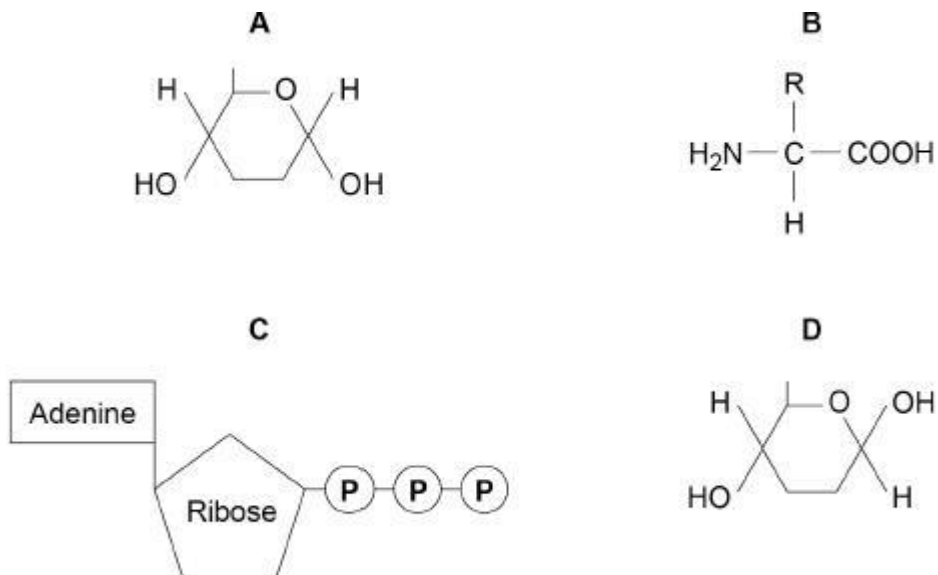


### 3.1.1 Monomers and polymers

#### Q1.

The diagram below shows the structure of molecules found in organisms.



- (a) Complete the table below by putting the correct letter, **A**, **B**, **C** or **D**, in the box next to each statement. Each letter may be used once, more than once, or not at all.

Letter	Statement
	is a monomer in an enzyme's active site
	is a monomer in cellulose
	is produced during photosynthesis and respiration
	forms a polymer that gives a positive result with a biuret test

(4)

- (b) Raffinose is a trisaccharide of three monosaccharides: galactose, glucose and fructose. The chemical formulae of these monosaccharides are:

- galactose =  $C_6H_{12}O_6$
- glucose =  $C_6H_{12}O_6$
- fructose =  $C_6H_{12}O_6$

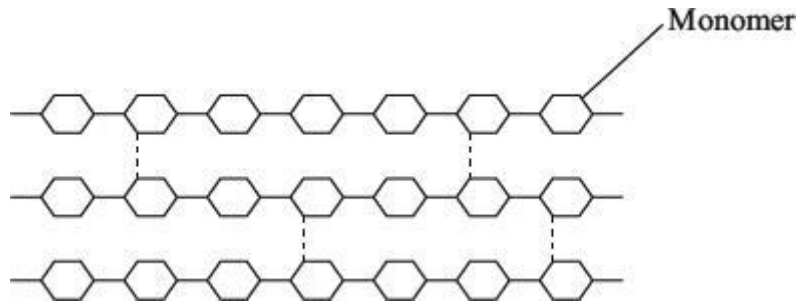
Give the number of carbon atoms, hydrogen atoms and oxygen atoms in a molecule of raffinose.

Number of carbon atoms \_\_\_\_\_

Number of hydrogen atoms \_\_\_\_\_

Number of oxygen atoms \_\_\_\_\_





(a) Name the monomer present in cellulose.

\_\_\_\_\_ (1)

(b) Name the type of reaction that converts cellulose to its monomers.

\_\_\_\_\_ (1)

(Total 2 marks)

### 3.1.2 Carbohydrates

#### Q1.

(a) What term is used to describe the different structures of  $\alpha$ -glucose and  $\beta$ -glucose?

\_\_\_\_\_ (1)

(b) A student investigated the difference in the reducing sugar content of two fruit juices. He performed a biochemical test on each fruit juice using Benedict's solution. He then used a colorimeter with each test result.

Describe how the results from the colorimeter can identify the fruit juice containing the higher sugar content.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ (1)

(c) The student controlled variables in the test using Benedict's solution.

Give **two** variables the student controlled.

1 \_\_\_\_\_  
 2 \_\_\_\_\_ (2)

(d) Apples consist of flesh tissue which surrounds core tissue where the seeds are located.

A student has an apple with a mass of 180 g  
The ratio of flesh tissue to core tissue in this apple is 5:1  
8% of the whole apple is sugar.

Calculate the mass of sugar in the flesh tissue.

Show your working.

Answer \_\_\_\_\_ g

(2)

- (e) Iodine solution stains fresh apple tissue black. When iodine solution is added to apples stored for a week, the stain is less black.

The water potential of apple juice decreases when apples are stored.

Suggest why the water potential of apple juice decreases when apples are stored.

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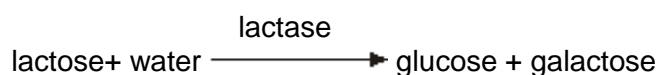
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(2)

(Total 8 marks)

## Q2.

Lactose is a disaccharide sugar which can be broken down by the enzyme lactase into two monosaccharides, glucose and galactose.



- (a) The formula for galactose is  $\text{C}_6\text{H}_{12}\text{O}_6$ . What is the formula for lactose?

---

(2)

- (b) A solution containing the enzyme lactase was added to a lactose solution. The solution was incubated at 40 °C for one hour. Sample **A** was removed from the tube before incubation. Sample **B** was removed after one hour.

- (i) Describe a chemical test you could carry out on sample **A** to show that lactose is a reducing sugar.

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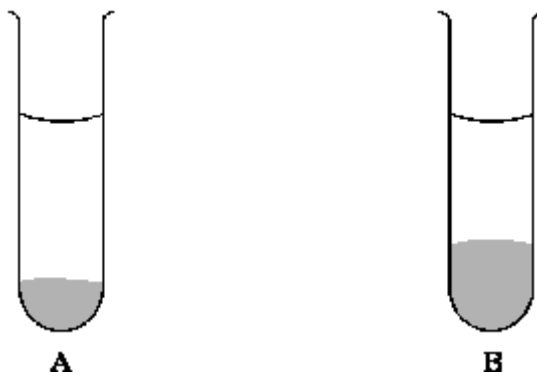
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(2)

- (ii) This chemical test was carried out on samples **A** and **B**. All experimental variables were the same in the testing of the two samples. Both tubes were left for ten minutes to allow the precipitate to settle. The diagram shows the result.



Is galactose a reducing sugar? \_\_\_\_\_

Explain how the results in the diagram support your answer.

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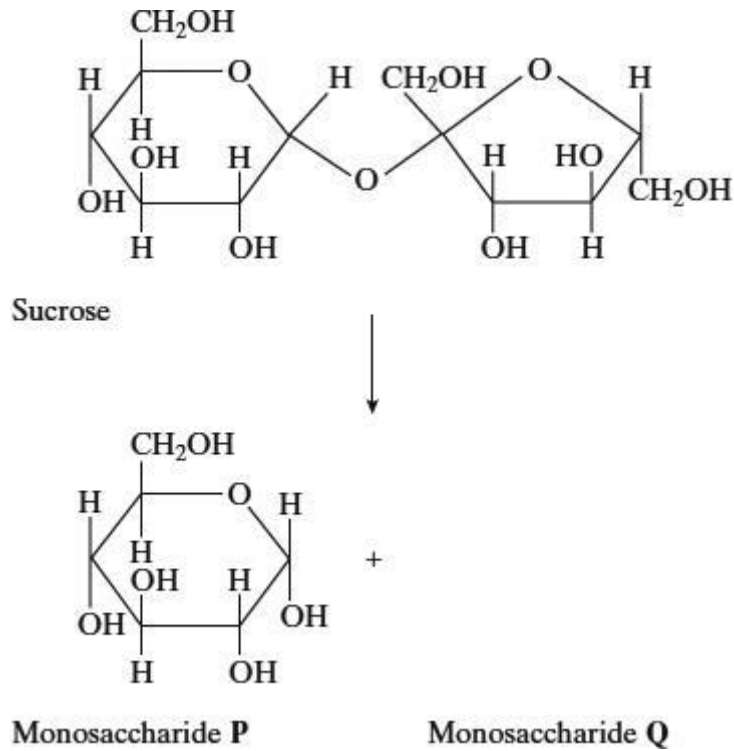
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(2)

(Total 6 marks)

**Q3.**

Sucrose is a disaccharide. It is formed from two monosaccharides **P** and **Q**. The diagram shows the structure of molecules of sucrose and monosaccharide **P**.



- (a) (i) Name monosaccharide **Q**.

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(1)

- (ii) Draw the structure of a molecule of monosaccharide **Q** in the space above.

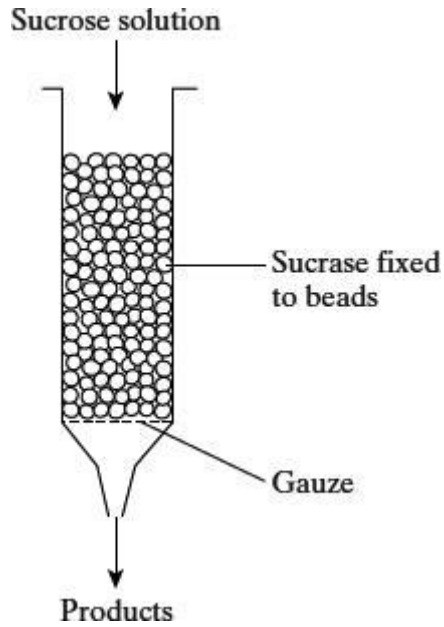
(1)

- (b) The enzyme sucrase catalyses the breakdown of sucrose into monosaccharides. What type of reaction is this breakdown?

---

(1)

- (c) The diagram shows apparatus used in breaking down sucrose. The enzyme sucrase is fixed to inert beads. Sucrose solution is then passed through the column.



Describe a biochemical test to find out if the solution collected from the apparatus contains

(i) the products;

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(2)

(ii) the enzyme.

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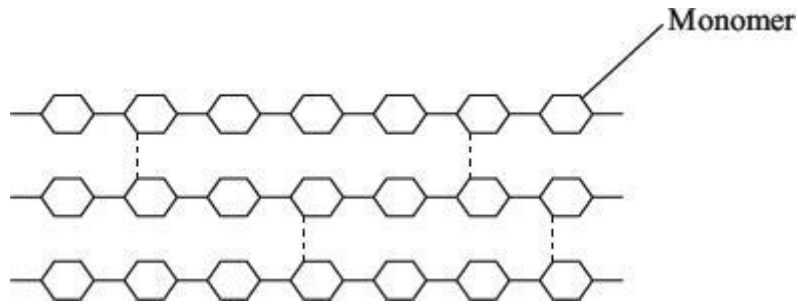
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(2)

(Total 7 marks)

**Q4.**

Cellulose is made from one type of monomer. The monomers are held together by bonds. The diagram shows parts of three cellulose molecules in a cell wall.



(a) Name the monomer present in cellulose.

\_\_\_\_\_ (1)

(b) Name the type of reaction that converts cellulose to its monomers.

\_\_\_\_\_ (1)

(c) Cotton is a plant fibre used to make cloth. Explain how cellulose gives cotton its strength.

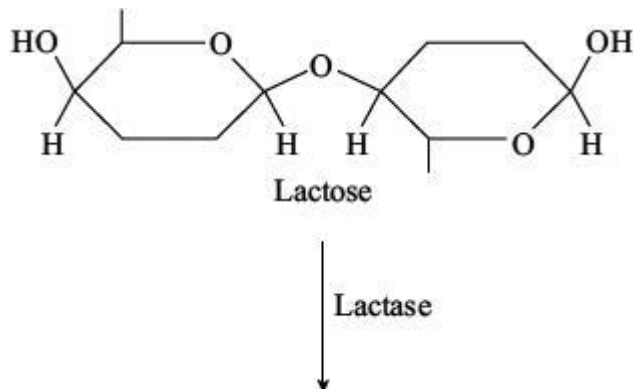
\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

(3)  
 (Total 5 marks)

**Q5.**

Lactose is a disaccharide found in milk. In the human small intestine, the enzyme lactase catalyses the hydrolysis of lactose to the monosaccharides, galactose and glucose. These monosaccharides are then absorbed into the blood.

Complete the diagram to show the hydrolysis of lactose to galactose and glucose.



(Total 2 marks)

### 3.1.4.1 General properties of proteins

#### Q1.

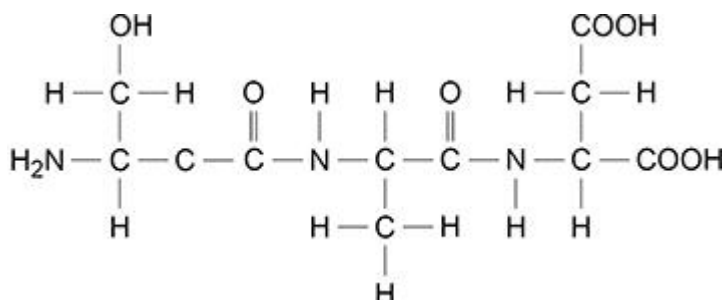
Amino acids are used to make proteins. **Table 1** shows the R groups of six different amino acids.

**Table 1**

Amino acid	R group	Amino acid	R group
Alanine	CH <sub>3</sub>	Glutamic acid	CH <sub>2</sub> CH <sub>2</sub> COOH
Asparagine	CH <sub>2</sub> CONH <sub>2</sub>	Glycine	H
Aspartic acid	CH <sub>2</sub> COOH	Serine	CH <sub>2</sub> OH

- (a) Use **Table 1** to identify the **three** different amino acids used to make the polypeptide shown in **Figure 1**.

**Figure 1**



Left amino acid \_\_\_\_\_

Middle amino acid \_\_\_\_\_

Right amino acid \_\_\_\_\_

(2)

- (b) **Table 2** shows three statements and names of four biological molecules.

Put a Tick (✓) in each box where the statement is true for the biological molecule.

**Table 2**

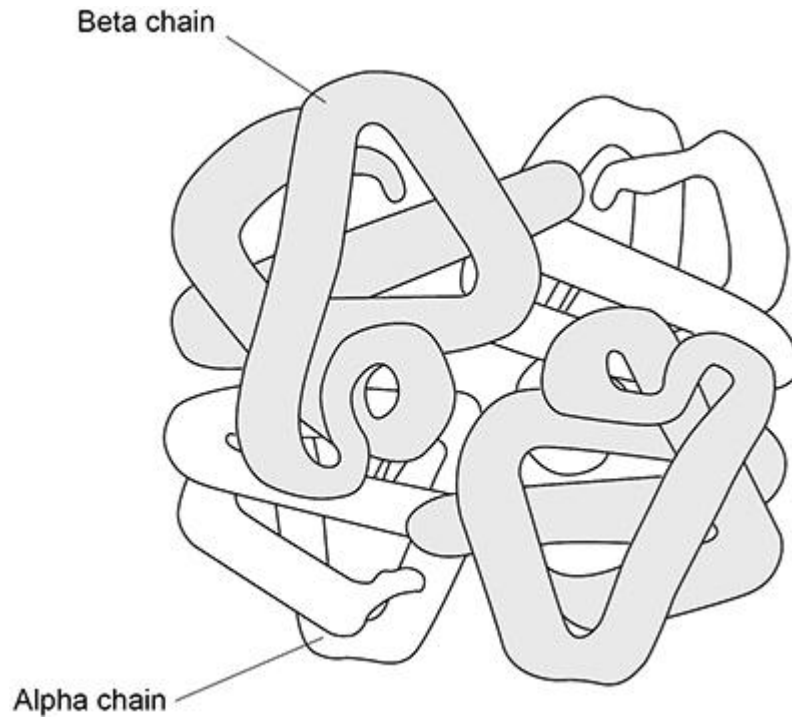
Statement	DNA	ATP	Reverse transcriptase	Phospholipid
Contains peptide bonds				

Is formed using a condensation reaction				
Is a polymer				

(3)

Figure 2 represents the structure of adult human haemoglobin.

Figure 2



- (c) The number of amino acids in the beta chains in **Figure 2** is 3.546% greater than in the alpha chains. Each alpha chain contains 141 amino acids.

Calculate how many amino acids there are in total in the haemoglobin molecule shown in **Figure 2**. Give your answer to the nearest whole number.

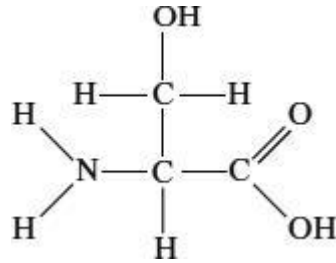
Answer \_\_\_\_\_ amino acids

(2)

(Total 7 marks)

**Q2.**

The diagram shows the structure of the amino acid serine.



- (a) (i) Draw a box on the diagram around the R group of serine and label the box with the letter **R**. (1)
- (ii) Draw a circle around each of the parts of the serine molecule which would be removed when **two** other amino acid molecules join directly to it. (1)
- (b) (i) Which **two** substances are formed when two amino acid molecules join together?
1. \_\_\_\_\_ (1)
2. \_\_\_\_\_ (1)
- (ii) Name the type of bond formed between the joined pair of amino acid molecules.
- \_\_\_\_\_ (1)
- (c) Explain how a change in the primary structure of a globular protein may result in a different three-dimensional structure.
- \_\_\_\_\_ (3)
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- (Total 7 marks)

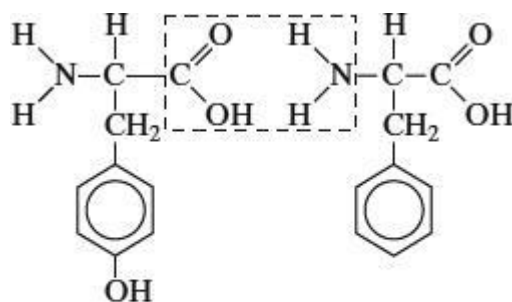
**Q3.**

- (a) Describe how you would use a biochemical test to show that a solution contained protein.
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

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(2)

The diagram shows the structure of two amino acid molecules, tyrosine and phenylalanine.



Tyrosine

Phenylalanine

(b) Copy from the diagram the R group in the phenylalanine molecule.

(1)

(c) (i) In the space below, draw the chemical bond formed when these two amino acids are joined by condensation. You need only draw the parts of the molecules shown in the box.

(2)

(ii) Name this bond.

\_\_\_\_\_

(1)

(d) Tyrosine can be made in the body by hydroxylating phenylalanine. Use the diagram to explain the meaning of *hydroxylating*.

\_\_\_\_\_

\_\_\_\_\_

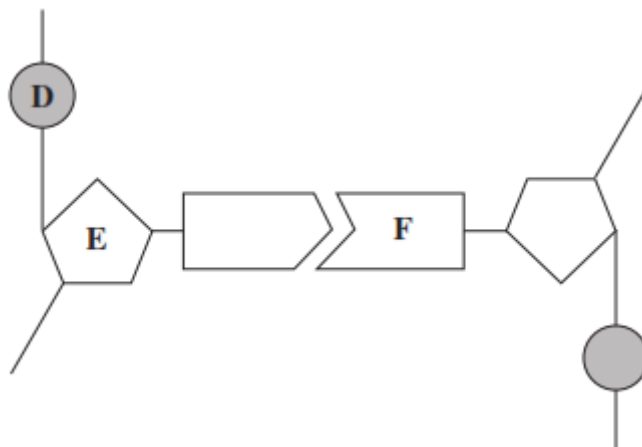
(1)

(Total 7 marks)

### 3.1.5.1 Structure of DNA and RNA

#### Q1.

(a) The diagram shows one pair of nucleotides of a DNA molecule.



Name \_\_\_\_\_

D \_\_\_\_\_

E \_\_\_\_\_

F \_\_\_\_\_

(3)

(b) Complete the table to give **two** differences between the structure of DNA and the structure of RNA.

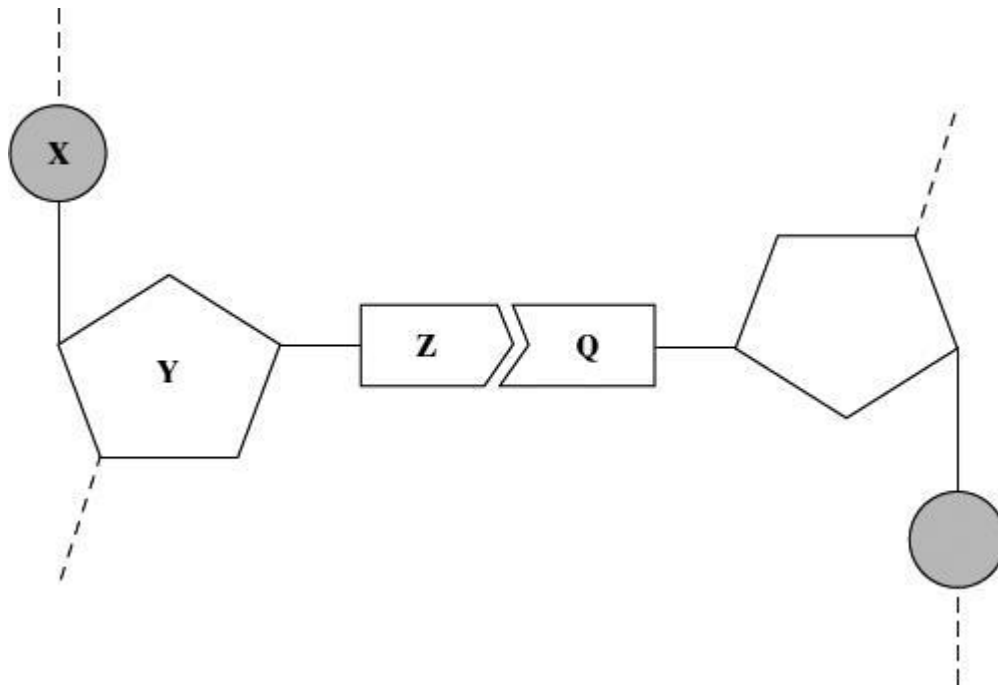
	DNA	RNA
1		
2		

(2)

(Total 5 marks)

#### Q2.

The diagram shows one nucleotide pair of a DNA molecule.



(a) Name the parts of the nucleotide labelled **X**, **Y** and **Z**.

**X** \_\_\_\_\_

**Y** \_\_\_\_\_

**Z** \_\_\_\_\_

(3)

(b) What type of bond holds **Z** and **Q** together?

\_\_\_\_\_

(1)

(c) A sample of DNA was analysed. 28% of the nucleotides contained thymine. Calculate the percentage of nucleotides which contained cytosine. Show your working.

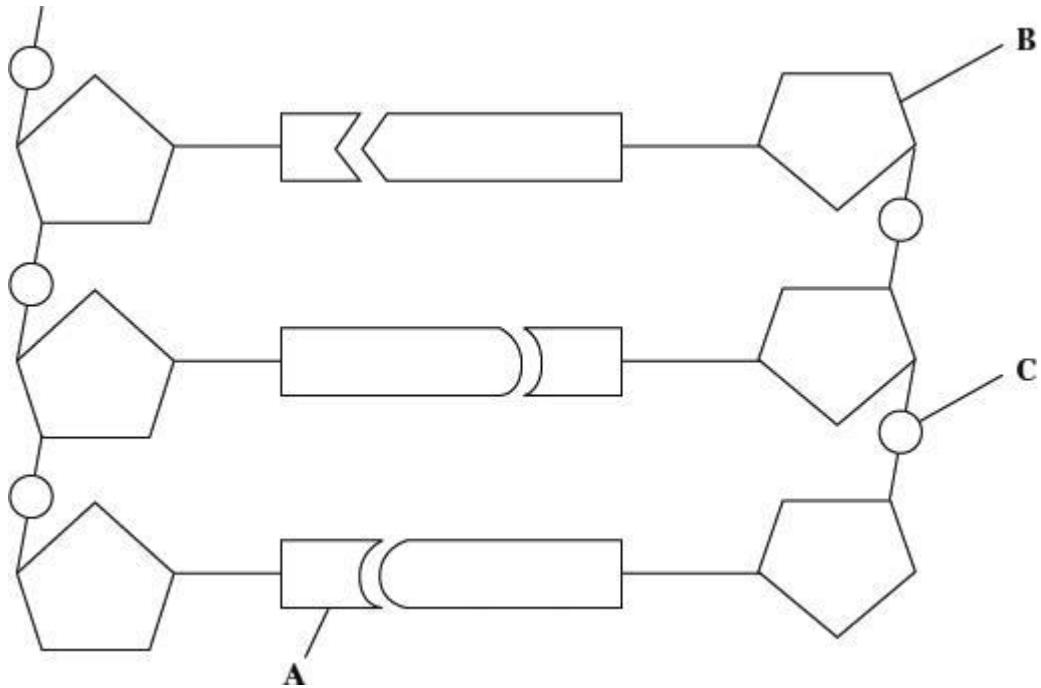
Answer \_\_\_\_\_ %

(2)

(Total 6 marks)

### Q3.

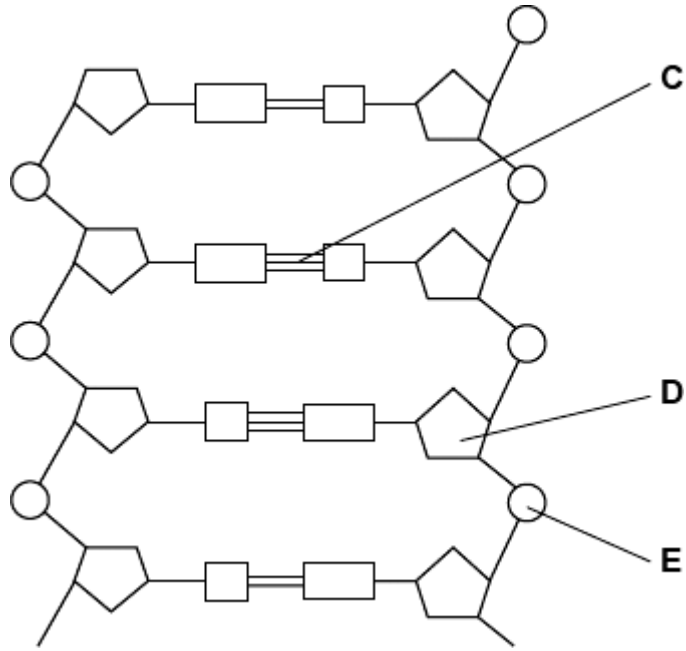
The diagram shows a short section of a DNA molecule.



- (a) On the diagram draw a box round **one** nucleotide. (1)
- (b) Use the letters in the diagram to indicate a part of the molecule which
- (i) is **not** a base and is different in an RNA molecule;
- \_\_\_\_\_
- (ii) contains nitrogen.
- \_\_\_\_\_
- (2)
- (c) (i) The sequence of bases on one strand of DNA is important for protein synthesis. What is its role?
- \_\_\_\_\_
- \_\_\_\_\_
- (1)
- (ii) How are the two strands of the DNA molecule held together?
- \_\_\_\_\_
- (1)
- (iii) Give **one** advantage of DNA molecules having two strands.
- \_\_\_\_\_
- \_\_\_\_\_
- (1)
- (Total 6 marks)**

**Q4.**

The diagram shows part of a DNA molecule.



- (a) (i) DNA is a polymer. What is the evidence from the diagram that DNA is a polymer?

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(1)

- (ii) Name the parts of the diagram labelled **C**, **D** and **E**.

Part **C** \_\_\_\_\_

Part **D** \_\_\_\_\_

Part **E** \_\_\_\_\_

(3)

- (iii) In a piece of DNA, 34% of the bases were thymine.

Complete the table to show the names and percentages of the other bases.

Name of base	Percentage
Thymine	34
	34

(2)

(b) A polypeptide has 51 amino acids in its primary structure.

(i) What is the minimum number of DNA bases required to code for the amino acids in this polypeptide?

(1)

(ii) The gene for this polypeptide contains more than this number of bases.

Explain why

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(1)

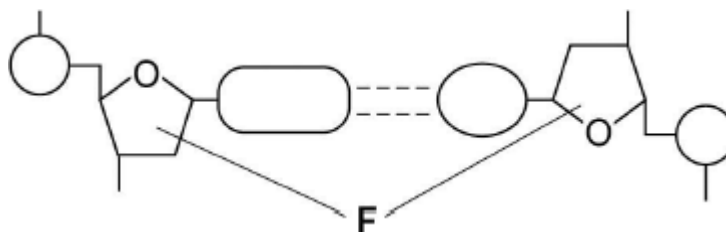
(Total 8 marks)

### 3.1.5.2 DNA replication

**Q1.**

**Figure 1** shows one base pair of a DNA molecule.

**Figure 1**



(a) Name part **F** of each nucleotide.

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(1)

(b) Scientists determined that a sample of DNA contained 18% adenine.

What were the percentages of thymine and guanine in this sample of DNA?

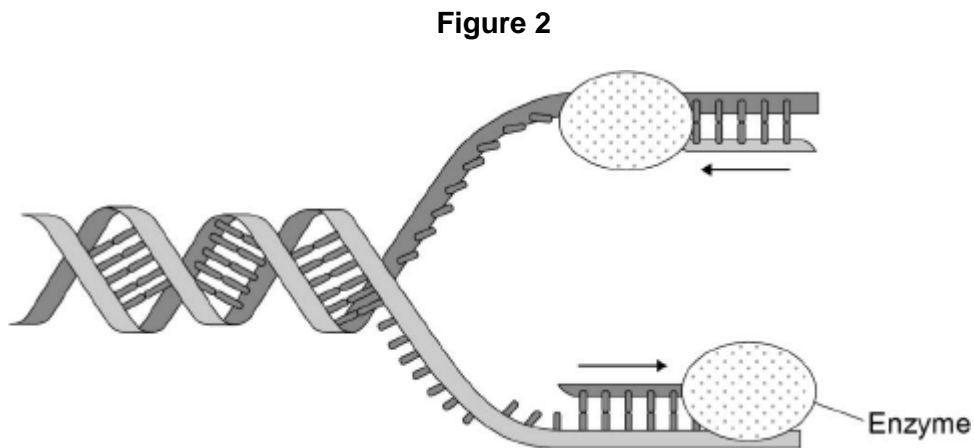
Percentage of thymine

Percentage of guanine

(2)

During replication, the two strands of a DNA molecule separate and each acts as a template for the production of a new strand.

Figure 2 represents DNA replication.



(c) Name the enzyme shown in **Figure 2**.

\_\_\_\_\_

(1)

The arrows in **Figure 2** show the directions in which each new DNA strand is being produced.

(d) Use **Figure 1**, **Figure 2** and your knowledge of enzyme action to explain why the arrows point in opposite directions.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(4)

(Total 8 marks)

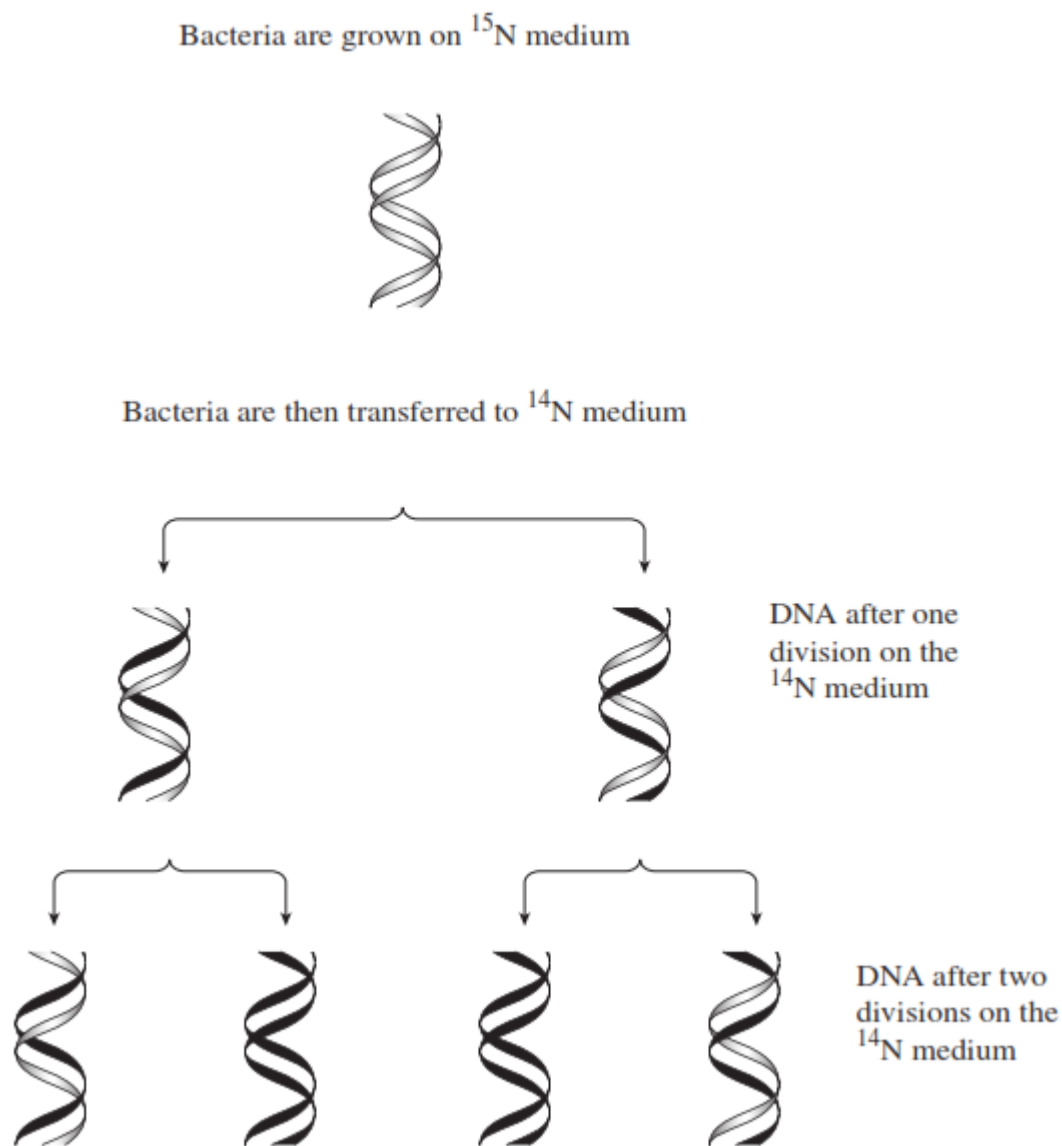
**Q2.**

The bases in DNA nucleotides contain nitrogen.

Researchers grew bacteria on a medium containing <sup>15</sup>N ('heavy' nitrogen) for several generations. They then transferred the bacteria to a medium containing <sup>14</sup>N ('ordinary' nitrogen). They analysed DNA from the bacteria at three stages:

1. whilst the bacteria were growing on the <sup>15</sup>N medium
2. after one division of the bacteria on the <sup>14</sup>N medium
3. after two divisions of the bacteria on the <sup>14</sup>N medium

The diagram shows their results.



(a) Describe how the proportion of DNA that contained  $^{15}\text{N}$  changed at each division when bacteria were grown on the  $^{14}\text{N}$  medium.

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(2)

(b) The change in the proportion of DNA containing  $^{15}\text{N}$  is due to the way in which DNA replicates. Explain how.

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**Q3.**

- (a) Explain why the replication of DNA is described as semi-conservative.

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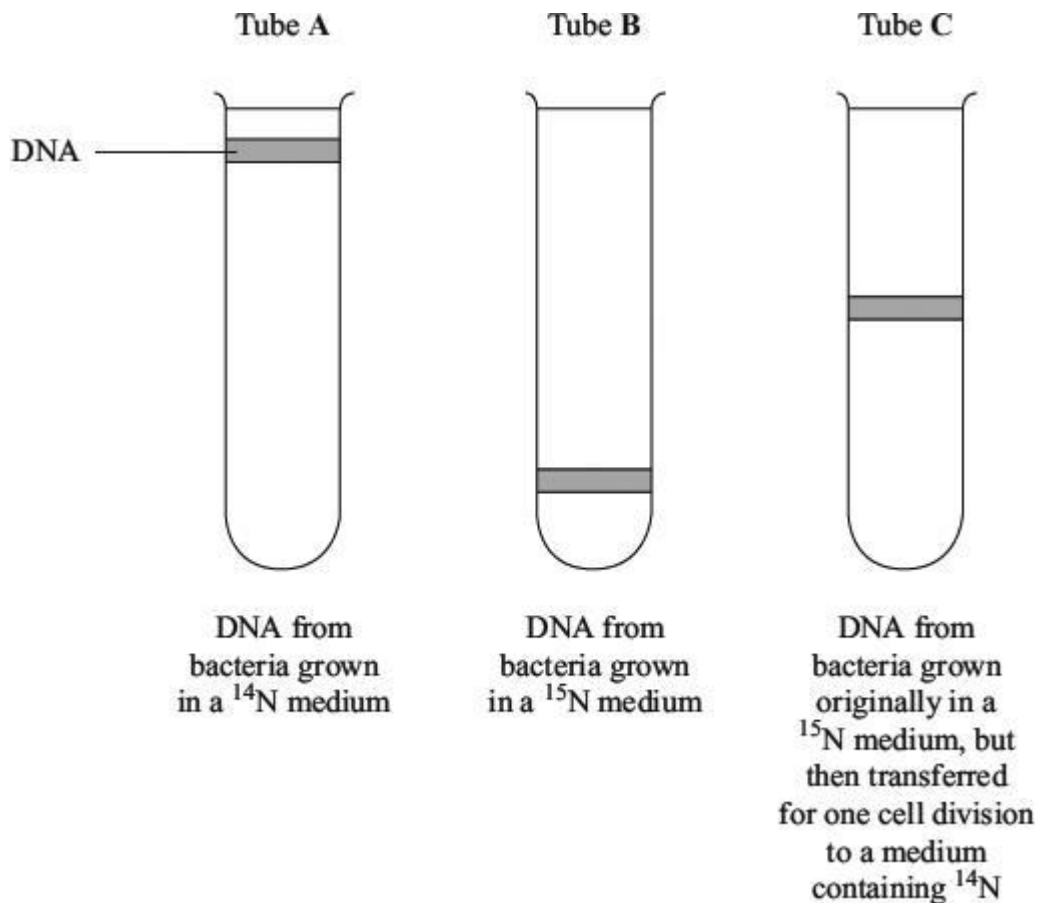
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(2)

- (b) Bacteria require a source of nitrogen to make the bases needed for DNA replication. In an investigation of DNA replication some bacteria were grown for many cell divisions in a medium containing  $^{14}\text{N}$ , a light form of nitrogen. Others were grown in a medium containing  $^{15}\text{N}$ , a heavy form of nitrogen. Some of the bacteria grown in a  $^{15}\text{N}$  medium were then transferred to a  $^{14}\text{N}$  medium and left to divide once. DNA was isolated from the bacteria and centrifuged. The DNA samples formed bands at different levels, as shown in the diagram.



- (i) What do tubes **A** and **B** show about the density of the DNA formed using the two different forms of nitrogen?

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(1)

(ii) Explain the position of the band in tube **C**.

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(2)

(c) In a further investigation, the DNA of the bacterium was isolated and separated into single strands. The percentage of each nitrogenous base in each strand was found. The table shows some of the results.

DNA sample	Percentage of base present			
	Adenine	Cytosine	Guanine	Thymine
Strand 1	26		28	14
Strand 2	14			

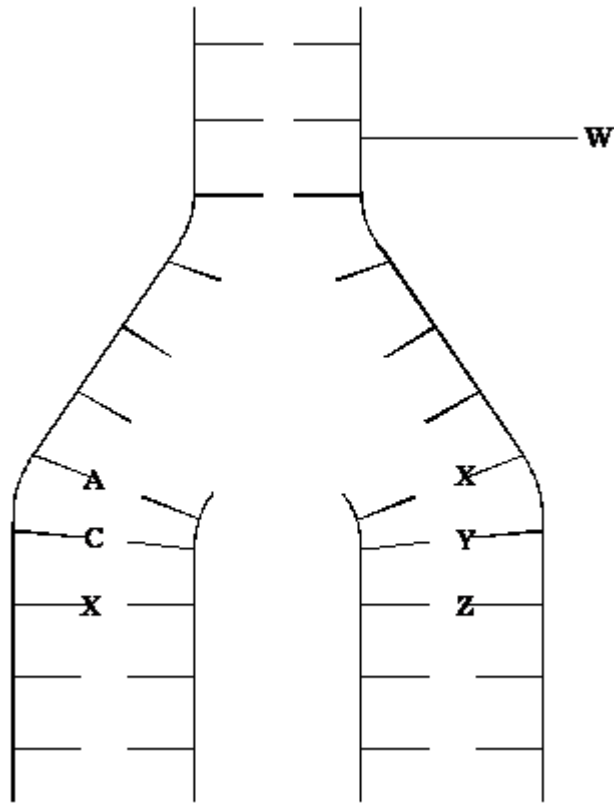
Use your knowledge of base pairing to complete the table.

(2)

(Total 7 marks)

**Q4.**

The diagram shows the process of DNA replication. The horizontal lines represent the positions of bases.



(i) What is represented by the part of the DNA molecule labelled **W**?

\_\_\_\_\_ (1)

(ii) In the diagram, **A** represents adenine and **C** represents cytosine.

Name the base found at

position **X**; \_\_\_\_\_

position **Y**; \_\_\_\_\_

position **Z**. \_\_\_\_\_

(3)  
(Total 4 marks)

**Q5.**

(a) Describe how DNA is replicated.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

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(6)  
(Total 6 marks)

**Q6.**

(a) DNA helicase is important in DNA replication. Explain why.

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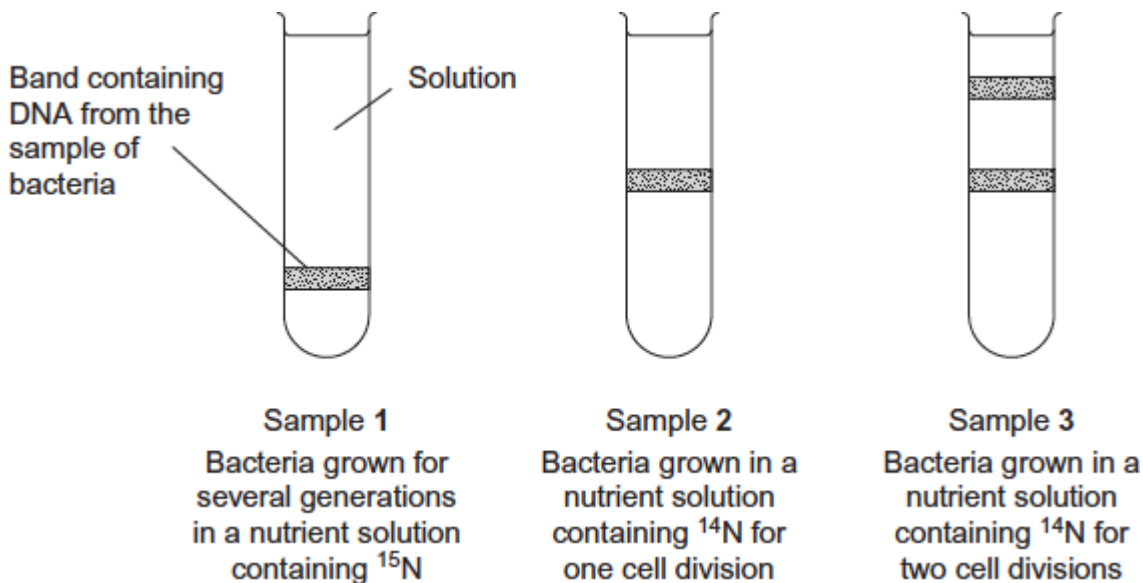
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(2)




Scientists investigating DNA replication grew bacteria for several generations in a nutrient solution containing a heavy form of nitrogen ( $^{15}\text{N}$ ). They obtained DNA from a sample of these bacteria.

The scientists then transferred the bacteria to a nutrient solution containing a light form of nitrogen ( $^{14}\text{N}$ ). The bacteria were allowed to grow and divide twice. After each division, DNA was obtained from a sample of bacteria.

The DNA from each sample of bacteria was suspended in a solution in separate tubes. These were spun in a centrifuge at the same speed and for the same time. The diagram shows the scientists' results.

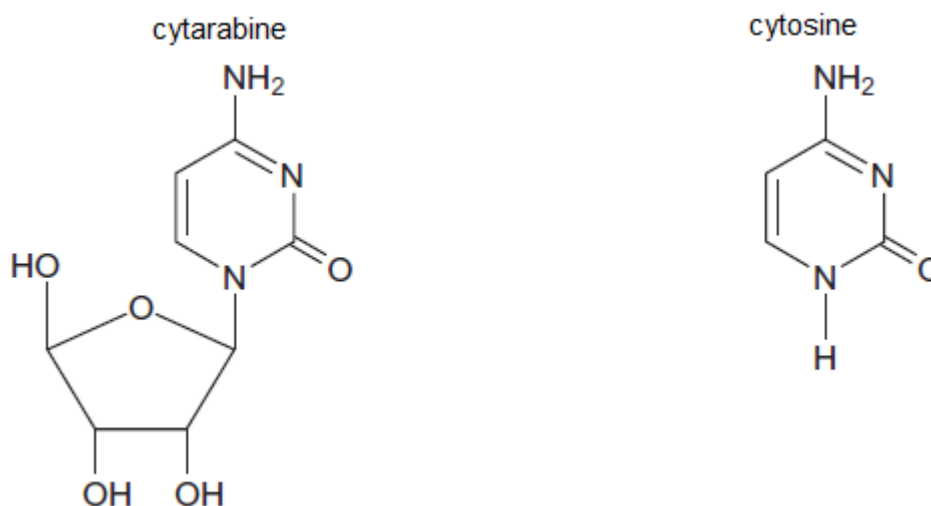


- (b) The table shows the types of DNA molecule that could be present in samples 1 to 3. Use your knowledge of semi-conservative replication to complete the table with a tick if the DNA molecule is present in the sample.

Sample	Type(s) of DNA molecule present in each sample		
	$^{15}\text{N} \ ^{15}\text{N}$ 	$^{15}\text{N} \ ^{14}\text{N}$ 	$^{14}\text{N} \ ^{14}\text{N}$ 
1			
2			
3			

(3)

- (c) Cytarabine is a drug used to treat certain cancers. It prevents DNA replication. The diagram shows the structures of cytarabine and the DNA base cytosine.



- (i) Use information in the diagram to suggest how cytarabine prevents DNA replication.

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(2)

- (ii) Cytarabine has a greater effect on cancer cells than on healthy cells. Explain why.

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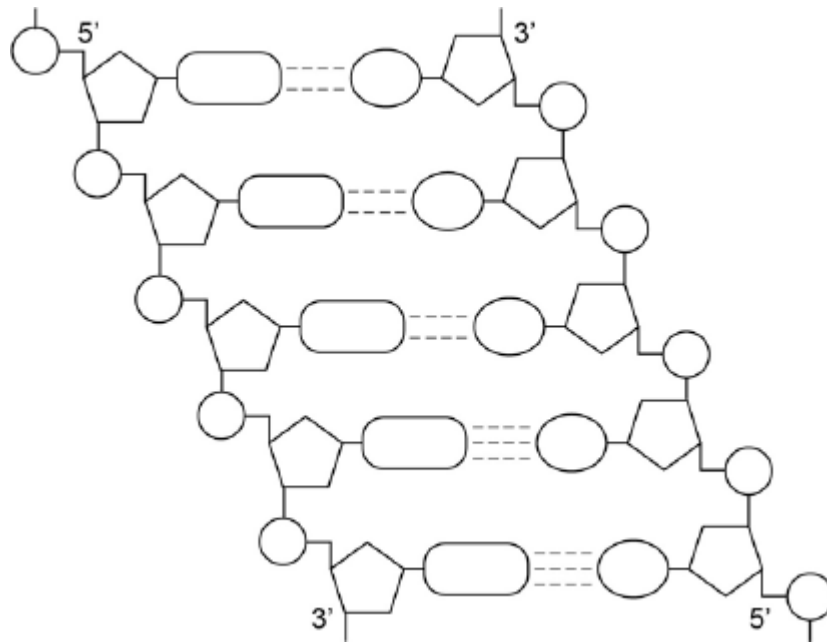


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(1)  
(Total 8 marks)

**Q7.**

The following figure represents part of a DNA molecule.



(a) Draw a box around a single nucleotide.

(1)

The table below shows the percentage of bases in each of the strands of a DNA molecule.

DNA strand	Percentage of each base			
	A	C	G	T
Strand 1	16			
Strand 2		21	34	

(b) Complete the table by adding the missing values.

(2)

(c) During replication, the two DNA strands separate and each acts as a template for the production of a new strand. As new DNA strands are produced, nucleotides can only be added in the 5' to 3' direction.

Use the figure in part (a) and your knowledge of enzyme action and DNA replication to explain why new nucleotides can only be added in a 5' to 3' direction.

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(4)  
(Total 7 marks)

### 3.1.6 ATP

#### **Q1.**

Cells constantly hydrolyse ATP to provide energy.

- (a) Describe how ATP is resynthesised in cells.

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(2)

- (b) Give **two** ways in which the hydrolysis of ATP is used in cells.

1. \_\_\_\_\_

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2. \_\_\_\_\_

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(2)  
(Total 4 marks)

#### **Q2.**

- (a) Describe how an ATP molecule is formed from its component molecules.

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**3.1.8 Inorganic ions**

**Q1.**

- (a) Explain a property of iron ions that enables these ions to carry out their role in red blood cells.

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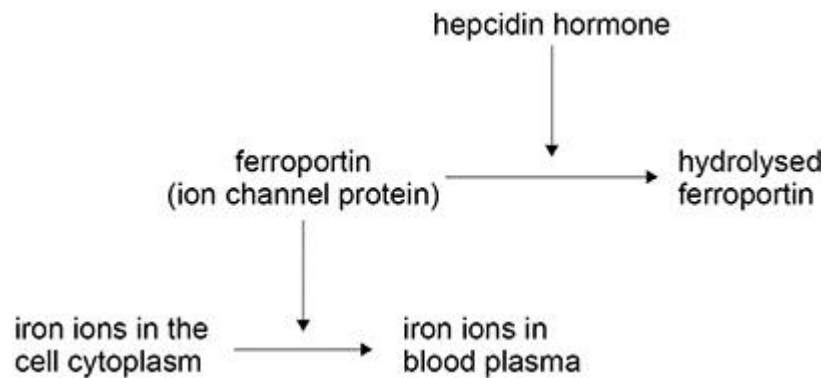
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- (b) The hormone hepcidin controls the iron ion concentration in blood plasma. Hepcidin affects ferroportin, the iron ion channel protein in cell-surface membranes.

The figure below shows how hepcidin controls the iron ion concentration in plasma.



People with the disease haemochromatosis do **not** produce hepcidin.

Use information in above figure to explain why the iron ion concentration is higher in the plasma of people with haemochromatosis.

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- (c) The mass of iron ions in the plasma of a person with haemochromatosis is 6104  $\mu\text{g}$ . The iron ion concentration in the plasma of a healthy person is  $50 \mu\text{g dm}^{-3}$ . The volume of blood in each of these people is  $4000 \text{ cm}^3$ .

Calculate the ratio of the mass of iron ions in the plasma of the person with haemochromatosis to the mass of iron ions in the plasma of the healthy person.

Answer \_\_\_\_\_

(2)

(Total 7 marks)

## Q2.

Water and inorganic ions have important biological functions within cells.

- (a) Other than sodium, name **one** inorganic ion and give **one** example of its biological importance in a cell.

Name of inorganic ion \_\_\_\_\_

Biological importance \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(2)

(Total 2 marks)

## Q3.

- (a) Describe the roles of iron ions, sodium ions, and phosphate ions in cells.

\_\_\_\_\_

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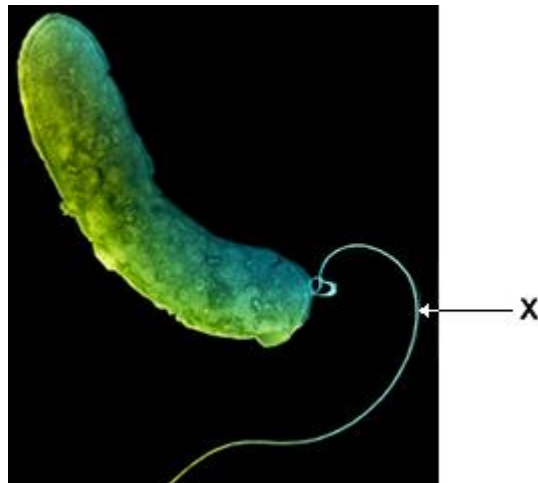
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(5)  
(Total 5 marks)

### 3.2.1.2 Structure of prokaryotic cells and of viruses

#### Q1.

- (a) The figure below is an image of a bacterium obtained using a scanning electron microscope.



Name the structure labelled X.

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(1)

- (b) The figure above is different from an image of this bacterium obtained using a transmission electron microscope.

Describe and explain **one** difference between these images.

Description \_\_\_\_\_

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Explanation \_\_\_\_\_

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(2)

- (c) The resolution of an image obtained using an electron microscope is higher than the resolution of an image obtained using an optical microscope.

Explain why.

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(1)

- (d) A student determined the size of a cell structure from a photograph obtained using a microscope.

He used a ruler and a calculator and gave the answer in  $\mu\text{m}$

Describe how the student determined the size of the structure.

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(2)

- (e) Name **two** structures found in **all** bacteria that are **not** found in plant cells.

1 \_\_\_\_\_

2 \_\_\_\_\_

(2)

- (f) Name **two** features of HIV particles that are **not** found in bacteria.

Do **not** include attachment protein in your answer.

1 \_\_\_\_\_

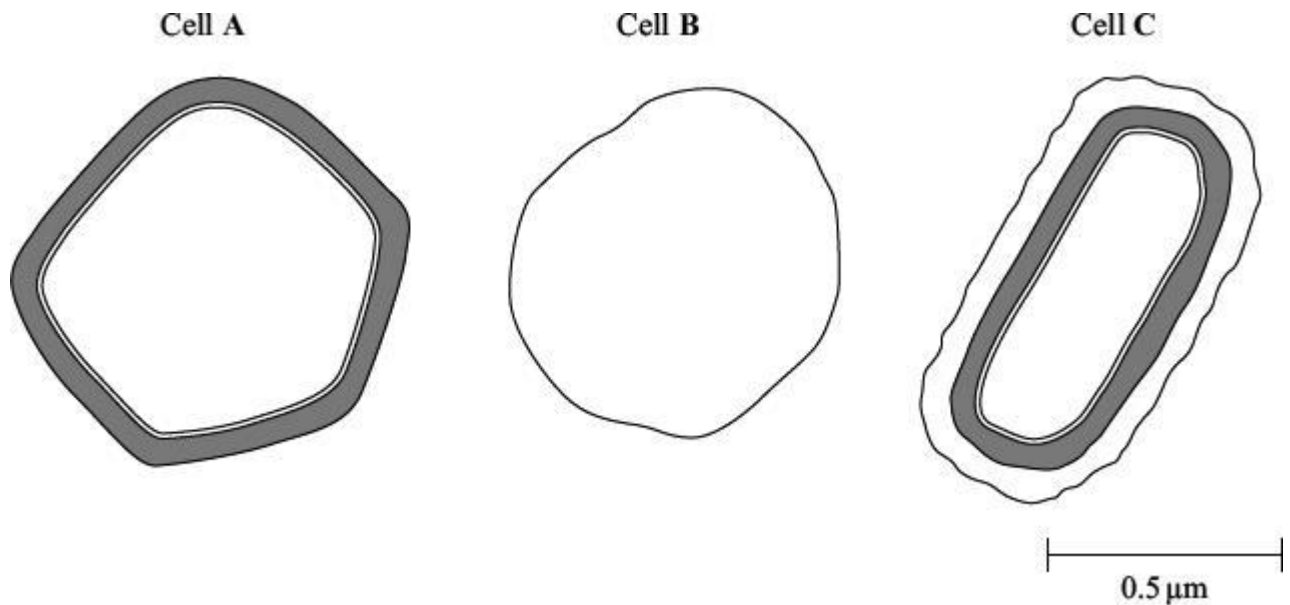
2 \_\_\_\_\_

(2)

(Total 10 marks)

## Q2.

The diagram shows the outer layers of three different cells, **A**, **B** and **C**.



(a) What is the evidence from the diagram that

(i) cell **B** is an animal cell,

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(1)

(ii) cell **C** is a prokaryotic cell?

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(1)

(b) Explain how you would calculate the magnification of cell **C**.

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(1)

(c) Cell **A** is a plant cell. Name a polysaccharide which may be found in cell **A** but would not be found in the animal cell.

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(1)

(d) Penicillin is an antibiotic. It prevents the formation of bacterial cell walls. As a result, bacterial cells that have been treated with penicillin swell and burst as water enters.

(i) Explain how water enters a bacterial cell.

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(2)

(ii) Suggest why penicillin has no effect on plant cells.

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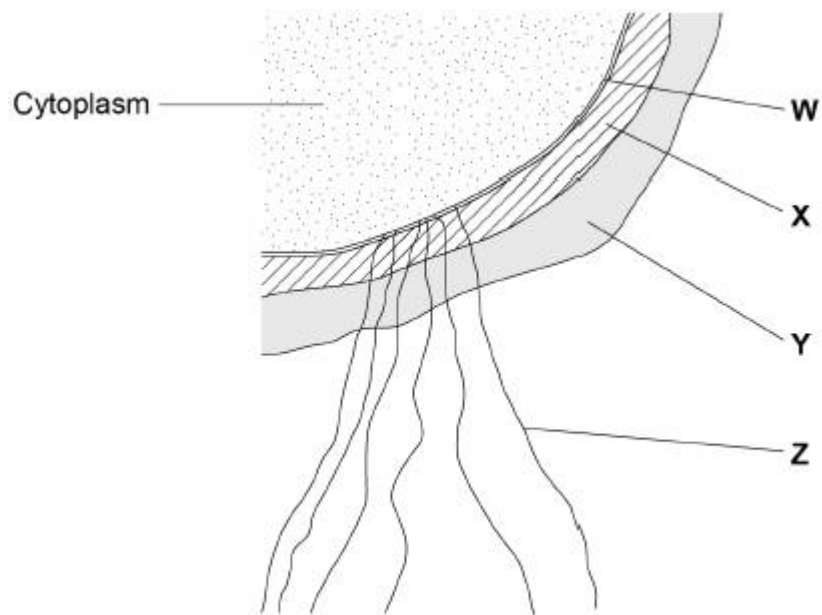
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(1)

(Total 7 marks)

**Q3.**

The diagram shows part of a prokaryotic cell.



(a) Name the structures labelled **W** to **Z** in the diagram.

**W** \_\_\_\_\_

**X** \_\_\_\_\_

**Y** \_\_\_\_\_

**Z** \_\_\_\_\_

(2)

(b) Name the main biological molecule in:

**W** \_\_\_\_\_

**X** \_\_\_\_\_

(2)

(c) Name the process by which prokaryotic cells divide.

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(5)  
(Total 10 marks)

**Q2.**

- (a) Contrast how an optical microscope and a transmission electron microscope work **and** contrast the limitations of their use when studying cells.

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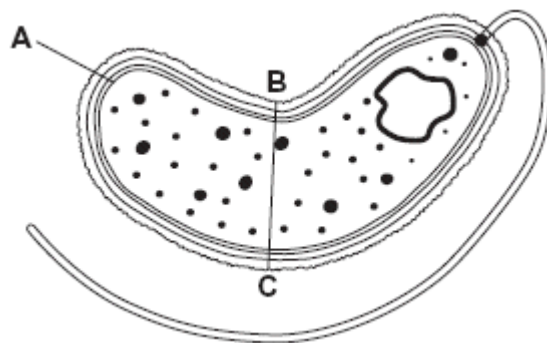
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(6)  
(Total 6 marks)

**Q3.**

The diagram shows a cholera bacterium. It has been magnified 50 000 times.



(a) Name **A**.

\_\_\_\_\_ (1)

(b) Name **two** structures present in an epithelial cell from the small intestine that are **not** present in a cholera bacterium.

1. \_\_\_\_\_

2. \_\_\_\_\_

(2)

(c) Cholera bacteria can be viewed using a transmission electron microscope (TEM) or a scanning electron microscope (SEM).

(i) Give **one** advantage of using a TEM rather than a SEM.

\_\_\_\_\_  
\_\_\_\_\_

(1)

(ii) Give **one** advantage of using a SEM rather than a TEM.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(1)

(d) Calculate the actual width of the cholera bacterium between points **B** and **C**. Give your answer in micrometres and show your working.

\_\_\_\_\_  $\mu\text{m}$

(2)

(Total 7 marks)

**Q4.**

A biologist prepared a sample of organelles labelled **C** from liver. He used the following method.

1. Added to the liver tissues an ice-cold, buffered solution with the same water potential as the liver tissue.
2. Mixed the liver and solution in a blender.
3. Filtered the mixture from the blender.
4. Spun the filtered liquid in a centrifuge at a low speed. A pellet appeared in the bottom of the centrifuge tube.
5. Poured off the liquid above the pellet into a second centrifuge tube and spun this at a higher speed to obtain the sample of organelles labelled **C**.

- (a) Explain why the solution the biologist used was ice-cold, buffered and the same water potential as the liver tissue (step 1).

Ice-cold \_\_\_\_\_

\_\_\_\_\_

Buffered \_\_\_\_\_

\_\_\_\_\_

Same water potential \_\_\_\_\_

\_\_\_\_\_

**(3)**

- (b) Explain why the biologist used a blender and then filtered the mixture (steps 2 and 3).

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**(2)**

- (c) Name the organelle that made up most of the first pellet after centrifuging at a low speed (step 4).

\_\_\_\_\_

**(1)**

- (d) The second centrifuge tube was spun at a higher speed to obtain the sample of organelles labelled **C** in the diagram (step 5).

Suggest why.

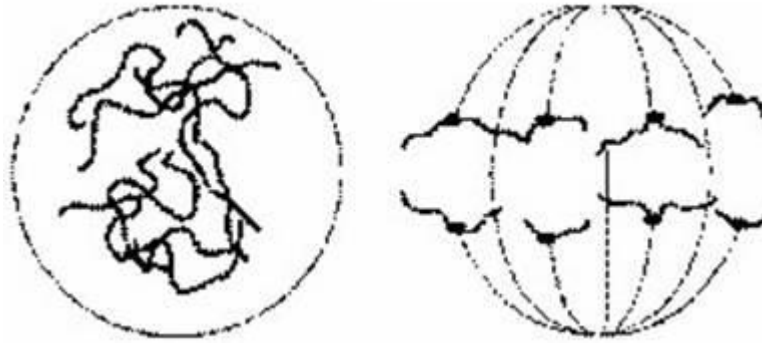
\_\_\_\_\_

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**3.2.2 All cells arise from other cells**

**Q1.**

(a) The photographs show two stages in mitosis of a plant cell.



**A**

**B**

Name stages **A** and **B**. In each case describe what is happening to the chromosomes.

(i) Stage **A** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

(ii) Stage **B** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

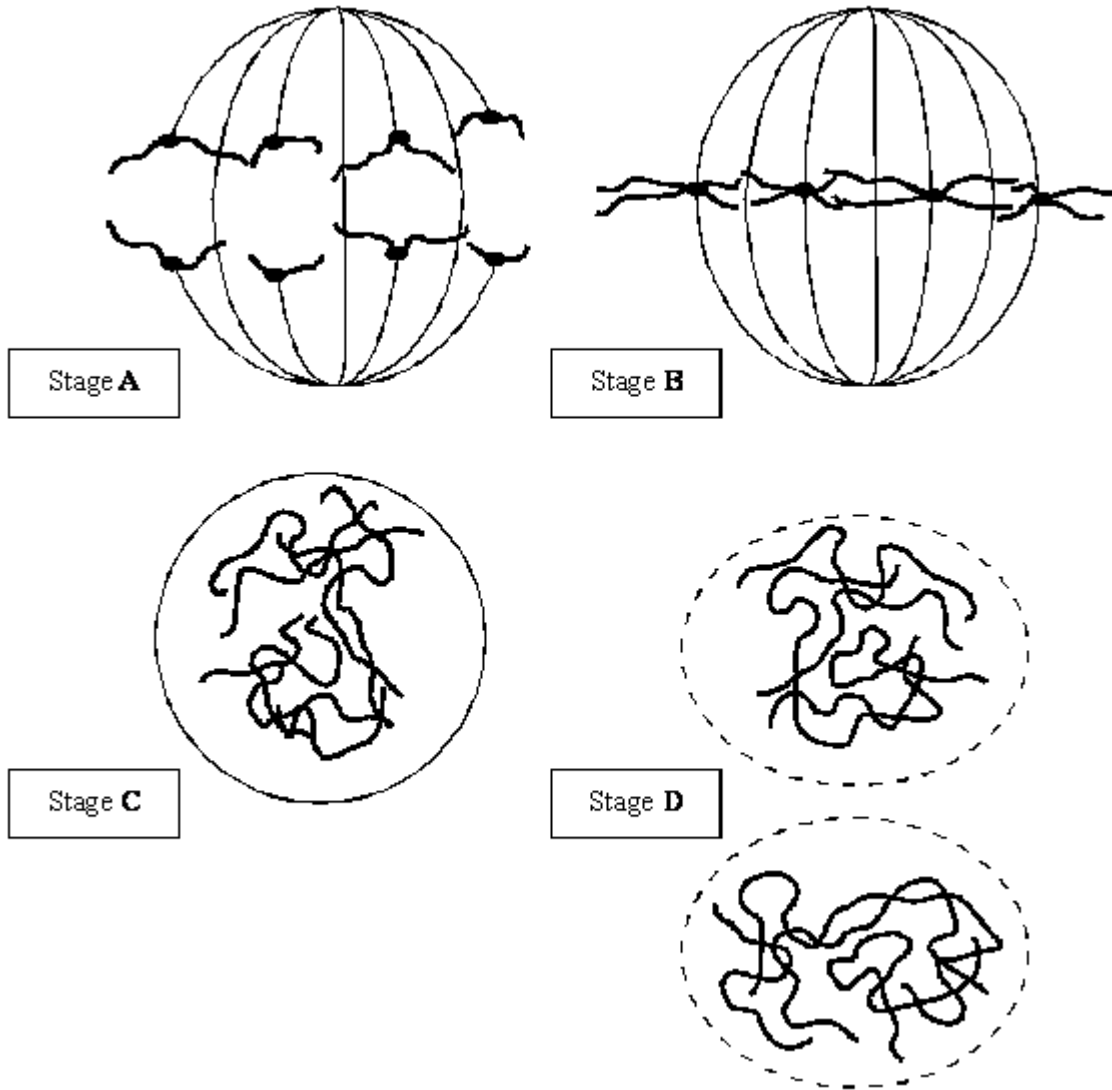
(b) Describe **two** events during interphase which prepare a cell for mitosis.

1. \_\_\_\_\_  
\_\_\_\_\_  
2. \_\_\_\_\_  
\_\_\_\_\_

(2)  
(Total 6 marks)

**Q2.**

The diagrams show four stages of mitosis.



(a) (i) Name stage **A**.

\_\_\_\_\_

(1)

(ii) Starting with stage **C**, give the stages **A** to **D** in the correct order.

**C** \_\_\_\_\_

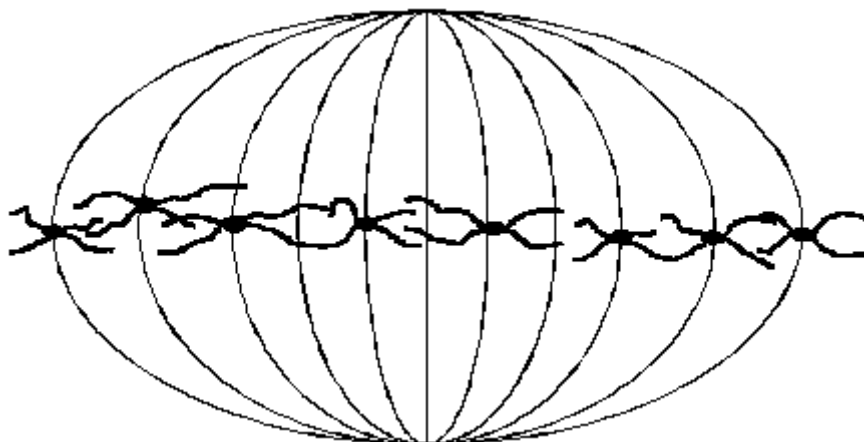
(1)

(iii) Describe and explain the appearance of one of the chromosomes in stage **B**.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

- (b) Colchicine is a substance that prevents the formation of the spindle in mitosis. Dividing cells were treated with colchicine. This stopped them dividing. After a few hours, the colchicine was removed and the cells began to divide again. The diagram shows the chromosomes from one of the treated cells at stage **B** after the cell began dividing again.



- (i) What has happened to the chromosome number?

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(1)

- (ii) Suggest an explanation for the change in the chromosome number.

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(1)

(Total 6 marks)

**Q3.**

- (a) The following statements describe stages of mitosis.

- A** chromosomes align at the centre of the cell attached to spindle fibres
- B** chromatids are in groups at the poles
- C** chromosomes become visible
- D** chromatids move towards the poles

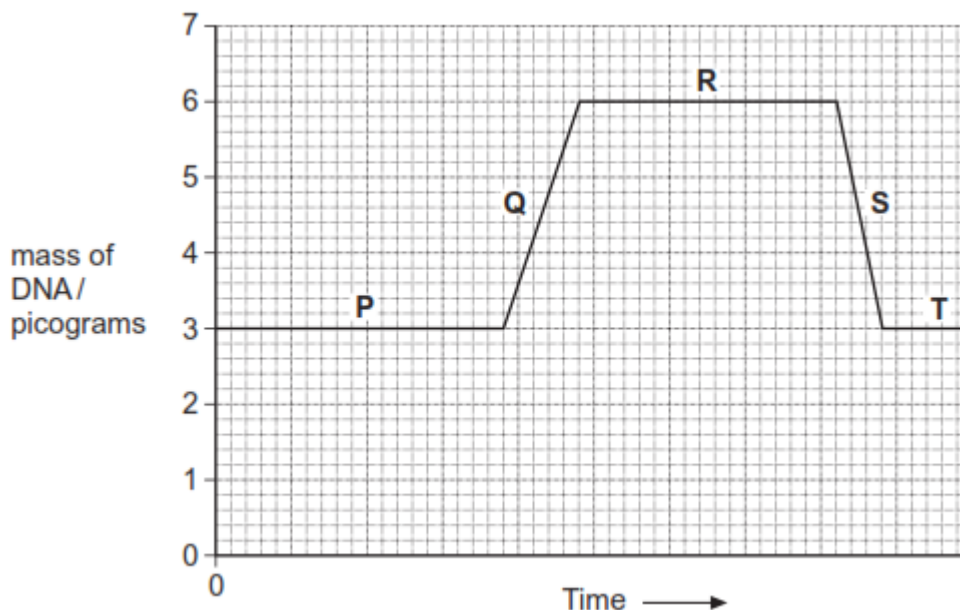
Complete the table by entering the appropriate letter.

Stage of mitosis	Letter of description of the stage
Prophase	
Metaphase	
Anaphase	
Telophase	

(3)

- (b) The graph shows changes in the mass of DNA in a cell during one cell cycle.

Five stages have been identified on the graph.



(i) Which letter represents the stage when DNA is replicating?

(1)

(ii) Explain the change in the DNA content during stage S.

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(1)

(Total 5 marks)

**Q4.**

A student prepared a stained squash of cells from the root tips of garlic to calculate a mitotic index. He:

1. cut the end 5 mm from 10 garlic roots
2. placed the root tips into a Petri dish containing 5 cm<sup>3</sup> of hydrochloric acid for 12 minutes
3. rinsed the root tips in distilled water
4. placed one of the root tips on a microscope slide and added toluidine blue stain
5. placed a coverslip onto the microscope slide, and gently pressed the coverslip downwards on the root tip
6. observed the root tip using an optical microscope.

(a) Suggest why the student soaked the root tips in hydrochloric acid in step 2.

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(2)

- (b) Pressing the coverslip downwards enabled the student to observe the stages of mitosis clearly.

Explain why.

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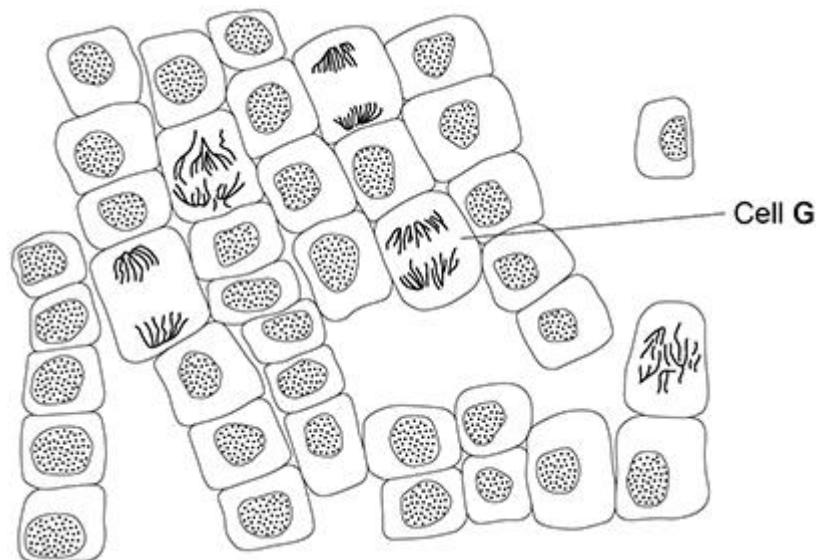
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(2)

The diagram below shows the student's drawing of one field of view.



- (c) Name the stage of mitosis shown in cell **G**. Explain the appearance of this cell.

Stage of mitosis \_\_\_\_\_

Explanation \_\_\_\_\_

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(2)

- (d) Use the diagram above to calculate a mitotic index for the cells in this field of view.

Mitotic index \_\_\_\_\_

(1)

- (e) Other students in the class followed the same method, but calculated different mitotic indices.

Apart from student errors, suggest **two** explanations why.

1 \_\_\_\_\_

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2 \_\_\_\_\_

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(2)

(Total 9 marks)

**Q5.**

- (a) What is a tumour?

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(2)

- (b) Describe how you would determine a **reliable** mitotic index (MI) from tissue observed with an optical microscope.

Do **not** include details of how you would prepare the tissue observed with an optical microscope.

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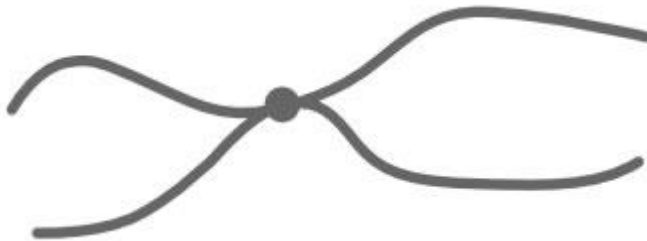
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(3)  
(Total 5 marks)

**Q6.**

- (a) The diagram shows a chromosome at the start of mitosis.



Describe and explain the appearance of the chromosome.

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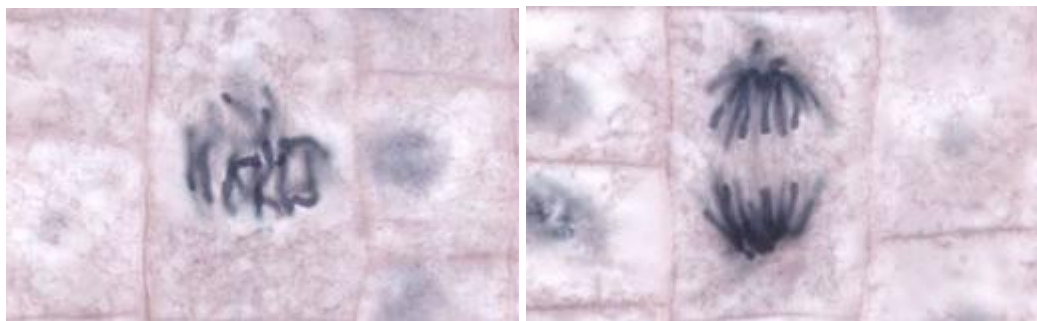
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(2)

- (b) The photographs show two stages in mitosis.

Stage A

Stage B



By Dr. phil.nat Thomas Geier, Fachgebiet Botanik der Forschungsanstalt Geisenheim.  
[CC-BY-SA-3.0], via Wikimedia Commons

Name stages **A** and **B**. Describe what is happening to the chromosomes in each stage.

(i) Stage **A** \_\_\_\_\_

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(2)

(ii) Stage **B** \_\_\_\_\_

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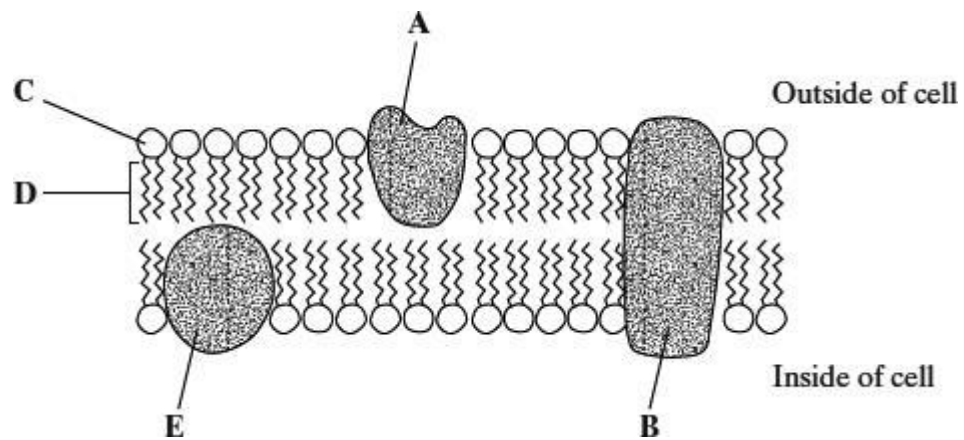
(2)

(Total 6 marks)

### 3.2.3 Transport across membranes

**Q1.**

The diagram shows part of a cell surface membrane.



(a) Complete the table by writing the letter from the diagram which refers to each part of the membrane.

Part of membrane	Letter
Channel protein	
Contains only the elements carbon and hydrogen	

(2)

(b) Explain why the structure of a membrane is described as *fluid-mosaic*.

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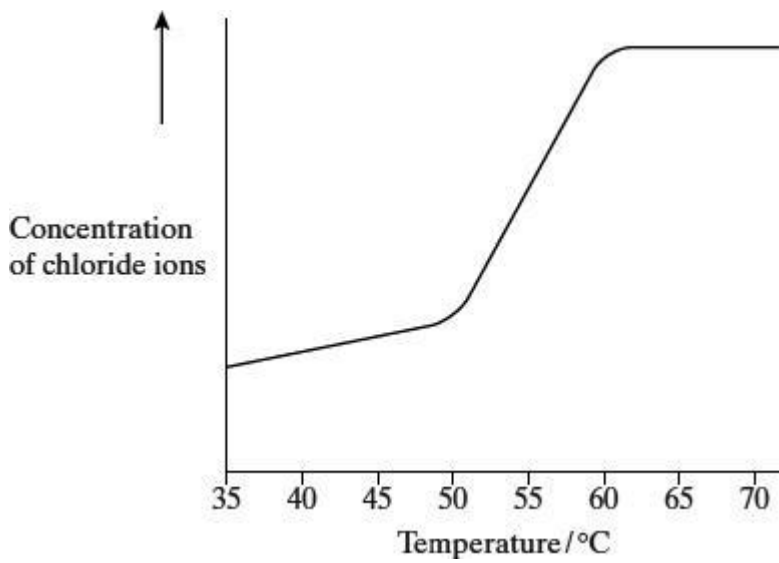
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(2)

(c) When pieces of carrot are placed in water, chloride ions are released from the cell vacuoles. Identical pieces of carrot were placed in water at different temperatures. The concentration of chloride ions in the water was measured after a set period of time. The graph shows the results.



Describe and explain the shape of the curve.

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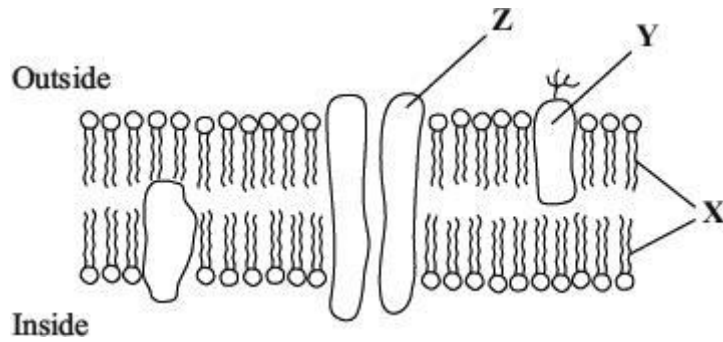
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(3)

(Total 7 marks)

**Q2.**

The diagram shows part of a plasma membrane.



(a) Describe **two** functions of the structure made from the parts labelled X.

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

(2)

(b) Give **one** function of the molecule labelled Y.

\_\_\_\_\_

\_\_\_\_\_

(1)

(c) The part labelled Z is involved in facilitated diffusion of substances across the membrane.

(i) Give **one** similarity in the way in which active transport and facilitated diffusion transport substances across the membrane.

\_\_\_\_\_

\_\_\_\_\_

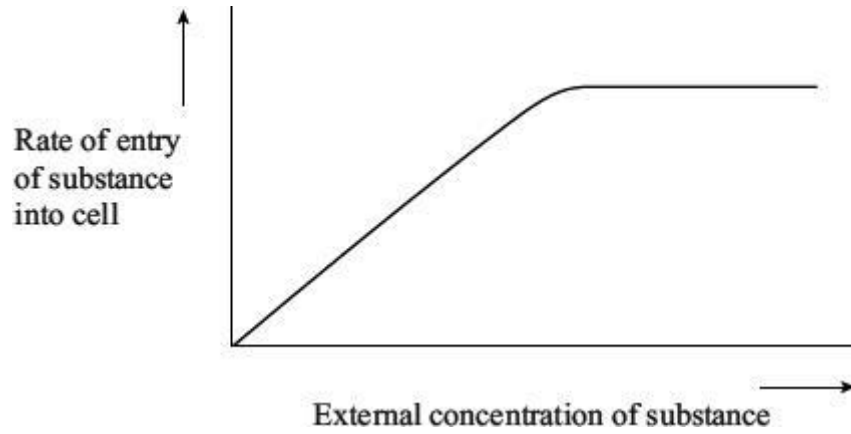
(ii) Give **one** way in which active transport differs from facilitated diffusion.

\_\_\_\_\_

\_\_\_\_\_

(2)

(iii) The graph shows the relationship between the concentration of a substance outside a cell and the rate of entry of this substance into the cell.



Explain the evidence from the graph that this substance is entering the cell by facilitated diffusion and not by simple diffusion.

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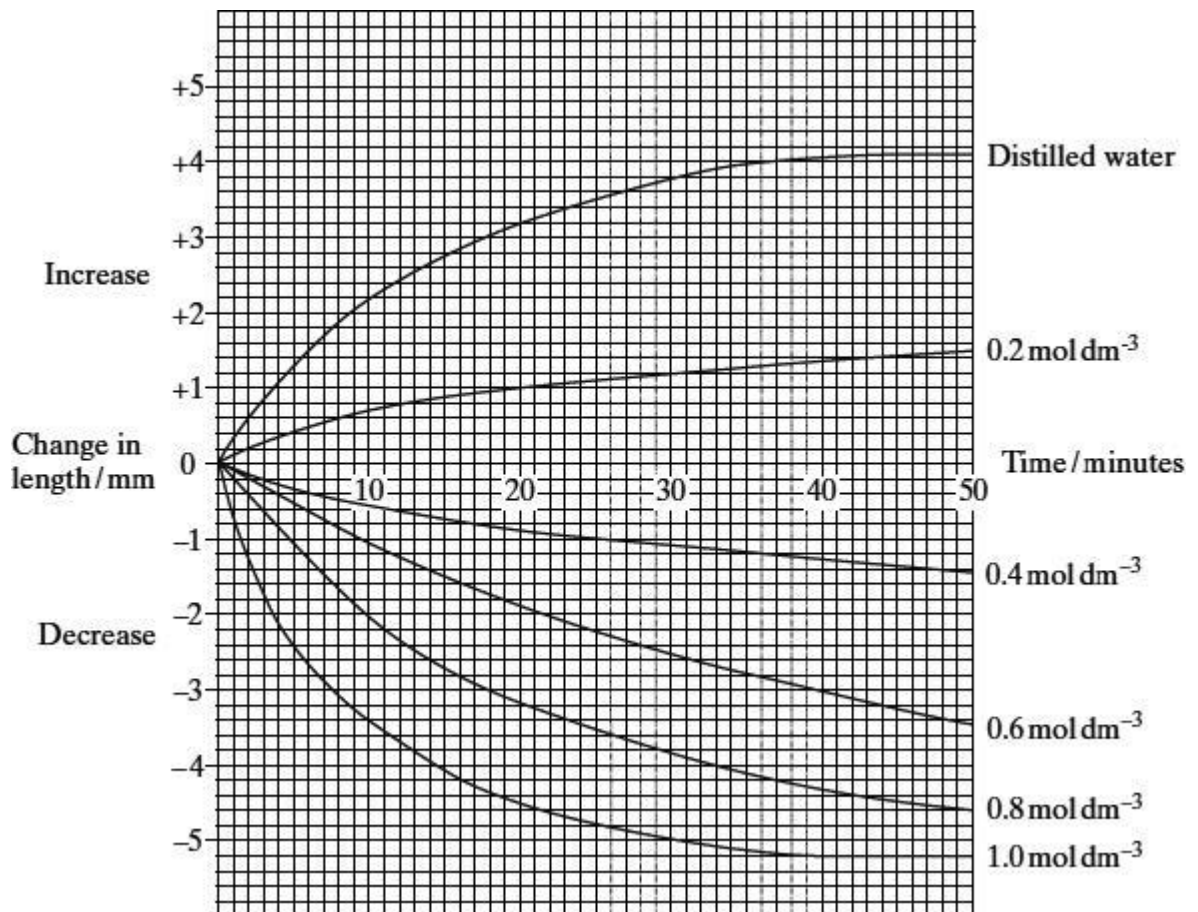
(2)

(Total 7 marks)

**Q3.**

Six cylinders of a standard size were cut from a single large potato. One cylinder was placed in distilled water and the others were placed in sucrose solutions of different concentrations. The length of each cylinder was measured every 5 minutes for the next 50 minutes.

The graph shows the changes in length at each sucrose concentration.



(a) Explain why

(i) the potato cylinder in distilled water increased in length;

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(2)

(ii) the potato cylinder in the 1.0 mol dm<sup>-3</sup> sucrose solution showed no further decrease in length after 40 minutes.

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(2)

(b) (i) Describe the difference in the rate of decrease in length during the first 10 minutes between the cylinder in the 0.4 mol dm<sup>-3</sup> and the cylinder in the 0.8 mol dm<sup>-3</sup> solution.

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(1)

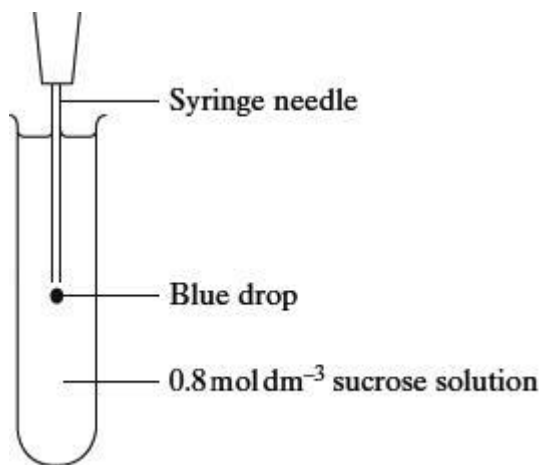
(ii) Use your knowledge of water potential to explain this difference.

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(1)

(c) After 45 minutes the potato cylinder in the  $0.8 \text{ mol dm}^{-3}$  solution was removed and blue dye added to this solution. Some of this blue-stained solution was drawn into a syringe. A drop was then released, slowly, halfway down a test tube of fresh  $0.8 \text{ mol dm}^{-3}$  sucrose solution as shown in the diagram. The blue drop quickly moved to the surface of the liquid in the test tube.



(i) The density of a solution depends on its concentration. The more concentrated the solution the greater its density. Explain why the blue drop had a lower density and therefore moved up.

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(2)

(ii) A sucrose solution of concentration  $0.3 \text{ mol dm}^{-3}$  has a water potential which is equivalent to that of the potato cells. Describe and explain what would happen to the blue drop from this solution.

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(2)

**Q4.**

- (a) The structure of a plasma membrane is described as a fluid mosaic. Explain why.

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(2)

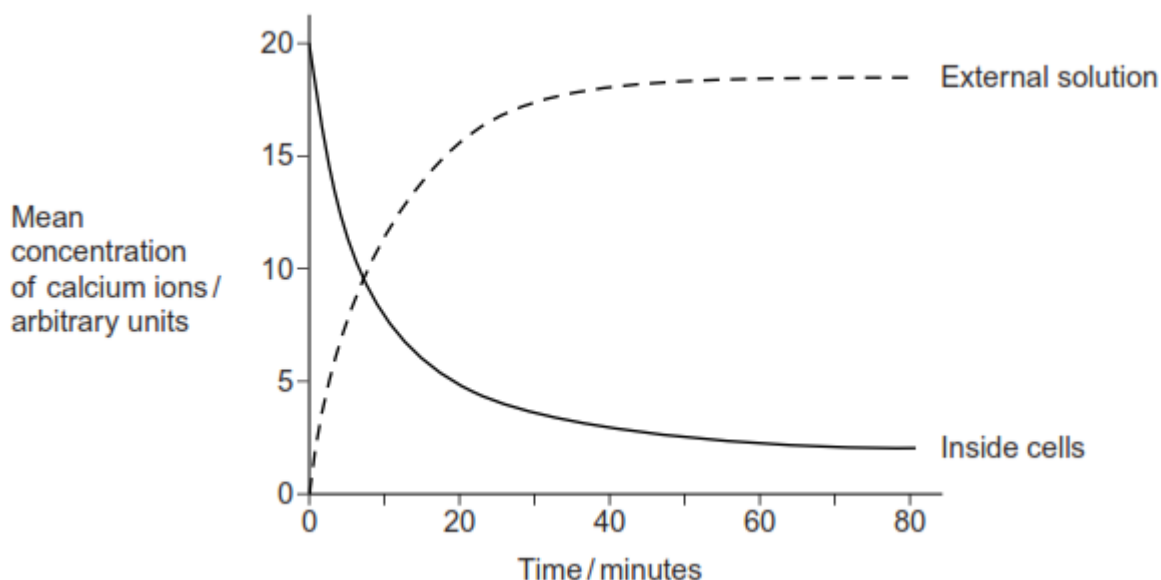
- (b) Give **two** functions of proteins in plasma membranes.

1. \_\_\_\_\_

2. \_\_\_\_\_

(2)

Scientists investigated the movement of calcium ions across the plasma membrane of human cells. They placed human cells in a solution of calcium ions. At regular intervals, they measured the concentration of calcium ions in the external solution and the concentration of calcium ions inside the cells. Their results are shown in the graph.



- (c) By what process did the calcium ions leave the cells after 10 minutes? Use evidence from the graph to support your answer.

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**Q5.**

(a) Describe **two** differences between active transport and facilitated diffusion.

1. \_\_\_\_\_  
\_\_\_\_\_  
2. \_\_\_\_\_  
\_\_\_\_\_

(2)

(b) Explain why molecules of oxygen and carbon dioxide are able to diffuse across membranes.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

(c) Explain why ventilation of the lungs increases the efficiency of gas exchange.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

(Total 6 marks)

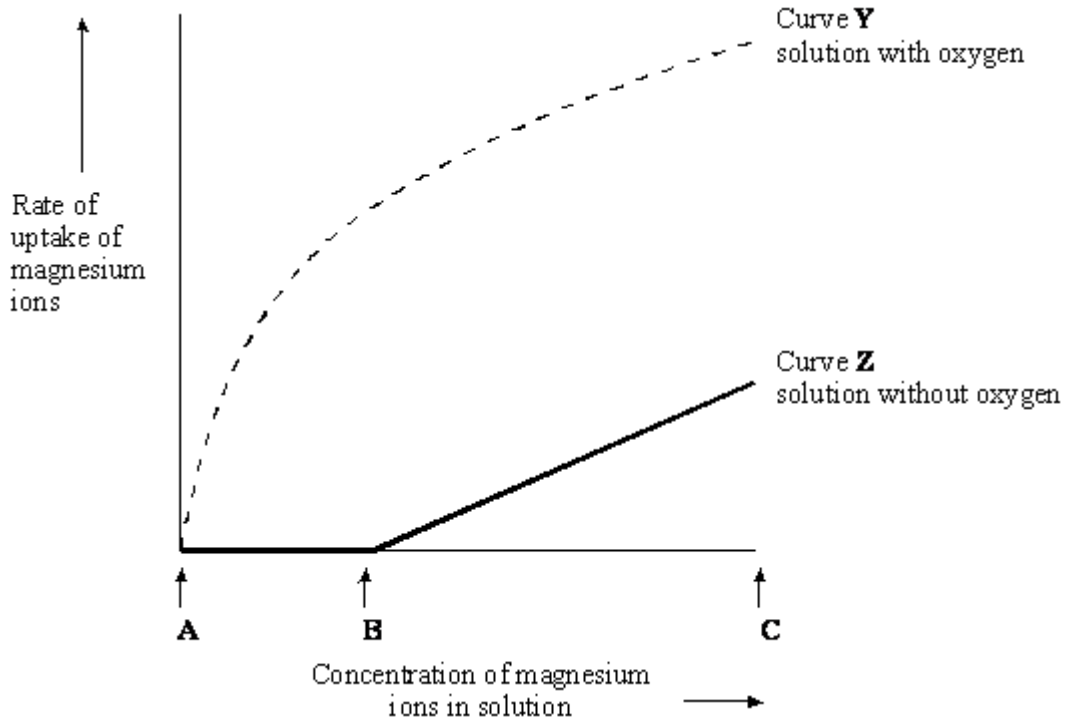
**Q6.**

(a) Oxygen and water move through plasma membranes into cells. Describe **two** ways in which these movements are similar.

1. \_\_\_\_\_  
\_\_\_\_\_  
2. \_\_\_\_\_  
\_\_\_\_\_

(2)

The graph shows the effect of concentration on the rate of uptake of magnesium ions by root hair cells.



- (b) For curve **Y** name the process the cells are using to absorb magnesium ions between concentrations **A** and **B**. Use information in the graph to explain your answer.

Name of process \_\_\_\_\_

Explanation \_\_\_\_\_

\_\_\_\_\_

(2)

- (c) In the solution without oxygen, explain why no magnesium ions are taken up between concentrations **A** and **B**.

\_\_\_\_\_

(1)

- (d) For curve **Z** explain why the rate of uptake increases between **B** and **C**.

\_\_\_\_\_

(1)

(Total 6 marks)

### 3.2.4 Cell recognition and the immune system

**Q1.**

- (a) An antigen in a vaccine leads to the production of antibodies. Describe the part played by B lymphocytes in this process.

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(4)

- (b) Hepatitis B vaccine contains a viral antigen produced by genetically modified bacteria. Describe how the isolated gene that codes for a protein in the virus's coat could be transferred to the bacterial cells.

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(3)

(Total 7 marks)

**Q2.**

- (a) What is an antigen?

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(2)

- (b) A zookeeper was bitten by a snake. The bite contained venom which is a poison. He was given an injection of antivenom. This antivenom contained antibodies against this snake venom.

The antivenom did not give the zookeeper lasting protection against this snake venom. Explain why.

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(Extra space) \_\_\_\_\_

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(2)  
(Total 4 marks)

**Q3.**

Doctors use Zevalin to kill cancerous B-cells. Zevalin is a monoclonal antibody which has a highly radioactive substance called yttrium attached to it. The antibody binds to the surface of B-cells and the radioactivity kills the cells.

- (a) Only B-cells are killed by Zevalin.

Explain why.

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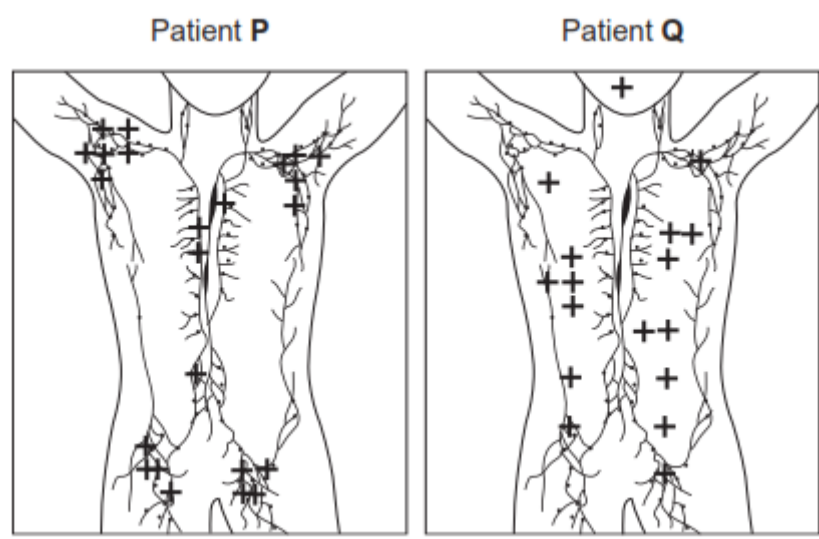


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(2)

The cancerous B-cells are found mainly in the lymphatic system of patients. Before treating any patient with Zevalin containing yttrium, doctors test the patient with a different form of Zevalin. This form has radioactive indium attached to the antibody instead of yttrium. The radioactivity from indium is strong enough for doctors to detect but not strong enough to kill a patient's cells.

The diagram shows the lymphatic systems of two patients, **P** and **Q**, after being given Zevalin with indium. The crosses (+) show where indium was detected.



- (b) The doctors decided they could treat Patient **P** with Zevalin containing yttrium but **not** Patient **Q**.  
Suggest why Patient **P** could be treated with Zevalin containing yttrium and Patient **Q** could not.

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(Extra space)

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(3)

- (c) Suggest **one** reason for the difference in distribution of the radioactivity detected in these patients.

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(2)

- (d) The antibody in Zevalin comes from mice. Patients are tested for antibodies against Zevalin before treatment for their cancer.  
Suggest why.

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(2)

(Total 9 marks)

**Q4.**

- (a) The MMR vaccine contains *attenuated* microorganisms.  
What is an *attenuated* microorganism?

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(2)

(b) A child was given the MMR vaccine and was given a second dose of the vaccine as a booster later.

(i) It took more than a week for antibodies to appear in the child's blood after the first vaccination. Explain why.

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(2)

(ii) The concentration of antibodies increased immediately after the second vaccination. Explain why.

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(2)

(Total 6 marks)

**Q5.**

Read the following passage.

An anti-gal antibody is a type of antibody that helps to fight infections caused by bacteria. If a person has a bacterial infection, for example *Salmonella*, anti-gal antibodies bind to antigens on the surface of the *Salmonella*. Not all the anti-gal antibodies are used to fight the infection. Even after the infection, anti-gal antibodies remain in the blood.

5

Scientists have made adaptor molecules to try to use the anti-gal antibodies against viruses such as HIV. The adaptor molecules are proteins. Each adaptor molecule had a receptor site to which the HIV binds. This receptor site was similar to the receptor site on human cells to which the HIV binds. The adaptor molecule has another site to which an anti-gal antibody will bind.

10

The scientists then investigated whether adding adaptor molecules and anti-gal antibodies can prevent HIV entering cells. They added adaptor molecules and anti-gal antibodies to a culture of human cells. They then added HIV to the culture. Their results showed that 90% of the virus particles failed to infect cells.

15

The scientists are hoping to develop a different type of adaptor molecule to use against MRSA.



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(6)

(c) (i) HIV infects some human cells, such as T-cells, but not others. Suggest why.

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(2)

(ii) Antibiotics are **not** used to treat viral infections, such as HIV. Explain why.

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(2)

(d) (i) When HIV, anti-gal and the *adaptor molecule* were added to a culture of human cells, 90% of the virus did **not** infect human cells. (lines 12-15). Explain why.

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(2)

(ii) Explain why a different type of adaptor molecule will have to be made to use against MRSA. (lines 16-17)

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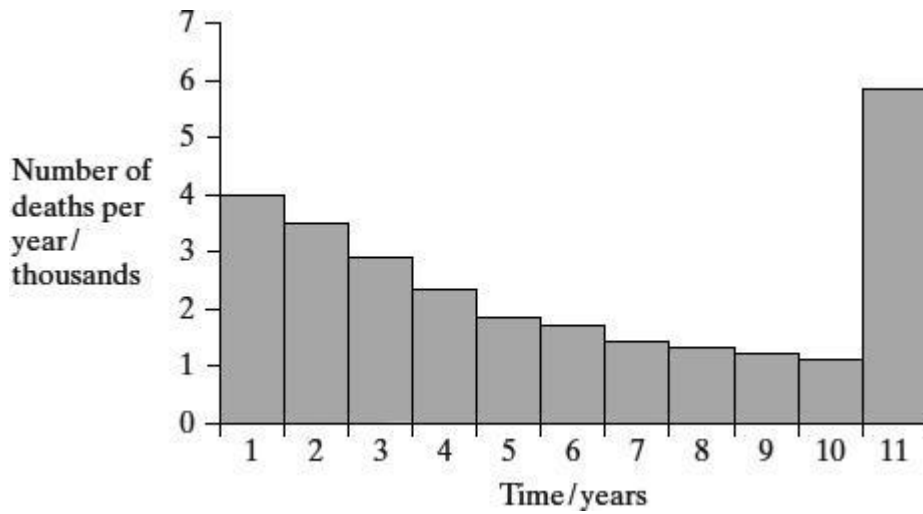
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(2)

(Total 20 marks)

**Q6.**

- (a) The graph shows the number of deaths from influenza per year in a developed country.



- (i) Suggest an explanation for the change in the number of deaths from influenza during the first 10 years.

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(1)

- (ii) Suggest an explanation for the large increase in the number of deaths from influenza in year 11.

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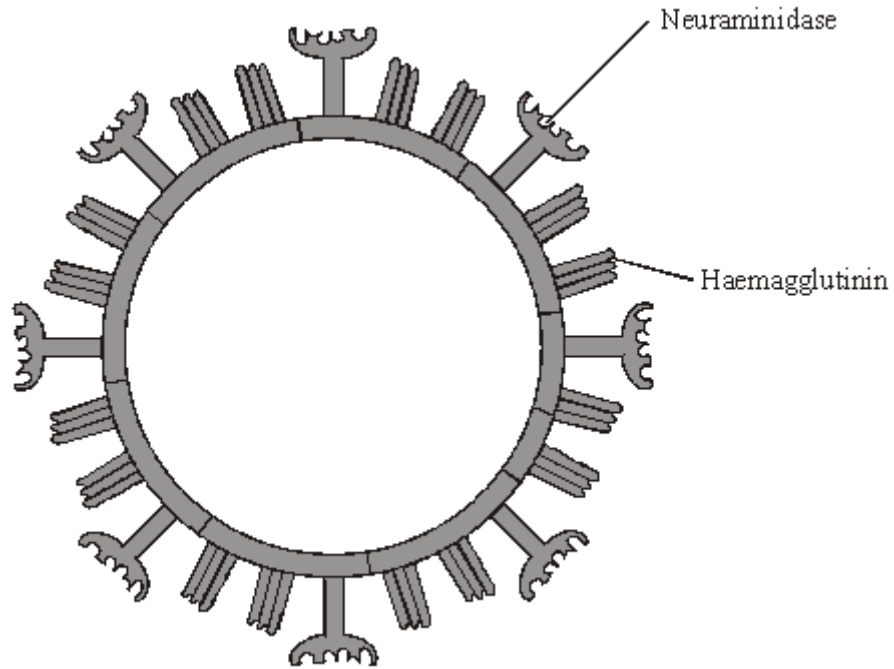
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(2)

- (b) The diagram shows some of the structures on the outside of an influenza virus.



Haemagglutinin and neuraminidase are protein molecules. Haemagglutinin binds to receptor molecules on the surface of epithelial cells in the breathing system. Neuraminidase is an enzyme which breaks down molecules in the surface membrane of epithelial cells and allows the viruses to be released from the cells.

(i) Describe how T lymphocytes recognise and respond to the influenza virus.

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(2)

(ii) Describe how B lymphocytes respond to the influenza virus.

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(2)

(c) New drugs have recently become available for treating influenza. One type is a neuraminidase inhibitor. Explain how this type of drug would act as a treatment for influenza.

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### 3.3.2 Gas Exchange

#### Q1.

- (a) Describe how air is taken into the lungs.

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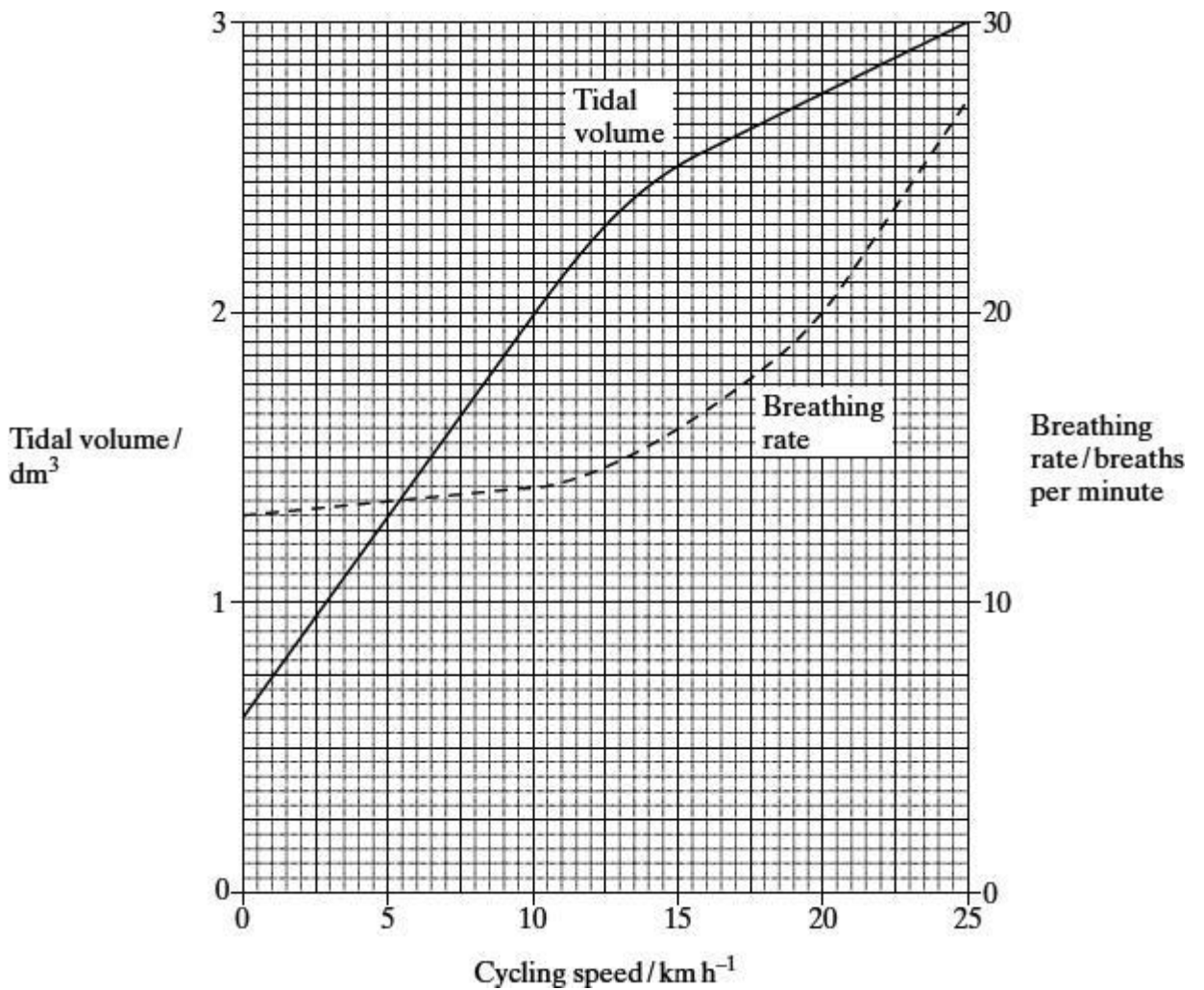
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(3)

The volume of air breathed in and out of the lungs during each breath is called the tidal volume. The breathing rate and tidal volume were measured for a cyclist pedalling at different speeds. The graph shows the results.



(b) Describe the **two** curves.

(i) Tidal volume

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(ii) Breathing rate

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(2)

(c) Calculate the total volume of air breathed in and out per minute when the cyclist is cycling at 20 km h<sup>-1</sup>. Show your working.

\_\_\_\_\_ dm<sup>3</sup>

(2)

(Total 7 marks)

**Q2.**

(a) When first hatched, the young of some species of fish are less than 2 mm long. Explain how these young fish get enough oxygen to their cells without having gills.

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(2)

(b) Mackerel are fast swimming fish whereas toadfish only swim slowly. The table shows some features of the gills of these fish.

	Thickness of lamellae / $\mu\text{m}$	Number of lamellae per mm of gill length
Mackerel	5	32
Toadfish	35	8

Use evidence from the table to explain how mackerel are able to swim faster than toadfish.

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(3)  
(Total 5 marks)

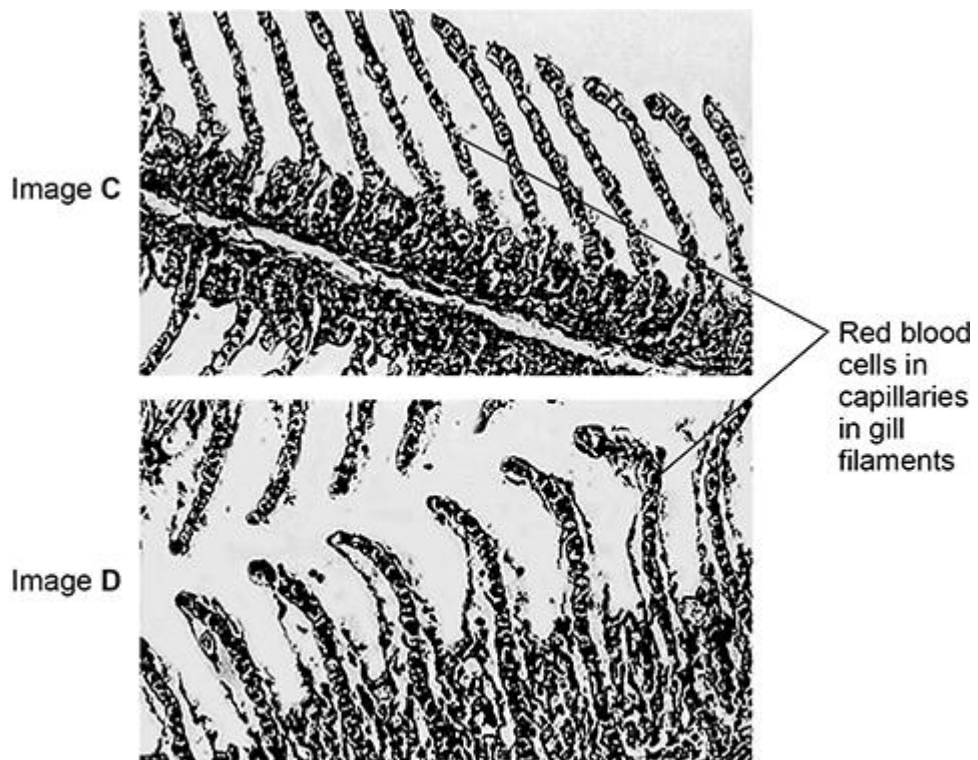
**Q3.**

**Figure 1** shows images of gills from two fish as seen through an optical microscope.

Image **C** shows gills from a fish with healthy gills.

Image **D** shows gills from a fish with damaged gills.

**Figure 1**



Magnification  $\times 160$

- (a) To observe the fish gills with the optical microscope, the scientists used **two** different stains. The first stain binds to DNA; the second stain binds to the red blood cells.

Explain why a second stain would be needed to stain the red blood cells. Suggest which molecule the stain could bind to in the red blood cells.

Explanation \_\_\_\_\_

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Molecule \_\_\_\_\_

(2)

- (b) Using **Figure 1**, the scientists calculated the surface area to volume ratios for each gill filament in these two fish. Some of their results are shown in **Table 1**.

Complete **Table 1**. State your calculated volume and surface area:volume ratio to 2 significant figures.

**Table 1**

Fish gill	Surface area / $\mu\text{m}^2$	Volume / $\mu\text{m}^3$	Surface area:volume ratio
Healthy	$7.4 \times 10^3$	$2.3 \times 10^4$	_____
Damaged	$1.1 \times 10^4$	_____	0.13:1

(2)

- (c) The damage to the gills causes uncontrolled cell division in the cells around the capillaries in the gill filaments.

Other than surface area:volume ratio, describe **one** way this uncontrolled cell division changes the gills, as shown in **Figure 1**.

Explain how this difference would affect gas exchange.

Difference \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Explanation \_\_\_\_\_

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\_\_\_\_\_

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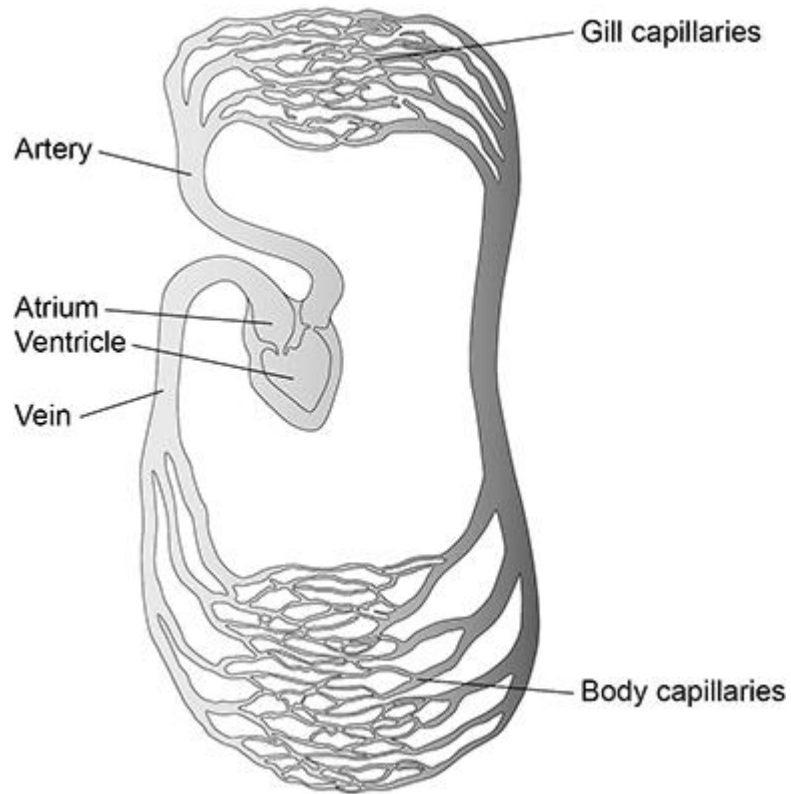
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(3)

**Figure 2** shows the general pattern of blood circulation in fish.

**Figure 2**



(d) Use **Figure 2** to complete **Table 2** to show **two** differences between the circulation of blood in fish and the circulation of blood in a mammal.

**Table 2**

Difference	Circulation of blood in fish	Circulation of blood in mammal
1		
2		

(2)  
(Total 9 marks)

**Q4.**

(a) Describe **two** differences between active transport and facilitated diffusion.

1. \_\_\_\_\_  
\_\_\_\_\_

2. \_\_\_\_\_  
\_\_\_\_\_

(2)

(b) Explain why molecules of oxygen and carbon dioxide are able to diffuse across membranes.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

(c) Explain why ventilation of the lungs increases the efficiency of gas exchange.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

(Total 6 marks)

**Q5.**

(a) Describe how the structure of the insect gas exchange system:

- provides cells with sufficient oxygen
- limits water loss.

Explain your answers.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



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(6)

**Table 1** compares some features of water and air.

Feature	Water	Air
Relative density	1000	1
Maximum concentration of oxygen / $\text{cm}^3 \text{dm}^{-3}$	9	130

**Table 1**

**Table 2** shows some features of gas exchange in a fish and in a mammal.

Feature	Fish	Mammal
Percentage of oxygen extracted from water or air	80	25
Oxygen consumption at rest / $\text{cm}^3 \text{kg}^{-1} \text{hour}^{-1}$	100	200

**Table 2**

- (b) (i) The fish has a body mass of 0.2 kg. Calculate the volume of water it will need to pass over its gills each hour to supply the oxygen required when resting. Show your working.

Answer \_\_\_\_\_  $\text{dm}^3 / \text{hour}^{-1}$

(2)

- (ii) Ventilation in mammals involves movement of air to and from the gas exchange surface in a tidal pattern. Using information in the tables, explain

why it is easier to move water over the gas exchange surface of a fish in one direction rather than in a tidal pattern.

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**(2)**

- (c) A rise in the temperature of water decreases the amount of oxygen dissolved in the water. As the water temperature rises, the rate of ventilation in a fish also rises. Explain the advantage of this.

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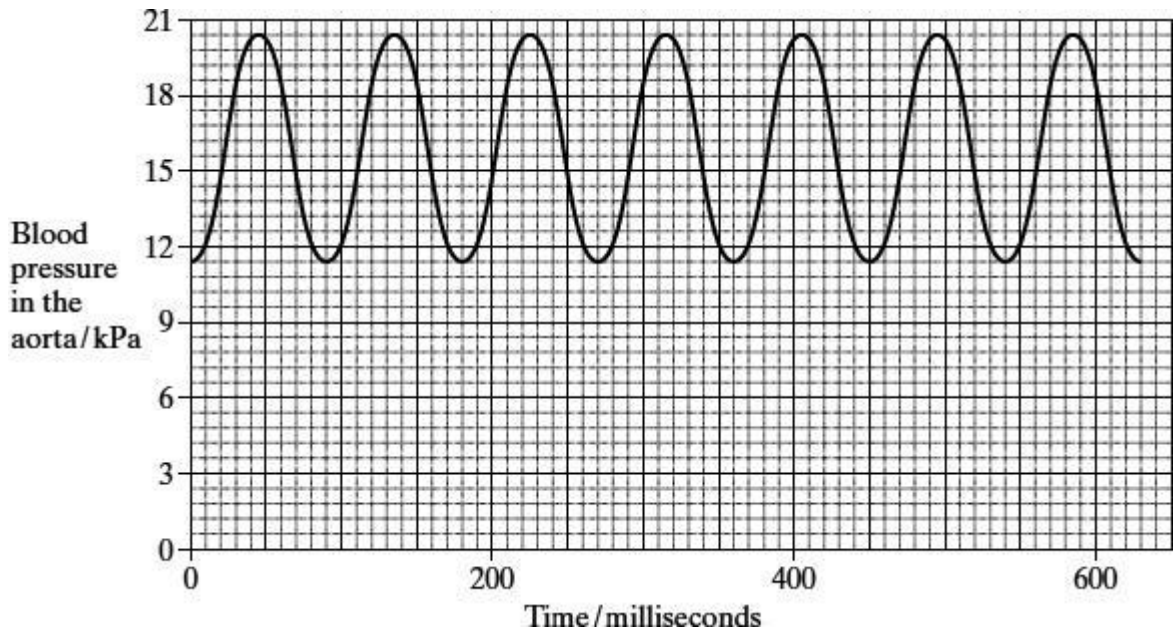
**(2)**

**(Total 12 marks)**

### 3.3.4.1 Mass transport in animals

#### Q1.

The graph shows the changes in pressure which take place in the aorta of a mouse during several heartbeats.



- (a) Which chamber of the heart produces the increase in pressure recorded in the aorta?

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(1)

- (b) The pressure of blood in the aorta decreases during each heartbeat but does not fall below 10 kPa. Explain what causes the pressure of blood to

- (i) decrease during each heartbeat;

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(1)

- (ii) stay above 10 kPa.

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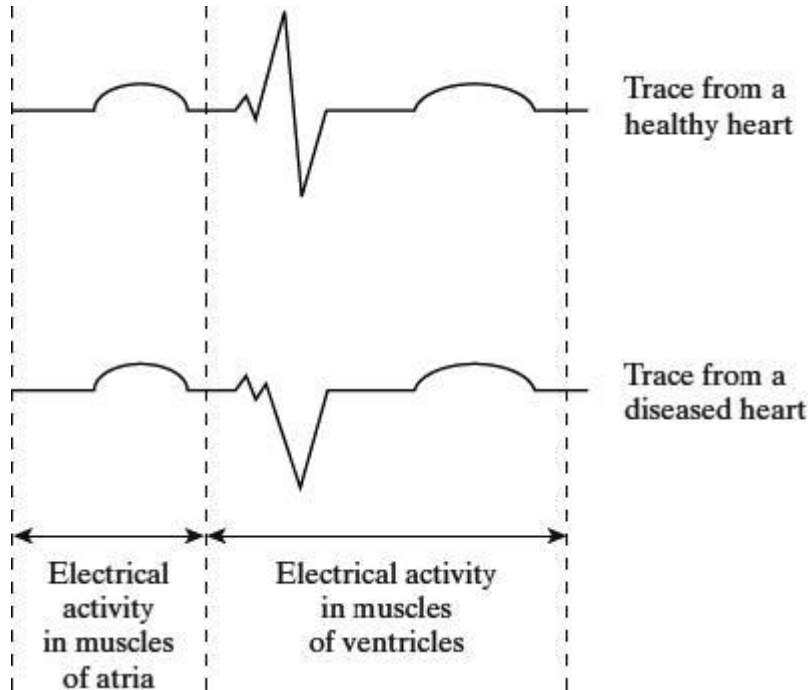
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(2)



(6)

- (b) An electrocardiogram (ECG) measures the electrical changes occurring in cardiac muscle as a heart is beating. An ECG trace for a healthy person and an ECG trace for a person suffering from heart disease are shown.



- (i) Describe the route taken when electrical impulses are transmitted from the sinoatrial node to the muscles of the ventricles in a healthy heart.

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(2)

- (ii) Explain how information from these ECG traces suggests that the damage caused to the diseased heart is unlikely to have affected the sinoatrial node.

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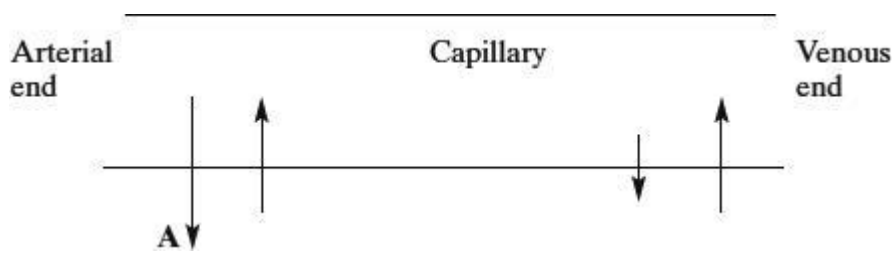
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(2)

(Total 10 marks)

Q3.

Tissue fluid is formed when water and small molecules pass out of capillaries at their arterial end. The diagram shows some pressures involved in tissue fluid formation. The relative lengths of the arrows indicate the size of the pressures.



- (a) What causes the pressure represented by the arrow labelled **A**?

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(1)

- (b) Explain why there is a net loss of water from a capillary at the arterial end.

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(2)

- (c) The total volume of fluid that passes from the capillaries to the surrounding tissue fluid is normally greater than the volume that is reabsorbed into them. Describe what happens to this extra fluid.

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(2)

- (d) Tissue fluid accumulates in the tissues of people who do not eat enough protein. Explain why.

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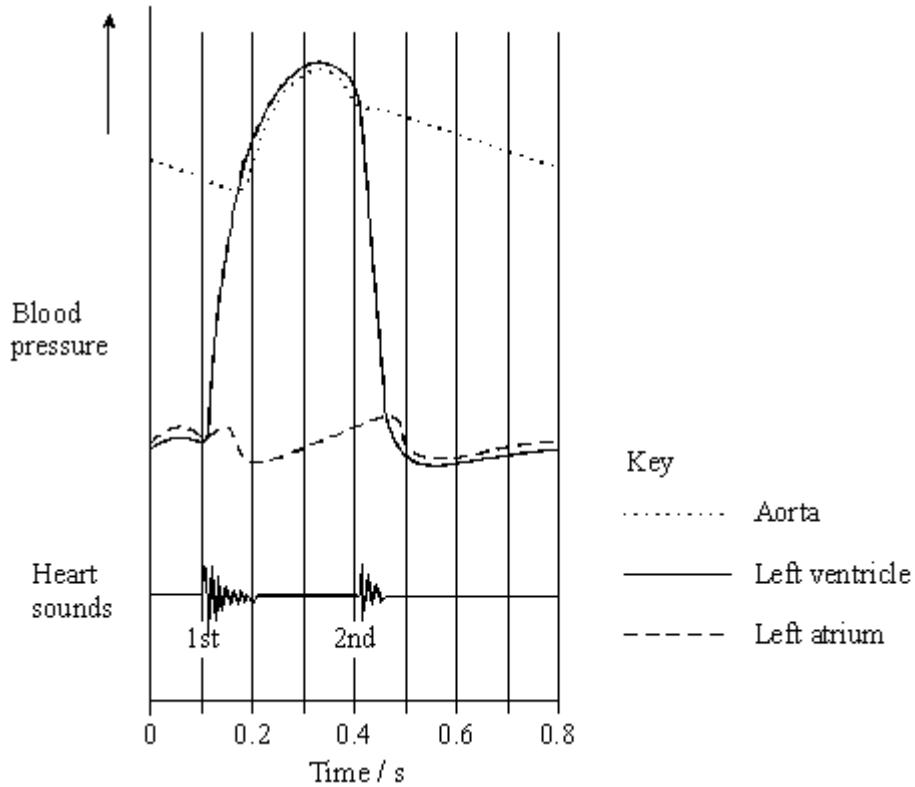
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(2)

(Total 7 marks)

**Q4.**

The graph shows changes in pressure in the aorta, left ventricle and left atrium during one heart beat.



- (a) The maximum pressure in the left atrium is lower than the maximum pressure in the left ventricle. What causes this difference in maximum pressure?

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(1)

- (b) A stethoscope can be used to listen to the sounds made by the heart.

- (i) What is the evidence from the graph that the first heart sound is caused by the atrioventricular valve closing?

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(1)

- (ii) What causes the second heart sound? Give the reason for your answer.

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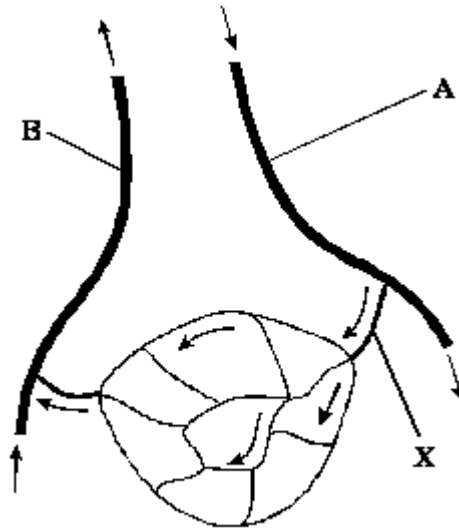
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(2)

(Total 4 marks)

**Q5.**

The diagram shows some blood vessels in muscle tissue.



Not drawn to scale

- (a) (i) Which type of blood vessel is **X**?

\_\_\_\_\_

(1)

- (ii) Name **two** substances which are at a higher concentration in the blood at **A** than in the blood at **B**.

1. \_\_\_\_\_

2. \_\_\_\_\_

(1)

- (b) The table shows the mean diameter of the lumen and the rate of blood flow in some types of human blood vessel.

Type of blood vessel	Mean diameter of lumen / $\mu\text{m}$	Rate of blood flow / $\text{cm s}^{-1}$
Artery	400	10 – 40
Arteriole	30	0.1 – 10
Capillary	8	less than 0.1

Using information in the table, explain what causes the rate of blood flow to be slower in capillaries than in other vessels.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(2)

(c) (i) Which type of blood vessel has most elastic tissue in its wall?

\_\_\_\_\_

(1)

(ii) How does this elastic tissue help to smooth out the flow of blood in the blood vessel?

\_\_\_\_\_

\_\_\_\_\_

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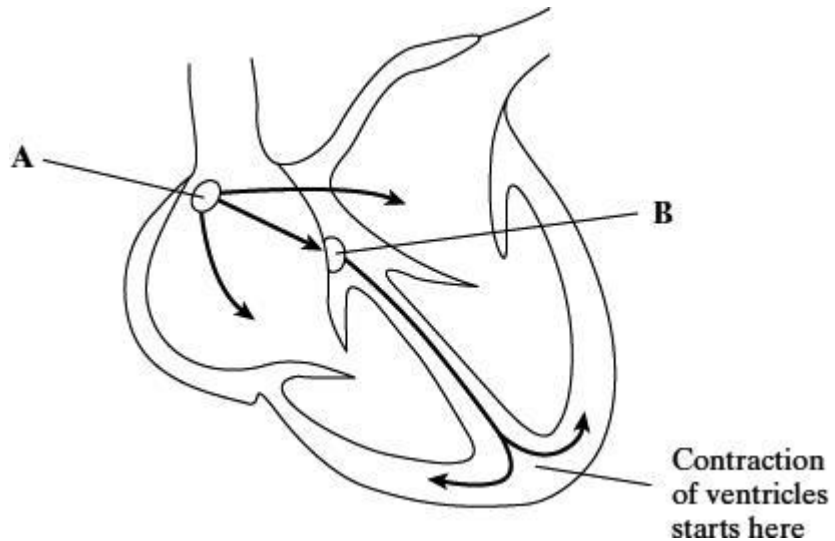
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(2)

(Total 7 marks)

**Q6.**

The diagram shows the pathways in the heart for the conduction of electrical impulses during the cardiac cycle.



(a) The table shows the blood pressure in the left atrium, the left ventricle and the aorta at different times during part of a cardiac cycle.

Time / s	Blood pressure / kPa		
	Left atrium	Left ventricle	Aorta
0.0	0.5	0.4	10.6
0.1	1.2	0.7	10.6
0.2	0.3	6.7	10.6
0.3	0.4	17.3	16.0

0.4	0.8	8.0	12.0
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(i) At which time is blood flowing into the aorta?

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(1)

(ii) Between which times are the atrioventricular valves closed?

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(1)

(b) The maximum pressure in the left ventricle is higher than the maximum pressure in the right ventricle. What causes this difference in pressure?










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(1)

(c) The information below compares some features of different blood vessels.

		Blood vessel		
		Artery	Capillary	Vain
<b>Property</b>	Mean diameter of vessel	4.0 mm	8.0 $\mu\text{m}$	5.0 mm
	Mean thickness of wall	1.0 mm	0.5 $\mu\text{m}$	0.5 mm
		<b>Relative thickness (shown by length of bar)</b>		
<b>Tissues present in wall</b>	Endothelium			
	Elastic tissue			
	Muscle			

Use the information to explain how the structures of the walls of arteries, veins and capillaries are related to their functions.

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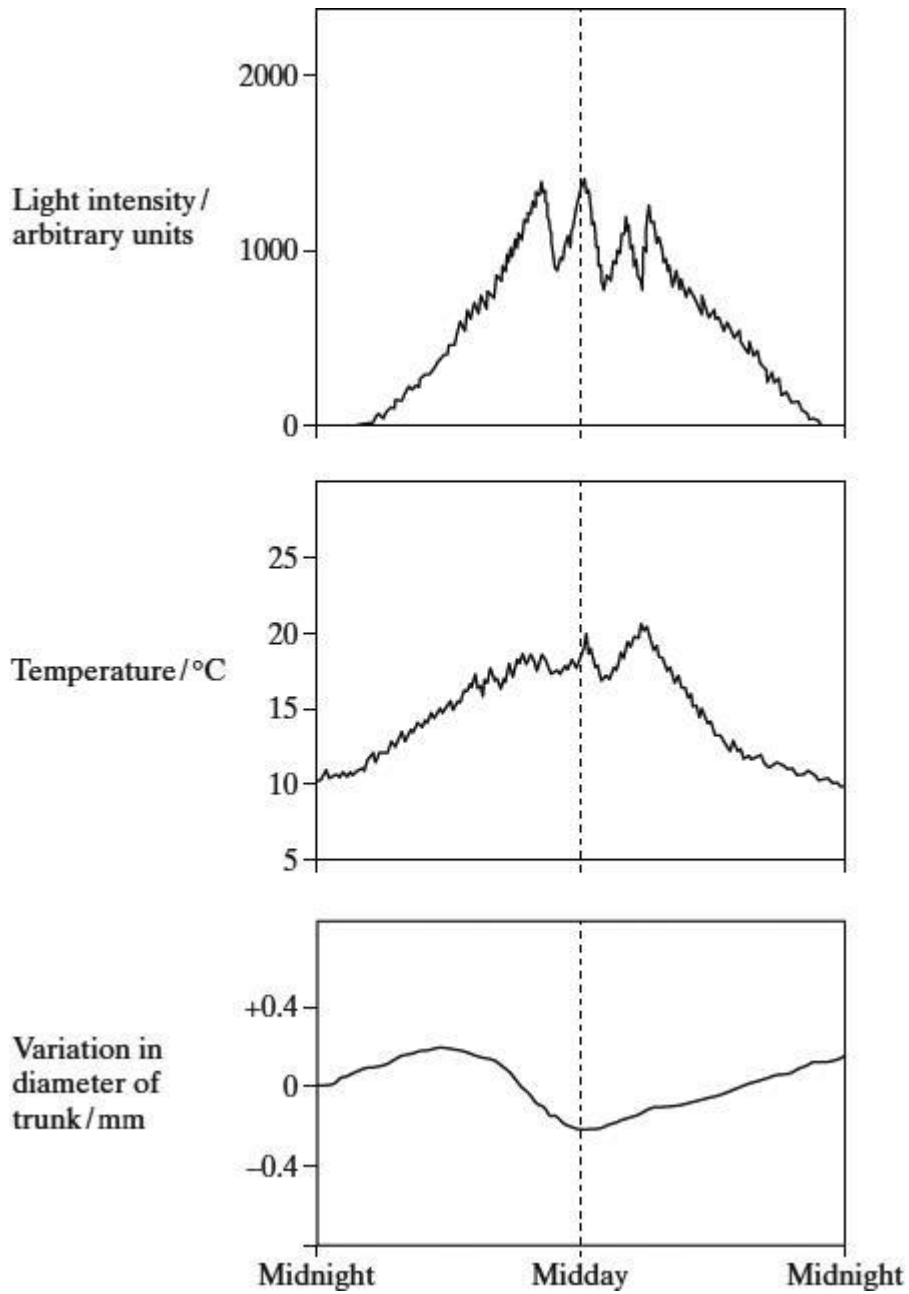
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(6)  
(Total 9 marks)

**3.3.4.2 Mass transport in plants**

**Q1.**

- (a) The graphs show the daily changes in environmental temperature and light intensity, and changes in the diameter of the trunk of a pine tree.



Use information from the graphs, and your knowledge of the cohesion-tension theory of water movement through a plant, to explain why the diameter of the trunk is smallest at midday.

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(6)

- (b) Describe and explain **three** ways in which the leaves of xerophytic plants may be adapted to reduce water loss.

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(3)

(Total 9 marks)

**Q2.**

- (a) Describe how water is moved through a plant according to the *cohesion-tension* hypothesis.

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(4)

- (b) The mass of water lost from a plant was investigated. The same plant was used in every treatment and the plant was subjected to identical environmental conditions. In some treatments, the leaves were coated with a type of grease. This grease provides a waterproof barrier. The results of the investigation are given in the table.

Treatment	Mass lost in 5 days / g
No grease applied	10.0
Grease applied only to the upper surface of every leaf	8.7
Grease applied to both surfaces of every leaf	0.1

(i) What is the advantage of using the same plant in every treatment?

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(1)

(ii) Why was it important to keep the environmental conditions constant?

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(1)

(iii) What is the evidence that the grease provides a waterproof barrier?

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(1)

(c) (i) Calculate the mass of water lost in 5 days through the upper surface of the leaves.

Answer \_\_\_\_\_

(1)

(ii) Use your knowledge of leaf structure to explain why less water is lost through the upper surface of leaves than is lost through the lower surface.

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(2)

(Total 10 marks)

**Q3.**

(a) Explain how each of the following is related to the function of xylem tissue.

(i) Xylem tissue contains hollow tubes.

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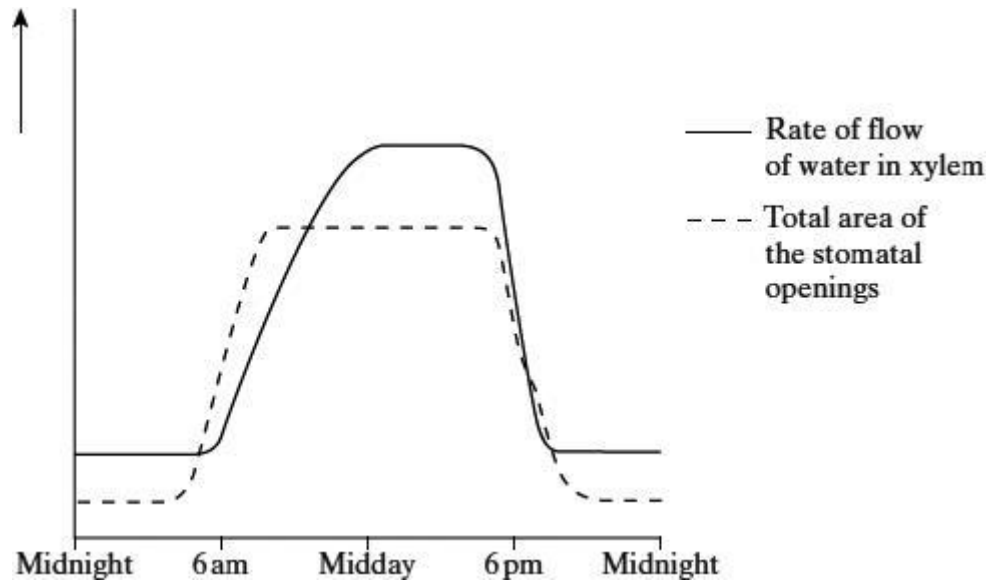
(ii) Lignin is present in xylem cell walls.

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(2)

(b) In an investigation the total area of the stomatal openings and the rate of flow of water through xylem were measured in a plant over a period of 24 hours. The results are shown in the graph.



(i) Describe the relationship between the rate of flow of water and the total area of the stomatal openings for the period of time between midday and midnight.

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(1)

(ii) Between 8 am and midday the rate of flow of water continues to rise although the total area of the stomatal openings remains constant. Explain why the rate of flow of water rises.

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(1)

(iii) How would the curve showing the total area of the stomatal openings differ if the investigation was repeated on a dull day?

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(1)

- (c) Some xerophytic plants have sunken stomata. Explain the advantage of this adaptation.

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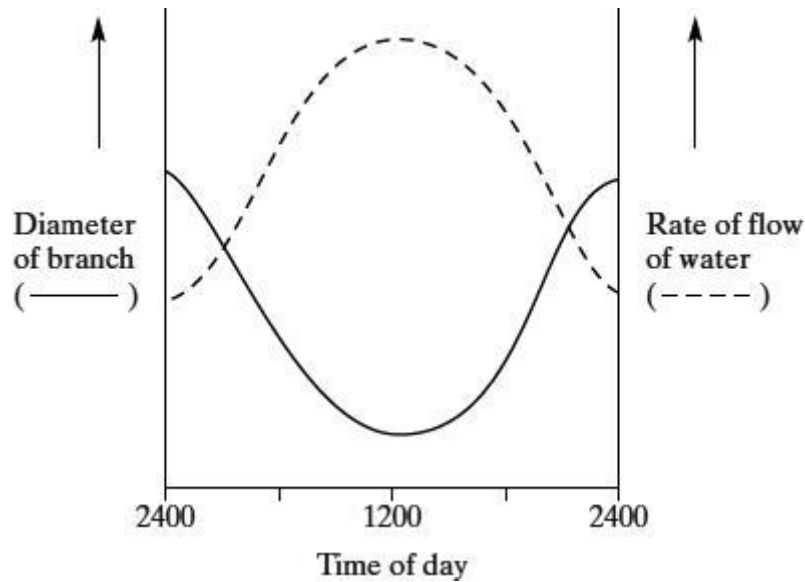
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(2)

(Total 7 marks)

**Q4.**

- (a) The diameter of a branch of a tree and the rate of flow of water through the branch were measured over a 24-hour period. The results are shown in the graph.



Using your knowledge of cohesion-tension theory

- (i) describe and explain the changes in rate of flow of water in the branch over the 24 hour period;

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(3)

- (ii) explain why the diameter of the branch decreased during the first 12 hours.

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(1)

- (b) A stem was cut from a transpiring plant. The cut end of the stem was put into a solution of picric acid, which kills plant cells. The transpiration stream continued. Suggest an explanation for this observation.

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(2)

(Total 6 marks)

**Q5.**

- (a) The table shows the transpiration rate of a group of plants exposed to different humidities at a temperature of 25°C.

Humidity / %	Transpiration rate / arbitrary units
20	26.0
40	21.0
50	16.5
60	11.0
70	9.5

Describe and explain the relationship between humidity and transpiration rate.

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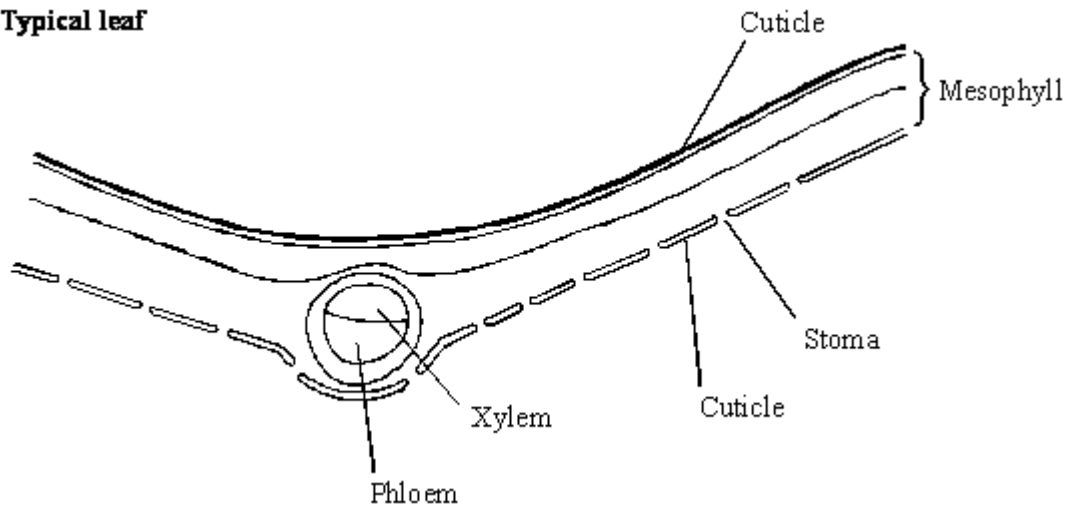
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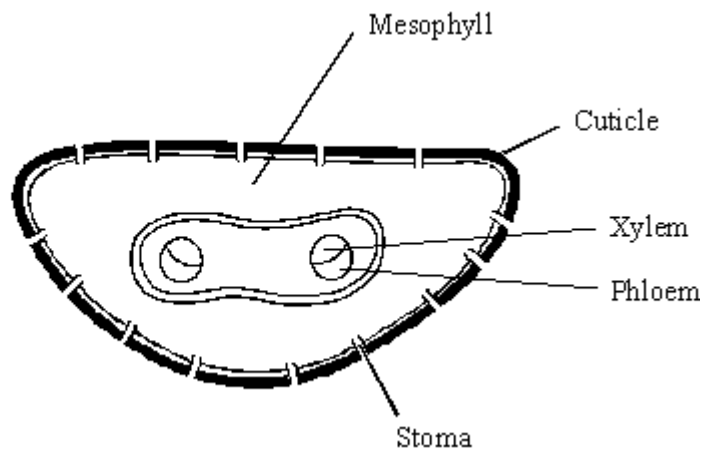
(3)

- (b) The diagrams show a section through a typical leaf and a section through a leaf from a xerophytic plant. The xerophytic leaf has a lower transpiration rate than the typical leaf.

**Typical leaf**



**Xerophytic leaf**



Describe **two** features shown in the diagram of the xerophytic leaf which reduce transpiration rate. Explain how each of these features contributes to a lower transpiration rate.

Feature 1 \_\_\_\_\_

Explanation \_\_\_\_\_

Feature 2 \_\_\_\_\_

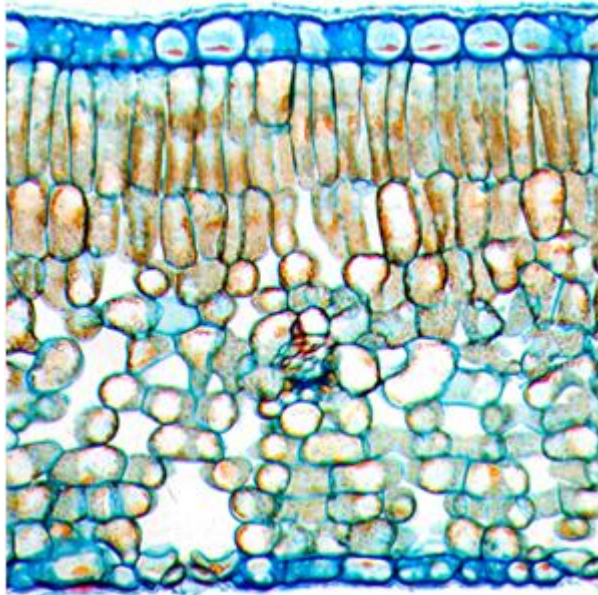
Explanation \_\_\_\_\_

(4)

(Total 7 marks)

**Q6.**

The figure below is a photograph of a vertical section through a leaf observed using an optical microscope.



(a) In the box below:

- produce a scientific drawing of the arrangement of tissues shown in the figure above
- label **one** of the tissues in your drawing

Do **not** draw individual cells.



(3)

A scientist investigated factors that affect the shelf life of cut flowers.

A cut flower is the part of the stem with the flower bud attached after it has been cut from a plant.

The shelf life is the number of days the cut flowers are in good enough condition to be sold.

He:

- took 12 cut flowers from a rose plant
- determined the mean number of stomata per  $\text{mm}^2$  on the leaves
- determined the transpiration rate for each cutting
- stored the cut flowers on a shelf in a brightly lit room
- determined the shelf life of the cut flowers.

The table below shows his results.



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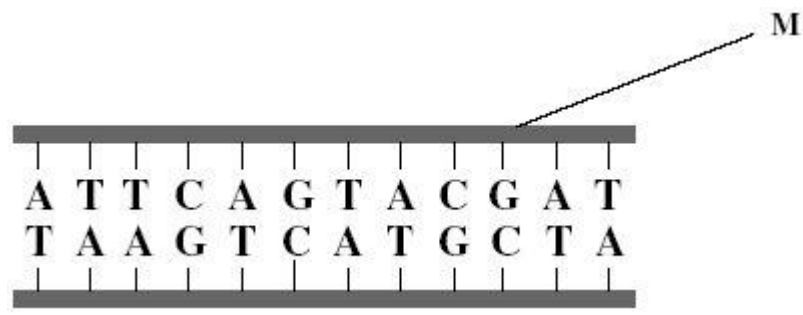
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(3)  
(Total 10 marks)

**3.4.1 DNA, genes and chromosomes**

**Q1.**

The diagram shows part of a DNA molecule.



- (a) Name the **two** components of the part of the DNA molecule labelled **M**.
1. \_\_\_\_\_
2. \_\_\_\_\_

(2)

- (b) What is the maximum number of amino acids for which this piece of DNA could code?

(1)

- (c) Scientists calculated the percentage of different bases in the DNA from a species of bacterium. They found that 14% of the bases were guanine.

- (i) What percentage of the bases in this species of bacterium was cytosine?

Answer \_\_\_\_\_

(1)

- (ii) What percentage of the bases in this species of bacterium was adenine?

Answer \_\_\_\_\_

(1)

- (d) The scientists found that, in a second species of bacterium, 29% of the bases were guanine.

Explain the difference in the percentage of guanine bases in the two species of bacterium.

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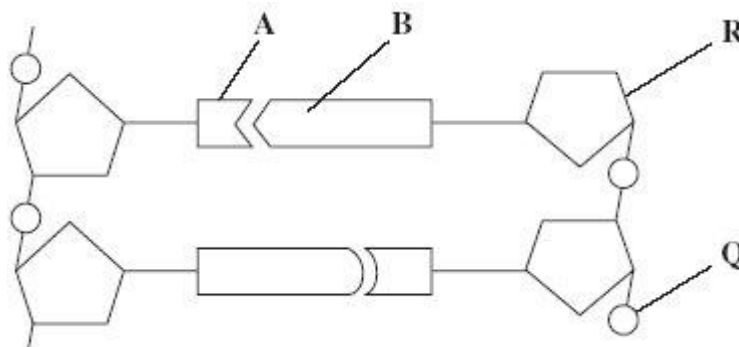
(2)

(Total 7 marks)

**Q2.**

**Figure 1** shows a short section of a DNA molecule.

**Figure 1**



- (a) Name parts **R** and **Q**.

(i) **R** \_\_\_\_\_

(ii) **Q** \_\_\_\_\_

(2)

- (b) Name the bonds that join **A** and **B**.

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(1)

- (c) Ribonuclease is an enzyme. It is 127 amino acids long.

What is the minimum number of DNA bases needed to code for ribonuclease?

(1)

- (d) **Figure 2** shows the sequence of DNA bases coding for seven amino acids in the enzyme ribonuclease.

**Figure 2**

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

The number of each type of amino acid coded for by this sequence of DNA bases is shown in the table.

Amino acid	Number present
Arg	3
Met	2
Gln	1
Asn	1

Use the table and **Figure 2** to work out the sequence of amino acids in this part of the enzyme. Write your answer in the boxes below.

Gln						
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(1)

- (e) Explain how a change in a sequence of DNA bases could result in a non-functional enzyme.

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(3)

(Total 8 marks)

**Q3.**

The diagram shows a short sequence of DNA bases.

**TTTGTATACTAGTCTACTTCGTTAATA**

- (a) (i) What is the maximum number of amino acids for which this sequence of DNA bases could code?



(1)

- (ii) The number of amino acids coded for could be fewer than your answer to part (a)(i).

Give **one** reason why.

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(1)

- (b) Explain how a change in the DNA base sequence for a protein may result in a change in the structure of the protein.

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(3)

- (c) A piece of DNA consisted of 74 base pairs. The two strands of the DNA, strands **A** and **B**, were analysed to find the **number** of bases of each type that were present. Some of the results are shown in the table.

	Number of bases			
	C	G	A	T
Strand A	26			
Strand B	19		9	

Complete the table by writing in the missing values.

(2)

(Total 7 marks)

### 3.4.2 DNA and protein synthesis

#### Q1.

- (a) What is a gene?

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(1)

- (b) Describe how the production of messenger RNA (mRNA) in a eukaryote cell is different from the production of mRNA in a prokaryote cell.

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(2)

- (c) Scientists produced a short, single-stranded, artificial nucleic acid, called PNA. The PNA binds to a small section of DNA.

The scientists introduced PNA into cells and discovered that these cells produced less mRNA than cells that did not contain PNA.

Suggest how PNA affected the transcription of the section of DNA.

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(2)

- (d) Describe the role of ATP in the process of translation in protein synthesis.

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(2)

**(Total 7 marks)**

**Q2.**

(a) Give the **two** types of molecule from which a ribosome is made.

1 \_\_\_\_\_

2 \_\_\_\_\_

(2)

(b) Complete the table to give **four** structural differences between a DNA molecule and an mRNA molecule.

	DNA structure	mRNA structure
1		
2		
3		
4		

(4)

(Total 6 marks)

**Q3.**

(a) Complete the table to give **two** differences between DNA and RNA.

Difference	DNA	RNA
1		
2		

(2)

(b) Describe the part played by RNA in protein synthesis.

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(Extra space) \_\_\_\_\_

(3)  
(Total 5 marks)

**Q4.**

- (a) (i) What is the role of RNA polymerase in transcription?

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(1)

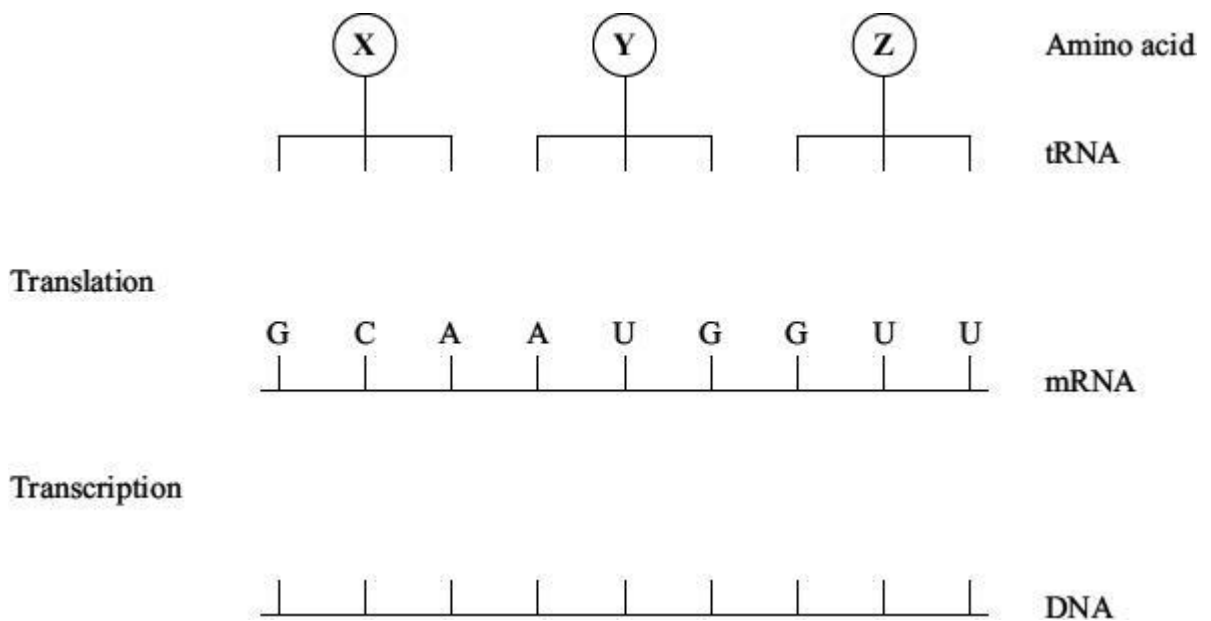
- (ii) Name the organelle involved in translation.

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(1)

- (b) **Figure 1** shows some molecules involved in protein synthesis.

**Figure 1**



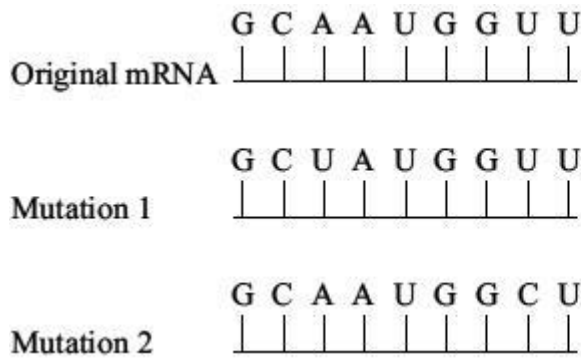
Complete **Figure 1** to show

- (i) the bases on the DNA strand from which the mRNA was transcribed;  
(ii) the bases forming the anticodons of the tRNA molecules.

(2)

**Figure 2** shows the effects of two different mutations of the DNA on the base sequence of the mRNA. The table shows the mRNA codons for three amino acids.

**Figure 2**



Amino acid	mRNA codon
methionine	AUG
valine	GUC GUU
alanine	GCA GCC GCU

(c) Name the type of mutation represented by mutation 1.

\_\_\_\_\_ (1)

(d) Use the information in the table to

(i) identify amino acid **X** in **Figure 1**;

\_\_\_\_\_ (1)

(ii) explain how each mutation may affect the polypeptide for which this section of DNA is part of the code.

Mutation 1 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ (2)

Mutation 2 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ (2)

(Total 10 marks)

**Q5.**

Lysozyme is an enzyme consisting of a single polypeptide chain of 129 amino acids.

(a) What is the minimum number of nucleotide bases needed to code for this enzyme?

\_\_\_\_\_ (1)

(b) The diagram shows the sequence of bases in a section of the mRNA strand used to synthesise this enzyme.

G G U C U U U C U U A U G G U A G A U A U

- (i) Give the DNA sequence which would be complementary to the first four bases in this section of mRNA.

\_\_\_\_\_

(1)

- (ii) How many different types of tRNA molecule would attach to the section of mRNA shown in the diagram?

\_\_\_\_\_

(1)

- (c) Give **two** factors which might increase the frequency at which a mutation in DNA occurs.

1. \_\_\_\_\_

2. \_\_\_\_\_

(2)

- (d) Two single base mutations occurred in the DNA coding for this section of mRNA. These mutations caused an alteration in the sequence of amino acids in the enzyme. The diagram shows the original and altered sequences of amino acids.

Original amino acid sequence	Gly	Leu	Ser	Tyr	Gly	Arg	Tyr
Original mRNA base sequence	GGU	CUU	UCU	UAU	GGU	AGA	UAU

Altered amino acid sequence	Gly	Leu	Tyr	Leu	Trp	Arg	Tyr
Altered mRNA base sequence	GGU	CUU				AGA	UAU

- (i) Use the mRNA codons provided in the table to complete the altered mRNA base sequence in the diagram.

Amino acid	mRNA codons which can be used
Arg	AGA
Gly	GGU
Leu	CUU or UUA
Ser	UCU
Trp	UGG
Tyr	UAU or UAC

(1)

- (ii) Use the information provided to determine the precise nature of the **two** single base mutations in the DNA.

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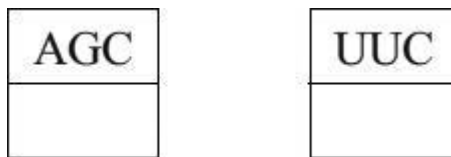
(3)

(Total 9 marks)

**Q6.**

- (a) **Figure 1** shows the exposed bases (anticodons) of two tRNA molecules involved in the synthesis of a protein.

**Figure 1**



Complete the boxes to show the sequence of bases found along the corresponding section of the coding DNA strand.

(2)

- (b) Describe the role of tRNA in the process of translation.

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(3)

- (c) **Figure 2** shows the sequence of bases in a section of DNA coding for a polypeptide of seven amino acids.

**Figure 2**

TACAAGGTCGTCTTTGTCAAG

The polypeptide was hydrolysed. It contained four different amino acids. The number of each type obtained is shown in the table.

Amino acid	Number present
Phe	2
Met	1
Lys	1
Gln	3

Use the base sequence shown in **Figure 2** to work out the order of amino acids in the polypeptide. Write your answer in the table below.

Met						
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(2)

(Total 7 marks)

### 3.4.3 – Genetic diversity can arise as a result of mutation or during meiosis

#### Q1.

(a) Describe viral replication.

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(3)

(b) Complete the table below by putting a tick (✓) where the feature is part of a cell cycle involving mitosis or a cell cycle involving binary fission.

Feature	Cell cycle involving:	
	mitosis	binary fission

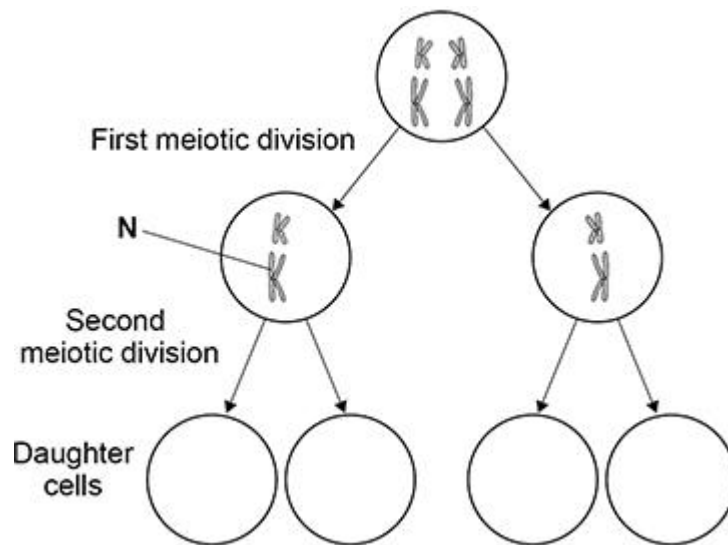
Replication of linear DNA		
Replication of circular DNA		
Produces 2 daughter cells		
Produces 4 daughter cells		
Happens in prokaryotic cells		
Happens in eukaryotic cells		

(2)

**Figure 1** represents a cell undergoing meiosis. It shows the chromosomes in the parent cell and in the two cells formed after the first meiotic division.

The second division of meiosis proceeds normally except that non-disjunction occurs in the chromosome labelled **N**.

**Figure 1**



(b) Complete **Figure 1** to show the chromosomes inside the daughter cells formed after the second meiotic division.

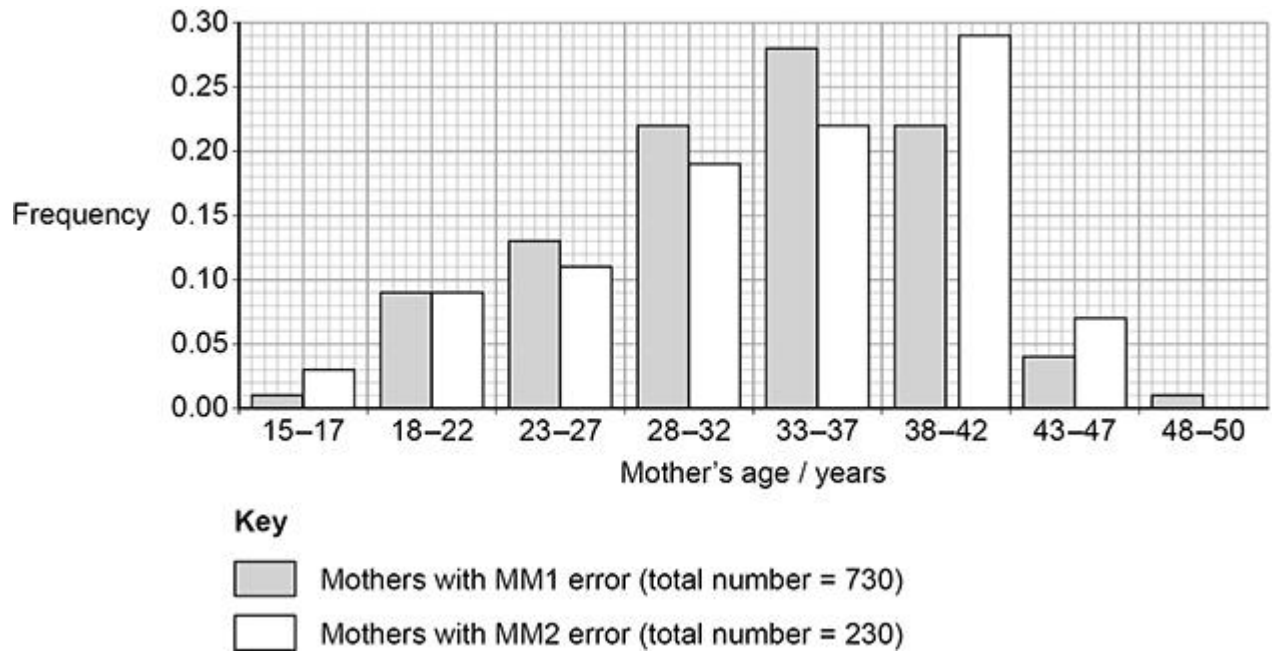
(2)

Doctors studied babies born with a mutation caused by chromosome non-disjunction during gamete formation in their mother.

They determined each mother's age at the time of childbirth and whether the non-disjunction happened in the first meiotic division (MM1 error) or in the second meiotic division (MM2 error).

**Figure 2** shows the doctors' results.

**Figure 2**



- (d) A student concluded that there were more mothers of age >37 with MM2 errors than with MM1 errors.

Using **Figure 2** and suitable calculations show why this conclusion is **not** valid.

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(2)  
(Total 9 marks)

**Q2.**

- (a) Describe how the process of meiosis results in haploid cells.  
Do **not** include descriptions of how genetic variation is produced in meiosis.

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(4)

- (b) **Figure 1** shows the arrangement of chromosomes in a cell during the first meiotic division.

**Figure 1**



A scientist observed 300 cells. All of the cells were at exactly the same stage of meiosis as the cell shown in **Figure 1**.

Use your knowledge of the independent segregation of homologous chromosomes to calculate how many of these cells are expected to have an **identical arrangement** of chromosomes to those shown in **Figure 1**. Assume no crossing over occurs.

Answer \_\_\_\_\_

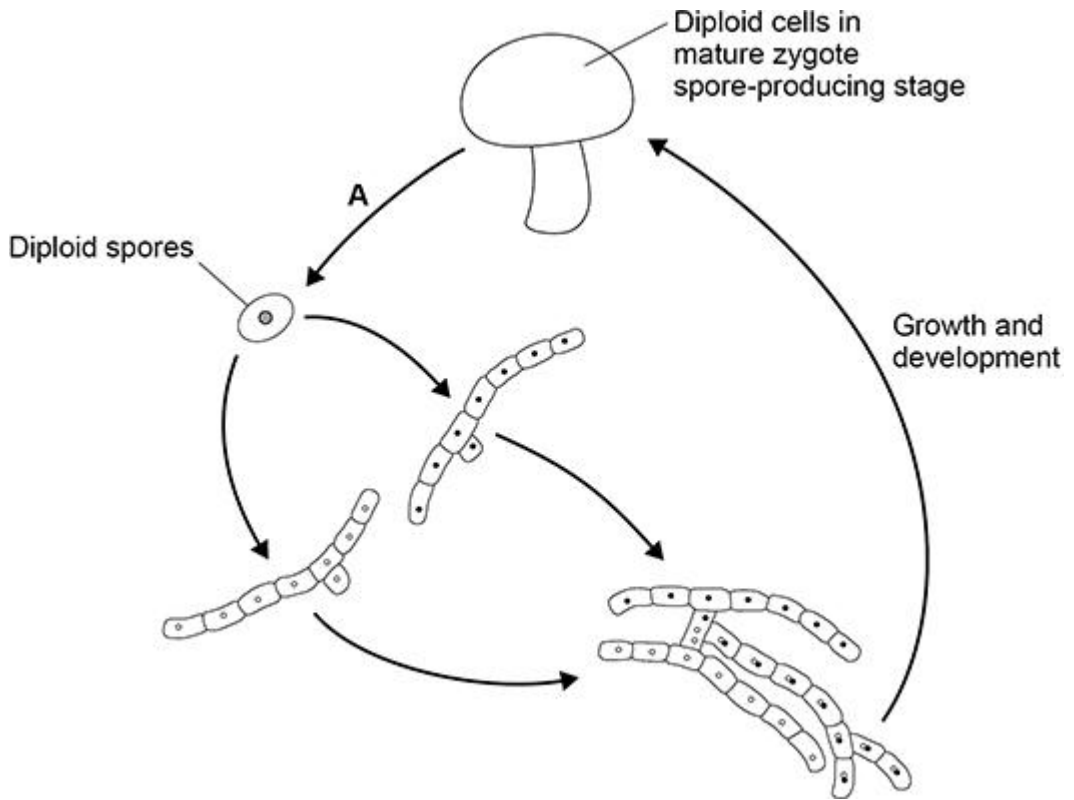
(2)

- (c) Draw a diagram to show the chromosomes in one gamete produced by meiosis from the cell shown in **Figure 1**.

(1)

- (d) **Figure 2** shows the life cycle of a fungus. The life cycle includes sexual reproduction.

**Figure 2**



What is the name of the process shown by arrow **A** in **Figure 2**?

Tick (✓) **one** box.

- Binary fission
- Fertilisation
- Meiosis
- Mitosis

(1)  
(Total 8 marks)

**Q3.**

- (a) Explain the importance of meiosis in the life cycles of organisms which reproduce sexually.

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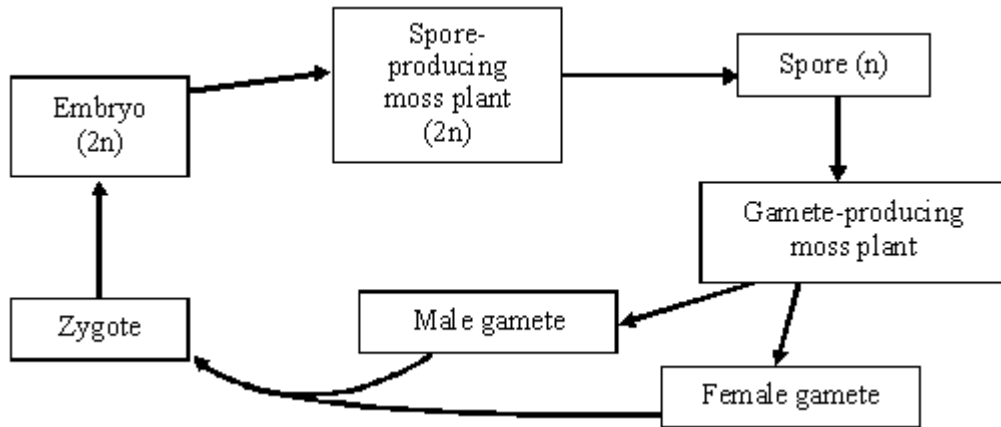
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(3)

(b) The diagram shows the life cycle of a moss plant.



On the diagram mark with an **M** where meiosis takes place.

(1)

(Total 4 marks)

**Q4.**

(a) During meiosis, one chromosome from each homologous pair goes to each of the cells produced. Explain why this is important.

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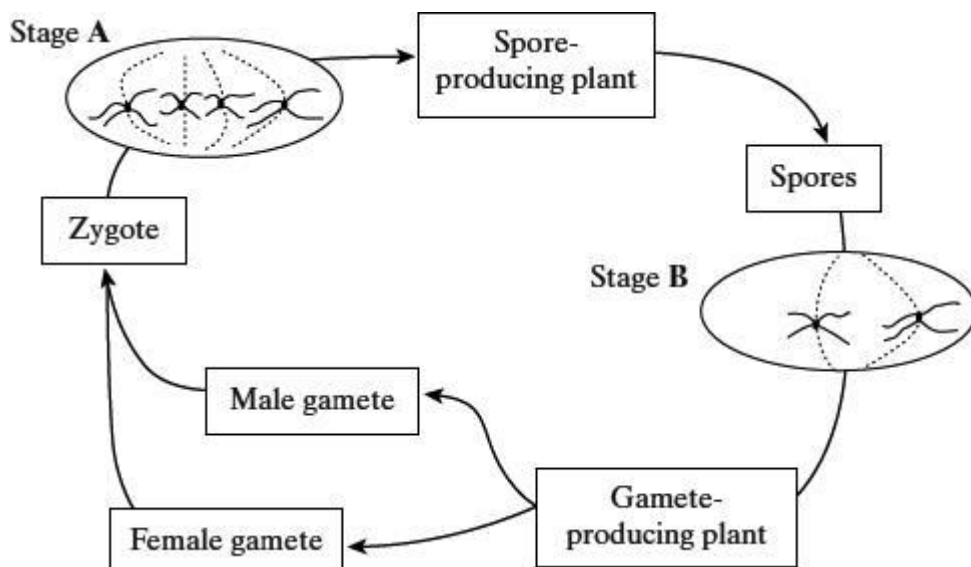
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(2)

(b) The diagram shows the life cycle of a fern plant. Drawings of the chromosomes during cell division are shown for the stages that give the spore-producing plant and the gamete-producing plant.



(i) What is the diploid number of chromosomes in this fern plant?

\_\_\_\_\_

(1)

(ii) Explain the difference in the number of chromosomes at stages **A** and **B**.

\_\_\_\_\_

\_\_\_\_\_

(1)

(iii) Are the male and female gametes produced by mitosis or meiosis?

Explain your answer.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

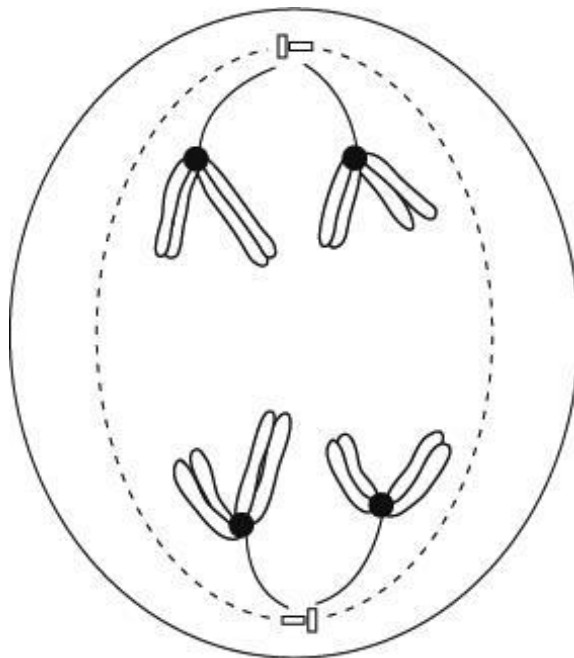
\_\_\_\_\_

(2)

(Total 6 marks)

**Q5.**

(a) The diagram shows a cell undergoing cell division.



Identify the type and stage of cell division shown. Give evidence from the diagram to support your answer.

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\_\_\_\_\_

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(3)

(b) Describe how crossing over occurs during meiosis I.

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(2)

(Total 5 marks)

**3.4.4 Genetic diversity and adaptation**

**Q1.**

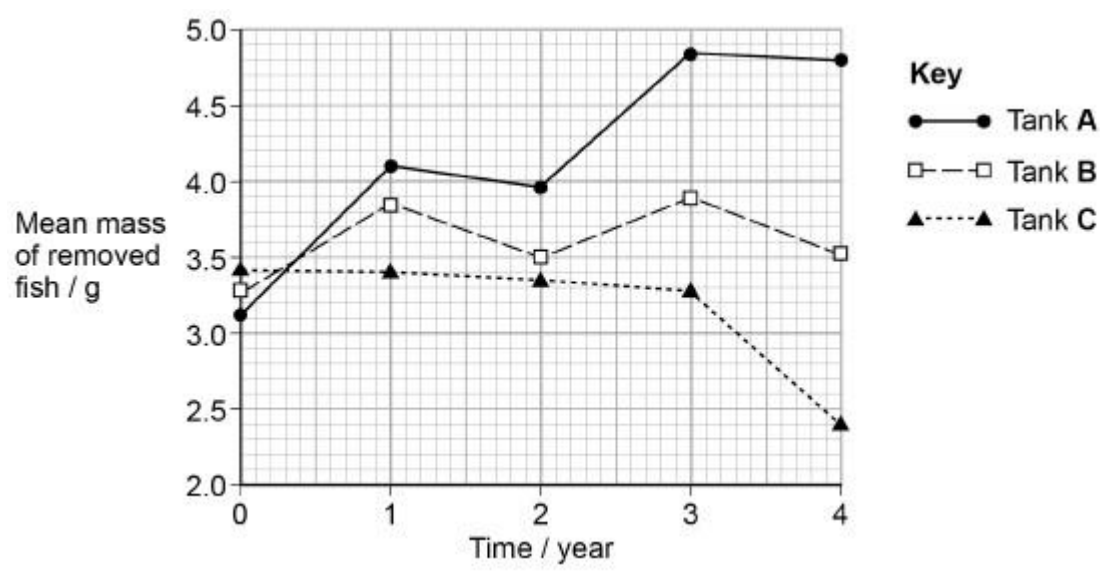
Scientists investigated changes in the mass of fish from three populations of the same species. The fish they used had a life cycle of one year.

The scientists set up three fish tanks, each containing a separate population. Each year the scientists removed all the fish from each tank and determined the mean mass of the fish removed. They then put back 10% of each population in the following way.

- Tank **A** – put back only the largest fish.
- Tank **B** – put back fish at random.
- Tank **C** – put back only the smallest fish.

During each year the fish were left to grow and reproduce.

The scientists' results are shown in the graph.



- (a) What type of selection were the scientists modelling in this investigation by putting back only the largest or only the smallest fish in Tank **A** and Tank **C**? Give a reason why.

Type of selection \_\_\_\_\_

Reason \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

- (b) Explain the purpose of Tank **B**.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

- (c) Calculate the ratio of the mean mass of fish removed from Tank **A** to the mean mass of fish removed from Tank **C** at 1 year **and** at 4 years.

How much greater is the ratio at 4 years compared with the ratio at 1 year?

Ratio at 1 year = \_\_\_\_\_

Ratio at 4 years = \_\_\_\_\_

How much greater at 4 years = \_\_\_\_\_

(2)

- (d) Sea fishing is regulated in law. The size of the mesh used in some fishing nets is controlled so that small fish can escape but large fish are captured. This regulation is designed to protect populations of wild fish.

Using all the information in this question, evaluate whether the scientists'



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(4)

- (b) Use the information provided to explain why the number of people showing LP would **rapidly** increase once selection for this condition had been established.

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(2)

- (c) Lactase persistence is caused by a mutation in DNA. This mutation does not occur in the gene coding for lactase.

Suggest and explain how this mutation causes LP.

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(2)

(Total 8 marks)

**Q3.**

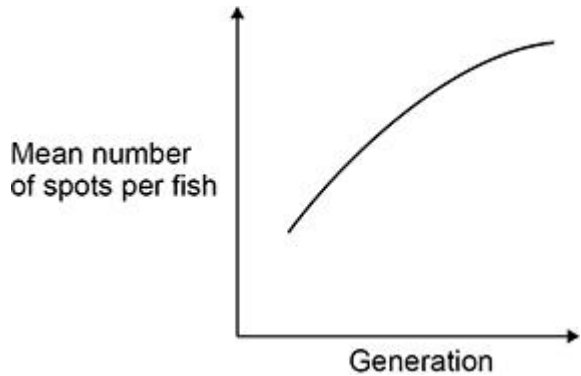
Guppies are small fish with brightly coloured spots on their body.

The number of spots on a guppy is controlled by genes.

A scientist investigated guppy breeding in a large population of guppies in a fish tank. The fish tank contained brightly coloured stones. After each generation of breeding, she counted the number of spots on every guppy.

**Figure 1** shows her results.

**Figure 1**



- (a) The scientist concluded that the mean number of spots on the guppies changed in this fish tank because the brightly coloured stones had affected the behaviour of the guppies.

The guppies did **not** behave aggressively towards each other and their feeding behaviour did **not** change.

Suggest **one** type of guppy behaviour that could be affected by the presence of brightly coloured stones.

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(1)

- (b) Suggest:

- a further investigation the scientist could do to confirm that the brightly coloured stones had affected guppy behaviour
- a null hypothesis for the new investigation.

Further investigation \_\_\_\_\_

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Null hypothesis \_\_\_\_\_

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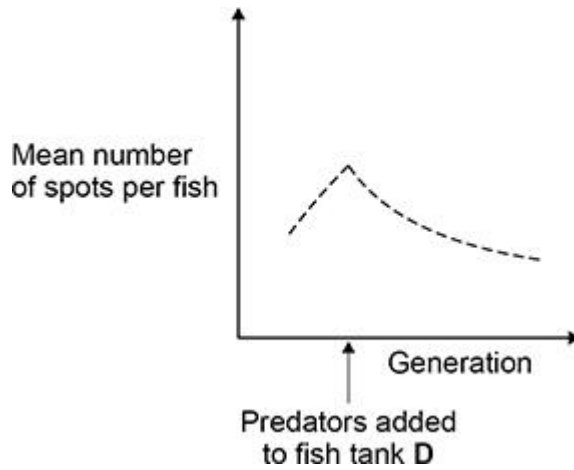
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(2)

- (c) The scientist repeated the investigation of guppy breeding in an identical fish tank, but added predators of the guppies into the fish tank at the fourth generation of breeding.

**Figure 2** shows her results.

Figure 2



Name the type of selection the scientist investigated in this fish tank.

Explain why this selection affected the frequency of alleles in the population of guppies in this fish tank.

Type of selection \_\_\_\_\_  
\_\_\_\_\_

Explanation \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
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(4)  
(Total 7 marks)

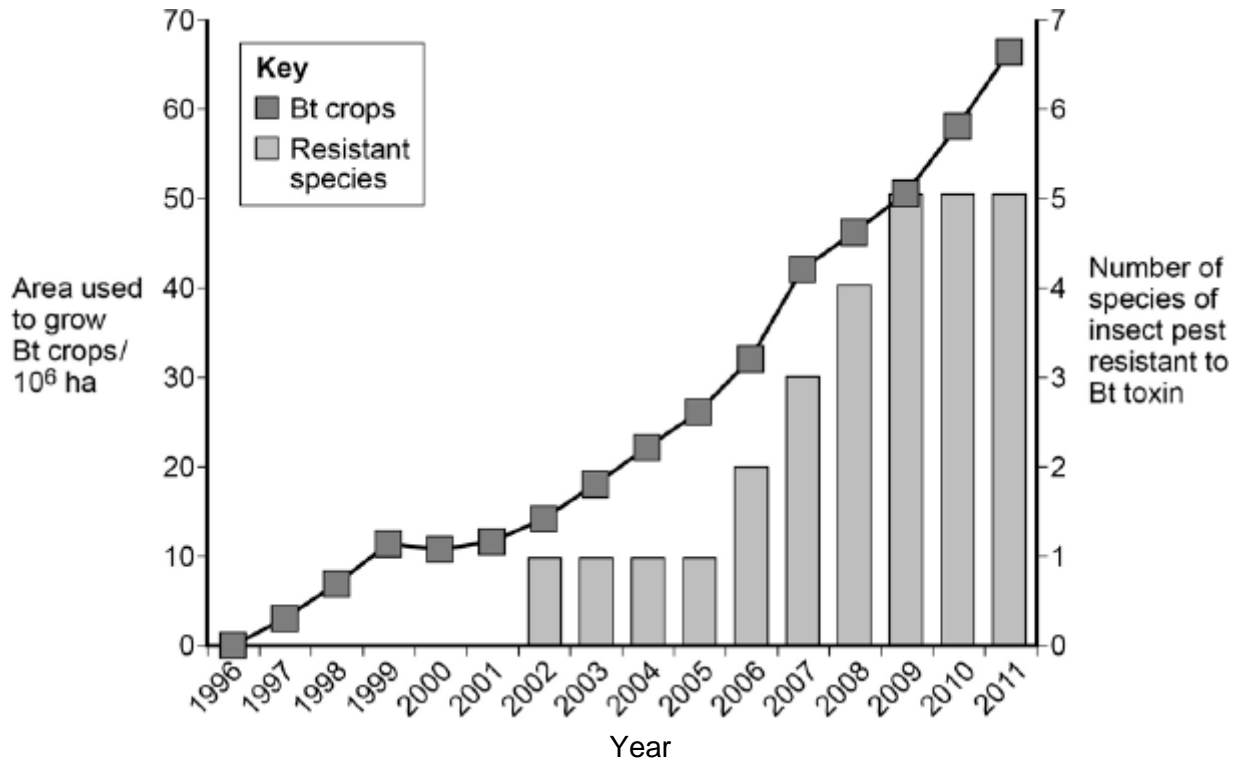
**Q4.**

To reduce the damage caused by insect pests, some farmers spray their fields of crop plants with pesticide. Many of these pesticides have been shown to cause environmental damage.

Bt plants have been genetically modified to produce a toxin that kills insect pests. The use of Bt crop plants has led to a reduction in the use of pesticides.

Scientists have found that some species of insect pest have become resistant to the toxin produced by the Bt crop plants.

The figure below shows information about the use of Bt crops and the number of species of insect pest resistant to the Bt toxin in one country.



(a) Can you conclude that the insect pest resistant to Bt toxin found in the years 2002 to 2005 was the same insect species? Explain your answer.

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(1)

(b) One farmer stated that the increase in the use of Bt crop plants had caused a mutation in one of the insect species and that this mutation had spread to other species of insect. Was he correct? Explain your answer.

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(4)

(c) There was a time lag between the introduction of Bt crops and the appearance of the first insect species that was resistant to the Bt toxin. Explain why there was a time lag.

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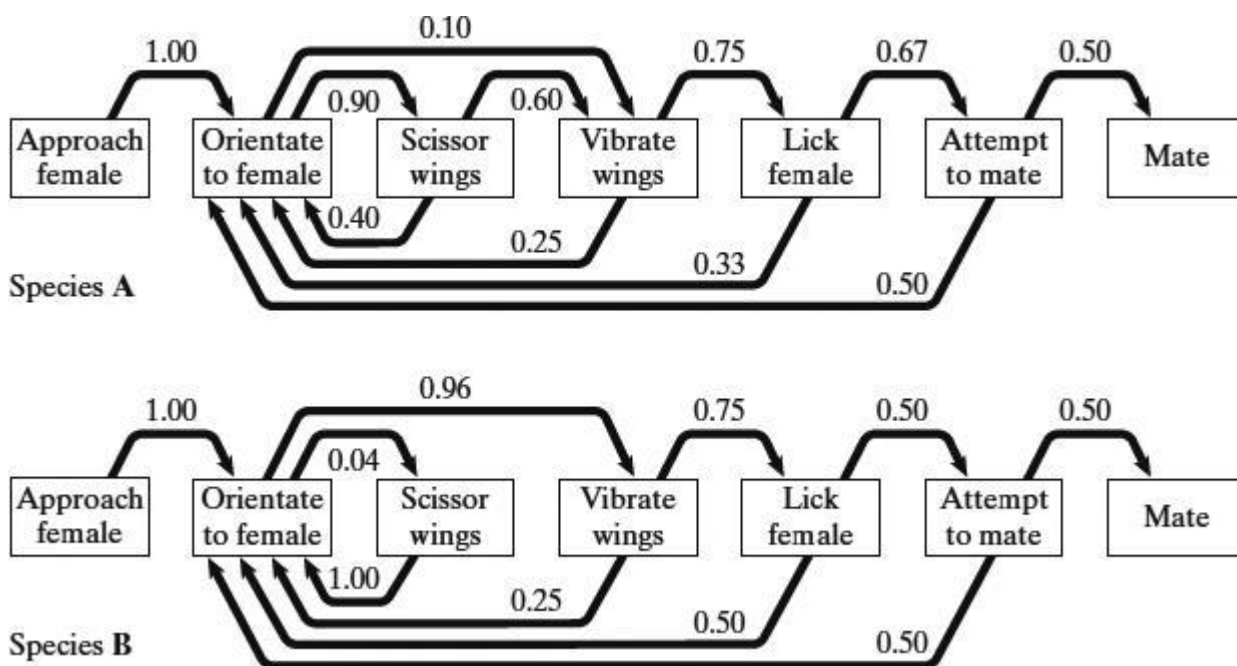
(3)  
(Total 8 marks)

### 3.4.5 Species and taxonomy

Q1.

Courtship and mating in fruitflies can occur equally well in the light or dark.

The diagrams show the courtship sequence of males from two closely related species of fruitfly (species **A** and species **B**). The numbers show the probability of one courtship element following from another.



- (a) Once a male of species **A** has orientated to the female, what is the probability that he will perform each courtship element once only and then attempt to mate? Show your working.

Probability \_\_\_\_\_

(2)

(b) Suggest how the courtship sequences provide evidence to support the claim that the two species are

(i) closely related;

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(1)

(ii) separate species.

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(1)

(c) During courtship, vibration of the wings creates a sound. The sound is different in the two species of fruitfly. Explain how this prevents mating between members of different species.

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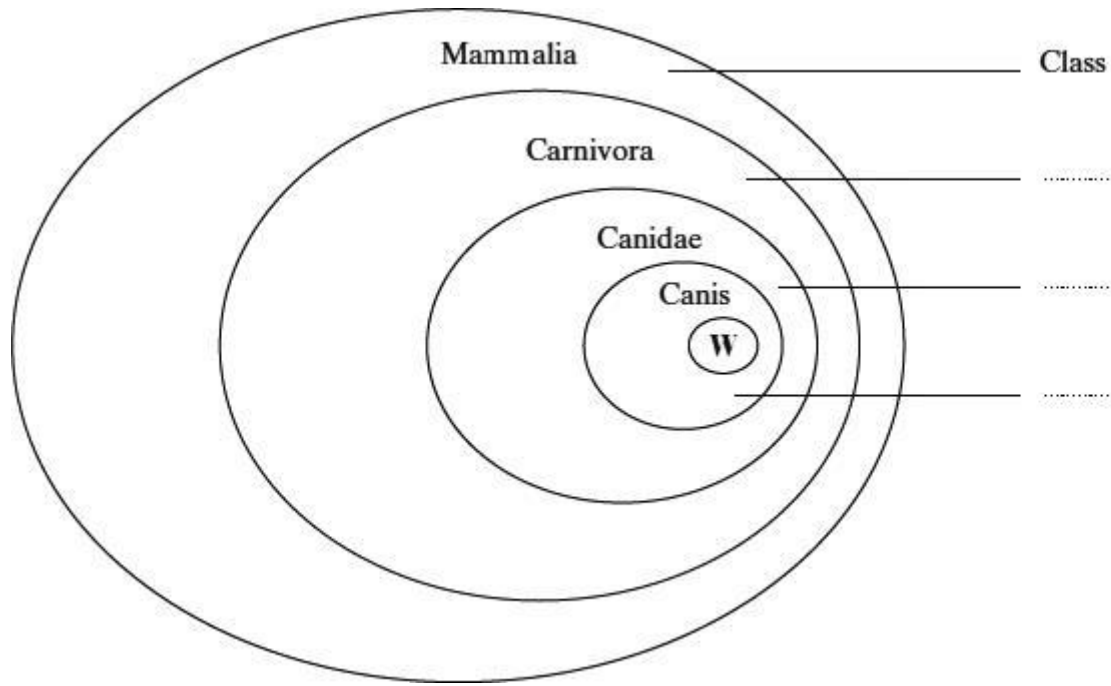
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(2)

(Total 6 marks)

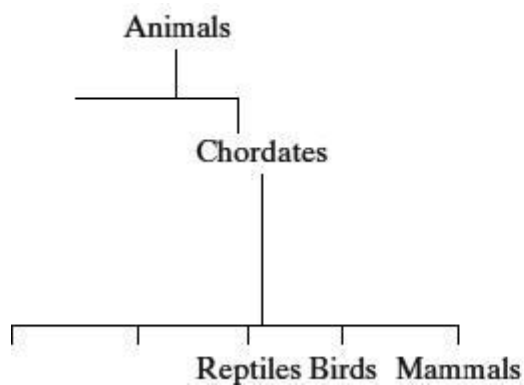
**Q2.**

(a) The mammals form a class called the Mammalia within the animal kingdom. The grey wolf is a species of mammal. **Figure 1** shows the groups within the Mammalia to which the wolf (labelled **W**) belongs.

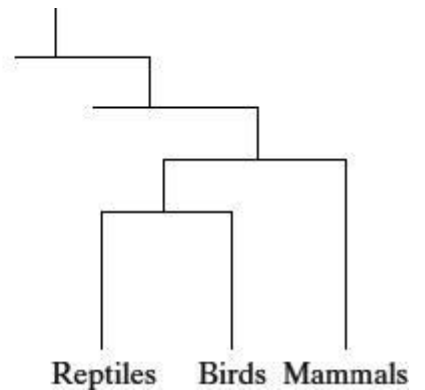


**Figure 1**

- (i) Label **Figure 1** to show the names of the groups. (2)
- (ii) The lion, *Panthera leo*, belongs to another group in the Carnivora, called the Felidae. Add this information to **Figure 1**, using the letter L to represent the lion species. (1)
- (b) The diagrams show two systems of classification of mammals. **Figure 2** shows a simple hierarchy. **Figure 3** shows a phylogenetic system.



**Figure 2**



**Figure 3**

- (i) What is meant by a hierarchy?

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(1)

- (ii) By reference to **Figures 2** and **3**, explain how a phylogenetic system differs from a simple hierarchy.

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(3)  
(Total 7 marks)

**Q3.**

- (a) Describe how organisms are grouped in a phylogenetic classification system.

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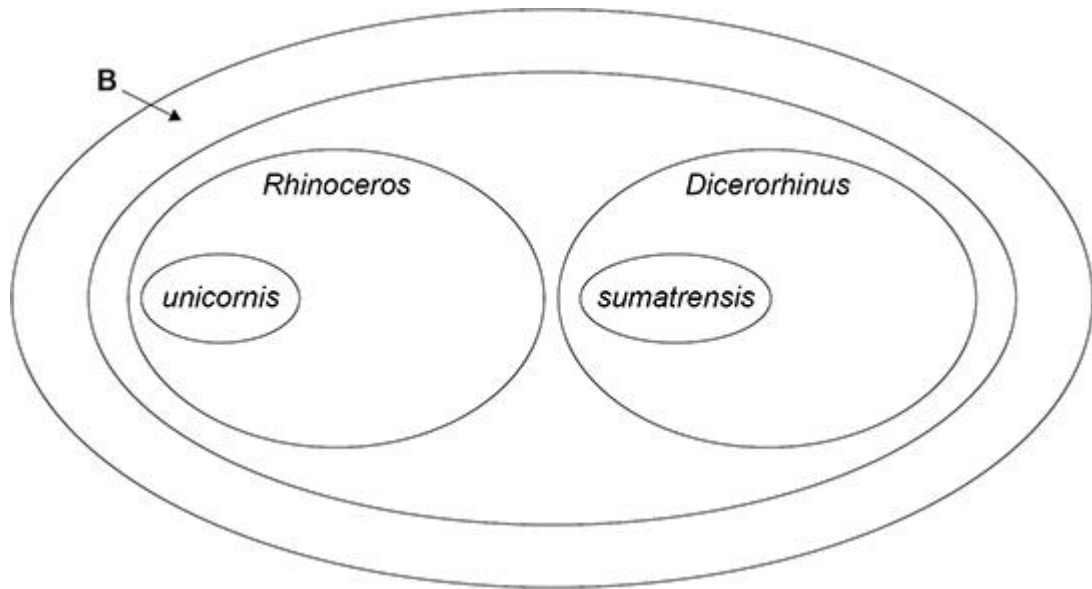
(2)

**Table 1** shows some of the taxa in the phylogenetic classification of a rhinoceros species.

**Table 1**

<b>Taxon name</b>	<b>Scientific name</b>
Class	Mammalia
Order	Perissodactyla
Family	Rhinocerotidae
Genus	<i>Rhinoceros</i>
Species	<i>unicornis</i>

The figure below shows the relationship between the taxa in the classification of two rhinoceros species: *Rhinoceros unicornis* and *Dicerorhinus sumatrensis*.



(b) Use information in **Table 1** to give the **scientific** name of the taxon labelled **B** in the figure above.

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(1)

(c) Draw an oval on the figure above to show the species *Rhinoceros sondaicus*.

(1)

Scientists investigated a phylogenetic relationship between individuals of five species of rhinoceros.

The scientists:

- determined the DNA base sequence of the *cyt b* gene of each rhinoceros
- compared each *cyt b* DNA base sequence with that of **one** Indian rhinoceros (called the reference rhinoceros)
- calculated the percentage difference between each *cyt b* DNA base sequence and that of the reference rhinoceros.

**Table 2** shows their results.

**Table 2**

Investigated species of rhinoceros	Percentage difference in DNA base sequences compared with the reference Indian rhinoceros
Indian	2
Javan	5
Sumatran	13
White	14
Black	14

(d) What can you conclude about the likely phylogenetic relationships between these species? Evaluate your conclusion.



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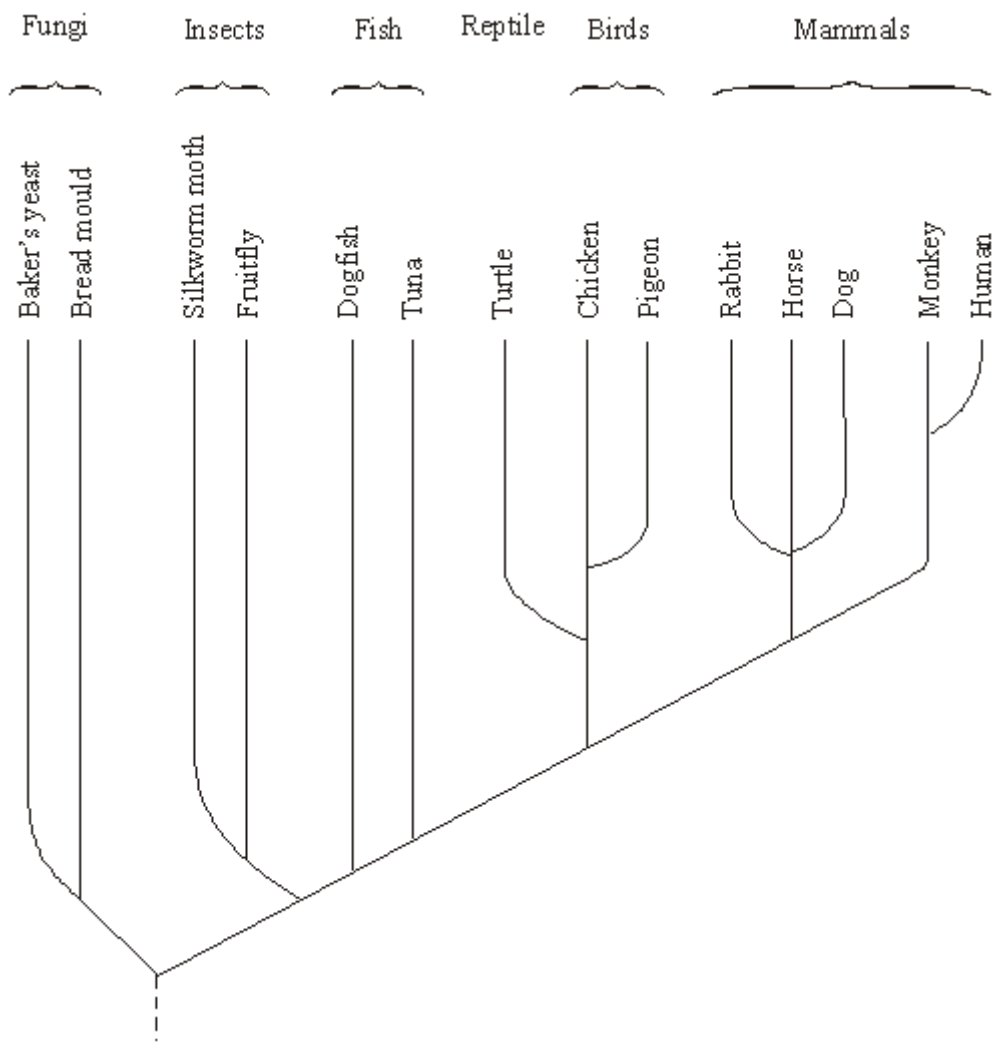
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(3)

Cytochrome c is a protein with about 100 amino acids and is present in all eukaryotic organisms. It has the same three-dimensional shape in all species, but only 30 of the amino acids are the same in all species. The amino acid sequence of cytochrome c has been used to construct the phylogenetic tree shown below.



(b) Name the kingdoms represented in this phylogenetic tree.

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(1)

(c) What does the phylogenetic tree show about the evolutionary relationship between fungi and insects?

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(2)

- (d) Suggest how information on amino acid sequences is used to construct a phylogenetic tree.

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(2)

- (e) Suggest **one** advantage and **one** disadvantage of using cytochrome c to construct a phylogenetic tree.

Advantage

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Disadvantage

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(2)

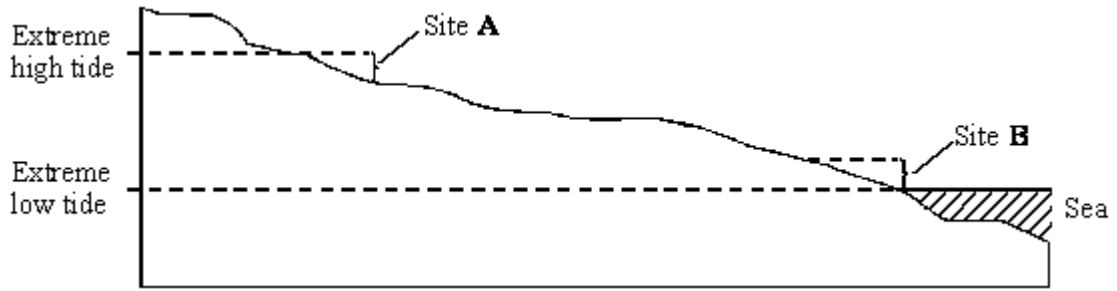
(Total 10 marks)

### **3.4.6 – Biodiversity within a Community**

#### **Q1.**

Parts of the sea shore form a very hostile environment for living organisms. Twice each day the incoming and outgoing tides alternately cover the organisms on the sea shore with water and then leave them exposed. The force of the waves could also dislodge any organisms that were not firmly attached.

The diagram shows a section through a rocky shore. Two sites were studied: site **A** was on the upper shore and site **B** on the lower shore.



The table shows the seaweeds that were found growing at sites **A** and **B**.

Site A: upper shore	Mean number per m <sup>2</sup>	Site B: lower shore	Mean number per m <sup>2</sup>
<i>Ascophyllum nodosum</i>	2	<i>Corallina officinalis</i>	31
<i>Fucus spiralis</i>	10	<i>Fucus serratus</i>	8
<i>Fucus vesiculosus</i>	4	<i>Laminaria digitata</i>	15
<i>Pelvetia canaliculata</i>	6	<i>Laminaria hyperborea</i>	3
		<i>Laminaria saccharina</i>	6
		<i>Laurencia pinnatifida</i>	18
		<i>Palmaria palmata</i>	6
Index of diversity		Index of diversity	4.77

(a) (i) Use the formula 
$$d = \frac{N(N-1)}{\sum n(n-1)}$$

where **d** = index of diversity  
**N** = total number of organisms of all species  
**n** = total number of organisms of a particular species

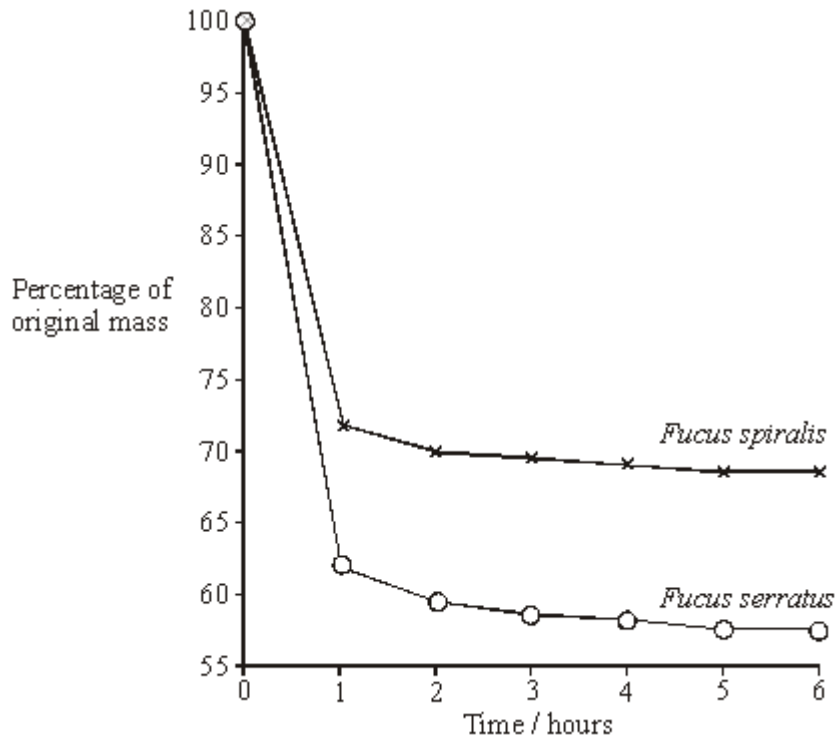
to calculate the index of diversity for the seaweeds growing at site **A**.  
 Show your working.

Index of diversity at site **A** = \_\_\_\_\_ (2)

(ii) Give **one** advantage of calculating the index of diversity rather than just recording the number of species present.

\_\_\_\_\_  
 \_\_\_\_\_ (1)

(b) Availability of water is one abiotic factor which determines the distribution of seaweeds. The graph shows loss in mass due to water evaporation for two of the seaweed species. The two seaweeds belong to the same genus but one was found only on the upper shore and the other only on the lower shore.



Explain how the results shown in the graph relate to the distribution of these two seaweeds on the sea shore.

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(3)  
(Total 6 marks)

**Q2.**

(a) What information is required to calculate an index of diversity for a particular community?

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(1)

(b) Farmers clear tropical forest and grow crops instead. Explain how this causes the diversity of insects in the area to decrease.

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(3)

Farmers manage the ditches that drain water from their fields. If they do not, the ditches will become blocked by plants. Biologists investigated the effects of two different ways of managing ditches on farmland birds.

- Ditch **A** was cleared of plants on both banks
- Ditch **B** was cleared of plants on one bank.

The graph shows the number of breeding birds of all species along the two ditches, before and after management.



- (c) (i) The points on the graph have been joined with straight lines rather than with a smooth curve. Explain why they have been joined with straight lines.

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(1)

- (ii) It would have been useful to have had a control ditch in this investigation. Explain why.

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(1)

- (d) A farmer who wanted to increase the diversity of birds on his land read about this investigation.

He concluded that clearing the plants from one bank would not decrease diversity as much as clearing the plants from both banks. Evaluate this conclusion.

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(3)

(Total 9 marks)

**Q3.**

- (a) A student investigated the diversity of plants at several sites on a golf course. At each site she took a large number of random samples.

- (i) Explain the importance of taking a large number of samples at each site.

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(1)

- (ii) Explain the importance of taking samples at random.

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(1)

The student collected data from one part of the golf course and calculated an index of diversity.

The table shows her data.

Species	Number of plants per m <sup>2</sup>
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Sheep's fescue	11
Creeping buttercup	6
Clover	5
Dandelion	2
Sheep's sorrel	1
Lady's bedstraw	7
Stemless thistle	4

The index of diversity can be calculated from the formula

$$d = \frac{N(N - 1)}{\sum n(n - 1)}$$

where

$d$  = index of diversity

$N$  = total number of organisms of all species

$n$  = total number of organisms of each species

- (b) Use the formula to calculate the index of diversity for the plants on this part of the golf course. Show your working.

Answer \_\_\_\_\_

(2)

- (c) The golf course was surrounded by undeveloped grassland from which it had been produced.

The golf course had

- some areas of very short grass which was cut frequently
- some areas of longer grass which was cut less frequently
- some areas of long grass and shrubs which were never cut.

The index of diversity for the insects on the golf course was higher than that for the surrounding undeveloped grassland.

Explain the effect of developing this golf course on the index of diversity of insects.

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(3)  
(Total 7 marks)

**Q4.**

Scientists investigated the species of insects found in a wood and in a nearby wheat field. The scientists collected insects by placing traps at sites chosen at random both in the wood and in the wheat field.

The table shows the data collected in the wood and in the wheat field.

Species of insect	Number of organisms of each species	
	Wood	Wheat field
Bird-cherry oat aphid	0	216
Beech aphid	563	0
Large white butterfly	20	0
Lacewing	12	3
7-spot ladybird	36	0
2-spot ladybird	9	1
Total number of organisms of all species	640	220

- (a) The scientists collected insects at sites chosen at random. Explain the importance of the sites being chosen at random.

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(1)

- (b) (i) Use the formula

$$d = \frac{N(N-1)}{\sum n(N-1)}$$

to calculate the index of diversity for the insects caught in the wood, where

$d$  = index of diversity

$N$  = total number of organisms of all species

$n$  = total number of organisms of each species

Show your working.

Answer \_\_\_\_\_

(2)

- (ii) Without carrying out any further calculations, estimate whether the index of diversity for the wheat field would be higher or lower than the index of diversity for the wood.

Explain how you arrived at your answer.

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(2)

- (c) A journalist concluded that this investigation showed that farming reduces species diversity. Evaluate this conclusion.

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(2)

- (d) Farmers were offered grants by the government to plant hedges around their fields. Explain the effect planting hedges could have on the index of diversity for animals.

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(2)

**(Total 9 marks)**

## Required practical 4 – Membrane permeability

### Q1.

A student investigated the effect of ethanol, hydrochloric acid and temperature on the loss of red pigment from beetroot cells.

During the procedure, the student:

- added 10 cm<sup>3</sup> water into one test tube
- added 10 cm<sup>3</sup> ethanol into a second test tube
- added 10 cm<sup>3</sup> hydrochloric acid into a third test tube
- put the three tubes into a 25 °C water bath
- cut four cylinders of tissue from a beetroot
- put a cylinder into each tube and fitted bungs
- added 10 cm<sup>3</sup> water into a fourth test tube and put this tube into a 70 °C water bath
- placed the fourth cylinder into this tube and fitted a bung
- later removed the cylinders from the tubes
- estimated the intensity of red pigment in each solution by eyesight.

- (a) Give **one** way in which the student could ensure the first three beetroot cylinders were kept at 25 °C throughout her experiment.

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(1)

- (b) Give **two** variables that the student did **not** control in her procedure.

1 \_\_\_\_\_

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2 \_\_\_\_\_

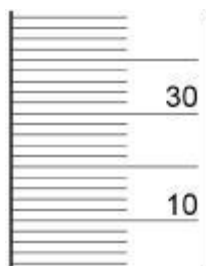
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(2)

- (c) The student used a measuring cylinder to obtain 10 cm<sup>3</sup> of each solution.

**Figure 1** shows some of the scale graduations on the side of this measuring cylinder.

**Figure 1**



What is the uncertainty of taking a reading of 10 cm<sup>3</sup> with this measuring cylinder?

Suggest how you could reduce the uncertainty calculated.

Uncertainty  $\pm$  \_\_\_\_\_  $\text{cm}^3$

Reducing uncertainty \_\_\_\_\_

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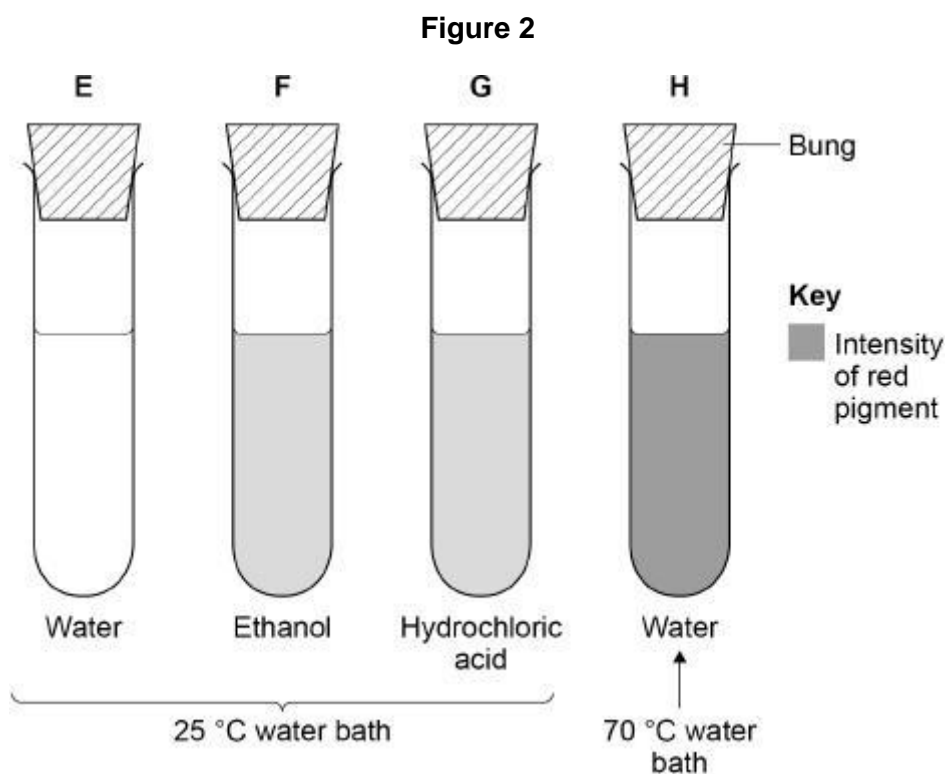
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(2)

A different student used the same procedure and she controlled **all** variables appropriately. Her results are shown in **Figure 2**.



- (d) Using **Figure 2**, what can you conclude about the damage caused to beetroot cells by water, ethanol, hydrochloric acid and different temperatures?

Provide explanations for your conclusions.

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(4)  
(Total 9 marks)

**Q2.**

The cells of beetroot contain a red pigment. A student investigated the effect of temperature on the loss of red pigment from beetroot. He put discs cut from beetroot into tubes containing water. He maintained each tube at a different temperature. After 25 minutes, he measured the percentage of light passing through the water in each tube.

- (a) The student put the same volume of water in each tube.

Explain why it was important that he controlled this experimental variable.

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(2)

- (b) Describe a method the student could have used to monitor the temperature of the water in each tube.

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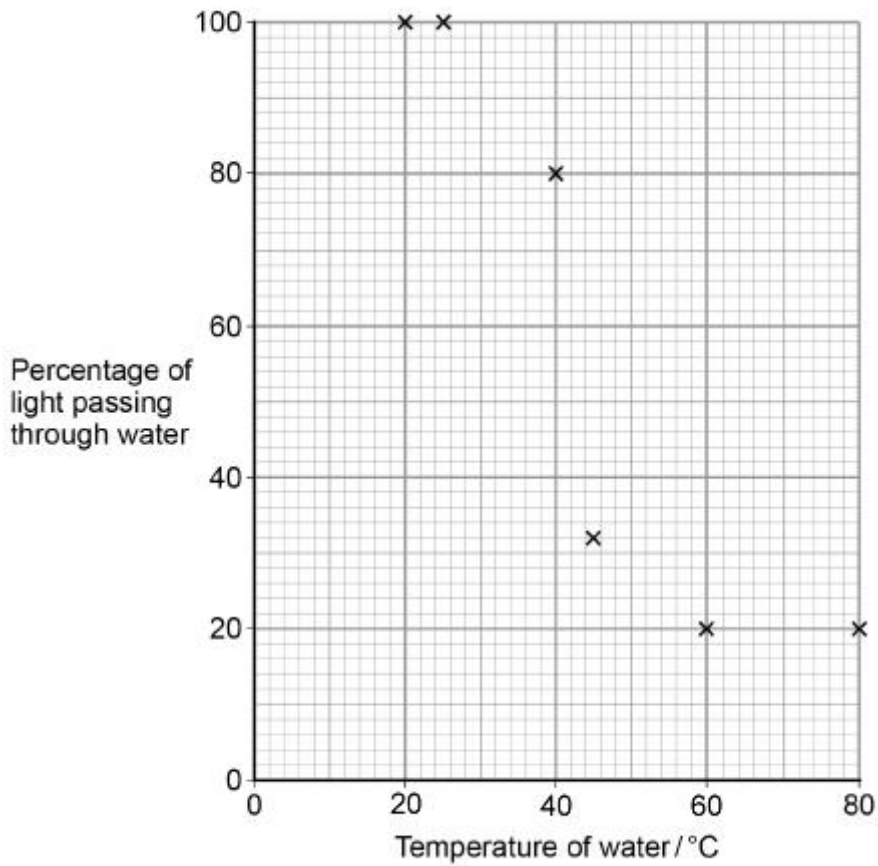
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(1)

The graph shows the student's results.



(c) Draw a suitable curve on the graph above.

(1)

(d) The decrease in the percentage of light passing through the water between 25 °C and 60 °C is caused by the release of the red pigment from cells of the beetroot.

Suggest how the increase in temperature of the water caused the release of the red pigment.

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(2)

(Total 6 marks)

### Required practical 6 – Aseptic technique

#### Q1.

A student investigated the effect of three types of disinfectant on the growth of *Lactobacillus* bacteria.

During the investigation, the student:

- boiled the agar before pouring the agar plates
- transferred 0.5 cm<sup>3</sup> of a diluted liquid culture of *Lactobacillus* onto each agar plate
- left some agar plates as controls
- added to other agar plates different concentrations of the disinfectants as shown in the table in part (a).

After 2 days, she counted the number of colonies of bacteria on each agar plate.

(a) Explain the purpose of:

boiling the agar \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

transferring the same volume of liquid culture onto each agar plate.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(2)

The three disinfectants used by the student were Lysol, propan-2-ol and ammonia.

The table shows the student's results.

Concentration of disinfectant / arbitrary units	Number of colonies of bacteria		
	Lysol	Propan-2-ol	Ammonia
0	300	300	300
5	0	290	300
10	0	195	295
15	0	0	275
20	0	0	240

The liquid culture the student transferred was diluted by 1 in 10 000 (10<sup>-4</sup>).

(b) Use information in this question to calculate how many bacteria were present in 1 cm<sup>3</sup> of undiluted liquid culture.

Answer = \_\_\_\_\_

(2)

- (c) The student concluded that the minimum concentration of propan-2-ol needed to stop the growth of *Lactobacillus* was 15 units. This conclusion is incorrect.

Describe how you could obtain a more accurate estimate of the minimum concentration of propan-2-ol needed to stop the growth of this species of bacterium.

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(2)

(Total 6 marks)

**Q2.**

- (a) Name the process by which bacterial cells divide.

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(1)

A microbiologist investigated the ability of different plant oils to kill the bacterium *Listeria monocytogenes*. She cultured the bacteria on agar plates. She obtained the bacteria from a broth culture.

- (b) Describe **two** aseptic techniques she would have used when transferring a sample of broth culture on to an agar plate. Explain why each was important.

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(4)

The microbiologist tested five different plant oils at two different temperatures and determined the minimum concentration of plant oil that killed the *L. monocytogenes*.

The table below shows her results.

Plant oil	Minimum concentration of plant oil that killed <i>Listeria monocytogenes</i> / percentage	
	4 °C	35 °C
Bay	0.10	0.04
Cinnamon	0.08	0.08
Clove	0.05	0.05
Nutmeg	>1.00	0.05
Thyme	0.02	0.03

(c) Which plant oil is least effective at killing *L. monocytogenes* at 35 °C?

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(1)

*L. monocytogenes* is a pathogen of great concern to the food industry, especially in foods stored in refrigeration conditions (4 °C) where, unlike most food-borne pathogens, it is able to multiply. It has been suggested that plant oils, together with refrigeration may help to reduce the growth of *L. monocytogenes*.

(d) What conclusions can be drawn about the effectiveness of using plant oils with refrigeration to reduce food-borne infections caused by *L. monocytogenes*?

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(3)

(e) Plant oils are hydrophobic and can cross the cell-surface membrane of the bacterium. The low temperature of 4 °C can slow the rate of entry of plant oils into the cells.

Suggest how the low temperature slows the rate of entry.

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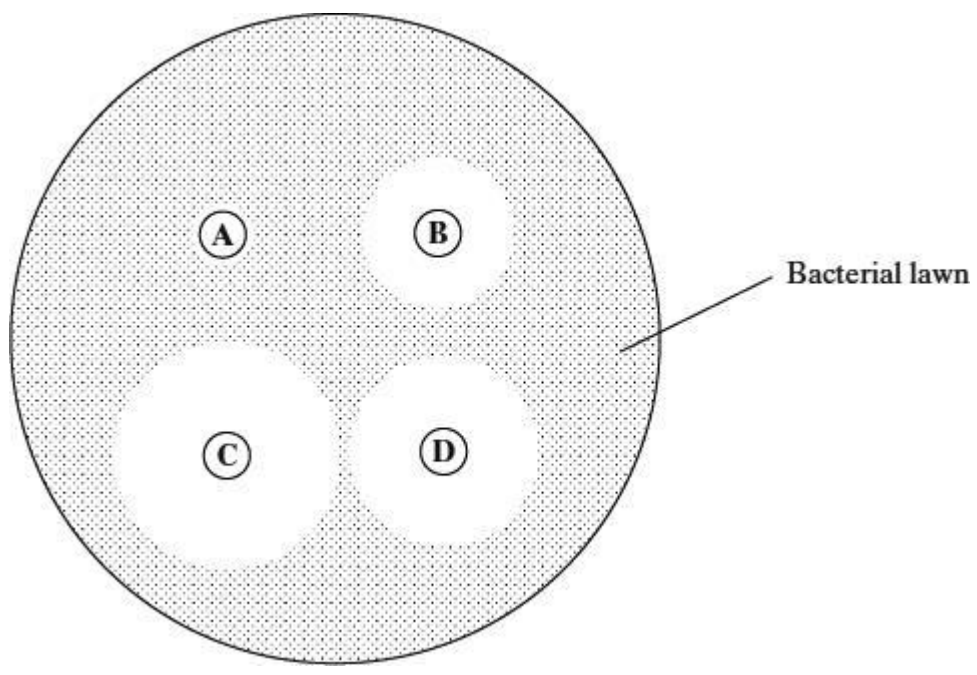
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(1)  
(Total 10 marks)

**Q3.**

An agar plate was flooded with a culture of a species of bacterium usually found in the mouth. Four sterile paper discs, **A**, **B**, **C** and **D**, each containing a different brand of mouthwash, were then placed on the agar plate. The drawing shows the appearance of the plate after it had been incubated at 37°C for three days.



- (a) Describe the aseptic techniques that would be used when flooding the agar plate with bacteria.

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(3)

- (b) The effectiveness of a mouthwash can be measured by calculating the total area of a paper disc and the clear zone around it. The area of a circle is given by  $\pi r^2$ , where  $r$  is the radius of the circle. Calculate how many times more effective mouthwash **C** is than mouthwash **B**. Show your working.

Mouthwash **C** is \_\_\_\_\_ times more effective than mouthwash **B**.



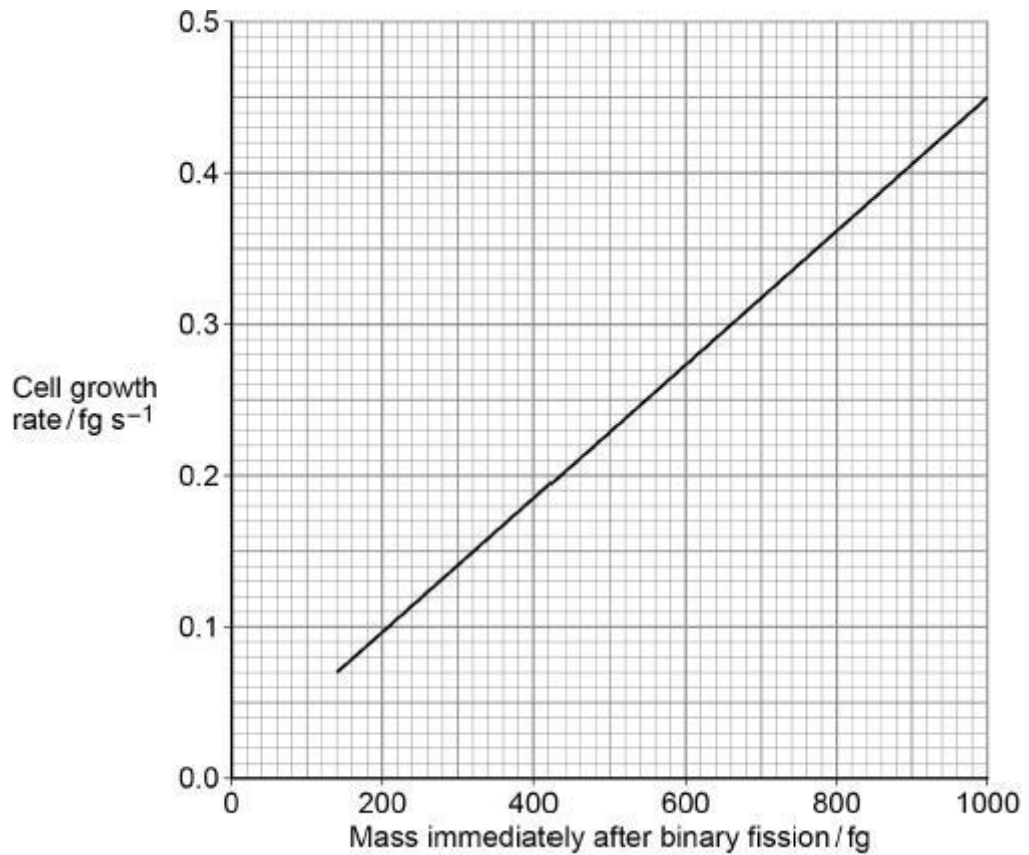




**Q2.**

The cell growth rate of the bacterium *Bacillus subtilis* is proportional to its mass immediately after binary fission.

The graph below shows this relationship.



- (a) The mass of the bacterial cells was measured in femtograms (fg).

1 fg (femtogram) =  $1 \times 10^{-15}$  g

Place a tick (✓) in the box next to the number that is equal to 680 fg

0.000 000 000 006 8 g

$6.8 \times 10^{-13}$  g

$6.8 \times 10^{-15}$  g

$$6.8 \times 10^{-17} \text{ g}$$



(1)

A scientist determined the growth rate of a *B. subtilis* cell by measuring its mass for 5 minutes.

In those 5 minutes, the cell's mass increased by 90 fg

- (b) Use this information and the graph above to determine the mass of this cell immediately after binary fission.

Show your working.

Answer \_\_\_\_\_ fg

(2)

(Total 3 marks)

### MS0.2 Recognise and use expressions in decimal and standard form

#### Q1.

Read the following passage.

5 DNA is a stable molecule but, even under normal cell conditions, spontaneous changes occur to the DNA nucleotide sequence. One example of a spontaneous change occurs when a cytosine base in a guanine–cytosine nucleotide pair is changed to a uracil base. This produces a guanine–uracil nucleotide pair in the DNA molecule. Scientists estimate this type of spontaneous change occurs to 100 guanine–cytosine nucleotide pairs in the genome of healthy human cells every day.

10 In healthy cells, enzyme-controlled processes repair these spontaneous changes in the DNA molecule by changing uracil bases back to cytosine bases. If these repairs do **not** happen, the uracil DNA nucleotide attracts an adenine DNA nucleotide when the DNA is replicated in the cell cycle. A mutation of the original DNA has now occurred.

15 Healthy cells with damaged DNA produce enzyme **X**. This enzyme slows the cell cycle by delaying the start of DNA replication. People with the disease ataxia telangiectasia (AT) do not produce functional enzyme **X**. Mutations occur at a higher rate in people with AT.

Use the information in the passage and your own knowledge to answer the following questions.

(b) The DNA in a human genome contained  $3 \times 10^9$  nucleotide pairs.

Assume 40% of these nucleotide pairs are guanine–cytosine nucleotide pairs.

Use this information and lines 5–7 to calculate the percentage of guanine–cytosine nucleotide pairs that change to guanine–uracil nucleotide pairs in this genome every day.

Give your answer in standard form.

Show your working.

Answer \_\_\_\_\_ %

(2)

(Total 2 marks)

## Q2.

(d) The enzyme maltase catalyses the hydrolysis of maltose to glucose.

A scientist investigated maltase activity in two different maltose solutions, **G** and **H**.

For each solution, he measured:

- the total number of glucose molecules produced by complete hydrolysis of the maltose
- the time taken for the complete hydrolysis of the maltose.

The table below shows his results.

Solution	Total number of glucose molecules produced	Time taken for complete hydrolysis of maltose / s
<b>G</b>	$4 \times 10^7$	20
<b>H</b>	$6 \times 10^8$	

Complete the table by calculating the time taken for the complete hydrolysis of the maltose in solution **H**. Assume the rate of maltase activity is the same in solution **G** and in solution **H**.

Show your working.

**MS0.3 Use ratios, fractions and percentages**

**Q1.**

- (a) There are an estimated 229 million cases of human malaria worldwide per year. 94% of these cases are found in Africa, but are not caused by *P. vivax*. *P. vivax* does cause 61% of the cases of human malaria outside Africa.

Use this information to calculate the number of cases worldwide caused by *P. vivax* each year.

Answer \_\_\_\_\_ cases of malaria

(1)

**Q2.**

After a heart attack, cardiomyocytes (cardiac muscle cells) die, and become infarcted tissue. Infarcted tissue cannot contract.

Stem cells in bone marrow **cannot** move to the infarcted tissue and differentiate into cardiomyocytes.

Scientists used laboratory rats to investigate if bone marrow stem cell transplants could be used to repair infarcted tissue resulting from a heart attack.

They split the rats into three groups.

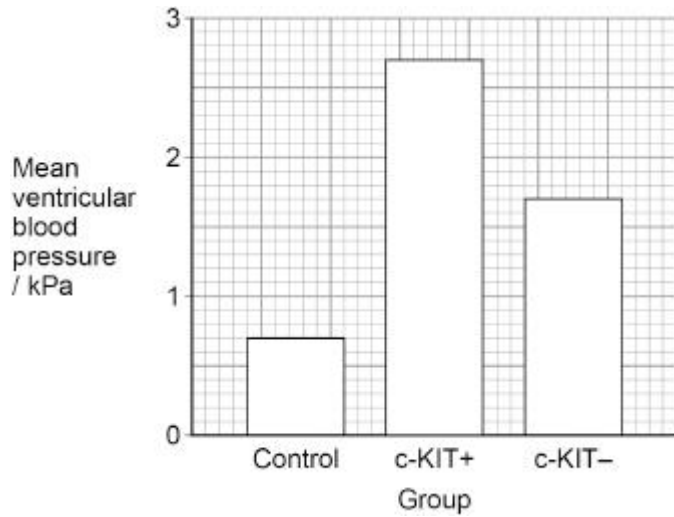
- **Control** group did not get a transplant of bone marrow stem cells.
- **c-KIT+** group got a transplant of bone marrow stem cells with a functioning *c-KIT* gene.
- **c-KIT-** group got a transplant of bone marrow stem cells with **no** functioning *c-KIT* gene.

After 9 days, the scientists measured the mean ventricular blood pressure of each of the three groups.

**Figure 2** shows their results.

The differences between the groups were all statistically significant.

**Figure 2**



- (a) Nine days after transplantation, the **c-KIT+** group showed that 68% of infarcted tissue was made up of new cardiomyocytes. The control group had **no** new cardiomyocytes.

Assuming that mean ventricular blood pressure is directly proportional to the number of cardiomyocytes, calculate the percentage of infarcted tissue that was made up of new cardiomyocytes in the **c-KIT-** group.

Answer \_\_\_\_\_ %

(2)

### Q3.

- (a) The mass of iron ions in the plasma of a person with haemochromatosis is  $6104 \mu\text{g}$   
 The iron ion concentration in the plasma of a healthy person is  $50 \mu\text{g dm}^{-3}$   
 The volume of blood in each of these people is  $4000 \text{ cm}^3$

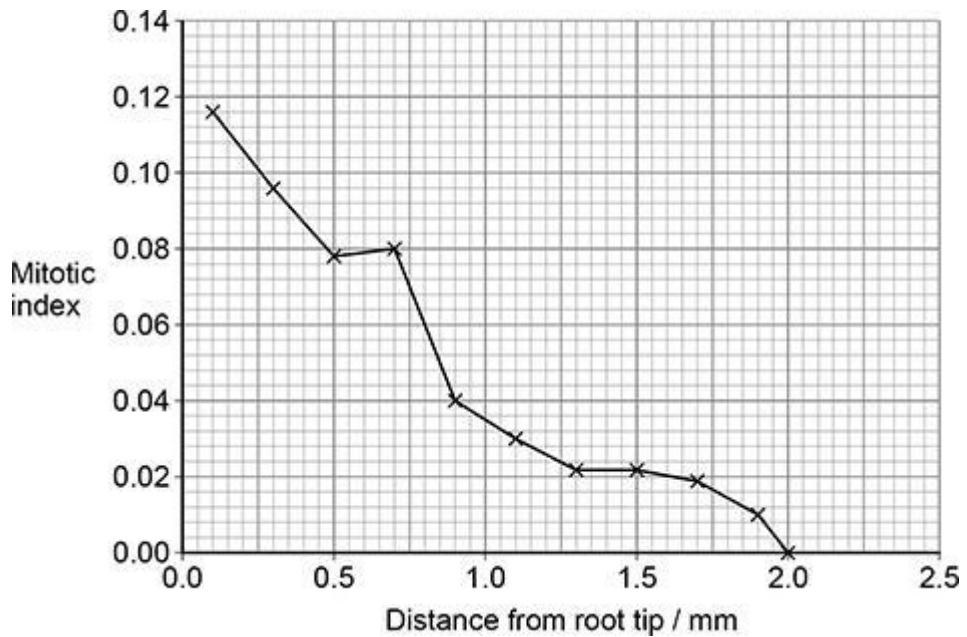
Calculate the ratio of the mass of iron ions in the plasma of the person with haemochromatosis to the mass of iron ions in the plasma of the healthy person.

**MS1.4 Understand simple probability**

**Q1.**

- (a) A scientist used an optical microscope to determine the mitotic index in cells at different distances from the tip of onion roots.

The graph below shows the results.



Complete the word equation used to determine each mitotic index in the graph above.

Mitotic Index =

(1)

- (b) The scientist used data from the graph above to calculate a correlation coefficient (r). The scientist then used a statistical test to determine the probability (P) associated with the value of r.

$r = -0.98$  ( $P < 0.05$ )

What can you conclude from this result?

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**Q2.**

A medical officer investigated the effectiveness of five different types of influenza vaccine. A total of 1350 people agreed to be vaccinated. The medical officer divided these into five groups. The number who suffered from influenza in the following year was recorded. The results are shown in the table.

Type of influenza vaccine	Number of people vaccinated			
	Suffered from influenza	Did not suffer from influenza	Total	Proportion suffering from influenza
I	43	237	280	0.15
II	52	198	250	0.21
III	25	245	270	0.09
IV			260	0.18
V	57	233	290	0.20

- (a) Complete the spaces in the table for the people vaccinated with type IV vaccine.

(1)

- (b) The medical officer used a statistical test to assess the effectiveness of the five different vaccines.

- (i) What would be the null hypothesis?

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(1)

- (ii) The statistical test gave a probability of less than 0.05. What conclusion can be drawn from this?

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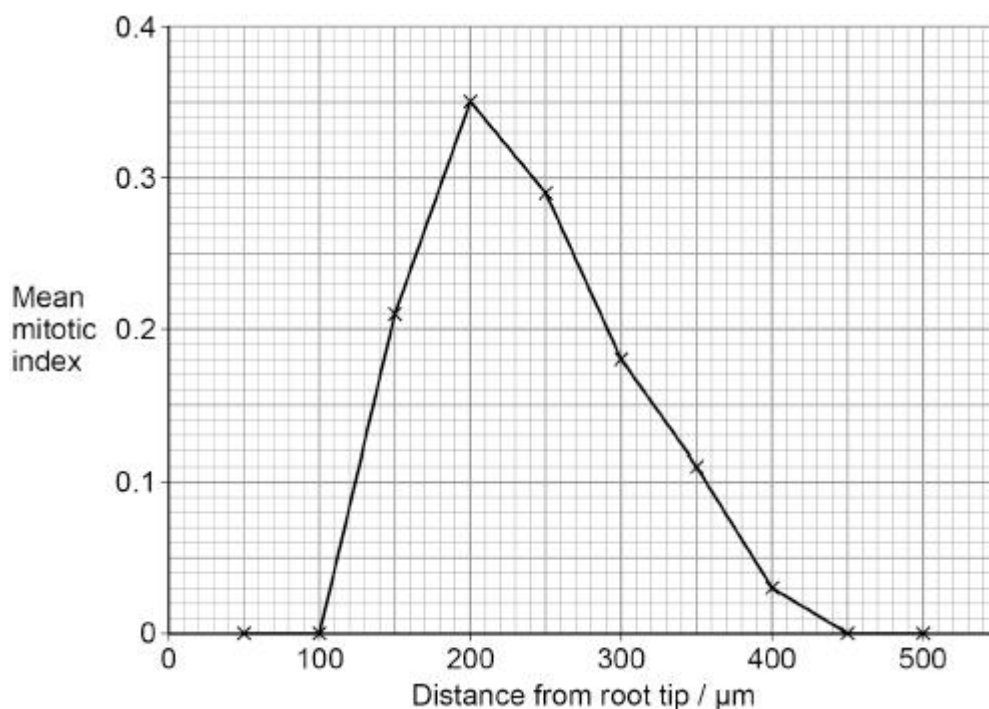
(1)

**MS1.9 Select and use statistical test****Q1.**

- (a) Scientists determined the mean mitotic index at 50  $\mu\text{m}$  intervals away from the root

tip in 10 young plant roots.

The graph below shows the scientists' results.



State the null hypothesis for this investigation.

Name the statistical test needed to determine whether the difference between the mean mitotic index at 200  $\mu\text{m}$  and at 300  $\mu\text{m}$  is significant.

Null hypothesis \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Statistical test \_\_\_\_\_

(2)

## Q2.

- (a) Name the statistical test you should use to determine if the observed frequencies of the four phenotypes differed significantly from the frequencies expected according to the Hardy–Weinberg equation.

State how many degrees of freedom should apply.

Statistical test \_\_\_\_\_

Number of degrees of freedom \_\_\_\_\_

(2)

## Q3.

- (a) The student could determine the median, mode and range from his measurement of

shell heights in these populations.

Give **two** other statistical values the student could calculate from his measurement of shell heights in these populations.

1 \_\_\_\_\_

2 \_\_\_\_\_

(1)

**Q4.**

Scientists measured the mean amino acid concentration in white wines made from grapes grown organically and white wines made from grapes that were not grown organically.

- (a) The scientists used a statistical test to determine whether there was a significant difference in the amino acid concentration in the two types of white wine. They obtained a value for P of 0.04.

Name the statistical test the scientists used and give a reason for your answer.

Was the difference significant? Give a reason for your answer.

Name of statistical test \_\_\_\_\_

Reason for choice \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Explanation of test result \_\_\_\_\_

\_\_\_\_\_

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(3)

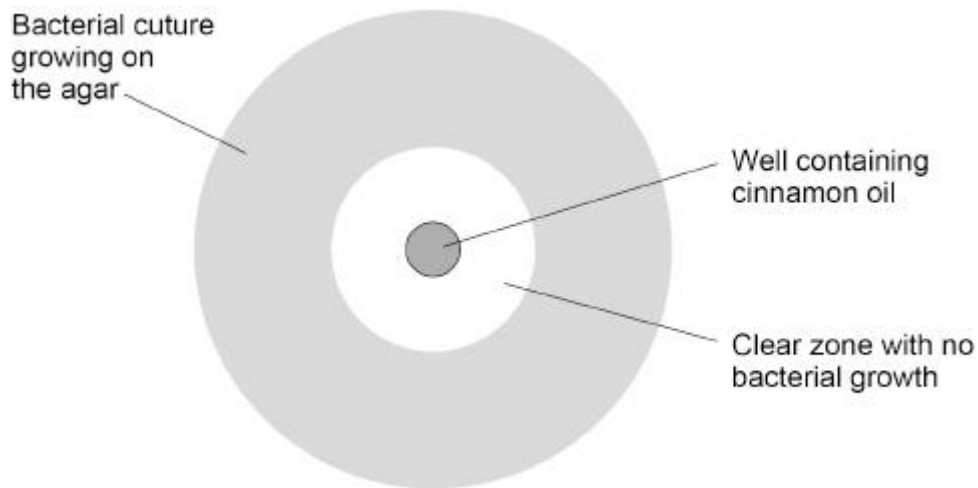
**MS1.10 Understand measures of dispersion, including standard deviation and range**

**Q1.**

A student investigated the use of cinnamon oil as an antimicrobial substance. She investigated the effect of cinnamon oil on the growth of five different bacterial cultures grown on agar plates.

The student kept the plates at 25 °C for 24 hours.

The figure below shows what one of her plates looked like after 24 hours.



The student measured the diameter of the clear zone with no bacterial growth around each well. She made these measurements to the nearest whole mm

The table shows her results.

Bacterial culture	Diameter of clear zone / mm		
	Cinnamon oil	Positive control	Negative control
<i>Bacillus</i> spp.	15	14	0
<i>Staphylococcus aureus</i>	20	17	0
<i>Listeria monocytogenes</i>	18	12	0
<i>Escherichia coli</i>	16	12	0
<i>Klebsiella</i> spp.	14	12	0
Median for all cultures			0
Mean for all cultures			0
Standard deviation for all cultures	2.4	2.2	0

- (a) The mean  $\pm$  2 standard deviations includes over 95% of the data.

Use this information to consider whether the standard deviations suggest the differences in means are likely to be due to chance.

Explain your answer, including at least **one** calculation.

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**Q2.**

- (a) Cholesterol is a type of lipid transported in the blood. High blood cholesterol concentrations can lead to cardiovascular disease.

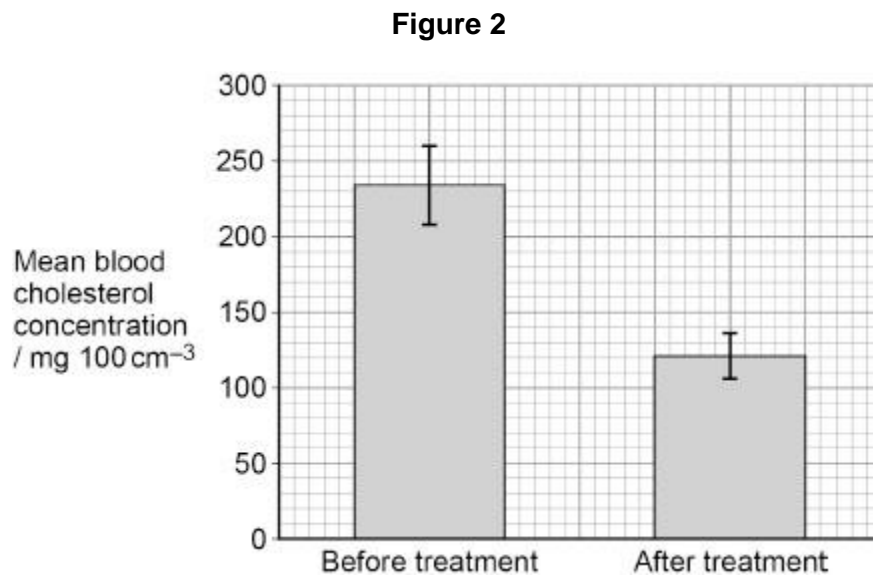
Scientists studied the effectiveness of the drug cholestyramine (CA) in lowering blood cholesterol concentration.

They:

- gave 10 patients CA for 1 month
- measured the blood cholesterol concentrations at the start of the study and after 1 month of treatment with CA.

**Figure 2** shows the scientists' results.

The error bars represent  $\pm 2$  standard deviations from the mean, which includes over 95% of the data.



Use the information provided to evaluate the effectiveness of the drug CA in reducing blood cholesterol concentration.

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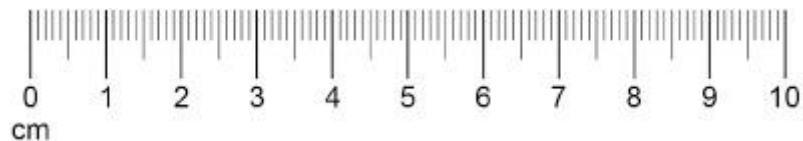
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(5)  
(Total 5 marks)

**MS1.11 Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined**

**Q1.**

- (a) Another student investigated the variation in leaf length using the ruler shown in the figure below.



The student measured the length of one leaf as 86 mm

State the uncertainty of this measurement **and** use this to calculate the percentage uncertainty in the length measurement.

Uncertainty \_\_\_\_\_ mm

Percentage uncertainty \_\_\_\_\_

(2)  
(Total 2 marks)

**Q2.**

- (a) The student used a sterile pipette with 0.1 cm<sup>3</sup> graduations to transfer 2 cm<sup>3</sup> of *B. subtilis* into each test tube.

What is the uncertainty in measuring 2 cm<sup>3</sup> with this pipette?

Calculate the percentage uncertainty of this 2 cm<sup>3</sup> measurement.

Uncertainty \_\_\_\_\_ cm<sup>3</sup>

Percentage uncertainty \_\_\_\_\_

**(2)**

**(Total 2 marks)**

## MS4.1 Calculate the circumferences, surface areas and volumes of regular shapes

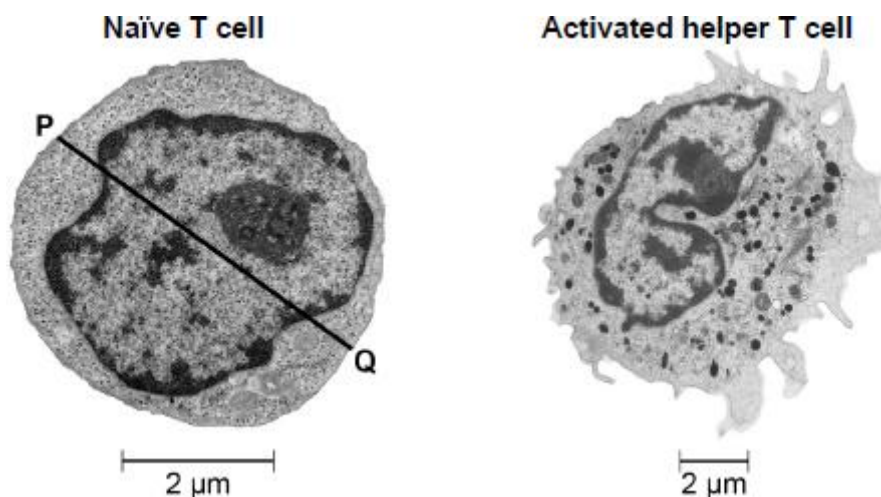
### Q1.

Scientists investigated the activation of T lymphocytes.

The scientists studied two types of cell:

- naïve T cells, which are T cells that have not yet been in contact with a foreign antigen
- activated helper T cells, which are T cells that have been activated by a foreign antigen.

The figure below shows electron microscope images of the two types of cell.



The activated helper T cell has a volume of  $463 \mu\text{m}^3$

- (a) Calculate the volume of the naïve T cell shown in the figure. Then calculate how many times larger the activated helper T cell volume is compared with the naïve T cell volume. Assume the cell is spherical. Use line **PQ** to measure the diameter of the naïve T cell.

$$\text{Volume of a sphere} = \frac{4}{3}\pi r^3 \text{ where } \pi \text{ is } 3.14$$

Show your working.

Volume of naïve T cell \_\_\_\_\_  $\mu\text{m}^3$

Number of times larger the activated helper T cell volume is compared with the naïve T cell volume \_\_\_\_\_

(3)

### Q2.

- (a) An ileum cell **without** microvilli has  $7.85 \mu\text{m}^2$  of cell surface in contact with digested substances.

A scientist found an ileum cell with 1000 microvilli. The microvilli cover the entire cell surface in contact with digested substances.

Microvilli are  $0.1\ \mu\text{m}$  in diameter and  $1\ \mu\text{m}$  in length.  
The surface area of a microvillus is calculated using this equation

$$2\pi r l + \pi r^2$$

where  $\pi$  is 3.14,  
r is the radius,  
l is the length.

Calculate the ratio of the area of the ileum cell surface **with** microvilli to the area of ileum cell surface **without** microvilli.

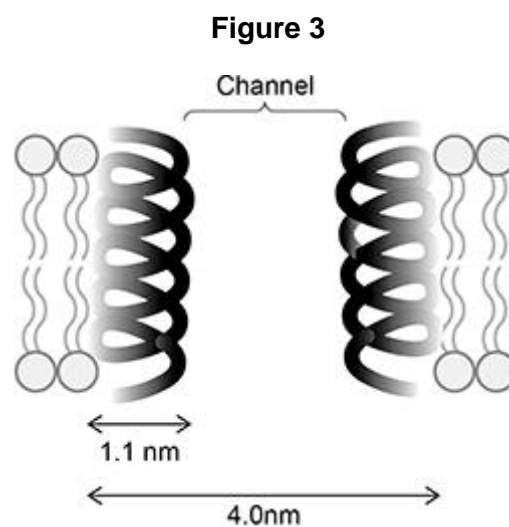
Show your working.

Ratio \_\_\_\_\_ :1

(2)

### Q3.

**Figure 3** shows further information about a channel formed in the cell-surface membrane by the APs.



- (d) Use **Figure 3** to calculate the cross-sectional area of the channel through which ions can pass.  
Assume the cross-sectional area is circular.  
Use  $\pi = 3.14$  in your calculation. Give your answer in  $\text{nm}^2$  **and** to 1 decimal place.

Answer \_\_\_\_\_ nm<sup>2</sup>

(2)