PEARSON EDEXCEL IAL BIOLOGY · YBI11

BIOLOGY



EXAM QUESTION PACK

UNIT 1: MEMBRANES, PROTEINS, DNA AND GENE EXPRESSION

SCORE	PERCENTAGE
/563	%

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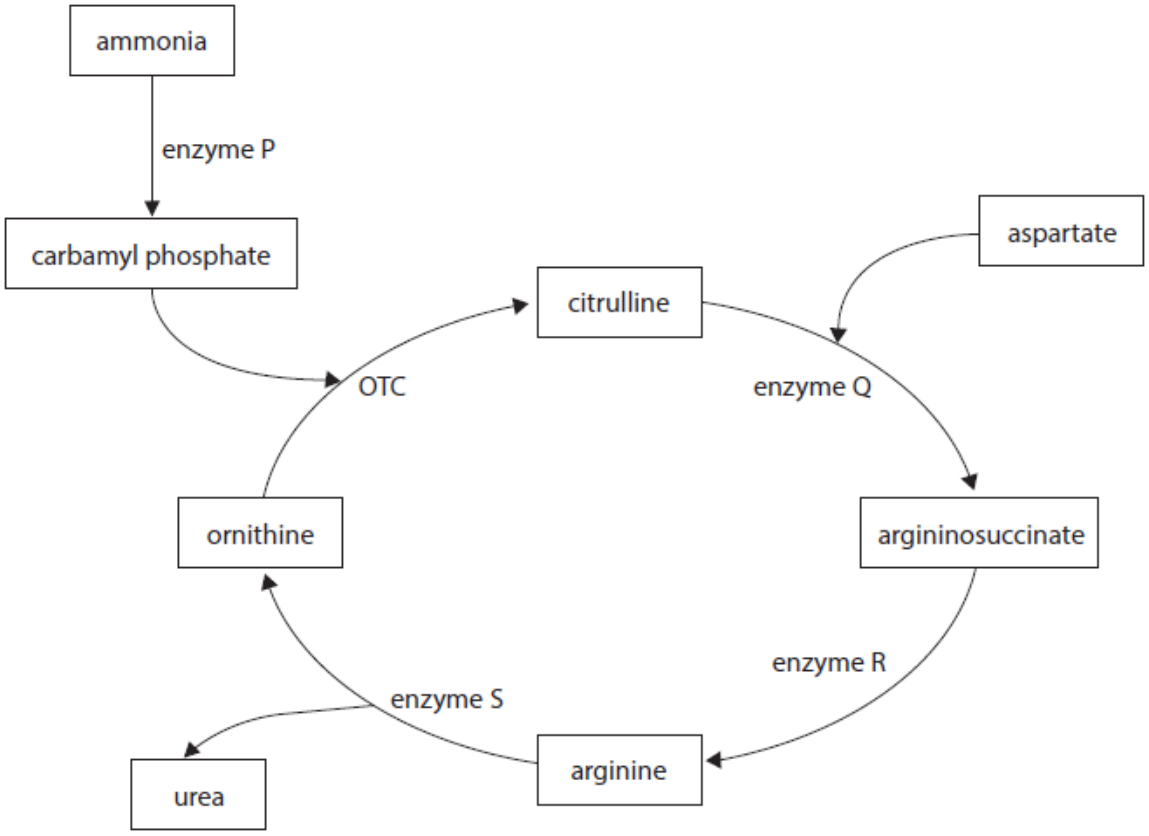
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Q1.

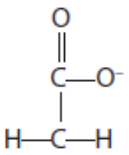
The amino acid aspartate is converted into the amino acid arginine in the urea cycle.

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.

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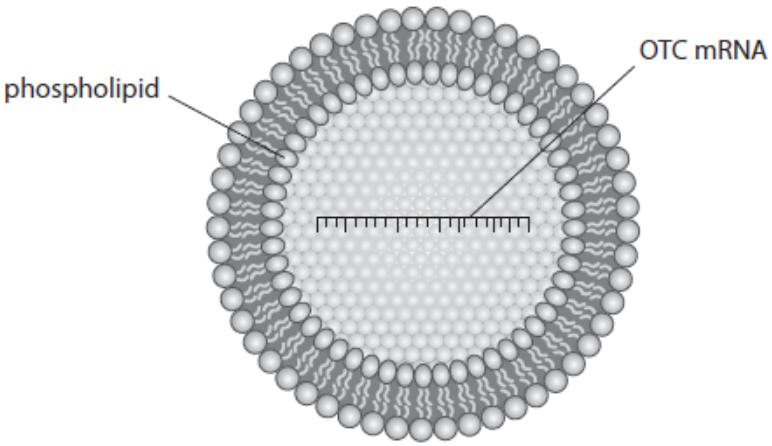
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*(ii) Targeted mRNA therapy is being developed to treat OTC deficiency in mice.

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.

Mice	Concentration of ammonia in blood plasma / μmol dm^{-3}
normal without treatment	50
with OTC deficiency and without treatment	240
with OTC deficiency and with treatment	40

Explain how this treatment works.

Use the information in the diagram of the urea cycle, the diagram of the particle and the table of results to support your answer.

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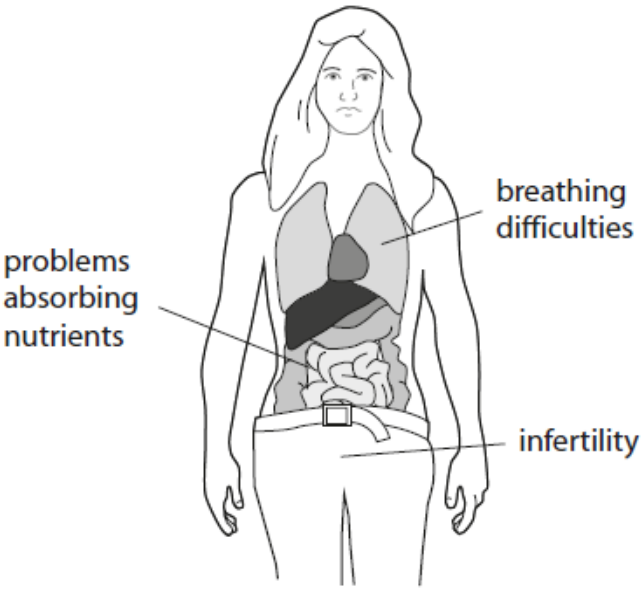
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(b) The diagram shows some health problems associated with cystic fibrosis, in a female.



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

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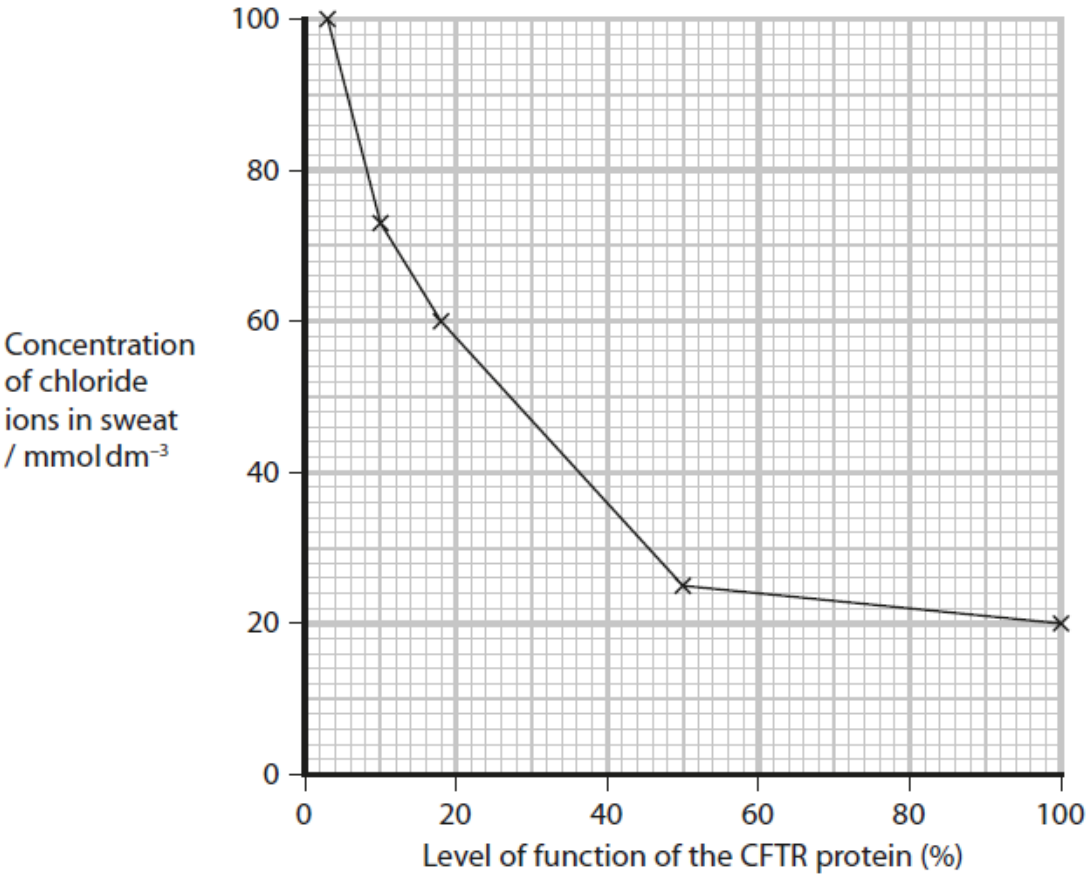
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(c) The graph shows the correlation between the concentration of chloride ions in sweat and the level of function of the CFTR protein.



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.

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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)

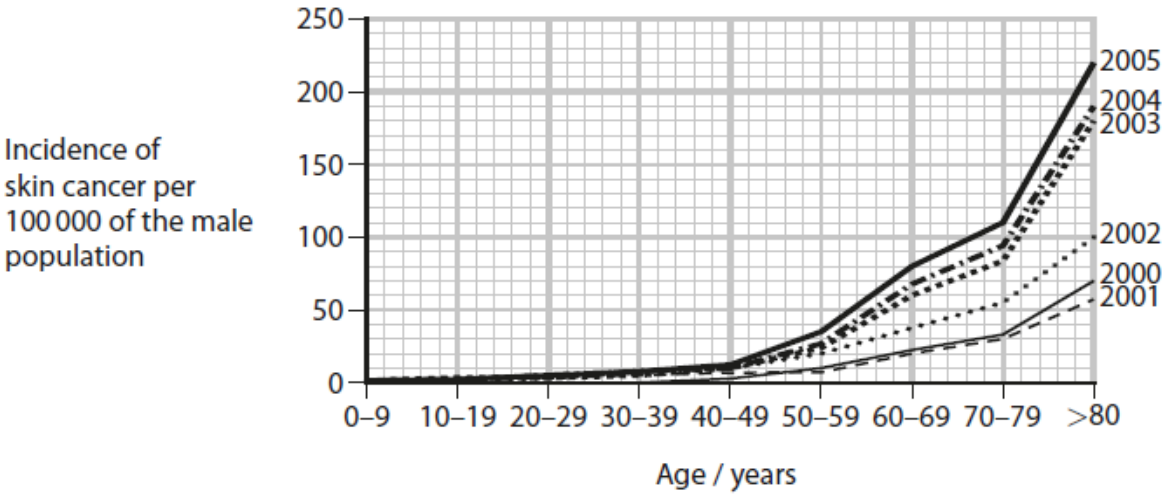
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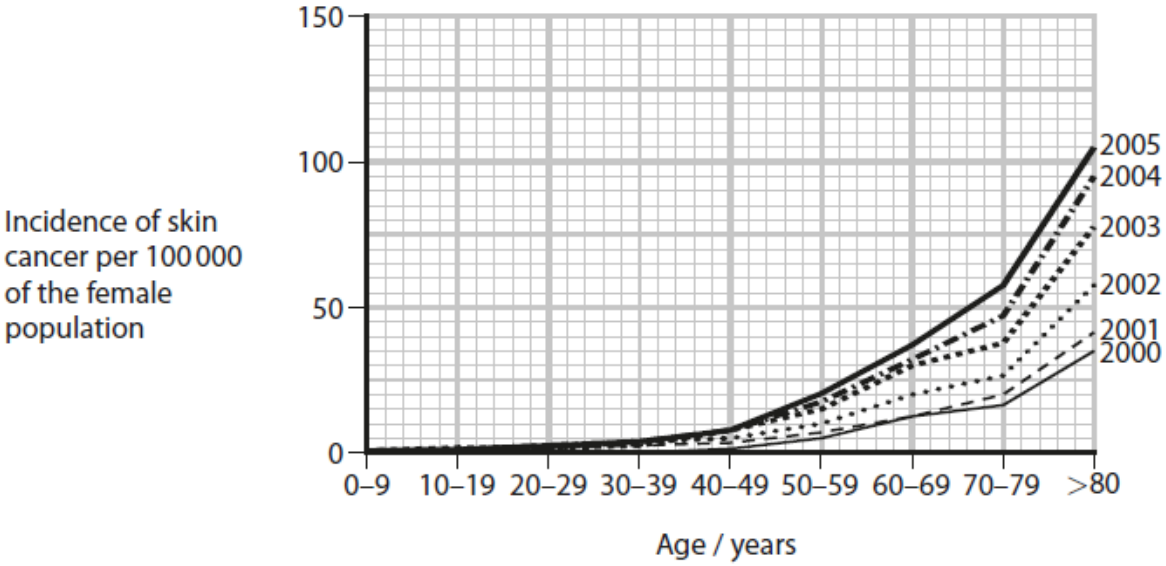
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(b) Exposure to ultraviolet light is associated with the development of skin cancer.

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





(i) The graphs show some correlations.

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

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(ii) Describe the correlations shown by these graphs.

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

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*(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.

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(Total for question = 14 marks)

Q4.

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 ☒ .

A person with diabetes has a blood glucose level that can be too high.

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

(a) Which polysaccharide does the liver store?

(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**.

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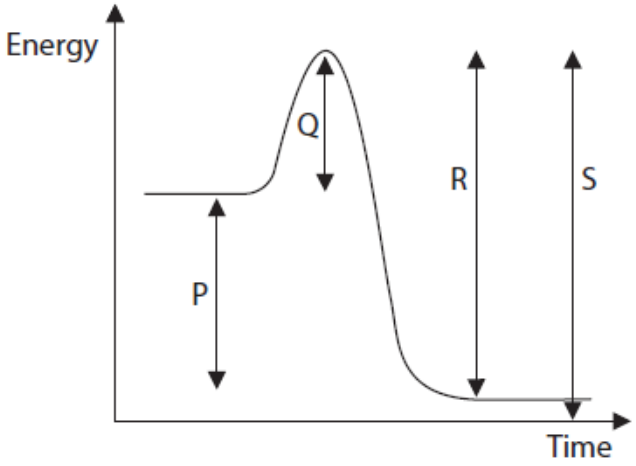
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(b) The graph shows the energy changes during an enzyme catalysed reaction.



Which arrow shows the energy required to start the reaction?

(1)

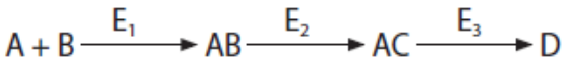
☒ **A** P

☒ **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)

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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	.....

(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

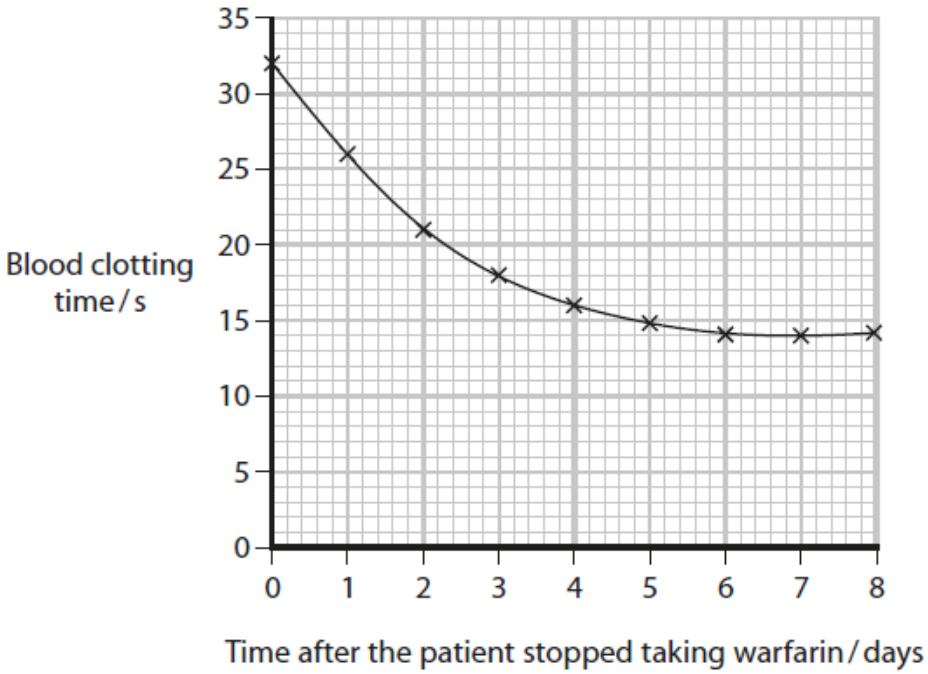
☒ **B** an antihypertensive

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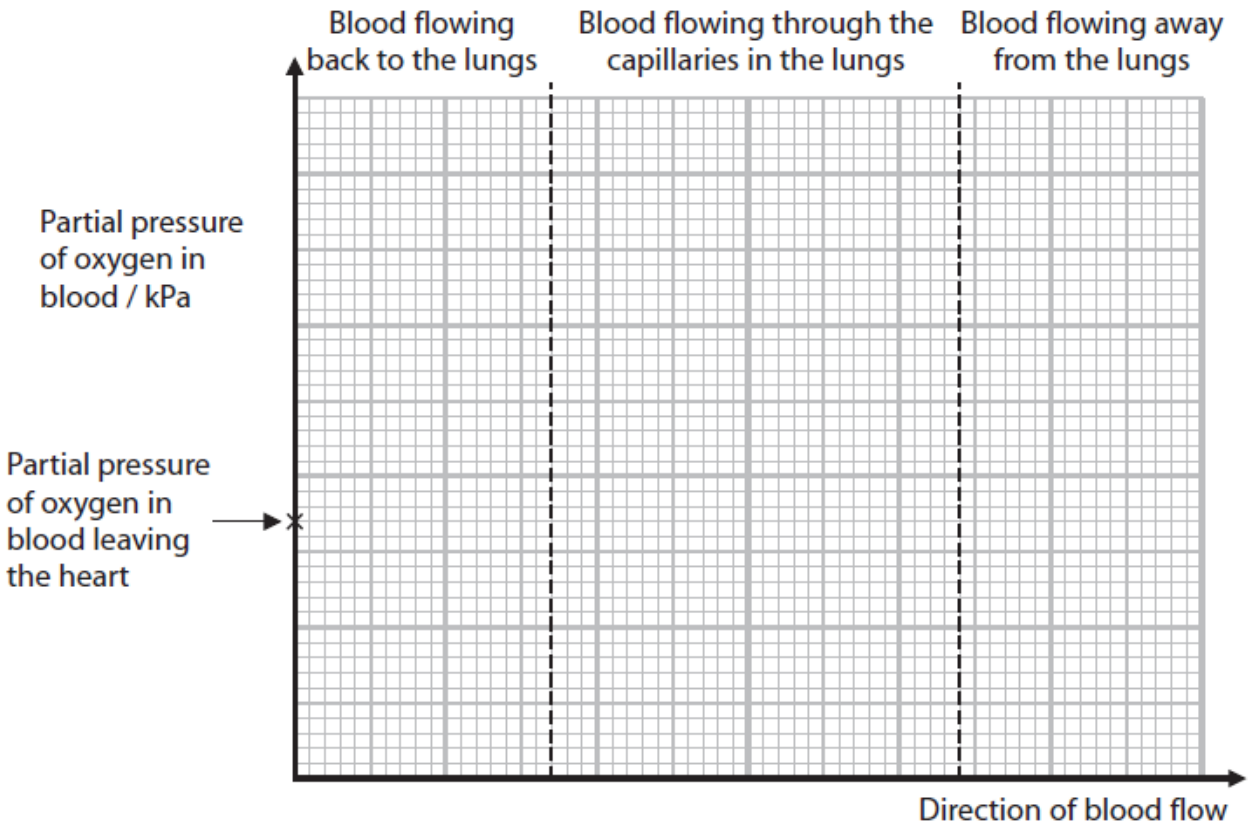
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(d) Deoxygenated blood is taken to the lungs and oxygenated blood is taken away from the lungs.

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

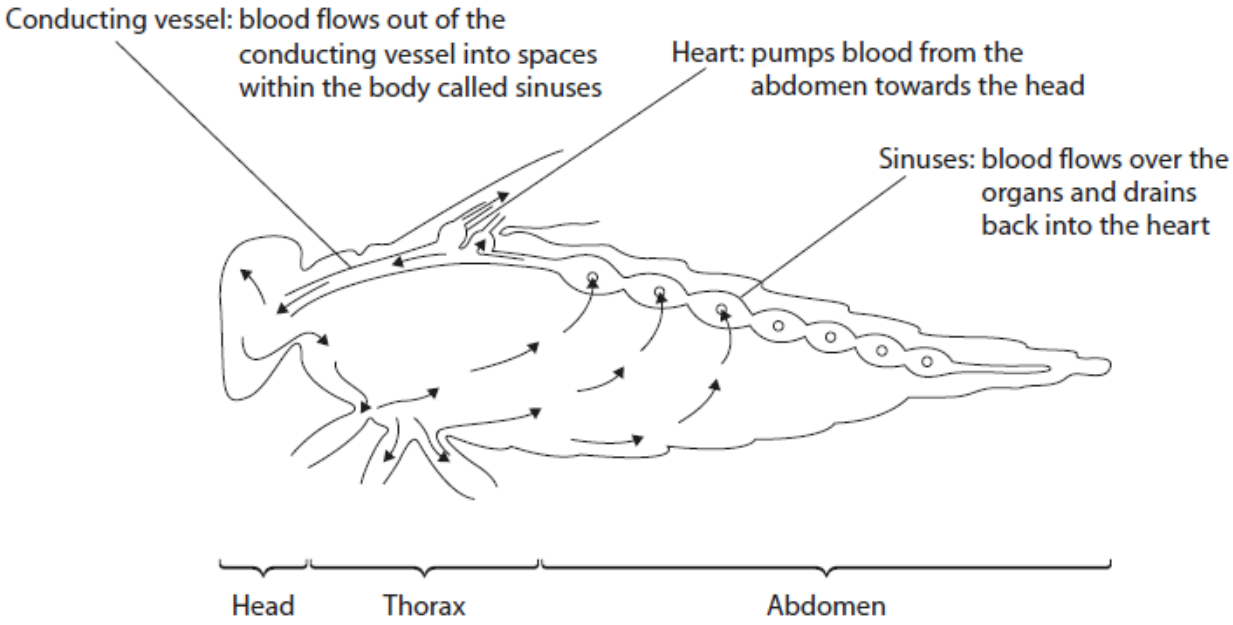
(iii) Which row of the table describes a saturated lipid?

(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 mm^2.

(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.

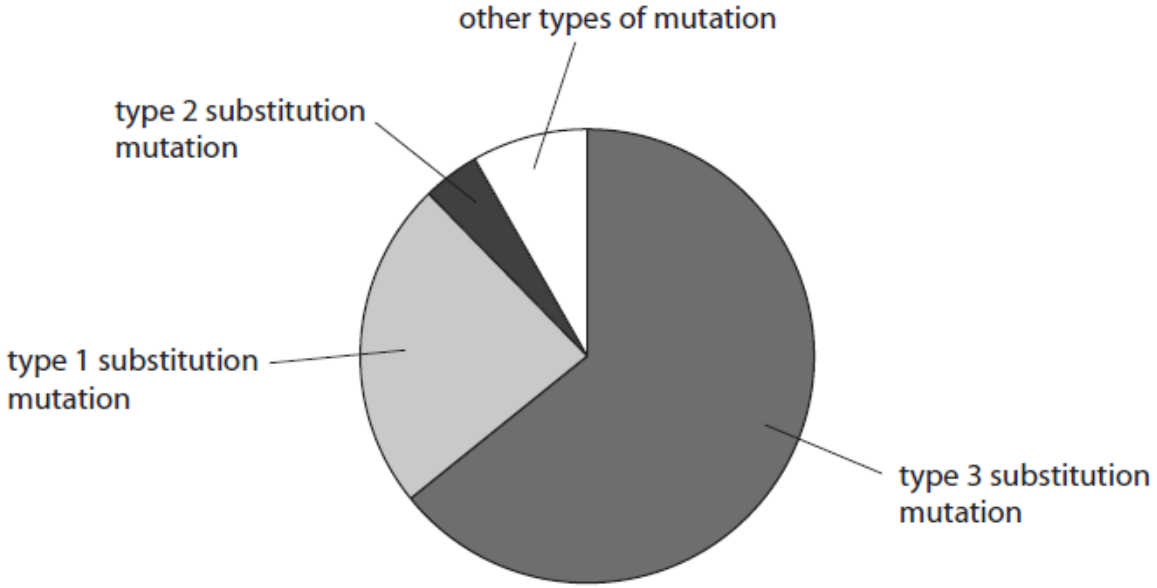
Give your answer to two decimal places.

(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.

1 .....

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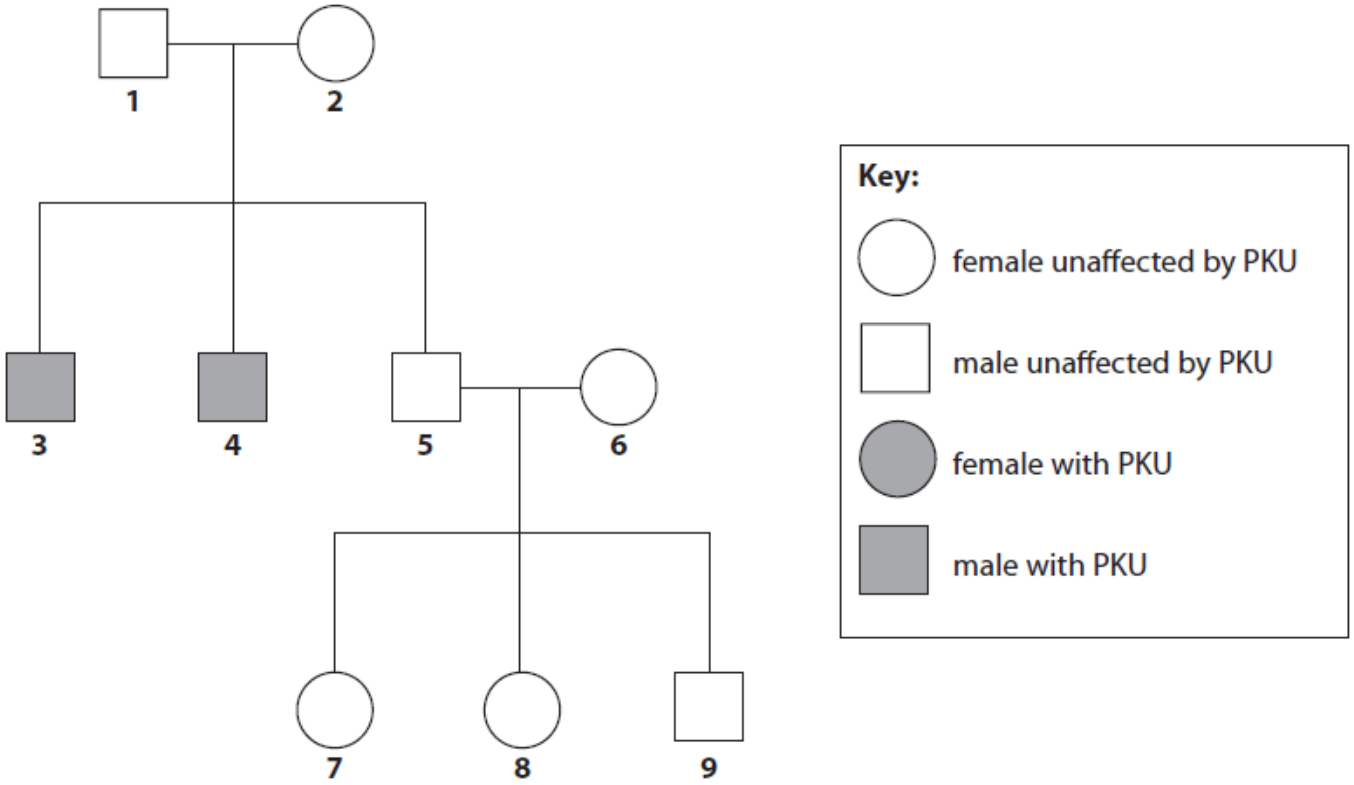
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(c) Phenylketonuria (PKU) is a genetic disorder.

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.

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(Total for question = 15 marks)

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)

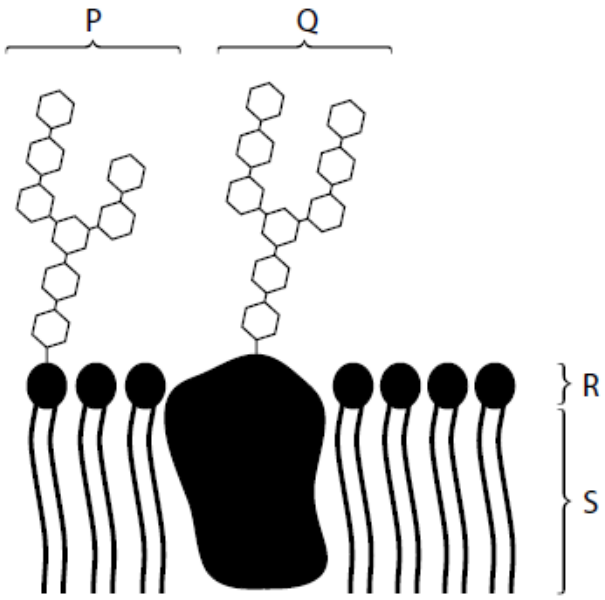
☒ **A** the hydrophobic heads dissolve in the aqueous (water) environment

☒ **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.

(3)

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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)

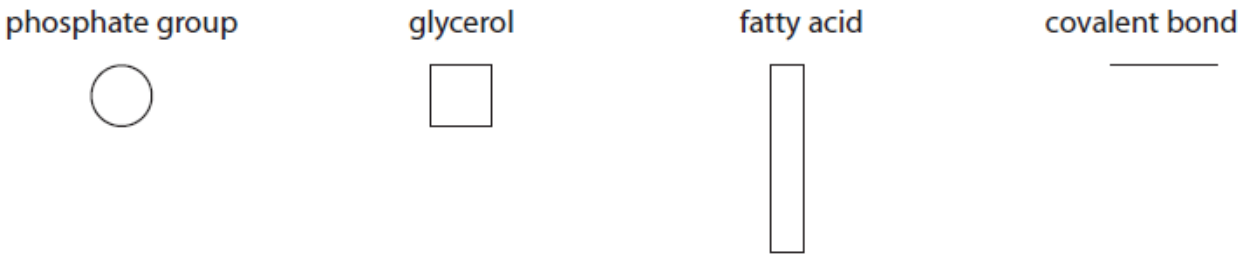
Q12.

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.



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

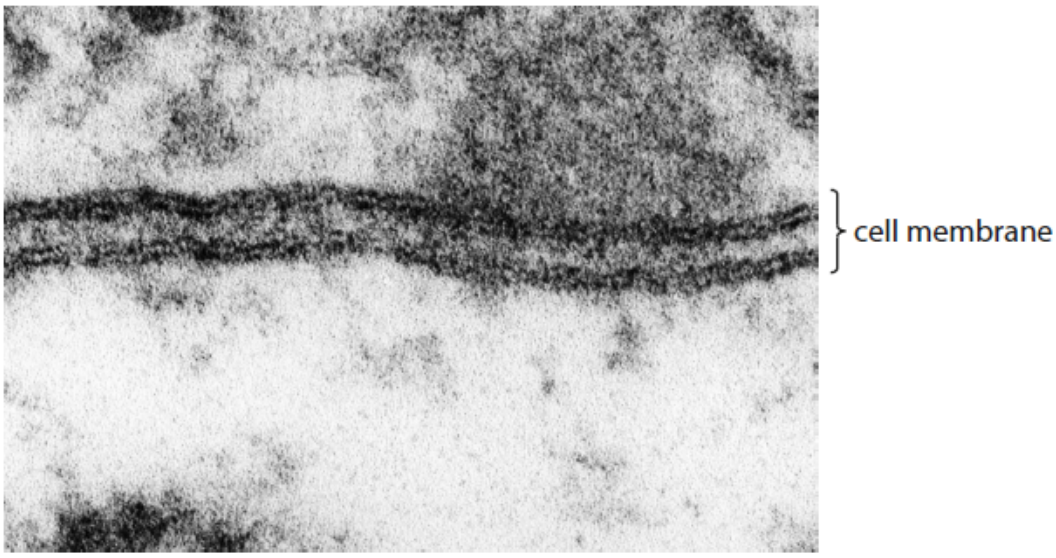
☒ **D** three

(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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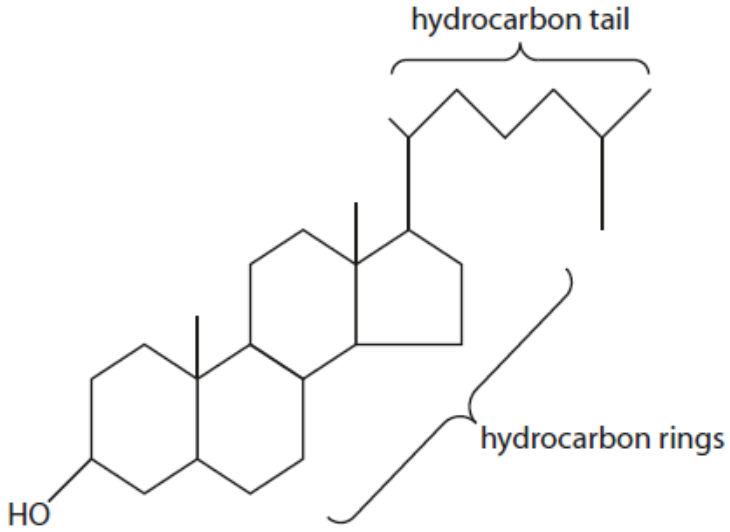
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(b) Cell membranes contain cholesterol.

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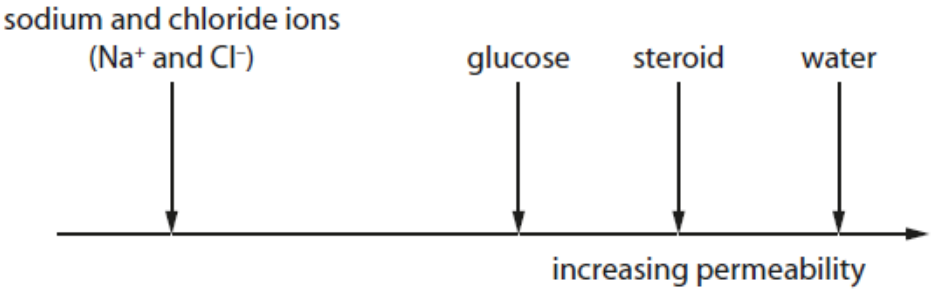
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(c) The diagram shows the permeability of cell membranes to some chemicals.



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.

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(Total for question = 12 marks)

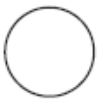
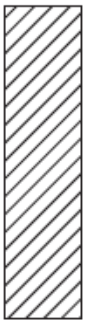
Q14.

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	

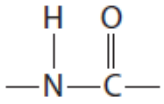
(i) Draw a diagram of a phospholipid, using the information in the table.

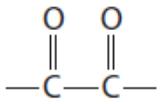
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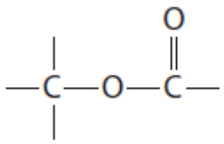
(ii) One of the bonds present in phospholipids is an ester bond.

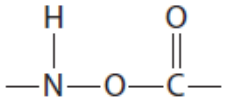
Which diagram shows an ester bond?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(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.

(2)

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

(2)

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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.

(2)

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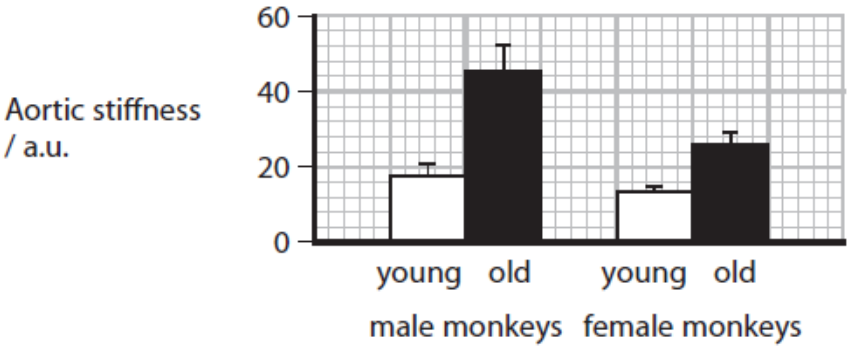
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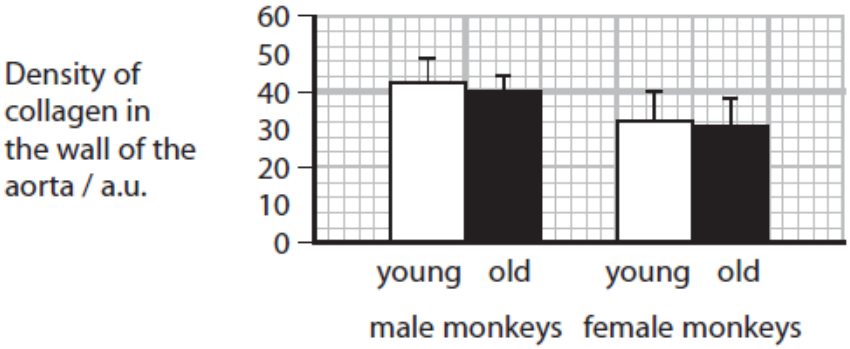
*(b) Age and sex affect the types and density of collagen found in the wall of the aorta.

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.

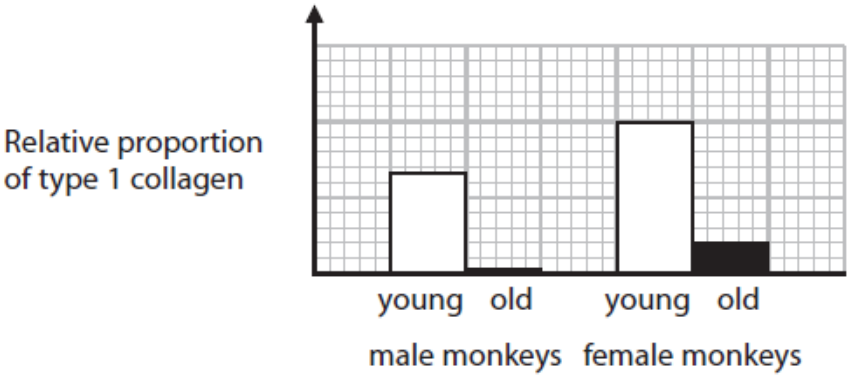
The graphs show the results of this study.

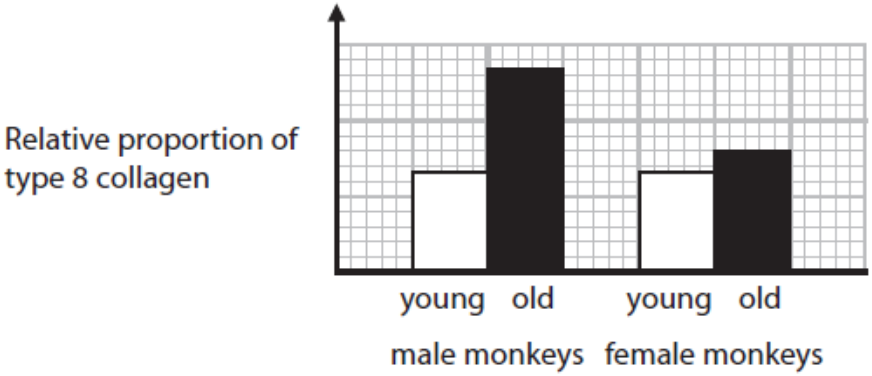




In another study, scientists investigated the effect of age and sex on two types of collagen present in the wall of the aorta.

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





Comment on the effect of age and sex on the types of collagen found in the wall of the aorta and aortic stiffness.

Use the information in the graphs to support your answer.

(6)

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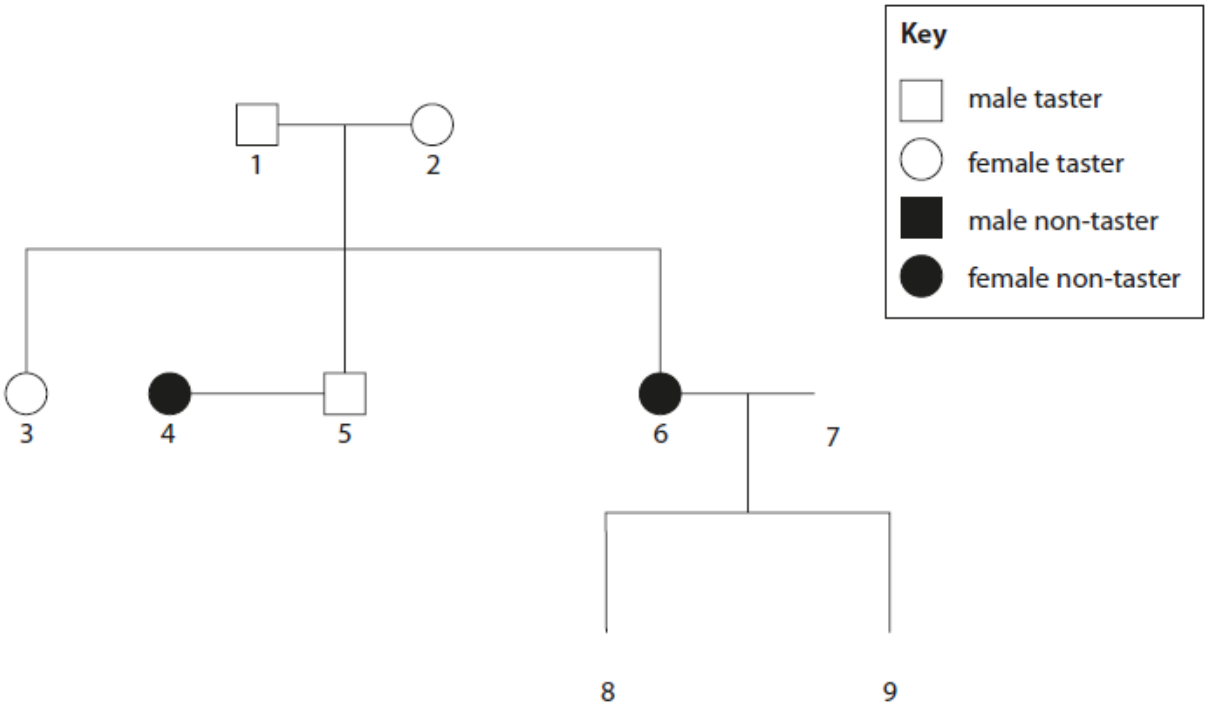
(Total for question = 11 marks)

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

(2)

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(c) Explain which is the dominant allele.

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

(2)

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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.

(2)

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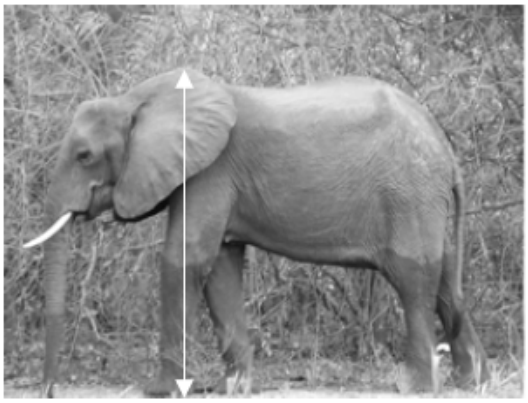
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(Total for question = 9 marks)

Q17.

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





Magnification ×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)

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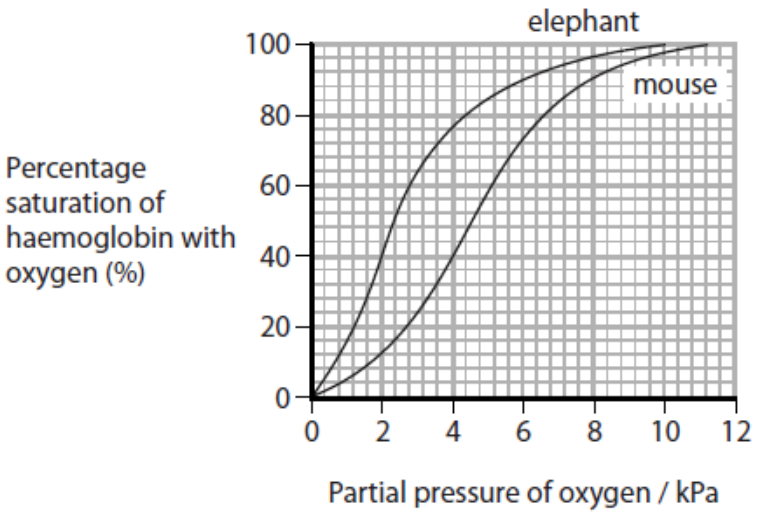
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* (c) Graph 1 shows the oxygen dissociation curve of haemoglobin for a mouse and for an elephant.

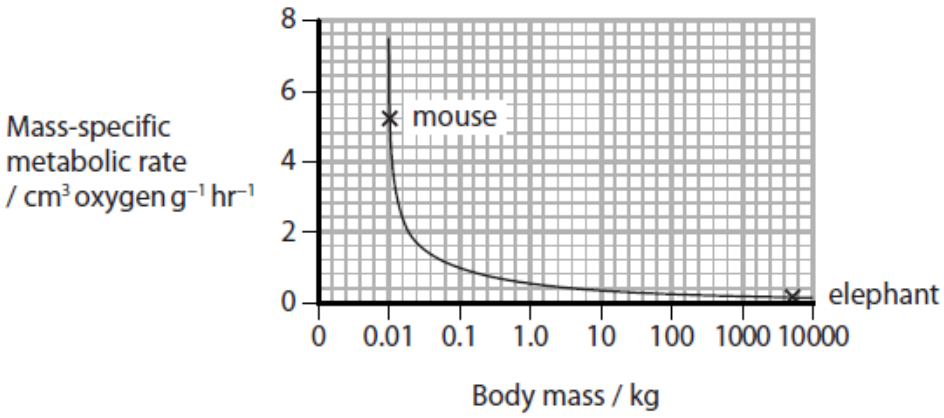
Graph 1



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.

Graph 2



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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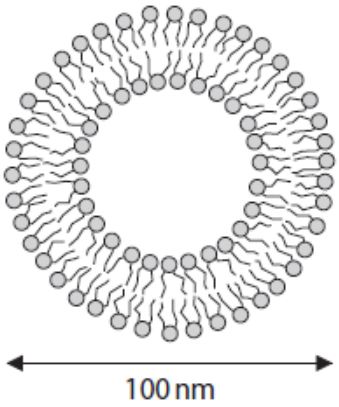
(Total for question = 11 marks)

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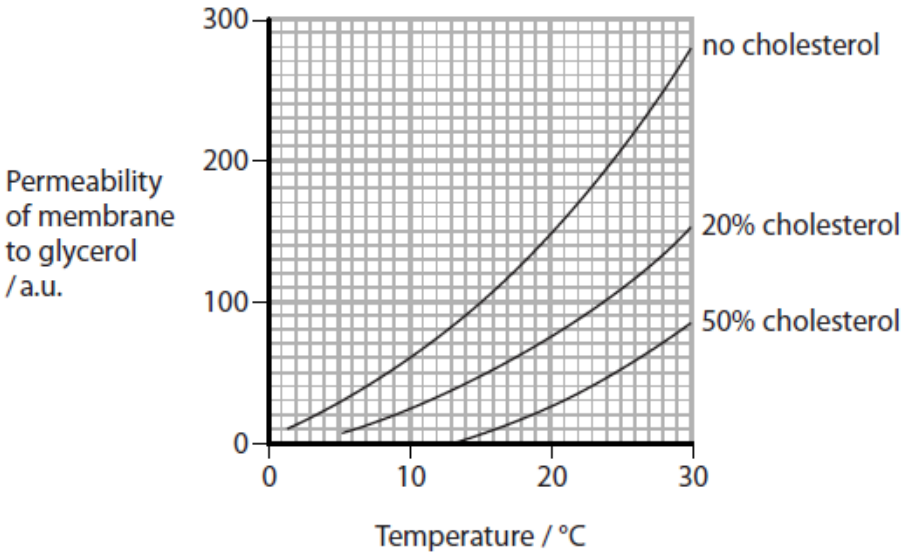
(b) The presence of cholesterol in the membrane affects membrane permeability.

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.

(3)

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

(2)

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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.

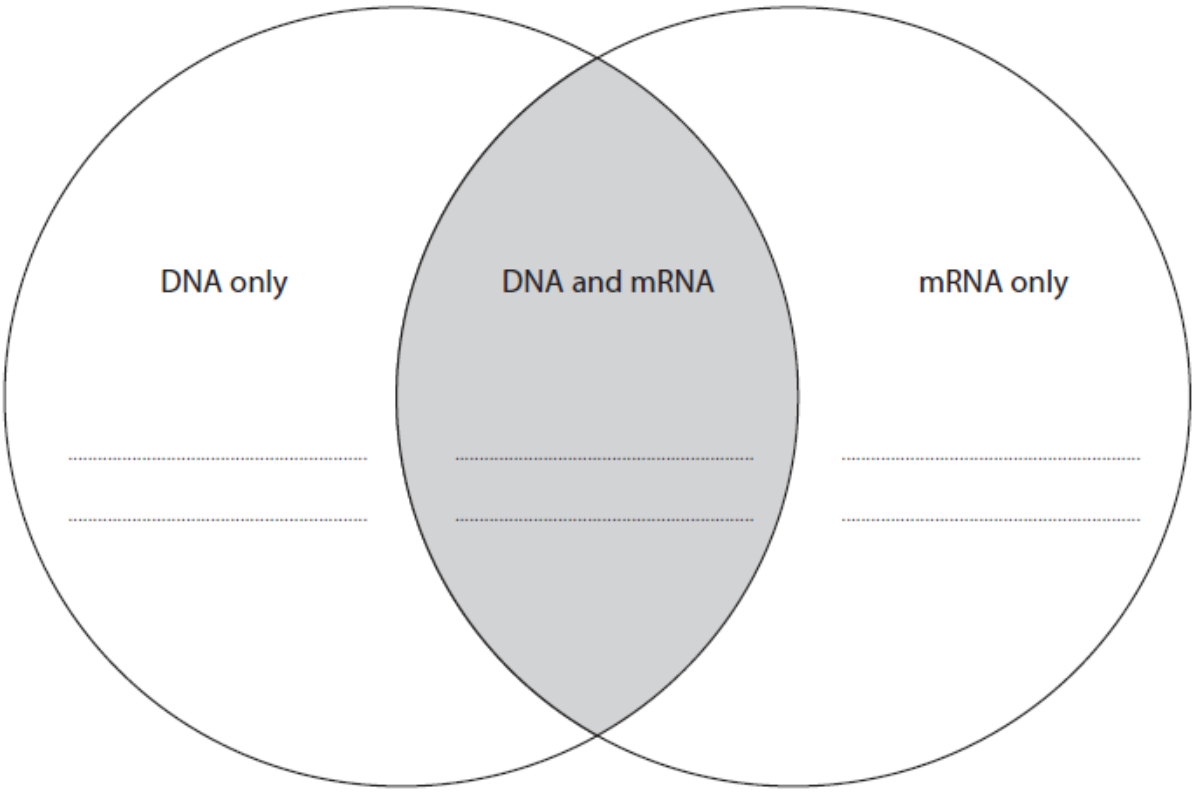
Polynucleotides include DNA and messenger RNA (mRNA).

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 ☒ .

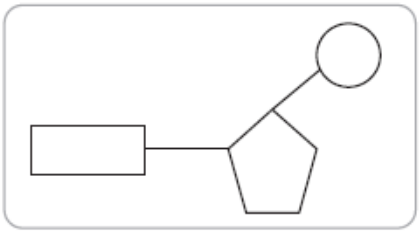
Both DNA and RNA are polynucleotides.

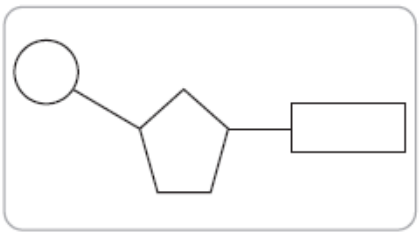
(a) The table shows how the components of polynucleotides can be represented.

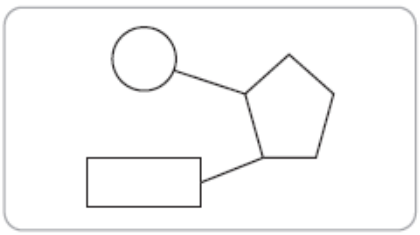
Component	Representation
sugar	
phosphate group	
cytosine or thymine	
adenine or guanine	
covalent bond	
hydrogen bond	

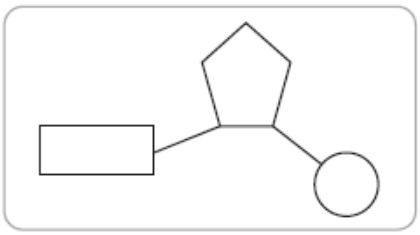
(i) Which diagram shows a mononucleotide?

(1)

☒ A 

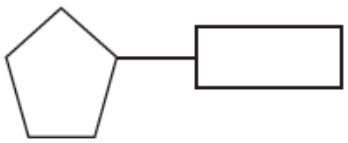
☒ B 

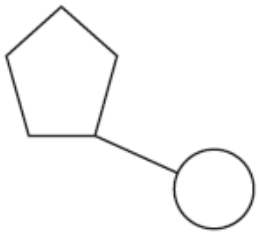
☒ C 

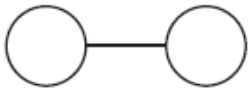
☒ D 

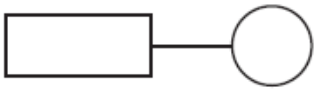
(ii) Which diagram shows two components joined by a phosphodiester bond?

(1)

☒ A 

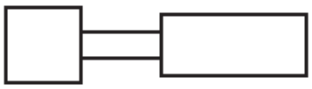
☒ B 

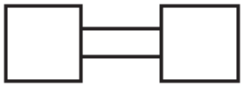
☒ C 

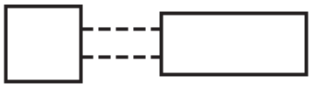
☒ D 

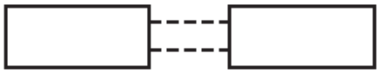
(iii) Which diagram shows complementary base pairing?

(1)

☒ A 

☒ B 

☒ C 

☒ D 

(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

(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)

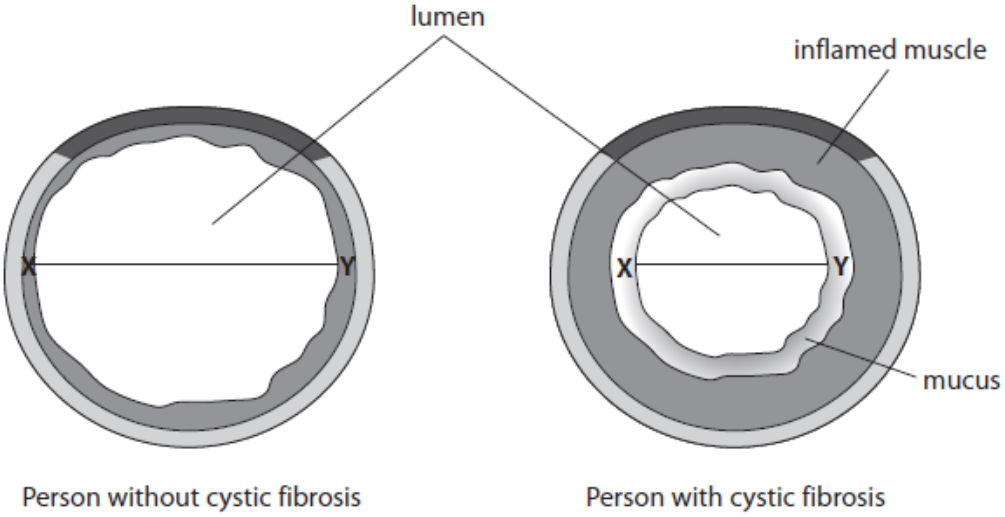
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(Total for question = 7 marks)

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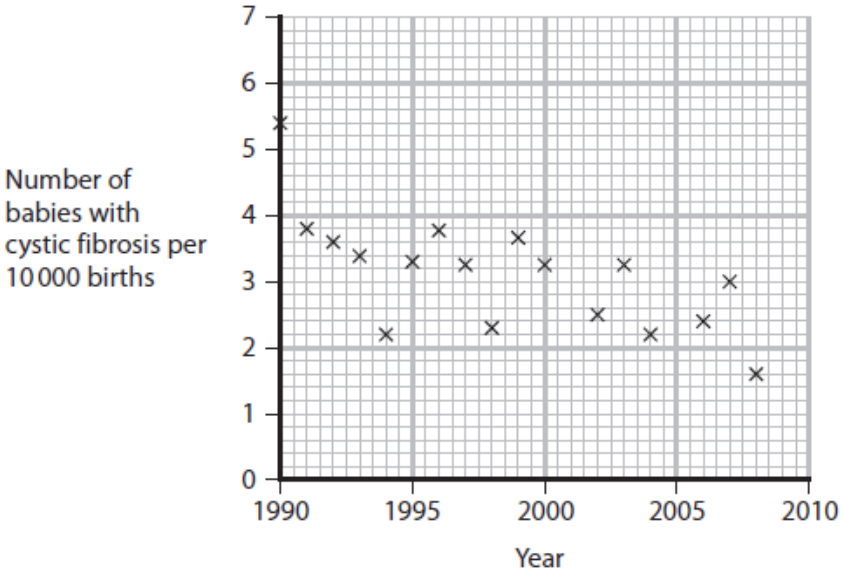
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(b) The graph shows the number of babies with cystic fibrosis per 10 000 births in one country, from 1990 to 2008.



(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 in a box ☒. 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.

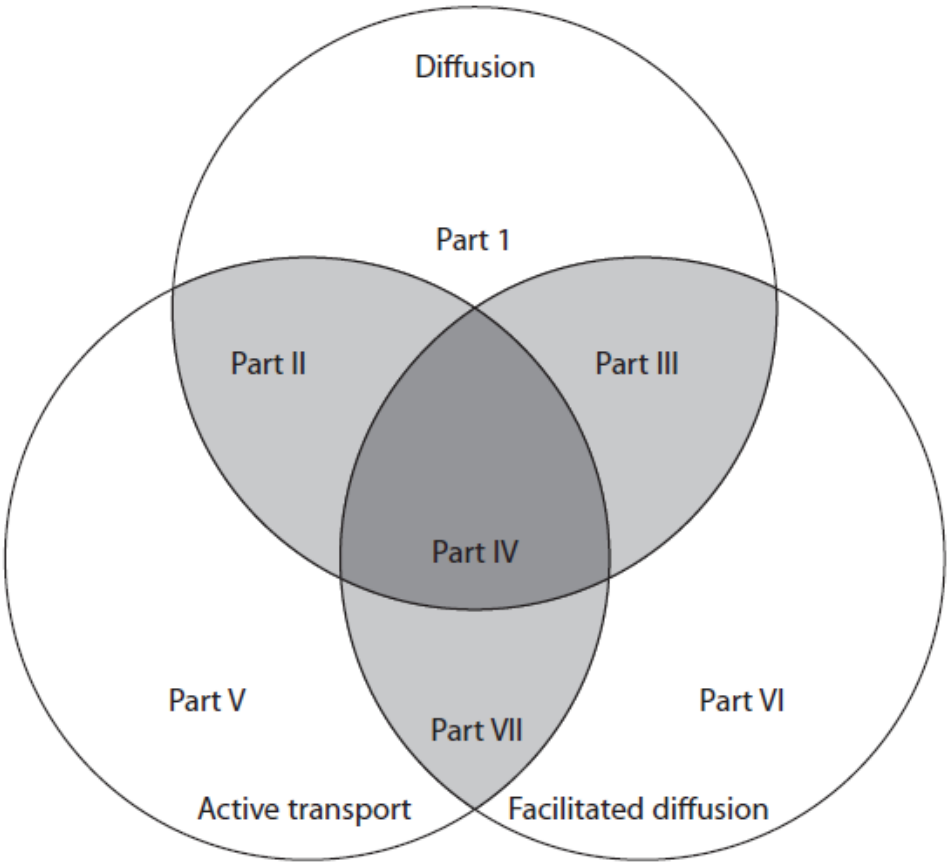
Processes by which substances can move into a cell or out of a cell include diffusion, facilitated diffusion, active transport and osmosis.

(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?

(1)

☒ **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.



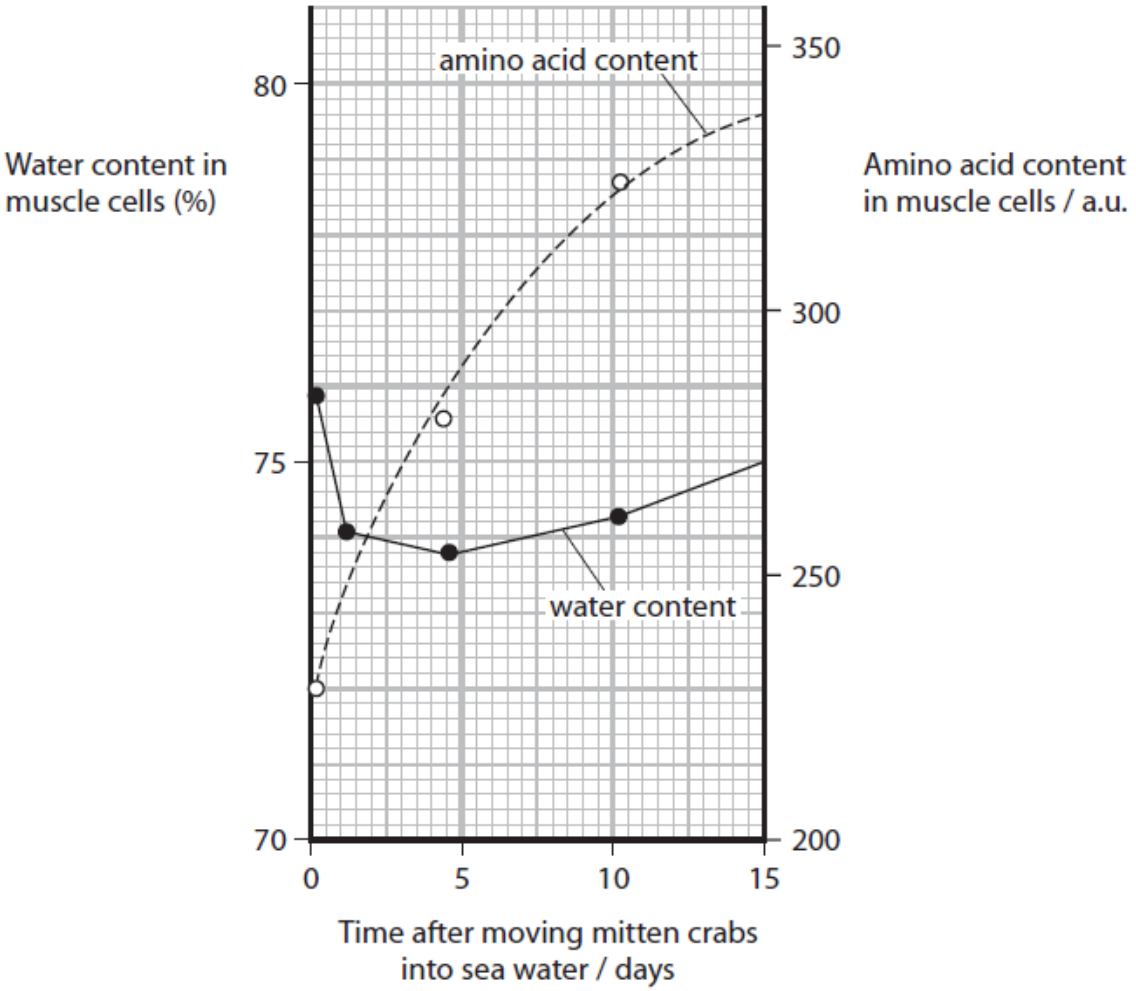
(Source: © WILDLIFE GmbH / Alamy Stock Photo)

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.

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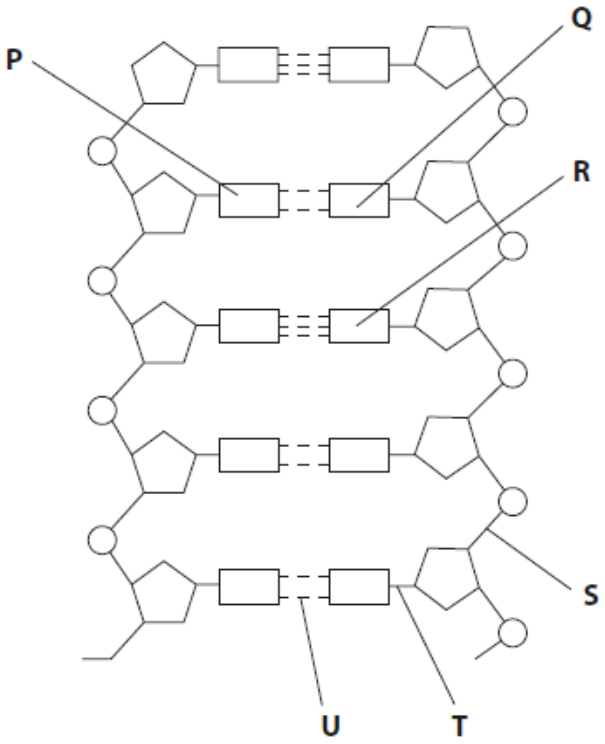
(Total for question = 12 marks)

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.

Stage 1

Bacteria grown for several generations in a culture medium containing heavy nitrogen (N^{15})

↓

Stage 2

Bacteria from stage 1 grown for one generation in a culture medium containing light nitrogen (N^{14})

↓

Stage 3

Bacteria from stage 2 grown for one generation in a culture medium containing light nitrogen (N^{14})

↓

Stage 4

Bacteria from stage 3 grown for one generation in a culture medium containing light nitrogen (N^{14})

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.

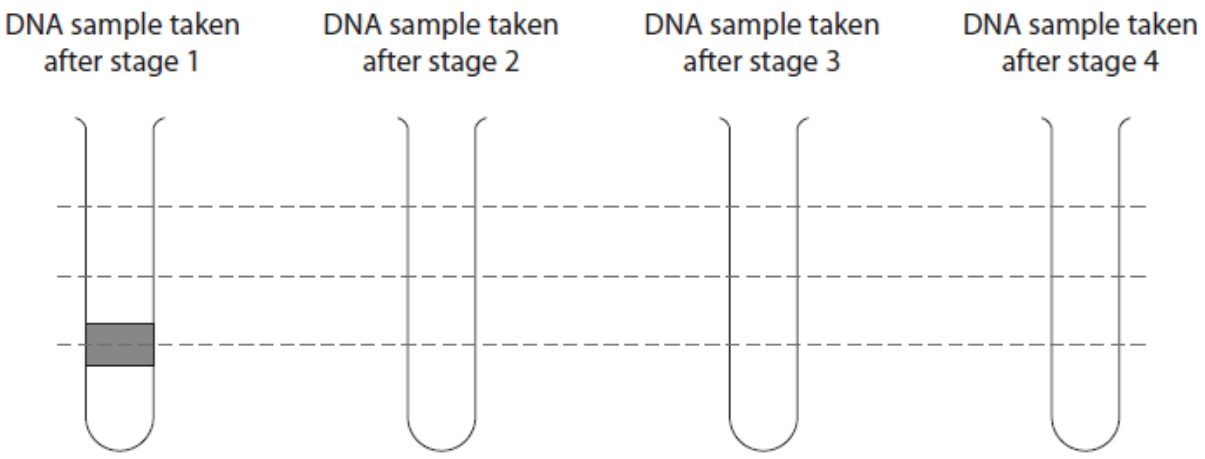
The height of each band is proportional to the percentage of DNA molecules in the sample.

(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.

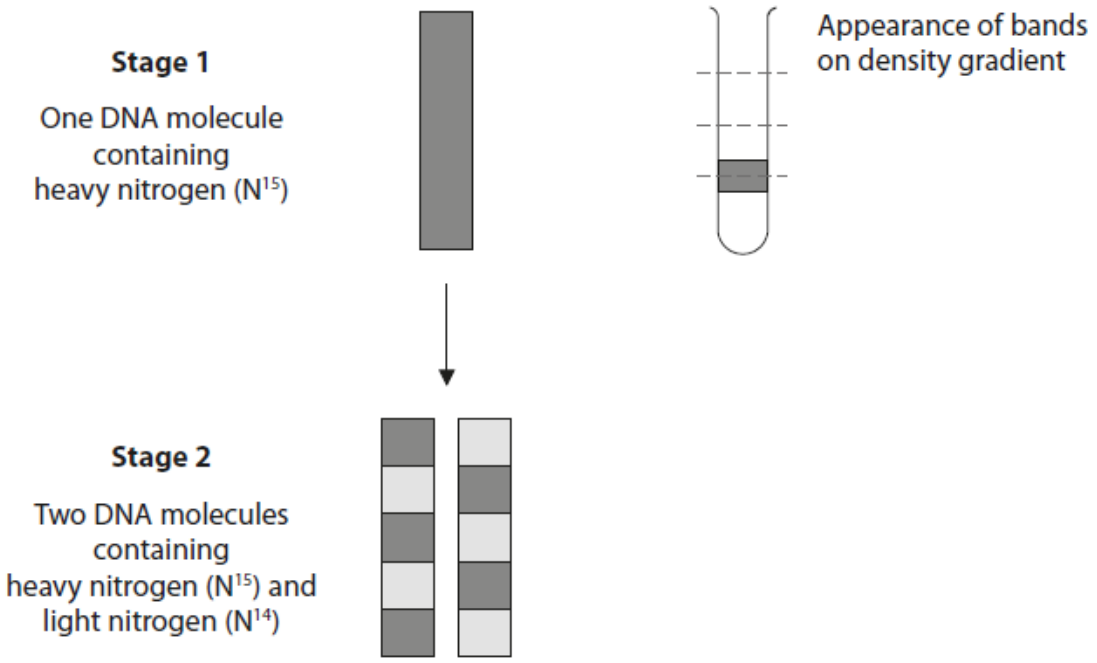
The first one has been done for you.

(5)



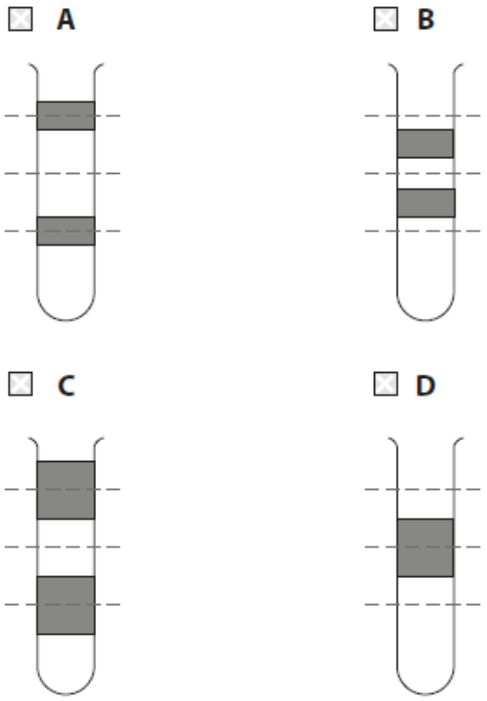
(ii) The experiments of Meselson and Stahl disproved the dispersive theory of DNA replication.

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)

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(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)

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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)

Q26.

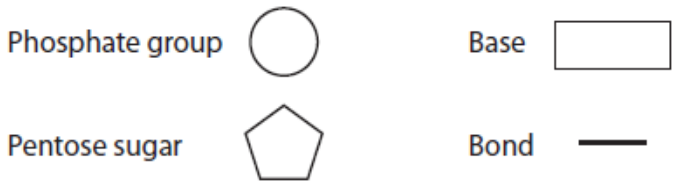
Nucleic acids include DNA and RNA.

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

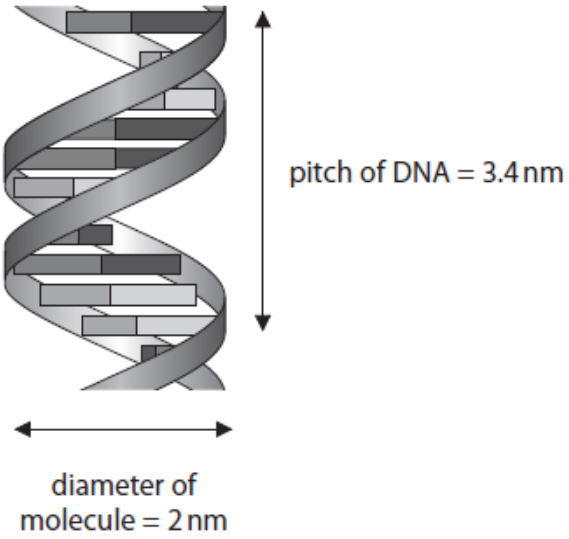
Draw a diagram to show two mononucleotides joined together in a single strand of DNA.

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.

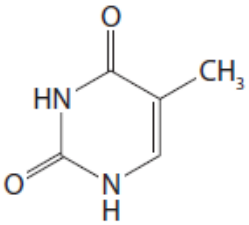
Give your answer to an appropriate number of significant figures.

(1)

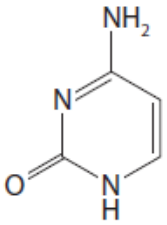
Answer ..... nm

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

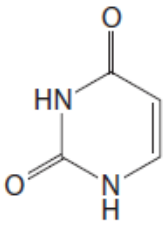
Bases **P** and **S** can form three hydrogen bonds each and bases **Q** and **R** can form two hydrogen bonds each.



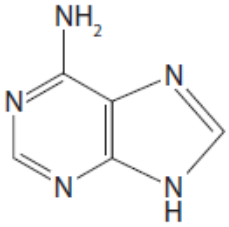
thymine



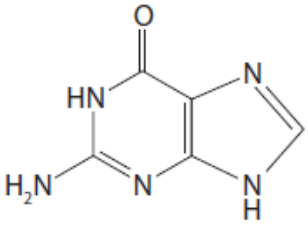
base **P**



base **Q**



base **R**



base **S**

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).

(4)

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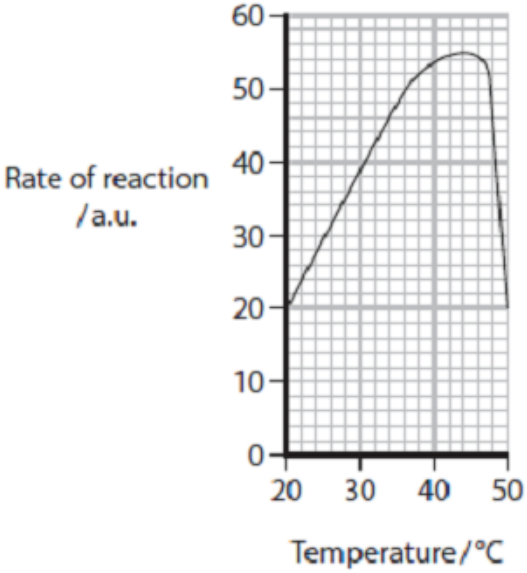
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(c) The graph shows the effect of temperature on the rate of reaction of pectinase.



(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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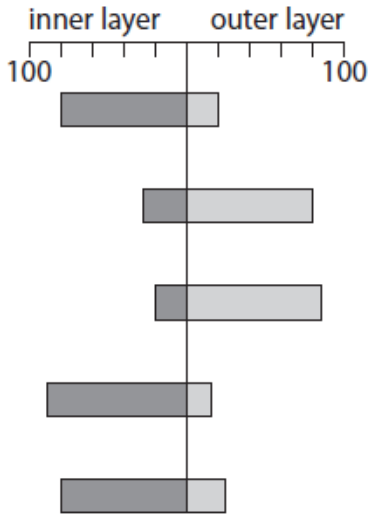
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(Total for question = 5 marks)

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 (%)
phosphatidylethanolamine	30	
phosphatidylcholine	27	
sphingomyelin	23	
phosphatidylserine	15	
other types	5	

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.

(4)

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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.

(4)

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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)

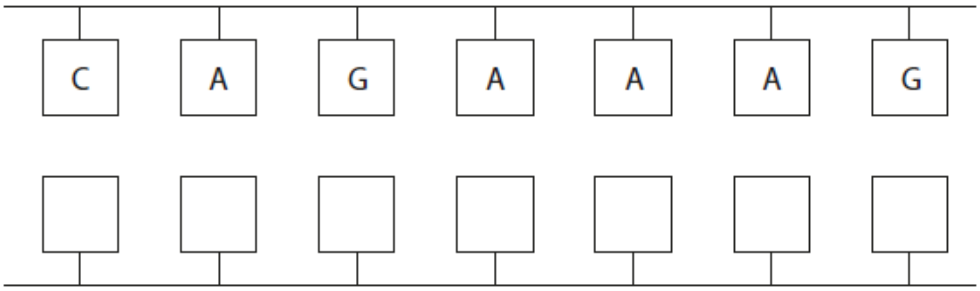
Answer .....

(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 ΔF508 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)

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.



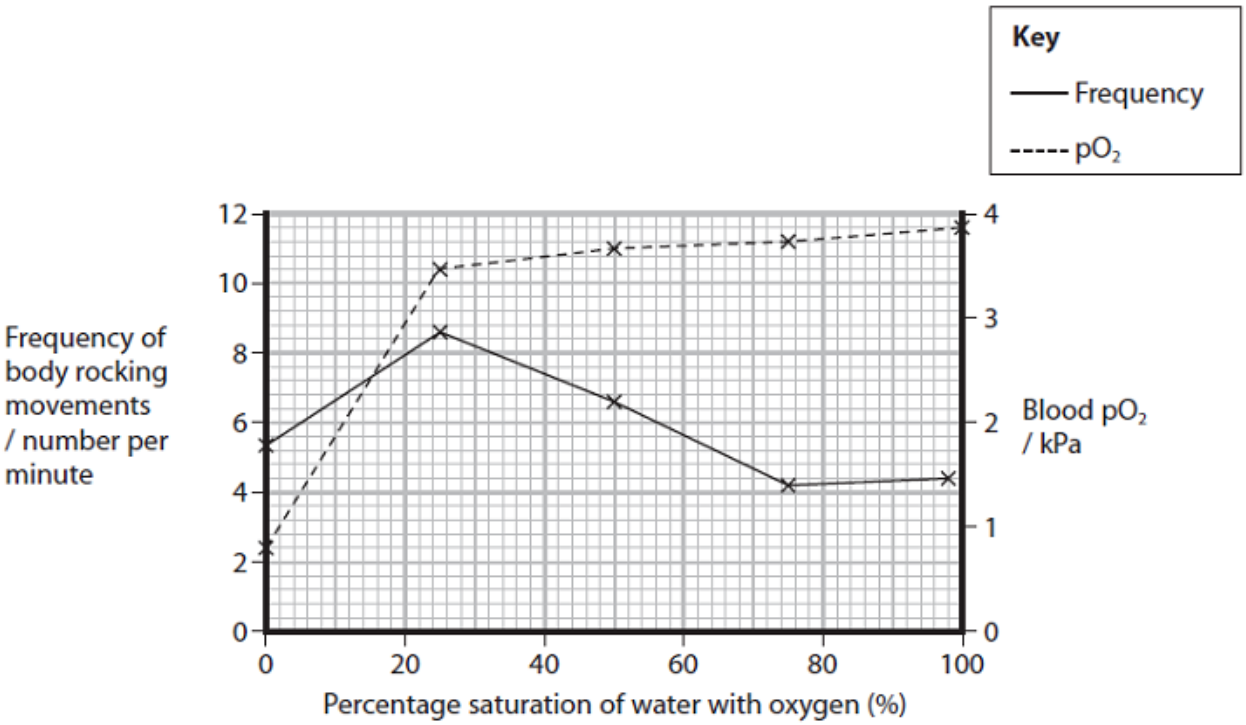
(Source: © Robert Hamilton/Alamy Stock Photo)

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.



Discuss how the structure and behaviour of these salamanders are adapted for gas exchange.

(6)

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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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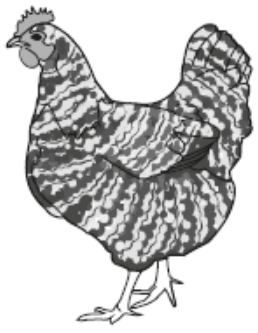
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(Total for question = 7 marks)

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.

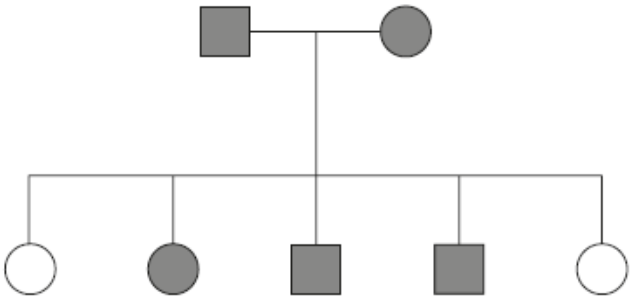
The photograph shows a white Bengal tiger with black stripes.

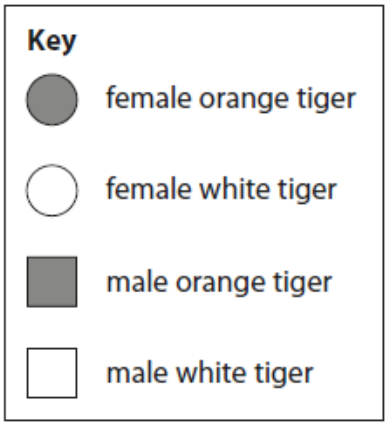


(Source: Caroline Wilcox)

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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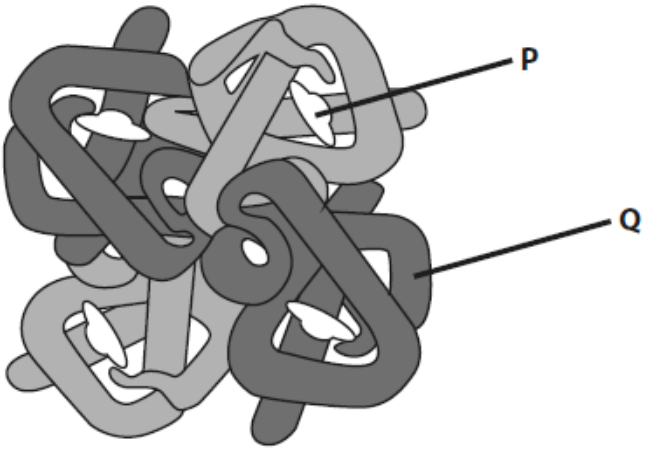
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(Total for question = 9 marks)

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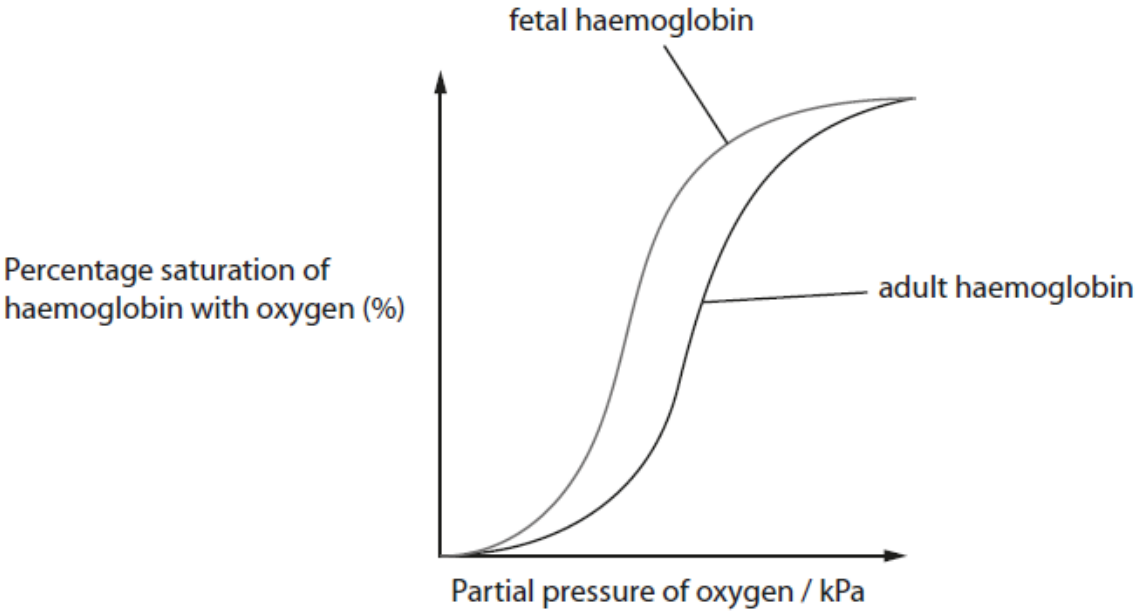
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(b) The graph shows the oxygen dissociation curves of adult and fetal haemoglobin.



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

(2)

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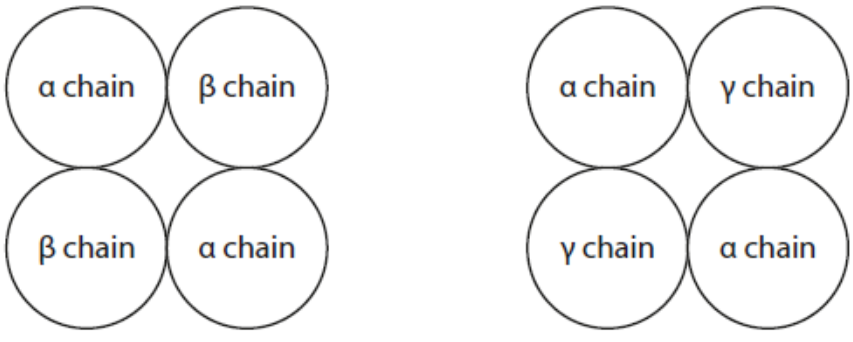
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(ii) The structures of adult and fetal haemoglobin are different.

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.

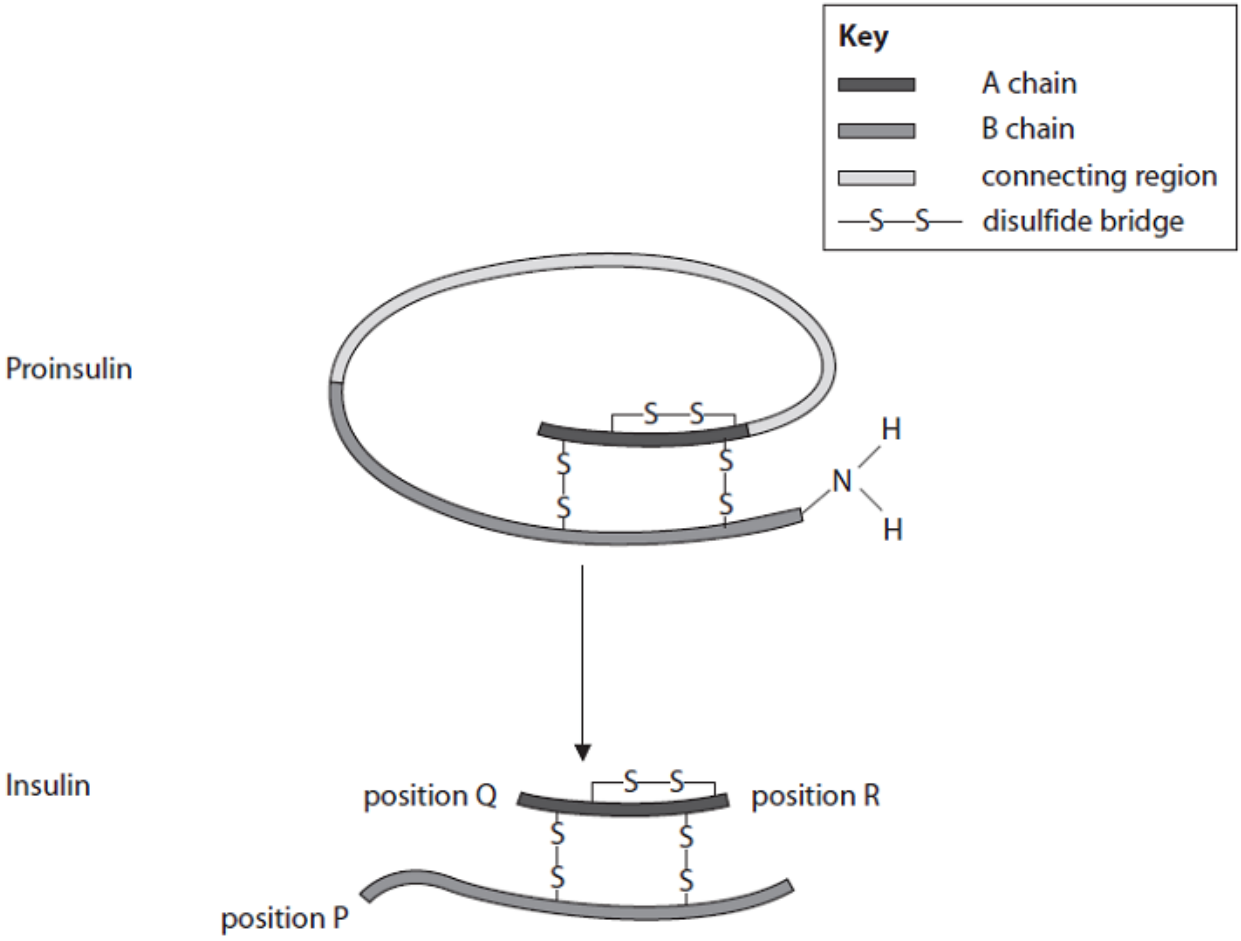
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

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 (NH_2) 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

- increase the synthesis of glycogen.

In a study using rats, the effects of a cinnamon extract on levels of glucose in the blood was determined.

In this study a group of healthy rats and a group of rats with induced diabetes were used. The rats were given either the cinnamon extract or water, each day for 30 days.

The table shows the results of this study.

Time / days	Levels of glucose in the blood in healthy rats / mg dm^{-3}		Levels of glucose in the blood in rats with induced diabetes / mg dm^{-3}	
	Rats given water	Rats given cinnamon extract	Rats given water	Rats given cinnamon extract
0	106	102	395	378
10	101	103	403	346
20	99	96	419	384
30	94	90	493	369

Explain the results of this study.

(6)

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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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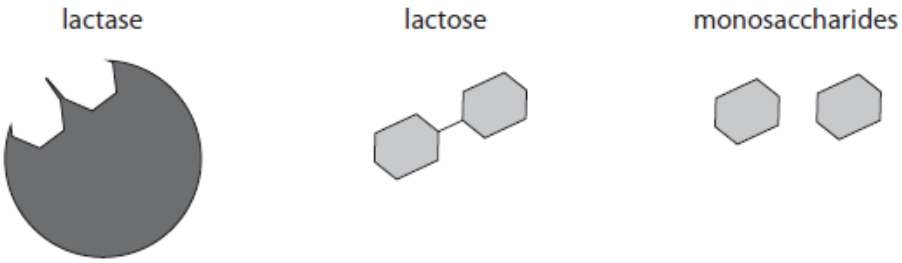
(Total for question = 10 marks)

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.

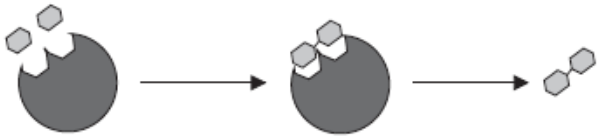


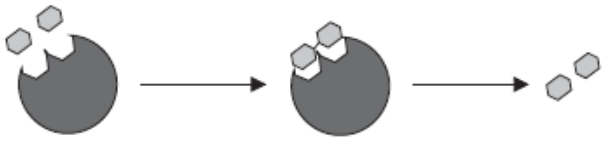
Which diagram shows the sequence of events for the hydrolysis of lactose?

(1)

☒ A 

☒ B 

☒ C 

☒ D 

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

(1)

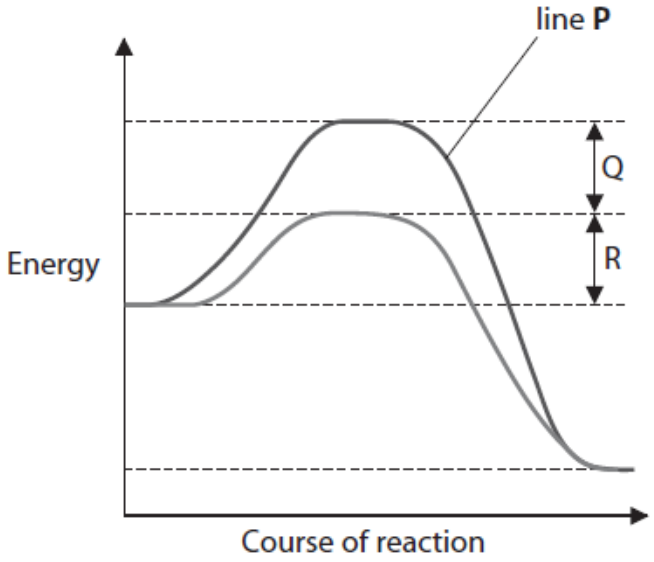
☒ **A** fructose and sucrose

☒ **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.

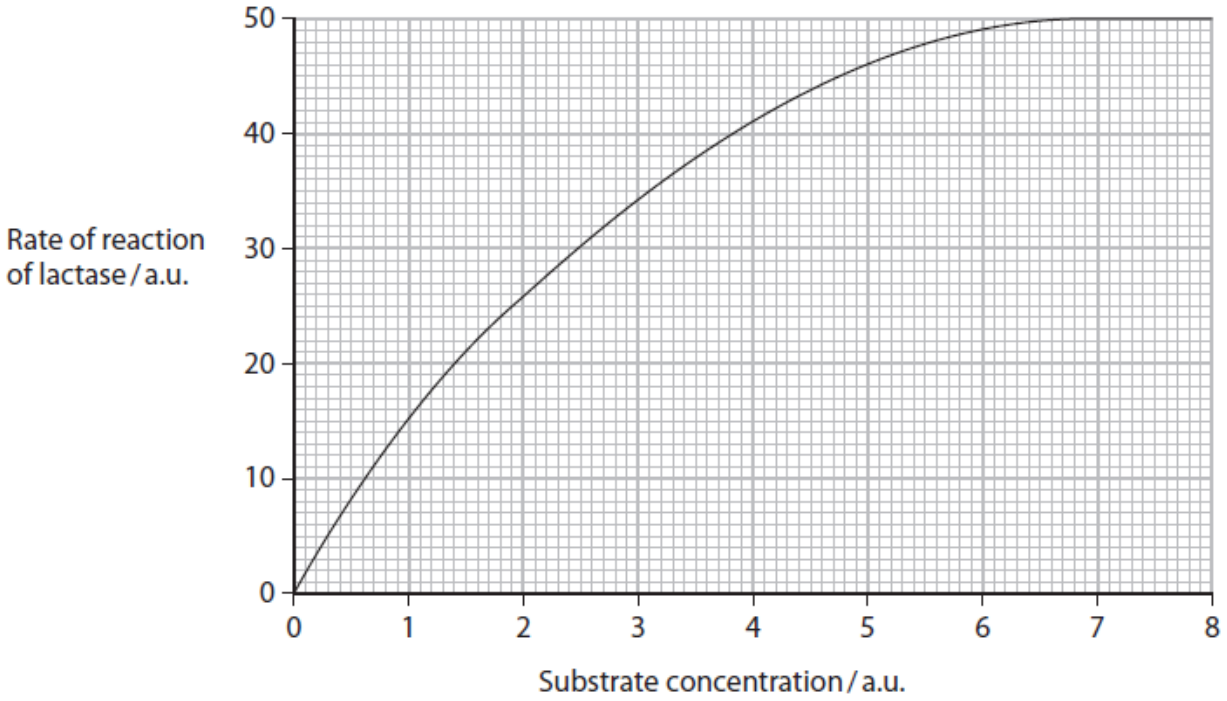


Which row in the table describes line **P** and identifies the letter that shows the decrease in activation energy due to lactase?

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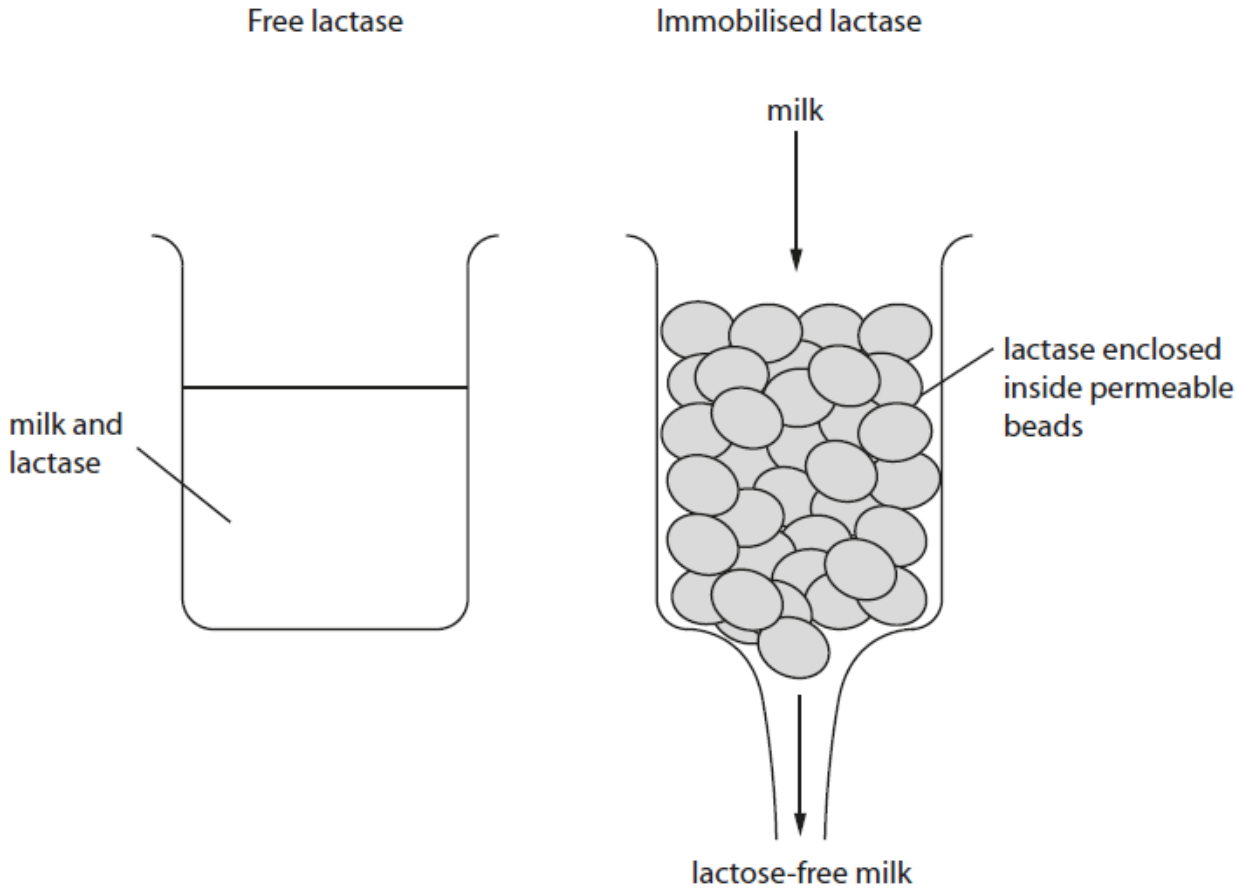
(b) People with lactose intolerance can drink lactose-free milk.

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)

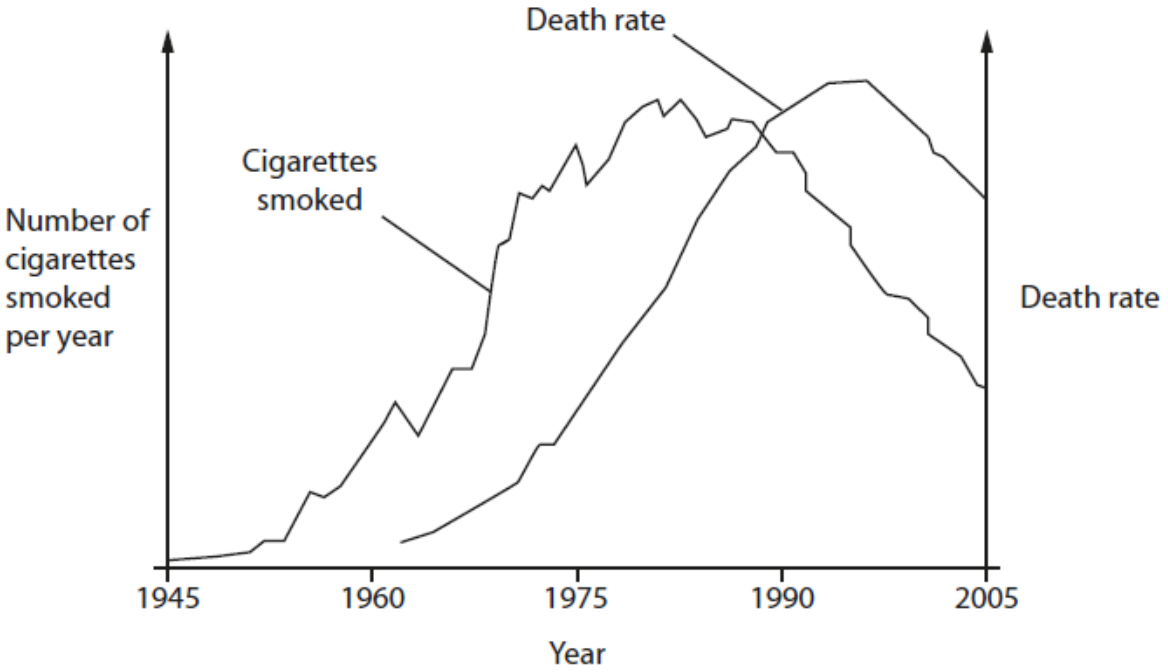
Q12.

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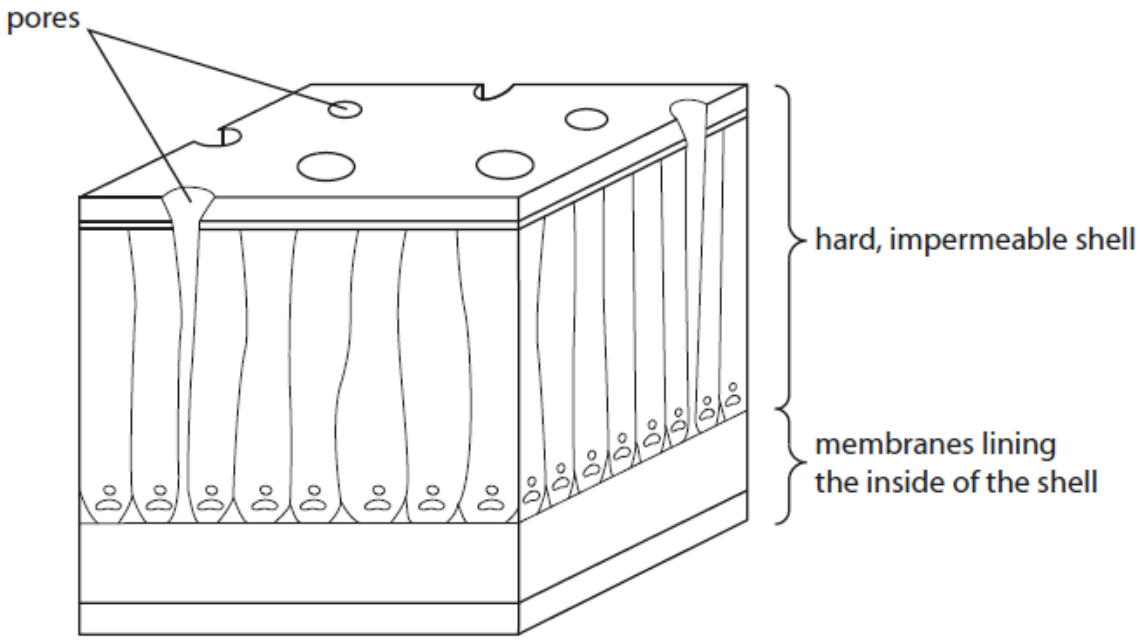
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(b) Bird embryos develop inside hard-shelled eggs.

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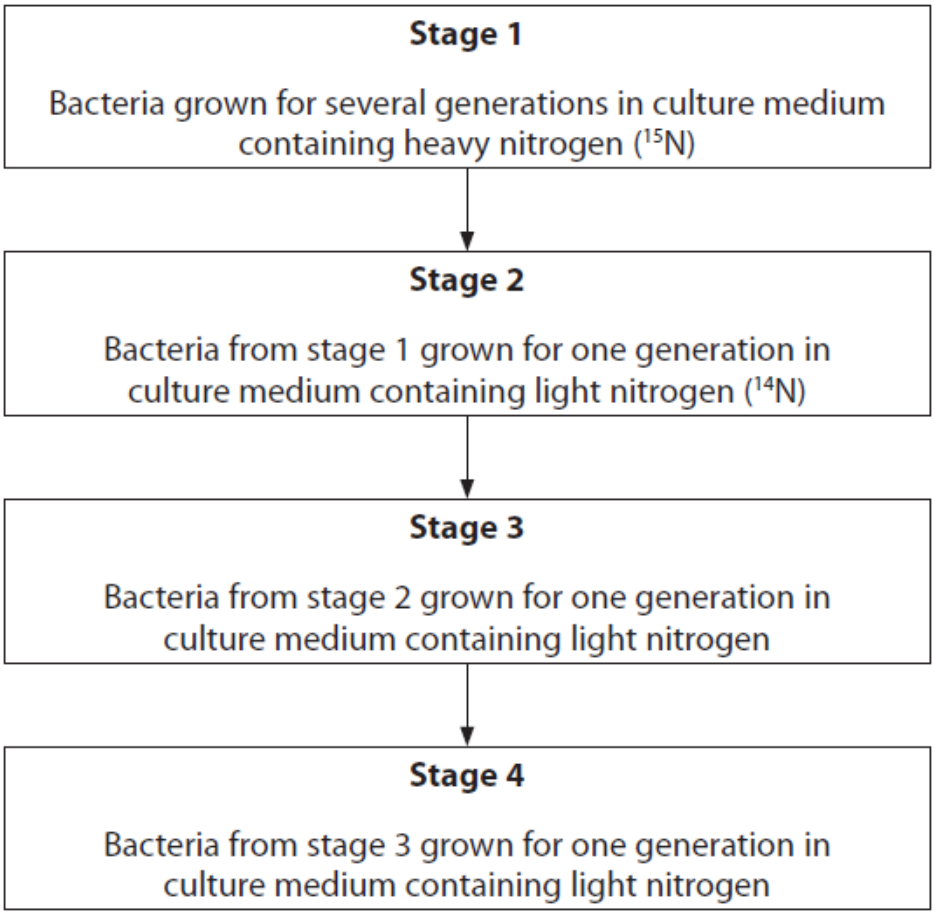
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(b) The flow chart summarises part of one experiment performed by Meselson and Stahl.



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			

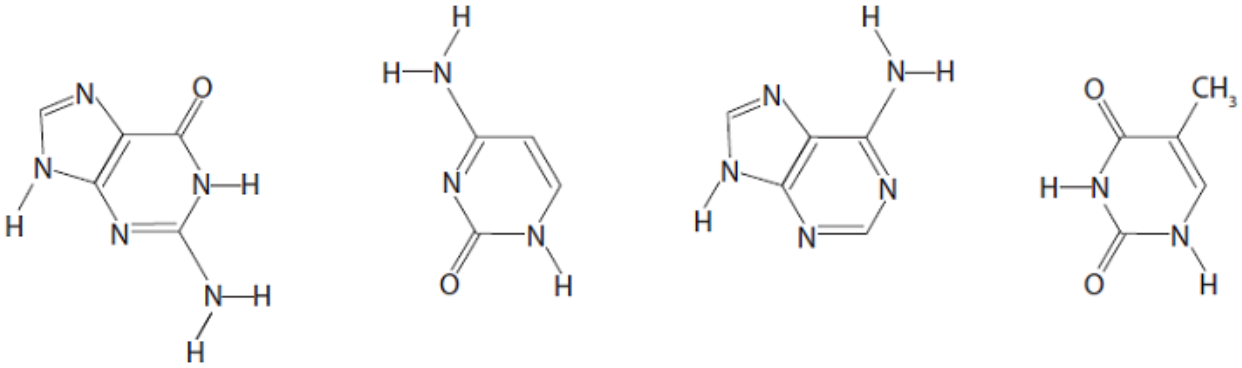
(Total for question = 8 marks)

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.



guanine cytosine adenine thymine

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.

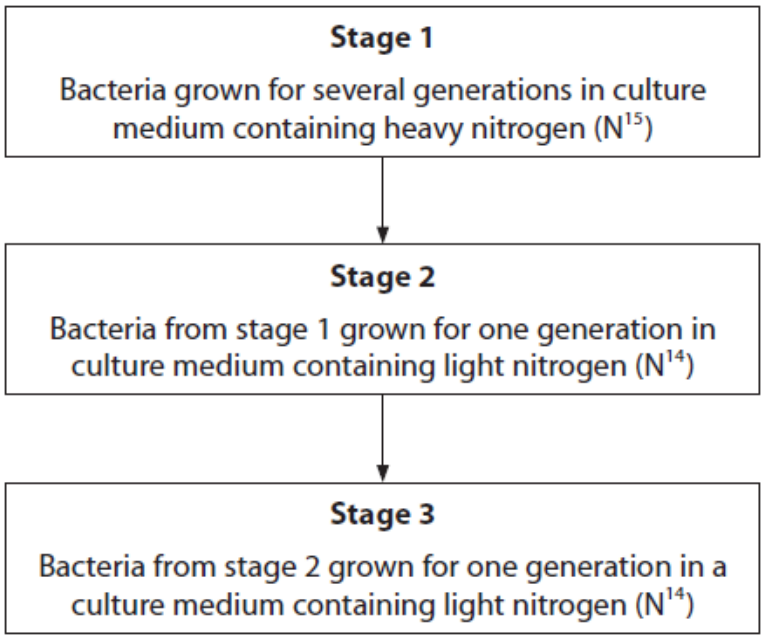
(2)

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.

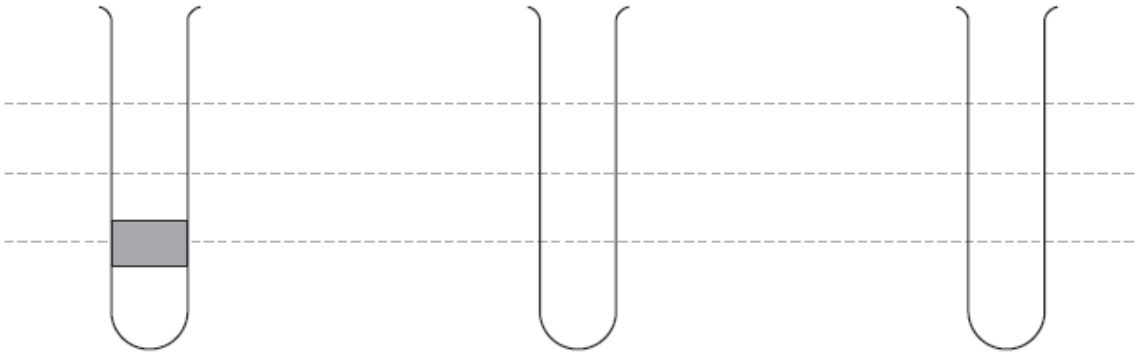
The width of each band is proportional to the percentage of molecules in the sample.

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

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

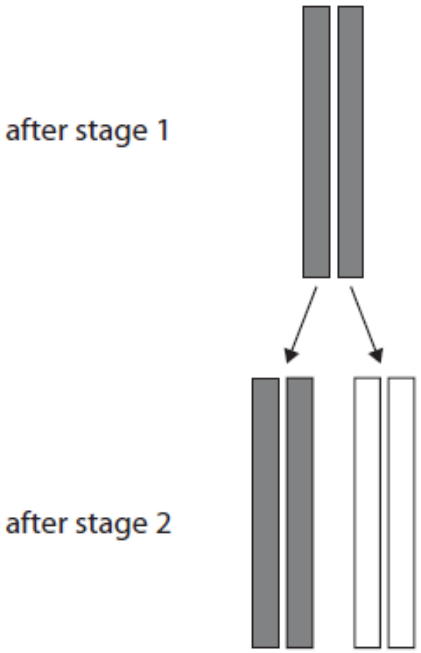
The first one has been done for you.

(3)



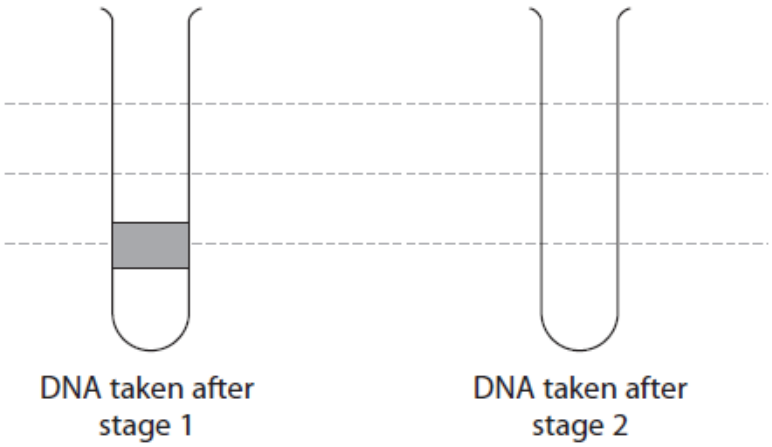
(ii) One competing theory was the conservative theory.

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



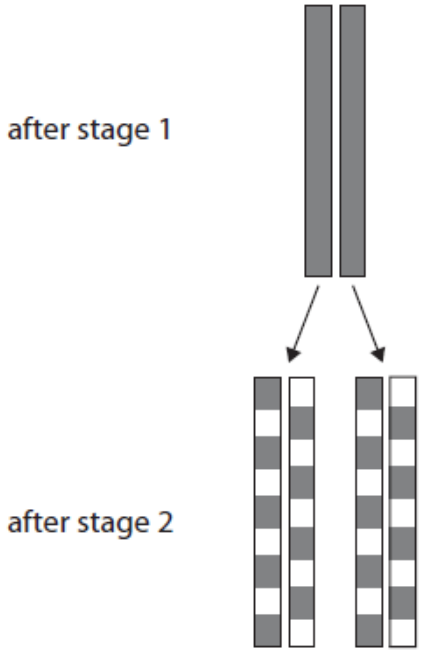
Complete the diagram to show the position of the bands on the density gradient in a tube if this was the correct theory.

(2)



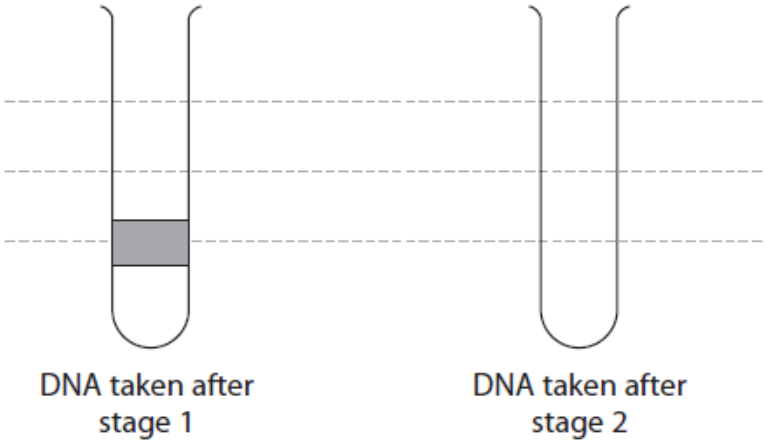
(iii) Another competing theory was the dispersive theory.

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

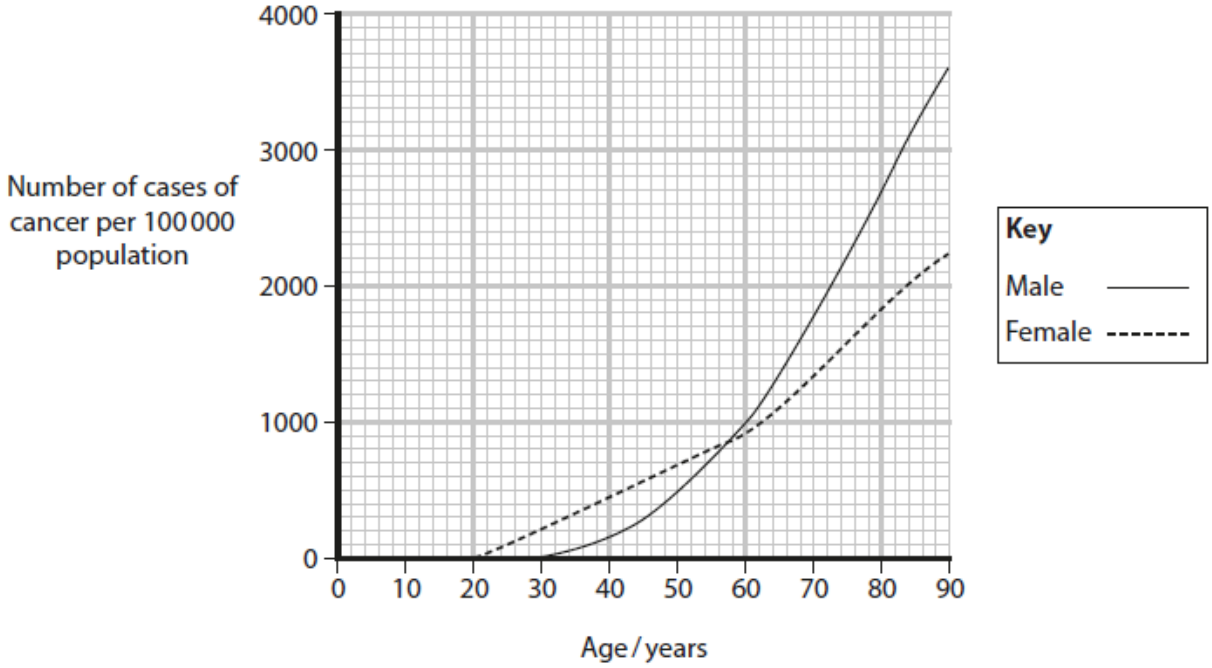
(b) Name **two** types of mutation.

(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.

(6)

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

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

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

(1)

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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.

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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.

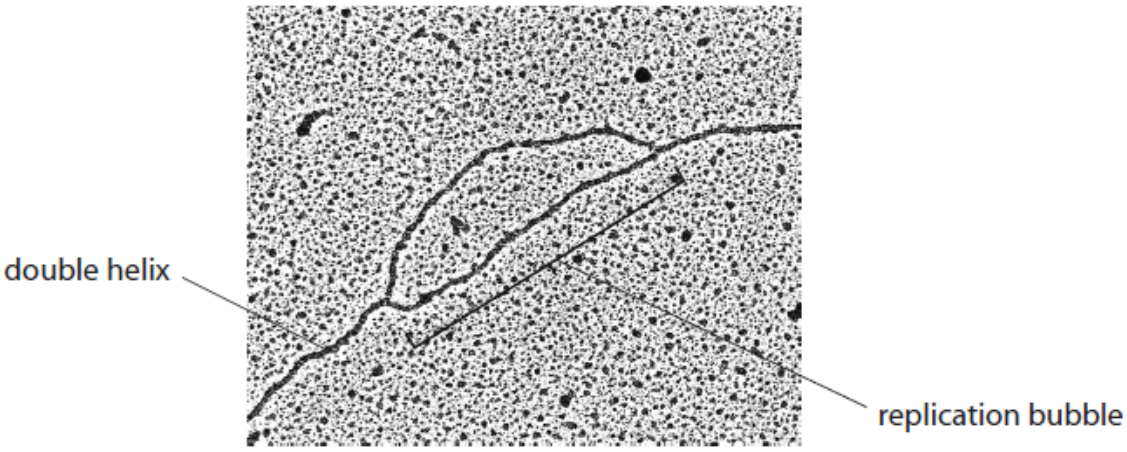
Assume that replication starts at one end of the molecule and continues to the other end.

(2)

Answer ..... hours

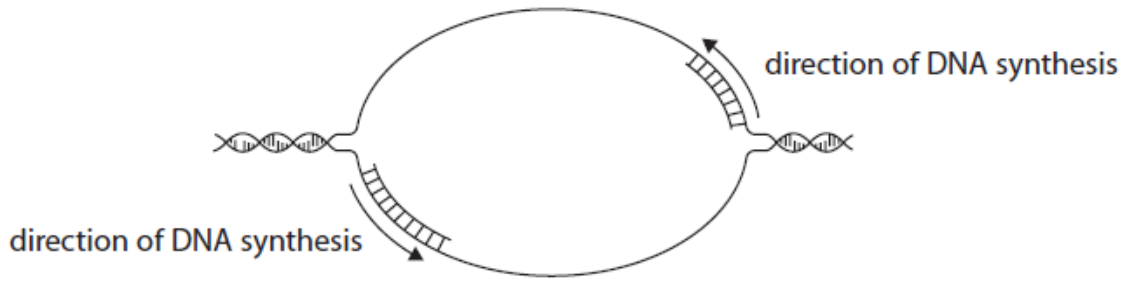
(c) In human cells, replication of DNA occurs at several sites along the molecule. These sites are called replication bubbles.

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.

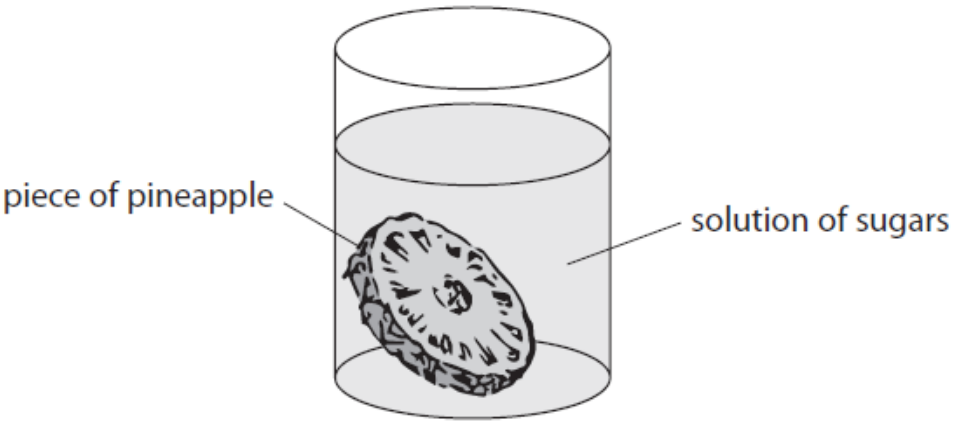
Give your answer in **g dm^{-3}**.

(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.

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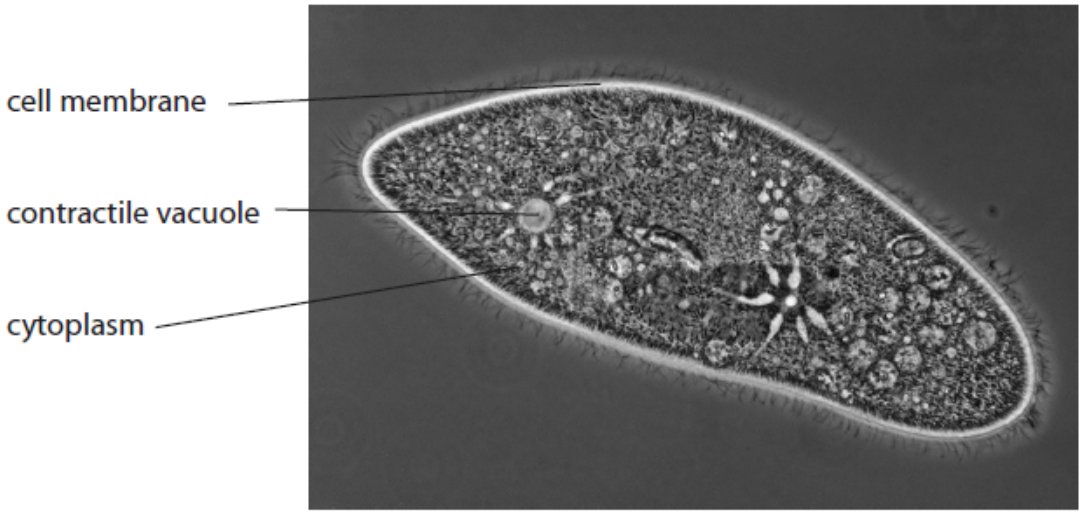
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(Total for question = 10 marks)

Q19.

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

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



magnification ×400

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

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

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

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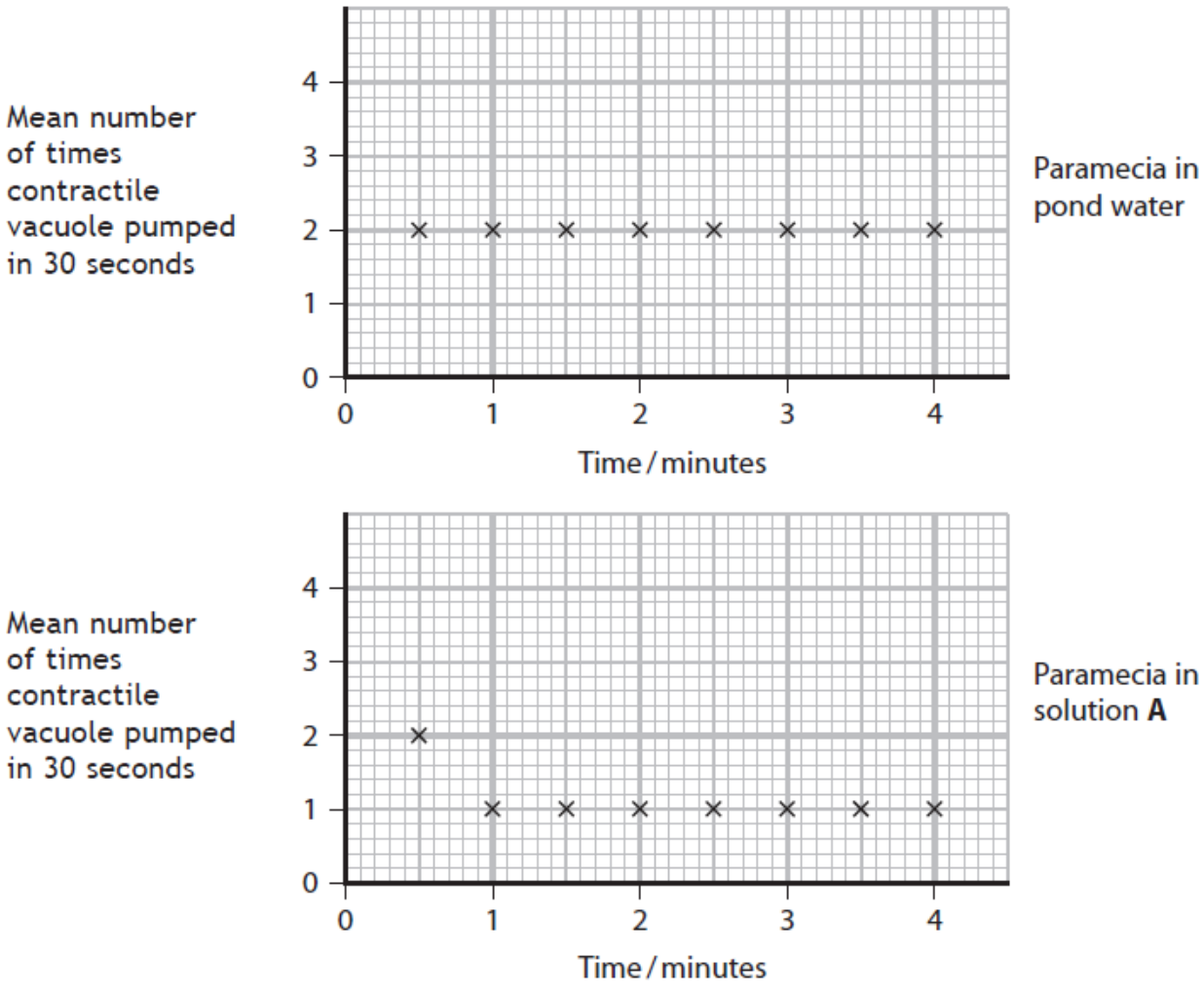
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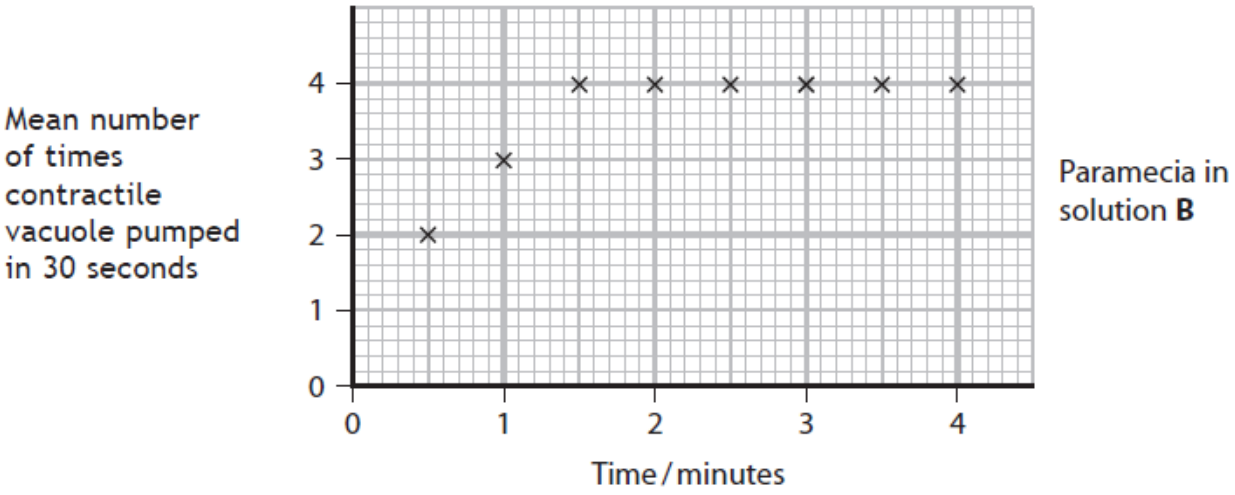
* (b) In an investigation, paramecia were placed in three separate solutions: pond water, solution **A** and solution **B**.

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.





Explain the results of this investigation.

Use the information in the graphs to support your answer.

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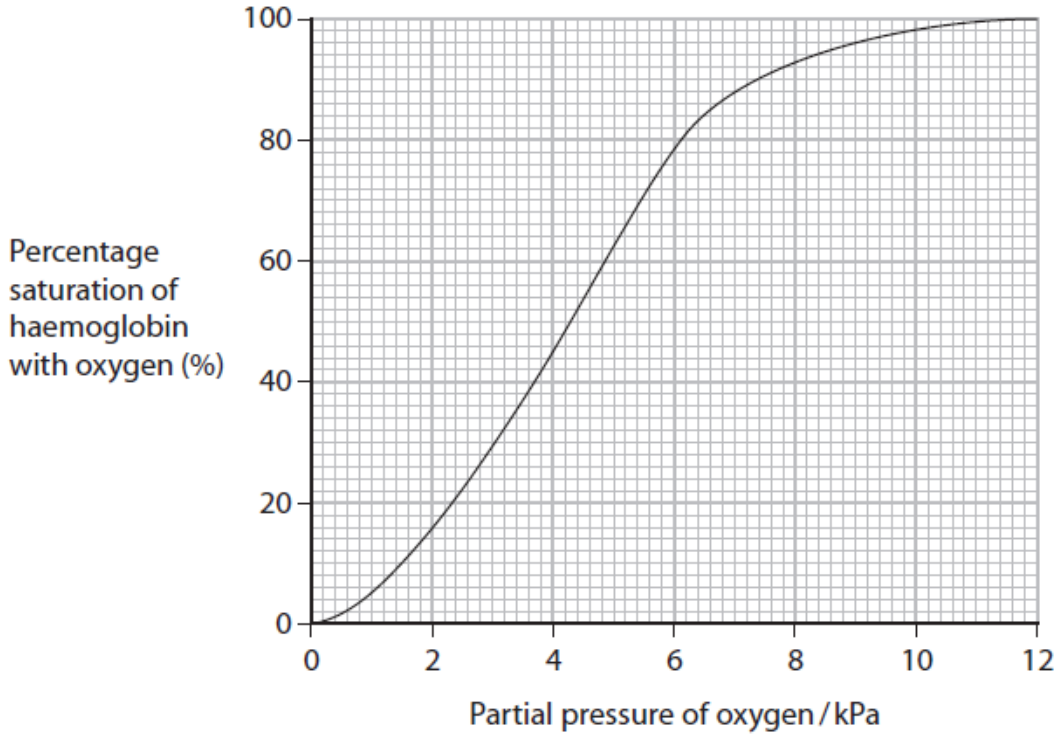
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(Total for question = 11 marks)

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)

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

(3)

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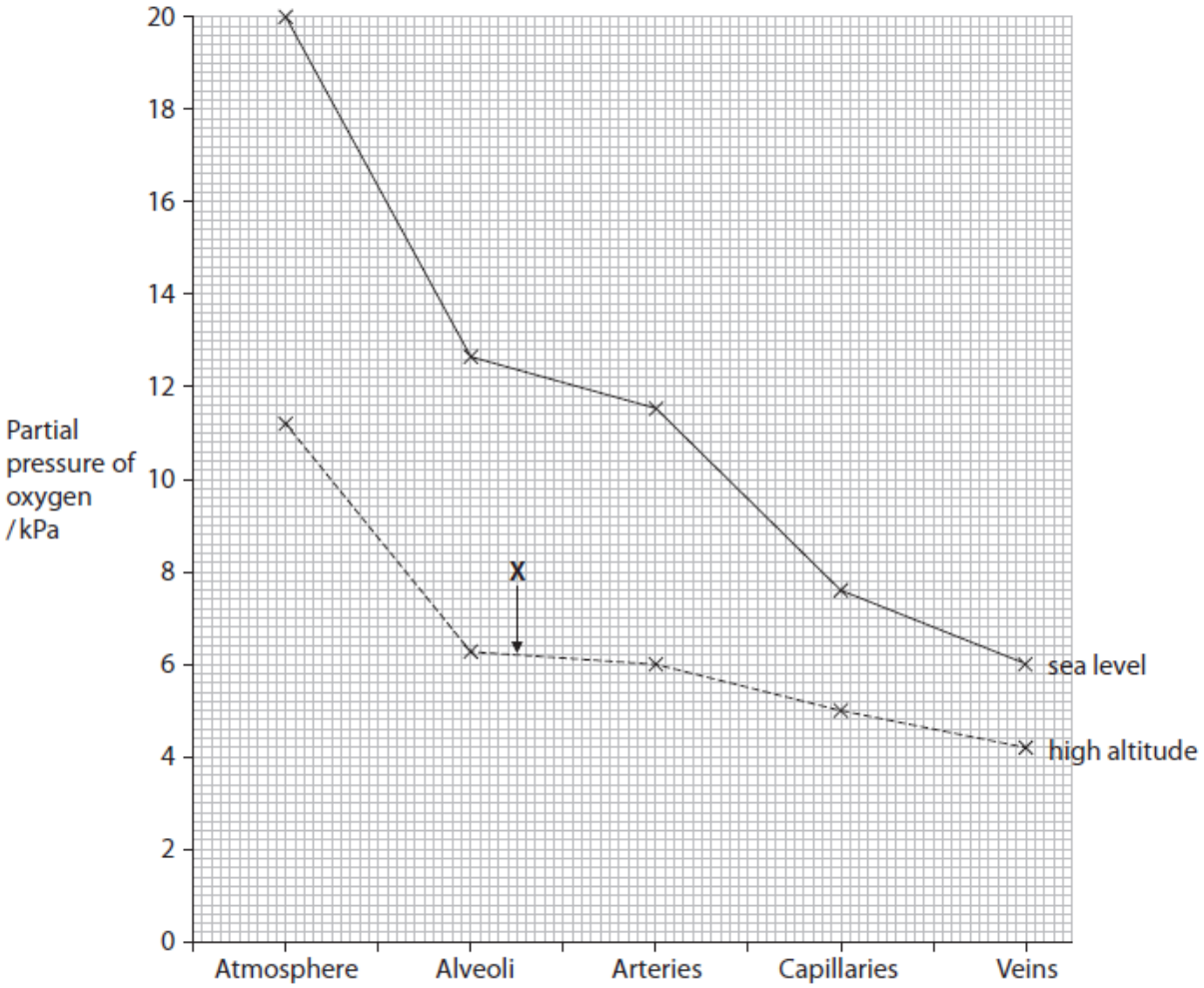
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(b) The oxygen cascade describes the differences in the partial pressure of oxygen between different blood vessels and the external atmosphere.

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)

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(ii) Explain why the partial pressure of oxygen decreases as the blood flows through the arteries and into the veins.

(3)

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(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.

(1)

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.

(4)

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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	☐	☐	☐	☐

(Total for question = 7 marks)

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)

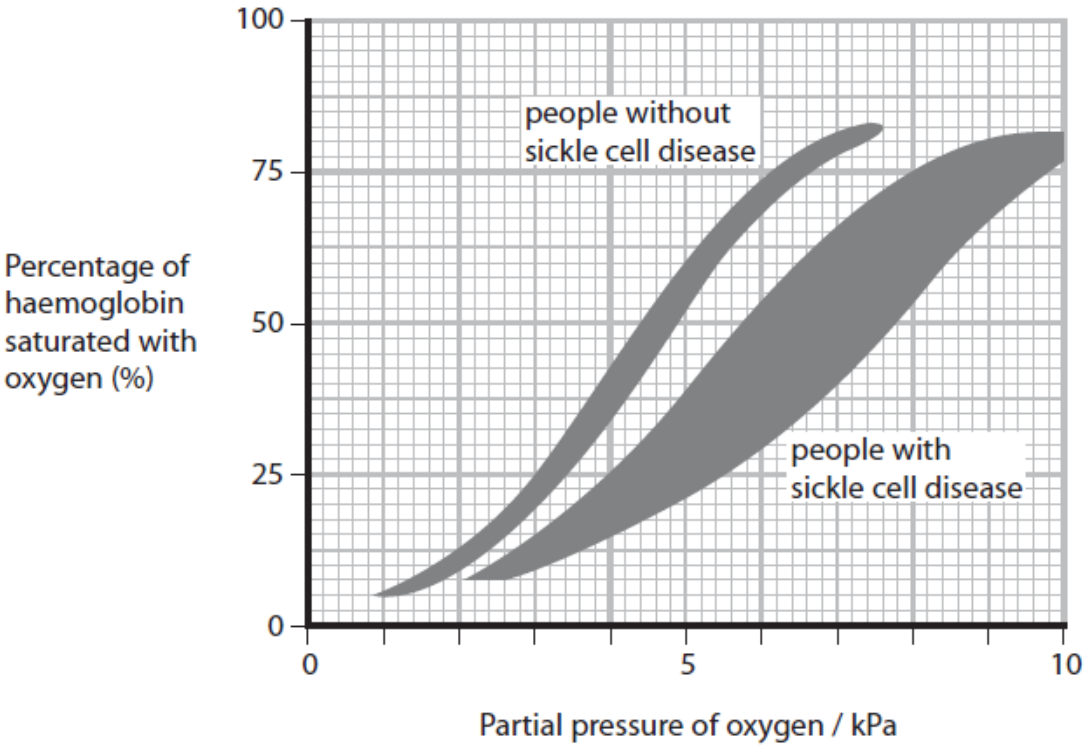
Answer .....

(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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2 .....

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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)

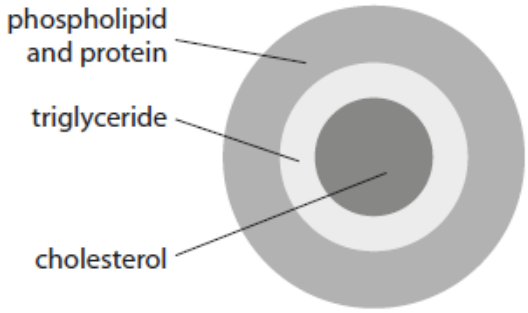
Q25.

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.

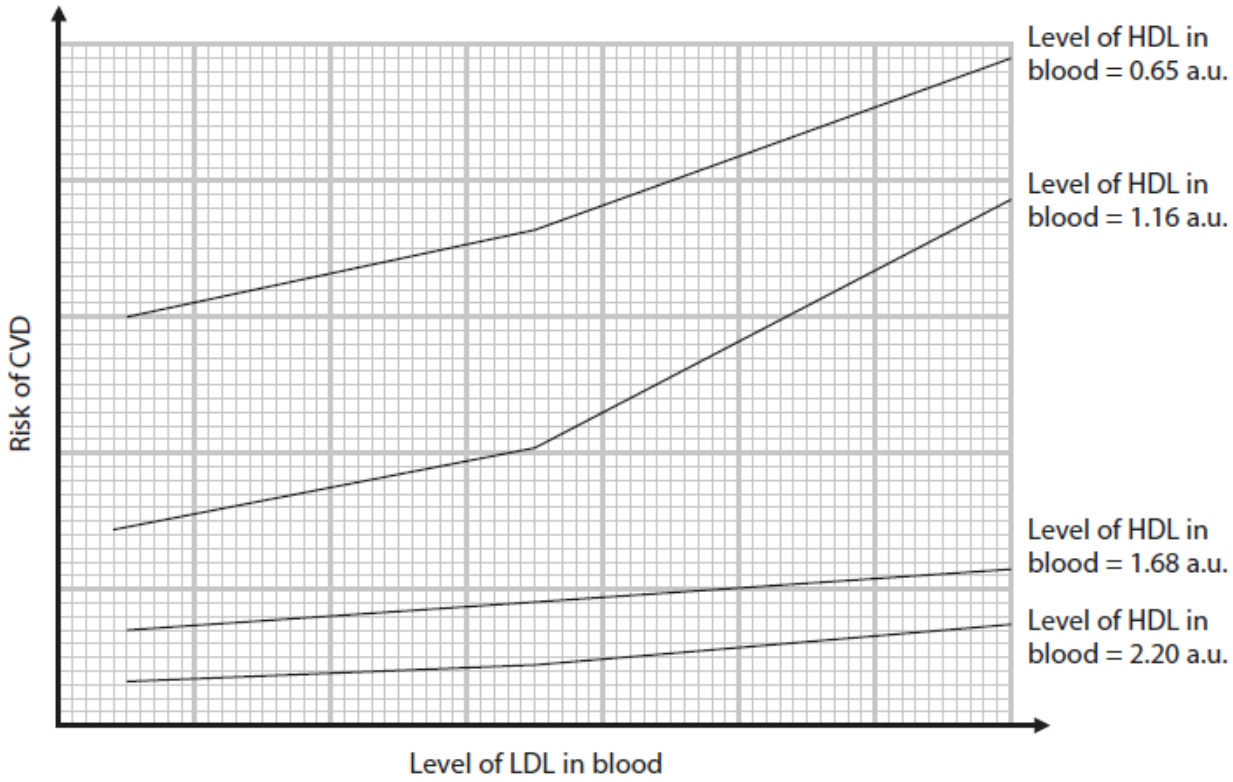
Diameter of LDL / nm	Volume of LDL / nm^3	Volume of cholesterol / nm^3	Ratio of LDL volume to cholesterol volume
19	3590	523	7:1
24		523	

(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.

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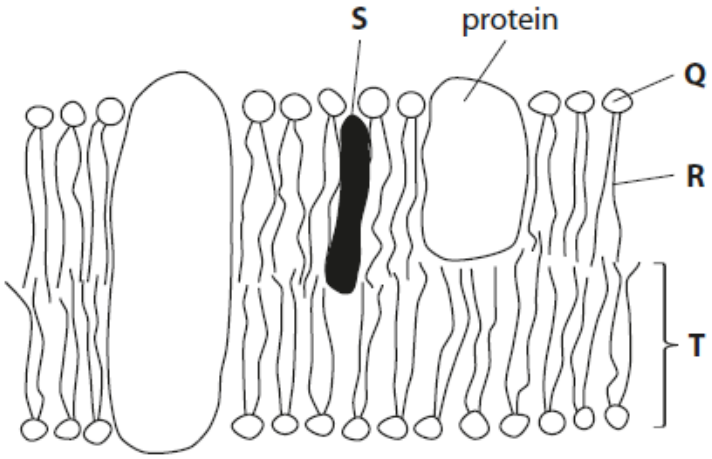
(Total for question = 15 marks)

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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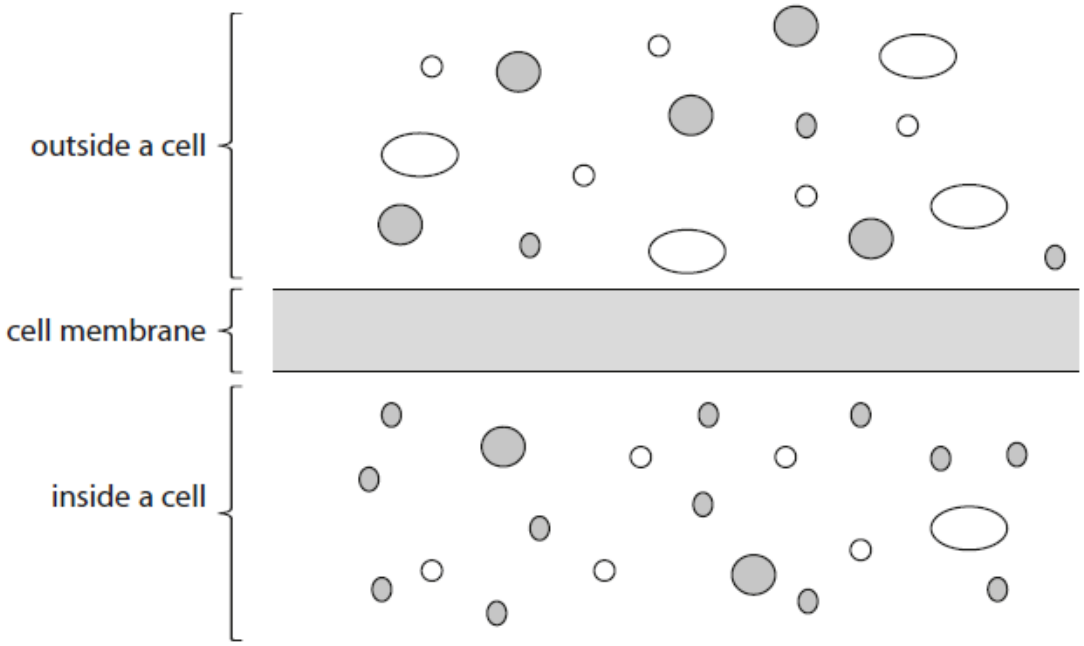
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*(c) The diagram and table give information about some molecules found inside and outside a cell.

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)

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(Total for question = 13 marks)