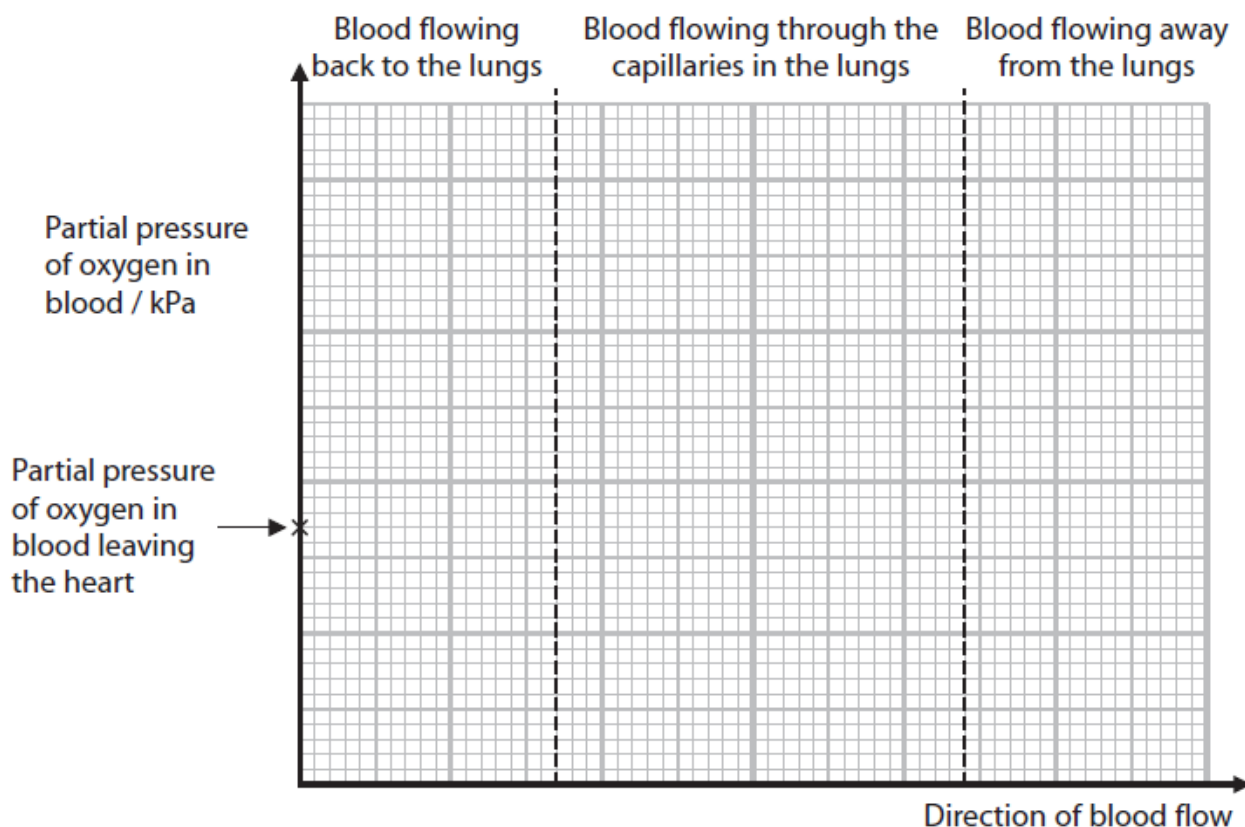
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(d) Deoxygenated blood is taken to the lungs and oxygenated blood is taken away from the lungs.

Complete the graph to show the changes in partial pressure of oxygen in the blood as it flows back to the lungs, through the lungs and away from the lungs.

(3)



(Total for question = 10 marks)

Q9.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

The butterfly is an insect that feeds on nectar produced by flowers.

The photograph shows a butterfly feeding on a flower.



(Source: James Schwabel / Alamy Stock Photo)

(a) The nectar in flowers contains nutrients including sugars, amino acids and lipids.

(i) The sugars in the nectar are fructose, glucose and sucrose.

Which of these contain glycosidic bonds?

(1)

- ☐ **A** fructose only
- ☐ **B** sucrose only
- ☐ **C** fructose and glucose
- ☐ **D** fructose and sucrose

(ii) Which row of the table describes how amino acids are joined together to form a protein?

(1)

	name of bond	type of reaction
☐ A	ester	condensation
☐ B	ester	hydrolysis
☐ C	peptide	condensation
☐ D	peptide	hydrolysis

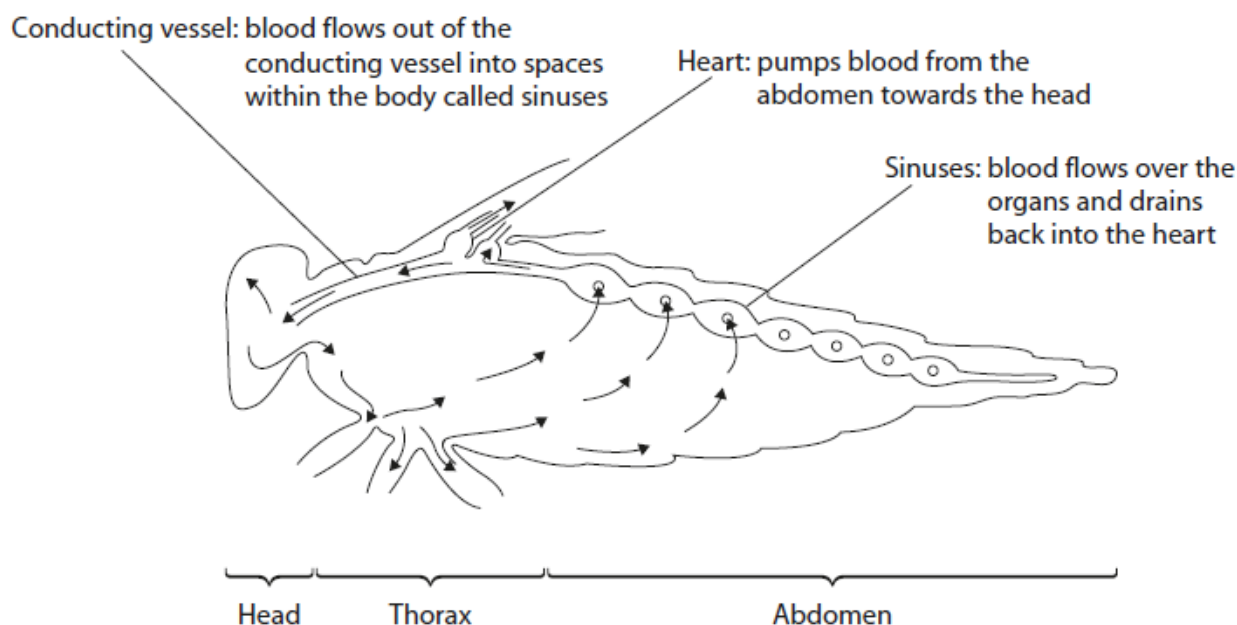
(iii) Which row of the table describes a saturated lipid?

(1)

	carbon-carbon double bonds	carbon : hydrogen ratio
☐ A	absent	higher than in an unsaturated fatty acid chain
☐ B	absent	lower than in an unsaturated fatty acid chain
☐ C	present	higher than in an unsaturated fatty acid chain
☐ D	present	lower than in an unsaturated fatty acid chain

(b) The circulatory system of an insect is described as an open system. This means that the blood is not contained inside blood vessels but flows through cavities called sinuses.

The diagram shows part of the circulatory system of an insect.



(i) The length of the head of a butterfly is 4 mm, the thorax is 6 mm and the abdomen is 18 mm.

Estimate the surface area to volume ratio of the butterfly.

Assume that the insect is a cylinder of diameter 4 mm and the surface area is 360 mm².

(2)

Answer

(ii) Explain why the circulation of a butterfly is different from the circulation of a mammal.

(2)

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(iii) The blood flowing through the sinuses of the butterfly is separated from the organs by collagen.

Describe the structure of collagen.

(2)

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(Total for question = 6 marks)

Q10.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Mutations can give rise to cancer or genetic disorders.

(a) Cancer is one of the main causes of death in the world.

In 2018, in the UK, there were 541 589 deaths in total and 166 800 of these were due to cancer.

Calculate the ratio of deaths caused by cancer to deaths not caused by cancer.

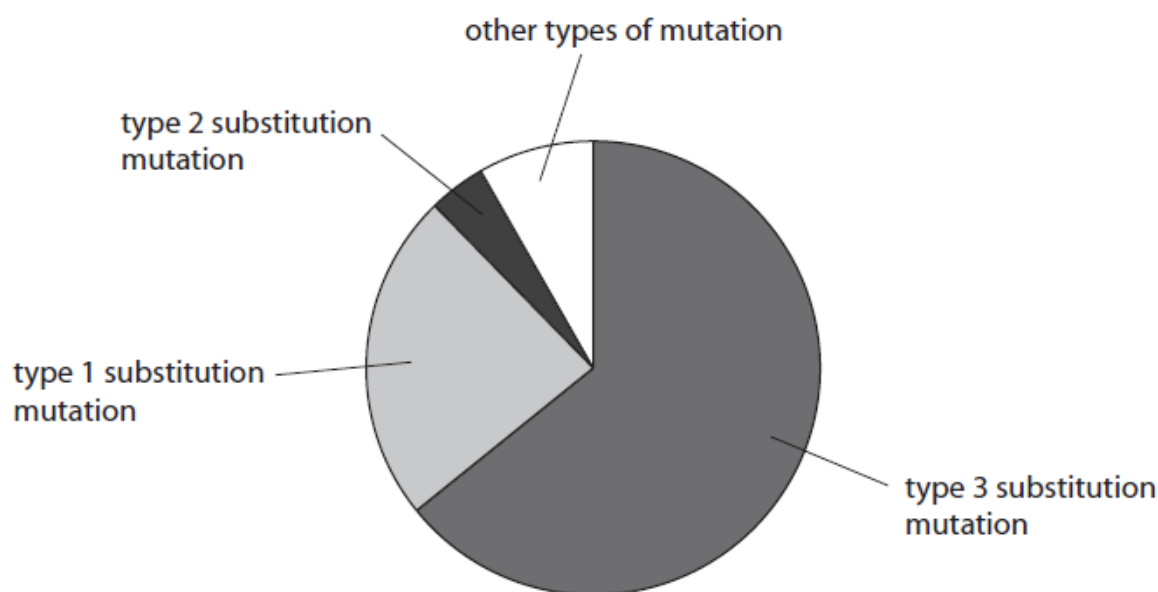
Give your answer to two decimal places.

(2)

Answer

(b) Scientists have identified many mutations in cancer cells and are trying to identify the mutations that are significant.

The chart shows the proportion of cancers caused by some types of mutation.



(i) Name **two** other types of mutation.

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2

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(ii) Estimate the percentage of cancers caused by type 3 substitution mutations.

(1)

Answer

.....%

(iii) A type 1 substitution mutation in a gene alters the DNA and mRNA but does **not** affect the protein synthesised from the mutated gene.

Explain how a substitution mutation can alter the DNA and mRNA but **not** the protein.

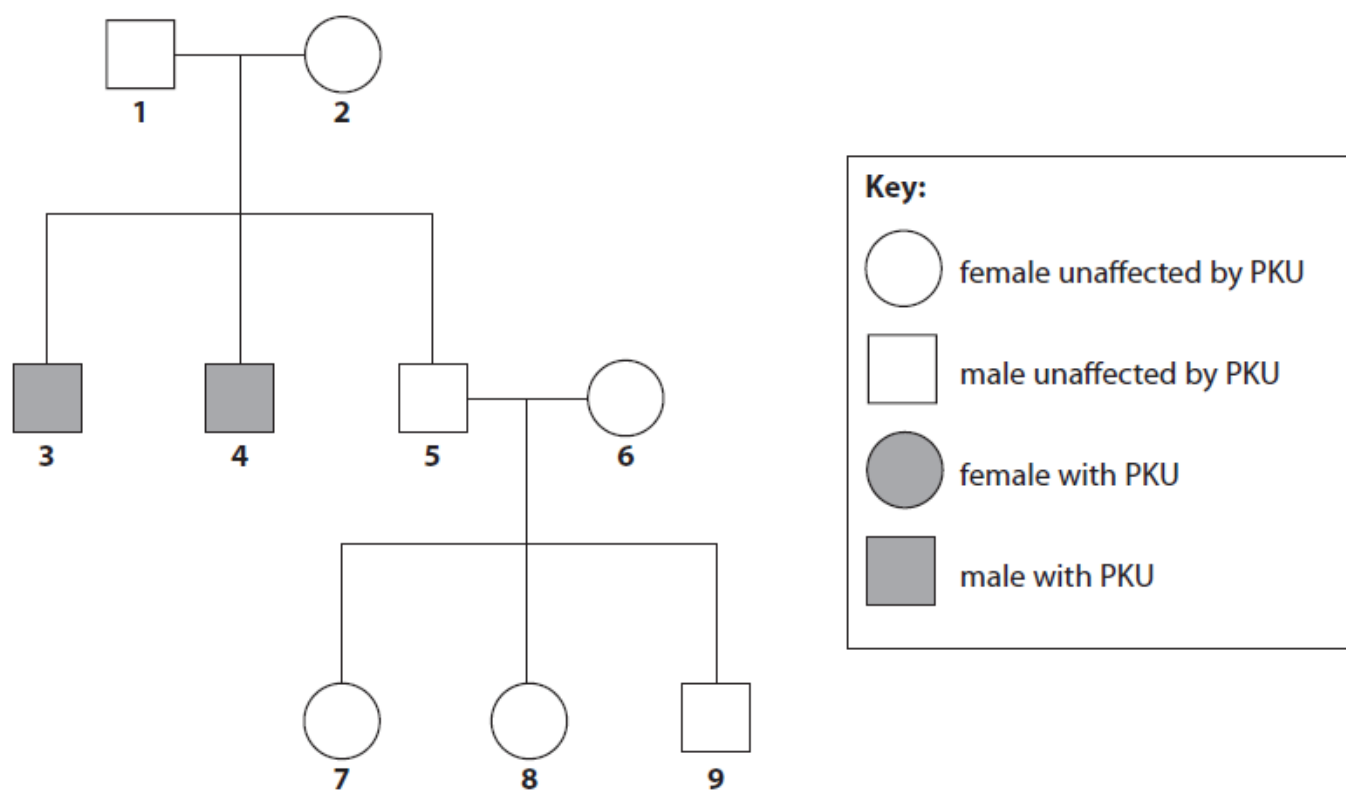
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(c) Phenylketonuria (PKU) is a genetic disorder.

This disorder is inherited in a similar way to cystic fibrosis.

The pedigree diagram shows the phenotypes of individuals in one family affected by PKU.



(i) What is the probability of couple **1** and **2** having a fourth child that is a male affected by PKU?

(1)

☒ **A** 0.000

☐

B 0.125

☐ **C** 0.250

☐ **D** 0.500

* (ii) Discuss the extent to which this pedigree diagram can be used to identify the genotypes of all the members of this family.

(6)

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Q11.

The cell membrane is important in the control of which substances can enter and leave the cell.

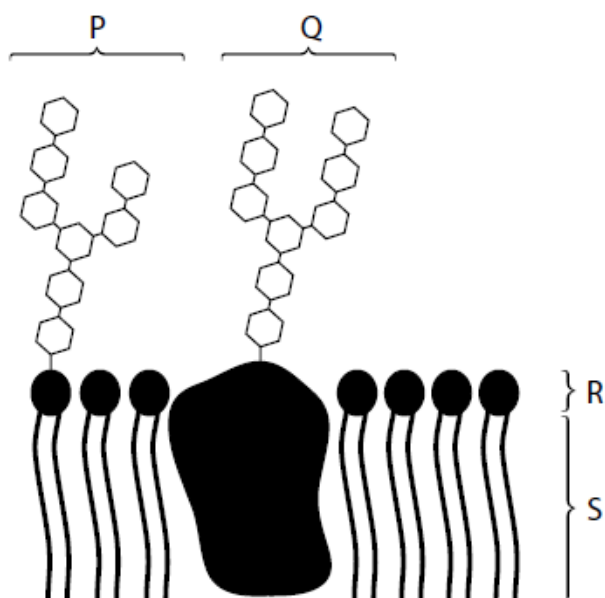
(a) The cell membrane consists of a phospholipid bilayer.

(i) Why do phospholipids form a bilayer?

(1)

- ☐ **A** the hydrophobic heads dissolve in the aqueous (water) environment
- ☐ **B** the hydrophobic heads move away from the aqueous (water) environment
- ☐ **C** the hydrophobic tails dissolve in the aqueous (water) environment
- ☐ **D** the hydrophobic tails move away from the aqueous (water) environment

(ii) This diagram shows part of a cell membrane.



Which letter represents a membrane glycoprotein?

(1)

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

(b) State what is meant by the term **osmosis**.

(1)

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(c) Compare and contrast exocytosis and endocytosis.

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(d) Explain why oxygen molecules can pass directly through the cell membrane.

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(Total for question = 9 marks)

Q12.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The cell membrane controls which substances can enter and leave a cell.

The cell membrane is a phospholipid bilayer with proteins embedded in it.

(a) (i) The shapes show the components of a phospholipid.

phosphate group



glycerol



fatty acid



covalent bond



Draw a diagram to show the structure of a phospholipid, using these shapes.

(2)

(ii) Which type of bond is found in this molecule?

(1)

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

(b) (i) How does a nonpolar molecule move through a cell membrane, down a concentration gradient into a cell?

(1)

- ☒ **A** by active transport
- ☒ **B** by diffusion
- ☒ **C** by exocytosis
- ☒ **D** by osmosis

(ii) How many of the following statements are correct for the transport of a substance by endocytosis?

- transports substances out of the cell
- the cell membrane surrounds the substance
- can only transport substances down a concentration gradient

(1)

- ☐ **A** none
- ☐ **B** one
- ☐ **C** two
- ☐ **D** three

(Total for question = 5 marks)

Q13.

The structure and properties of the cell membrane are important in controlling which molecules can enter and leave a cell.

(a) The photograph shows part of a cell membrane, as seen using an electron microscope.



(Source: © Dennis Kunkel Microscopy / Science Photo Library)

The width of this cell membrane is 5.00 nm.

A phosphate head of a phospholipid is between 0.8 and 0.9 nm in diameter and the fatty acid tails are between 1.25 and 1.75 nm long.

Explain how this electron micrograph provides evidence for the structure of the cell membrane.

Use the information given to support your answer.

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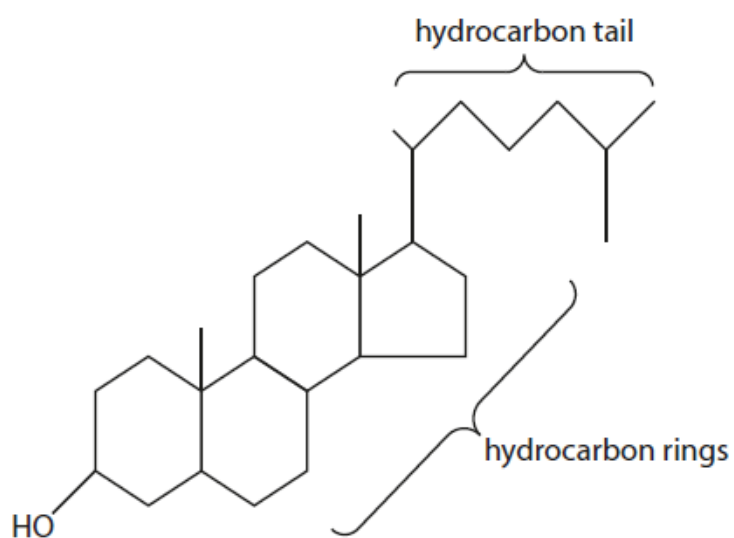
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(b) Cell membranes contain cholesterol.

The molecular formula of cholesterol is $C_{27}H_{46}O$.

The diagram shows a cholesterol molecule.



Explain the location of cholesterol in cell membranes.

Use the information in the diagram to support your answer.

(3)

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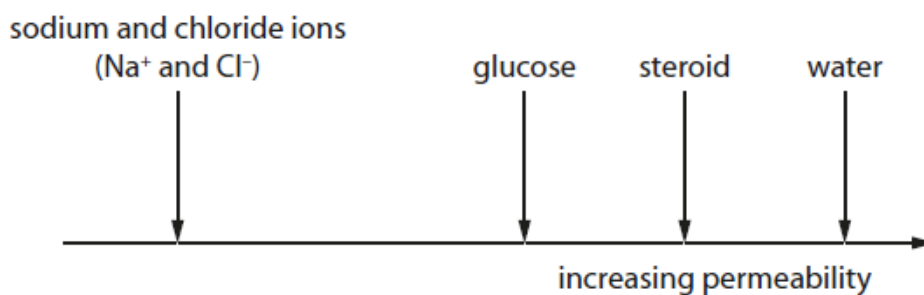
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(c) The diagram shows the permeability of cell membranes to some chemicals.



The sodium and chloride ions, glucose and water are polar chemicals.

A steroid is a non-polar chemical.

(i) Describe the dipolar nature of water.

(2)

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(ii) Explain the permeability of cell membranes to each chemical shown in the diagram.

(4)

(Total for question = 12 marks)

Q14.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The components of a cell membrane determine its properties.

The membrane is a phospholipid bilayer.

(a) The table shows one way that the components of phospholipids can be drawn.

Component	Way of drawing the component
phosphate group	
glycerol	
fatty acid	
bond	

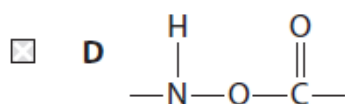
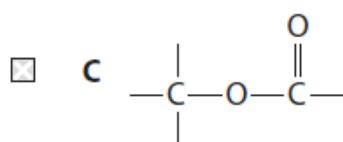
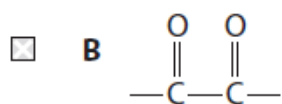
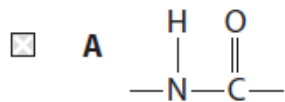
(i) Draw a diagram of a phospholipid, using the information in the table.

(2)

(ii) One of the bonds present in phospholipids is an ester bond.

Which diagram shows an ester bond?

(1)



(b) The fluidity of a membrane is increased by a number of factors:

- increase in temperature
- increase in the proportion of unsaturated fatty acids
- decrease in cholesterol
- fatty acids with shorter side chains.

(i) Explain why an increase in temperature increases the fluidity of the membrane.

(2)

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(ii) Which row in the table describes an unsaturated fatty acid compared with a saturated fatty acid with the same number of carbon atoms?

(1)

	Has double bonds between two carbons	Number of hydrogens
☐ A	no	fewer than the saturated fatty acid
☐ B	no	more than the saturated fatty acid
☐ C	yes	fewer than the saturated fatty acid
☐ D	yes	more than the saturated fatty acid

(iii) Explain why a decrease in cholesterol increases the fluidity of the membrane.

(2)

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(iv) Suggest why a fatty acid with a shorter side chain will increase the fluidity of a membrane.

(1)

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(c) Studies have shown that when fish are moved into water at a lower temperature, the fatty acid content of their membranes changes.

(i) Suggest how the content of the fatty acids in these membranes may have changed.

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(ii) Suggest why these changes are necessary for the survival of the fish.

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(Total for question = 13 marks)

Q15.

Collagen is a component of the wall of the aorta.

(a) (i) Describe the structure of collagen.

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(ii) Explain the role of collagen in the wall of the aorta.

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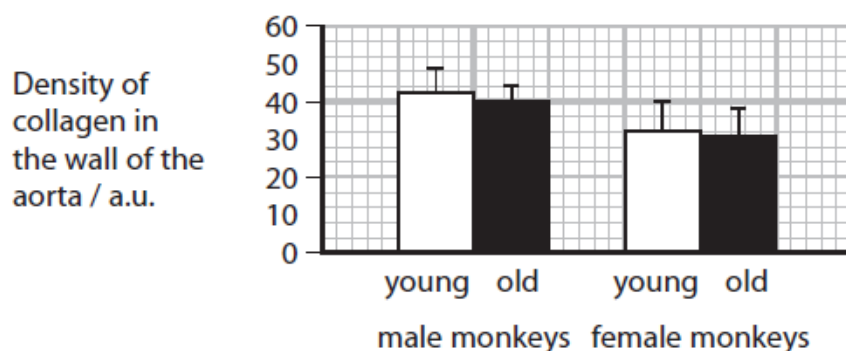
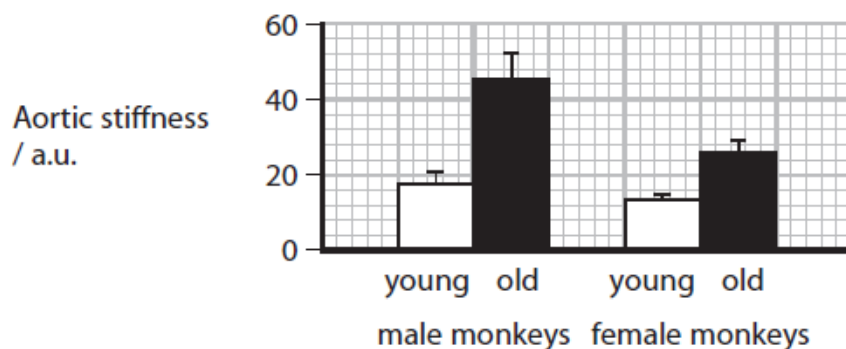
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*(b) Age and sex affect the types and density of collagen found in the wall of the aorta.

These are thought to cause aortic stiffness.

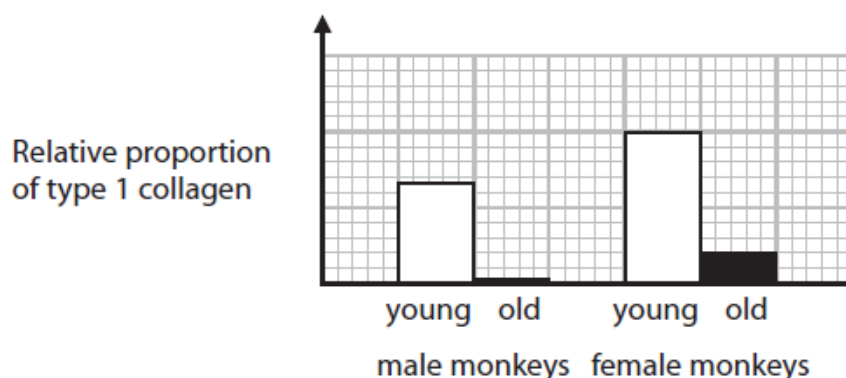
In one study, scientists investigated the effect of age and sex on aortic stiffness and the density of collagen in the wall of the aorta.

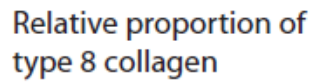
The graphs show the results of this study.



In another study, scientists investigated the effect of age and sex on two types of collagen present in the wall of the aorta.

The graphs show the relative proportion of each type of collagen in each group of monkeys.





Use the information in the graphs to support your answer.

This image shows a full page of white paper with horizontal dashed lines, resembling notebook paper. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

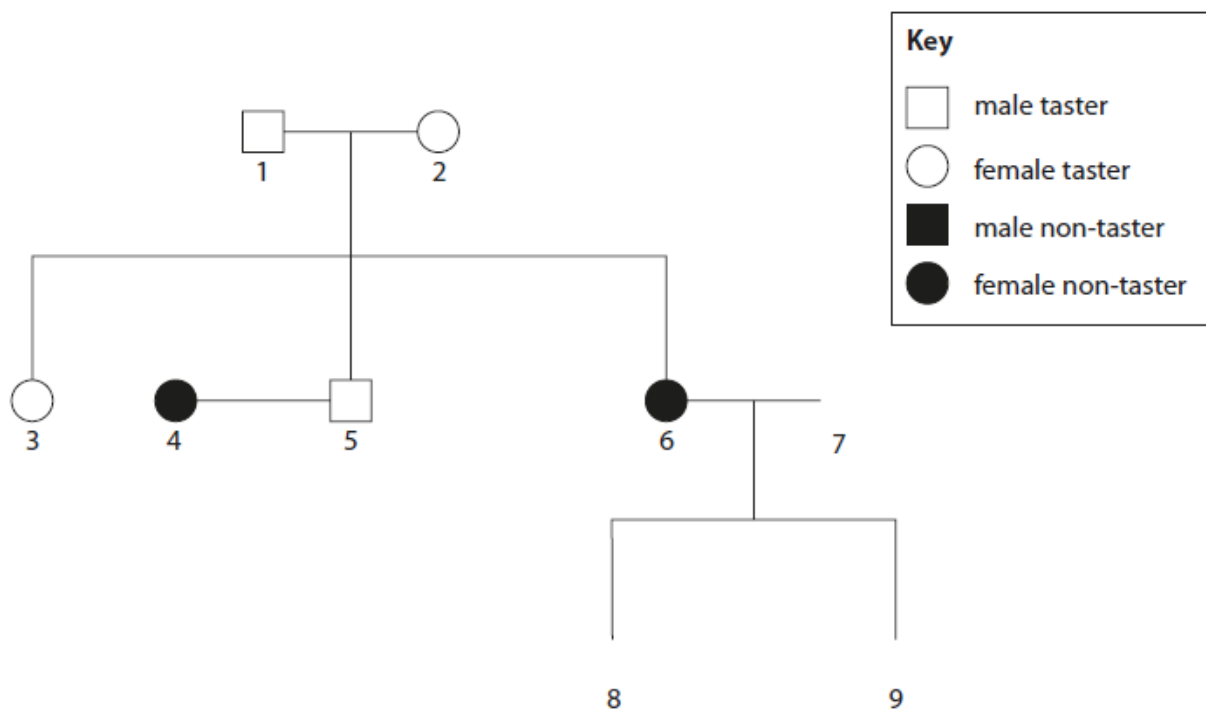
(Total for question = 11 marks)

Q16.

Phenylthiocarbamide (PTC) is a chemical that has a very bitter taste to some individuals (tasters).

The ability to taste PTC is determined by a gene that codes for a bitter-taste receptor on the tongue.

The pedigree diagram shows some of the tasters and non-tasters in a family.



(a) Complete the diagram to show the following information:

(1)

- individual 7 as a male taster
- individual 8 as a male non-taster
- individual 9 as a female taster.

(b) Describe the difference between each of the following pairs of terms, using the information in the pedigree diagram to illustrate your answer.

(i) Gene and allele

(2)

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(ii) Genotype and phenotype

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(c) Explain which is the dominant allele.

Use the information in the pedigree diagram to support your answer.

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(d) Explain why this gene is unlikely to be located on the X chromosome.

Use the information in the pedigree diagram to support your answer.

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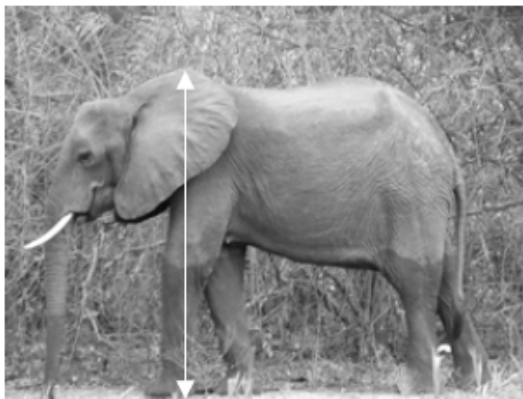
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(Total for question = 9 marks)

Q17.

The photographs show two mammals, an elephant and a mouse.



Magnification $\times 0.02$

(a) The height of a mouse is 3 cm.

Calculate how many times taller an elephant is than a mouse.

Use the white line drawn on the photograph of the elephant to calculate this value.

(2)

Answer

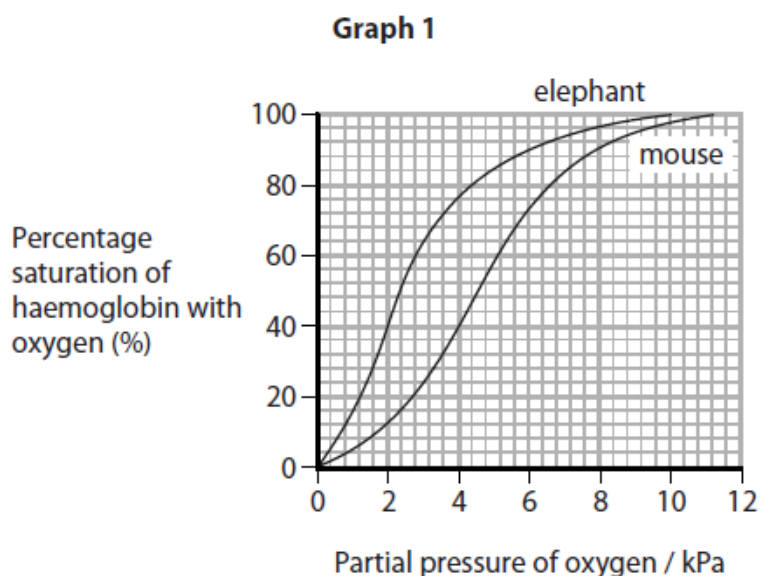
(b) The respiratory system of an elephant is different from that of other mammals.

The lungs are attached to the chest cavity wall and diaphragm by collagen fibres.

Describe how the lungs of an elephant are adapted for gas exchange.

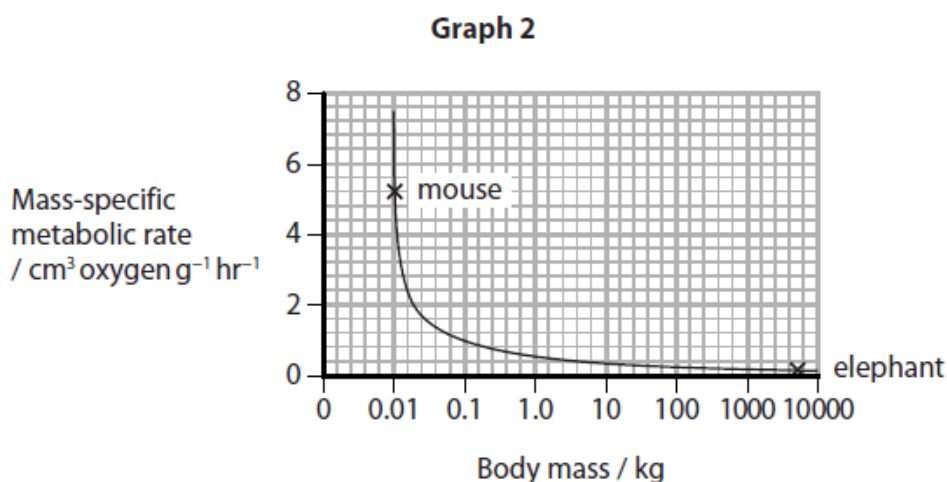
(3)

* (c) Graph 1 shows the oxygen dissociation curve of haemoglobin for a mouse and for an elephant.



Graph 2 shows the mass-specific metabolic rate for a mouse and for an elephant.

Mass-specific metabolic rate is a measure of how much oxygen is needed for chemical reactions per gram of body tissue.



Explain the difference in the oxygen dissociation curves of haemoglobin for a mouse and for an elephant.

Use the information in both graphs to support your answer.

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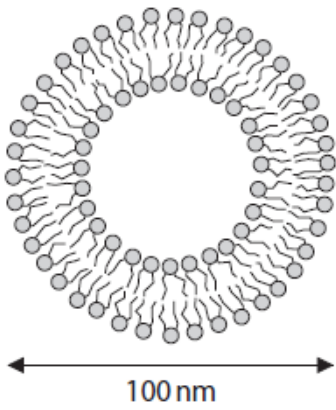
(Total for question = 11 marks)

Q18.

Liposomes are spherical structures composed of phospholipids. They can be made by adding phospholipids to water.

Liposomes can be used to study membrane permeability.

(a) The diagram shows a liposome.



(i) Calculate the volume of this liposome, using the formula

$$V = \frac{4}{3} \pi r^3$$

(2)

Answer

(ii) Explain the arrangement of phospholipids in liposomes.

(2)

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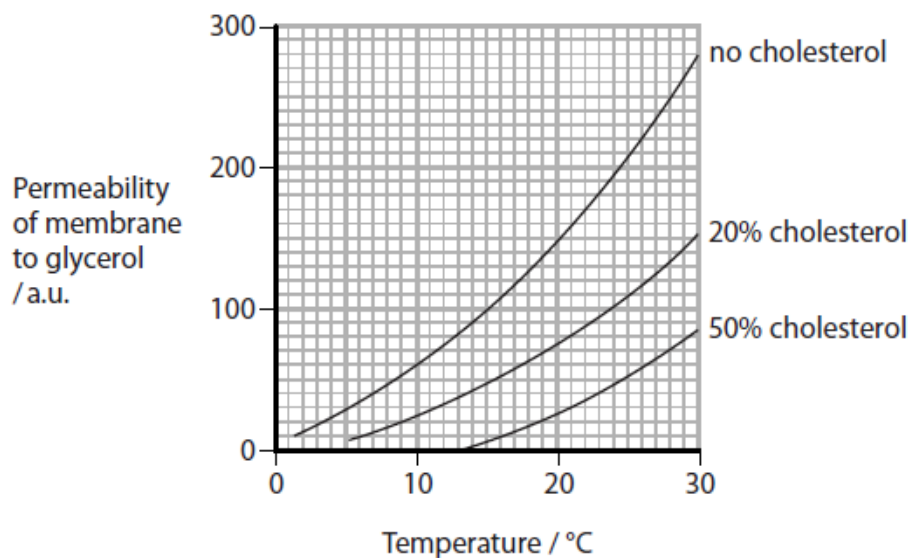
(b) The presence of cholesterol in the membrane affects membrane permeability.

A student investigated the effect of cholesterol on the permeability of liposomes to glycerol at different temperatures.

Liposomes were made by replacing 20% and 50% of the phospholipid with cholesterol.

Liposomes without cholesterol were also made.

The graph shows the results of this investigation.



(i) How does glycerol pass through the liposome membrane?

(1)

- ☐ **A** active transport
- ☐ **B** diffusion
- ☐ **C** endocytosis
- ☐ **D** osmosis

(ii) Describe the effects of cholesterol and temperature on membrane permeability, as shown in the graph.

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(iii) Explain why cholesterol and temperature affect membrane permeability.

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(Total for question = 10 marks)

Q19.

Polysaccharides, lipids, nucleic acids and proteins are large molecules found in living organisms.

(a) Polymers are large molecules made of monomers. The table gives information about some of these polymers.

Complete the table by filling in the empty boxes with either the name of the monomer, the elements present in each monomer or the type of bond between monomers.

(4)

Polymer	Monomer	Elements present in monomer	Type of bond between monomers
polysaccharides	monosaccharide		glycosidic
nucleic acid		carbon, hydrogen, oxygen, phosphorus and nitrogen	
protein	amino acid		peptide

(b) Triglycerides are lipids.

Describe how an unsaturated triglyceride is synthesised.

(3)

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(Total for question = 7 marks)

Q20.

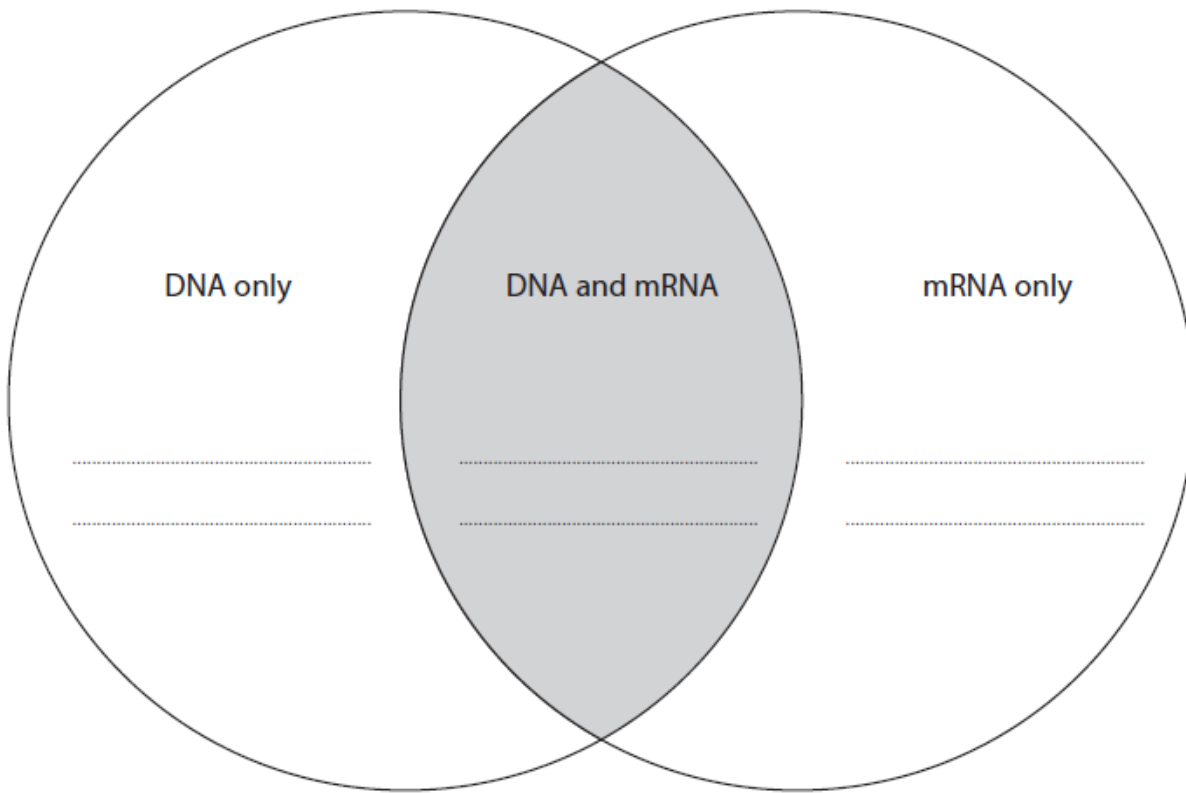
Polynucleotides include DNA and messenger RNA (mRNA).

Some components of polynucleotides are found in both DNA and mRNA.
Other components are found only in DNA or in mRNA.

A Venn diagram can be drawn to represent this information. Components found in both DNA and mRNA are written in the part of the diagram where the circles overlap.

Complete the Venn diagram by writing the name of **two** components in each part of the diagram.

(6)



(Total for question = 6 marks)

Q21.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

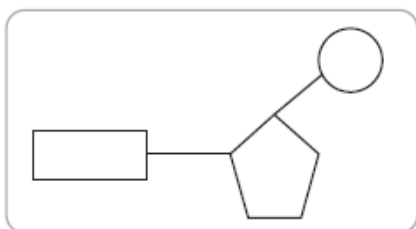
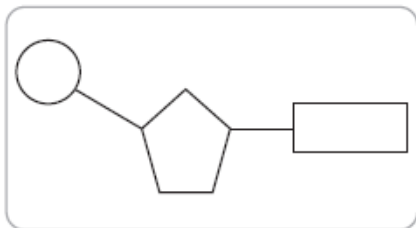
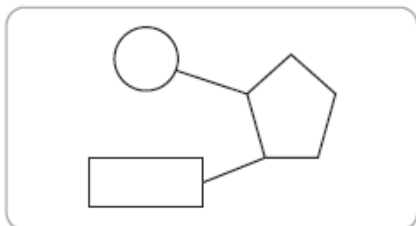
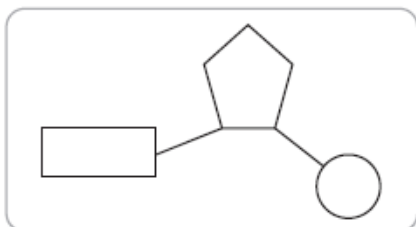
Both DNA and RNA are polynucleotides.

(a) The table shows how the components of polynucleotides can be represented.

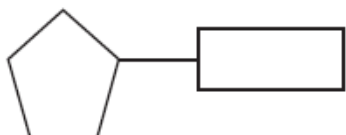
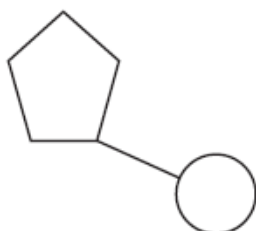
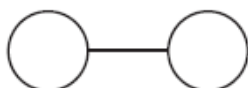
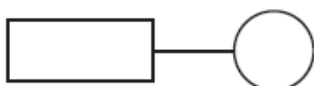
Component	Representation
sugar	
phosphate group	
cytosine or thymine	
adenine or guanine	
covalent bond	
hydrogen bond	

(i) Which diagram shows a mononucleotide?

(1)

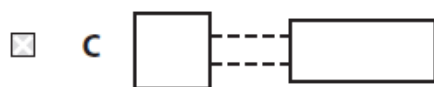
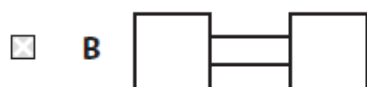
**A****B****C****D**

(ii) Which diagram shows two components joined by a phosphodiester bond?

(1)**A****B****C****D**

(iii) Which diagram shows complementary base pairing?

(1)



(b) The diagram shows a sequence of bases in a DNA template (antisense) strand.

A	T	T	G	G	C	G	A	G	A	A	C
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(i) The table shows some statements about the new complementary DNA strand and the mRNA strand synthesised using this sequence of bases.

For each statement, put **one** cross ☒ in the appropriate box, in each row, to show the correct statement about these strands.

(3)

Statement	both the new complementary DNA strand and the mRNA strand	only the new complementary DNA strand	only the mRNA strand	neither strand
The number of guanines will be the same as in the template strand	☒	☒	☒	☒
The number of thymines will be the same as the number of adenines in the template strand	☒	☒	☒	☒
There will be no adenine present	☒	☒	☒	☒

(ii) Name the process that synthesises a mRNA strand using the DNA template strand.

(1)

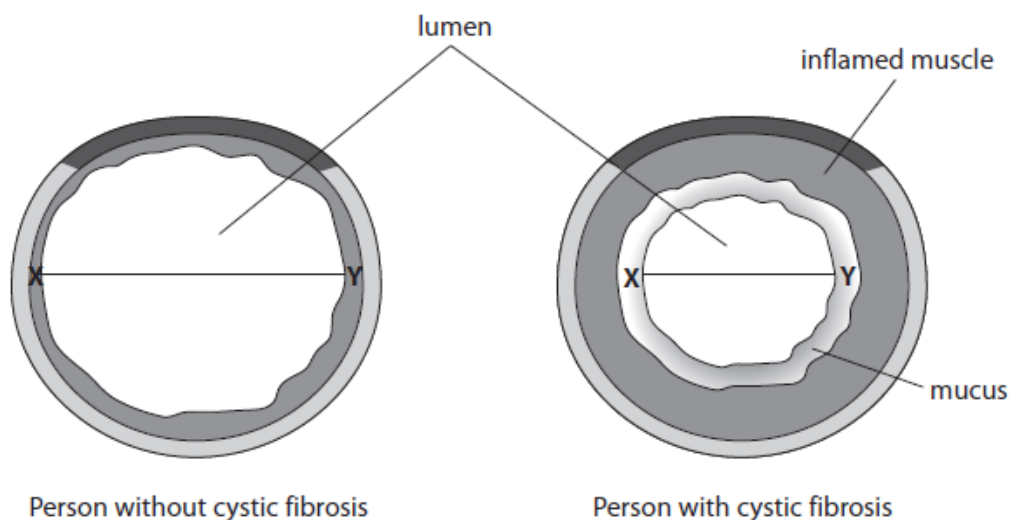
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(Total for question = 7 marks)

Q22.

Cystic fibrosis is an inherited disorder.

(a) The diagrams show a cross section through a trachea from a person without cystic fibrosis and from a person with cystic fibrosis.



(i) Calculate the percentage decrease in the diameter of the lumen of the trachea from a person with cystic fibrosis.

Take your measurements between **X** and **Y** on each diagram.

(2)

Answer

* (ii) Explain why cystic fibrosis causes the differences shown in the diagrams.

(6)

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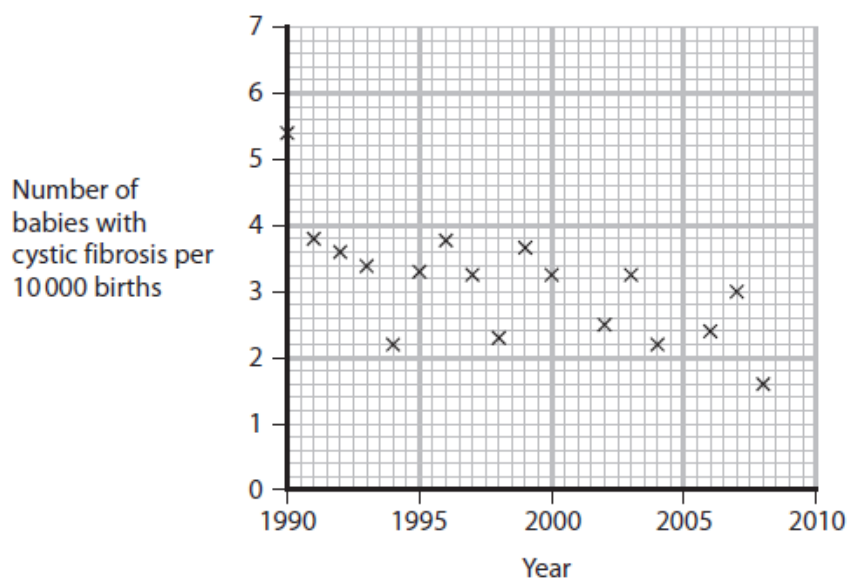
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(b) The graph shows the number of babies with cystic fibrosis per 10 000 births in one country, from 1990 to 2008.



(i) Explain how the identification of carriers, using genetic screening, could have contributed to the downward trend shown in this graph.

(3)

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(ii) Describe the ethical issues relating to genetic screening.

(3)

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(Total for question = 14 marks)

Q23.

Some questions must be answered with a cross ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The cell membrane controls which substances can move into the cell or out of the cell.

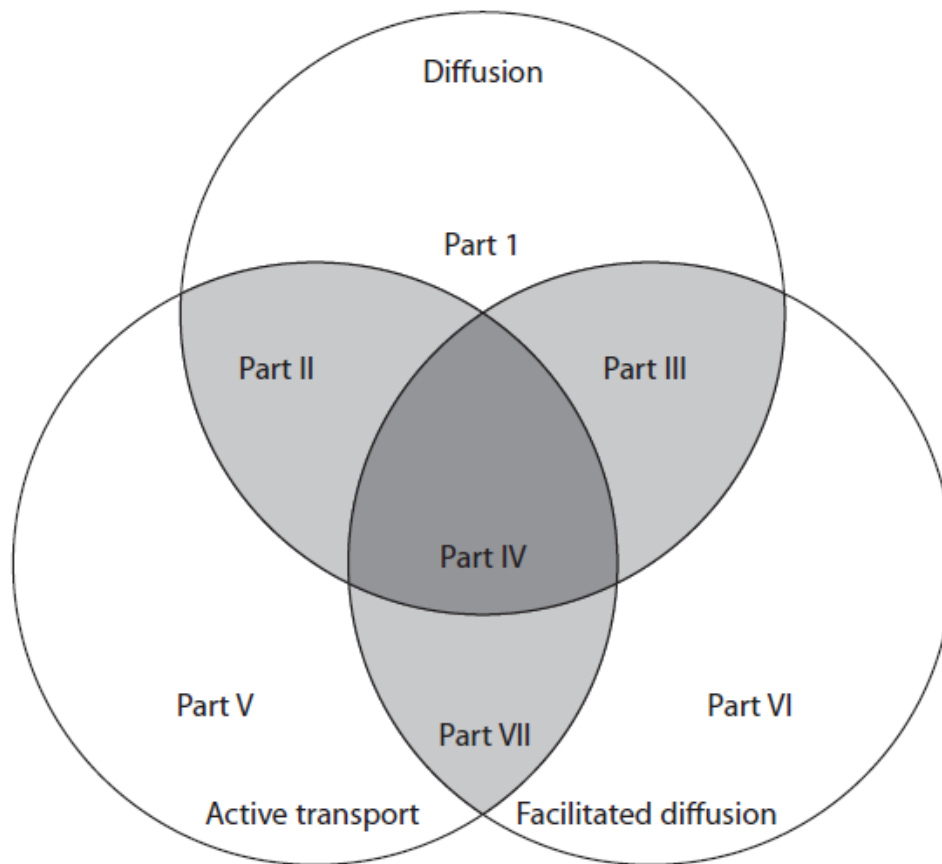
Processes by which substances can move into a cell or out of a cell include diffusion, facilitated diffusion, active transport and osmosis.

(a) A Venn diagram can be used to show the similarities and differences between diffusion, facilitated diffusion and active transport.

Statements about similarities can be written in the numbered parts of the circles that overlap.

For example, statements about similarities shared by all three processes would be written in Part IV.

Statements about differences can be written in the numbered parts of the circles that do not overlap.



(i) Which part would contain the statement: uses proteins?

(1)

- ☐ **A** II
- ☐ **B** III
- ☐ **C** IV
- ☐ **D** VII

(ii) Which part would contain the statement: needs energy in the form of ATP?

(1)

- ☐ **A** II
- ☐ **B** V
- ☐ **C** VI
- ☐ **D** VII

(iii) Which part would contain the statement: solutes can only move down a concentration gradient?

- ☐ **A** II
- ☐ **B** III
- ☐ **C** V
- ☐ **D** VII

(b) Osmosis can be defined as the movement of free water molecules through a partially permeable membrane, down a water potential gradient.

Explain this definition.

(3)

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*(c) The photograph shows a Chinese mitten crab.



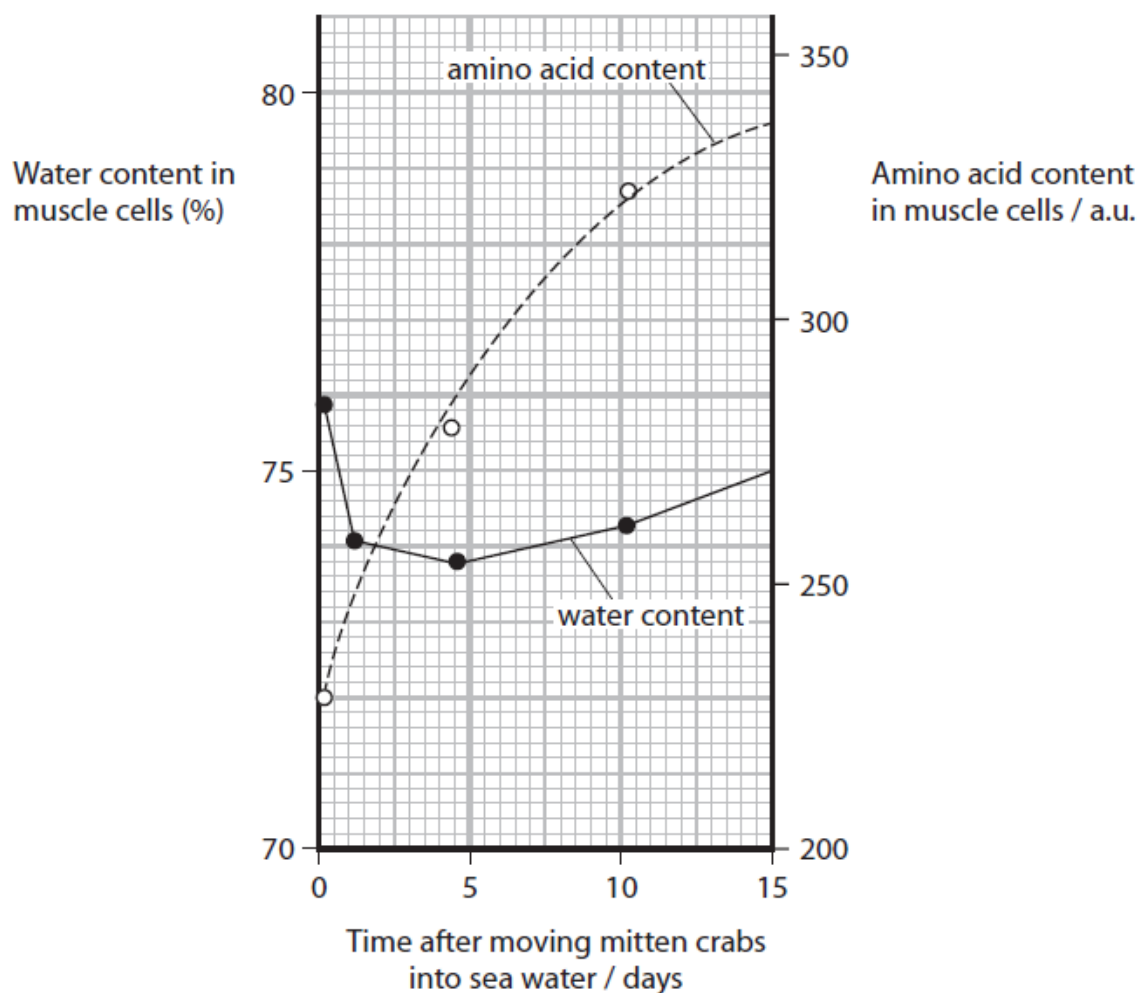
(Source: © WILDLIFE GmbH / Alamy Stock Photo)

Mitten crabs spend most of their lives in fresh water and only return to the sea to breed.

In an investigation, mitten crabs were kept in fresh water and then moved into sea water.

The water content and amino acid content in the muscle cells of these crabs were measured for 15 days after moving them from fresh water into sea water.

The graph shows the results of this investigation.



Sea water has a higher concentration of salt than fresh water.

Explain the changes in water content and amino acid content in the muscle cells of the crabs in this investigation.

(6)

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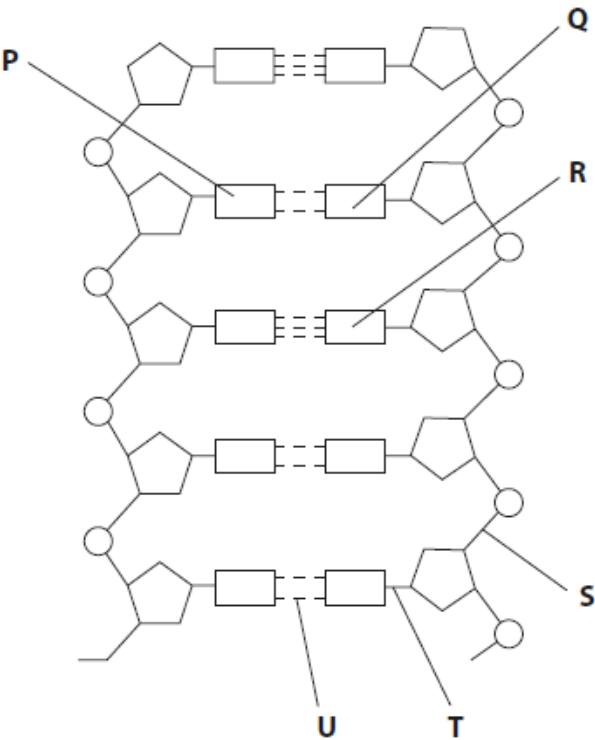
(Total for question = 12 marks)

Q24.

The polynucleotide DNA is composed of mononucleotides linked together.

Two polynucleotides form a DNA molecule.

(a) The diagram shows part of a DNA molecule.



(i) Draw a circle around **one** mononucleotide that includes the base labelled **R**.

(1)

(ii) Which row of the table identifies the bonds labelled **S**, **T** and **U**?

(1)

	S	T	U
☐ A	hydrogen	phosphodiester	covalent
☐ B	hydrogen	covalent	phosphodiester
☐ C	phosphodiester	hydrogen	covalent
☐ D	phosphodiester	covalent	hydrogen

(iii) The base labelled **P** is adenine.

Which is the base labelled **Q**?

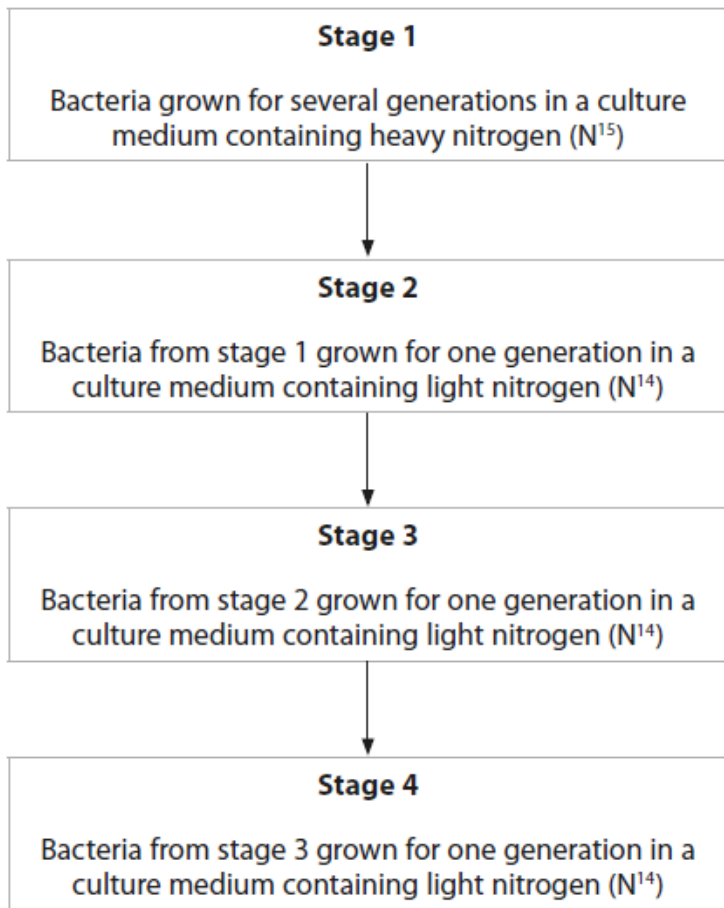
(1)

- ☐ **A** cytosine
- ☐ **B** guanine
- ☐ **C** thymine
- ☐ **D** uracil

(b) Meselson and Stahl carried out experiments that provided evidence for the semi-conservative replication of DNA.

Heavy nitrogen (N^{15}) and light nitrogen (N^{14}) were used in these experiments.

The flow chart summarises part of one experiment performed by Meselson and Stahl.



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 the lighter DNA molecules.

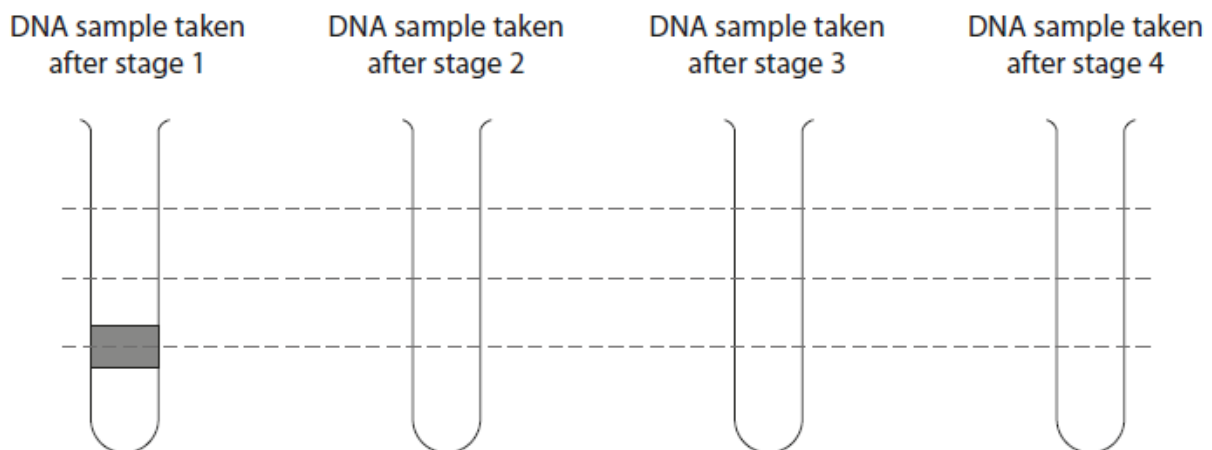
The height of each band is proportional to the percentage of DNA molecules in the sample.

(i) Complete the diagram to show the results of this experiment.

Use the dotted lines to help you to position the bands on the diagram.

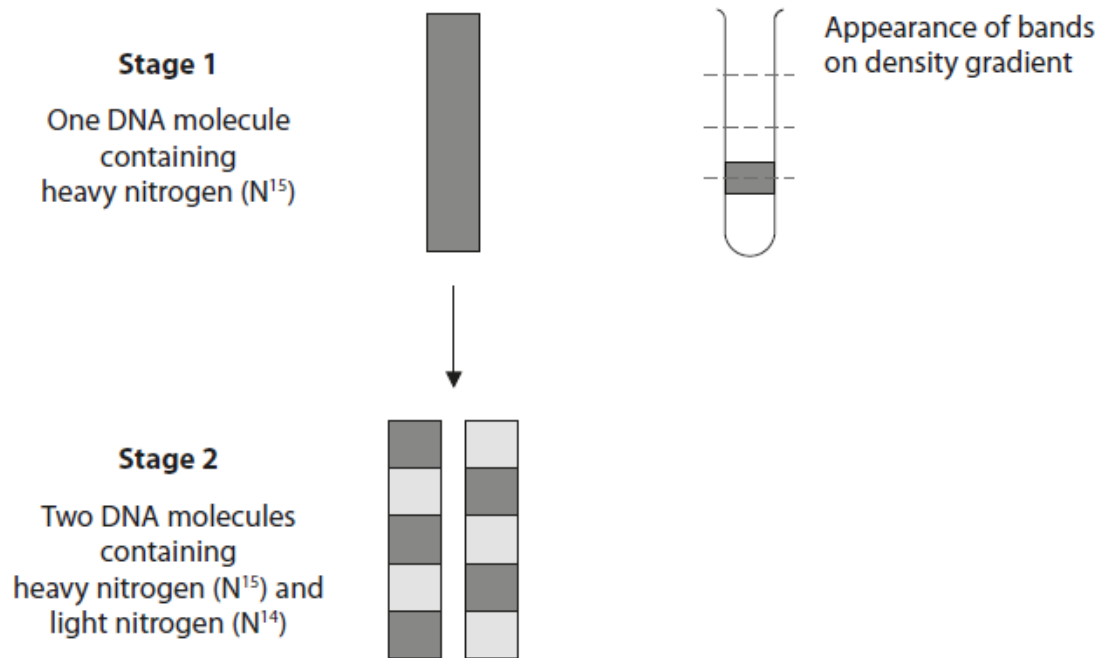
The first one has been done for you.

(5)



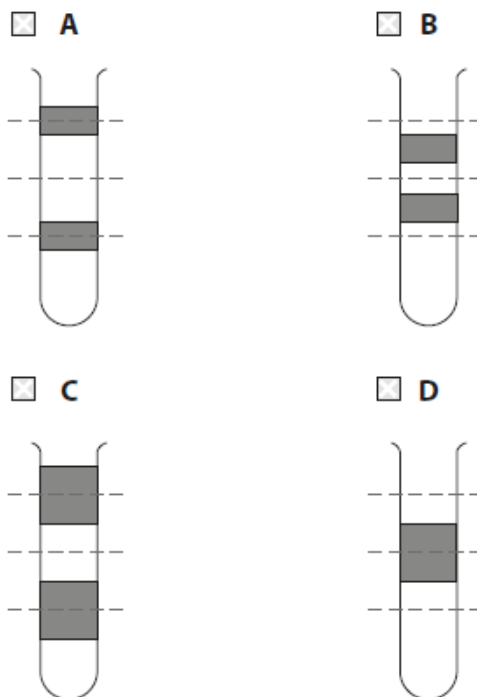
(ii) The experiments of Meselson and Stahl disproved the dispersive theory of DNA replication.

The diagram shows the expected results if the dispersive theory was correct.



Which diagram would show the bands of DNA molecules on the density gradient at stage 2, if the dispersive theory was correct?

(1)



(Total for question = 9 marks)

Q25.

Errors in DNA replication can give rise to mutations.

The diagram shows the bases in a length of DNA.

Length of DNA	A	T	G	C	T	C	A	T	T	T	A	C	C	A	T	C	G	A
Base number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

The table shows the genetic code for the amino acids.

Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid
AAA AAG	Lysine	CAA CAG	Glutamine	GAA GAG	Glutamic acid	TAC TAT	Tyrosine
AAC AAT	Asparagine	CAT CAC	Histidine	GAC GAT	Aspartic acid	TCA TCC TCG TCT	Serine
ACA ACC ACG ACT	Threonine	CCA CCC CCG CCT	Proline	GCA GCC GCG GCT	Alanine	TGG	Tryptophan
AGA AGG	Arginine	CGA CGC CGG CGT	Arginine	GGA GGC GGG GGT	Glycine	TGC TGT	Cysteine
AGC AGT	Serine	CTA CTC CTG CTT	Leucine	GTA GTC GTG GTT	Valine	TTA TTG	Leucine
ATA ATC ATT	Isoleucine					TTC TTT	Phenylalanine
ATG	Methionine						

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

(a) State the sequence of the first four amino acids coded for by this length of DNA.

(1)

(b) A change in a single base can cause a change in the amino acid sequence produced in protein synthesis.

(i) Name the type of each mutation described below.

(2)

Base number 3 becomes cytosine (C)

Base number 6 becomes number 5 in the sequence

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Base number 9 becomes number 10 in the sequence

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*(ii) Explain the possible effects of these three types of mutation on the amino acid sequence coded for by this length of DNA.

Use the information in the table to support your answer.

(6)

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(Total for question = 9 marks)

Nucleic acids include DNA and RNA.

(a) Each single strand of a DNA molecule is synthesised from mononucleotides.

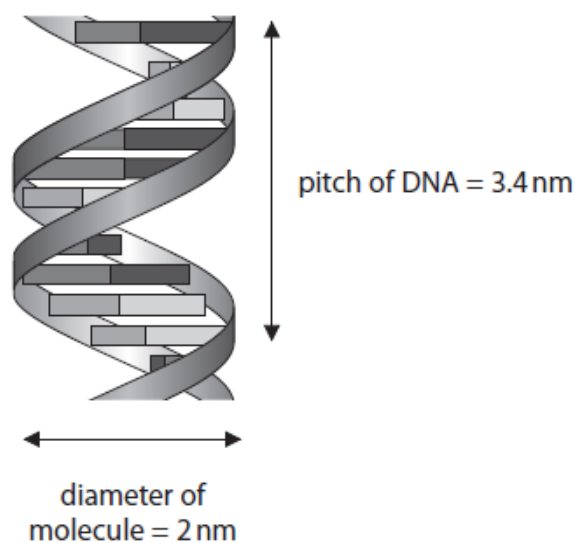
Draw a diagram to show two mononucleotides joined together in a single strand of DNA.

Use the symbols shown for each component in your diagram.

(3)



(b) The diagram represents part of a DNA molecule.



The pitch is the length of one complete turn in the double helix.

There are 10 base pairs in one pitch.

(i) Calculate the distance between one base and the next base on one strand of DNA.

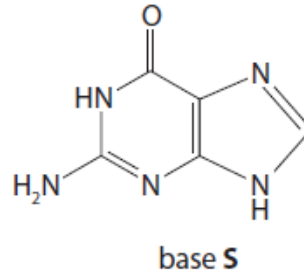
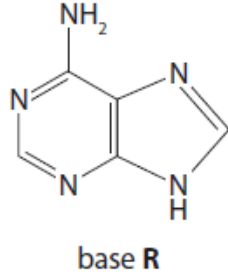
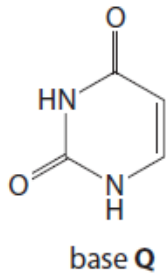
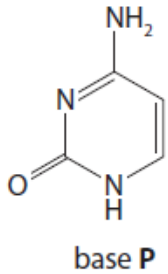
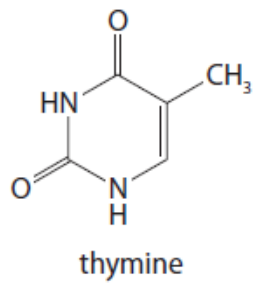
Give your answer to an appropriate number of significant figures.

(1)

Answer nm

(ii) The diagram shows the structure of thymine and four other bases, **P**, **Q**, **R** and **S**.

Bases **P** and **S** can form three hydrogen bonds each and bases **Q** and **R** can form two hydrogen bonds each.



Explain which of the four bases **P**, **Q**, **R** or **S** is adenine.

(2)

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(c) Compare and contrast the structure of messenger RNA (mRNA) with the structure of transfer RNA (tRNA).

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(Total for question = 10 marks)

Q27.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Pectinase is an enzyme that breaks down pectin. Pectin is present in the cell walls of fruits.

(a) What type of molecule is pectinase?

(1)

- ☐ **A** disaccharide
- ☐ **B** polysaccharide
- ☐ **C** protein
- ☐ **D** triglyceride

(b) Explain why enzymes are described as biological catalysts.

(2)

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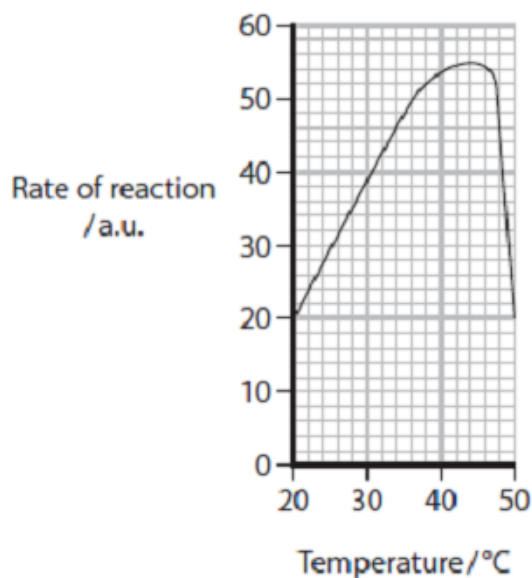
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(c) The graph shows the effect of temperature on the rate of reaction of pectinase.



(i) Calculate the effect on the rate of reaction of each degree increase in temperature between 46°C and 50°C.

Give your answer to two significant figures.

(1)

Answer a.u. per °C

(ii) State why there is a decrease in the rate of reaction above the optimum temperature.

(1)

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(Total for question = 5 marks)

Q28.

Platelets are involved in the blood clotting process.

(a) The table shows the phospholipid content of the membranes of platelets.

Phospholipid	Percentage of total membrane phospholipids (%)	Percentage distribution of phospholipids in the membrane (%)
		inner layer outer layer 100 100
phosphatidylethanolamine	30	100 100
phosphatidylcholine	27	100 100
sphingomyelin	23	100 100
phosphatidylserine	15	100 100
other types	5	100 100

When platelets trigger the blood clotting process, more phosphatidylserine molecules move into the outer layer of the membrane.

(i) Estimate the ratio of phosphatidylserine in the inner layer to that in the outer layer before the blood clotting process is triggered.

(1)

Answer

(ii) Describe the effect that the movement of phosphatidylserine into the outer layer will have on the content of phospholipids in the membranes of platelets.

(2)

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(iii) Describe how the movement of phosphatidylserine into the outer layer results in the production of thrombin in the blood clotting process.

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(b) Thrombin inhibitors are drugs that have an effect on the time taken for blood to clot.
Explain why thrombin inhibitors affect the time taken for blood to clot.

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(Total for question = 11 marks)

Q29.

Acute hepatic porphyria (AHP) is a very rare genetic disorder.

A drug has been developed to treat AHP.

(a) This drug was tested in a clinical trial involving 94 patients from 18 countries.

The drug was given to 48 of the patients. The other 46 patients were a control group.

(i) Comment on the design of this clinical trial.

(2)

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(ii) Each patient was given 2.5 mg of the drug per kg of body mass, once a month.

The drug is available as a solution with a concentration of 189 mg cm^{-3} .

Calculate the volume of drug that was given each month to a patient with a body mass of 64 kg.

(2)

Answer

(iii) Nausea was experienced by 27% of the patients receiving this drug.

Calculate the number of patients who experienced nausea.

(2)

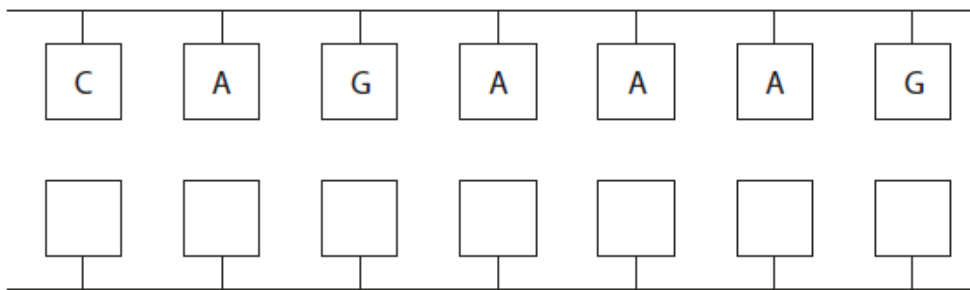
Answer

(b) This drug is a double-stranded RNA molecule.

(i) The diagram shows part of the base sequence on one of the RNA strands.

Complete the diagram to show the base sequence on the other RNA strand.

(2)



(ii) Describe the bonding in this double-stranded RNA molecule.

(3)

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(iii) In AHP, toxic porphyrin molecules build up.

The synthesis of the haem component of haemoglobin involves several steps.

Each step in the synthesis of haem is catalysed by a different enzyme.

This drug works by interfering with the mRNA copies from the gene coding for one of these enzymes.

Explain how the action of this drug helps patients with AHP.

(3)

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(Total for question = 14 marks)

Q30.

(a) Explain how human lungs are adapted for rapid gas exchange.

(3)

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(b) Cystic fibrosis is an inherited condition which reduces gas exchange.

The most frequently observed CFTR allele associated with cystic fibrosis carries the $\Delta F508$ mutation.

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

(1)

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(ii) The CFTR protein coded for by this mutation has one missing amino acid compared to the functioning protein.

Explain how this mutation results in a non-functioning CFTR protein.

(4)

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(iii) Explain why people with cystic fibrosis may develop lung infections.

(4)

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(Total for question = 12 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
(a)	A diagram that shows: • COOH group and NH₂ group (1) • H and the aspartate R group (1) • all attached to a central C (1)	Accept charged groups	(3)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: • because (the urea cycle has) many (stages / steps / reactions) (1) • therefore, the product of one stage is the substrate of the next stage (1) • and enzymes are specific to one substrate (1) • substrates (bind / attach / fit) to (specific) active site / credit reference to lock and key theory / credit reference to induced fit (1)	ACCEPT each stage has (new / different) substrate / different substrates (in the process) ACCEPT if active site is referred to in the context of an enzyme-substrate complex	(3)

Question number	Answer	Additional guidance	Mark
(c)(i)	An answer that includes three of the following points: • genetic screening / named screening method / looking for a mutation • biochemical test / blood test / description of named molecule whose level would be different • family history / pedigree analysis	IGNORE where the molecules maybe found	(3)

Question number	Answer
* (c)(ii)	Indicative content: Table of results: • OTC mRNA treatment reduces the levels of ammonia back to nearly normal { Diagram of urea cycle: • ammonia levels will build up if carbamyl phosphate is not combined with ornithine • OTC deficiency will result in carbamyl phosphate not combining with ornithine Diagram of particle: • particle targets liver and this is where the urea cycle takes place • the phospholipids will fuse with the liver cells to enable the mRNA to enter the cells • because the phospholipids can move • the phospholipids will protect the mRNA • from hydrolytic enzymes • the mRNA will be translated inside the liver cells • producing functional OTC • the OTC will combine carbamyl phosphate with ornithine • reducing the levels of urea

	Aspects to cover : D_d - description of data E_d - explanation of data : ammonia converted to urea because ornithine cycle functioning D_r - recognition of mRNA involved in translation E_r - explanation that functional OTC can be produced D_p - comment on role of particle E_p - explanation of phospholipid particle Level 1 1 mark : one description 2 marks : one description and one explanation or two descriptions Level 2 3 marks : two descriptions and one explanation or three descriptions 4 marks : two descriptions and two explanations Level 3 5 marks : three descriptions and two explanations 6 marks : three descriptions and three explanations
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Q2.

Question number	Answer	Additional guidance	Mark
(a)	An explanation that includes the following points: - because the mutated gene results in a faulty (CFTR) protein (1) - so chloride ions do not move out of the cells (1) - decreasing the water potential inside the cell (1) - therefore water {leaves the mucus / enters the cells} by <u>osmosis</u>(1)	ACCEPT less effective ACCEPT reduced movement of chloride ions / sodium ion channel not inhibited / sodium ions not prevented from entering cell ACCEPT decreasing {osmotic potential / solute potential} / increasing solute concentration IGNORE decreasing water concentration	(3)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes five of the following points: - because the mucus blocks the airways (1) - therefore {air flow to lungs / gas exchange} is reduced (1) - because mucus prevents <u>pancreatic</u> enzymes from entering the small intestine (1) - therefore large food molecules not broken down (and cannot be absorbed) (1) - because the mucus prevents sperm passing through the cervix (1) - therefore sperm cannot reach the egg cell (1)	ACCEPT duodenum / gut / digestive tract named enzyme secreted by pancreas ACCEPT named large food molecule ACCEPT reach the {oviducts / fallopian tubes}	(5)

Question number	Answer	Mark
(c)(i)	C 40 The only correct answer is C. <i>A is incorrect because</i> <i>B is incorrect because</i> <i>D is incorrect because</i>	(1)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An explanation that includes the following points: - because (the graph shows that) the level of CFTR protein function varies between 3 and 18% (1) - because (the graph shows that) individuals diagnosed with cystic fibrosis have a range in concentration of chloride ions in sweat (1) - therefore the CFTR protein must be affected to different extents (by different mutations) (1)		(2)

Q3.

Question number	Answer	Additional guidance	Mark
(a)	change in the base {sequence / order} of DNA	ACCEPT change in the number of chromosomes / damage to chromosome / loss of part of chromosome	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	a change in one variable is reflected in a change in another variable	ACCEPT a description that only mentions 'change' once DO NOT ACCEPT causes / results in	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A description that includes the following points: - incidence of skin cancer increases with (an increase in) age (1) - incidence of skin cancer increases with an increase in the years (1) - males have higher incidence of skin cancer than females (1)	ACCEPT converse throughout ACCEPT in either context of males or females or both ACCEPT in either context of males or females or both	(3)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An answer that includes three of the following points: - as age increase there is more time for mutations to {build up / occur} (1) - people are spending more time in the sun (1) - more UV light reaching the earth's surface (1) - more men have {jobs / hobbies} outside (1) - men have a greater genetic disposition to skin cancer (1)	ACCEPT the older you are the more exposure to risk factors / the more cell divisions the more chance of mutations ACCEPT an example of why this may happen e.g. going on more holidays in hot countries ACCEPT ozone layer depletion ACCEPT men smoke more	(3)

Question number	Answer
* (c)	Indicative content: Repeatability: - sample size is small - smokers are being studied and their sample size is very small* - no statistical data available - no indication of the location of the individuals (could be a validity comment as well) Validity: - mean age at diagnosis is similar but not identical - there is a greater range of ages for males than females - no indication of the actual ages of the people - so there could be more people at the extremes in one group - no information about other lifestyle factors - e.g. working in polluted environment, living in the city - no information about non-lifestyle factors - e.g. ethnicity - no indication if individuals lived with other smokers (passive smokers) - no indication of how long people been smoking for* - no indication of how many cigarettes were smoked by the smoker each day* - no indication if the non-smokers had ever smoked previously* - no indication of severity of emphysema* - no indication if emphysema is self-diagnosed or clinical diagnosis* Level 1 : comments on the design of the study 1 mark = 1 comment 2 marks = 3 comments Level 2 : comments on the design of the study 3 marks = 4 comments, at least one of which is from each category 4 marks = 5 comments, at least one of which is from each category Level 3 : comments on the design of the study and makes at least one link correctly with repeatability or validity 5 marks = 5 comments at least one of which is linked to repeatability or validity 6 marks = 6 comments at least one of which is linked to repeatability or validity and includes a specific comment about {smoking / emphysema}* ACCEPT reproducible / reliable IGNORE accurate / precise (6)

Q4.

Question number	Answer	Mark
(a)	C glycogen The only correct answer is C. <i>A is incorrect because amylopectin is found in plant cells only</i> <i>B is incorrect because cellulose is found in plant cells only</i> <i>D is incorrect because starch is found in plant cells only</i>	(1)

Question number	Answer	Mark
(b)	D lactose and sucrose The only correct answer is D. <i>A is incorrect because fructose is a monosaccharide and therefore not digested</i> <i>B is incorrect because fructose and galactose are both monosaccharides and therefore not digested</i> <i>C is incorrect because galactose is a monosaccharide and therefore not digested</i>	(1)

Question number	Answer	Additional guidance	Mark
(c)(i)	190 900 000 / 191 000 000 / 191 million / 1.909×10^8 / 1.91×10^8		(1)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An explanation that includes three of the following points: - because (prenatal testing) can cause abortion (1) - because false negative or false positive results can be avoided (if patient already has diabetes) (1) - because of issues arising if another genetic condition is found (1) - because an individual could live a healthy life (as only a genetic predisposition) (1) - because of the ethics associated with destroying embryos (IVF) (1)		(3)

Question number	Answer	Additional guidance	Mark
(a)	An answer that makes reference to the following points: • {protein / found in organisms} (1) • that {decreases activation energy / speeds up (the rate of) reaction} (without being used up) (1)	ACCEPT in our {bodies / cells / cytoplasm} / in a named organism ACCEPT description of activation energy	(2)

Question number	Answer	Mark
(b)	The only correct answer is B (Q) A is incorrect because Q is the activation energy C is incorrect because Q is the activation energy D is incorrect because Q is the activation energy	(1)

Question number	Answer	Additional guidance	Mark
(c)	An explanation that includes the following points: • substrate {binds / fits / forms enzyme-substrate complex} to the <u>active site</u> of the enzyme (1) • due to the <u>shape</u> of the {active site / enzyme / substrate} (1) • which is due to the {R groups / amino acids} (forming the active site) (1) • AB <u>and</u> AC {are a different shape to A and B / do not fit into E₁} (1)	ACCEPT are not complementary to (E ₁) enzyme	(3)

Question number	Answer	Additional guidance	Mark
(d)	A description that includes the following points: • pH 4 is the {most suitable / best} pH (1) • 30°C is the {most suitable / best} temperature (1) • pH 2 <u>and</u> 60°C (both) denature the enzyme (1)		(2)

Q6.

Question number	Answer	Additional guidance	Mark												
(a)	<table><tr><th>Name</th><th>Role</th><th>Property</th></tr><tr><td>thromboplastin</td><td>(catalyses the) conversion of prothrombin into thrombin (1)</td><td>soluble</td></tr><tr><td>thrombin (1)</td><td>catalyses the conversion of fibrinogen into fibrin</td><td>soluble (1)</td></tr><tr><td>fibrin</td><td>Any two of the following points: • form a network of fibres / mesh (1) • trap (platelets / blood cells) (1) • form a scab to (seal the wound / stop bleeding) (1) • form a scab to prevent the entry of bacteria (1) </td><td>insoluble (1)</td></tr></table>	Name	Role	Property	thromboplastin	(catalyses the) conversion of prothrombin into thrombin (1)	soluble	thrombin (1)	catalyses the conversion of fibrinogen into fibrin	soluble (1)	fibrin	Any two of the following points: • form a network of fibres / mesh (1) • trap (platelets / blood cells) (1) • form a scab to (seal the wound / stop bleeding) (1) • form a scab to prevent the entry of bacteria (1)	insoluble (1)	IGNORE reference to calcium ions / vitamin K ACCEPT insoluble ACCEPT two points made in one sentence DO NOT ACCEPT completely wrong statements	(6)
Name	Role	Property													
thromboplastin	(catalyses the) conversion of prothrombin into thrombin (1)	soluble													
thrombin (1)	catalyses the conversion of fibrinogen into fibrin	soluble (1)													
fibrin	Any two of the following points: • form a network of fibres / mesh (1) • trap (platelets / blood cells) (1) • form a scab to (seal the wound / stop bleeding) (1) • form a scab to prevent the entry of bacteria (1)	insoluble (1)													

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: - because (gene / (defective) allele) located on the X chromosome (1) - because defective allele is recessive (1) - therefore, males with (defective / haemophilia) allele will only have that allele (1)	ACCEPT X-linked disease / sex-linked disease / inherited on the X chromosome ACCEPT (mutated / affected) allele / (haemophilia / disease) is recessive ACCEPT males will not carry a (healthy / normal) allele females need (both defective alleles / to be homozygous for defective alleles) to have haemophilia	(3)

Q7.

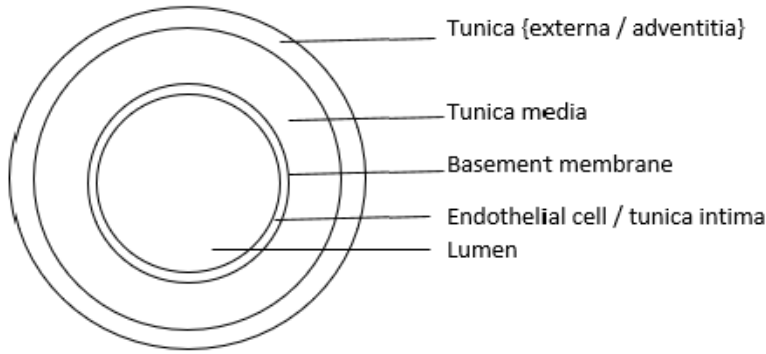
Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following points: - thromboplastin (1) - active site (1) - platelets / (red / white) blood cells / erythrocytes (1)	IGNORE calcium ions / Ca⁺⁺ IGNORE clot / scab	(3)

Question number	Answer	Mark
(a)(ii)	A The only correct answer is A. <i>B is incorrect because antihypertensives are used to lower blood pressure</i> <i>C is incorrect because platelet inhibitors affect platelets</i> <i>D is incorrect because statins lower blood cholesterol</i>	(1)

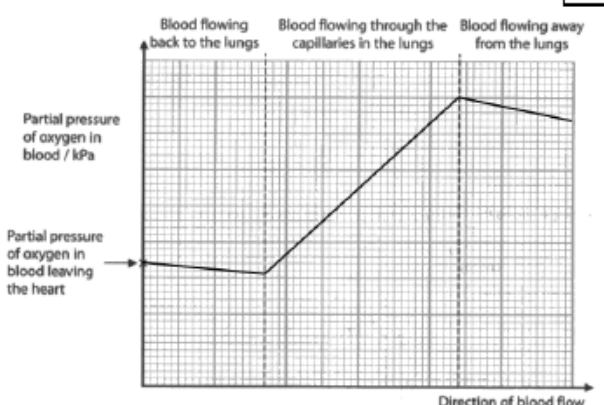
Question number	Answer	Additional guidance	Mark
(b)	- tangent drawn at 2 days (1) - correct answer up to 2 decimal places and units (1)	Example of calculation: ACCEPT straight line touching outside of curve at 2 ACCEPT in range of 2.7 to 4.5 {s day⁻¹ / s per day / s/day} ACCEPT with or without a minus sign	(2)

Q8.

Question number	Answer	Additional guidance	Mark
(a)	A description that makes reference to the following points: - one structure (1) - linked function (1)	e.g. single layer of cells / pores / small diameter ACCEPT thin cells / walls e.g. (single layer) gas exchange / diffusion of gases (in the lungs) (pores) plasma forced out / WBC leave / molecules can leave (small diameter) all cells close to capillaries	(2)

Question number	Answer	Additional guidance	Mark
(b)	A drawing that shows the following points: • lumen + {three layers / three other layers + endothelial layer / two layers + endothelial layer} (1) • one feature correctly labelled (1) • a second feature correctly labelled (1)	 ACCEPT Epithelial {layer / lining / cells} / fenestrated membrane Tunica interna Layer of (smooth) muscle <u>and</u> elastic fibres (and collagen) for 1 layer Award marks for longitudinal section NB regards mp 2 and 3 1 right + 1 wrong label = 1 mark 2 right + 1 wrong label = 1 mark 1 right + 2 wrong labels = 0 marks	(3)

Question number	Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following points: • to prevent backflow (of blood) (1) • (as blood is usually returning) {under low pressure / (often) against gravity} (1)	ACCEPT so that blood returns to the heart blood flow is in one direction	(2)

Question number	Answer	Additional guidance	Mark
(d)	A drawing that shows the following points: • pp of O₂ remaining constant as blood flows to lungs (1) • pp of O₂ rising as blood flows through the capillaries (1) • pp of O₂ remaining constant as blood flows away from lungs (1)	ACCEPT within 1 sm square of the verticals in each section ACCEPT slightly decreasing (within 1 large square) ACCEPT slightly decreasing (within 1 large square) 	(3)

Q9.

Question number	Answer	Mark
(a)(i)	B The only correct answer is B. <i>A is incorrect because fructose is a monosaccharide</i> <i>C is incorrect because both glucose and fructose are monosaccharides</i> <i>D is incorrect because fructose is a monosaccharide</i>	(1)

Question number	Answer	Mark		
(a)(ii)	C <table><tr><td>peptide</td><td>condensation</td></tr></table> The only correct answer is C. <i>A is incorrect because ester bonds are in lipids</i> <i>B is incorrect because ester bonds are in lipids and hydrolysis splits bonds</i> <i>D is incorrect because hydrolysis splits bonds</i>	peptide	condensation	(1)
peptide	condensation			

Question number	Answer	Mark
(a)(iii)	B absent lower The only correct answer is B. <i>A is incorrect because saturated fatty acids have more hydrogens than unsaturated fatty acid of same length</i> <i>C is incorrect because there are no carbon carbon double bonds in saturated fatty acids</i> <i>D is incorrect because there are no carbon carbon double bonds in saturated fatty acids</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	- volume of cylinder calculated (1) - ratio of surface area : volume to max 2 dps (1)	Example of calculation: $(3 \times 2 \times 2 \times 28 / \pi \times 2 \times 2 \times 28 / 22/7 \times 2 \times 2 \times 28) 336 / 352 \text{ (mm}^3\text{)}$ e.g 1.02 : 1 / 1.07 : 1 / 1 : 1 ACCEPT ratio given the wrong way round e.g. 1 : 09 NB ecf if {incorrect rounding from above / diameter used} for 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes two of the following points: (because the insect is small) the cells will not be far from the {sinuses / blood} (1) (so) diffusion can supply the {oxygen / nutrients / named nutrient} (from the blood) (1) - because the insect is small it does not have {double circulation / blood vessels / closed circulatory system / complex circulatory system / high pressure} OR - because the insect has a low {metabolic rate / oxygen demand}(1) - diffusion can supply the oxygen (from blood / tracheoles) / the oxygenated and deoxygenated blood <u>does not need to be kept separate</u> (1) - because the insect is small it does not have {double circulation / blood vessels / closed circulatory system / complex circulatory system / high pressure}	IGNORE ref to surface area to volume ratio ACCEPT small diffusion distance between cells and {sinuses / blood} ACCEPT remove carbon dioxide diffusion supplies oxygen to cells from the tracheoles IGNORE has an open system because this is in the question IGNORE has an open system because this is in the question	(2)

Question number	Answer	Additional guidance	Mark
(b)(iii)	A description that includes two of the following points: - fibrous protein (1) {triple / three stranded} helix (held with hydrogen bonds) (1) (short) repeating sequences of amino acids / high {hydroxyproline / proline / glycine} content / every third amino acid is glycine(1)	IGNORE refs to secondary / tertiary / quaternary structure throughout NB piece together IGNORE alpha	(2)

Q10.

Question number	Answer	Additional guidance	Mark
(a)	- number of deaths not due to cancer calculated (1) 0.45 : 1 / 0.45 (1)	(541589 - 166800) 374 789 ACCEPT 1 : 2.25 Bald answer of 0.45 : 1 or 0.45 or 1 : 2.25 = 2 marks	(2)

	Answer	Additional guidance	Mark
(b)(i)	An answer that includes the following points: insertion and deletion (1)	ACCEPT chromosome or translocation IGNORE point / gene / frameshift / addition / subtraction / substitution / named disorders / missense / nonsense / inversion / duplication	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	65 (%)	ACCEPT any number to one decimal place in the range 58.0 to 67.0	(1)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An explanation that includes four of the following points: • substitution mutation swaps one base (in the DNA sequence / gene) (1) • this will result in a different <u>base</u> being inserted into the mRNA (during transcription) (1) • the genetic <u>code</u> is degenerate (1) • therefore codes for the same amino acid (1) • and therefore the protein will have the same {structure / function} as the R groups will be the same (1)	ACCEPT substitution only affects one base example using two sets of bases	(4)

Question number	Answer	Mark
(c)(i)	The only correct answer is B, 0.125 <i>A is incorrect because 1 in 4 chance of having child with PKU and 1 in 2 chance of having a boy</i> <i>C is incorrect because 1 in 4 chance of having child with PKU and 1 in 2 chance of having a boy</i> <i>D is incorrect because 1 in 4 chance of having child with PKU and 1 in 2 chance of having a boy</i>	(1)

Question number	Answer	Additional guidance	Mark
* (c)(ii)	Group 1 : Individuals 1 and 2 - must be carriers / heterozygous (S) - because they did not have PKU but some of their children did (E) Group 2 : Individuals 3 and 4 - must be homozygous (S) - because they both had PKU (E) - because both alleles need to be recessive (E) Group 3 : Individuals 5 and / or 6 - cannot tell if homozygous dominant or heterozygous / carrier (S) - because both these genotypes will give an individual without PKU (E) - we do not know anything about individual 6's family (U) - because no evidence in individuals 7, 8 or 9 of the disease (U) - so less likely that they are both carriers (U) Group 4 : Individuals 7 and / or 8 and / or 9 - cannot tell if they are homozygous dominant or heterozygous (S)	Level 1 1 mark = genotypes for one group of individuals stated OR women are XX and men are XY OR a description of what pedigree diagrams {show / can be used for} 2 marks = explanation for one group OR genotypes for two groups stated Level 2 3 marks = explanations for two groups 4 marks = explanations for three or four groups with no uncertainty Level 3 5 marks = three groups explaining the uncertainty of either group 3 or 4 6 marks = four groups explaining the uncertainty of both groups 3 and 4	(6)

	- because both these genotypes will give an individual without PKU (E) - and we cannot determine genotypes of individuals 5 and 6 (U) - no offspring to give any clues (U) - but PKU is in individual 5's family (U) - so any of individuals 7, 8 or 9 could be carriers (U)	NB max 2 marks if they have discussed in relation to sex linkage	
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Q11.

Question number	Answer	Mark
(a)(i)	D the hydrophobic tails move away from the aqueous (water) environment	(1)

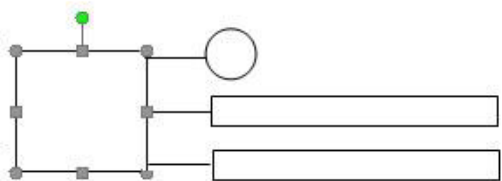
Question number	Answer	Mark
(a)(ii)	B Q	(1)

Question number	Answer	Mark
(b)	diffusion of water molecules down a water potential gradient through a partially permeable membrane	(1)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes the following points: similarities: - both used to transport large particles / large quantities of material (1) - both involve (phospholipid) membrane vesicles (1) difference: - exocytosis is export and endocytosis is import of material (1)	Accept a description of both processes	(3)

Question number	Answer	Mark
(d)	An explanation that includes the following points: - oxygen molecule is small (1) - oxygen molecule is non-polar (1) (it can, therefore) pass between gaps {in cell membrane / between hydrophobic tails} (1)	(3)

Q12.

Question number	Answer	Additional guidance	Mark
(a)(i)	A diagram that makes reference to the following points: - one glycerol (squarish / labelled), two fatty acids (rectangular / labelled), one phosphate and three bonds shown (1) - all components drawn together correctly (1)	 ecf if: {one / three} fatty acids drawn attached to glycerol but rest correct glycerol missing but two fatty acids attached to head with bonds bonds missing but all four components are touching correctly	(2)

Question number	Answer	Mark
(a)(ii)	The only correct answer is A (ester) B is incorrect because glycosidic bonds are found in carbohydrates C is incorrect because there are no hydrogen bonds in phospholipids D is incorrect because peptide bonds are found in proteins	(1)

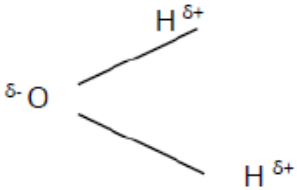
Question number	Answer	Mark
(b)(i)	The only correct answer is B (by diffusion) A is incorrect because active transport moves polar molecules C is incorrect because nonpolar molecules can diffuse through the nonpolar fatty acids D is incorrect because only water moves by osmosis	(1)

Question number	Answer	Mark
(b)(ii)	The only correct answer is B (one) A is incorrect because the second statement is the only correct one C is incorrect because the second statement is the only correct one D is incorrect because the second statement is the only correct one	(1)

Q13.

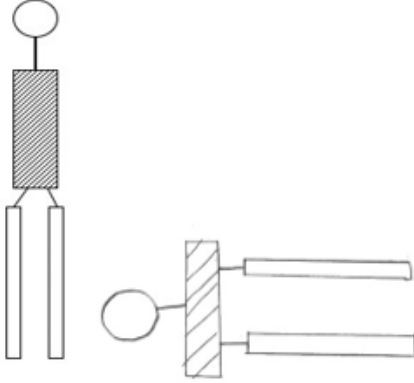
Question number	Answer	Additional guidance	Mark
(a)	An explanation that includes the following points: - because it shows that it is {made of two layers of phospholipid / bilayer} (1) - the size of a phospholipid is in the range 2.05 nm to 2.65 nm (1) - therefore the width of the membrane (5 nm) is within a bilayer range (of 4.1 nm to 5.3 nm) (1)	Accept it shows two layers of phosphate heads separated by a band of lipids	(3)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes three of the following points: - cholesterol is a non-polar molecule (1) - fatty acid tails are non-polar (1) - cholesterol will be located within the {fatty acid tails / non-polar part} of membrane (1) - OH group will be located near the phosphate heads (1)	Accept hydrophobic for non-polar in all points Accept {hydrocarbon tail / hydrocarbon rings} are non-polar	(3)

Question number	Answer	Additional guidance	Mark
(c)(i)	A description that includes the following points: {small / weak / delta / partial} positive charge on hydrogen (1) {small / weak / delta / partial} negative charge on oxygen (1)	Accept both points from a diagram 	(2)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An explanation that includes the following points: • water is small enough to move by {osmosis / diffusion} (betweenthe phospholipids) (1) • steroid (is non-polar so) can diffuse through the {membrane / phospholipids} (1) • glucose (is polar so) passes through {protein channels / carrierproteins / by facilitated diffusion} (1) • ions (are polar so) pass through {protein channels / carrier proteins / by facilitated diffusion / active transport} (1)	Accept description of water movingthrough {protein channels / aquaporins} Accept steroid is not repelled by fattyacid tails Accept movement by active transport Accept ions are repelled by fatty acidtails so cannot get through membrane	(4)

Q14.

Question number	Answer	Additional guidance	Mark
(a)(i)	A diagram that includes the following points: • one glycerol (shaded / labelled), two fatty acids (not shaded / labelled), one phosphate and three bonds shown (1) • all components drawn together correctly (1)	 ecf if: {one / three} fatty acids drawn attached to glycerol but rest correct glycerol missing but fatty acids attached to head with bonds bonds missing but all four components are touching correctly {all shaded / nothing shaded} with no labels	(2)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An explanation that includes the following points: - cholesterol interacts with {phospholipids / fatty acids} (1) (if less cholesterol) movement of <u>phospholipids</u> no longer restricted (by interaction with cholesterol) (1)	NB we are not looking for the idea that cholesterol is acting as a barrier or taking up space ACCEPT bonds ACCEPT so <u>phospholipids</u> can move around more	(2)

Question number	Answer	Additional guidance	Mark
(b)(iv)	will require less (kinetic) energy to move / because there are fewer interactions (with {other fatty acids / phospholipids / cholesterol}) (1)	ACCEPT bonds converse for longer chains	(1)

Question number	Answer	Additional guidance	Mark
(c)(i)	An answer that includes the following points: - convert saturated fatty acids into unsaturated fatty acids (1) - convert long side chains into shorter ones (1)	ACCEPT become unsaturated / increase in unsaturated / decrease in saturated fats ACCEPT become shorter	(2)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An answer that includes two of the following points: • to maintain the fluidity of the membrane (1) • so that membrane can change shape (1) • so that fusion of membranes can occur (1) • so that substances can continue to move across membrane (1)	ACCEPT otherwise the fluidity will decrease ACCEPT named example e.g. phagocytosis, endocytosis, exocytosis, red blood cells, formation of vesicles ACCEPT named example e.g. of nuclei (during fertilisation) fusion of vesicles ACCEPT named substance	(2)

Q15.

Question number	Answer	Additional guidance	Mark
(a)(i)	A description that includes three of the following points: • fibrous protein (1) • (protein) composed of {three polypeptide chains / three-stranded / triple} <u>helix</u> (1) • held by hydrogen bonds (between the chains) (1) • credit details of the chains (1)	e.g every third amino acid is a glycine, repeating sequences of amino acids, high content of {glycine / proline / hydroxyproline}	(3)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes the following points: - gives (the wall) (tensile) strength (1) - so that the aorta {does not get damaged by / can withstand} pressure (of the blood leaving the heart) (1)	IGNORE refs to elastic properties and recoil IGNORE prevents aorta from collapsing	(2)

Question number	Answer	Additional guidance	Mark
* (b)	Indicative content: Graph 1 - older male monkeys have more stiffness than younger males (D) - older female monkeys have more stiffness than younger females (D) - older males have more stiffness than older females (D) - probably significant as error bars do not overlap (C) - not much difference in stiffness between younger males and females (D) - as error bars overlap (C) - age increases aortic stiffness in both males and females (C) - age has a greater effect on aortic stiffness in males than females (C) Graph 2 - density of collagen decreases slightly with age (D) - males of all ages have (slightly) more collagen than females (C) - probably not significant as error bars overlap (C) - neither age nor sex affects density of collagen (C) - changes in stiffness do not appear to be related to the density of collagen (C) Graph 3 - higher type 1 in younger monkeys than older ones (D)	Level 1 1 mark = description made from one graph (D) Level 2 2 marks = descriptions made from two graphs (D) 3 marks = plus one conclusion made (C) 4 marks = plus two conclusions made (C) Level 3 5 marks = two conclusions and comments on the other two graphs 6 marks = three conclusions that includes the asterisked conclusion (C*) and comments on the other two graphs Description = comparison of one variable Conclusion = summary statement that includes both age and sex	(6)

	- more type 1 in females than males at each age (D) - no error bars shown to judge significance (C) Graph 4 - more type 8 in older male monkeys (D) - may not be a difference in type 8 between older and younger females (D) • no error bars to judge significance (C) - the type of collagen appears to determine stiffness (C) - stiffness associated with decrease in type 1 and increase in type 8 (C*)	interpretation of error bar and significance of data – not reliability links between 2 graphs	
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Q16.

Question number	Answer	Additional guidance	Mark
(a)	7  and 8  and 9 		(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	A description that includes the following points: - gene is a sequence of bases coding for a {(poly)peptide / sequence of amino acids} + gene for bitter-taste receptor (1) - allele is a {version of the gene / information coded by the gene} + {tasting / not tasting} (receptor) (1)	ACCEPT protein NB Two correct definitions but no examples = 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A description that includes the following points: - genotype is the combination of alleles + {TT / tt / Tt} (1) - phenotype is the {expressed / observable} {characteristic / trait / feature} + {taster / non-taster}	ACCEPT any pair of letters ACCEPT characteristic that can be measured {tasting / not tasting} (receptor) NB Two correct definitions but no examples = 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(c)	An explanation that includes the following points: - dominant allele is (having a receptor that) can taste bitter taste(1) - because individuals 1 and 2 were tasters who had children of both phenotypes (1)	ACCEPT children who could taste and children who could not taste	(2)

Question number	Answer	Additional guidance	Mark
(d)	An explanation that includes the following points: - because individual 6 was a female non-taster (1) - and her father was a taster (1)		(2)

Q17.

Question number	Answer	Additional guidance	Mark
(a)	A calculation in which: - actual height of elephant - how many times taller the elephant is than the mouse	Example of calculation: $4.5 \div 0.02 = 225 / 230 / 235$ (cm) 75 / 76.67 / 76.7 / 77 / 78 / 78.3 / 78.33 IGNORE units	(2)

Question number	Answer	Additional guidance	Mark
(b)	A description that includes the following points: - attachment of lungs to {chest cavity / diaphragm} {increases volume / decreases pressure} (1) Any two from: <u>alveoli</u> provide a large surface area for faster diffusion (1)	ACCEPT to {take in / hold} large volume of air ACCEPT thin walls	(3)

	<u>alveoli</u> formed from {one cell layer / flattened / squamous} epithelial cells for small diffusion distance (1) - concentration gradient maintained by {ventilation / blood flow / good blood supply} (1)	ACCEPT large network of capillaries	
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Question number	Answer	Mark
* (c)	Answers will be credited according to candidate's 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 indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content - oxygen dissociation curve for the mouse is shifted to the right - mouse haemoglobin has a lower affinity for oxygen than the elephant haemoglobin - therefore haemoglobin can supply oxygen to the tissues at lower pp of oxygen - because the rate of respiration in the mouse is higher - a mouse has a higher mass-specific metabolic rate than the elephant - because the mouse loses more body heat - because it has a larger surface area to volume ratio - because the mouse is more active - because it has to escape predators - the rate of respiration of the mouse is going to be	(6)

	greater than the elephant • therefore pp of oxygen in mouse tissues will be lower • therefore haemoglobin needs to be releasing oxygen • when blood cannot supply oxygen at a fast enough rate	
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Level	Marks	
	0	No awardable content.
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information and with a focus on mainly just one piece of scientific information. The explanation will contain basic information, with some attempt made to link knowledge and understanding to the given context.
2	3-4	An explanation will be given, with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An explanation is made that is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning, which is clear and logically structured.

Q18.

Question number	Answer	Additional guidance	Mark
(a)(i)	A calculation in which: • substitute values correctly into the equation (1) • correct answer with units (1)	<u>Example of calculation</u> $V = \frac{4 \times \pi \times 50 \times 50 \times 50}{3}$ volume = 523 599 / 5.2 x10⁵ nm³ CE applies if 100 has been used in calculation instead of 50 ALLOW correct conversions with different units No working: e.g. 523 599 / 5.2 x10⁵ nm³ / 523 333 nm³ gains 2 marks e. g. 4 186 667 / 4.2 x10⁶ nm³ gains 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes the following points: - because {hydrophobic / non-polar} tails {move away from / repelled by} the {aqueous environment / water} (1) {hydrophilic / polar} heads {interact with / associate / dissolve in} the {aqueous environment / water} (1)	NB if no other marks awarded, allow 'hydrophilic heads face water and hydrophobic tails face away from water' for 1 mark	(2)

Question number	Answer	Mark
(b)(i)	The only correct answer is B. <i>A is incorrect because the liposome has no protein and cannot generate ATP.</i> <i>C is incorrect because liposomes cannot take up molecules by endocytosis.</i> <i>D is incorrect because water only moves by osmosis.</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A description that includes the following points: - increase in temperature increases membrane permeability (1) - increase in cholesterol decreases membrane permeability (1) - cholesterol has a greater effect on membrane permeability at higher temperatures (1)	ACCEPT converse throughout	(3)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An explanation that includes the following points: - because an increase in temperature increases the movement of phospholipids (1) - because the cholesterol decreases fluidity (of the membrane) (1)	ACCEPT fills the gaps between the phospholipid tails / acts as a barrier / reduces movement of phospholipids	(2)

Q19.

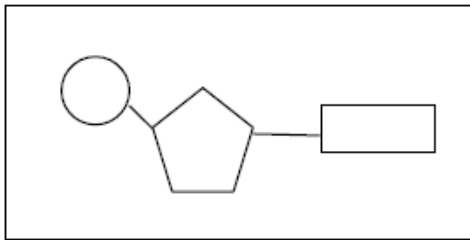
Question number	Answer				Additional guidance	Mark
(a)	Polymer	Monomer	Elements in monomer	Type of bond	ACCEPT chemical symbols C, H, O	(4)
	Carbohydrates	monosaccharide	carbon, hydrogen and oxygen	glycosidic		
	Nucleic acids	(mono)nucleotide	carbon, hydrogen, oxygen, phosphorus and nitrogen	phosphodiester		
	Proteins	amino acid	carbon, hydrogen, oxygen, (sulfur) and nitrogen	peptide	ACCEPT chemical symbols C, H, O, N, S	

Question number	Answer	Additional guidance	Mark
(b)	A description that includes three of the following points: TWO FROM • (one) glycerol and three fatty acids (1) • joined by {condensation reaction / ester bond} (1) • by enzymes (1) AND • (at least) one fatty acid is {unsaturated / has a CC double bond}(1)		(3)

Q20.

Question number	Answer	Additional guidance	Mark
	A description that includes the following points: DNA only • deoxyribose • thymine DNA and mRNA accept two from • phosphate (group) • cytosine • guanine • adenine mRNA only • ribose • uracil	Items should not be written in "both" space as well as "mRNA" or "DNA" space Names of bases should be written in full (not just letter abbreviations) and broadly correct IGNORE nitrogenous base, pentose sugar, purine, pyrimidine	(6)

Q21.

Question number	Answer	Mark
(a)(i)	B  <i>A is incorrect because the phosphate should be joined to C4</i> <i>C is incorrect because the base should be attached to C1</i> <i>D is incorrect because the phosphate should be joined to C4 and the base should be attached to C1</i>	(1)

Question number	Answer	Mark
(a)(ii)	B <i>A is incorrect because a phosphate is attached to the sugar not the base</i> <i>C is incorrect because a phosphodiester joins a sugar with a phosphate, not two phosphates</i> <i>DC is incorrect because the phosphate is joined to the sugar not the base</i>	(1)

Question number	Answer	Mark
(a)(iii)	C <i>A is incorrect because complementary bases are joined by hydrogen bonds</i> <i>B is incorrect because one large base and one small base are joined together by hydrogen bonds</i> <i>D is incorrect because one large base and one small base are joined together</i>	(1)

Question number	Answer				Mark
(b)(i)					
Statement	Correct statement about				
	both strands	only the complementary DNA strand	only the mRNA strand	neither strand	
The number of guanines will be the same as in the template strand				X	
The number of thymines will be the same as the number of adenines in the template strand		X			
There will be no adenine present				X	
(3)					

Question number	Answer	Additional guidance	Mark
(b)(ii)	transcription (1)	IGNORE {post-transcription modification /protein synthesis} DO NOT ACCEPT {translation / reverse transcription}	(1)

Q22.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following points: • decrease in diameter measured and calculated (1) • percentage decrease calculated (1)	ACCEPT (4.6 – 2.9) or 1.7 $(1.7 \div 4.6) \times 100 = 36.96 / 37$ IGNORE 37.0 Correct answer gets 2 marks. ACCEPT correctly calculated and rounded answer from wrong measurements for one mark	(2)

Question number	Answer	Mark
* (a)(ii)	Indicative content: Descriptions of diagrams (D points) - reduced diameter of lumen (in person with CF) - thicker or inflamed muscle layer (in person with CF) - more mucus (in person with CF) Cystic fibrosis (C points) - CF results in the production of very {sticky / thick} mucus (credit this point only once) - CF is due to a {mutation in the CFTR gene / faulty CFTR allele} (resulting in) {the CFTR protein not functioning properly / abnormal or defective CFTR protein / abnormal channel proteins / CFTR channel blocked} - this affects transfer of chloride ions out of cells (Cl⁻ accumulate in cells so) {water moves out of mucus / water remains in cytoplasm} / mucus is dehydrated } Change in lumen diameter (L points) - CF results in the production of very {sticky / thick} mucus (credit this point only once) - diameter of lumen in patient with CF is reduced - because the mucus builds up (because the) cilia cannot move / beat (idea of cilia normally clearing mucus) (because the) cilia cannot move mucus away (it is too thick) (credit this only once) - Inflammation of muscle (narrows lumen) (credit this only once) Inflammation (I points) - cilia cannot move mucus away (it is too thick) (credit this only once) - mucus (is very sticky and) traps bacteria - bacteria have ideal growth conditions (in mucus) - bacteria can cause (chest) infections - CF characterised by coughing {to remove mucus / as a result of infection} {coughing / infection} damages {cells / tissues} (lining airways) (leading to) inflammation of muscle (credit this only once)	(6)

Level	Marks	
	0	No awardable content
1	1 - 2	Level 1: description of diagrams 1 mark: one D or one C point 2 marks: second D or C point
2	3 - 4	Level 2: explanation of either change in diameter of lumen or inflammation linked to CF 3 marks: three L points or 3 I points 4 marks: as 3 marks plus additional C point
3	5 - 6	Level 2: explanation of both change in diameter of lumen and inflammation linked to CF 5 marks: three L points and 3 I points 6 marks: as 5 marks plus additional C point

Question number	Answer	Additional guidance	Mark
(b)(i)	An explanation that includes the following points: • because parents (who are carriers) may decide {not to have a child / to adopt a child} (1) • because parents (who are carriers) may choose {IVF / PIGD} (1) • because embryos identified as having cystic fibrosis may be aborted (1)	ACCEPT screening allows choice of unaffected partner Not just "make an informed choice" ACCEPT idea that affected foetus can be identified by CVS / amniocentesis / pre-natal screening (leading to abortion) ACCEPT only healthy embryos implanted (after IVF/ PIGD) IGNORE references to CVS / amniocentesis except in context of mp3	(3)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An answer that includes three of the following points: - screening may result in {an abortion /taking a human life} that is {unethical/ against religious or cultural beliefs of some people} (1) - spare embryos from IVF are destroyed which is taking a human life (1) - individuals who are genetically linked may be {exposed to unwanted facts / disadvantaged} following testing (1) - screening may produce false results or {CVS / amniocentesis} increases risk of miscarriage (which results in death of foetus)	ACCEPT foetus for embryo ACCEPT embryo has a right to life (in context of abortion) / embryo cannot give consent / parents can make informed choice (after test)/ comment on perceived worth of (affected) child ACCEPT embryo has a right to life in context of IVF / comment on potential selection of traits of embryo in IVF (not just "designer babies") IGNORE references to foetus/baby in this context ACCEPT reference to family members IGNORE violation of privacy (too vague)	(3)

Q23.

Question number	Answer	Mark
(a)(i)	The only correct answer is D <i>A is incorrect because diffusion does not use proteins</i> <i>B is incorrect because diffusion does not use proteins</i> <i>C is incorrect because diffusion does not use proteins</i>	(1)

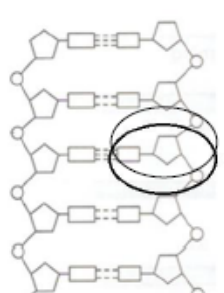
Question number	Answer	Mark
(a)(ii)	The only correct answer is B <i>A is incorrect because diffusion does not use energy</i> <i>C is incorrect because facilitated diffusion does not use energy</i> <i>D is incorrect because facilitated diffusion does not use energy</i>	(1)

Question number	Answer	Mark
(a)(iii)	The only correct answer is B <i>A is incorrect because solutes can move against their concentration gradient in active transport</i> <i>C is incorrect because solutes can move against their concentration gradient in active transport</i> <i>D is incorrect because solutes can move against their concentration gradient in active transport</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: • (free water molecules) because some water molecules are {restricted / prevented} from movement (1) • (partially permeable membrane) because membrane allows some (types of) molecules to pass through it (1) • (down a water potential gradient) because water molecules move {from a dilute solution to a more concentrated one / from a high osmotic potential to a lower one / from a high solute potential to a lower one} (1)	ACCEPT a description ACCEPT from a low concentration of solute to a high concentration of solute from hypotonic to hypertonic solution IGNORE from a high water concentration to a lower one	(3)

Question number	Answer	Additional guidance	Mark
* (c)	Indicative content: • water content decreases when crabs first moved (D) • because water passes out of cells by {osmosis / description of osmosis} (E) • water content then increases gradually (D) • because of the increase in amino acid concentration (E) • amino acid increases (D) • sharply at first and then rate decreases (D) • because {insoluble / muscle} proteins broken down into amino acids (E) • by hydrolysis (E) • because crab eats more {protein / amino acids} (E) • which is digested into amino acids (E) • which are taken up into the cells by {active transport / facilitated diffusion} (from the blood) (E) • water content increases because the amino acid content increase (E) • which makes the cytoplasm more concentrated than the sea water (E) • therefore crabs do not die from dehydration (E)	Level 1 1 mark = simple description of one graph 2 marks = simple description of both graphs Level 2 3 marks = and a simple explanation of one graph 4 marks = and a simple explanation of both graphs Level 3 5 marks = a simple explanation of one graph and a more detailed explanation for the other graph 6 marks = a more detailed explanation for both graphs	(6)

Q24.

Question number	Answer	Additional guidance	Mark
(a)(i)	• circle drawn around R, the attached sugar and a phosphate group	 ACCEPT the phosphate group on either C3 or C5	(1)

Question number	Answer	Mark			
(a)(ii)	The only correct answer is D <table border="1"> <tr> <td>phosphodiester</td><td>covalent</td><td>hydrogen</td></tr> </table> <i>A is incorrect because S is a phosphodiester bond, T is a covalent bond and U is a hydrogen bond</i> <i>B is incorrect because S is a phosphodiester bond and U is a hydrogen bond</i> <i>C is incorrect because T is a covalent bond and U is a hydrogen bond</i>	phosphodiester	covalent	hydrogen	(1)
phosphodiester	covalent	hydrogen			

Question number	Answer	Mark
(a)(iii)	The only correct answer is C Thymine <i>A is incorrect because adenine is complementary to thymine</i> <i>B is incorrect because adenine is complementary to thymine</i> <i>D is incorrect because adenine is complementary to thymine</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	A diagram that shows the following points: - a band the same width as stage 1 in the middle of the tube (1) - bands drawn at the top and middle of tube (1) - both bands narrower than stage 1 (1) - bands drawn at the top and middle of tube (1) - top band drawn narrower than stage 1 but wider than stage 3 and lower band drawn narrower than stage 3 (1)	DNA taken after stage 2 DNA taken after stage 3 DNA taken after stage 4	(5)

Question number	Answer	Mark
(b)(ii)	The only correct answer is B <i>A is incorrect because neither DNA molecule is made of all heavy nitrogen or light nitrogen</i> <i>C is incorrect because neither DNA molecule is made of all heavy nitrogen or light nitrogen + bands are too wide</i> <i>D is incorrect because it has only one band</i>	(1)

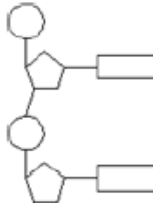
Q25.

Question number	Answer	Additional guidance	Mark
(a)	methionine leucine isoleucine tyrosine (1)	ACCEPT met leu iso tyr combinations of names and abbreviations	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	Base number 3 becomes cytosine (C) substitution Base number 6 becomes number 5 in the sequence deletion Base number 9 becomes number 10 in the sequence insertion	All three correct = 2 marks Any one or two correct = 1 mark IGNORE point mutation throughout IGNORE swapping mutation IGNORE elimination / frameshift IGNORE addition / frameshift	(2)

Question number	Answer
* (b)(II)	Indicative content: Substitution: - only affects one triplet codon - may not change the amino acid - e.g. number 6 becomes A, would still code for leucine - may change amino acid - e.g. number 1 becomes G, resulting in valine - may result in a stop codon - e.g. number 12 becomes G Deletion: - one base removed will shift the reading frame back one place - all amino acids after the mutation will be affected - closer to the start of the gene the greater the affect - fewer amino acids coded for - e.g. remove base 4 and sequence becomes methionine serine phenylalanine threonine Insertion: - one base added will shift the reading frame forward one place - all amino acids after the mutation will be affected - closer to the start of the gene the greater the affect - e.g. add C between numbers 9 and 10 and sequence becomes leucine proline serine

	Aspects to comment on: 1. Substitution changing the amino acid 2. Deletion changing sequence 3. Insertion changing sequence 4. Stop codons appearing shortening the sequence 5. Substitution may have no effect 6. Position of (insertion / addition) significant Level 1 1 mark : correct statement about mutations 2 marks : 1 aspect commented on with a corresponding illustration OR 2 or more aspects commented on but no illustrations Level 2 3 marks : 2 aspects commented on with corresponding illustrations OR 3 or more aspects commented but only 1 or 2 illustrations 4 marks : 3 aspects commented on with corresponding illustrations Level 3 5 marks : 4 aspects commented on with corresponding illustrations 6 marks : 5 aspects commented on with corresponding illustrations
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Question number	Answer	Additional guidance	Mark
(a)	An answer that includes the following points: - two mononucleotides shown (joined in one strand only) (1) - each base bonded to C1 of pentose sugar (1) - phosphate group bonded to C3 of one sugar and C5 of the other sugar (1)	IGNORE labels including second strand if drawn / additional mononucleotides / one mononucleotide including second strand if drawn / additional mononucleotides <u>example of diagram</u> 	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	0.38 (nm)	ACCEPT 0.4	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes the following points: - R (or Q) because it forms two hydrogen bonds (1) - R (or S) because it is {large / double-ring / purine} base (1)	ACCEPT not bases P and S because they form 3 hydrogen bonds ACCEPT not bases P and Q because they are {small / single-ring / pyrimidine} ACCEPT Q for correct reason or S for correct reason if neither mark points awarded	(2)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes at least one similarity and one difference: similarities: • both contain {RNA (mono)nucleotides / ribose sugar / uracil (and adenine, cytosine and guanine) / phosphodiester bonds} (1) • both are single stranded (1) differences: • mRNA is a straight chain and tRNA is {folded / clover-leaf shaped} / mRNA does not have hydrogen bonds and tRNA does (1) • {size / length} of mRNA is variable and the {size / length} of tRNA is constant (1) • mRNA has codons and tRNA has {anticodons / amino acid binding sites} (1)	DO NOT PIECE TOGETHER ACCEPT letters for bases	(4)

Q27.

Question number	Answer	Additional guidance	Mark
(a)	The correct answer is C, protein <i>A is incorrect because enzymes are proteins</i> <i>B is incorrect because enzymes are proteins</i> <i>D is incorrect because enzymes are proteins</i>		(1)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: • because they are found in living organisms (1) • because they speed up the rate of reaction (without being used up) (1)	ACCEPT in our bodies / named organism / are proteins / in cells / in cytoplasm ACCEPT lower {activation energy / description of activation energy}	(2)

Question number	Answer	Additional guidance	Mark
(c)(i)	• 8.5 (a.u. per °C)	IGNORE decrease of / ↓ / -	(1)

Question number	Answer	Additional guidance	Mark
(c)(ii)	• because the {enzyme is denatured / active site to change shape / bonds to break} (1)	DO NOT ACCEPT starts to	(1)

Q28.

Question number	Answer	Additional guidance	Mark
(a)(i)	• 9 : 1	ACCEPT 6 : 1 / 5 : 1	(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	A description that includes the following points: • will not have any effect on the total membrane phospholipids (1) • the inner layer will have a relatively higher content of the other phospholipids / the outer layer will have a relatively lower content of the other phospholipids (1)	ACCEPT increase phospholipid content in outer layer and decrease content in inner layer	(2)

Question number	Answer	Additional guidance	Mark
(a)(iii)	A description that includes the following points: • will alter membrane {properties / permeability / fluidity} (1) • so that platelets will release thromboplastin (1) • thromboplastin is {an enzyme / a catalyst} (1) • that converts prothrombin into thrombin (1)	NB thromboplastin catalyses prothrombin into thrombin = 2 marks	(4)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: • thrombin is an <u>enzyme</u> (1) • because the inhibitor will change the shape of the active site (of thrombin) (1) • therefore thrombin cannot bind to fibrinogen (1) • therefore {less / no} fibrinogen will be converted into fibrin (1) • therefore there is {less / no} {mesh / fibrin / fibres} to trap {blood cells / platelets} (1)	ACCEPT inhibitor blocks the active site / fewer active sites available ACCEPT {less / no} thrombin to bind to fibrinogen / fewer collisions / fewer enzyme substrate complexes formed ACCEPT slower conversion	(4)

Q29.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes two of the following points: (46 / 48 / 94 patients is) not a very large sample size (1) {18 countries / variety of people} probably means that other variables not taken into account (1) - but AHP is a very rare disorder so not many patients available (1)	IGNORE refs to reliability, validity ACCEPT in the context of 'these' people named variable e.g. lifestyle, diet, other diseases IGNORE sex / age	(2)

Question number	Answer	Additional guidance	Mark
(a)(ii)	- mass of drug needed for that patient (1) {0.8 / 0.85 / 0.847} cm³ (1) OR - volume of drug to give 2.5 mg (1) {0.8 / 0.85 / 0.847} cm³ (1)	Example of calculation: $64 \times 2.5 / 160$ IGNORE units ACCEPT cc / mls $2.5 \div 189 / 0.0132275$ ACCEPT cc / mls NB Bald answer of {0.8 / 0.85 / 0.847} cm³ = 2 marks Bald answer of {160 / 0.01 / 0.013 / 0.132} = 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(a)(iii)	27% of 48 calculated (1) 12 / 13 (1)	Example of calculation: $27 \times 48 \div 100 / 12.96$ ACCEPT 25 as an ecf for 1 mark (27% of 94)	(2)

Question number	Answer	Additional guidance	Mark
(b)(i)	G U C U U U C	All correct = 2 marks One wrong base given OR one wrong base given consistently = 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	A description that includes three of the following points: - phosphodiester bonds between (adjacent) {ribose and phosphate / (mono)nucleotides} (in each strand) (1) - covalent bonds attaching base to a {ribose (sugar) / sugar} (1) {hydrogen / H} bonds between (complementary) bases (holding two strands together) (1) {hydrogen / H} bonds holding double helix together (1)	ACCEPT sugar DO NOT ACCEPT deoxyribose ACCEPT between {C and G / U and A} DO NOT ACCEPT between {T and A / other incorrect base pairs} IGNORE incorrect number of H bonds	(3)

Question number	Answer	Additional guidance	Mark
(b)(iii)	An answer that includes three of the following points: {no / less / affected} translation of the mRNA (1) (altered mRNA) affects shape of {protein / active site} (1) {no / less / slower} haem production (1) {no / less} (toxic) porphyrin (1)	ACCEPT a description of translation DO NOT ACCEPT transcription / description of transcription ACCEPT no {protein / enzyme} formed	(3)

Q30.

Question number	Answer	Marks
(a)	An explanation that includes the following points: - many small alveoli to provide a large surface area to increase the rate of diffusion (1) - thin epithelium to increase rate of diffusion (1) - good blood supply to maintain diffusion gradient (1)	(3)

Question number	Answer	Mark
(b)(i)	a version of a gene	(1)

Question number	Answer	Mark
(b)(ii)	An explanation that includes the following points: • there will be a different sequence of R groups (1) • therefore the CFTR protein has a different tertiary structure (1) • because of different {types of / position of} bonds between the R groups (1) • therefore the movement of chloride ions through the cell membrane is affected (1)	(4)

Question number	Answer	Mark
(b)(iii)	An explanation that includes any four of the following points: • produces very thick, sticky mucus (1) • because of reduced water transport from cells (1) • cilia lining airways are unable to move mucus (1) • therefore microorganisms get trapped in the mucus (1) • mucus provides suitable growth conditions for growth of microorganisms (1)	(4)

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Gas exchange requires diffusion.

The rate of diffusion is dependent on the surface area, the diffusion distance and the concentration gradient.

The rate of diffusion can be calculated using the formula:

$$\text{rate of diffusion} \propto \frac{\text{surface area} \times \text{concentration gradient}}{\text{diffusion distance}}$$

(a) Name the law on which this formula is based.

(1)

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(b) What will happen to the rate of diffusion if all three of the following are changed at the same time?

- the surface area is halved
- the concentration gradient is halved
- the diffusion distance is halved

(1)

☐ **A** it will stay the same

☐ **B** it will be a quarter of its value

☐ **C** it will halve

☐ **D** it will double

(c) The properties of gas exchange surfaces include:

- a large surface area
- a short diffusion distance
- a high concentration gradient.

Describe how mammalian lungs are adapted to have each of these three properties.

(3)

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*(d) The photograph shows a hellbender salamander.



(Source: © Robert Hamilton/Alamy Stock Photo)

These salamanders live in freshwater streams that are shallow and fast-flowing.

They use their lungs and the surface of their skin for gas exchange.

They also use body rocking and swaying movements in the water.

The graph shows the relationship between the frequency of body rocking movements, blood pO_2 and the percentage saturation with oxygen of the water they live in.

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(Total for question = 11 marks)

Q2.

Cystic fibrosis is an inherited recessive disease caused by mutations in a gene on chromosome 7.

(a) Give the meaning of the term **gene**.

(1)

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(b) Explain how mutations result in cystic fibrosis.

(3)

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(c) Population carrier screening (PCS) is one type of genetic screening.

This involves screening people who want a child to see if they are carriers of genetic disorders.

In one country, the number of babies born with cystic fibrosis went down following the introduction of PCS.

Suggest why the number of babies born with cystic fibrosis went down.

(3)

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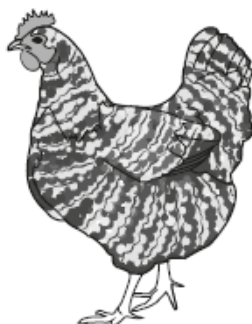
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(Total for question = 7 marks)

Q3.

The drawing shows a speckled chicken. These chickens have a mixture of black and white feathers.



The colour of the feathers of a chicken is an example of codominance.

One parent of this speckled chicken had white feathers and the other parent had black feathers.

(a) Describe the difference between each of the following pairs of terms, using feather colour to illustrate your answer.

(i) Gene and allele

(3)

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(ii) Genotype and phenotype

(3)

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(b) A black chicken was mated with a speckled chicken. They had 25 chicks.

Determine the expected number of speckled chicks.

You **must** use a genetic diagram.

(3)

Answer

(c) In an experiment, several pairs of speckled chickens were mated together.

They produced 480 chicks.

The table shows the expected number of speckled chicks, white chicks and black chicks. It also shows the actual number of each type of chick.

Steps in the calculation for the statistics test	Colour of feathers of chicks		
	Speckled	White	Black
Observed number (O)	243	125	112
Expected number (E)	240	120	120
(O-E)			
$\frac{(O-E)^2}{E}$			

This table can be used in a statistics test.

(i) Name the statistics test being used to analyse these data.

(1)

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(ii) Complete this table to show the missing values.

(2)

(iii) Calculate $\sum \frac{(O-E)^2}{E}$

(1)

Answer

(iv) Explain how a critical value table could be used to accept or reject a null hypothesis for this experiment.

(2)

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(Total for question = 15 marks)

Q4.

Rabbits can have brown fur or white fur.

A heterozygous rabbit will have brown fur.

(a) Draw a genetic diagram to show the genotypes and corresponding phenotypes of the baby rabbits produced if two heterozygous rabbits were bred together.

(3)

(b) A number of heterozygous pairs of rabbits were bred together and produced 284 baby rabbits.

Calculate the expected number of homozygous brown rabbits, heterozygous brown rabbits and white rabbits produced.

(3)

Number of homozygous brown rabbits

Number of heterozygous brown rabbits

Number of white rabbits

(Total for question = 6 marks)

Q5.

Most Bengal tigers are orange with black stripes but there is a very small number of Bengal tigers that are white with black stripes.

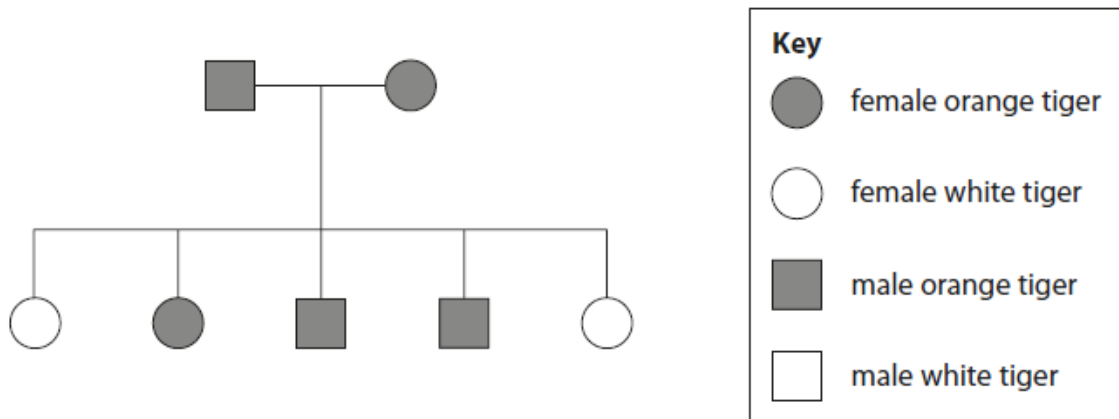
The photograph shows a white Bengal tiger with black stripes.



(Source: Caroline Wilcox)

White tiger offspring are produced by two Bengal tigers that each carry at least one recessive allele for a gene affecting coat colour.

The pedigree diagram shows the phenotypes in one family of tigers, bred in captivity.



(a) The phenotype is affected by the genotype.

State what is meant by the term **genotype**.

(1)

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(b) State the probability that the next tiger born to these two parents will be female.

(1)

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(c) Determine the expected phenotypic ratio of orange tigers to white tigers born to the parents shown in this pedigree diagram.

Use a genetic diagram to support your answer.

(3)

Answer

(d) The incidence of white tigers in the wild is 1 in 10 000 Bengal tigers.

There are approximately 6000 Bengal tigers in captivity, 200 of which are white.

Calculate the incidence of white tigers in captivity.

(1)

Answer

(Total for question = 6 marks)

Q6.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

Humans store energy as glycogen.

(a) (i) Which is the correct statement about the formation of glycogen?

(1)

☐ **A** α glucose molecules join together by a condensation reaction

☐ **B** α glucose molecules join together by a hydrolysis reaction

☐ **C** β glucose molecules join together by a condensation reaction

☐ **D** β glucose molecules join together by a hydrolysis reaction

(ii) Name the bond that joins two glucose molecules together.

(1)

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(iii) Explain how the structure of glycogen relates to its role as an energy storage molecule.

(3)

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(b) Von Gierke disease is one type of glycogen storage disease (GSD).

(i) Between one in 20 000 and one in 25 000 babies are born with GSD.

About 25% of patients with GSD are thought to have Von Gierke disease.

In one country, 3.8 million babies were born in one year.

Estimate the number of babies born each year with Von Gierke disease in this country.

(2)

Answer

(ii) Von Gierke disease is an inherited disease.

Suggest why the majority of these babies are born to parents who are not affected by Von Gierke disease.

(2)

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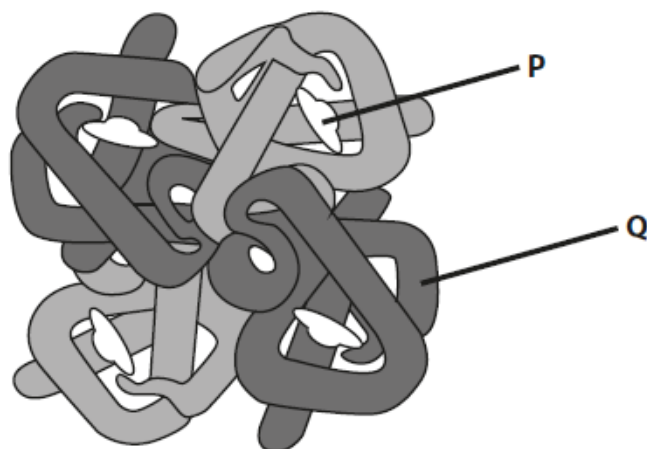
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(Total for question = 9 marks)

Q7.

The role of haemoglobin is to transport oxygen and carbon dioxide in the blood.

The diagram shows the structure of adult haemoglobin



(a) (i) State the role of the structure labelled **P**.

(1)

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(ii) Explain the properties of amino acids located on the outer surface of the haemoglobin, for example at position **Q**.

(2)

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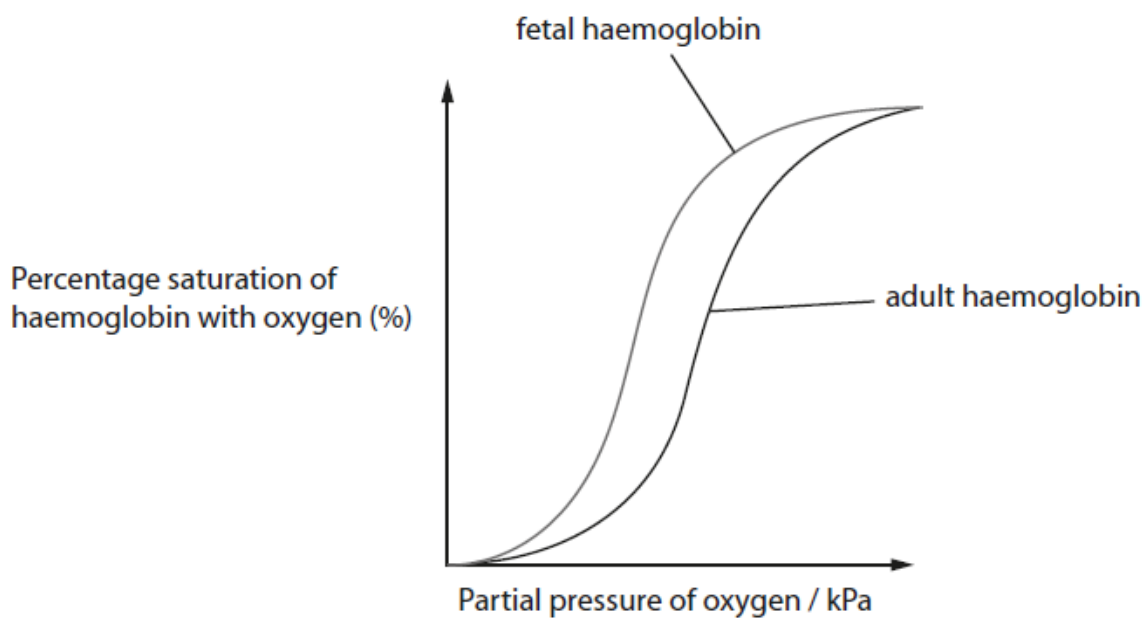
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(b) The graph shows the oxygen dissociation curves of adult and fetal haemoglobin.



(i) Explain why the oxygen dissociation curve of adult haemoglobin is different from that of fetal haemoglobin.

(2)

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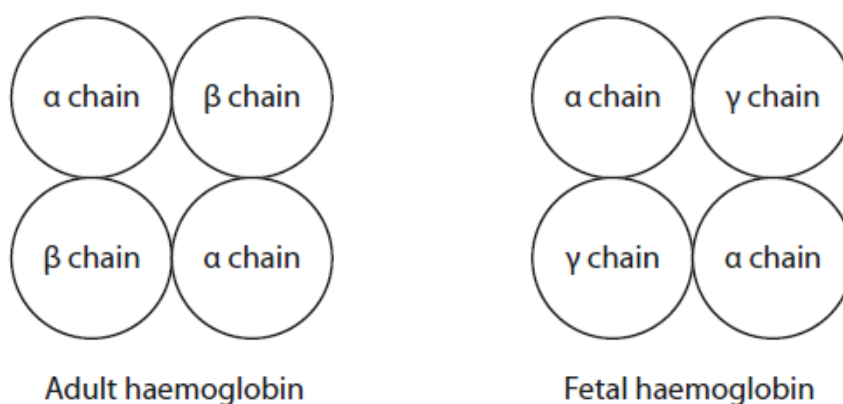
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(ii) The structures of adult and fetal haemoglobin are different.

The diagram shows the structure of adult and fetal haemoglobin.



The table shows the number of amino acids in each type of chain.

Type of chain	Number of amino acids
α	141
β	146
γ	146

The amino acids in the α chains are the same in adult and fetal haemoglobin.
The β and γ chains differ in 39 of their amino acids.

Calculate the percentage of amino acids that are different in adult and fetal haemoglobin.

(2)

Answer %

(Total for question = 7 marks)

Q8.

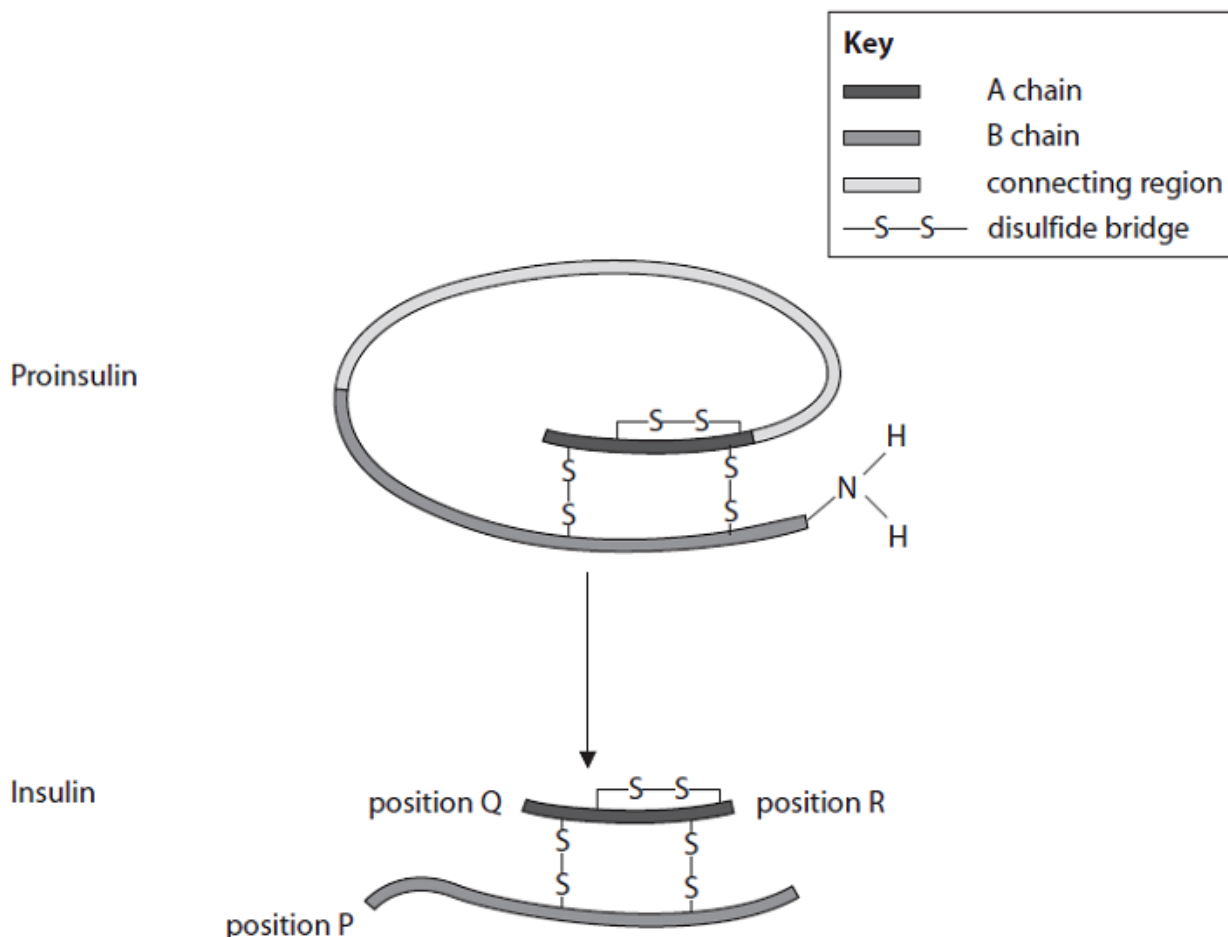
Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Insulin is a small protein composed of two peptide chains, the A chain and the B chain.

Insulin is made from the protein proinsulin.

Proinsulin is composed of the A chain and the B chain joined by a sequence of amino acids called the connecting region.

The diagram shows how insulin is formed from proinsulin.



(a) The connecting region is removed from proinsulin, leaving the A chain connected to the B chain by disulfide bridges (—S—S—).

Which row of the table shows the position of an amino group (NH₂) and a carboxyl group (COOH)?

(1)

	Amino group	Carboxyl group
☒ A	position R	position P
☒ B	position P	position R
☒ C	position Q	position R
☒ D	position Q	position P

(b) Proinsulin is composed of 84 amino acids.

Insulin is composed of 51 amino acids.

(i) What percentage of proinsulin is the connecting region?

(1)

Answer %

(ii) There are three disulfide bridges in insulin. Each disulfide bridge is formed between the R groups of two cysteine amino acids.

Give the ratio of amino acids forming disulfide bridges in insulin to those not forming disulfide bridges in insulin.

(1)

Answer

(c) Suggest how insulin is synthesised from proinsulin.

Use the information in the diagram to support your answer.

(2)

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(d) Insulin lowers the levels of glucose in the blood. This glucose is taken up by the liver and stored as glycogen.

Compare and contrast the structure of glucose with the structure of glycogen.

(3)

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*(e) Type 2 diabetes is a disorder that can result from ineffective or insufficient insulin. It is a risk factor for cardiovascular disease (CVD).

Cinnamon is a spice that has been shown to:

- increase the uptake of glucose from the blood into the liver

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(Total for question = 14 marks)

Q9.

Genetic screening can be used to test for aneuploidy.

Aneuploidy is the presence of an abnormal number of chromosomes in a cell.

Aneuploidy can affect the miscarriage rate of implanted embryos.

Following screening, only embryos with the correct number of chromosomes are implanted into the female.

The table shows the miscarriage rate of two groups of implanted embryos:

- embryos not screened for aneuploidy
- embryos screened and shown not to have aneuploidy.

Age range of women at implantation / years	Miscarriage rate (%)	
	Implanted embryos not screened for aneuploidy	Implanted embryos screened and shown not to have aneuploidy
<35	12.0	11.2
35 to 37	16.8	13.0
38 to 40	25.0	13.6
41 to 42	37.9	16.3
>42	58.8	17.2

(a) Explain how this data shows that there is a correlation between the age of the women and the miscarriage rate.

(2)

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(b) (i) Explain the conclusions that can be made from these data about the causes of miscarriage.

(2)

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(ii) Explain why conclusions made using these data may not be valid.

(3)

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(c) Discuss the implications of screening embryos for aneuploidy before implantation.

(3)

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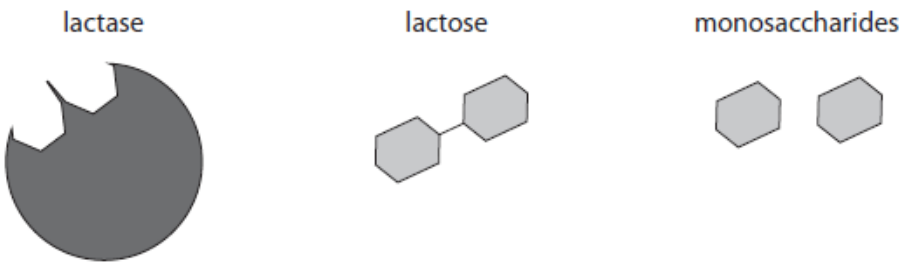
(Total for question = 10 marks)

Q10.

Answer the question with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

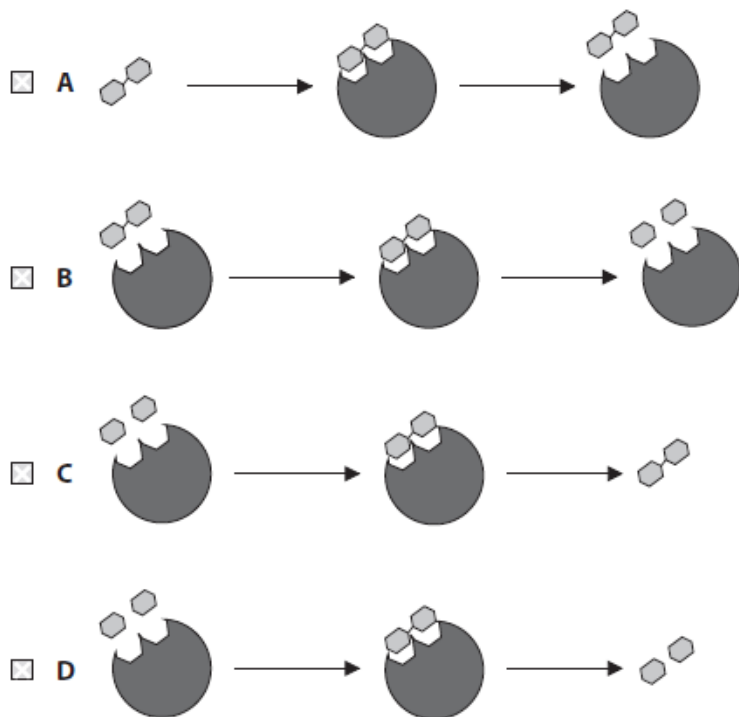
Lactase is an enzyme that catalyses the hydrolysis of lactose.

(a) (i) The diagrams show symbols for lactase, lactose and the monosaccharides of lactose.



Which diagram shows the sequence of events for the hydrolysis of lactose?

(1)

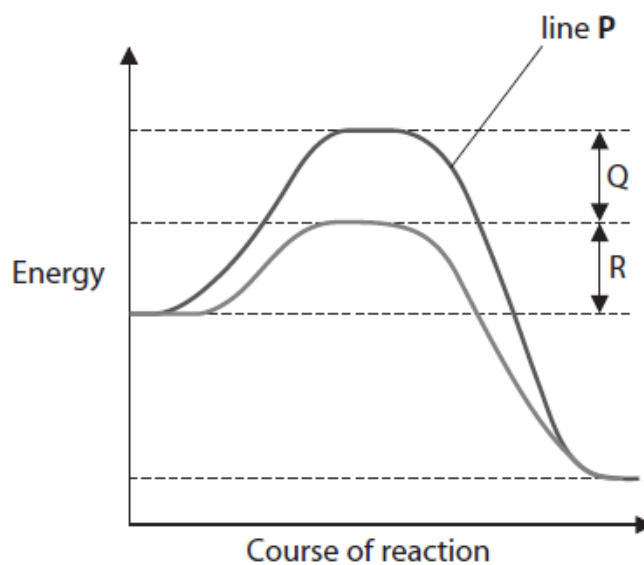


(ii) Which of the following are the monosaccharides present in lactose?

(1)

- ☐ **A** fructose and sucrose
- ☐ **B** galactose and glucose
- ☐ **C** glucose and fructose
- ☐ **D** sucrose and galactose

(b) The graph shows the energy changes for the hydrolysis of lactose, with and without lactase.

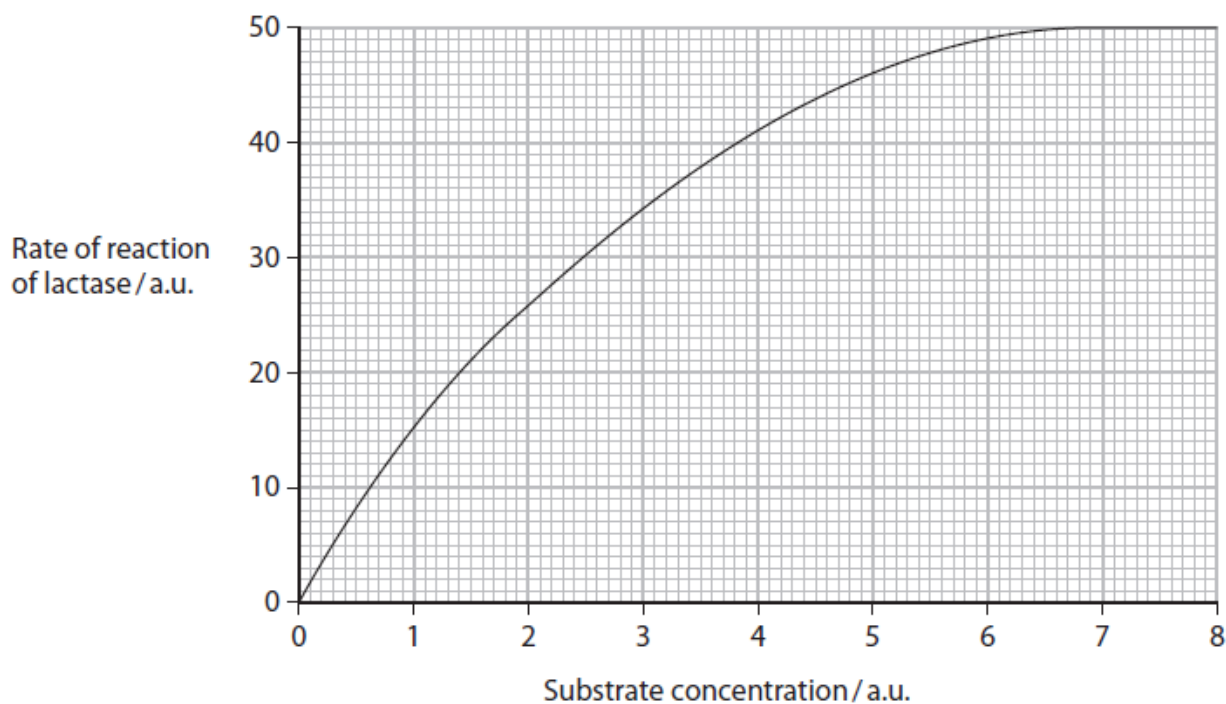


Which row in the table describes line **P** and identifies the letter that shows the decrease in activation energy due to lactase?

(1)

	Line P	Decrease in activation energy due to lactase
☐ A	reaction with enzyme	Q
☐ B	reaction with enzyme	R
☐ C	reaction without enzyme	Q
☐ D	reaction without enzyme	R

(c) The graph shows the relationship between substrate concentration and the rate of reaction of lactase.



(i) Explain why substrate concentration affects the rate of reaction.

(2)

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(ii) The reaction rate (V) at each substrate concentration can be calculated using the formula

$$V = \frac{V_{\max} \times S}{K + S}$$

$V_{\max}$ is the maximum rate of reaction

K is the substrate concentration when the rate of reaction is half the rate of $V^{\max}$

S is the substrate concentration.

Calculate the reaction rate (V) at a substrate concentration of 4 a.u.

(2)

Answer

(Total for question = 7 marks)

Q11.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

People with lactose intolerance cannot digest lactose.

Lactose intolerance is due to a lack of the enzyme lactase.

(a) (i) Which are the products of lactose digestion?

(1)

- ☐ **A** fructose and galactose
- ☐ **B** fructose and glucose
- ☐ **C** galactose and glucose
- ☐ **D** glucose and glucose

(ii) Explain how the three-dimensional structure of lactase affects the mechanism of action of this enzyme.

(3)

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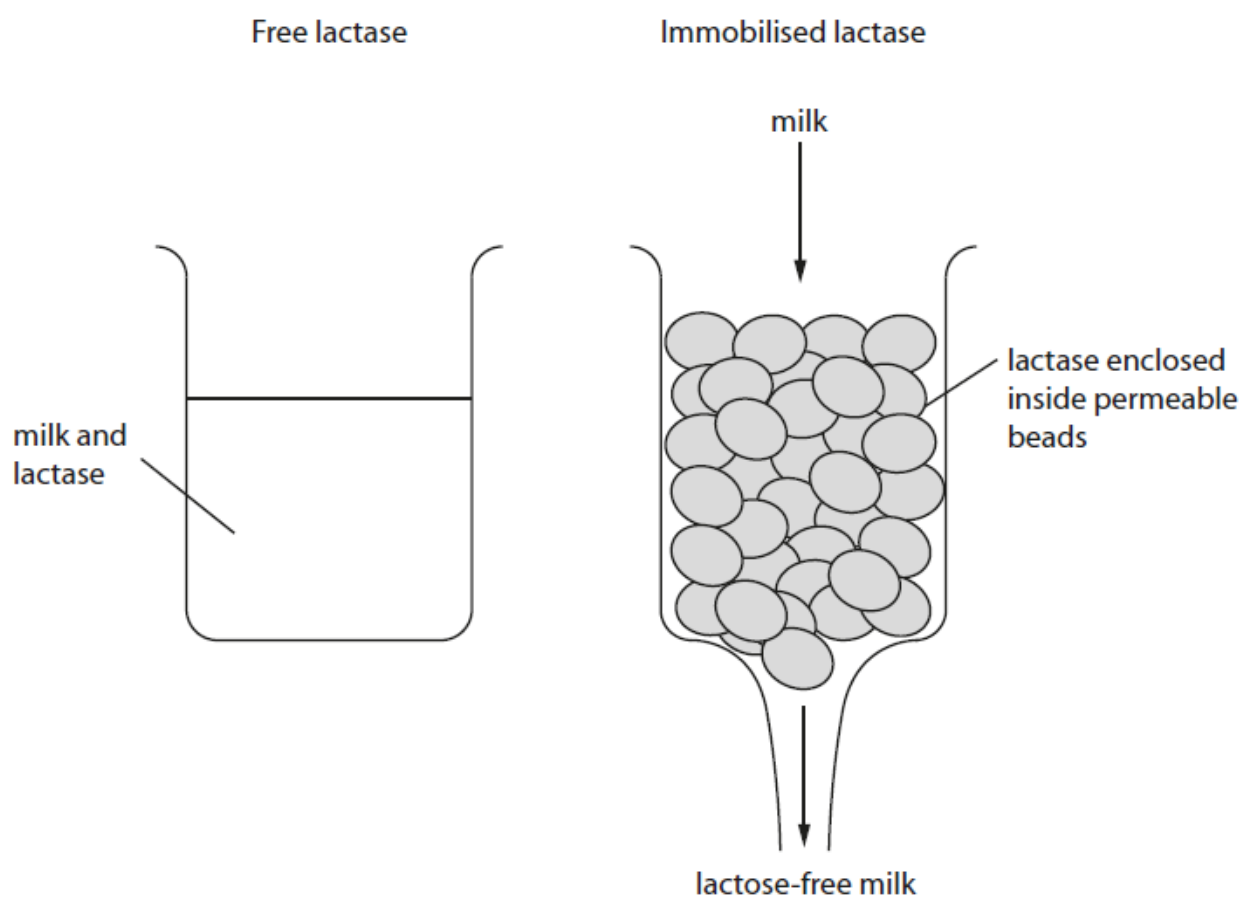
(b) People with lactose intolerance can drink lactose-free milk.

Lactose-free milk is produced by treating milk with lactase.

There are two ways of removing lactose from milk:

- mixing a solution of lactase with the milk (free lactase)
- enclosing the lactase inside permeable beads and pouring the milk over them (immobilised lactase).

The diagrams show these two methods.



(i) Suggest **one** advantage of using immobilised lactase.

(1)

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(ii) The table shows the effect of pH on the activity of free lactase and immobilised lactase.

pH	Activity of free lactase / a.u.	Activity of immobilised lactase / a.u.
2	0	0
3	0	38
4	75	75
5	94	98
6	63	76
7	56	63
8	28	35

Explain the effects of pH on the activity of these two enzymes.

(4)

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(iii) Suggest how the rate of activity of the lactase could be measured.

Include appropriate units in your answer.

(2)

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(c) Congenital lactose intolerance (CLI) is an extremely rare genetic disorder.

Most people with CLI are found in one country.

Suggest why most people with CLI are found in one country.

(2)

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(Total for question = 13 marks)

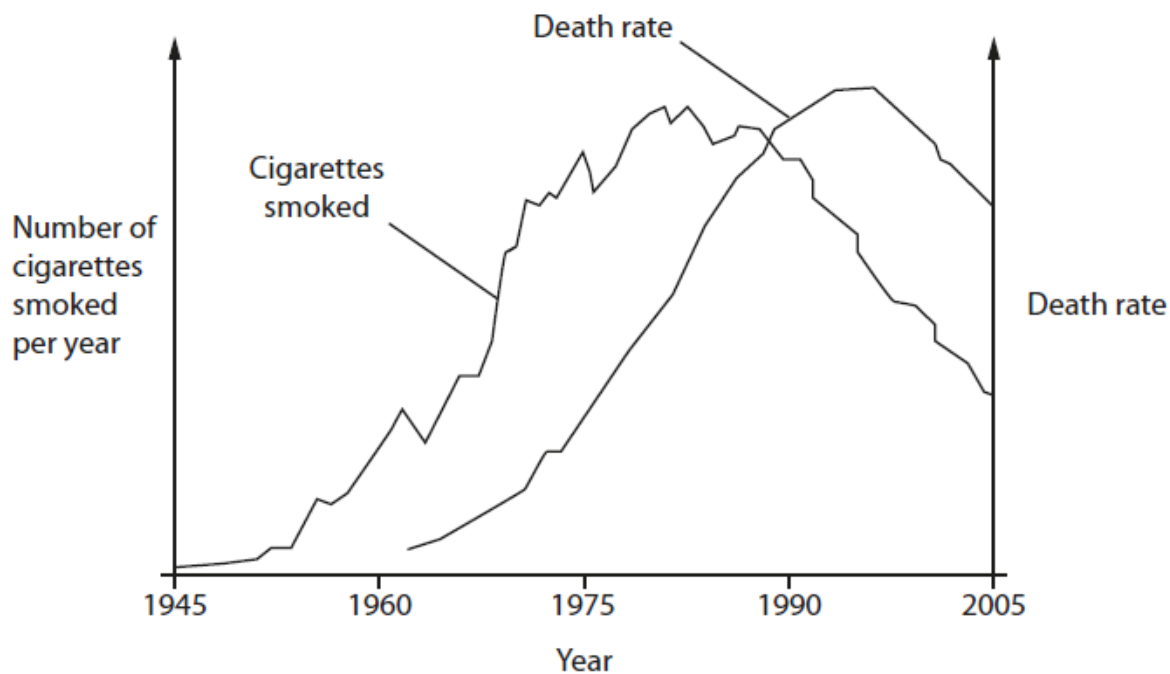
Q12.

Gas exchange surfaces have specific adaptations.

(a) Lungs contain the gas exchange surfaces of humans.

Smoking causes lung damage.

(i) The graph shows that there is a correlation between smoking and death rate from lung cancer in men.



Explain how this graph shows that there is a correlation between smoking and death rate from lung cancer in men.

(2)

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(ii) Smoking is a cause of emphysema.

People with emphysema have weakened alveoli that can collapse, creating fewer but larger alveoli.

Explain how this will affect gas exchange in people with emphysema.

(2)

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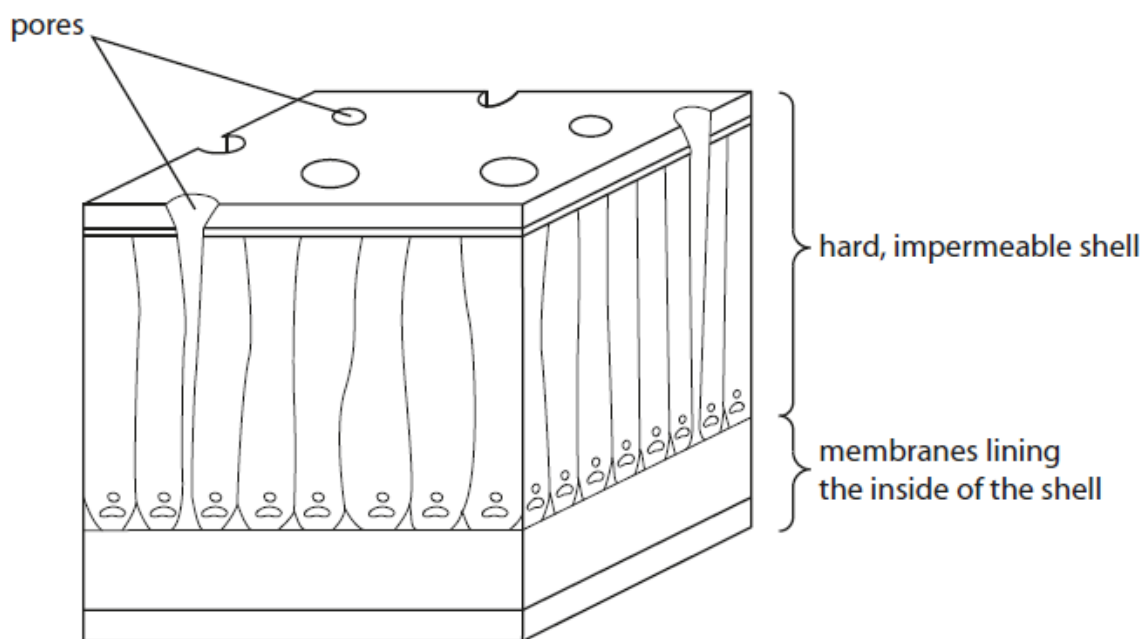
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(b) Bird embryos develop inside hard-shelled eggs.

Gas exchange occurs across the shell of the egg. The oxygen diffuses into the bloodstream of the developing embryo and carbon dioxide diffuses back out.

The diagram shows a section through the shell of an egg.



The thickness of the egg shell is 0.5 mm. The density of the pores in the shell varies from 40 to 400 per cm^2 .

Explain the factors that would determine the rate of diffusion of gases between the air and the tissues of the embryo.

Use the information in the diagram, the question and your own knowledge to support your answer.

(6)

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(Total for question = 10 marks)

Q13.

Meselson and Stahl performed experiments that demonstrated semi-conservative replication of DNA.

(a) (i) State what is meant by the term semi-conservative replication.

(2)

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(ii) Name **one** enzyme involved in semi-conservative replication.

(1)

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(iii) Explain the importance of semi-conservative replication in the production of new cells.

(2)

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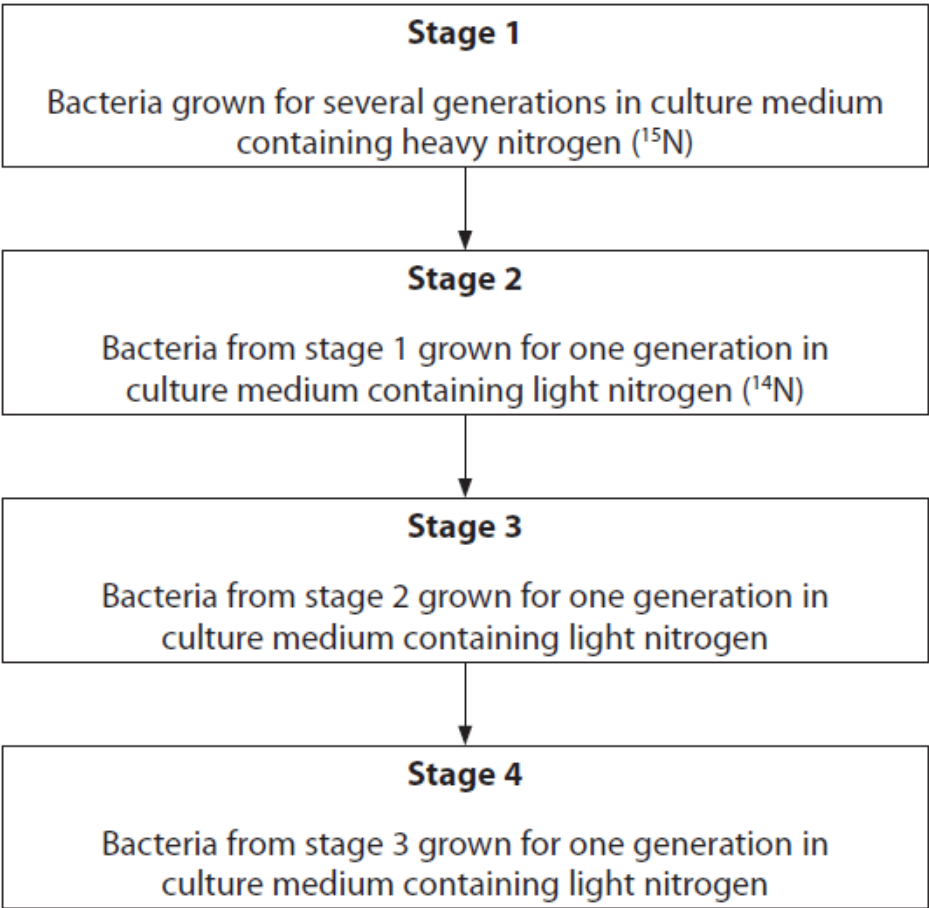
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(b) The flow chart summarises part of one experiment performed by Meselson and Stahl.



Complete the table to show the percentage of the total number of DNA molecules containing heavy nitrogen only, light nitrogen only or both heavy and light nitrogen, at the end of each stage.

(3)

End of stage	Percentage of DNA molecules containing		
	heavy nitrogen only	light nitrogen only	both heavy and light nitrogen
1			
2			
3			

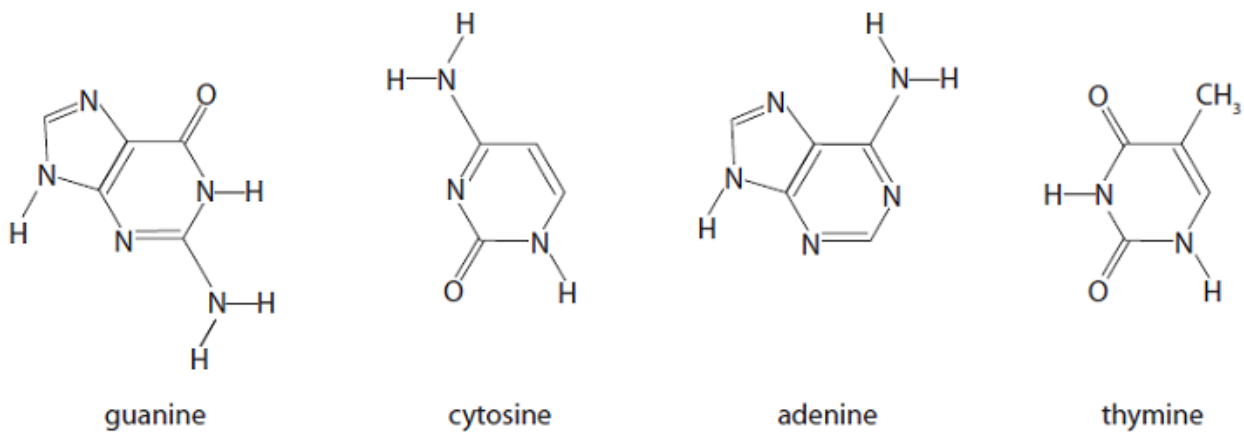
(Total for question = 8 marks)

Q14.

Mononucleotides are joined together to form DNA. Each mononucleotide is composed of a deoxyribose linked to a phosphate and one of four bases.

(a) The diagrams show the structure of the four bases.

Guanine and adenine have two ring structures, cytosine and thymine have one ring structure.



Explain the role of these bases in the structure of DNA.

Use the information in the diagram to support your answer.

(3)

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(b) The DNA of the bacterium *E. coli* has a mass of 3.1×10^9 daltons (Da) and consists of $4.7 \times$

10^6 base pairs.

(i) Calculate the mean mass of a base pair.

Express your answer in standard form.

(1)

Answer Da

(ii) Calculate the total mass of DNA produced after three cell divisions.

Give your answer in grams, where 1 dalton = 1.67×10^{-24} grams.

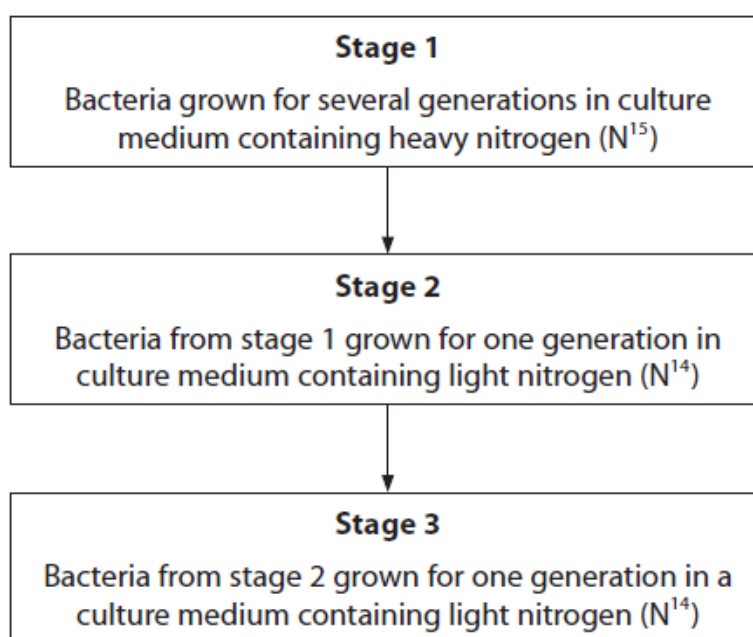
(2)

Answer g

(c) Meselson and Stahl provided data that supported the theory that DNA replicates by semi-conservative replication and disproved competing theories.

Heavy nitrogen (N^{15}) and light nitrogen (N^{14}) were used in their experiments.

The flow chart summarises part of one experiment performed by Meselson and Stahl.



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

The heavier DNA molecules form bands lower down the gradient than the lighter DNA molecules.

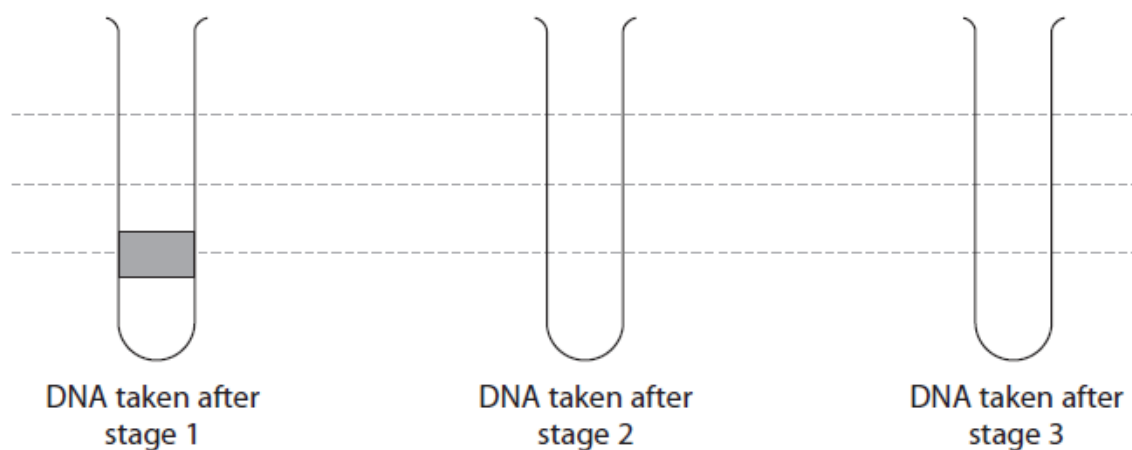
The width of each band is proportional to the percentage of molecules in the sample.

(i) Complete the diagram to show the results of this investigation.

Use the dotted lines to help you position the bands on the diagram.

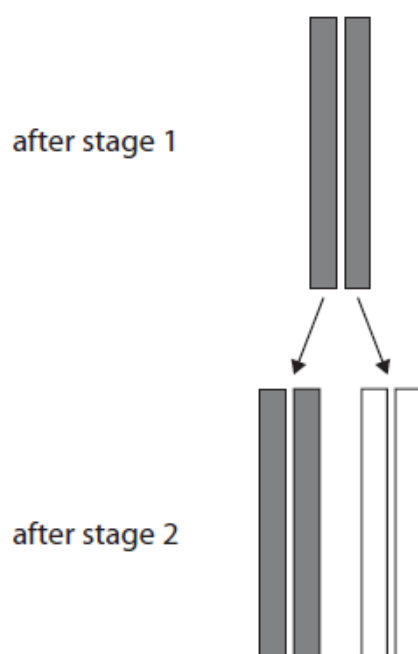
The first one has been done for you.

(3)



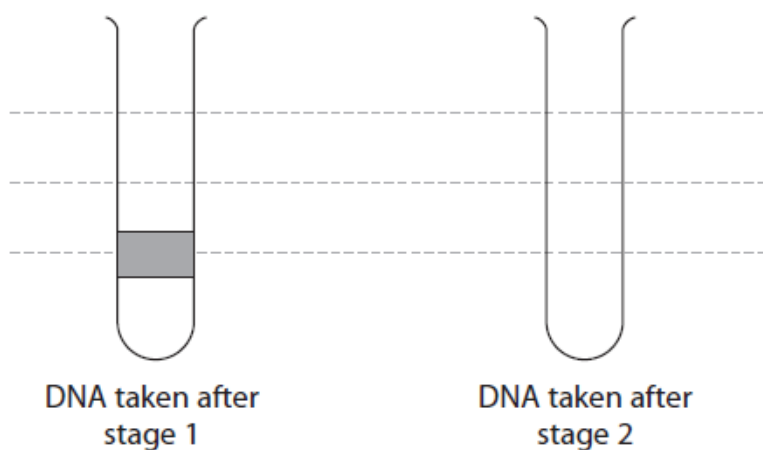
(ii) One competing theory was the conservative theory.

The diagram shows the conservative theory for the replication of DNA.



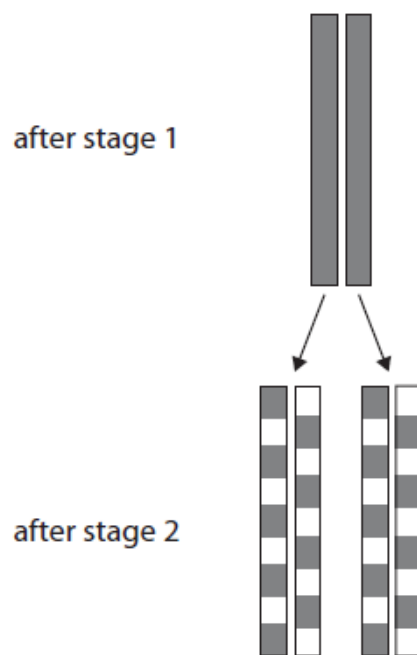
Complete the diagram to show the position of the bands on the density gradient in a tube if this was the correct theory.

(2)



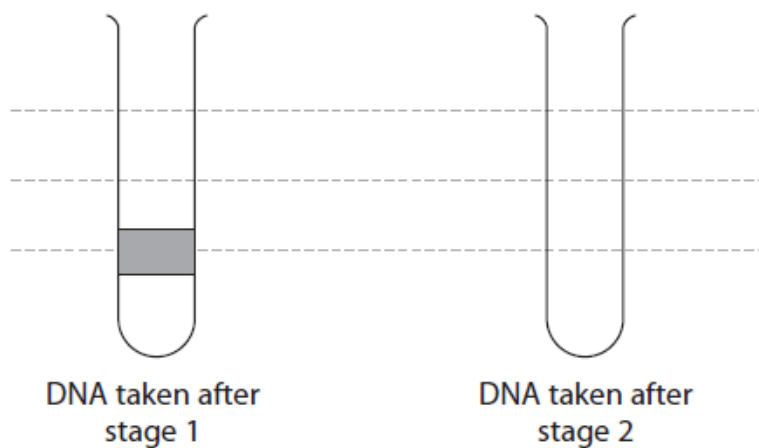
(iii) Another competing theory was the dispersive theory.

The diagram shows the dispersive theory.



Complete the diagram to show the position of the bands on the density gradient in a tube if this was the correct theory.

(2)



(Total for question = 13 marks)

Q15.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

Mutations can give rise to cancer.

(a) What is a mutation?

(1)

- ☐ **A** a change in the amino acid sequence in DNA
- ☐ **B** a change in the amino acid sequence in a protein
- ☐ **C** a change in the base sequence in DNA
- ☐ **D** a change in the base sequence in a protein

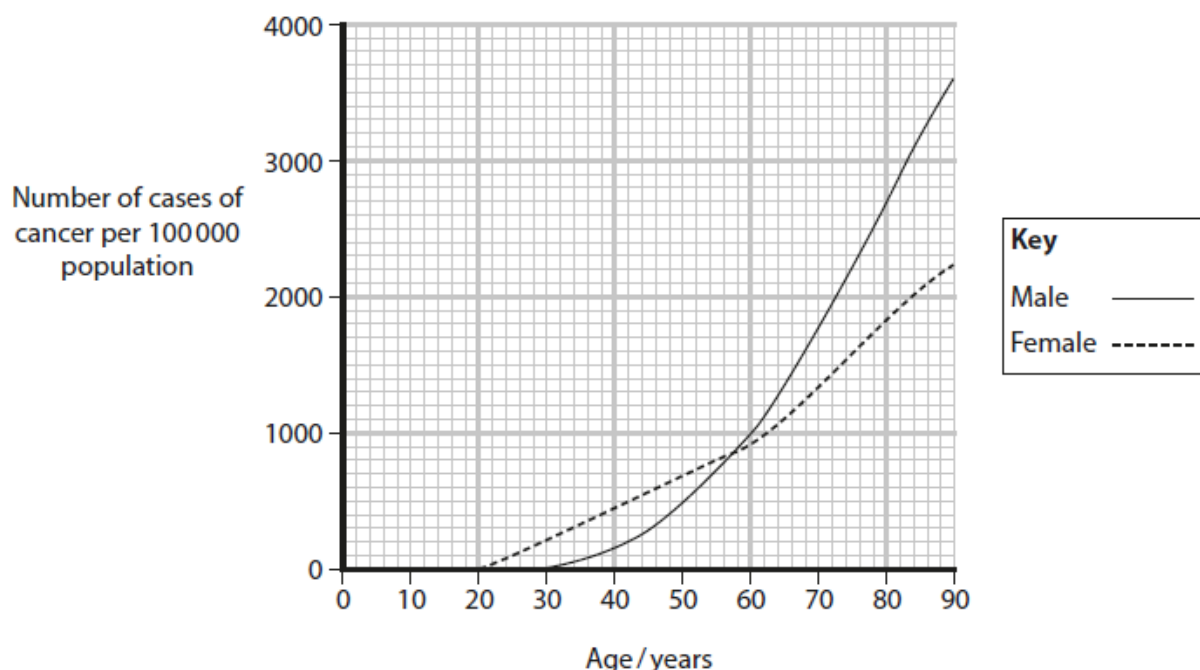
(b) Name **two** types of mutation.

(1)

1

2

(c) The graph shows the number of cases of one type of cancer in a human population.



Describe the effect of age and sex on the number of cases of cancer.

(3)

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(Total for question = 5 marks)

Q16.

A gene contains the genetic code for the sequence of amino acids in a polypeptide chain.

The table shows the genetic codes found in DNA.

Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid
AAA AAG	Lysine	CAA CAG	Glutamine	GAA GAG	Glutamic acid	TAC TAT	Tyrosine
AAC AAT	Asparagine	CAT CAC	Histidine	GAC GAT	Aspartate	TCA TCC TCG TCT	Serine
ACA ACC ACG ACT	Threonine	CCA CCC CCG CCT	Proline	GCA GCC GCG GCT	Alanine	TGG	Tryptophan
AGA AGG	Arginine	CGA CGC CGG CGT	Arginine	GGA GGC GGG GGT	Glycine	TGC TGT	Cysteine
AGC AGT	Serine	CTA CTC CTG CTT	Leucine	GTA GTC GTG GTT	Valine	TTA TTG	Leucine
ATA ATC ATT	Isoleucine					TTC TTT	Phenylalanine
ATG	Methionine						

The genetic codes TAA, TAG and TGA are stop codons, that do not code for amino acids.

*(a) Explain the nature of the genetic code.

Use information in the table to support your answer.

(b) The diagram shows the sequence of nucleotide bases in part of a DNA template (antisense) strand.

(i) Give the sequence of amino acids that is coded for by these bases.

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(ii) Explain the possible effects on a protein if there is a substitution mutation in the 9th base in this DNA strand.

Use information in the table to support your answer.

(5)

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(Total for question = 12 marks)

Q17.

An average-sized human chromosome contains a DNA molecule with about 300 million nucleotides, arranged in pairs.

(a) Describe the structure of a nucleotide pair.

(3)

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(b) Before a cell can divide, the DNA molecule has to replicate. This takes place in the S phase of the cell cycle.

Human DNA replicates at a rate of 50 nucleotides per second.

Calculate how long it would take, to the nearest hour, for 150 million nucleotides to replicate.

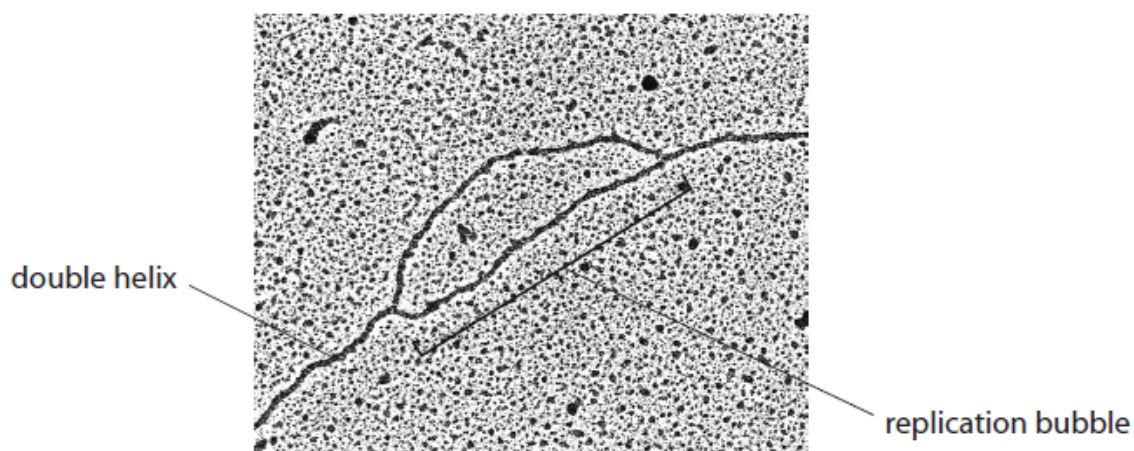
Assume that replication starts at one end of the molecule and continues to the other end.

(2)

Answer hours

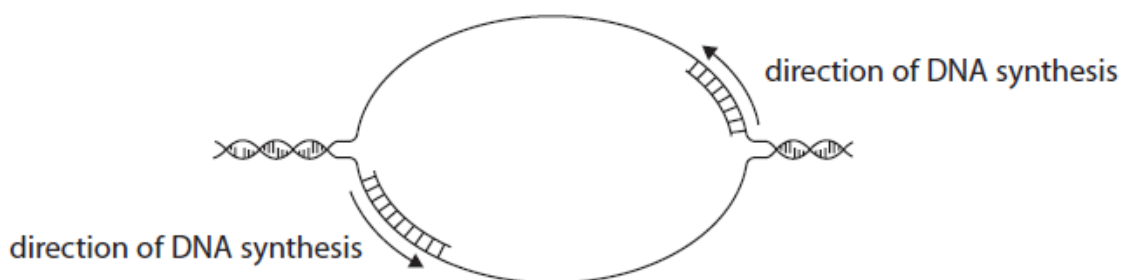
(c) In human cells, replication of DNA occurs at several sites along the molecule. These sites are called replication bubbles.

The photograph shows a replication bubble.



(Source: © Dr Gopal Murti / Science Photo Library)

The diagram shows how the DNA is replicated in one replication bubble.



(i) Explain the role of DNA polymerase in a replication bubble.

Use the information in the diagram and your own knowledge to support your answer.

(2)

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(ii) In human cells, S phase lasts about 10 hours.

Suggest why each DNA molecule is replicated using many replication bubbles.

(3)

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(Total for question = 10 marks)

Q18.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

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

(1)

	Monosaccharides	Disaccharides
☐ A	fructose only	glucose and sucrose
☐ B	glucose only	fructose and sucrose
☐ C	fructose and glucose	sucrose only
☐ D	glucose and sucrose	fructose only

(ii) Which type of bond joins two monosaccharides together to form a disaccharide?

(1)

- ☐ A ester
- ☐ B glycosidic
- ☐ C peptide
- ☐ D phosphodiester

(b) The table shows the concentration of these sugars in three pineapples.

Sugar	Concentration of sugar / g cm ⁻³		
	Pineapple 1	Pineapple 2	Pineapple 3
fructose	1.71	1.44	1.41
glucose	1.22	1.02	1.00
sucrose	9.08	7.77	8.81

(i) Calculate the mean concentration of glucose in these three pineapples.

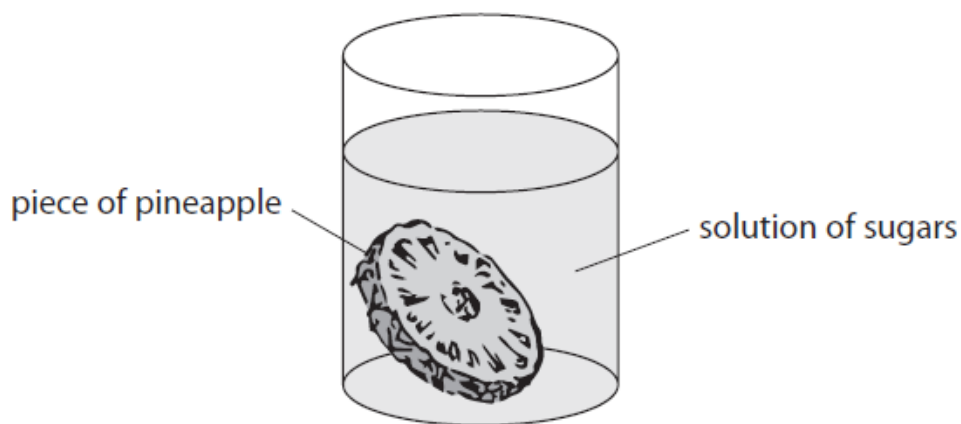
Give your answer in **g dm⁻³**.

(2)

Answer g dm⁻³

* (ii) Pineapples can be preserved by a process called osmotic dehydration in which pieces of pineapple are submerged in a solution of sugars.

The diagram shows how this process can be carried out.



Osmotic dehydration helps to preserve the pineapple by reducing the water content.

Osmotic dehydration also ensures that the concentration of each sugar in the pineapple does not change. This preserves the sweet taste of the pineapple.

Explain what the solution of sugars should contain to preserve pineapples.
Use the information in the table to support your answer.

(6)

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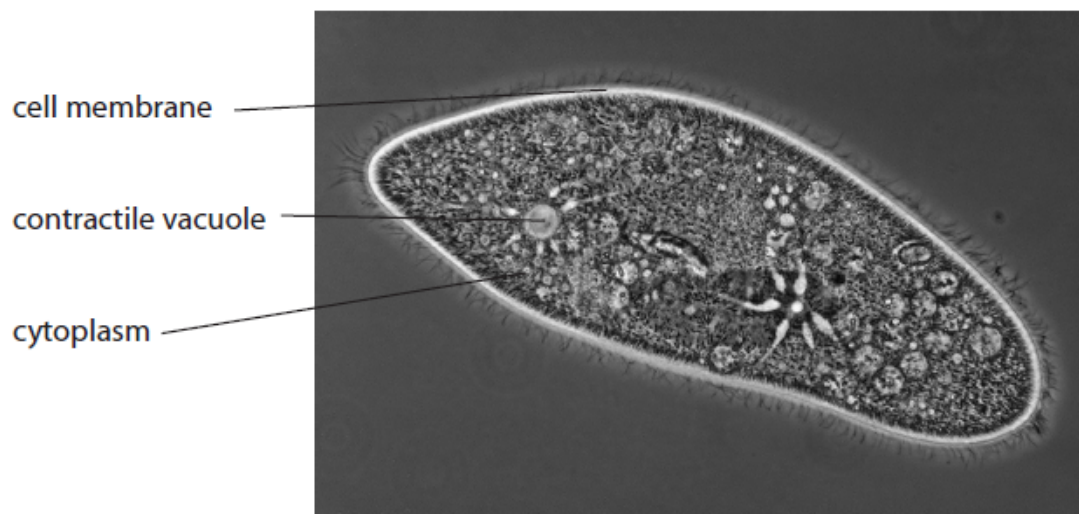
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(Total for question = 10 marks)

Q19.

Paramecia are single-celled organisms that live in pond water.

The photograph shows a single paramecium as seen using a light microscope.



magnification $\times 400$

© M.I. WALKER/SCIENCE PHOTO LIBRARY

Water enters the paramecium. The contractile vacuole pumps water back out of the paramecium.

(a) (i) Explain why water enters the paramecium.

(2)

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(ii) Explain the importance of the contractile vacuole in the paramecium.

(3)

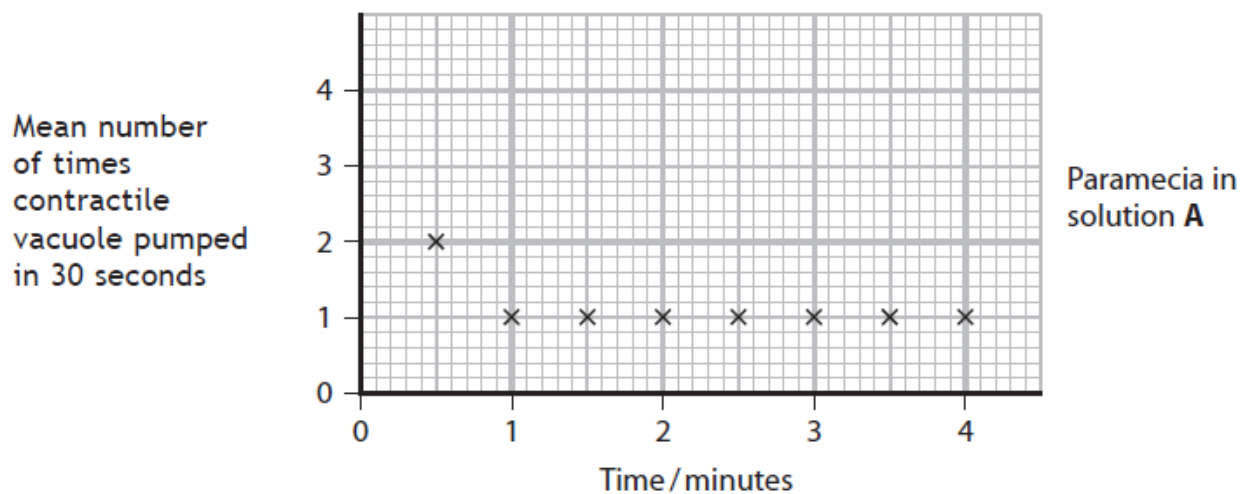
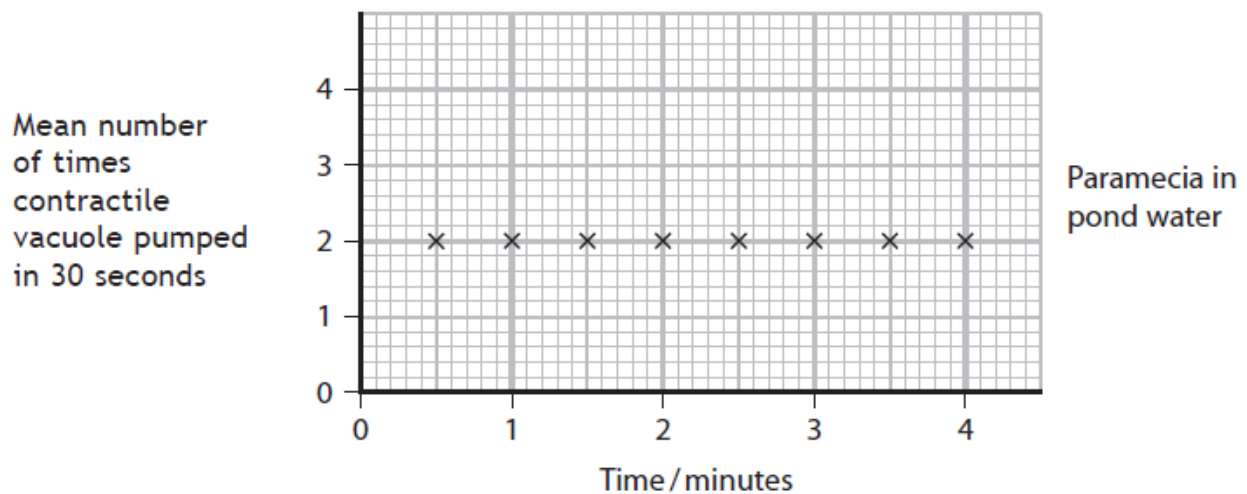
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* (b) In an investigation, paramecia were placed in three separate solutions: pond water, solution **A** and solution **B**.

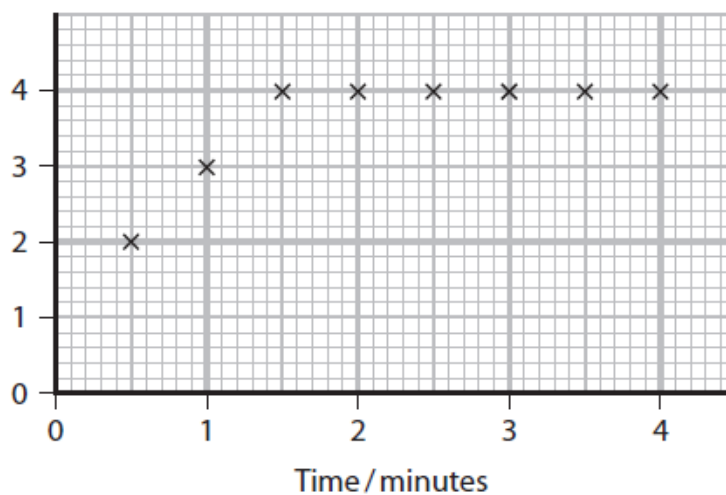
The paramecia were observed using a light microscope.

The number of times that the contractile vacuole pumped water out of the cell in 30-second intervals was recorded.

The graphs show the results of this investigation.



Mean number
of times
contractile
vacuole pumped
in 30 seconds



Paramecia in
solution B

Explain the results of this investigation.

Use the information in the graphs to support your answer.

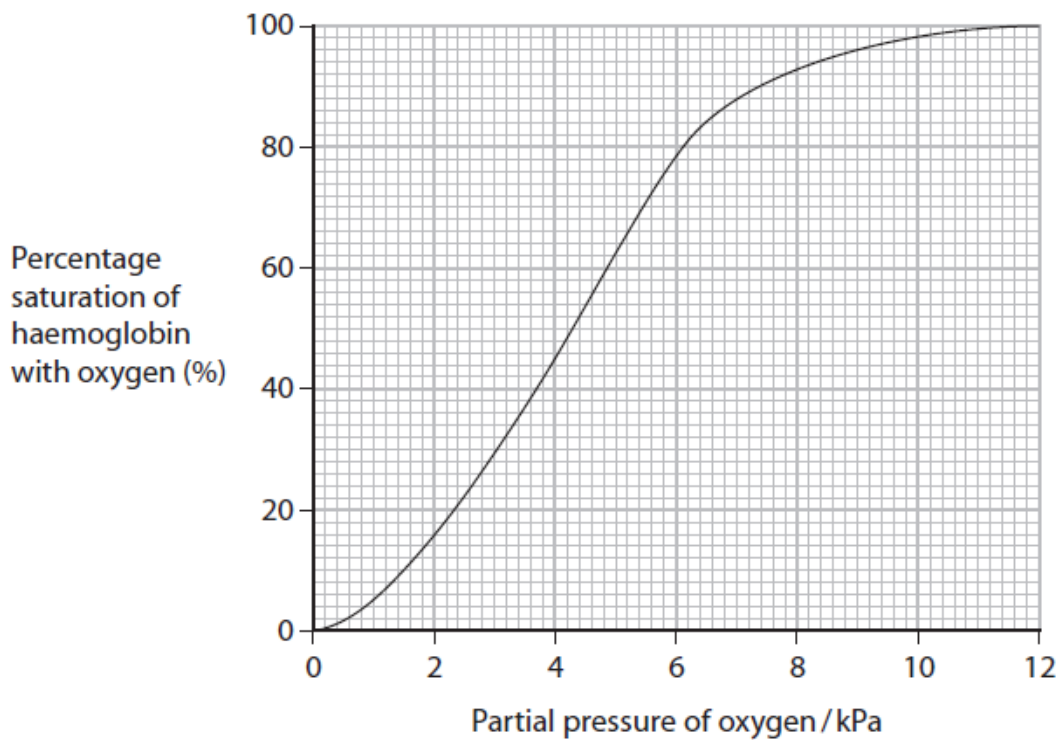
(6)

(Total for question = 11 marks)

Q20.

One role of haemoglobin is to transport oxygen.

The graph shows an oxygen dissociation curve of haemoglobin.



(a) (i) State what is meant by the term partial pressure.

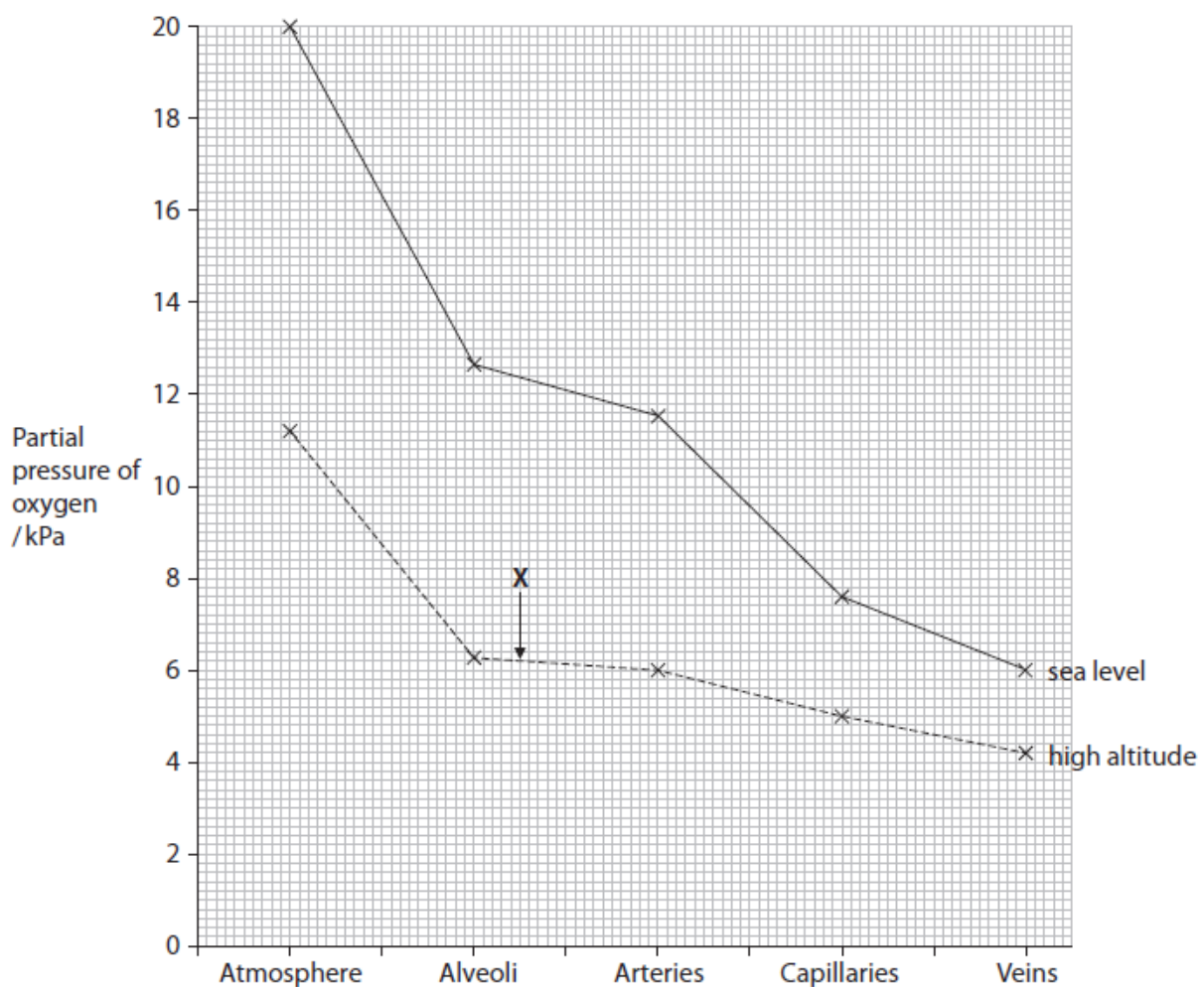
(1)

(ii) Explain how the structure of haemoglobin causes the oxygen dissociation curve of haemoglobin to be this sigmoidal (S) shape.

(3)

(b) The oxygen cascade describes the differences in the partial pressure of oxygen between different blood vessels and the external atmosphere.

The graph shows the partial pressures of oxygen for a person at sea level and a person at high altitude.



(i) Suggest why the partial pressure of oxygen in the air in the alveoli is lower than in the atmosphere.

(1)

[illegible]

(iii) Determine the percentage saturation of haemoglobin in the blood as it leaves the lungs of the person at high altitude.

Use the point marked **X** on the graph and the oxygen dissociation curve of haemoglobin.

Answer %

(iv) Explain why the percentage saturation of haemoglobin in a person at high altitude is much lower than in a person at sea level.

[illegible]

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(Total for question = 13 marks)

Q21.

The primary structure of a protein determines its secondary structure and its three-dimensional structure.

(a) Read through the following account of the primary structure of a protein.

(5)

Complete the account by writing the most appropriate word or words on the dotted lines.

The primary structure of a protein is the specific sequence of amino acids joined together by bonds.

These bonds are formed between the group of one amino acid and the group of an adjacent amino acid by a reaction.

These bonds are formed during the stage of protein synthesis called

(b) The table describes the types of bond that hold the secondary and the three-dimensional structures together.

Which type of bonding is true for each structure?

(2)

Structure	Hydrogen bonds only	Ionic bonds only	Both hydrogen and ionic bonds	Neither of these bonds
secondary structure	☐	☐	☐	☐
three-dimensional structure	☐	☐	☐	☐

Q22.

Red-green colour blindness is a common trait in humans.

(a) The gene for red-green colour blindness is located on the X chromosome.

State what is meant by the term **gene**.

(1)

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(b) Describe how the two strands of DNA forming the double helix in a gene are held together.

(2)

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(c) Explain why each codon for the DNA genetic code must contain at least three bases.

(3)

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(d) A red-green colour blind father and an unaffected heterozygous mother had a child.
Determine the probability of this child being red-green colour blind.
Use a genetic diagram to support your answer.

(3)

Probability

(Total for question = 9 marks)

Q23.

Sickle cell disease is caused by a gene mutation affecting the β -globin chain of haemoglobin.

(a) The mutation occurs in the seventh triplet code of this gene.

This mutation results in the amino acid Glu being replaced with the amino acid Val.

The table shows the sequence of bases in the first part of the DNA in a person who does not have sickle cell disease. It also shows the corresponding sequence of amino acids in the β -globin chain.

Position of triplet code	first	second	third	fourth	fifth	sixth	seventh	eighth	ninth
DNA	AUG	GUG	CAC	CUG	ACU	CCU	GAG	GAG	AAG
β -globin chain	(start)	Val	His	Leu	Thr	Pro	Glu	Glu	Lys

(i) Give the seventh triplet code in the gene for the β -globin chain in a person who has sickle cell disease.

(1)

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(ii) Name the type of mutation that causes sickle cell disease.

(1)

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(iii) The amino acid Glu is hydrophilic (polar) and the amino acid Val is hydrophobic (non-polar).

Suggest why this mutation causes haemoglobin molecules to stick together.

(3)

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(b) In 2020, about 140 million babies were born in the world.

About 305 800 babies are born with sickle cell disease each year.

Estimate the ratio of babies born with the disease to babies not born with the disease.

(2)

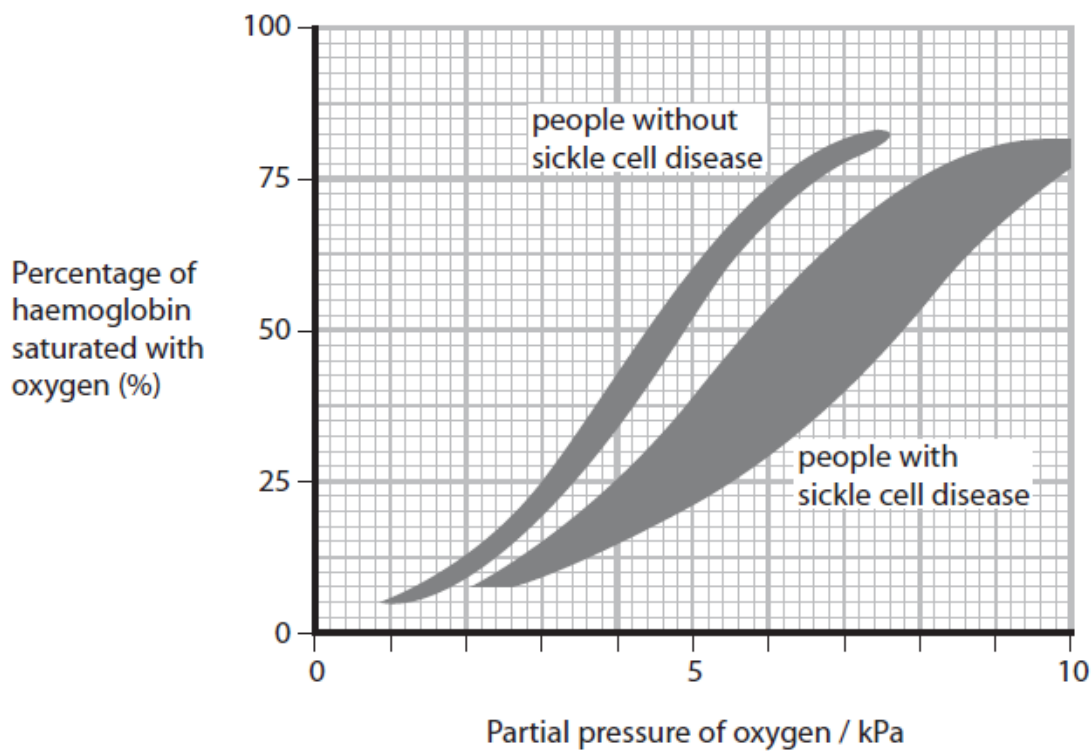
Answer

(c) The red blood cells in a person with sickle cell disease are sickle shaped and less elastic. They also have a shorter lifespan than healthy red blood cells.

These sickle shaped red blood cells cannot carry as much oxygen as healthy red blood cells and they get stuck in the capillaries.

The graph shows oxygen dissociation curves for groups of people with sickle cell disease and those without the disease.

The shaded areas represent the range of values for each group of people.



(i) A p50 value is the partial pressure of oxygen that results in 50% saturation of haemoglobin.

Calculate the largest difference in the p50 values between a person with sickle cell disease and a person without this disease.

Give your answer to an appropriate number of decimal places.

(2)

Answer kPa

(ii) Identify **two** conclusions, other than the difference in p50 values, that can be made from this graph.

(2)

Conclusion 1

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Conclusion 2

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(iii) The lifespan of a red blood cell in a person with sickle cell disease is 11 days.

This is 9.17% of the lifespan of a healthy red blood cell.

Calculate the lifespan of a healthy red blood cell.

Give your answer to the nearest day.

(1)

Answer days

(iv) Sickle cell disease can result in death.

Explain why the changes in the structure of haemoglobin and the shape of the red blood cells could result in death in a person with sickle cell disease.

(3)

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(Total for question = 15 marks)

Q24.

Hair straightening, or rebonding, is a hair styling technique used to straighten hair using either heat or chemicals.

(a) Hair is made from an insoluble fibrous protein called keratin.

(i) Describe **two** structural features of insoluble fibrous proteins.

(2)

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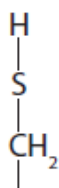
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(ii) Keratin contains a high proportion of the amino acid, cysteine.

Disulfide bridges form between the R groups of two cysteines.

The diagram shows the R group of cysteine.



Draw the complete structure of the amino acid, cysteine.

(3)

(b) The effect of two different temperatures on the lengths of the primary structure and secondary structure of a polypeptide was investigated.

The table shows the results of this investigation.

Structure of polypeptide	Length of structure / nm	
	at 25 °C	at 55 °C
primary	505	505
secondary	48	70

(i) Describe the secondary structure of a polypeptide.

(2)

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(ii) Explain the results of this investigation.

(4)

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(Total for question = 11 marks)

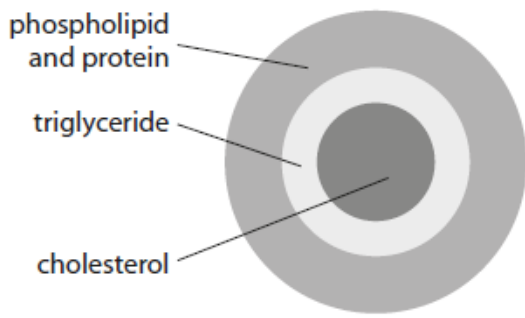
Q25.

Low-density lipoproteins (LDLs) transport lipids around the body in the blood.

Low-density lipoproteins can result in the development of atherosclerosis.

They can be absorbed into the endothelial cells lining arteries and broken down by free radicals.

The diagram shows a low-density lipoprotein containing cholesterol.



(a) Compare and contrast the structure of a triglyceride and a phospholipid.

(3)

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(b) Explain why the properties of LDLs enable cholesterol to be transported in the blood.

(3)

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(c) The diameters of LDLs range from 19 nm to 24 nm.

The table shows some information about LDLs.

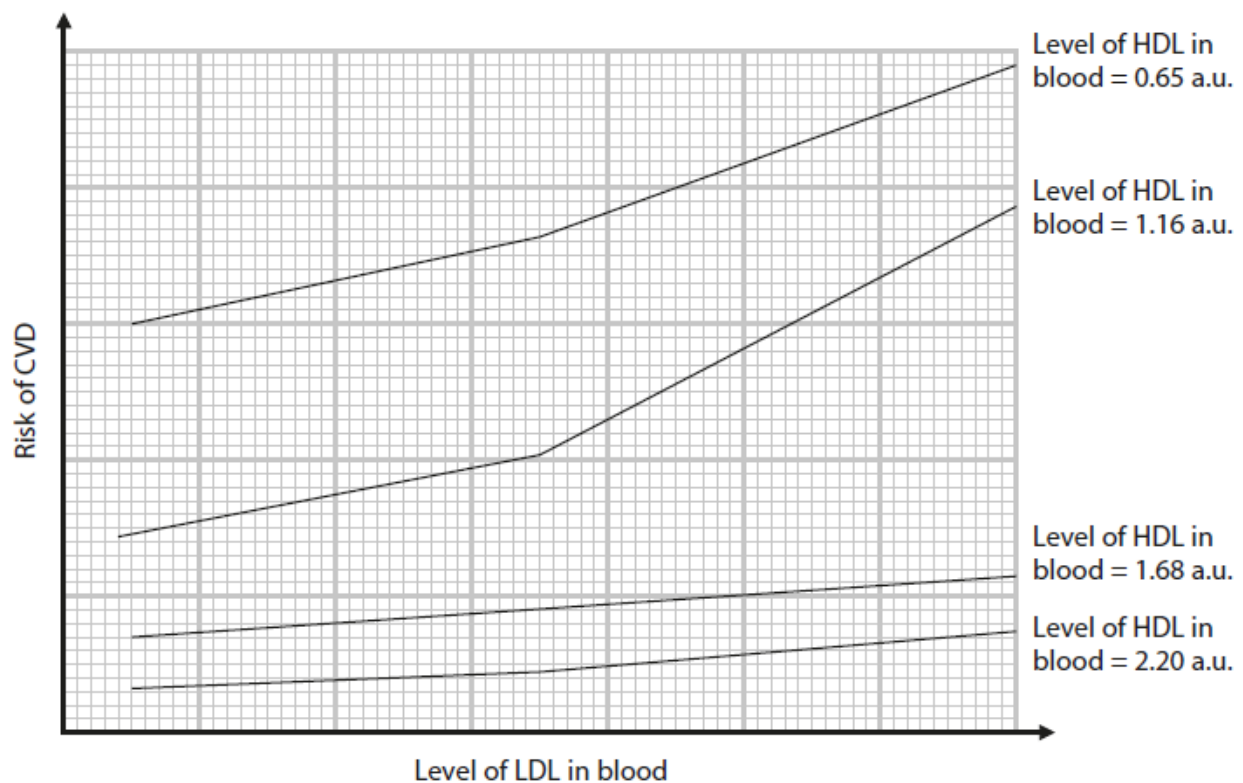
Diameter of LDL / nm	Volume of LDL / nm ³	Volume of cholesterol / nm ³	Ratio of LDL volume to cholesterol volume
19	3590	523	7:1
24		523	

(i) Complete the table by calculating the volume of LDL and the ratio of LDL volume to cholesterol volume.

Use the formula $v = \frac{4}{3}\pi r^3$

(3)

*(ii) The graph shows the relationship between LDLs, high-density lipoproteins (HDLs) and the risk of CVD.



Explain why measuring only the level of LDL in the blood is **not** a reliable predictor of CVD.

Use the graph, all the information in this question and your own knowledge to support your answer.

(6)

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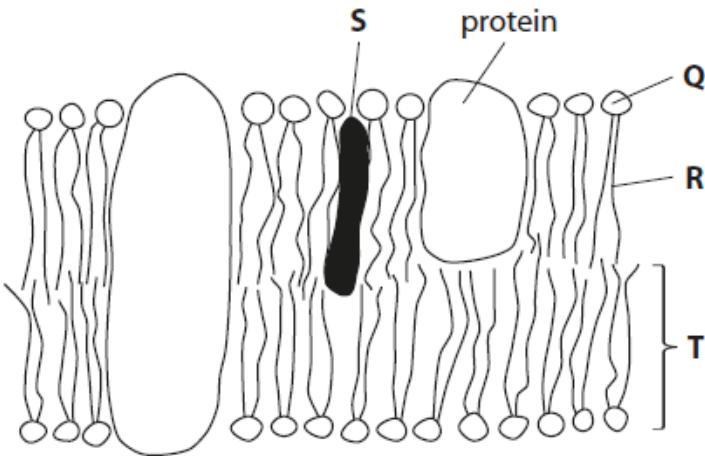
(Total for question = 15 marks)

Q26.

Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .

The structure of the cell membrane affects the properties of the cell membrane.

The diagram shows the structure of part of a cell membrane.



(a) (i) The magnification of this diagram is 1×10^7 .

The structure labelled **T** is 2 units long.

What is this unit?

(1)

☐ **A** cm

☐ **B** mm

☐ **C** μm

☐ **D** nm

(ii) Which structures contain a phosphate group?

(1)

☐ **A** **Q** and **R**

☐ **B** **Q** and **T**

☐ **C** **R** and **S**

☐ **D** **S** and **T**

(iii) Which ratio of the structures affects the fluidity of this membrane?

(1)

☐ **A** **Q : T**

☐ **B** **R : Q**

☐ **C** **R : T**

☐ **D** **S : T**

(b) Explain the role of the primary structure in determining the properties of the protein labelled in the diagram.

(4)

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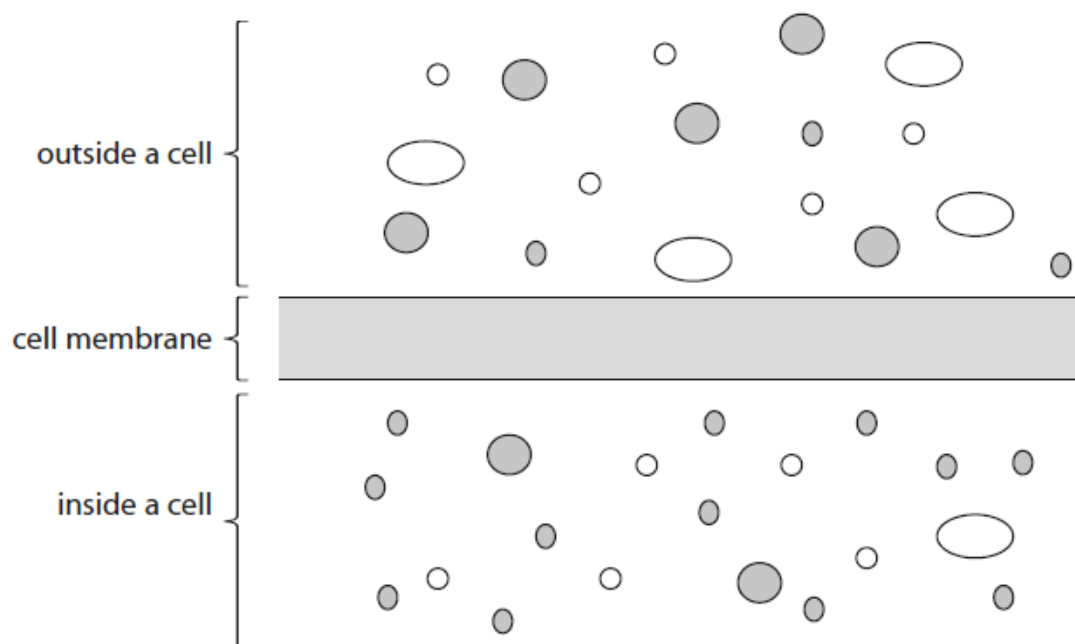
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[illegible]

Molecule	Key	Description
E		small dipolar molecule consisting of two hydrogen atoms and one oxygen atom
F		large polar molecule
G		non-polar molecule
H		small polar molecule



Explain why each of these molecules **enters** the cell by a different mechanism.

Use the information in the table and the diagram to support your answer.

(6)

(Total for question = 13 marks)

Q1.

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Question number	Answer	Mark
(b)	The only correct answer is C (it will halve) A is incorrect because the value will halve B is incorrect because the value will halve D is incorrect because the value will halve	(1)

Question number	Answer	Additional guidance	Mark
(c)	A description that includes the following points: - lots of alveoli for large surface area (1) {single-celled / thin-walled} {alveoli / capillaries} for short diffusion distance (1) - good blood supply for high concentration gradient (1)	ACCEPT lots of capillaries for large surface area air sacs for alveoli ref to lots of alveoli <u>and</u> thin-walled <u>and</u> good blood supply = 1 mark if no other marks awarded	(3)

Question number	Answer
* (d)	Answers will be credited according to candidate's 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 indicated as relevant. Additional content included in the response must be scientific and relevant. Structure • salamanders have both lungs and their skin for <u>more</u> gas exchange • lungs allow oxygen from air and skin oxygen from water • the skin is folded to increase surface area • flattened body to increase surface area • so that gas exchange will be faster • skin has a good blood supply so that there will be high concentration gradient • skin is very permeable to gases so that they can diffuse in faster Behaviour • salamanders live in fast-flowing water which will have high levels of oxygen • shallow water will also have higher levels of oxygen • shallow water will make breathing with lungs easier • the rocking / swaying movements stir up the water • which helps to aerate the water • so that water with higher oxygen content is in contact with their skin • so that there is a higher concentration gradient • so that {gas exchange / diffusion of gases} will be faster • the rocking / swaying maintains the levels of oxygen in the blood Graph • at low levels of oxygen in the water the frequency of rocking is high • accompanied by an increase in blood pO_2 • as oxygen levels in the water increase the frequency of rocking decreases • but the blood pO_2 continues to increase • sufficient oxygen in water to diffuse into lungs and skin • to maintain levels of oxygen • rocking stops to conserve energy (6)

			Additional guidance
Level 0	0	No awardable content	
Level 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.	Simple links made between gas exchange and information given or own knowledge 1 mark = 1 comment which can include a description of data 2 marks = 3 comments which can include a description of data
Level 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.	Extended links made between gas exchange and information given 3 marks = comments on both structure and behaviour with extended comment on one 4 marks = extended comments made on both structure and behaviour
Level 3	5-6	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant biological facts / concepts. Consequences are discussed which supported throughout by sustained linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Understanding of graph used to support discussion 5 marks = plus some discussion of graph to support answer 6 marks = plus an understanding of the relationships shown in the graph

Q2.

Question number	Answer	Additional guidance	Mark
(a)	the {length of DNA / sequence of (DNA) bases} that code for {amino acids / (poly)peptide / protein} (1)	ACCEPT nucleotides for bases primary structure of protein	(1)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: - because the mutation is in the gene coding for the CFTR (protein) (1) - therefore the CFTR (protein) does not function correctly (1) - credit details of dysfunction (resulting in very thick sticky mucus) (1) - therefore the mucus will be (very) {thick / sticky} (1)	ACCEPT mutation in CFTR gene ACCEPT change in structure e.g. reduced transport of chloride ions out of the cell sodium ions move into the cell water leaves the mucus and enters the cell	(3)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes three of the following points: - couples (both) carrying one copy of the mutation can be identified (1) - they can then make (an informed) {decision / choice} {about having a child} (1) - credit an example of their options (1) - resulting in fewer babies being born who are homozygous (1)	ACCEPT couples who are (both) heterozygous / have a CF allele DO NOT ACCEPT choose which embryos to implant e.g not having a child / adoption / IVF DO NOT ACCEPT have an abortion ACCEPT two copies of the mutation fewer heterozygous babies born	(3)

Q3.

Question number	Answer	Additional guidance	Mark
(a)(i)	A description that includes the following points: - gene is the {length of DNA / sequence of bases} coding for a (poly)peptide (1) - allele is the (different) {version / form / variation} of the gene (1) - gene for feather colour <u>and</u> allele for {white / black} feathers (1)	ACCEPT protein / sequence of aminoacids NB piece together DO NOT ACCEPT speckled feathers	(3)

Question number	Answer	Additional guidance	Mark
(a)(ii)	A description that includes the following points: - genotype is the combination of alleles (1) - phenotype is the {(observable) characteristics / appearance / traits} (1) - phenotype is the colour of the feathers <u>and</u> genotype is the presence of white and or black alleles (1)	ACCEPT mixture of alleles / the allelespresent DO NOT ACCEPT genes ACCEPT feature / ref to colour offeathers IGNORE ref to environment ACCEPT phenotype is {white / black / speckled / mixture of black and white} (feathers) genotype is {WW / BB / WB} or any other letters used NB piece together	(3)

Question number	Answer	Additional guidance	Mark
(b)	An answer that includes the following points: - parent's genotypes shown as BB and BW (1) - offspring's genotypes shown as BB and BW (1) - number of speckled chicks given as 12 or 13 (1)	ACCEPT other letters, including B and b DO NOT ACCEPT X and Y B for white and W for black ACCEPT other letters, including B and b CE from 1 CE from 2 provided whole number NB Bald answer = 1 mark	(3)

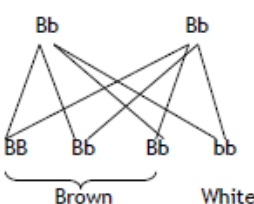
Question number	Answer	Additional guidance	Mark
(c)(i)	Chi squared (1)	ACCEPT Chi square / X squared / xsquared / X^2 / x^2 / χ^2 distribution (test) / chi (test) / closeness of fit / goodness of fit phonetic spellings e.g kai / cai / khi	(1)

Question number	Answer	Additional guidance	Mark																															
(c)(ii)	An answer that includes the following points: <table border="1"> <thead> <tr> <th rowspan="2">Steps in the calculation for the statistics test</th><th colspan="3">Colour of feathers of chicks</th></tr> <tr> <th>Speckled</th><th>White</th><th>Black</th></tr> </thead> <tbody> <tr> <td>Observed number (O)</td><td>243</td><td>125</td><td>112</td></tr> <tr> <td>Expected number (E)</td><td>240</td><td>120</td><td>120</td></tr> <tr> <td>(O-E)</td><td>3</td><td>5</td><td>-8</td></tr> <tr> <td>$\frac{(O-E)^2}{E}$</td><td>0.0375</td><td>0.2083</td><td>0.5333</td></tr> <tr> <td></td><td>9/240</td><td>25/120</td><td>64/120</td></tr> <tr> <td></td><td>3/80</td><td>5/24</td><td>8/15</td></tr> </tbody> </table>	Steps in the calculation for the statistics test	Colour of feathers of chicks			Speckled	White	Black	Observed number (O)	243	125	112	Expected number (E)	240	120	120	(O-E)	3	5	-8	$\frac{(O-E)^2}{E}$	0.0375	0.2083	0.5333		9/240	25/120	64/120		3/80	5/24	8/15	All correct = 2 marks One row correct = 1 mark ACCEPT 8 DO NOT ACCEPT -3 / -5 ACCEPT 2 or 3 or 4 dps but not necessarily consistently the same number. DO NOT ACCEPT recurring	(2)
Steps in the calculation for the statistics test	Colour of feathers of chicks																																	
	Speckled	White	Black																															
Observed number (O)	243	125	112																															
Expected number (E)	240	120	120																															
(O-E)	3	5	-8																															
$\frac{(O-E)^2}{E}$	0.0375	0.2083	0.5333																															
	9/240	25/120	64/120																															
	3/80	5/24	8/15																															

Question number	Answer	Additional guidance	Mark
(c)(iii)	0.8 / 0.78 / 0.779 / 0.7791 (1)	CE / rounding effect from (c)(ii) DO NOT ACCEPT 0 NB $187/240 = 0.7792$	(1)

Question number	Answer	Additional guidance	Mark
(c)(iv)	An explanation that includes two of the following points: • {calculate / use} the number of degrees of freedom • use (a probability) value of (up to or equal to) 5%/0.05 (1) • compare (calculated) {value / result} to (critical) value (1) • if the (calculated) {value / result} is greater than (critical)value then null hypothesis is rejected (1)	ACCEPT description of how to work out degrees of freedom NB mp 4 alone = 2 marks ACCEPT the converse argument any quoted figures for the calculated value	(2)

Q4.

Question number	Answer	Additional guidance	Mark
(a)	A diagram that shows the following: - genotype of parents / alleles in the gametes (1) - genotypes of offspring as BB, Bb and bb (1) - corresponding phenotypes shown as brown (BB and Bb) and white (bb) (1)	Accept other letters used for alleles  ACCEPT if clear from any ratios or percentages given CE throughout	(3)

Question number	Answer	Additional guidance	Mark
(b)	An answer that includes the following points: - number of homozygous brown rabbits shown (1) - number of heterozygous brown rabbits shown (1) - number of white rabbits shown (1)	CE from part (a) BB = 71 Bb = 142 bb = 71 ACCEPT 1 2 1 for 1 mark	(3)

Q5.

Question number	Answer	Additional guidance	Mark
(a)	combination of alleles (1)	IGNORE genetic composition / combination of information carried in the genes / all genetic (information / make up) DO NOT ACCEPT genes	(1)
Question number	Answer	Additional guidance	Mark
(b)	1 in 2 / 50:50 / 50% / 0.5 / ½	ACCEPT 2 in 4 / 1:1 / 2:2	(1)

Question number	Answer	Additional guidance	Mark
(c)	An answer that makes reference to the following points: • parents shown as heterozygotes (1) • genotypes of offspring shown (1) • 3 (orange) : 1 (white) (1)	CEs throughout ACCEPT any pair of letters chosen to represent alleles from Punnet square ACCEPT 1 white : 3 orange	(3)

Question number	Answer	Additional guidance	Mark
(d)	• 1 in 30 / 0.03 / 3.3% / $\frac{1}{30}$	ACCEPT 0.03 recurring / 3.3% recurring	(1)

Q6.

Question number	Answer	Mark
(a)(i)	A α glucose molecules join together by a condensation reaction B is incorrect because bonds form by condensation reactions C is incorrect because α glucose molecules join together D is incorrect because α glucose molecules join together by condensation reactions	(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	glycosidic (bond / link)	Accept covalent (bond) Ignore any numbers eg 1,4 glycosidic	(1)

Question number	Answer	Additional guidance	Mark
(a)(iii)	An explanation that includes the following points: • {polymer of glucose / polysaccharide} therefore has a high energy content (1) • {large molecule / polymer / polysaccharide} therefore {insoluble / has no osmotic effect} (1) • branched structure therefore {broken down / energy released / hydrolysis is} faster (1) • compact therefore has a high energy density (1)	Accept {large molecule / polymer} so does not diffuse Accept branched so can be broken down from several points at the same time Ignore easier to break down Accept compact so {high energy stored in a small space / many glucose molecules stored in a small space}	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	Answer that includes the following points: • estimate of number of babies with GSD (1) • estimate of mean number of babies with Von Gierke disease (1)	Accept any value between 150 and 200 Accept any value between 38 and 50 Accept non-whole numbers eg 38.5 Correct answer with no working (2)	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An answer that includes the following points: • because allele for Von Gierke disease may be recessive (1) • therefore (both) parents may be heterozygous (1) • because individuals with Von Gierke disease are less likely to have babies (1)	Accept disease caused by two recessive alleles Do not accept {gene / disease} is recessive Accept parents may be carriers (of the allele) Ignore mutation	(2)

Q7.

Question number	Answer	Additional guidance	Mark
(a)(i)	bind to an {oxygen (molecule) / O₂} (1)	Do not accept O Ignore binding to carbon dioxide	(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes the following points: - must have R groups that are {polar / hydrophilic} (1) - so that the {haemoglobin / protein} {can dissolve in (red bloodcell) cytoplasm / is soluble in water} (1)	Accept they are {polar / hydrophilic} Ignore dissolve in blood / plasma	(2)

Question number	Answer	Additional guidance	Mark
(b)(i)	An explanation that includes two of the following points: - oxygen dissociation curve for {maternal / adult} Hb is shifted to the right of curve for fetal Hb (1) - because oxygen needs to diffuse from {maternal / adult} blood into fetal blood (1) - therefore fetal haemoglobin needs to have a higher affinity for oxygen (1)	Accept shifted down for shifted to the right Accept converse Accept converse Accept because oxygen needs to dissociate from maternal haemoglobin and bind to fetal haemoglobin	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An answer that includes the following points: - total number of amino acids in haemoglobin calculated (1) - percentage of amino acids that are different calculated (1)	574 / 287 14 / 13.6 / 13.59 Correct answer with no working (2)	(2)

Question number	Answer	Mark
(a)	The only correct answer is A (position R, position P) <i>B is incorrect because P will have a carboxyl group and R will have an amino group (Q will have a carboxyl group)</i> <i>C is incorrect because P will have a carboxyl group and R will have an amino group (Q will have a carboxyl group)</i> <i>D is incorrect because P will have a carboxyl group and R will have an amino group (Q will have a carboxyl group)</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	• 39 / 39.3 / 39.29 (1)		(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	• 0.13 : 1 / 0.1 : 1 / 0.13 / 0.1 (1)	ACCEPT 1 : 7.5 / 1 : 8	(1)

Question number	Answer	Additional guidance	Mark
(c)	A description that includes the following points: • hydrolysis / using enzymes (1) • of the peptide bonds between P and the connecting chain <u>and</u> R and the connecting chain (1)	ACCEPT protease ACCEPT of peptide bonds between A chain and connecting region <u>and</u> B chain and connecting region	(2)

Question number	Answer	Additional guidance	Mark
(d)	An answer that includes the following points: Similarities : • alpha glucose (1) • contain C, H and O (only) (1) Differences : • glucose is a monosaccharide and glycogen is a polysaccharide (1) • glycogen has (1-4 / 1-6) glycosidic bonds but glucose does not (1)	DO NOT PIECE TOGETHER	(3)

Question number	Answer	Mark
* (e)	Indicative content: Healthy rats given water • levels of glucose {fell slightly / maintained} (D) • because the healthy rats were producing insulin (E) • so were controlling the blood glucose levels naturally (E) Healthy rats given cinnamon • levels of glucose very slightly lower (D) • as cinnamon was adding to the effect of insulin (CE) OR • levels of glucose very similar (D) • as cinnamon had no (added) effect in healthy rats (CE) Diabetic rats given water • levels of glucose rose (D) • levels of glucose were higher than healthy rats (D) • because diabetic rats had no insulin to control their blood glucose levels (E) Diabetic rats given cinnamon • unhealthy rats given cinnamon had fairly constant levels of glucose (D) • cinnamon lowered blood glucose by moving it into the liver (E) • cinnamon stimulated enzymes to convert glucose into glycogen (E) • so that it could not diffuse back into the blood (E) • levels of glucose were higher than in the healthy rats (D) • because cinnamon not as effective as insulin (CE) • possibly {not absorbed well / worked slowly / did not stimulate so many enzymes} (CE) • fluctuations in levels of glucose (D) • depending on how much glucose is used (E)	(6)

			Additional guidance
Level 0	0	No awardable content	
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information and with a focus on mainly just one piece of scientific information. The explanation will contain basic information, with some attempt made to link knowledge and understanding to the given context.	Simple descriptions of data with no real attempt of an explanation 1 mark = some description of the data 2 marks = detailed description of the data
Level 2	3-4	An explanation will be given, with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning, with some structure.	Some explanation given using the information given / own knowledge (E) 3 marks = simple explanation of what {cinnamon / insulin} is doing 4 marks = more detailed explanation of how {cinnamon / insulin} decreases glucose level
Level 3	5-6	An explanation is made that is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning, which is clear and logically structured.	Data logically explained with extended use of information provided (CE) 5 marks = plus a comparison made of effectiveness of cinnamon compared to insulin 6 marks = data explained in detail

Q9.

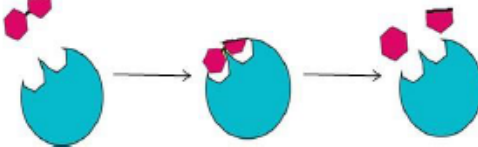
Question number	Answer	Additional guidance	Mark
(a)	An explanation that includes the following points: - because the rate of miscarriage increases with (increase in) age(1) - there is no evidence age is causing the miscarriage (1)	ACCEPT directly proportional to each other it shows that an increase in one variable is reflected by an increase in the other variable ACCEPT no evidence of causation	(2)

Question number	Answer	Additional guidance	Mark
(b)(i)	An explanation that includes the following points: - aneuploidy results in miscarriage because the screened embryos result in fewer miscarriages (1) - other {factors / named factor} cause miscarriages because {screened embryos / embryos that do not have aneuploidy} are miscarried (1)	ACCEPT converse where appropriate e.g. age, mutations, the process of implanting embryos, smoking, alcohol, dietary factors IGNORE lifestyle / screening causes miscarriage	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes three of the following points: - because no indication of sample size (1) - because no statistics presented (1) - because no idea how many of the unscreened embryos had aneuploidy (1) - other {lifestyles / factors / named factor} not {taken into account / not shown} (1) - false (negative / positive) results (1)	ACCEPT small sample size IGNORE age / sex	(3)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes three of the following points: • (preimplantation) screened embryos still result in miscarriages raising false hopes (1) • issues surrounding the embryos (that have aneuploidy) (1) • false (positive) results resulting in unnecessary {wastage / destruction} of embryos (1) • other (genetic) defects may be found (1)	DO NOT ACCEPT {fetus / baby} e.g. discarding the embryos is unethical ACCEPT false (negative) result leads to use of that embryo	(3)

Q10.

Question number	Answer	Mark
(a)(i)	B  The only correct answer is B. <i>A is incorrect because it shows the substrate unchanged</i> <i>C is incorrect because it shows lactose being made not broken down</i> <i>D is incorrect because the two substrates have not been bonded together</i>	(1)

Question number	Answer	Mark
(a)(ii)	B galactose and glucose The only correct answer is B. <i>A is incorrect because sucrose is not a monosaccharide</i> <i>C is incorrect because glucose and fructose are the monomers of sucrose</i> <i>D is incorrect because sucrose is not a monosaccharide</i>	(1)

Question number	Answer	Mark		
(b)	C <table><tr><td>reaction without enzyme</td><td>Q</td></tr></table> The only correct answer is C. <i>A is incorrect because line P shows the reaction without enzyme</i> <i>B is incorrect because line P shows the reaction without enzyme</i> <i>D is incorrect because R is the activation energy with the enzyme not the decrease</i>	reaction without enzyme	Q	(1)
reaction without enzyme	Q			

Question number	Answer	Additional guidance	Mark
(c)(i)	An explanation that includes the following points: - as the concentration (of substrate) increases there are more (substrate) molecules / particles (1) (therefore) a greater chance of {collisions with active site / enzyme substrate complexes forming} increasing the rate of reaction {rate/graph} levels off when {all active sites are filled (at any one time) / enzyme is saturated} (1)	ACCEPT converse for mp1 and 2 Piece together ACCEPT substrate concentration is limiting factor in the first part of the graph ACCEPT {greater frequency of collisions / collisions more likely to occur} etc ACCEPT enzyme for active site / "successful collisions" for collisions with active site IGNORE {more collisions / more enzyme-substrate complexes forming} ACCEPT {rate / graph} levels off {when enzyme becomes rate limiting / as enzyme is limiting factor} IGNORE idea of substrate being used up as reaction proceeds	(2)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An answer that includes the following points: • correct values for $V_{\max}$ and K read from the graph (1) • correct answer for values substituted into the formula (1)	$V_{\max} = 50$ $K = 1.9$ $V = \frac{50 \times 4}{1.9 + 4} = 33.898 / 34$ (ignore units) ACCEPT 33.9 IGNORE 33.90 / 33.89 Correct answer gets 2 marks ecf for mp2 if wrong values read from graph	(2)

Q11.

Question number	Answer	Mark
(a)(i)	C galactose and glucose A is incorrect because lactose consists of glucose and galactose monomers B is incorrect because lactose consists of glucose and galactose monomers D is incorrect because lactose consists of glucose and galactose monomers	(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes three of the following points: - lactase is soluble because of its {globular shape / external polar R groups} (1) (and therefore) lactase collides with lactose (1) - active site of lactase is complementary to the lactose (1) - Formation of enzyme-substrate complex lowers the activation energy (1)	Accept hydrophilic for polar Accept active site of lactase binds to lactose / active site allows enzyme-substrate complex to form Accept R group interactions break the glycosidic bonds	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	{lactase / enzyme} is reusable / milk is not contaminated with {lactase / enzyme} (1)	Accept higher enzyme activity	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes four of the following points: - pH {below 5 / above 5} reduces lactase activity (1) - because pH affects the shape of the active site (1) - due to ionisation of the R groups (1) - immobilised lactase is active at wider range of pH values (1) - immobilisation holds the R groups in place so active site does not change shape (1)	Accept pH 5 is the optimum for both enzymes / pH 4-6 is the optimum for both enzymes Accept active site denatured by pH Accept bonds between R groups are broken	(4)

Question number	Answer	Additional guidance	Mark												
(b)(iii)	An answer that includes the following points: - measure the decrease in concentration of lactose over time - see table for units OR - measure the increase in concentration of {glucose / galactose} over time - see table for units	Accept measure rate of loss of lactose Ignore: measure how long it takes for lactose to be fully broken down Accept measure rate of production of {glucose / galactose} Units can be expressed as: - mass per volume per time - mass volume⁻¹ time⁻¹ - amount per volume per time - amount volume⁻¹ time⁻¹ <table border="1"> <tr> <td>mass</td><td>volume</td><td>time</td></tr> <tr> <td>g / mg / µg / kg</td><td>cm⁻³ / mm⁻³ / dm⁻³ / litre⁻¹</td><td>s⁻¹ / min⁻¹ / hour⁻¹</td></tr> <tr> <td>amount</td><td>volume</td><td>time</td></tr> <tr> <td>mmol / mol / µmol</td><td>cm⁻³ / mm⁻³ / dm⁻³ / litre⁻¹</td><td>s⁻¹ / min⁻¹ / hour⁻¹</td></tr> </table>	mass	volume	time	g / mg / µg / kg	cm ⁻³ / mm ⁻³ / dm ⁻³ / litre ⁻¹	s ⁻¹ / min ⁻¹ / hour ⁻¹	amount	volume	time	mmol / mol / µmol	cm ⁻³ / mm ⁻³ / dm ⁻³ / litre ⁻¹	s ⁻¹ / min ⁻¹ / hour ⁻¹	(2)
mass	volume	time													
g / mg / µg / kg	cm ⁻³ / mm ⁻³ / dm ⁻³ / litre ⁻¹	s ⁻¹ / min ⁻¹ / hour ⁻¹													
amount	volume	time													
mmol / mol / µmol	cm ⁻³ / mm ⁻³ / dm ⁻³ / litre ⁻¹	s ⁻¹ / min ⁻¹ / hour ⁻¹													

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes two of the following points: - mutation (that resulted in CLI) occurred in the {gene / DNA} (of people living in one country) (1) - people from this country (had children that) stayed in this country(1) - relatively new mutation so has not had the chance to spread (1)	Accept limited emigration from this country / reproduction with others from same country Ignore idea that mutation is caused by drinking milk / not drinking milk	(2)

Question number	Answer	Additional guidance	Mark
(a)(i)	An explanation that includes the following points: - because both lines rise and fall (in parallel) (1) - but the line for deaths from lung cancer is a period of time after the line for cigarettes smoked (1)	Accept {delay / timelag} for deaths	(2)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes the following points: - alveoli will have a smaller surface area (to volume ratio) (1) - therefore the (rate of) diffusion of oxygen into the bloodstream will be slower (1)	Accept gas exchange area will be smaller Accept gas exchange for diffusion Ignore less gas exchange / diffusion	(2)

Question number	Answer						
* (b)	Indicative content: <table border="1"> <tr> <td>Egg points (E)</td><td> {number / density of pores} {width / size} of pores - area of pores - thickness of shell and membranes - rate of respiration of developing embryo - rate of blood flow of embryo - temperature - shell is impermeable / pores are permeable - shell supports membrane so there is a large SA for gas exchange </td></tr> <tr> <td>Theory points (T)</td><td> - Fick's Law of diffusion can be used to calculate diffusion rate - State Fick's Law (3) - because rate of diffusion depends on surface area / mp11 - because rate of diffusion depends on diffusion distance / mp11 - because rate of diffusion depends on concentration gradient / mp11 - speed of molecules depends on temperature - because rate of diffusion depends on what substances oxygen is passing through eg water / air - diffusion coefficient through air - diffusion coefficient through membranes </td></tr> <tr> <td>Explanation points (X) Accept converse for all</td><td> - increasing SA (or any named factor increasing this) causes increase in rate of diffusion - increasing distance (or any named factor increasing this) causes decrease in rate of diffusion - increasing conc gradient (or any named factor increasing this) causes increase in rate of diffusion - increasing temperature increases rate of diffusion </td></tr> </table>	Egg points (E)	{number / density of pores} {width / size} of pores - area of pores - thickness of shell and membranes - rate of respiration of developing embryo - rate of blood flow of embryo - temperature - shell is impermeable / pores are permeable - shell supports membrane so there is a large SA for gas exchange	Theory points (T)	- Fick's Law of diffusion can be used to calculate diffusion rate - State Fick's Law (3) - because rate of diffusion depends on surface area / mp11 - because rate of diffusion depends on diffusion distance / mp11 - because rate of diffusion depends on concentration gradient / mp11 - speed of molecules depends on temperature - because rate of diffusion depends on what substances oxygen is passing through eg water / air - diffusion coefficient through air - diffusion coefficient through membranes	Explanation points (X) Accept converse for all	- increasing SA (or any named factor increasing this) causes increase in rate of diffusion - increasing distance (or any named factor increasing this) causes decrease in rate of diffusion - increasing conc gradient (or any named factor increasing this) causes increase in rate of diffusion - increasing temperature increases rate of diffusion
Egg points (E)	{number / density of pores} {width / size} of pores - area of pores - thickness of shell and membranes - rate of respiration of developing embryo - rate of blood flow of embryo - temperature - shell is impermeable / pores are permeable - shell supports membrane so there is a large SA for gas exchange						
Theory points (T)	- Fick's Law of diffusion can be used to calculate diffusion rate - State Fick's Law (3) - because rate of diffusion depends on surface area / mp11 - because rate of diffusion depends on diffusion distance / mp11 - because rate of diffusion depends on concentration gradient / mp11 - speed of molecules depends on temperature - because rate of diffusion depends on what substances oxygen is passing through eg water / air - diffusion coefficient through air - diffusion coefficient through membranes						
Explanation points (X) Accept converse for all	- increasing SA (or any named factor increasing this) causes increase in rate of diffusion - increasing distance (or any named factor increasing this) causes decrease in rate of diffusion - increasing conc gradient (or any named factor increasing this) causes increase in rate of diffusion - increasing temperature increases rate of diffusion						

	Level 1 Up to 4 points from anywhere; 2 points for one mark and 4 points for 2 marks Level 2 5 points or more, from two best categories; 5 points for 3 marks, 6 points for 4 marks. Must achieve 6 marks to progress to level 3 Level 3 As level 2 plus up to 2 points from third category; 7 points for 5 marks and 8 points for 6 marks
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Q13.

Question number	Answer	Additional guidance	Mark
(a)(i)	An answer that includes the following points: - an increase in the number of (DNA) {molecules / double helices} (1) - each (new molecule) consists of one {parent / original / old} strand and one new strand (1)	ACCEPT {two / new} molecules are made (from one molecule)	(2)

Question number	Answer	Additional guidance	Mark
(a)(ii)	(DNA) helicase / polymerase / ligase (1)	ACCEPT swivelase / untwistase / topoisomerase	(1)

Question number	Answer	Additional guidance	Mark
(a)(iii)	An explanation that includes the following points: - because it results in genetically identical (daughter) cells (1) - that will have the same {structure / function} (as the parent cell) (1)	ACCEPT same {genetic information / genotype / alleles / DNA sequence}	(2)

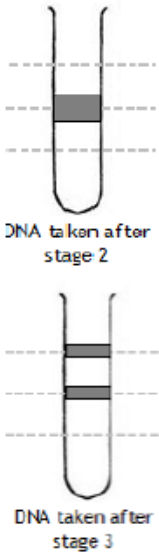
Question number	Answer	Additional guidance	Mark																			
(b)	<table border="1"> <thead> <tr> <th rowspan="2">Stage</th><th colspan="3">Percentage of the DNA molecules containing</th></tr> <tr> <th>heavy nitrogen only</th><th>light nitrogen only</th><th>both heavy and light nitrogen</th></tr> </thead> <tbody> <tr> <td>1</td><td>100</td><td>0</td><td>0</td></tr> <tr> <td>2</td><td>0</td><td>0</td><td>100</td></tr> <tr> <td>3</td><td>0</td><td>50</td><td>50</td></tr> </tbody> </table>	Stage	Percentage of the DNA molecules containing			heavy nitrogen only	light nitrogen only	both heavy and light nitrogen	1	100	0	0	2	0	0	100	3	0	50	50	N.B. mark the rows not the columns DO NOT ACCEPT empty boxes	(3)
Stage	Percentage of the DNA molecules containing																					
	heavy nitrogen only	light nitrogen only	both heavy and light nitrogen																			
1	100	0	0																			
2	0	0	100																			
3	0	50	50																			

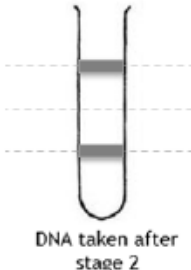
Q14.

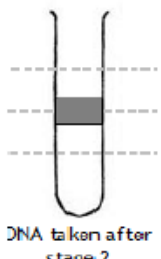
Question number	Answer	Additional guidance	Mark
(a)	An explanation that includes the following points: - form base pairs to hold the two {polynucleotide / strands} together (1) - because of the number of hydrogen bonds that each type of base can form (1) - a {large base / purine} bonds with a {small base / pyrimidine} (1) - so that the strands are parallel (1)	ACCEPT adenine and thymine form two hydrogen bonds <u>and</u> guanine and cytosine form three hydrogen bonds ACCEPT single ring bonds to double ring	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	6.6×10^2 (1)	ACCEPT 6.596×10^2	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	- mass of DNA after three divisions calculated (1) $\{4 / 4.1 / 4.14 / 4.142\} \times 10^{-14}$ (1)	$(3.1 \times 10^9 \times 8) \quad 24.8 \times 10^9$ NB Correct answer but wrong standard form = 1 mark ECF $\{2 / 1.6 / 1.55\} \times 10^{-14}$ = 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(c)(i)	A diagram that shows the following points: - a band the same width as stage 1 in the middle of the tube (1) - bands drawn at the top and middle of tube (1) - both bands half the width of stage 1 (1)	 DNA taken after stage 2 DNA taken after stage 3 NB For mp 3, if 1 band is drawn allow 1 mark if same width as the band in stage 1 level and above it	(3)

Question number	Answer	Additional guidance	Mark
(c)(ii)	A diagram that shows the following points: - bands drawn at the top and bottom of tube (1) - both bands half the width of stage 1 (1)	 DNA taken after stage 2 NB If 1 band is drawn allow 1 mark if same width as the band in stage 1 and above it	(2)

Question number	Answer	Additional guidance	Mark
(c)(iii)	A diagram that shows the following points: - one band drawn in the middle (1) - of similar thickness to band in stage 1 (1)	 DNA taken after stage 2	(2)

Q15.

Question number	Answer	Mark
(a)	C The only correct answer is C. <i>A is incorrect because amino acids are not found in DNA</i> <i>B is incorrect because a mutation is a change in DNA</i> <i>D is incorrect because there are no bases in protein</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)	Any two from: deletion insertion substitution (1)	ALLOW {chromosome / translocation} {point / gene} and {chromosome / translocation} IGNORE subtraction / addition / swapping / frameshift / nonsense / duplication / specific examples	(1)

Question number	Answer	Additional guidance	Mark
(c)	An answer that includes three of the following points: - as age increase the number of cases increases (in both males and females) (1) - up to 57 years of age {males and females have a similar number of cases / females have a higher incidence} (1) - above 57 the number of cases is higher in males (1) - onset of cancer is later in males than females (1)	ACCEPT converse where appropriate ACCEPT men and women throughout ACCEPT positive correlation IGNORE risk for cases ACCEPT 58 ACCEPT 58 NB penalise wrong age once IGNORE just figures quoted	(3)

Q16.

Question number	Answer	Additional guidance	Mark
* (a)	Indicative content: • triplet codon system (D) • because (at least) 20 codes needed for the amino acids (E) • e.g. AAC is code for asparagine (x) • degenerate code (D) • therefore some amino acids have more than one code (E) • e.g. threonine can be coded for by ACA, ACC, ACG or ACT (x) • non-overlapping code (D) • so each base on DNA is used in only one triplet codon (E) • e.g. AAC AGA codes for two amino acids (x)	ACCEPT three bases code for one amino acid ACCEPT each amino acid has its own code ACCEPT there are more codes than necessary ACCEPT discrete	(6)

Level 1 : refers to triplet codon system, degenerative code **or** non-overlapping code but no examples or explanation given

1 mark = 1 out of 3

2 marks = 2 out of 3 or 1 out of 3 + a linked example or explanation

Level 2 : refers to triplet codon system, degenerative code **or** non-overlapping code with either examples or explanation given

3 marks = at least 2 examples or 2 explanations or 1 of each

4 marks = at least 3 examples or 3 explanations or any combination of each

Level 3 : refers to triplet codon system, degenerative code **and** non-overlapping code with examples and explanation given

5 marks = at least 4 examples or explanations or any combination of each

6 marks = at least 5 examples or explanations or any combination of each

Question number	Answer	Additional guidance	Mark
(b)(i)	• methionine alanine cysteine proline isoleucine leucine	ACCEPT phonetic spelling / reasonable abbreviations / M A C P I L	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes the following points: - it will have no effect (on the polypeptide) if the ninth base becomes a T as this still codes for {cysteine / same amino acid} (1) - will code for a stop codon if the ninth base becomes an A (1) - therefore the {protein / polypeptide} will be {shorter / not formed} (1) - will code for tryptophan if the ninth base becomes G (1) - this could change the bonding in the protein (1) - changing the {structure / activity} of the protein (1)	ACCEPT only two amino acids will join together ACCEPT even if tryptophan not given / given wrongly ACCEPT even if tryptophan not given / given wrongly	(5)

Q17.

Question number	Answer	Additional guidance	Mark
(a)	A description that includes the following points: - contain {deoxyribose / pentose / 5 carbon sugar}, phosphate and bases (1) {mononucleotides / bases} held together by hydrogen bonds (1) - between {complementary bases / named example} (1)	NB ignore statements clearly relating to RNA ACCEPT pair contains purine and pyrimidine / (mono)nucleotide contains either purine or pyrimidine phosphate group / PO_4^{3-} DO NOT ACCEPT P / Pi / wrong formulae IGNORE stated number of H bonds ACCEPT A / T / C / G IGNORE descriptions of mononucleotides joined by phosphodiester bonds in a strand NB points can be awarded from clearly labelled diagrams	(3)

Question number	Answer	Additional guidance	Mark
(b)	- number of seconds for molecules to replicate calculated (1) 833 (1) OR - number of molecules replicated in 1 hour (1) 833 (1)	(150 million ÷ 50) 3 000 000 (50 × 60 × 60 =) 180 000 Bald answer of 833 = 2 marks Bald answer of 833.3 = 1 mark unless given as a recurring number	(2)

Question number	Answer	Additional guidance	Mark
(c)(i)	An explanation that includes the following points: - bind to each strand of the DNA (to initiate replication) (1) - credit function of DNA polymerase (1) - so that the DNA can be synthesised in both directions (1)	ACCEPT works at both ends of the bubble IGNORE ref to 3' / 5' e.g. lines up nucleotides (along each strand) forms phosphodiester bonds (between adjacent nucleotides) repairs mistakes in replication IGNORE forms hydrogen bonds between nucleotides	(2)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An answer that includes the following points: - to speed up the process (of DNA synthesis) (1) - so that S phase {is shorter / lasts 8 hours and not 833 hours} (1) - so that cell division is fast enough (1)	ACCEPT wrong figures implied from a wrong calculation	(3)

Question number	Answer	Mark		
(a)(i)	The only correct answer is C. <table><tr><td>fructose and glucose</td><td>sucrose only</td></tr></table> A is incorrect because glucose is also a monosaccharide not a disaccharide B is incorrect because fructose is also a monosaccharide and not a disaccharide D is incorrect because sucrose is not a monosaccharide and fructose is not a disaccharide	fructose and glucose	sucrose only	(1)
fructose and glucose	sucrose only			

Question number	Answer	Mark
(a)(ii)	The only correct answer is B glycosidic A is incorrect because ester bonds join organic acids and alcohols together C is incorrect because peptide bonds join amino acids together D is incorrect because phosphodiester bonds joins mononucleotides together	(1)

Question number	Answer	Additional guidance	Mark
(b)(i)	A calculation showing the following steps: - the mean calculated (1) - the mean converted to g dm^{-3} (1)	Example of calculation : $(1.22 + 1.02 + 1.00) \div 3 / 1.08$ $0.00108 / 0.0011 / 1.08 \times 10^{-3}$ Correct answer with no working shown gains both marks.	(1)

Question number	Answer
(b) (ii)	Indicative content: • sugar solution with a lower water potential than the cytoplasm of the cell (D) • sugar solution should be hypertonic (D) • so that water will pass out of the cytoplasm by osmosis (E) • concentration of sugar solution should be the same as the cytoplasm (D) • so that sugars will not diffuse out (E) • each individual sugar concentration should be the same as the cytoplasm (D) • mean concentration of sugars stated (fructose = 1.52, glucose = 1.08, sucrose = 8.55) (D) • range of sugar concentrations stated (from table) (D) • so that concentration of each sugar remains the same (E) • another solute needs to be used (D) • so that the sugar concentration remains the same but the water passes out (E)

	Level 1 : description of conditions needed for osmosis and maintaining sugar concentration 1 mark = a description of one condition 2 marks = a description of each condition or an explanation of one condition Level 2 : explanation of conditions needed for both osmosis and maintaining sugar concentration 3 marks = a description of one condition and an explanation of the other condition 4 marks = an explanation of each condition Level 3 : indicates that concentration of each sugar needs to be the same as in the pineapple and another solute needs to be included. 5 marks = and includes one of the above 6 marks = and includes both of the above
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Q19.

Question number	Answer	Additional guidance	Mark																		
(a)(i)	An explanation that includes the following points: - pond water has a higher water potential than {cytoplasm / Paramecium} (1) (therefore water moves by) osmosis(1)	ACCEPT converse for all points ACCEPT symbol for water potential (Ψ) ACCEPT inside of cell for {cytoplasm / Paramecium} and outside of cell for pond water <table border="1"><thead><tr><th colspan="3">Acceptable alternative terms</th></tr></thead><tbody><tr><td></td><td>Cytoplasm / inside cell</td><td>Pond water / outside cell</td></tr><tr><td>Water potential</td><td>lower</td><td>higher</td></tr><tr><td></td><td>hypertonic</td><td>hypotonic</td></tr><tr><td>Solute potential / osmotic potential</td><td>lower</td><td>higher</td></tr><tr><td>Conc of solute molecules</td><td>higher</td><td>lower</td></tr></tbody></table> All statements must be comparative eg hypertonic to / higher than... ACCEPT water moves {from an area of high to low water potential / down a water potential gradient / from low to high solute concentration}	Acceptable alternative terms				Cytoplasm / inside cell	Pond water / outside cell	Water potential	lower	higher		hypertonic	hypotonic	Solute potential / osmotic potential	lower	higher	Conc of solute molecules	higher	lower	(2)
Acceptable alternative terms																					
	Cytoplasm / inside cell	Pond water / outside cell																			
Water potential	lower	higher																			
	hypertonic	hypotonic																			
Solute potential / osmotic potential	lower	higher																			
Conc of solute molecules	higher	lower																			

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes the following points: - paramecium does not have a cell wall (1) (therefore) cannot stop the entry of water (1) (therefore if the water is not pumped out) {the cell will swell / pressure will increase} (1) - cell will burst (1)	ACCEPT cell for paramecium in all marking points ACCEPT paramecium is surrounded by (only) a cell membrane ACCEPT Cell will (continue to) fill with water ACCEPT cell membrane breaks	(3)

Question number	Answer	Additional guidance	Mark
* (b)	Indicative content: O marking point (credit once for correct reference, anywhere) reference to {osmosis / concentration gradient / concentration gradient of water molecules / area of high and low water potential} Pond water - E contractile vacuole pumping out water to prevent cell from swelling - C acting as a control to compare to solutions A and B Solution A - D contractile vacuole is not pumping so frequently (than in pond water) / less water is pumped out - E (therefore) less water entering the cell - C because the water potential of solution A is lower than that of the pond water - C water potential of {solution A / outside the cell} is higher than that of {the cytoplasm / inside the cell} so water is still entering D refers to delay at start	IGNORE reference to isotonic ACCEPT correct statement including: hypertonic / hypotonic; solute potential; solute concentration; concentration of water; ACCEPT converse in all cases IGNORE reference to isotonic	(6)

	Solution B - D contractile vacuole is pumping more often (than in pond water) - E (therefore) more water entering the cell - C because the water potential of solution B is greater than that of the pond water - C water potential of Solution B is (much) higher than the cytoplasm so water is still entering the cell - C water potential of solution B > solution A D refers to delay at start E delay in increase is due to time to produce sufficient energy	ACCEPT correct statement including: hypertonic / hypotonic; solute potential; solute concentration; concentration of water; ACCEPT converse in all cases IGNORE reference to isotonic	
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Level	Mark	
	0	No awardable content
1	1-2	Level 1: correct description of graphs with some reference to idea of osmosis 1 mark: one D or one O marking point 2 marks: second D marking point
2	3-4	Level 2: correct comparison of Solutions A and B with pond water or cytoplasm 3 marks: one C marking point 4 marks: second C marking point
3	5-6	Level 3: correct explanation of graphs 5 marks: one E marking point 6 marks: second E marking point

Q20.

Question number	Answer	Additional guidance	Mark
(a)(i)	pressure exerted by one (type of) gas in a mixture of gases (1)	ACCEPT pressure exerted by oxygen in a mixture of gases/air ACCEPT is a measure of concentration of a gas / concentration of oxygen (ignore location) IGNORE amount of oxygen / amount of gas / % of gas / proportion of gas	(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that includes three of the following points: • haemoglobin is composed of four sub-units (1) • binding of the first oxygen molecule is difficult (1) • binding of the other molecules becomes easier (1) • due to a conformational change (1) • as Hb becomes saturated less oxygen can bind (so the curve flattens out) (1)	ACCEPT context of release of oxygen from Hb for mp 2, 3 and 4 ACCEPT 4 haem groups / 4 polypeptide chains / 4 iron ions IGNORE slow binding ACCEPT cooperative binding ACCEPT increased affinity for other molecules IGNORE faster binding ACCEPT due to a change in the {3D/ tertiary} structure IGNORE change of shape	(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	An explanation that includes one of the following points: • {water vapour / carbon dioxide} is added to the air (1) • oxygen {used by cells / used in respiration} (1) • oxygen moves into {capillaries / blood} (1)	ACCEPT idea of carbon dioxide diffusing into the alveoli ACCEPT oxygen transported by blood IGNORE "to maintain a gradient for oxygen to diffuse"	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes the following points: - arteries take blood to {tissues / cells}, veins take blood away from {tissues / cells} (1) - oxygen diffuses (out of the capillaries) into {the tissues / cells} (1) - because there is a lower {partial pressure / concentration} in tissues / cells (1) - carbon dioxide is {increasing in / entering} (the blood) (1)	ACCEPT arteries take blood away from the heart and veins take it towards the heart. Can be pieced together. ACCEPT oxygen diffuses out of the blood ACCEPT oxygen {unloaded / released / dissociates} from haemoglobin ACCEPT because the {tissues / cells} are respiring (aerobically)	(3)

Question number	Answer	Additional guidance	Mark
(b)(iii)	Correct value for percentage saturation given (1)	81 ACCEPT 80 - 82	(1)

Question number	Answer	Additional guidance	Mark
(b)(iv)	An explanation that includes four of the following points: - partial pressure of oxygen (in the atmosphere) at high altitudes is low / lower (than at sea level)} (1) (therefore) the partial pressure of oxygen in the alveoli will be lower (1) - the concentration gradient between the alveoli and the blood will be smaller (1) (therefore) the rate of diffusion of oxygen into the blood will be slower (1) (therefore) the haemoglobin will not be able to bind to as much oxygen (1)	ACCEPT converse for all marking points ACCEPT {concentration of oxygen / level of oxygen} for partial pressure in all marking points ACCEPT less oxygen (available) at high altitude ACCEPT difference in concentration of oxygen between the alveoli and the blood IGNORE less diffusion, this is about rate ACCEPT lower partial pressure of oxygen in the blood ACCEPT less oxyhaemoglobin produced IGNORE saturation of Hb is low	(4)

Q21.

Question number	Answer	Additional guidance	Mark
(a)	peptide (1) amino / NH_2 / NH_3^+ / amine (1) carboxyl / COOH / CO_2H / COO^- / carboxylic (acid) (1) condensation (1) translation (1)	DO NOT ACCEPT dipeptide / polypeptide / amide ACCEPT second and third point either way round ACCEPT polymerisation / addition elimination	(5)

Question number	Answer					Mark
(b)						(2)
	Structure	Hydrogen bonds only	Ionic bonds only	Both hydrogen and ionic bonds	Neither of these bond	
	secondary structure	X	☒	☒	☒	
	three-dimensional structure	☒	☒	X	☒	

Q22.

Question number	Answer	Mark
(a)	sequence of bases of DNA that code for a polypeptide	(1)

Question number	Answer	Mark
(b)	A description that includes the following points: - complementary bases / named pair of complementary bases (1) - it enables the formation of {two hydrogen bonds between adenine and thymine / three hydrogen bonds between cytosine and guanine} (1)	(2)

Question number	Answer	Additional guidance	Mark
(c)	A explanation that includes the following points: - enough codons needed for 20 different amino acids (1) - four bases are used in the genetic code (1) (triplet code) provides {enough / 43 / 64} possible codons (1)	Allow descriptions of single and doublet code providing insufficient alternatives	(3)

Question number	Answer	Additional guidance	Mark
(d)	A answer that includes the following points: • correct genotypes of parents (1) • affected genotype of children correctly identified (1) • correct calculation of probability is 0.5 (1)	Accept 50%, 1 in 2, $\frac{1}{2}$	(3)

Q23.

Question number	Answer	Additional guidance	Mark
(a)(i)	• GUG	ACCEPT guanine uracil guanine / CAC / cytosine adenine cytosine IGNORE val / valine	(1)

Question number	Answer	Additional guidance	Mark
(a)(ii)	• substitution	DO NOT ACCEPT frameshift / deletion / addition / insertion IGNORE {gene / point} mutation	(1)

Question number	Answer	Additional guidance	Mark
(a)(iii)	An answer that includes the following points: • the R groups (of these two amino acids) have different {properties / bonding} (1) • glu may have repelled polar groups on other haemoglobin molecules (1) • {val / hydrophobic R group / hydrophobic part} might form other (hydrophobic) interactions (with other haemoglobin molecules) (1) • (part of haemoglobin containing) val (R group) turns away from {water / cytoplasm} (1)	ACCEPT amino acids have different properties ACCEPT bonds / Van der Waals DO NOT ACCEPT incorrect named bonds ACCEPT repels water DO NOT ACCEPT blood / plasma	(3)

Question number	Answer	Additional guidance	Mark
(b)	- number of non-affected babies calculated (1) 0.002 : 1 / 2×10^{-3} : 1 (1)	(140 million - 305 800 =) 139 694 200 0.002189 ACCEPT 0.0022 / 0.00219 / 0.002189 ACCEPT 1 : 457 / 456.8 NB 1 mark for 1 : 458 / 1 : 457.8 0.002184 : 1 (0.002 / 0.0022 / 0.0218) Bald answer = 2 marks	(2)

Question number	Answer	Additional guidance	Mark
(c)(i)	- values read correctly from the graph (1) 3.3 / 3.4 (1)	ACCEPT 4.4 / 4.9 and 5.7 / 5.8 / 7.7 / 7.8 ACCEPT ecf for correct subtraction using {4.4 / 7.7 / 7.8} and one incorrect value Bald answer = 2 marks	(2)

Question number	Answer	Additional guidance	Mark
(c)(ii)	An answer that includes the following points: - person without the disease has higher saturation than person with the disease (at all partial pressures of oxygen) (1) - there is {greater variability / wider range} (in the saturation) of a person with the disease than a person without the disease (at a particular partial pressure of oxygen) (1)	NB accept converse throughout but all conclusions must be comparative ACCEPT refs to affinity (for oxygen) IGNORE graph shifted	(2)

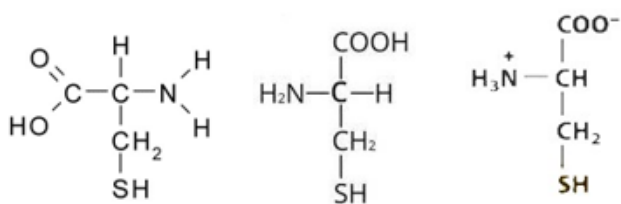
Question number	Answer	Additional guidance	Mark
(c)(iii)	120 (days) (1)		(1)

Question number	Answer	Additional guidance	Mark
(c)(iv)	An explanation that includes three of the following points: • (change in structure of haemoglobin) haemoglobin {binds / carries} less oxygen (1) • (shape of red blood cell) smaller surface area so less oxygen <u>diffuses</u> in / red blood cells get lodged in blood vessels preventing flow of blood to cells (1) • therefore less oxygen to {cells / tissues} so {less available for (aerobic) <u>respiration</u> / switch to <u>anaerobic respiration</u>} (1) • credit an example of why less oxygen to cells could be fatal (1)	NB accept converse where appropriate ACCEPT named cell / tissue e.g. heart attack, stroke, sepsis, infection	(3)

C1

Q24.

Question number	Answer	Additional guidance	Mark
(a)(i)	A description that includes two of the following points: • long (chains of amino acids / polypeptides / proteins) (1) • repeating sequences of amino acids (1) • high proportion of {small / non-polar / hydrophobic} {R groups / amino acids} (1) • (parallel) chains held with {cross links / hydrogen bonds}	IGNORE large ACCEPT a description IGNORE named amino acids ACCEPT hydrophobic groups on the outside IGNORE stated number of chains / refs to triple helix DO NOT ACCEPT other named bonds	(2)

Question number	Answer	Additional guidance	Mark
(a)(ii)	A diagram that includes the following points: - a central carbon atom (1) - an amino group and a carboxyl group (1) - a hydrogen and the cysteine R group (attached by the C) (1)		(3)

Question number	Answer	Additional guidance	Mark
(b)(i)	A description that includes the following points: β {pleated / sheet} / α helix (1) (held together by) hydrogen bonds (between amino acids) (1)	DO NOT ACCEPT {double helix / triple helix} even if β sheet named IGNORE B / A DO NOT ACCEPT other bonds DO NOT ACCEPT between the R groups	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that includes four of the following points: - primary structure remains the same length and secondary structure is longer with higher temperature (1) (primary structure remains the same length) because the peptide bonds are not affected (by the heat) (1) - secondary structure is shorter than primary structure because of the {folding / winding} (1) (secondary structure gets longer) because (the heat) hydrogen bonds break (1) - due to increase in vibration of the {R groups / amino acids / molecule} (1)	Piece together ACCEPT strong / hard to break ACCEPT increase in kinetic energy results in more movement within the molecule.	(4)

Q25.

Question number	Answer	Additional guidance	Mark
(a)	An answer that includes three of the following points: Similarities Any two from: • both contain a glycerol (1) • both contain fatty acids (1) • both contain ester bonds (1) Differences • triglycerides have three fatty acids and phospholipids have two fatty acids (1) • triglycerides do not contain a phosphate group but phospholipids do contain a phosphate group (1)	NB Do not piece together from two descriptions in separate sentences IGNORE diagrams	(3)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: • {protein / phosphate heads / phospholipid heads} are {soluble / hydrophilic / polar} and interact with {blood / plasma} (1) • {fatty acids / triglycerides / cholesterol} is {insoluble / non-polar / hydrophobic} (1) • therefore cholesterol is surrounded by {fatty acid tails / triglycerides} (1)		(3)

Question number	Answer	Additional guidance	Mark												
(c)(i)	- volume of sphere calculated / values substituted into the equation (1) - volume of sphere rounded up to nearest whole number (1) - ratio calculated (1)	Example of calculation = 6912 if using $\pi = 3$ = 7142.4 if using $\pi = 3.1$ = 7234.56 if using $\pi = 3.14$ = 7239.168 if using $\pi = 3.142$ = 7241.472 if using $\pi = 3.143$ = 7238.22947387 if pressing π on calculator = 6912 / 7142 / 7235 / 7239 / 7238 / 7241 ACCEPT 6910 / 7140 / 7240 NB Just these values given = 2 marks 14 : 1 13 : 1 if 6910 / 6912 CE apply throughout NB mark answer in table if different from in the working e.g. <table border="1"> <thead> <tr> <th>Diameter of LDL / nm</th><th>Volume of LDL / nm³</th><th>Volume of cholesterol / nm³</th><th>Ratio of LDL volume to cholesterol volume</th></tr> </thead> <tbody> <tr> <td></td><td></td><td></td><td></td></tr> <tr> <td></td><td>7235 = 2 marks</td><td></td><td>14 : 1 = 1 mark</td></tr> </tbody> </table>	Diameter of LDL / nm	Volume of LDL / nm ³	Volume of cholesterol / nm ³	Ratio of LDL volume to cholesterol volume						7235 = 2 marks		14 : 1 = 1 mark	(3)
Diameter of LDL / nm	Volume of LDL / nm ³	Volume of cholesterol / nm ³	Ratio of LDL volume to cholesterol volume												
	7235 = 2 marks		14 : 1 = 1 mark												

Question number	Answer	Additional guidance	Mark
* (c)(ii)	Indicative content: - as LDL increases, risk increases (K / G) - several factors beside LDLs can increase the risk of CVD (K) - example of a factor given e.g. high blood pressure (K) - LDLs can be different sizes (Q) - and therefore be absorbed by endothelial cells differently (Q) - and therefore get broken down at different rates (K / Q) - and therefore carry different volumes of cholesterol (Q) - level of HDL (in blood) affects risk (of CVD) (K / G) - example given from graph e.g. 0.65 a.u. has greater risk than 2.20 a.u. (G) - ratio of LDL : HDL affects risk (of developing CVD) (K / G) - the lower LDL : HDL the ratio the lower risk of CVD (K / G)		(6)
Own knowledge (K), information given in the graph (G), information in the question (Q) Level 1 : uses either (K), (G) or (Q) 1 mark = 1 comment, 2 marks = 2 comments Level 2 : uses two from (K), (G) or (Q) 3 marks = 3 comments, 4 marks = 4 comments Level 3 : uses (K), (G) and (Q) 5 marks = 5 comments, 6 marks = 6 comments			

Q26.

Question number	Answer	Mark
(a)(i)	D nm The only correct answer is D. <i>A is incorrect because cm would be 1×10^0</i> <i>B is incorrect because mm would be 1×10^{-1}</i> <i>C is incorrect because μm would be 1×10^{-4}</i>	(1)

Question number	Answer	Mark
(a)(ii)	B Q and T The only correct answer is B. <i>A is incorrect because R is a fatty acid and only contains C, H and O</i> <i>C is incorrect because R is a fatty acid and only contains C, H and O, S is cholesterol and only contains C, H and O</i> <i>D is incorrect because S is cholesterol and only contains C, H and O</i>	(1)

Question number	Answer	Mark
(a)(iii)	D S : T The only correct answer is D. <i>A is incorrect because</i> <i>B is incorrect because</i> <i>C is incorrect because</i>	(1)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that includes the following points: - because the sequence of amino acids determine the {tertiary / quaternary} structure of the protein (1) - by determining the {position / type} of bonds that form between the <u>R groups</u> (1) {hydrophobic / non-polar} {(R) groups / amino acids} on (the outside of) the part of the protein that is embedded in the fatty acid tails (1) {hydrophilic / polar} {(R) groups / amino acids} (on the outside of) the part of the protein that is {amongst the phosphate heads / facing the cytoplasm / facing the aqueous environment} (1)	ACCEPT pieced together ACCEPT a named bond between R groups	(4)

Question number	Answer
* (c)	Indicative content: Molecule E • enters by osmosis • because it is water • the number of the molecules F, G and H lower the water potential • so E moves down the water potential gradient Molecule F • enters by facilitated diffusion • down its concentration gradient • because it is polar and cannot pass through the fatty acid tails • therefore needs a protein to provide a polar channel for it to diffuse through Molecule G • enters by diffusion • because it is at a higher concentration outside the cell • and it is non-polar so can pass through the fatty acid tails Molecule H • enters by active transport • because it is at a higher concentration inside the cell • and therefore needs ATP and a protein to pump it across the membrane Level 1 : 1 mark = 1 relevant comment 2 marks = 3 relevant comments Level 2 : 3 marks = 4 relevant comments for at least two molecules 4 marks = 5 relevant comments for at least two molecules Level 3 : 5 marks = 6 relevant comments for at least three molecules 6 marks = 7 relevant comments from all four molecules (6)