## 3.1.2 Carbohydrates

# Q1.

(a) What term is used to describe the different structures of α-glucose and β-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.

**(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.

$$\text{lactose + water} \xrightarrow{\text{lactase}} \text{glucose + galactose}$$

(a) The formula for galactose is $C_6H_{12}O_6$. What is the formula for lactose?

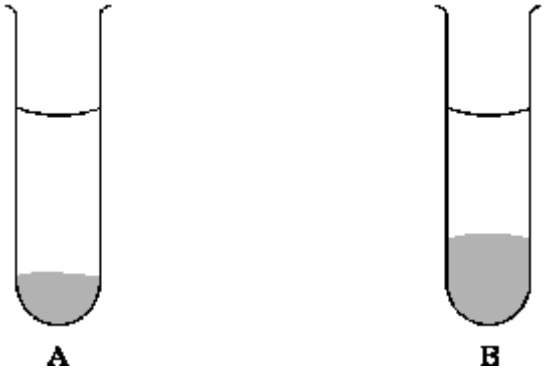
**(2)**

(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.

**(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.

_____

_____

_____

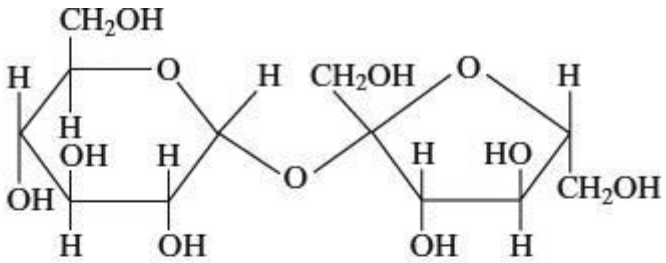
_____

**(2)**

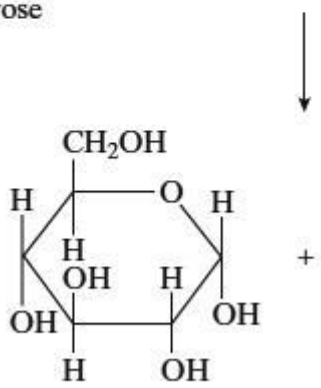
**(Total 6 marks)**

## 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**.



Sucrose



Monosaccharide **P**

Monosaccharide **Q**

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

_____

**(1)**

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

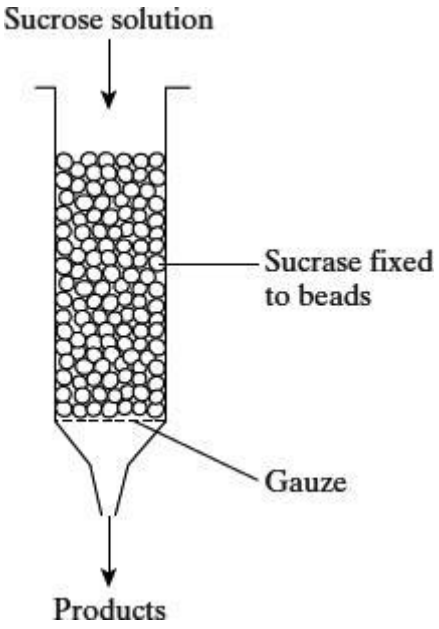
**(1)**

(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;

_____

_____

_____

_____

**(2)**

(ii) the enzyme.

_____

_____

_____

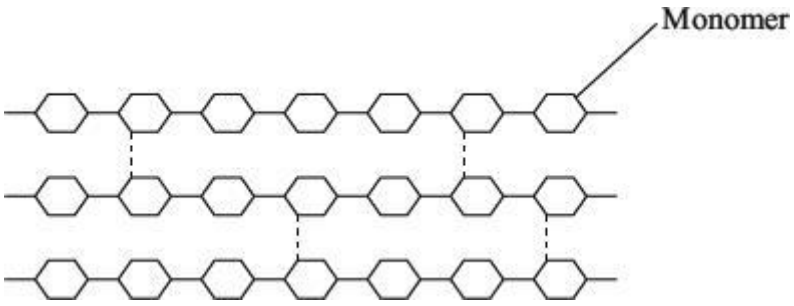
_____

**(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.

_____

_____

_____

_____

_____

_____

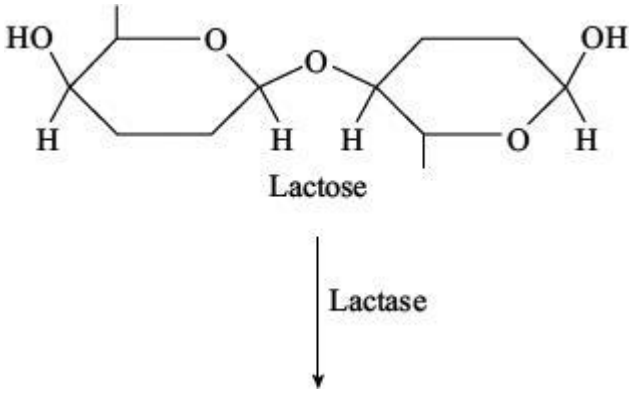
**(3)**

**(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.

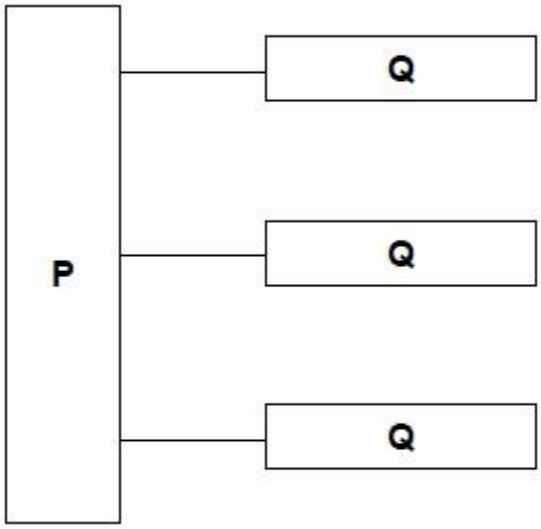



**(Total 2 marks)**

## 3.1.3 Lipids

## Q1.

The diagram represents a triglyceride.




(a) Name the molecules represented in the diagram by:

Box **P** _____

Box **Q** _____

**(2)**

(b) Name the type of bond between **P** and **Q** in the diagram.

_____

**(1)**

(c) Describe how you would test a liquid sample for the presence of lipid **and** how you would recognise a positive result.

_____

**(2)**

**(Total 5 marks)**

## Q2.

(a) **Figure 1** shows the structure of a molecule of glycerol and a molecule of fatty acid.

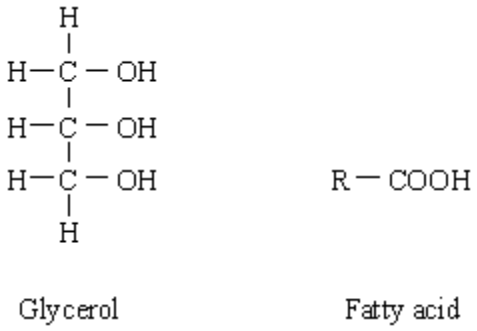



**Figure 1**

Draw a diagram to show the structure of a triglyceride molecule.

**(2)**

(b) Explain why triglycerides are **not** considered to be polymers.

**(1)**

(c) **Figure 2** shows two types of fat storage cell. Mammals living in cold conditions have more brown fat cells than mammals living in tropical conditions.

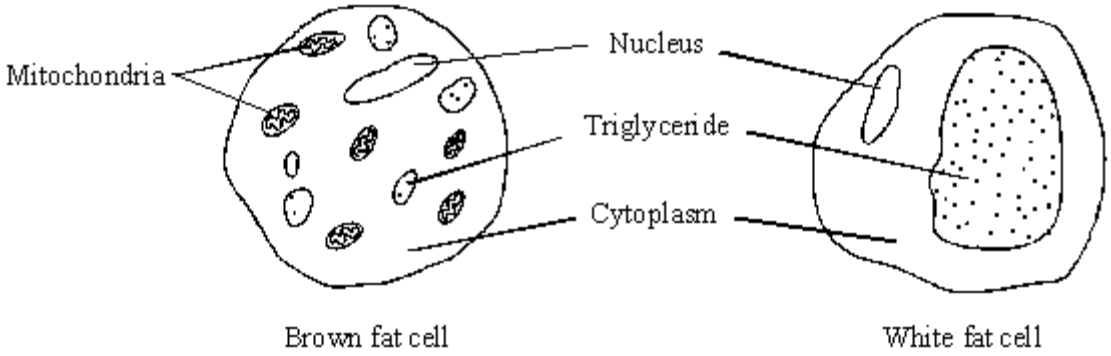



**Figure 2**

Using evidence from **Figure 2** to support your answer, suggest how the function of brown fat cells differs from that of white fat cells.

**(3)**

**(Total 6 marks)**

## Q3.

(a) Describe the difference between the structure of a triglyceride molecule and the structure of a phospholipid molecule.

**(1)**

(b) Describe how you would test for the presence of a lipid in a sample of food.

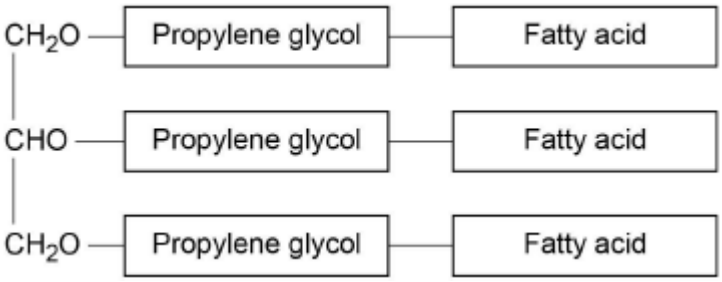
**(2)**

(c) Animal fats contain triglycerides with a high proportion of saturated fatty acids. If people have too much fat in their diet, absorption of the products of fat digestion can increase the risk of obesity. To help people lose weight, fat substitutes can be used to replace triglycerides in food.

Describe how a saturated fatty acid is different from an unsaturated fatty acid.

**(1)**

The diagram shows the structure of a fat substitute.




(d) This fat substitute **cannot** be digested in the gut by lipase.

Suggest why.

**(2)**

(e) This fat substitute is a lipid. Despite being a lipid, it cannot cross the cell-surface membranes of cells lining the gut.

Suggest why it **cannot** cross cell-surface membranes.

**(1)**

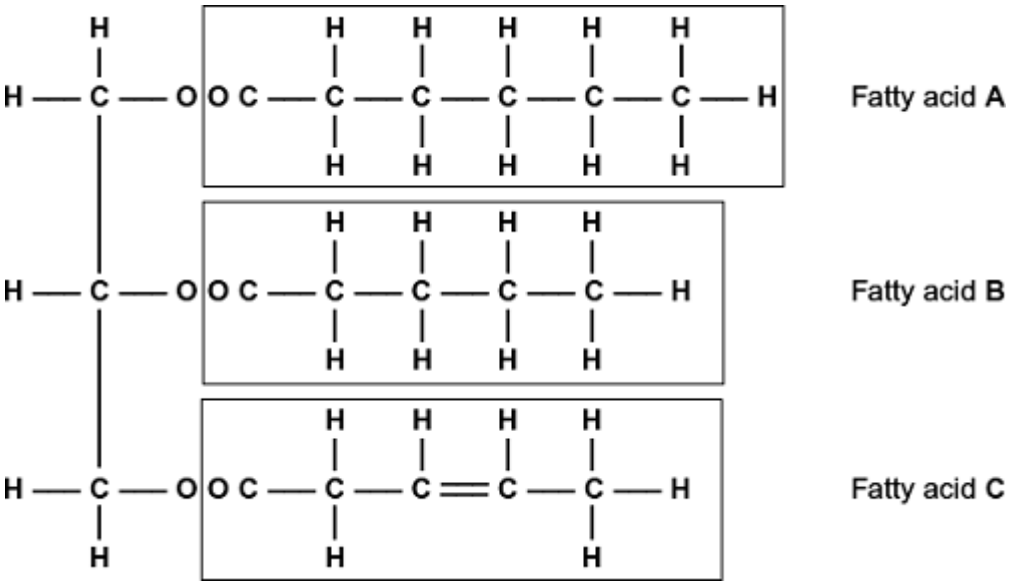
**(Total 7 marks)**

**Q4.**

(a) Some seeds contain lipids. Describe how you could use the emulsion test to show that a seed contains lipids.

**(3)**

(b) A triglyceride is one type of lipid. The diagram shows the structure of a triglyceride molecule.




(i) A triglyceride molecule is formed by condensation. From how many molecules is this triglyceride formed?

**(1)**

(ii) The structure of a phospholipid molecule is different from that of a triglyceride. Describe how a phospholipid is different.

_____

**(2)**

(iii) Use the diagram to explain what is meant by an unsaturated fatty acid.

_____

_____

_____

_____

**(2)**

**(Total 8 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.

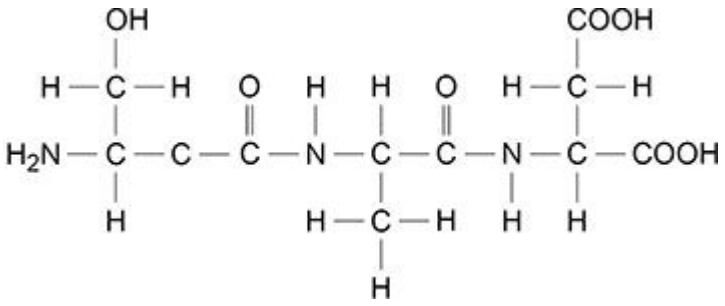
**Table 1**

| Amino acid | R group |
|---|---|
| Alanine | $CH_3$ |
| Asparagine | $CH_2CONH_2$ |
| Aspartic acid | $CH_2COOH$ |

| Amino acid | R group |
|---|---|
| Glutamic acid | $CH_2CH_2COOH$ |
| Glycine | H |
| Serine | $CH_2OH$ |

(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.

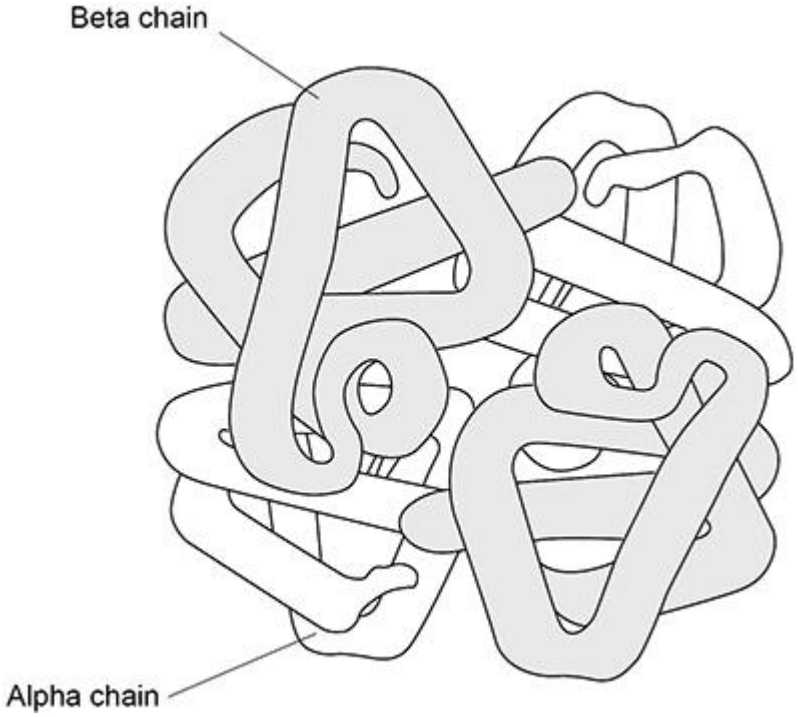
**Table 2**

| 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.

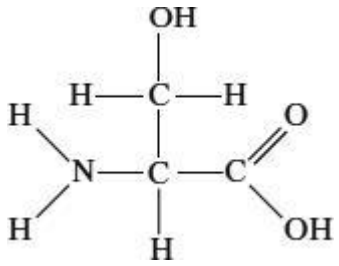
Answer _____ amino acids

**(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. _____

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.

_____

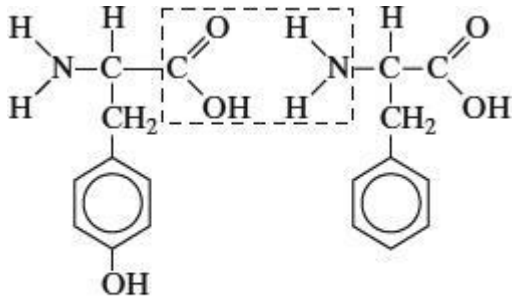
_____

_____

_____

**(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*.

_____

_____

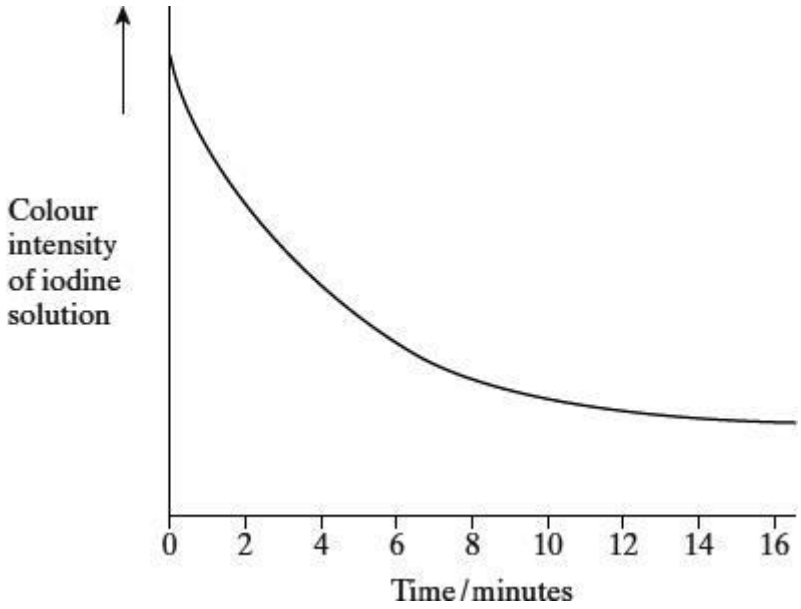
**(1)**

**(Total 7 marks)**

## 3.1.4.2 Many proteins are enzymes

### Q1.

In an investigation into carbohydrase activity, the contents from part of the gut of a small animal were collected. The contents were added to starch solution at pH 7 and kept in a water bath at 25°C. At one-minute intervals, samples were removed and added to different test tubes containing dilute iodine solution. The colour intensity of each sample was determined. The graph shows the results.




(a) Explain the change in colour intensity.

_____

_____

_____

_____

**(2)**

(b) Draw clearly labelled curves on the graph to show the expected result if the experiment was repeated

(i) at 35 °C;

(ii) at pH 2.

**(2)**

(c) Explain how

(i) raising the temperature to 35 °C affects carbohydrase activity;

(ii) decreasing the pH affects carbohydrase activity.

**(7)**

**(Total 11 marks)**

## Q2.

Gelatine is a protein. When a warm gelatine solution cools, it sets to form a jelly.
Fresh pineapple juice contains an enzyme that digests protein.
A student investigated the effect of pineapple juice on the setting of jelly.
He set up three different tubes of warm gelatine solution and recorded which had set after three hours. The contents of each tube and his results are shown in the table.

| Tube | Contents of tube | Jelly formed |
|---|---|---|
| **A** | 6 $cm^3$ gelatine + 2 $cm^3$ pineapple juice + 2 $cm^3$ water | No |
| **B** | 6 $cm^3$ gelatine + 2 $cm^3$ pineapple juice + 2 $cm^3$ hydrochloric acid | Yes |

| | | |
|---|---|---|
| **C** | 6 $cm^3$ gelatine + 2 $cm^3$ boiled pineapple juice + 2 $cm^3$ water | Yes |

(a) Explain why 2 $cm^3$ of water was added to tubes **A** and **C**.

**(2)**

(b) Explain the results of

tube **A**

tube **B**

**(4)**

(c) What was the purpose of tube **C**?

*(Extra space)*

**(3)**

**(Total 9 marks)**

## Q3.

(a) Describe how monomers join to form the primary structure of a protein.

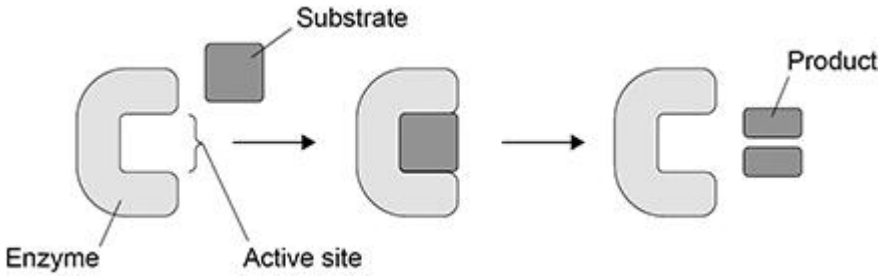
**(3)**

(b) Many proteins are enzymes.

In 1894, a scientist suggested the lock and key model of enzyme action.

**Figure 1** shows the lock and key model.

**Figure 1**




Describe **one** similarity and **one** difference between the induced-fit model of enzyme action and the lock and key model of enzyme action.

Similarity _____

Difference _____

**(2)**

(c) State how enzymes help reactions to proceed quickly at lower temperatures.

Do **not** write about active sites in your answer.

**(1)**

(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 |
|---|---|---|
| **G** | $4 \times 10^7$ | 20 |
| **H** | $6 \times 10^8$ | |

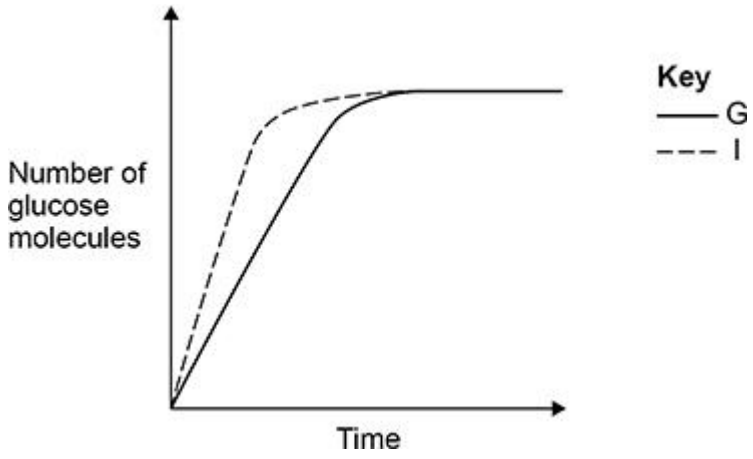
Complete the table by calculating the time taken for the complete hydrolysis of the maltose in solution **H**. Assume the rate of maltase activity is the same in solution **G** and in solution **H**.

Show your working.

**(2)**

(e) **Figure 2** shows the scientist's results for solution **G**. Curve **I** shows the results of a similar investigation in which he changed one independent variable.

**Figure 2**




Tick (✓) **one** box next to the statement that describes the independent variable that the scientist changed to give the results shown by curve **I** in **Figure 2**.

Addition of a competitive inhibitor ☐

Increased maltase concentration ☐

Increased maltose concentration ☐

Reduced temperature ☐

**(1)**

**(Total 9 marks)**

## Q4.

Two enzymes, **P** and **Q**, are proteins with quaternary structure which catalyse the same reaction, but they have different amino acid sequences.

(a) Define the **quaternary structure** of a protein.

_____

_____

_____

**(1)**

(b) Explain how two enzymes with different amino acid sequences can catalyse the same reaction.

_____

_____

_____

_____

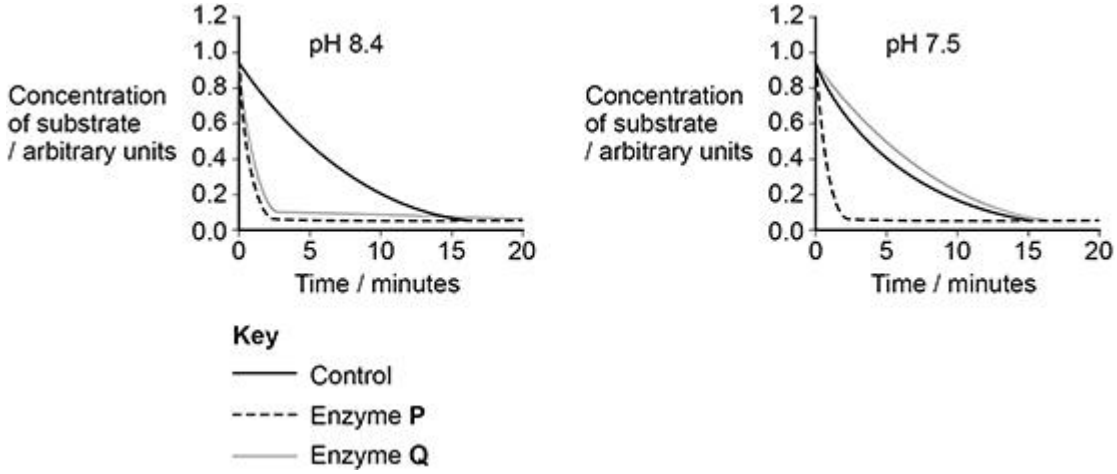
_____

_____

**(2)**

Scientists investigated the effect of pH 8.4 and pH 7.5 on the activity of enzymes **P** and **Q**.

The figure below shows their results.




(c) Describe what the scientists should place in the control tubes in this investigation.

**(3)**

(d) Give **three** conclusions you can make from the figure above.

1

2

3

**(3)**

**(Total 9 marks)**

## Q5.

Doctors investigated babies who were bottle-fed with baby-formula milk and suffered from colic. Colic is a condition that affects the gut and makes babies cry.

Each mother was given two solutions to add to her baby's milk. One solution contained the enzyme lactase, the other did not. The mother did not know which solution contained lactase. The mother added one of the solutions to her baby's milk for a week and recorded how long it cried each day. The mother then used the other solution for the second week.

The table shows the results.

| | **Mean crying time / hours day$^{-1}$** |
|---|---|
| **Milk with lactase** | 1.43 |
| **Milk without lactase** | 2.57 |

(a) Suggest an explanation for the results.

_____

_____

_____

_____

**(2)**

(b) The mothers were not told which solution contained lactase.

Suggest **one** reason why.

_____

_____

**(1)**

(c) Suggest **one** variable the doctors would have to control in this study to make it a fair test. Explain your answer.

Variable _____

Explanation _____

_____

_____

**(2)**

(d) The doctors concluded that adding lactase to milk was, '*A major breakthrough for babies with colic*.'

Evaluate the evidence for this conclusion.

*(Extra space)* _____

**(3)**

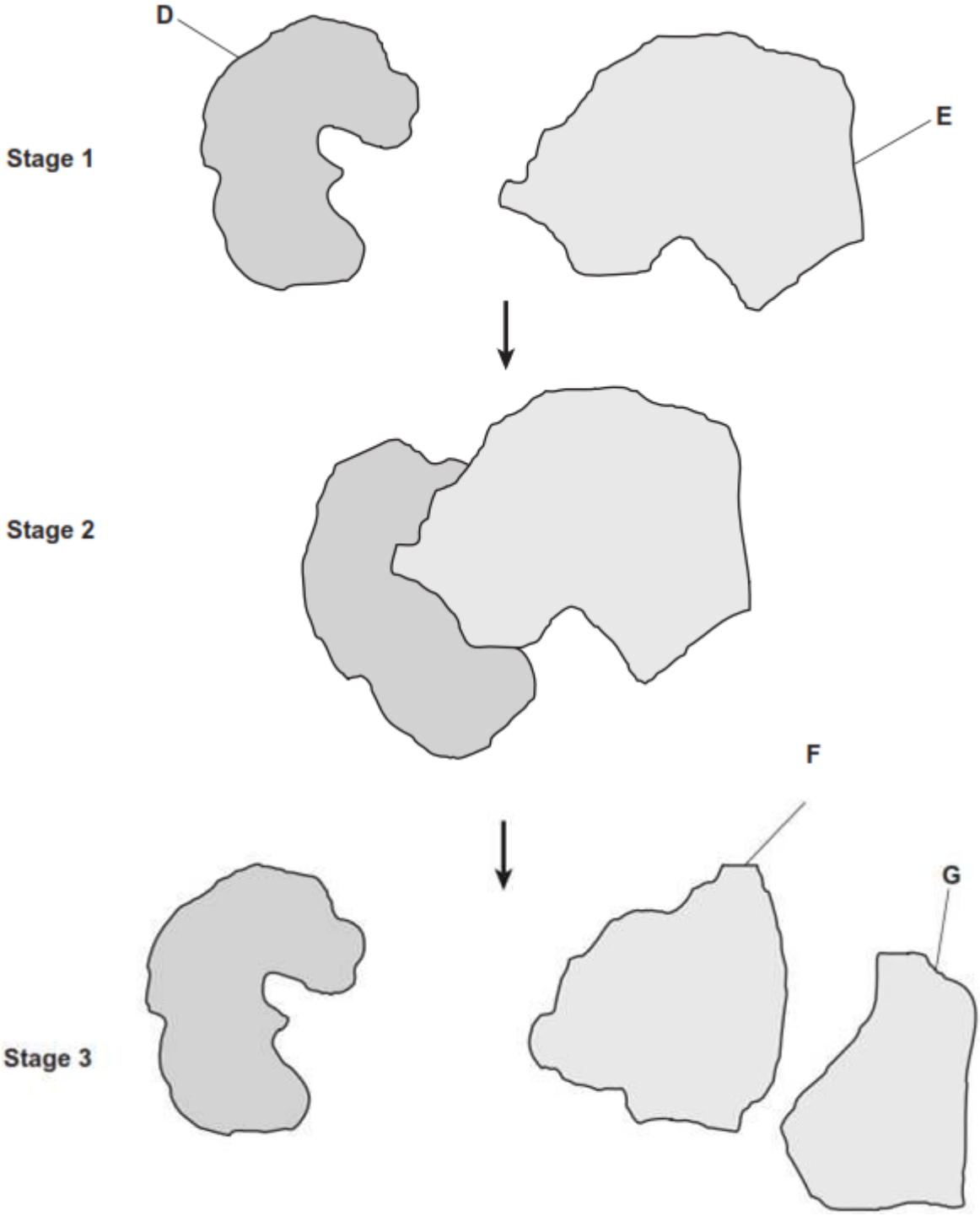
**(Total 8 marks)**

## Q6.

(a) What is an enzyme?

**(2)**

The diagram shows stages during an enzyme-catalysed reaction.




(b) Using the letters in the diagram, describe what is happening in this reaction.

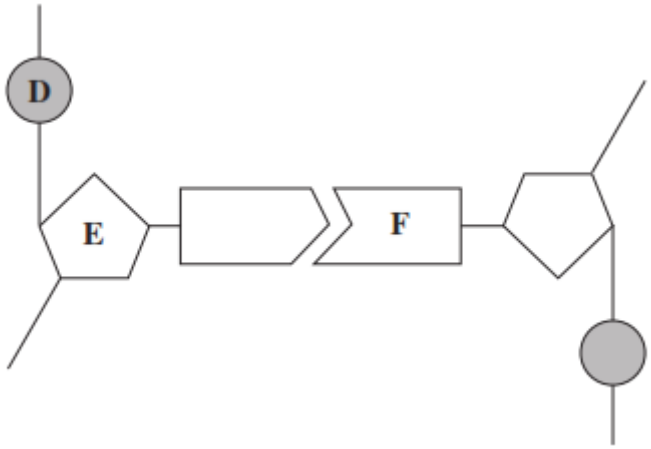
**(3)**

**(Total 5 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.

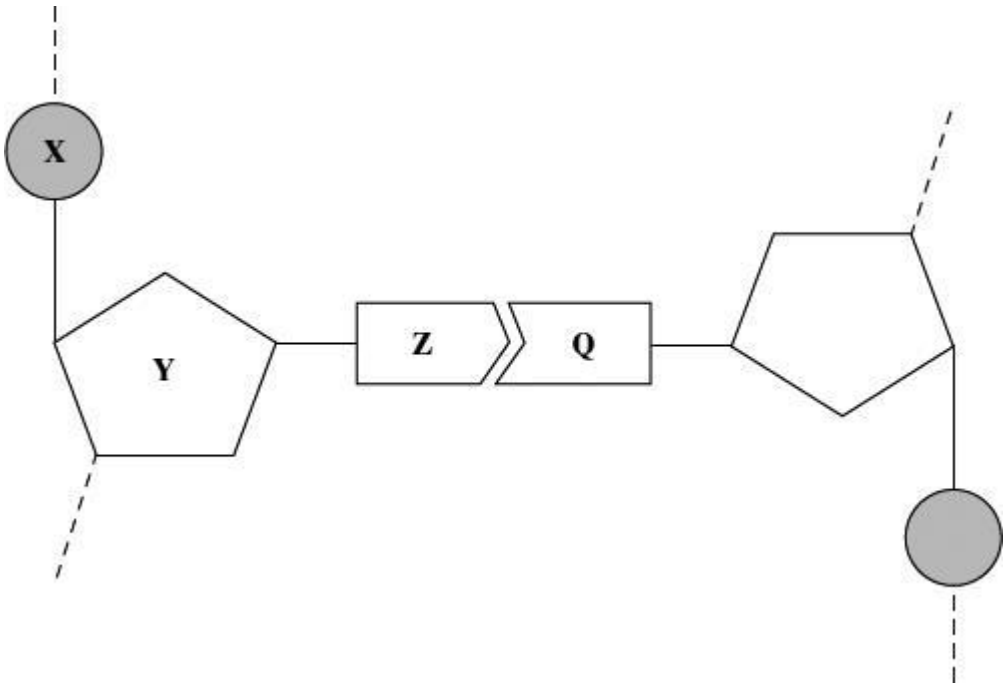
| | DNA | RNA |
|---|---|---|
| **1** | | |
| **2** | | |

**(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.

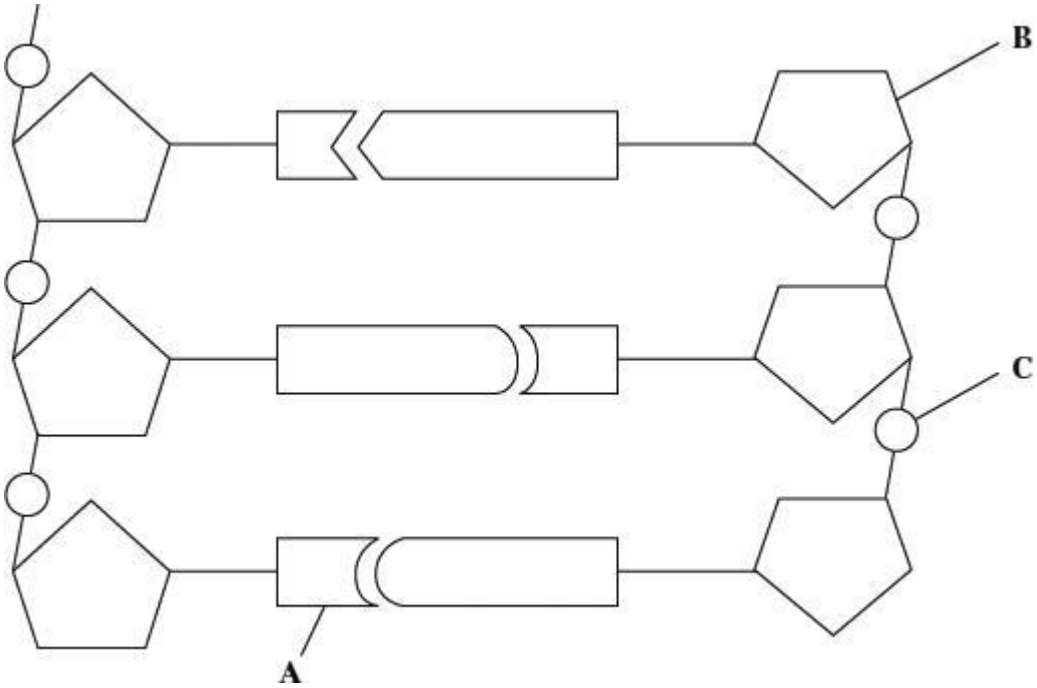
Answer _____ %

**(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.

_____

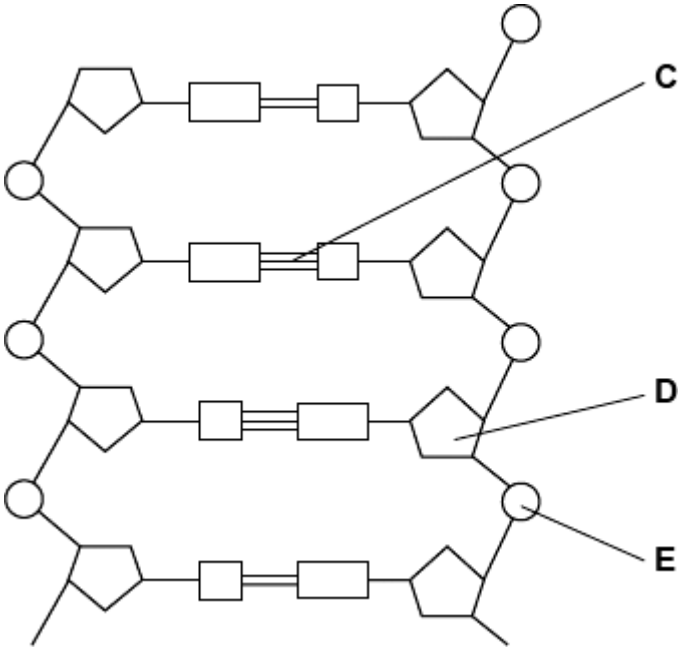
_____

**(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?

_____

_____

_____

**(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

_____

_____

_____

**(1)**

**(Total 8 marks)**

## 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.

_____

_____

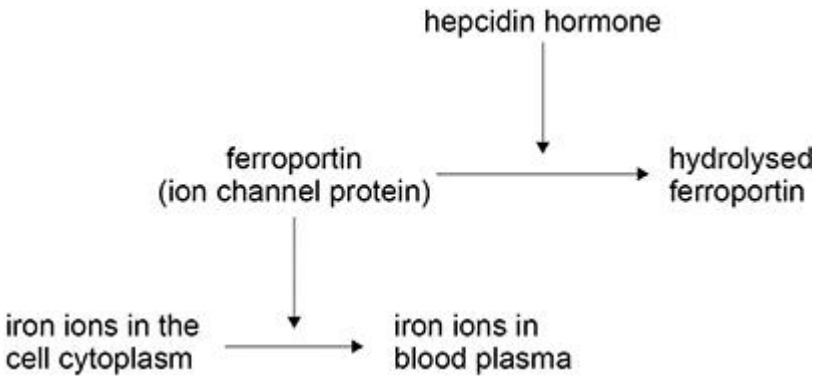
_____

_____

**(2)**

(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.

_____

_____

_____

_____

_____

_____

_____

_____

**(3)**

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

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.

**(5)**
**(Total 5 marks)**

## 3.2.1.1 Structure of eukaryotic cells

## Q1.

(a) Describe the structure and function of the nucleus.

_____

_____

_____

**(4)**

(b) Name the main polymer that forms the following cell walls.

Plant cell wall _____

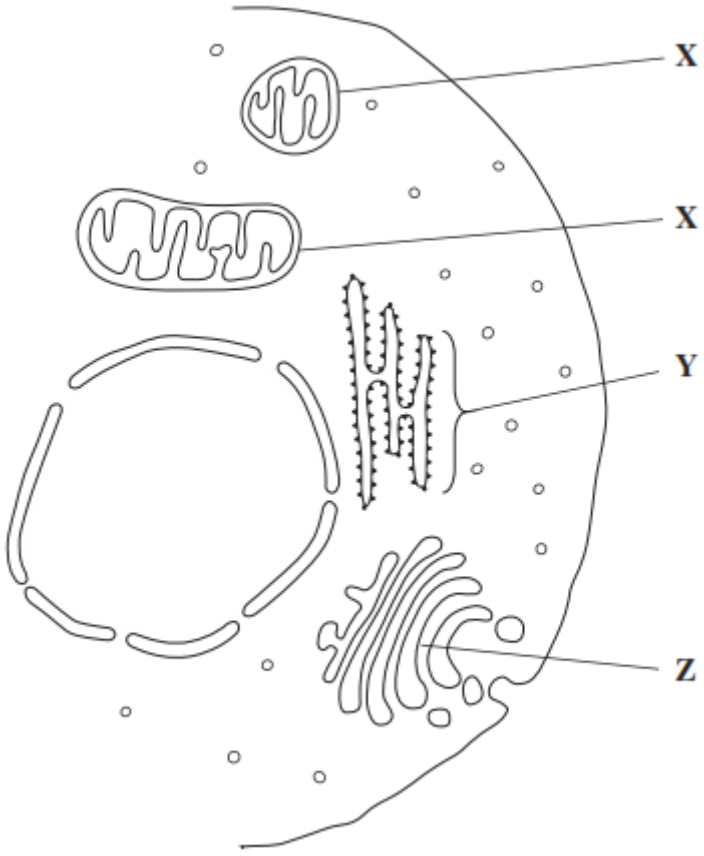
Fungal cell wall _____

**(1)**

**(Total 5 marks)**

## Q2.

The drawing shows part of a human cell.




(a) Name organelles

**X** _____

**Y** _____

**(2)**

(b) (i) The organelles labelled **X** all have very similar shapes in this cell.
Explain why they appear to have different shapes in this drawing.

_____

_____

*(Extra space)* _____

_____

**(1)**

(ii) Large numbers of organelles **X** and **Z** are found in mucus-secreting cells. Explain why.

_____

_____

_____

_____

*(Extra space)* _____

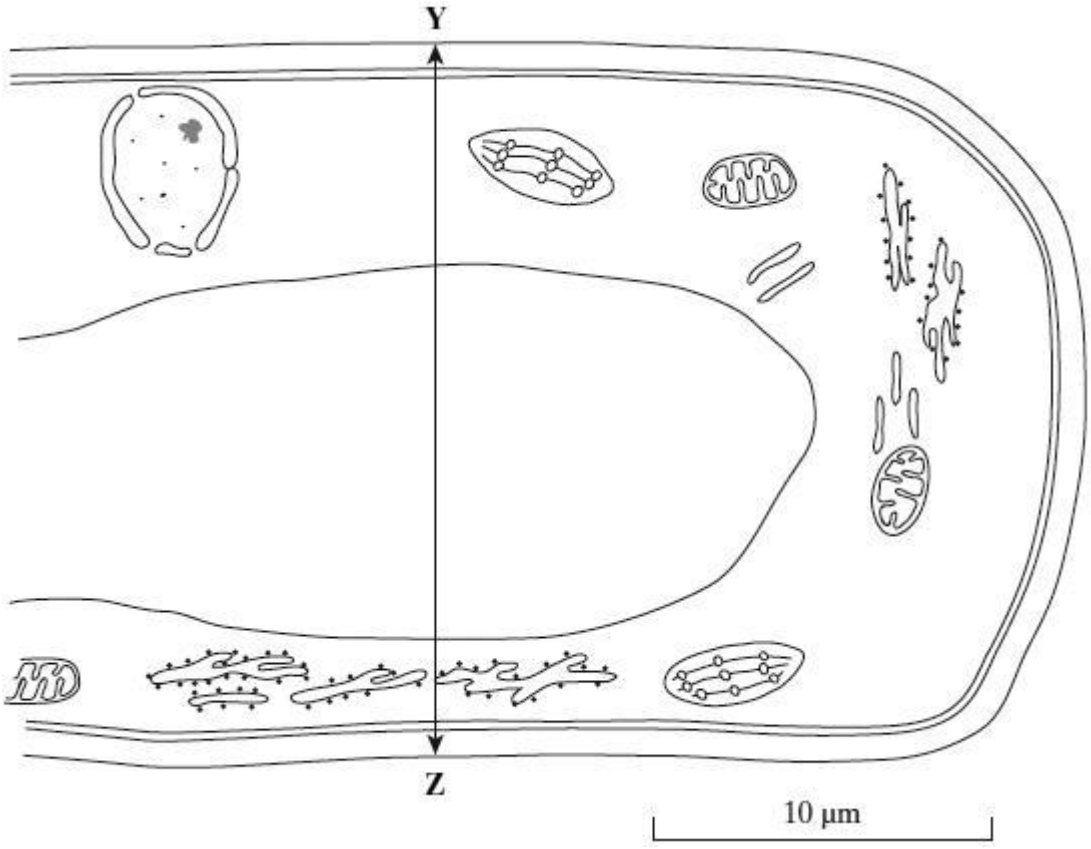
_____

**(2)**

**(Total 5 marks)**

## Q3.

The drawing shows part of a plant cell as seen with an electron microscope.




(i) Give **two** features shown in the drawing which are evidence that this cell is eukaryotic.

1. _____

_____

2. _____

_____

**(2)**

(ii) Calculate the actual width of the cell from **Y** to **Z**. Give your answer in micrometres (µm) and show your working.

Answer _____ µm

**(2)**

(iii) Give **one** way in which a typical animal cell differs from the cell shown in the drawing.

_____

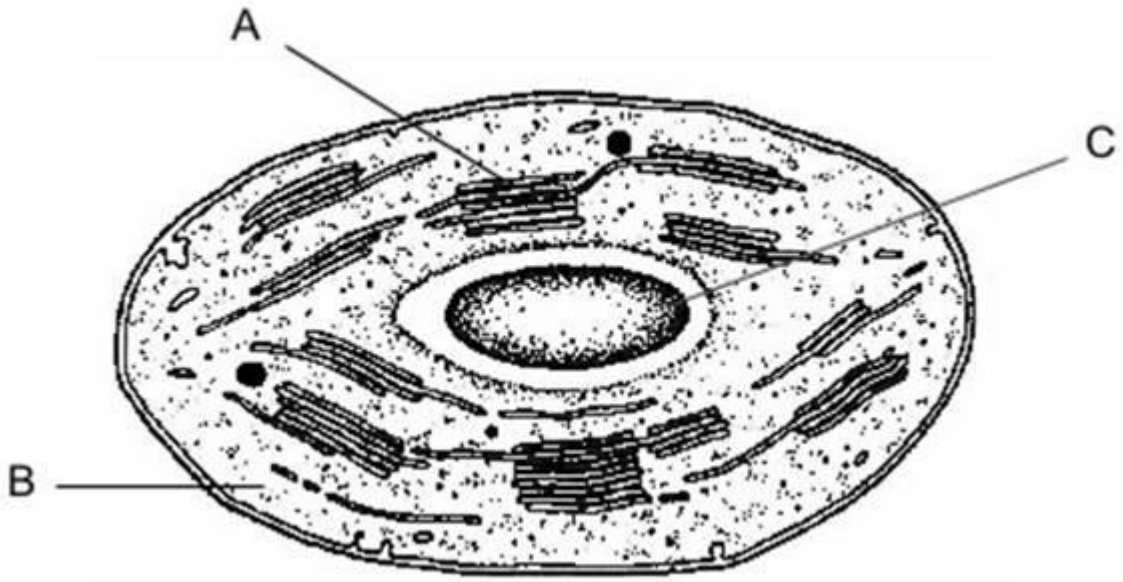
_____

**(1)**

**(Total 5 marks)**

## Q4.

The electron micrograph shows part of a chloroplast.




(a) Name the parts labelled **A** and **B** and, for each, describe **one** role in the process of photosynthesis.

**A** Name _____

Role _____

**B** Name _____

Role _____

**(4)**

(b) (i) Name the main substance present in the part labelled **C**.

_____

**(1)**

(ii) How is this substance formed?

_____

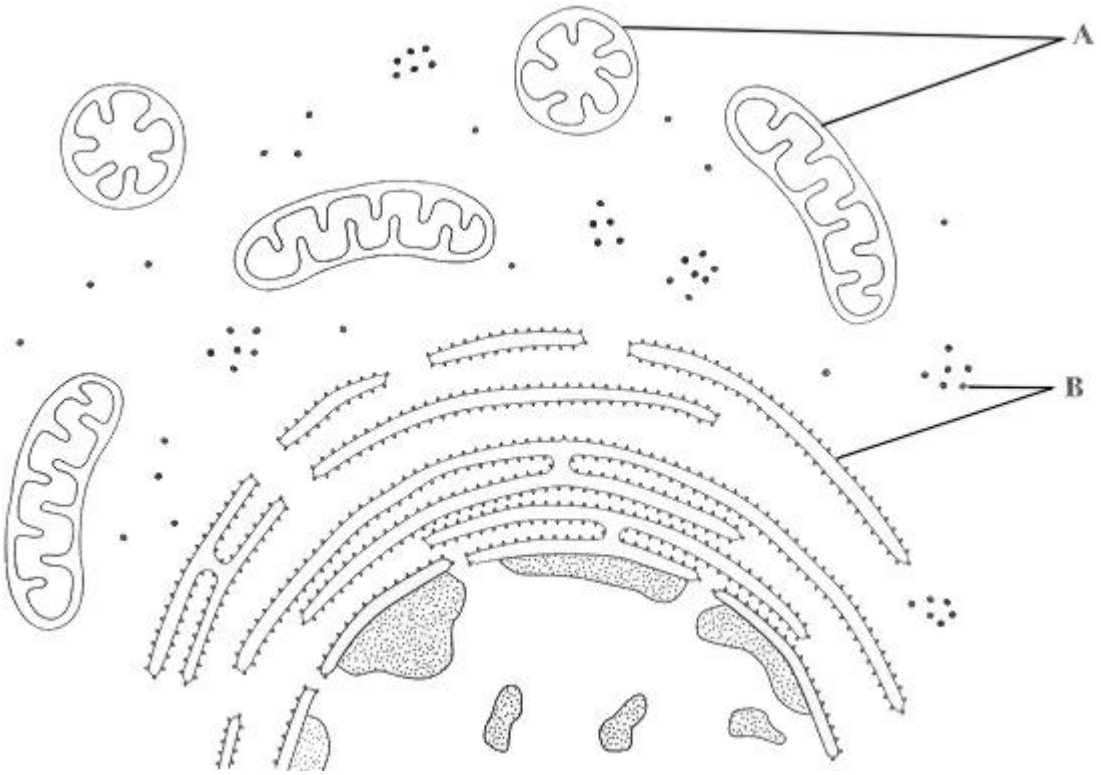
_____

**(1)**

**(Total 6 marks)**

## Q5.

The diagram shows part of an animal cell as seen through an electron microscope.




(a) Name the organelles labelled **A** and **B**.

**A** _____

**B** _____

**(2)**

(b) Explain why the shapes of the two organelles labelled **A** appear different.

_____

_____

_____

_____

**(2)**

(c) Give the function of organelle **B**.

_____

_____

**(1)**

(d) The epithelial cells of the small intestine have large numbers of organelle **A**. Explain how this is an adaptation for the function of these cells.

_____

_____

_____

_____

_____

_____

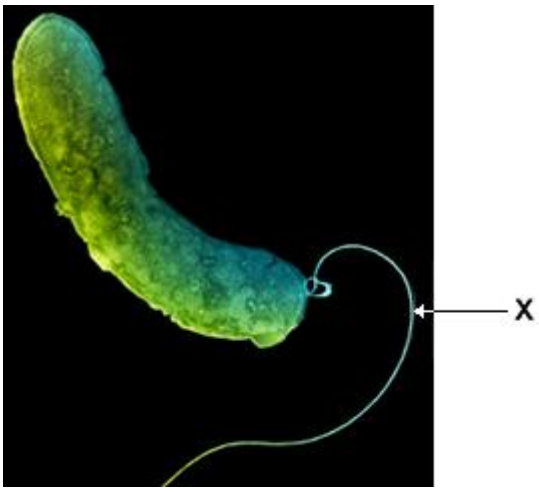
**(3)**

**(Total 8 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**.

_____

**(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 _____

_____

Explanation _____

_____

**(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.

_____

_____

_____

**(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 μm

Describe how the student determined the size of the structure.

_____

_____

_____

_____

**(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 _____

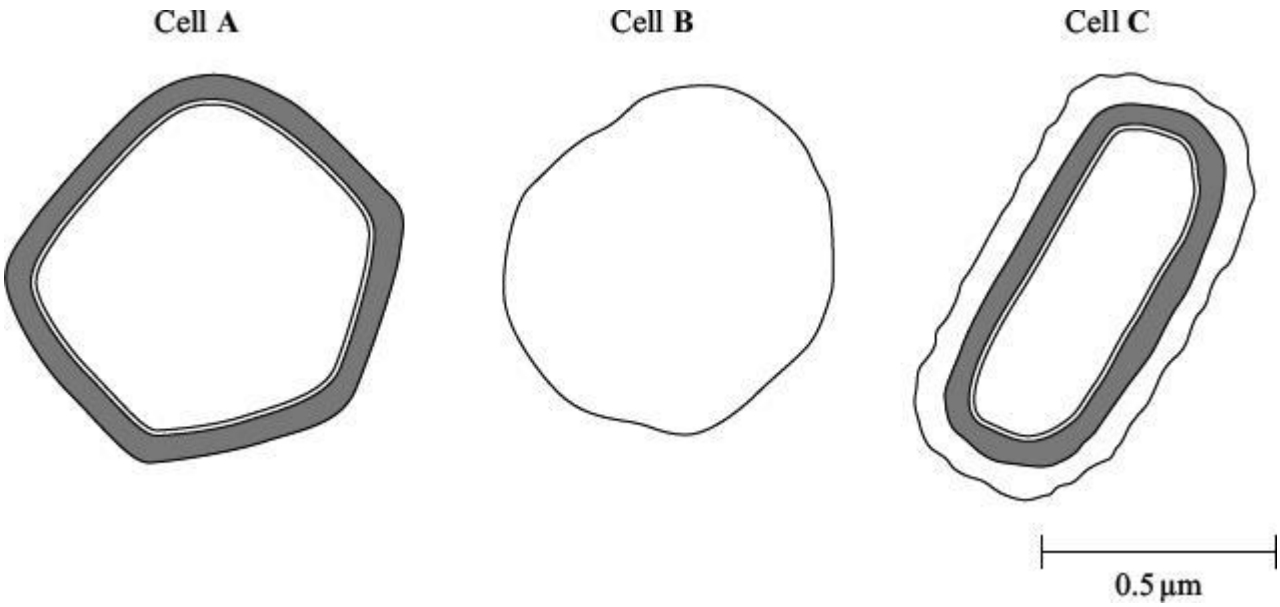
2 _____

**(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,

_____

_____

**(1)**

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

_____

_____

**(1)**

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

_____

_____

**(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.

_____

**(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.

_____

_____

_____

_____

**(2)**

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

_____

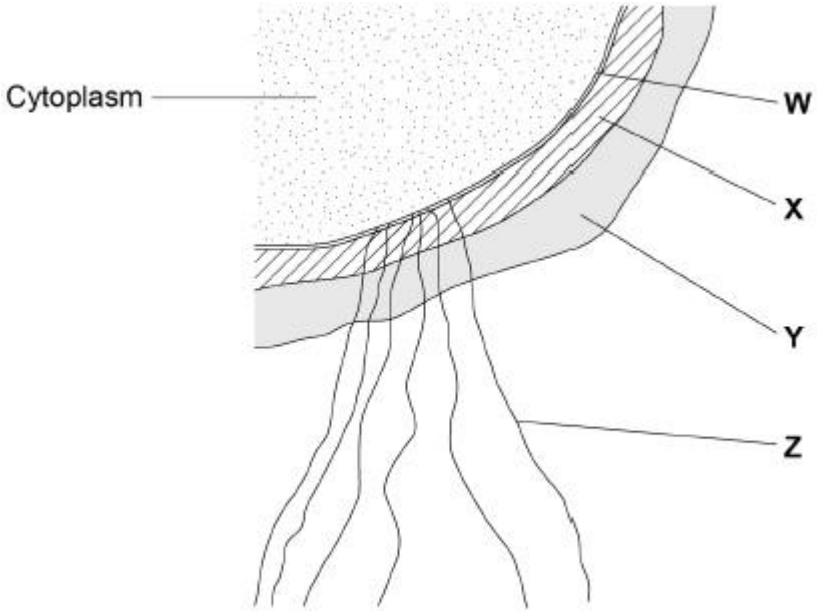
_____

**(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.

_____

**(1)**

(d) Some prokaryotic cells can divide every 30 minutes. A liquid culture contained a starting population of $1.35 \times 10^4$ cells.

Assuming each cell divides every 30 minutes, calculate how many cells there will be after 3 hours. Assume no cells die during this time.

Answer = _____

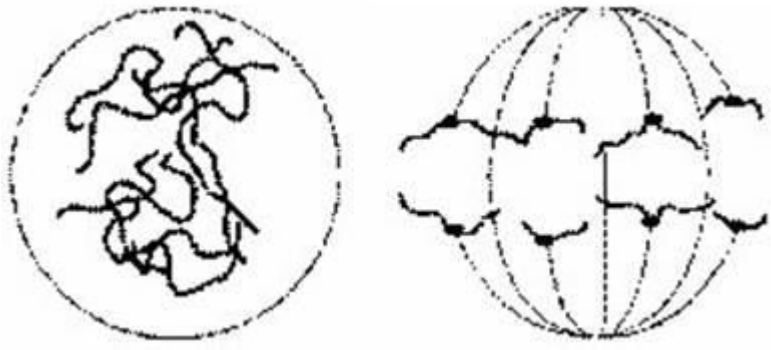
**(2)**

**(Total 7 marks)**

## 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. _____

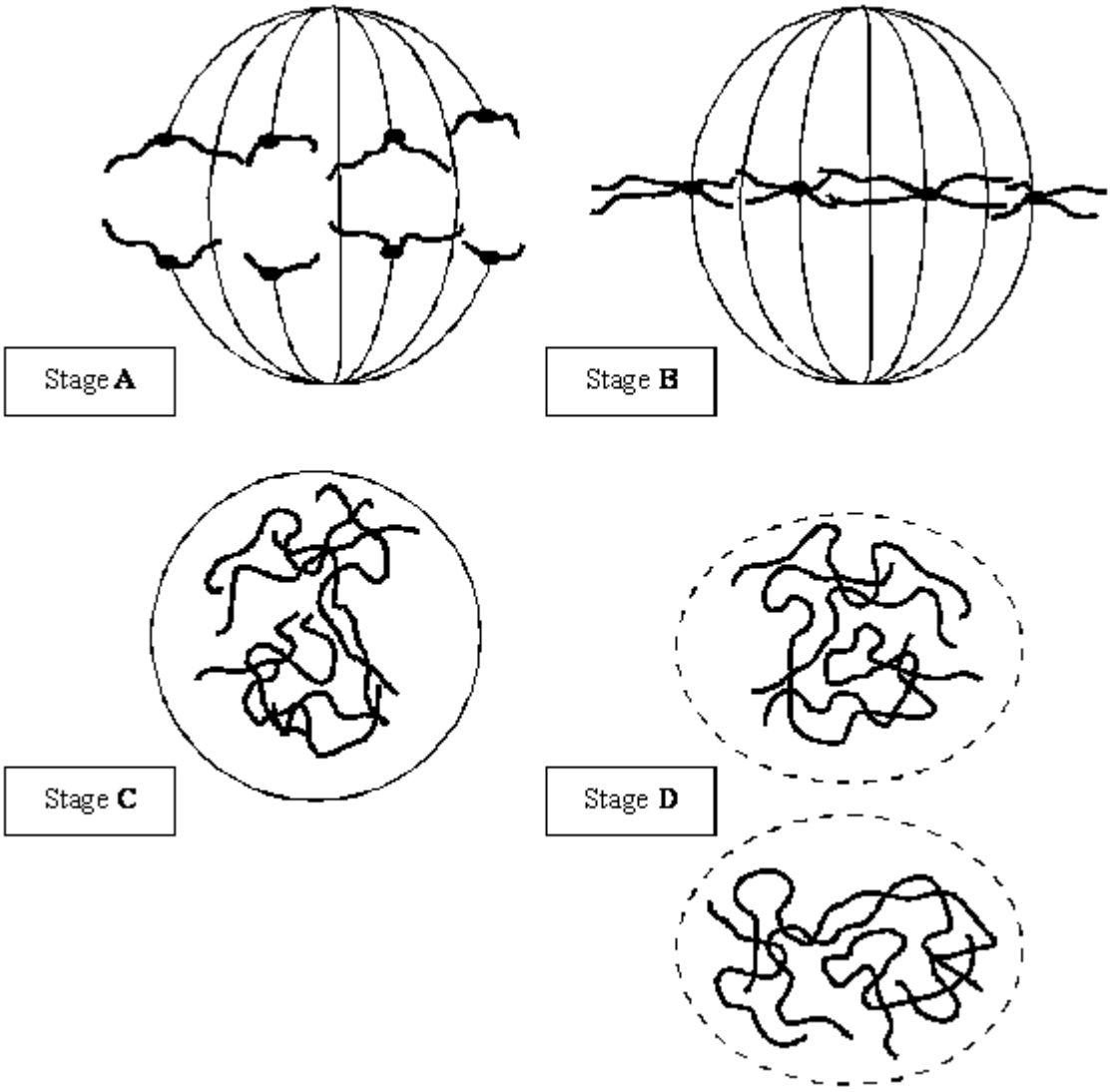
_____

**(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**.

_____

_____

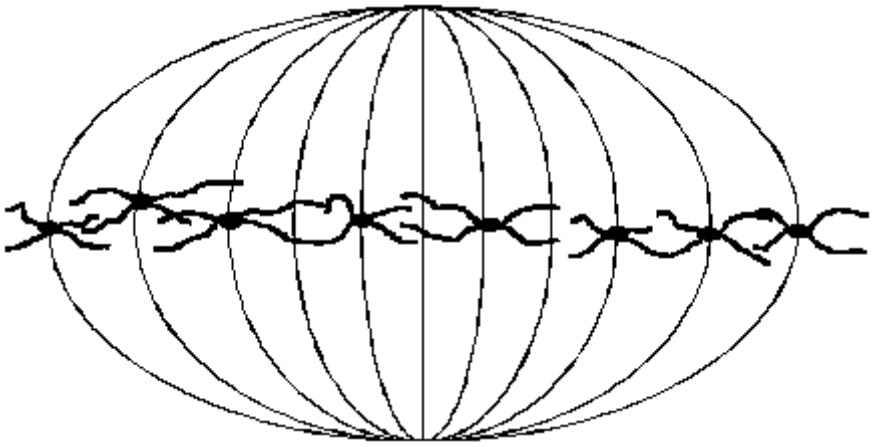
_____

_____

**(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?

_____

**(1)**

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

_____

_____

**(1)**

**(Total 6 marks)**

## Q3.

(a) The following statements describe stages of mitosis.

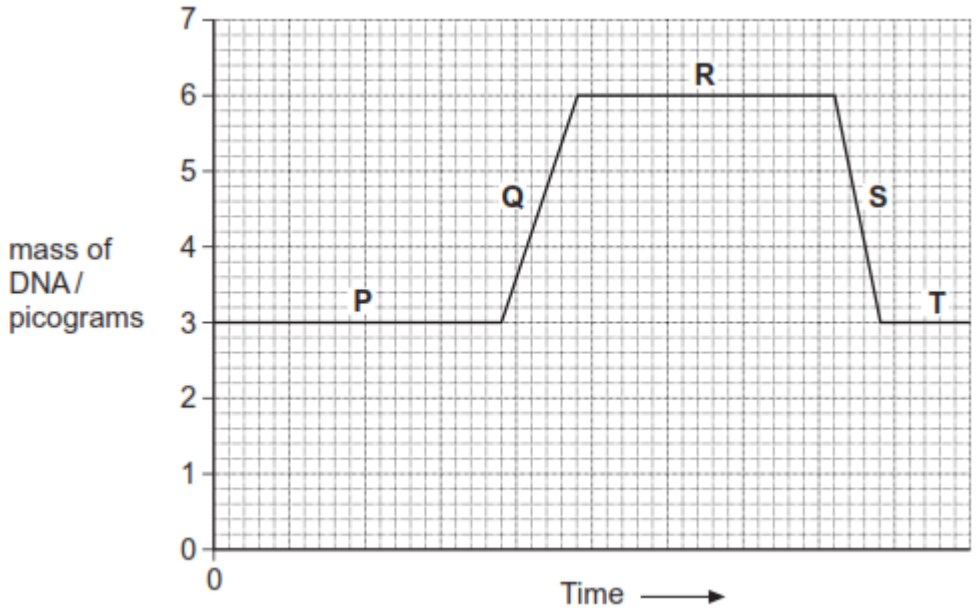
**A** chromosomes align at the centre of the cell attached to spindle fibres
**B** chromatids are in groups at the poles
**C** chromosomes become visible
**D** chromatids move towards the poles

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**.

_____

_____

**(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 $cm^3$ 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**.

_____

_____

_____

_____

_____

_____

_____

_____

**(2)**

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

Explain why.

_____

_____

_____

_____

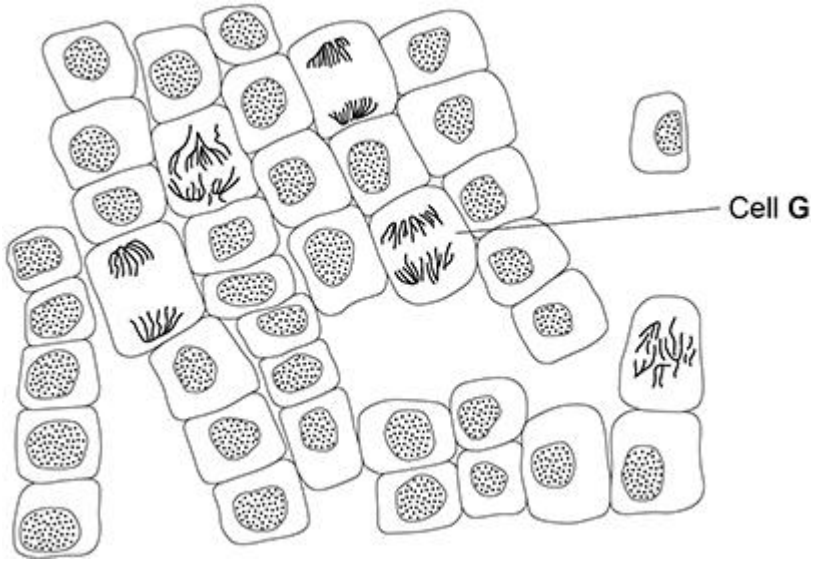
_____

_____

_____

**(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 _____

_____

_____

_____

_____

**(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 _____

_____

_____

2 _____

_____

_____

**(2)**

**(Total 9 marks)**

## Q5.

(a) What is a tumour?

_____

_____

_____

_____

**(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.

_____

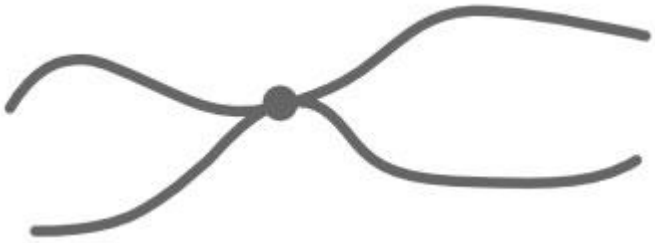
_____

**(3)**

**(Total 5 marks)**

## Q6.

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

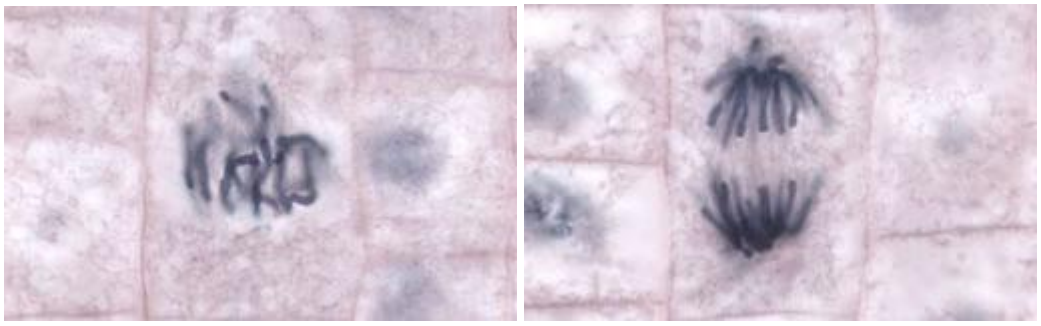


Describe and explain the appearance of the chromosome.

**(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** _____

_____

_____

_____

**(2)**

(ii) Stage **B** _____

_____

_____

_____

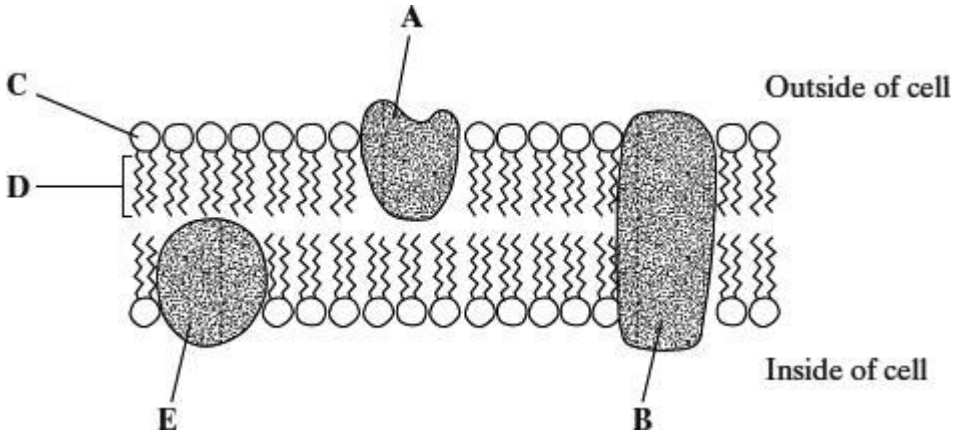
**(2)**

**(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)**

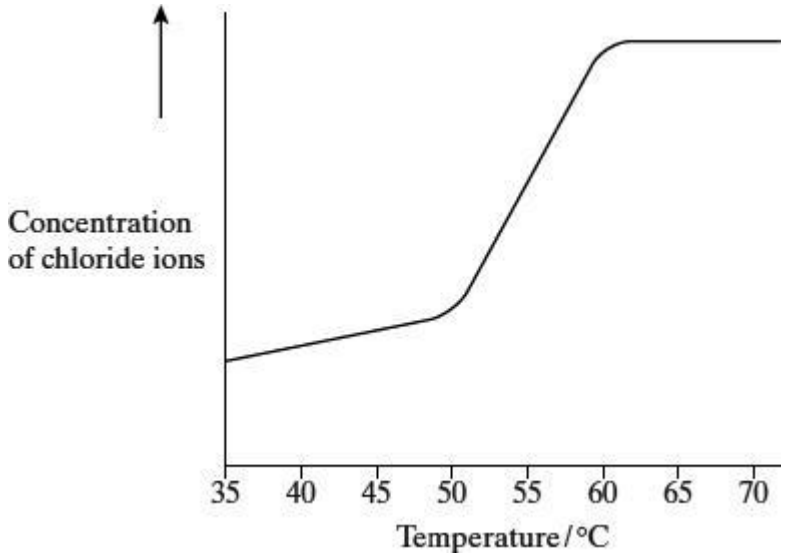
(b) Explain why the structure of a membrane is described as *fluid-mosaic*.

_____

_____

**(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.



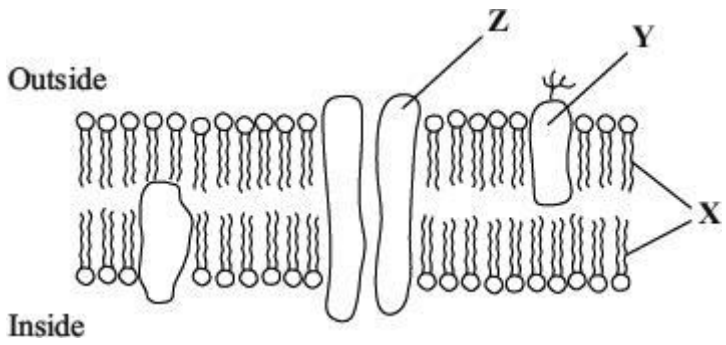

Describe and explain the shape of the curve.

**(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.

_____

_____

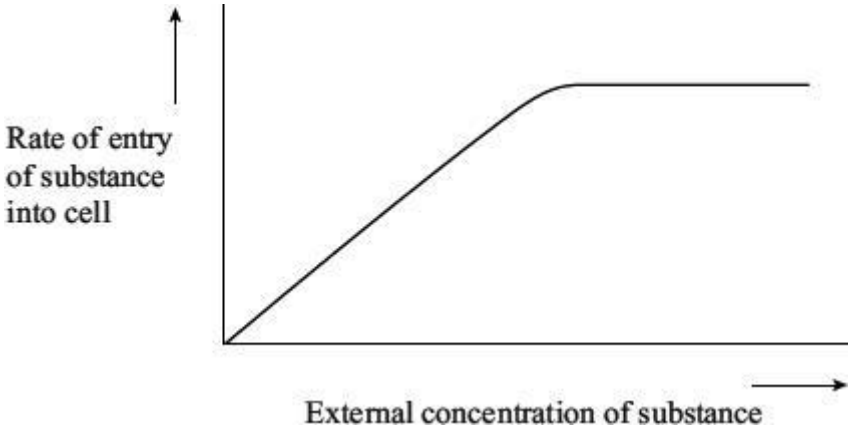
(ii) Give **one** way in which active transport differs from facilitated diffusion.

_____

_____

**(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.

_____

_____

_____

_____

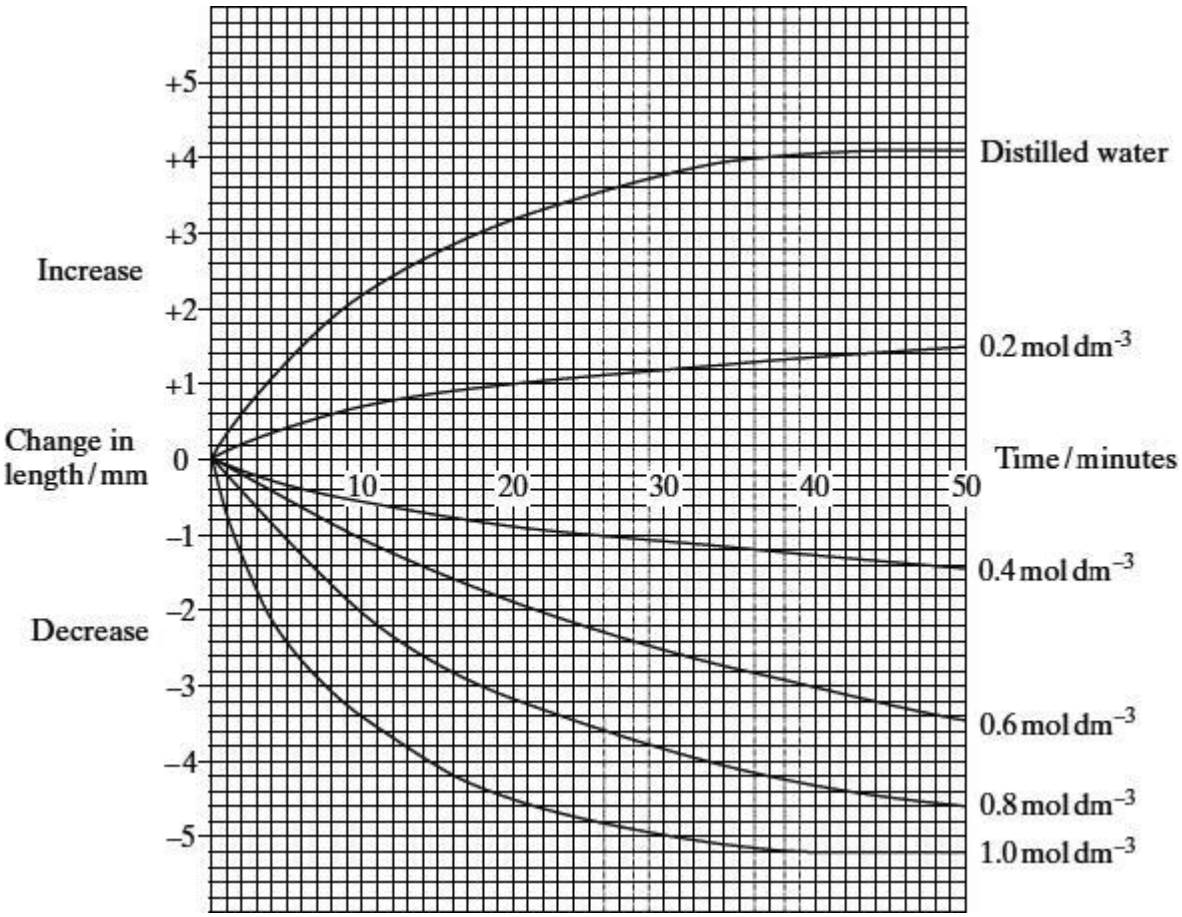
**(2)**

**(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;

_____

_____

_____

_____

**(2)**

(ii) the potato cylinder in the 1.0 mol $dm^{-3}$ sucrose solution showed no further

decrease in length after 40 minutes.

_____

_____

_____

_____

**(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 $dm^{-3}$ and the cylinder in the 0.8 mol $dm^{-3}$ solution.

_____

_____

**(1)**

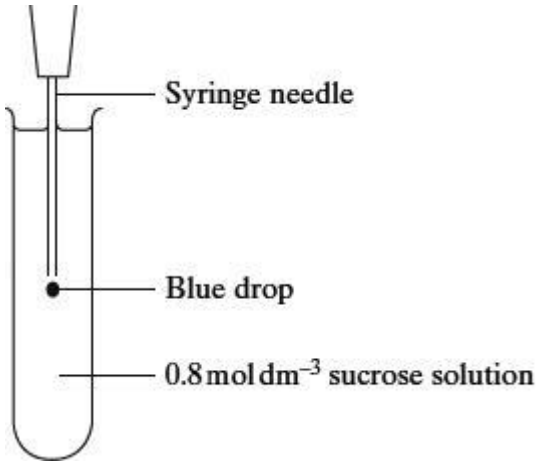
(ii) Use your knowledge of water potential to explain this difference.

_____

_____

**(1)**

(c) After 45 minutes the potato cylinder in the 0.8 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 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.

_____

_____

_____

_____

**(2)**

(ii) A sucrose solution of concentration 0.3 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.

_____

_____

_____

_____

**(2)**

**(Total 10 marks)**

## Q4.

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

_____

_____

_____

_____

**(2)**

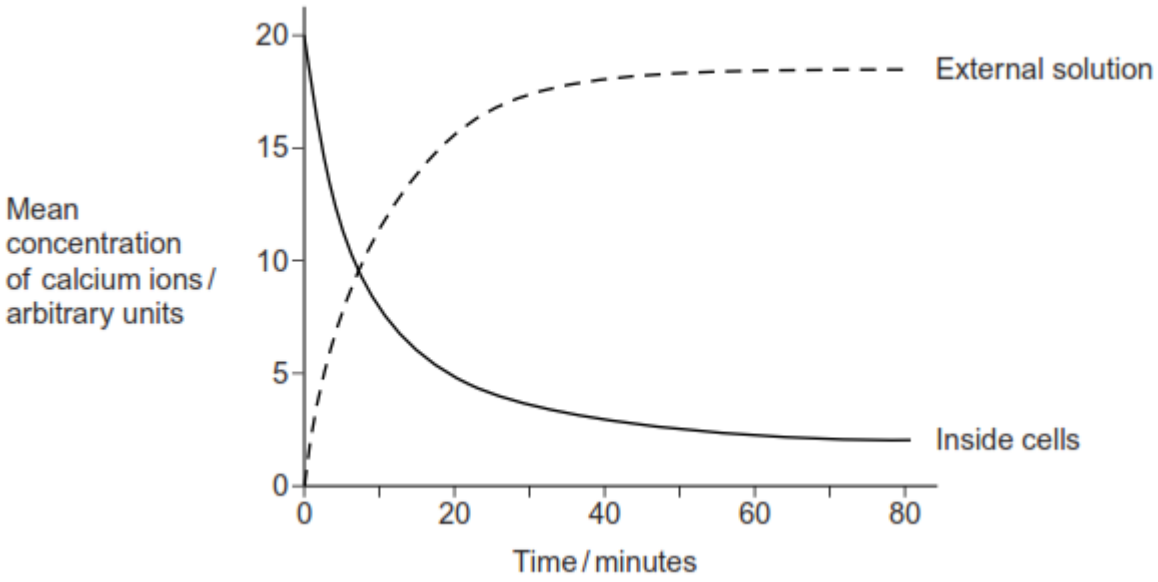
(b) Give **two** functions of proteins in plasma membranes.

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.

_____

_____

_____

_____

**(2)**

**(Total 6 marks)**

## 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. _____

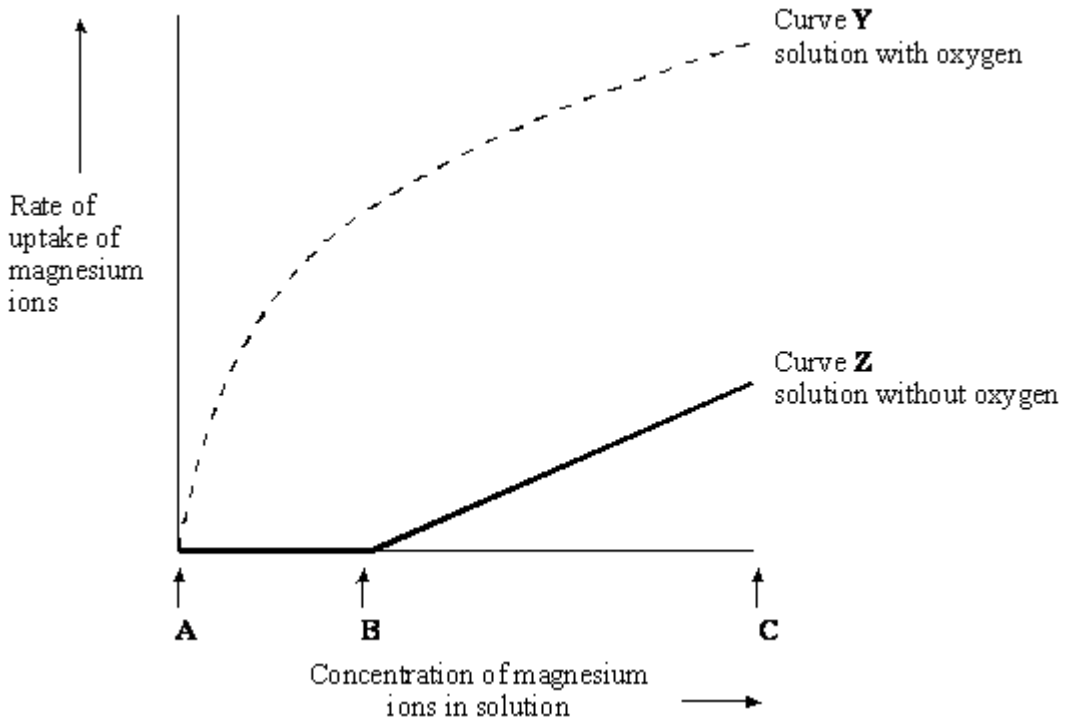
_____

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.

_____

_____

_____

_____

_____

_____

_____

**(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.

_____

_____

**(3)**
**(Total 7 marks)**

## Q2.

(a) What is an antigen?

**(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.

*(Extra space)*

**(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.

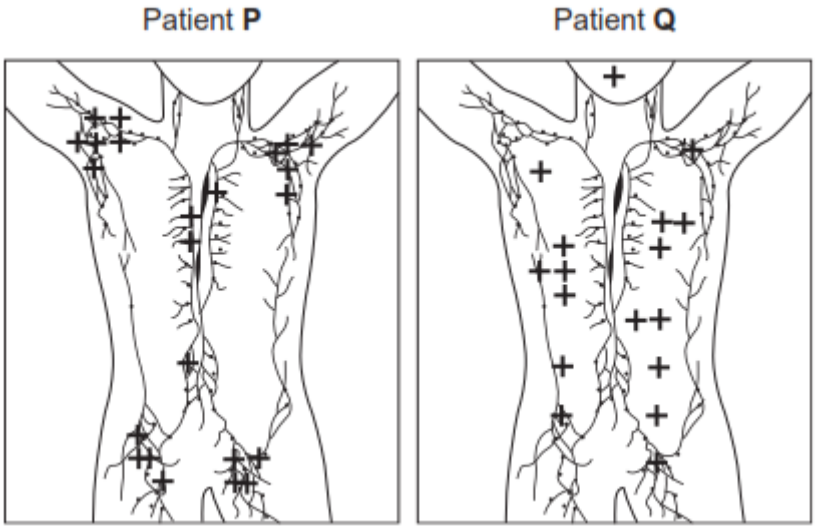
(a) Only B-cells are killed by Zevalin.

Explain why.

**(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.

*(Extra space)* _____

**(3)**

(c) Suggest **one** reason for the difference in distribution of the radioactivity detected in

these patients.

_____

_____

_____

_____

**(2)**

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

_____

_____

_____

_____

**(2)**

**(Total 9 marks)**

## Q4.

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

_____

_____

_____

_____

**(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.

_____

_____

_____

_____

**(2)**

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

_____

_____

_____

_____

**(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.

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.

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.

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

(a) (i) What is an antigen? (line 3)

_____

_____

_____

_____

**(2)**

(ii) Explain why antibodies against *Salmonella* do not normally bind to HIV.

_____

_____

_____

_____

**(2)**

(iii) Explain how the adaptor molecule allows anti-gal antibodies to associate with

HIV.

**(2)**

(b) Describe how humans produce antibodies against a pathogen such as *Salmonella*.

*(Extra space)*

**(6)**

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

**(2)**

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

_____

_____

_____

_____

**(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.

_____

_____

_____

_____

**(2)**

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

_____

_____

_____

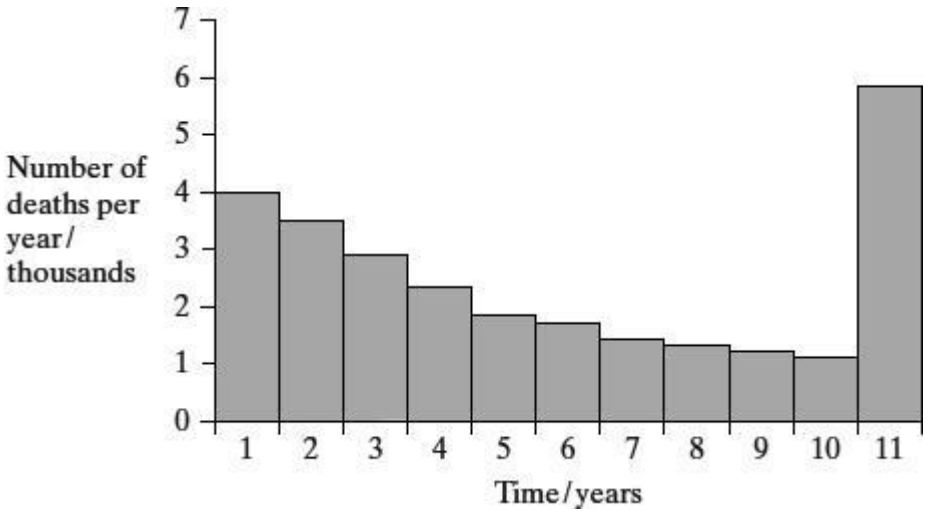
_____

**(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.

_____

_____

**(1)**

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

_____

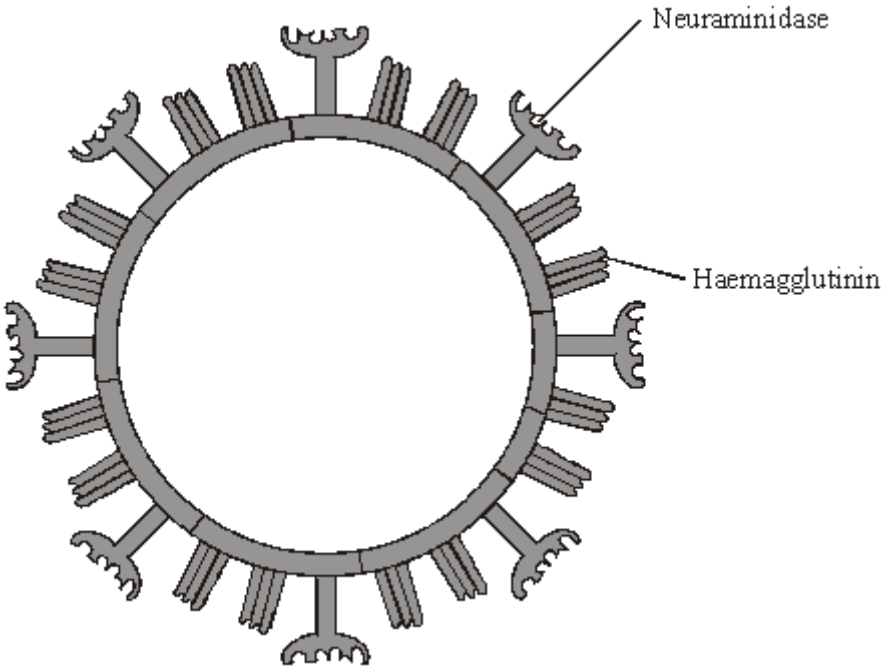
_____

_____

_____

**(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.

_____

_____

_____

_____

**(2)**

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

_____

_____

_____

_____

**(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.

_____

_____

_____

_____

**(2)**

**(Total 9 marks)**

## 3.3.1 Surface area to volume ratio

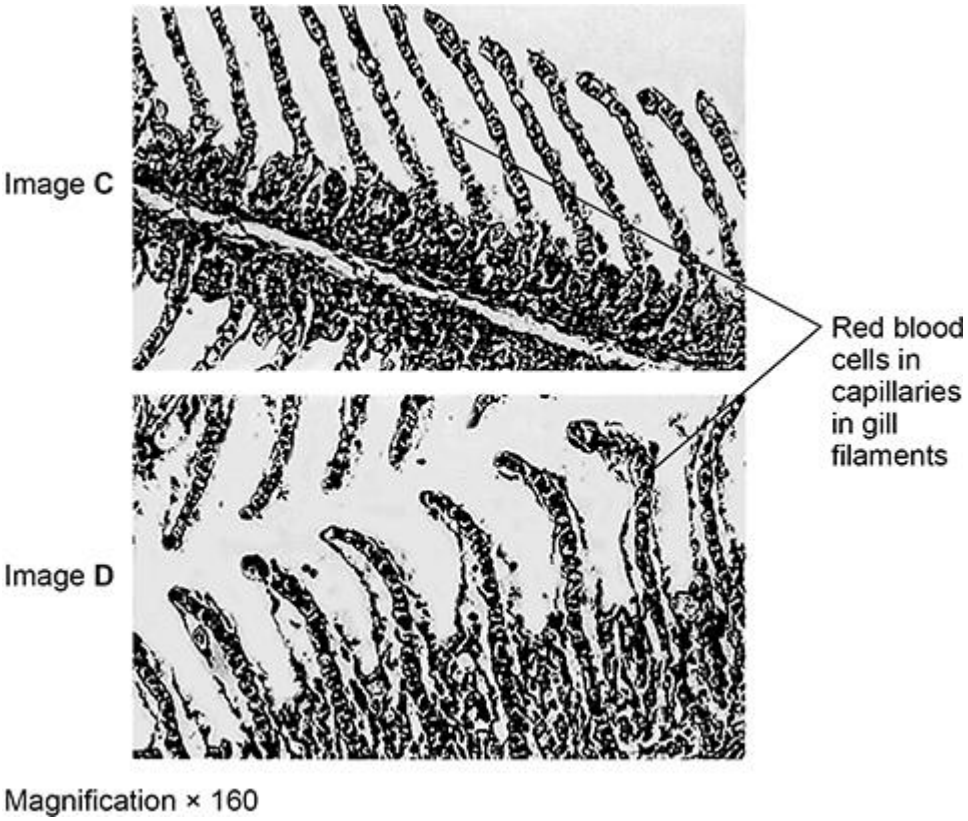
### Q1.

**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**




(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 _____

_____

_____

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 / μm²** | **Volume / μm³** | **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 _____

_____

_____

_____

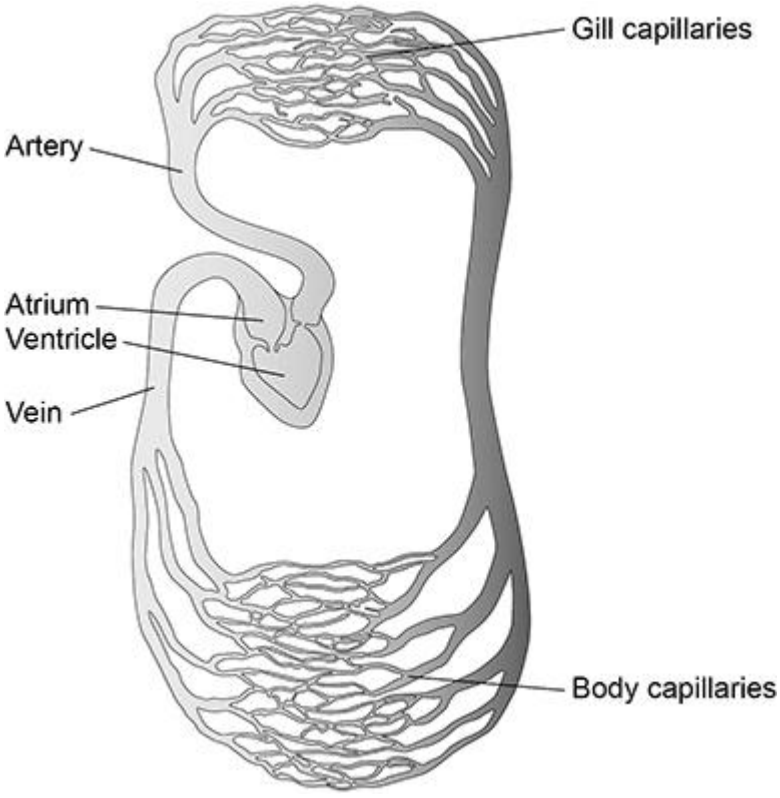
_____

_____

**(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**

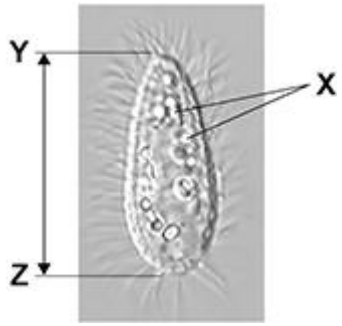
| Difference | Circulation of blood in fish | Circulation of blood in mammal |
|---|---|---|
| **1** | | |
| **2** | | |

**(2)**

**(Total 9 marks)**

## Q2.

*Uronema marinum* is a single-celled eukaryotic organism. The diagram below is a photograph of *U. marinum* taken through an optical microscope.




(a) In large cells of *U. marinum*, most mitochondria are found close to the cell-surface membrane. In smaller cells, the mitochondria are distributed evenly throughout the cytoplasm. Mitochondria use oxygen during aerobic respiration.

Use this information and your knowledge of surface area to volume ratios to suggest an explanation for the position of mitochondria in **large** *U. marinum* cells.

**(2)**
**(Total 2 marks)**

## 3.3.2 Gas Exchange

## Q1.

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

_____

_____

_____

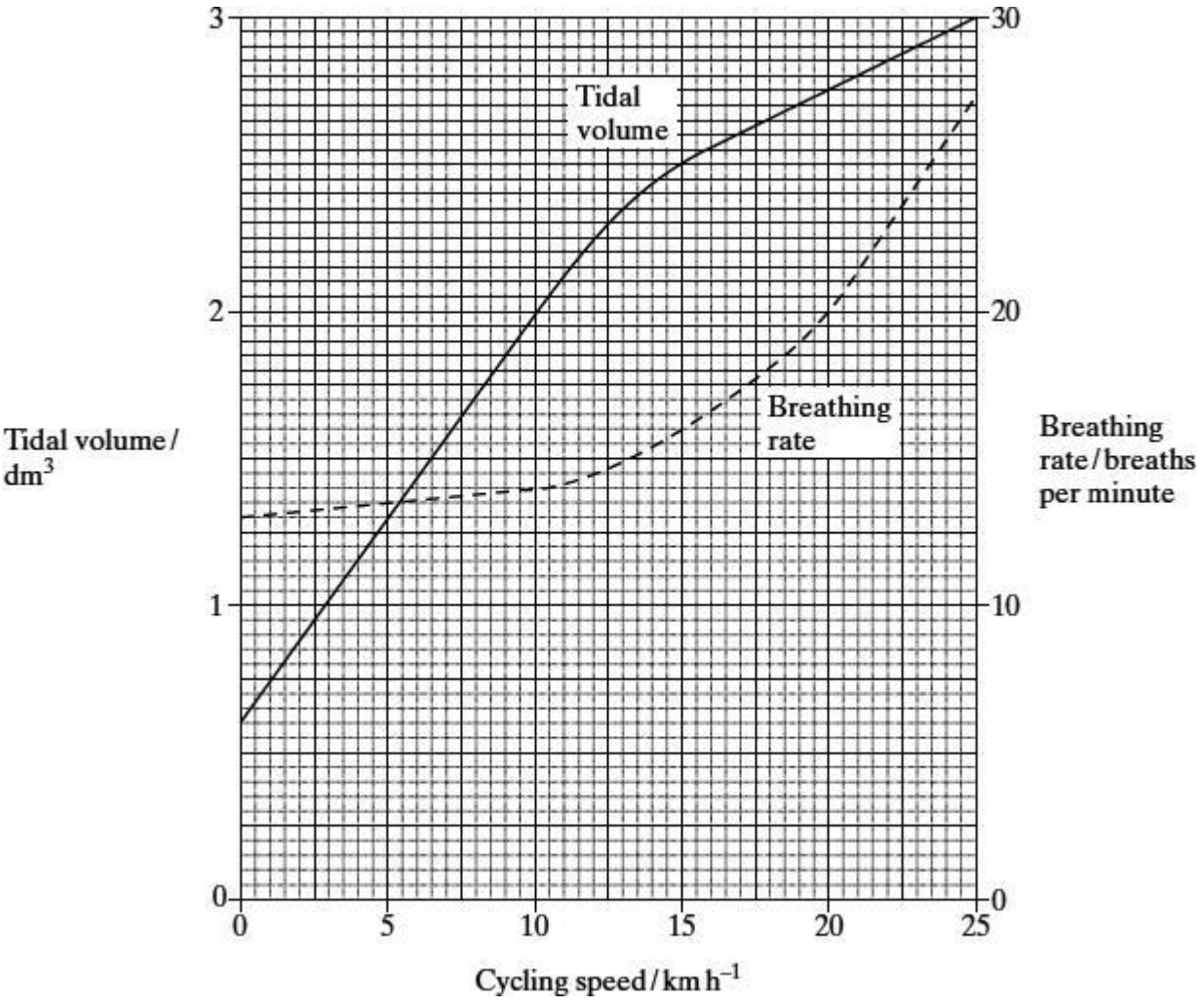
_____

_____

_____

**(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

_____

_____

_____

(ii) Breathing rate

_____

_____

_____

**(2)**

(c) Calculate the total volume of air breathed in and out per minute when the cyclist is cycling at 20 km $h^{-1}$. Show your working.

_____ $dm^3$

**(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.

_____

_____

_____

_____

**(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 / µm** | **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.

_____

_____

_____

_____

_____

**(3)**
**(Total 5 marks)**

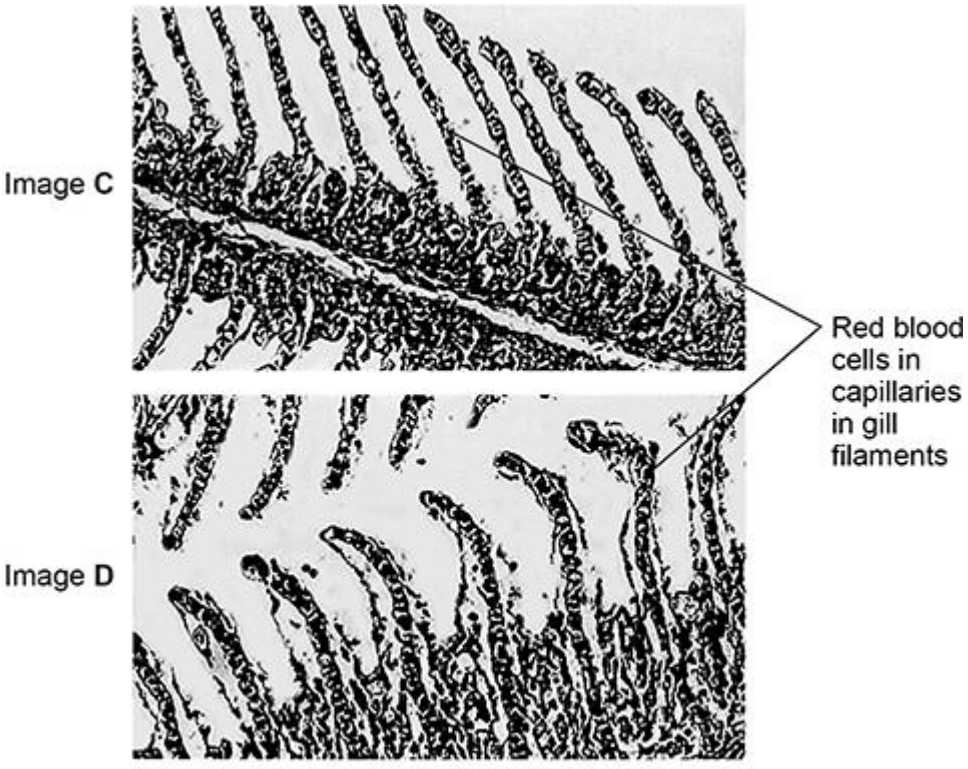
## Q3.

**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**




(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 _____

_____

_____

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 / μm$^2$** | **Volume / μm$^3$** | **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 _____

_____

_____

_____

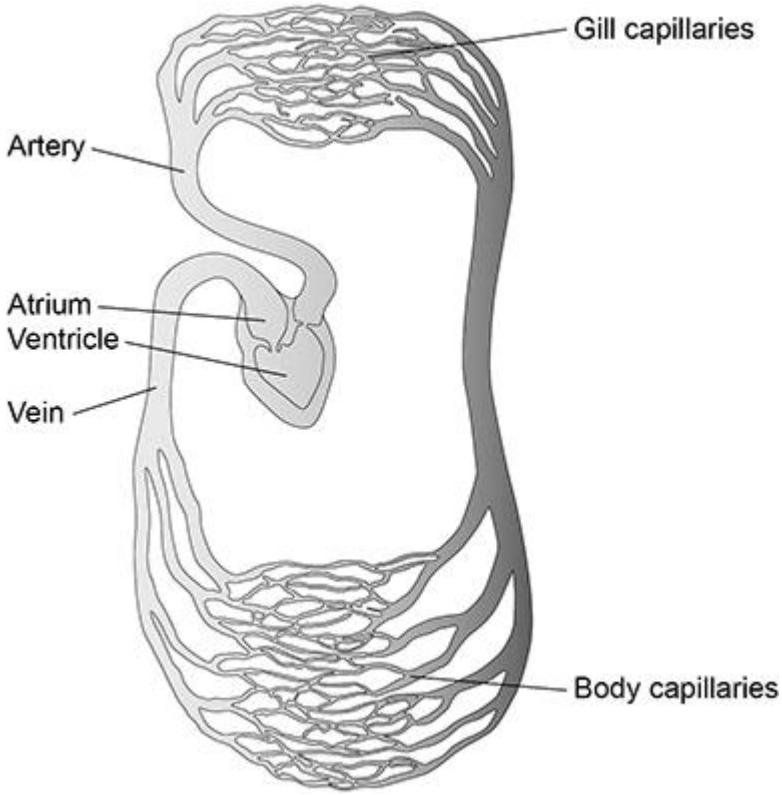
_____

_____

**(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.

_____

_____

_____

_____

_____

_____

_____

_____

**(5)**

(b) Describe how humans breathe in and out.

**(5)**

**(Total 10 marks)**

## Q6.

This question should be written in continuous prose, where appropriate.
Quality of Written Communication will be assessed in the answer.

(a) Explain how the ventilation mechanism of a fish and the structure of its gills result in the efficient uptake of oxygen from water.

**(6)**

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

| Feature | Water | Air |
|---|---|---|
| Relative density | 1000 | 1 |
| Maximum concentration of oxygen / $cm^3\ dm^{-3}$ | 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 / $cm^3\ kg^{-1}\ hour^{-1}$ | 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 _____ $dm^3$ / $hour^{-1}$

**(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.

_____

_____

_____

_____

**(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.

_____

_____

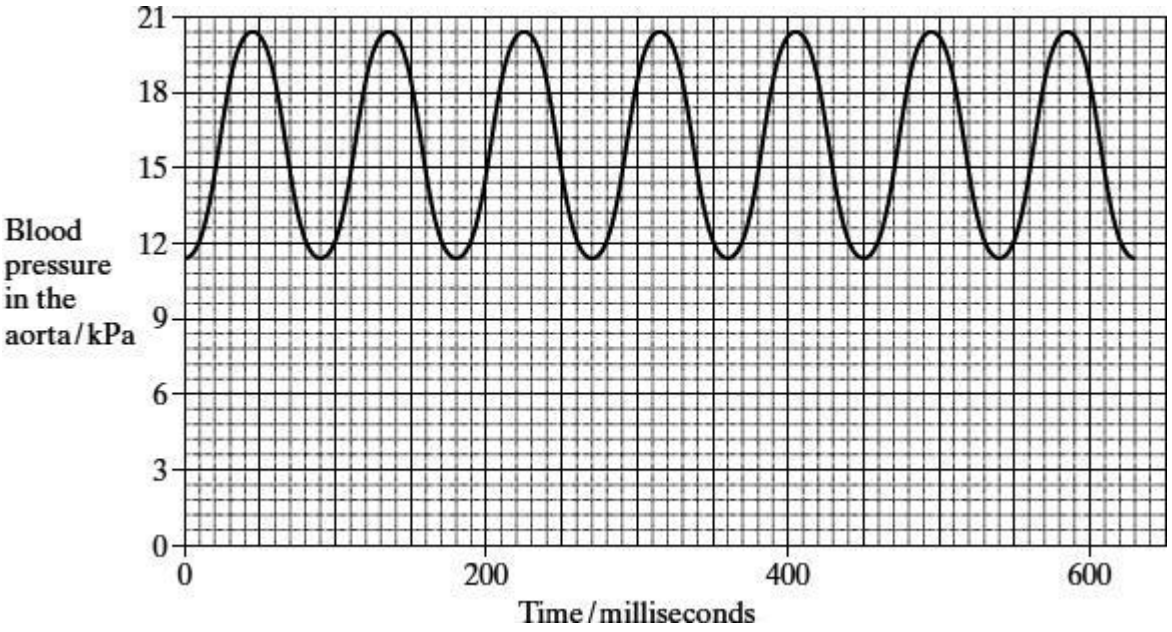
**(2)**

**(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?

_____

**(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;

_____

_____

**(1)**

(ii) stay above 10 kPa.

_____

_____

_____

_____

**(2)**

(c) The heart rate of a mouse is much higher than the heart rate of a human. Use the graph to calculate the heart rate of the mouse. Show your working.

Heart rate = _____ beats per minute

**(2)**

(d) The cardiac output is the volume of blood pumped by a heart in one minute. The stroke volume is the volume of blood pumped by a heart in a single heartbeat.

cardiac output = stroke volume × heart rate

The cardiac output for a mouse with a heart rate of 550 beats per minute is 16.6 $cm^3$ per minute. Calculate the stroke volume for this mouse. Show your working.

Stroke volume = _____ $cm^3$

**(2)**

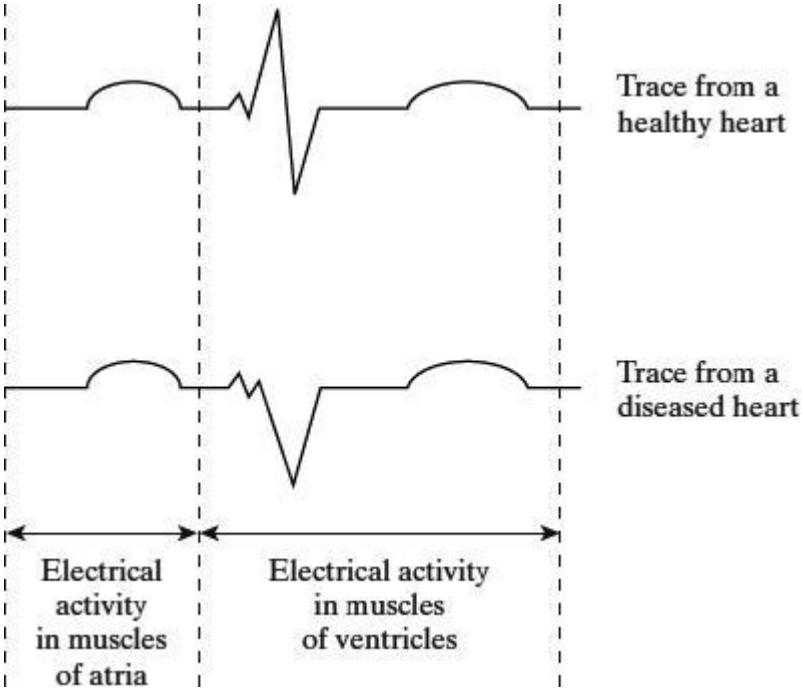
**(Total 8 marks)**

**Q2.**

(a) A woman takes moderate exercise. Explain what causes her heart rate to increase while she exercises.

**(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.

_____

_____

_____

**(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.

_____

_____

_____

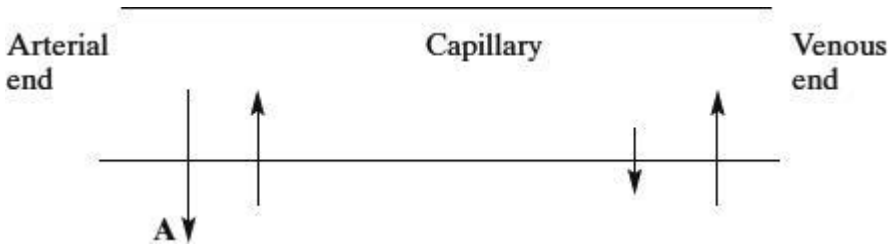
_____

**(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**?

_____

_____

**(1)**

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

_____

_____

_____

_____

**(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.

_____

**(2)**

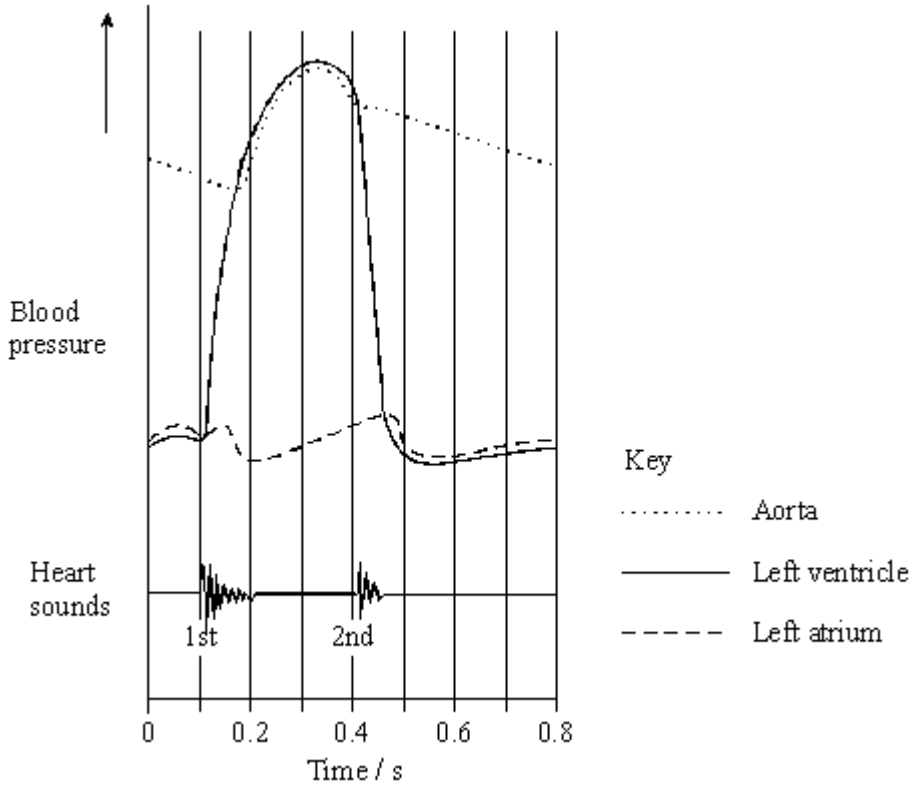
(d) Tissue fluid accumulates in the tissues of people who do not eat enough protein. Explain why.

**(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?

**(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?

_____

_____

**(1)**

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

_____

_____

_____

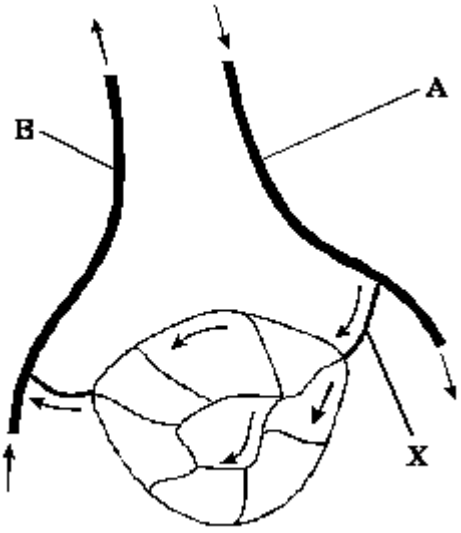
_____

**(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 / μm | Rate of blood flow / 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?

_____

_____

_____

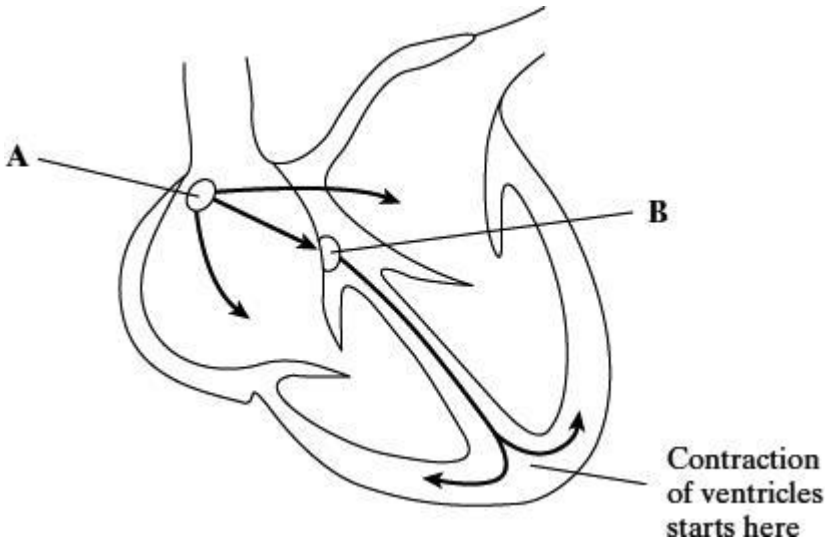
_____

**(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.

| | Blood pressure / kPa | | |
|---|---|---|---|
| **Time / s** | **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 |

(i) At which time is blood flowing into the aorta?

_____

**(1)**

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

_____

**(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?

_____

_____

**(1)**

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

| | | Blood vessel | | |
|---|---|---|---|---|
| | | **Artery** | **Capillary** | **Vain** |
| **Property** | Mean diameter of vessel | 4.0 mm | 8.0 μm | 5.0 mm |
| | Mean thickness of wall | 1.0 mm | 0.5 μm | 0.5 mm |
| | | **Relative thickness (shown by length of bar)** | | |
| **Tissues present in wall** | 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.

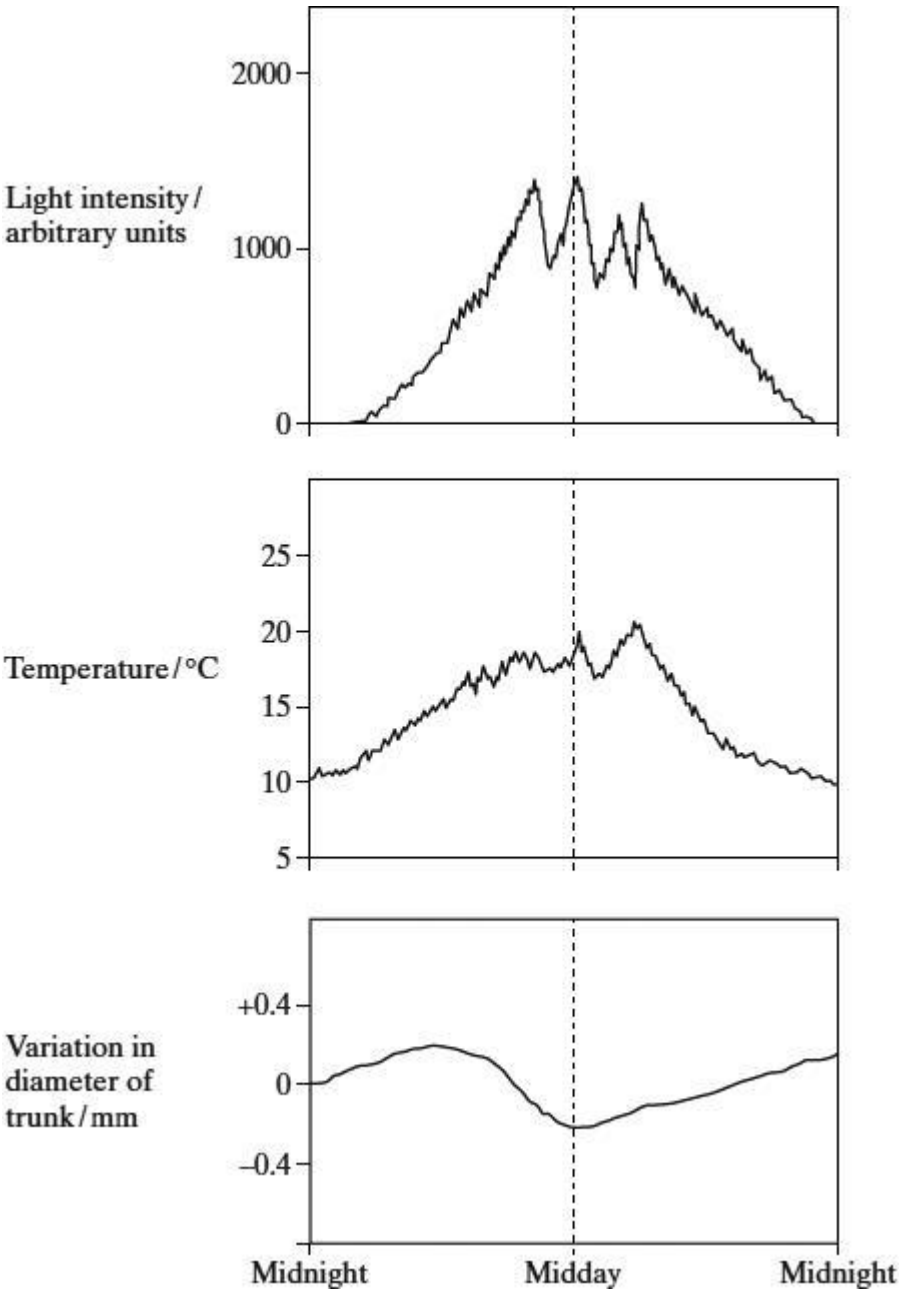
**(6)**

**(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.

**(6)**

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

**(3)**

**(Total 9 marks)**

## Q2.

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

**(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?

_____

_____

**(1)**

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

_____

_____

**(1)**

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

_____

_____

**(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.

_____

_____

_____

_____

**(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.

_____

_____

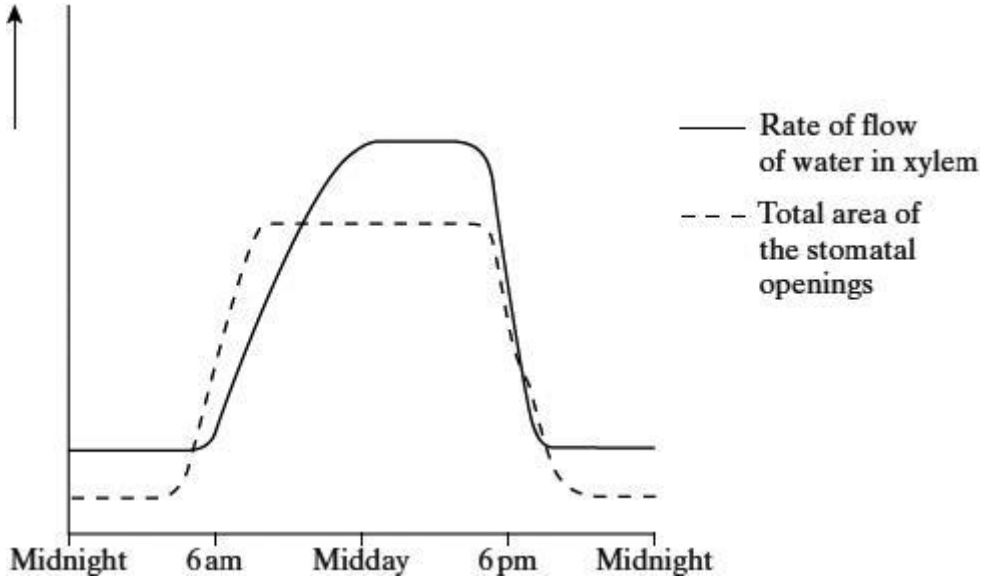
(ii) Lignin is present in xylem cell walls.

_____

_____

**(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.

_____

_____

**(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.

_____

**(1)**

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

_____

_____

**(1)**

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

_____

_____

_____

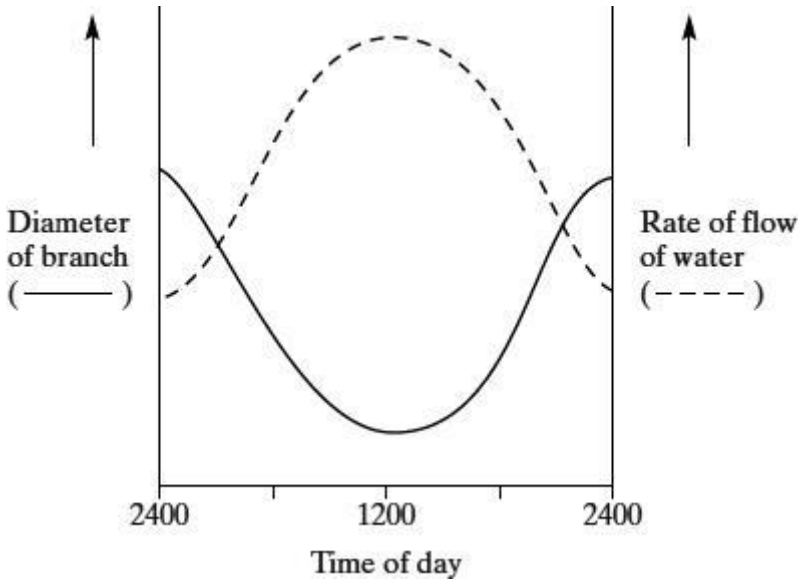
_____

**(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;

_____

_____

_____

_____

_____

_____

**(3)**

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

_____

_____

**(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.

_____

_____

_____

_____

**(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.

_____

_____

_____

_____

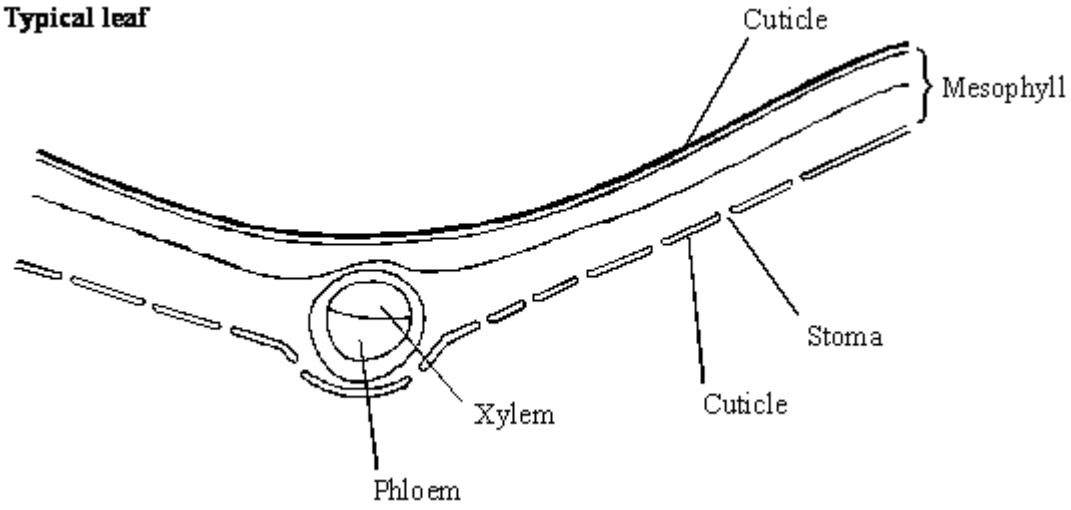
_____

_____

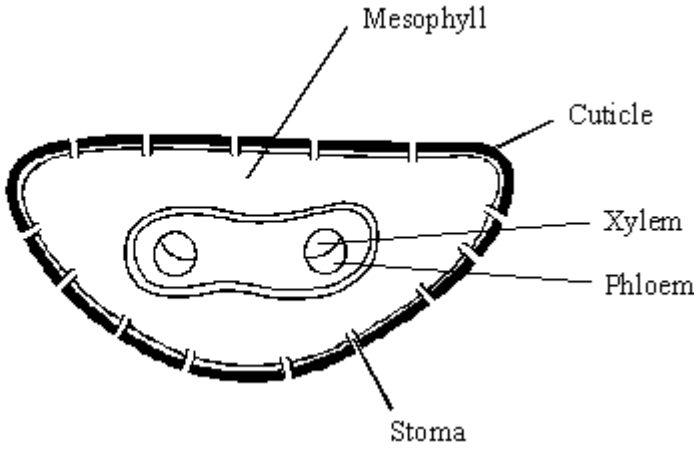
**(3)**

(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 _____

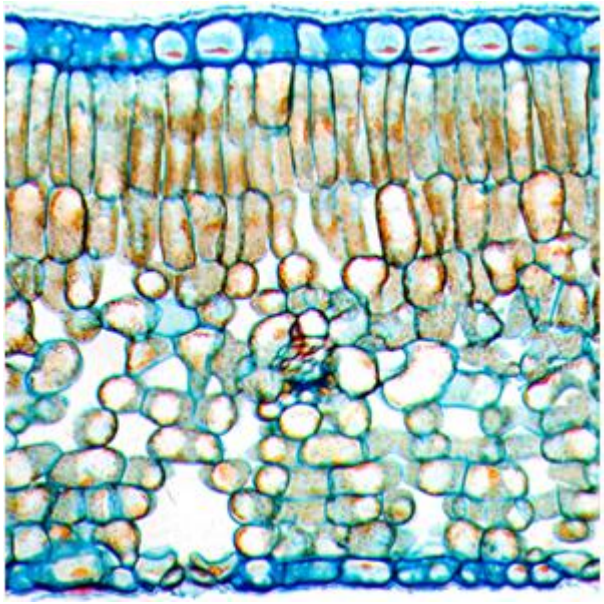
_____

**(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 $mm^2$ 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.

| Month cut flowers were obtained | Mean number of stomata / $mm^{-2}$ (± 2 SD) | Mean transpiration rate / $cm^3$ $day^{-1}$ (± 2 SD) | Mean shelf life / days (± 2 SD) |
|---|---|---|---|
| December | 23 (± 2) | 22 (± 3) | 5 (± 1) |
| April | 20 (± 3) | 15 (± 2) | 16 (± 2) |

A value of ± 2 SD (standard deviations) from the mean includes over 95% of the data.

(b) Using information in the table, what can you conclude about the effect of different factors on the mean shelf life of cut flowers?

Explain your conclusions.

**(4)**

(c) Other than a change in temperature, give **one** change the scientist could make to the environmental conditions to increase the cut flowers' shelf life.

Explain your answer.

_____

_____

_____

_____

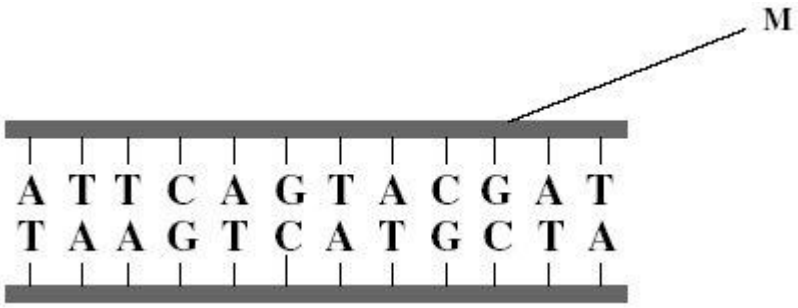
**(3)**

**(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.

_____

_____

_____

_____

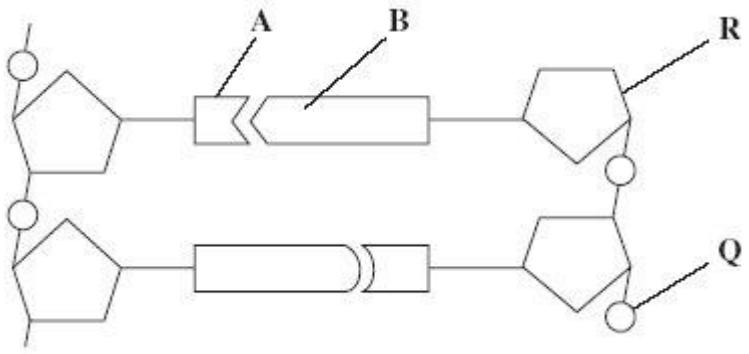
**(2)**

**(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**.

_____

**(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 | | | | | | |

**(1)**

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

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 8 marks)**

## Q3.

The diagram shows a short sequence of DNA bases.

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

(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.

_____

_____

**(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.

_____

_____

_____

_____

_____

_____

**(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?

**(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.

**(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.

**(2)**

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

**(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.

_____

_____

_____

_____

_____

_____

*(Extra space)* _____

_____

_____

**(3)**

**(Total 5 marks)**

## Q4.

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

_____

_____

**(1)**

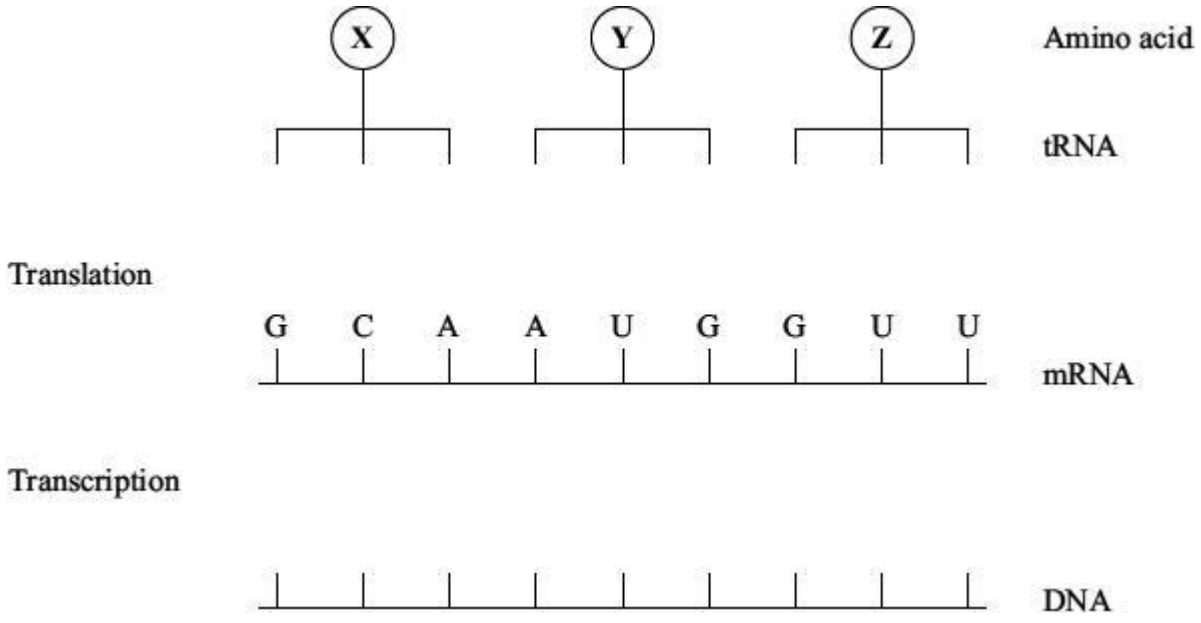
(ii) Name the organelle involved in translation.

_____

**(1)**

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

**Figure 1**




Complete **Figure 1** to show

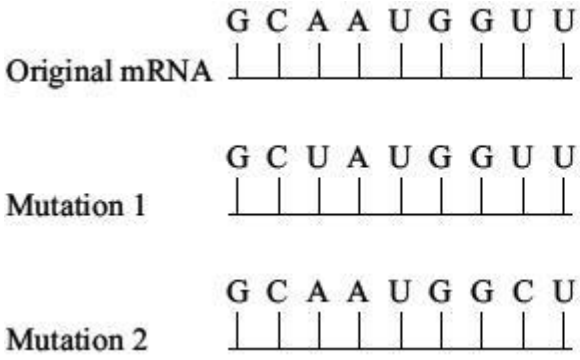
(i) the bases on the DNA strand from which the mRNA was transcribed;

(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<br>GUU |
| alanine | GCA<br>GCC<br>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.

_____

_____

_____

_____

_____

_____

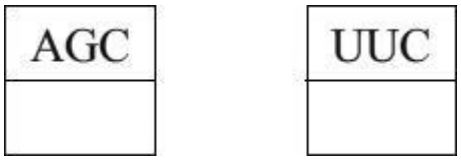
**(3)**

**(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.

_____

_____

_____

_____

_____

_____

**(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 | | | | | | |

**(2)**

**(Total 7 marks)**

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

# Q1.

(a) Describe viral replication.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(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.

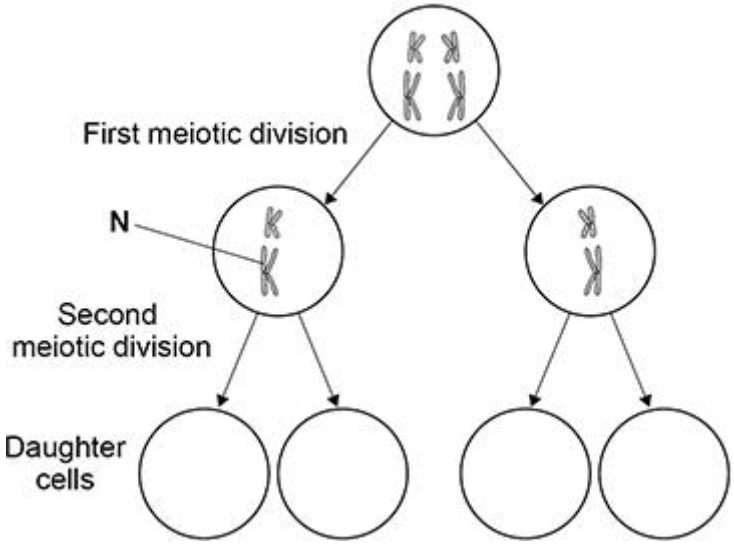
| **Feature** | **Cell cycle involving:** | |
|---|---|---|
| | **mitosis** | **binary fission** |
| Replication of linear DNA | | |
| Replication of circular DNA | | |
| Produces 2 daughter cells | | |
| Produces 4 daughter cells | | |
| Happens in prokaryotic cells | | |
| Happens in eukaryotic cells | | |

**(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.

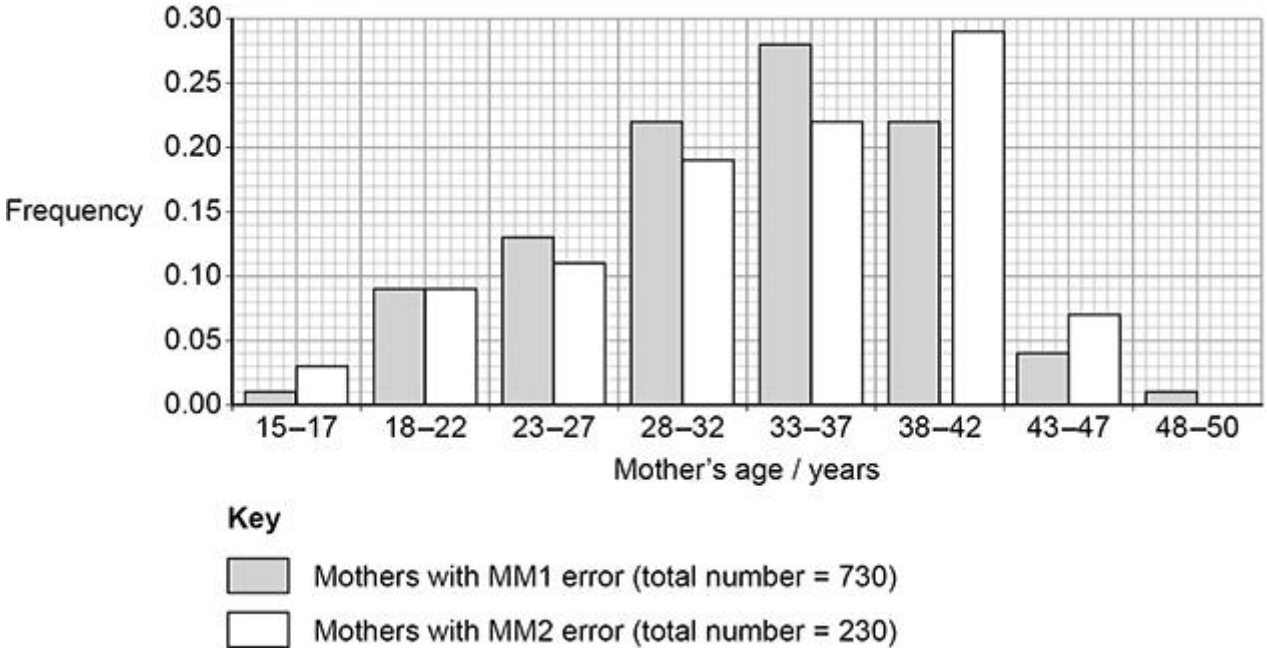
**(2)**

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.

_____

_____

**(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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

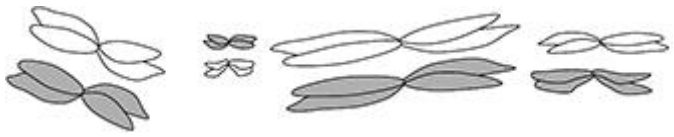
_____

_____

**(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 _____

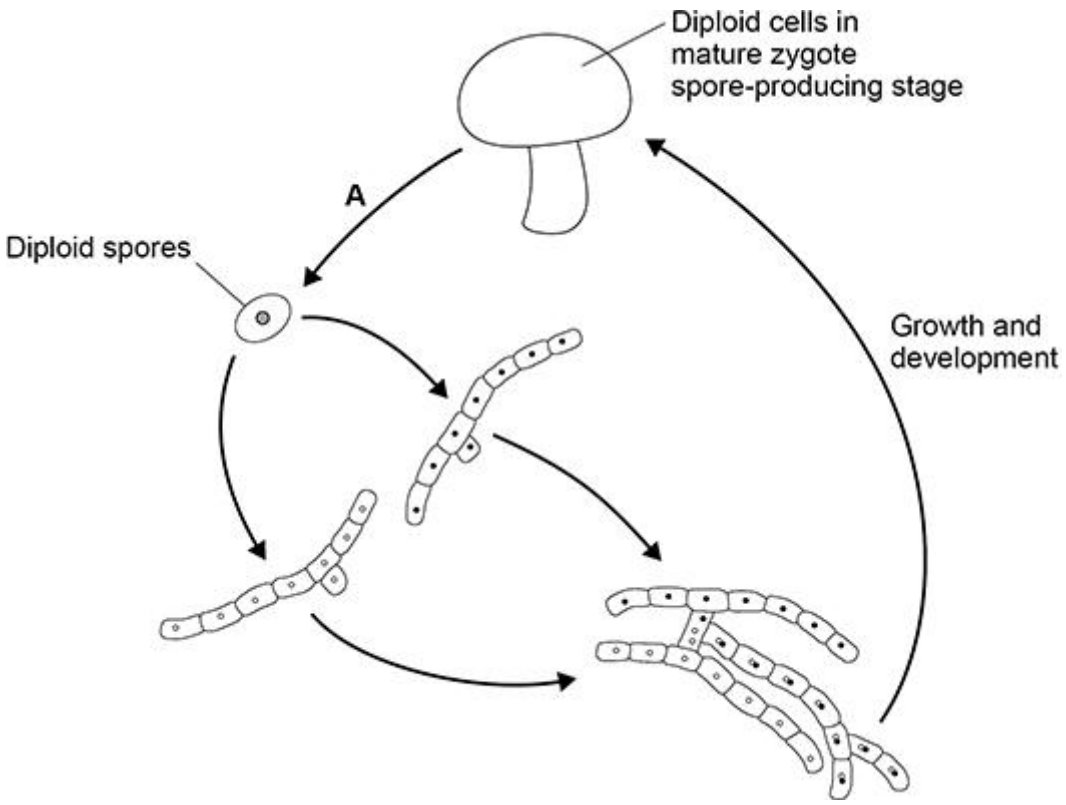
**(2)**

(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)**

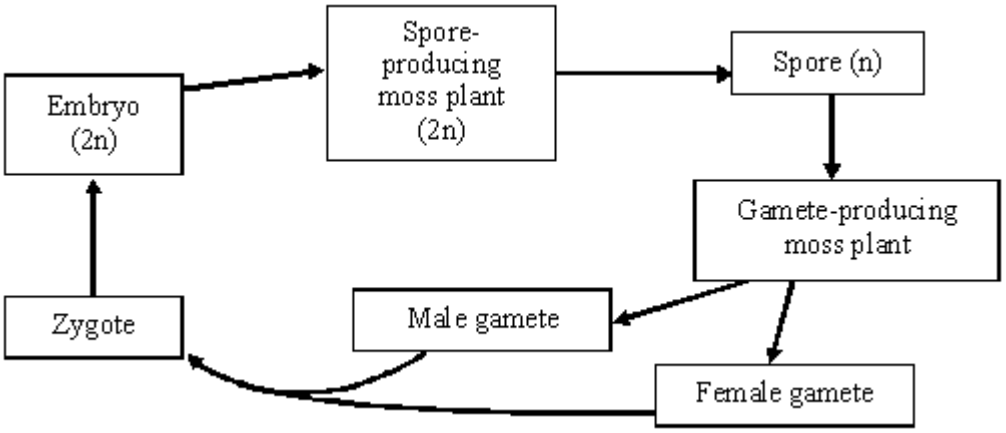
**(Total 8 marks)**

## Q3.

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

**(3)**

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




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

**(1)**

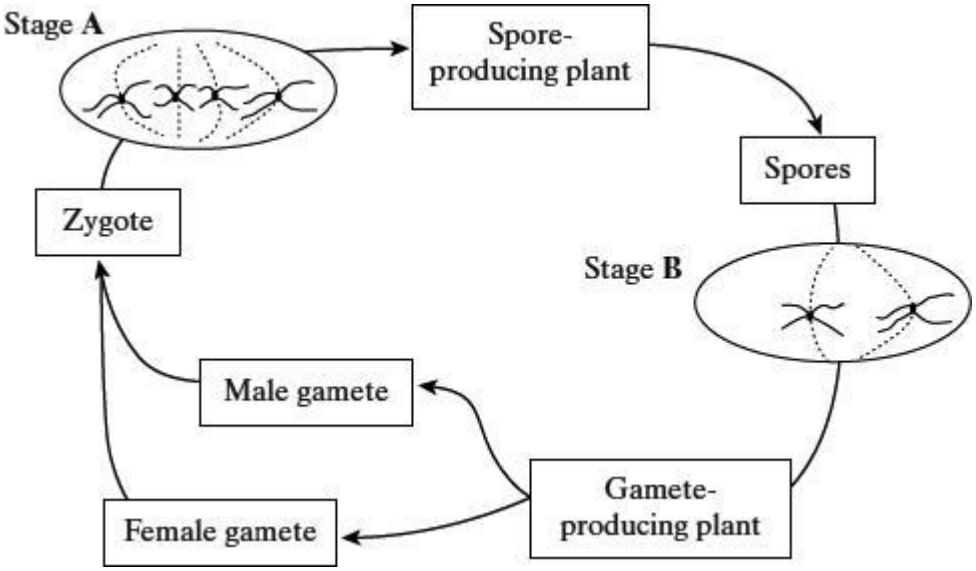
**(Total 4 marks)**

## Q4.

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

**(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.

_____

_____

_____

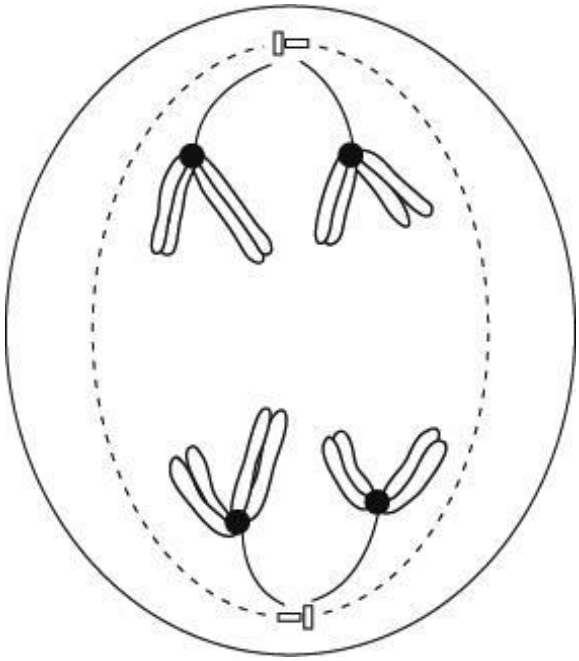
_____

**(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.

_____

_____

_____

_____

_____

_____

**(3)**

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

_____

_____

_____

_____

**(2)**

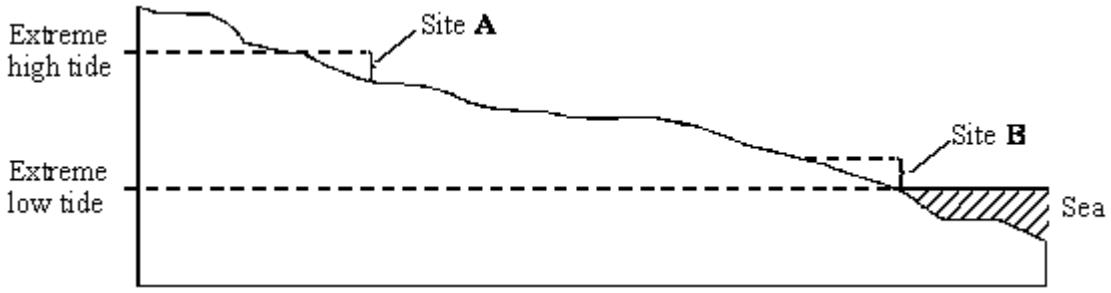
**(Total 5 marks)**

## 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 m² | Site B: lower shore | Mean number per m² |
|---|---|---|---|
| *Ascophyllum nodosum* | 2 | *Corallina officinalis* | 31 |
| *Fucus spiralis* | 10 | *Fucus serratus* | 8 |
| *Fucus vesiculosus* | 4 | *Laminaria digitata* | 15 |
| *Pelvetia canaliculata* | 6 | *Laminaria hyperborea* | 3 |
| | | *Laminaria saccharina* | 6 |
| | | *Laurencia pinnatifida* | 18 |
| | | *Palmaria palmata* | 6 |
| Index of diversity | | Index of diversity | 4.77 |

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

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.

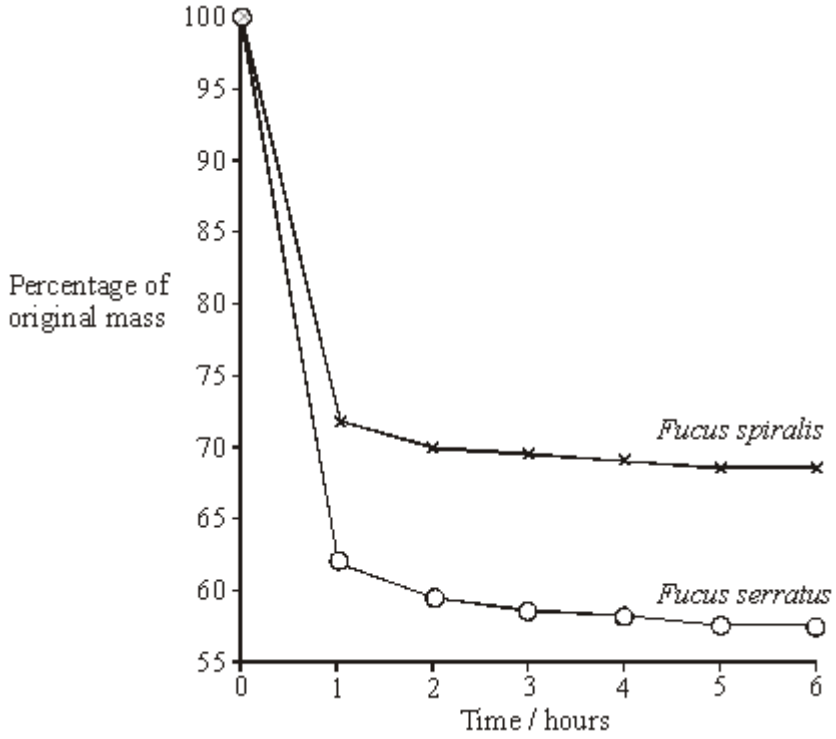
_____

_____

**(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.

_____

_____

_____

_____

_____

**(3)**

**(Total 6 marks)**

## Q2.

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

_____

_____

_____

**(1)**

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

_____

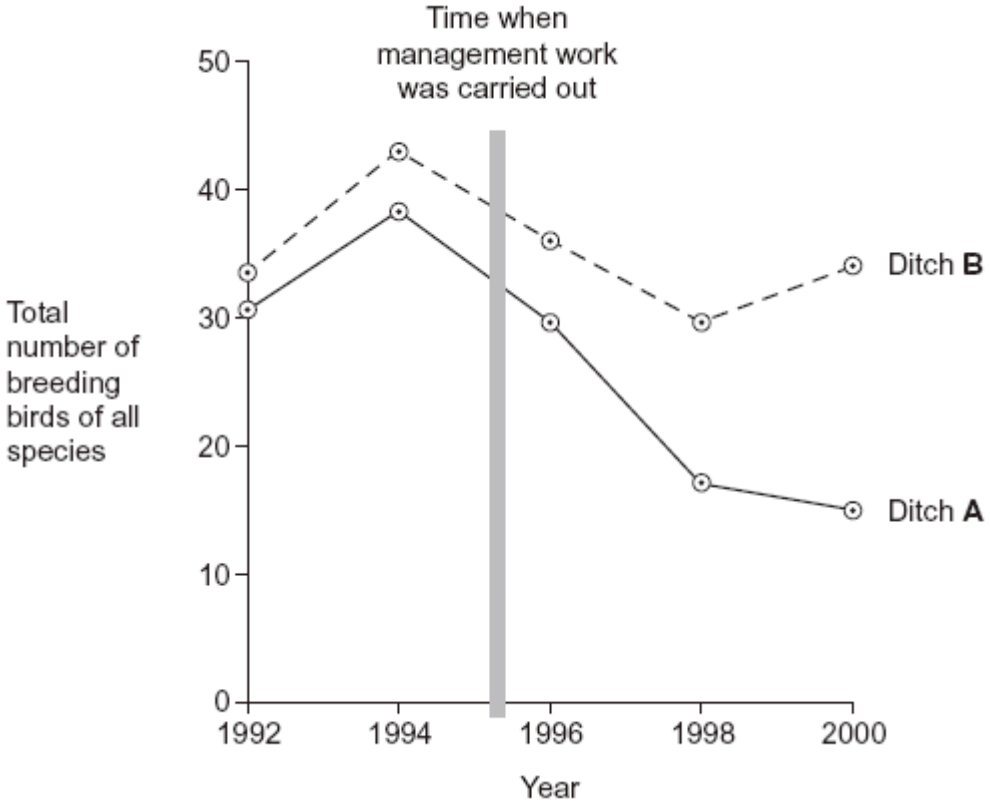
_____

**(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.

**(1)**

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

_____

_____

**(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.

_____

_____

_____

_____

_____

_____

**(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.

_____

_____

_____

**(1)**

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

_____

_____

_____

**(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 $m^2$** |
|---|---|

| | |
|---|---|
| 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.

_____

_____

_____

_____

_____

_____

**(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.

_____

_____

_____

**(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.

_____

_____

_____

_____

_____

**(2)**

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

_____

_____

_____

_____

_____

**(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.

_____

_____

_____

_____

_____

**(2)**

**(Total 9 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 $cm^3$ 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 ($10^{-4}$).

(b) Use information in this question to calculate how many bacteria were present in 1 $cm^3$ 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.

**(2)**

**(Total 6 marks)**

## Q2.

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

**(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.

**(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 *Listeria monocytogenes* / 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?

**(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*?

**(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.

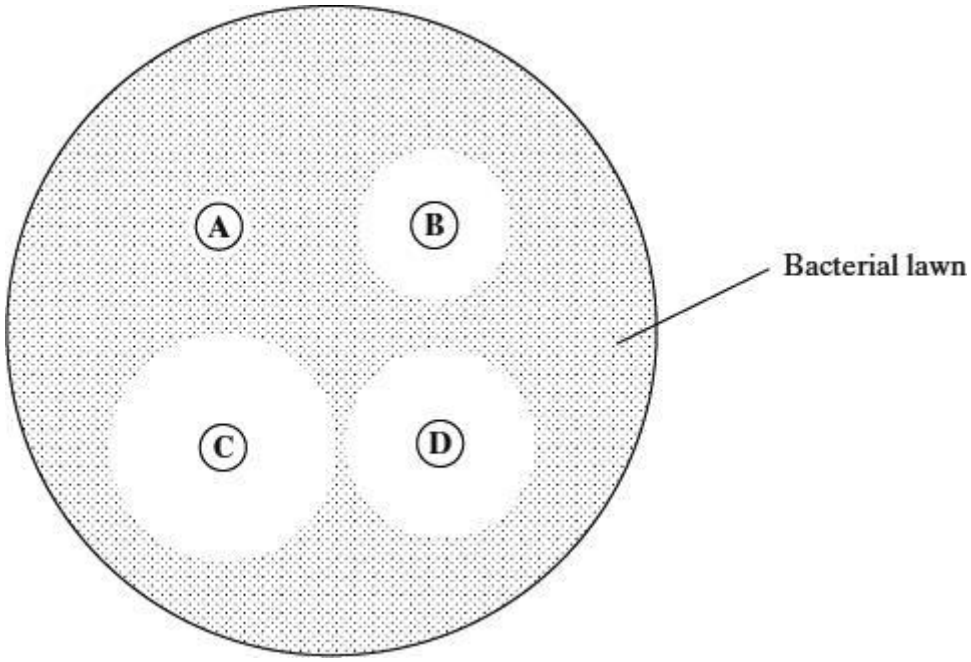
_____

**(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.

_____

_____

_____

_____

_____

_____

**(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**.

**(2)**

(c) Several factors affect the rate at which the antiseptic in the mouthwash from each paper disc diffuses through the agar. Describe the effect of **three** named factors on this rate.

1. _____

_____

2. _____

_____

3. _____

_____

**(3)**

**(Total 8 marks)**

## Q4.

(a) *Clostridium difficile* is a bacterial species that causes disease in humans.

Antibiotic-resistant strains of *C. difficile* have become a common cause of infection acquired when in hospital.

Explain how the use of antibiotics has led to antibiotic-resistant strains of bacteria becoming a common cause of infection acquired when in hospital.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(3)**

(b) Scientists suggested that factors, other than antibiotic use, led to the increase in antibiotic-resistant *C. difficile* infections. One suggested factor is people eating more trehalose in their diet.

Trehalose is a disaccharide formed from two glucose molecules.

Name another disaccharide formed from two glucose molecules.

_____

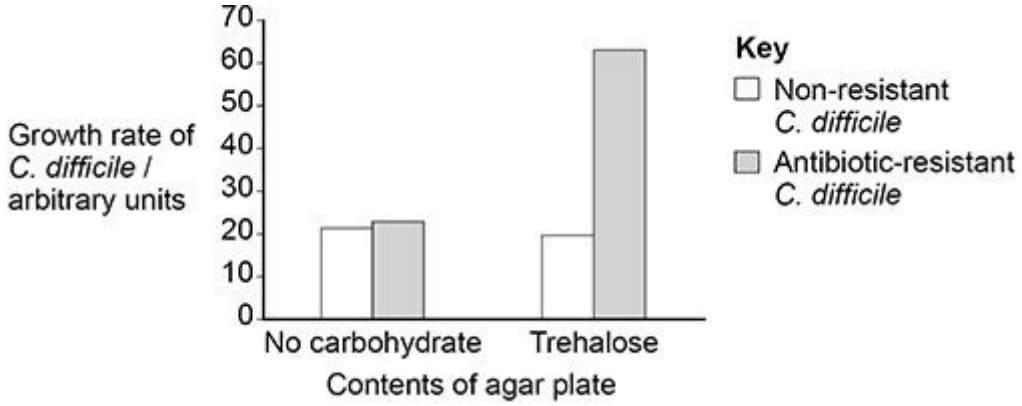
**(1)**

Scientists investigated the effect of trehalose on the growth rate of *C. difficile*.
They grew populations of non-resistant and antibiotic-resistant *C. difficile* on separate agar plates with:

- no carbohydrate added
- trehalose added.

They measured the growth rate of the *C. difficile*.

The graph below shows the scientists' results.




(c) Describe how the scientists could use aseptic techniques to transfer 0.3 $cm^3$ of *C. difficile* in liquid culture from a bottle onto an agar plate.

**(3)**

(d) Use the graph above to evaluate whether more trehalose in the diet could be a factor in the increased number of antibiotic-resistant *C. difficile* infections.

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(3)**

**(Total 10 marks)**

## 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.

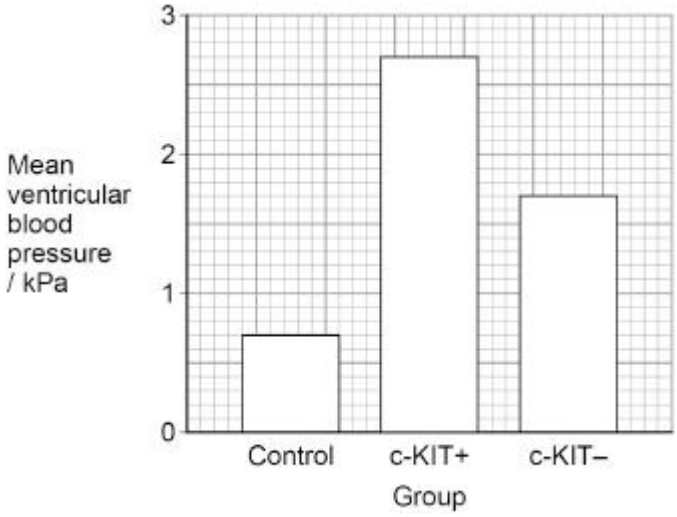
- **Control** group did not get a transplant of bone marrow stem cells.
- **c-KIT+** group got a transplant of bone marrow stem cells with a functioning *c-KIT* gene.
- **c-KIT–** group got a transplant of bone marrow stem cells with **no** functioning *c-KIT* gene.

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 µg The iron ion concentration in the plasma of a healthy person is 50 µg $dm^{-3}$ The volume of blood in each of these people is 4000 $cm^3$

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)**

**MS1.1 Use an appropriate number of significant figures and MS2.4 Solve algebraic equations**

## Q1.

(a) An enzyme's turnover number ($k_{cat}$) is the number of substrate molecules converted into product molecules by one enzyme molecule in 1 second. It is determined using this equation.

$$k_{cat} = \frac{\text{Maximum rate of enzyme-controlled reaction / μmol dm}^{-3}\text{ s}^{-1}}{\text{Enzyme concentration / μmol dm}^{-3}}$$

A scientist investigated the action of a protease enzyme. The scientist prepared a reaction mixture with a protease concentration of 0.0118 μmol $dm^{-3}$. The $k_{cat}$ for the protease is 110 substrate molecules per second.

Use this information and the formula to calculate the maximum rate of the protease-controlled reaction.

Give your answer to **3** significant figures.

Show your working.

Answer _____ μmol $dm^{-3}$ $s^{-1}$

**(2)**

**(Total 2 marks)**

## Q2.

The table below shows the height and mass of two adults.

| Person | Height / cm | Mass / kg |
|---|---|---|
| **A** | 181 | 90.90 |
| **B** | 149 | 62.62 |

The surface area of a person is estimated using the following formula:

$$\text{Surface area in m}^2 = \sqrt{\frac{\text{height in cm} \times \text{mass in kg}}{3600}}$$

The volume of a person is estimated using the following formula:

$$\text{Volume in m}^3 = \frac{\text{mass in kg}}{1010}$$

(a) Using suitable calculations, deduce which person has the smaller surface area to volume ratio.

Show your working **and** complete the sentence below.

Give your answer to 3 significant figures.

Person _____ has the smaller surface area to volume ratio which = _____

**(3)**

**(Total 3 marks)**

## MS1.3 Construct and interpret frequency tables and diagrams, bar charts and histogram

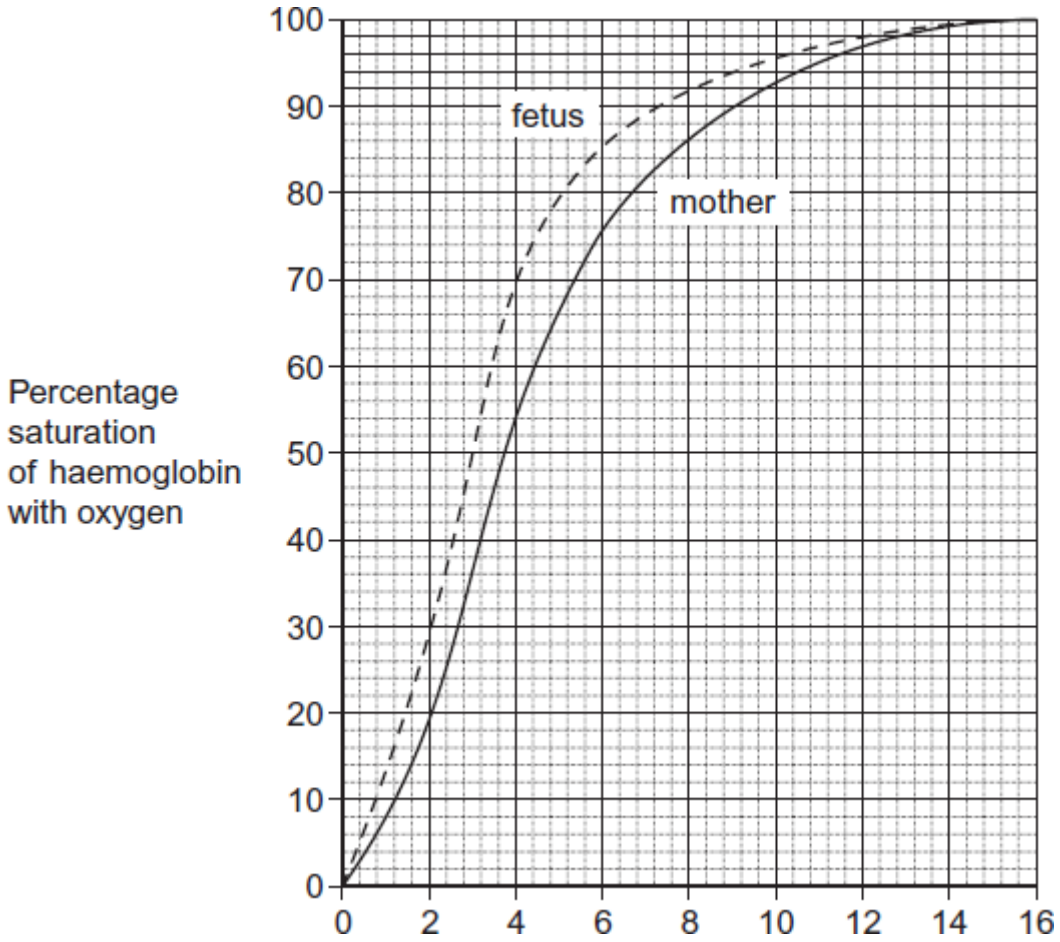
## Q1.

(a) The table shows three statements about some biological molecules. Complete the table with a tick in each box if the statement is true for haemoglobin, cellulose or starch.

| Statement | Haemoglobin | Cellulose | Starch |
|---|---|---|---|
| Has a quaternary structure | | | |
| Formed by condensation reactions | | | |
| Contains nitrogen | | | |

**(3)**

The graph shows oxygen dissociation curves for the haemoglobin of a mother and her fetus.




(b) What is the difference in percentage saturation between the haemoglobin of the mother and her fetus at a partial pressure of oxygen ($pO_2$) of 4 kPa?

**(1)**

(c) The oxygen dissociation curve of the fetus is to the left of that for its mother. Explain the advantage of this for the fetus.

**(2)**

(d) After birth, fetal haemoglobin is replaced with adult haemoglobin. Use the graph to suggest the advantage of this to the baby.

_____

_____

_____

_____

_____

**(2)**

(e) Hereditary persistence of fetal haemoglobin (HPFH) is a condition in which production of fetal haemoglobin continues into adulthood. Adult haemoglobin is also produced.

People with HPFH do not usually show symptoms. Suggest why.

_____

_____

_____

**(1)**

**(Total 9 marks)**

## Q2.

Doctors investigated the effect of the smoking habits of men on their non-smoking wives.

The doctors recruited 540 non-smoking women aged 40 or older. They divided these women into groups according to the smoking habits of their husbands.
After 14 years, the doctors recorded how many of the wives had died and their cause of death.

They used these data to determine the relative risk of a wife dying from a particular disease according to her husband's smoking habit.

In this comparison, they gave the relative risk to the wife of a non-smoker as 1.00. A value greater than 1.00 shows an increased risk compared to the wife of a non-smoker.

The results are shown in the table below.

| **Cause of death** | **Relative risk of wife dying** | | |
|---|---|---|---|
| | **Husband non-smoker** | **Husband smokes 1 to 19 cigarettes /day** | **Husband smokes more than 19 cigarettes / day** |
| Lung cancer | 1.00 | 1.61 | 2.08 |
| Emphysema | 1.00 | 1.29 | 1.49 |
| Cervical cancer | 1.00 | 1.15 | 1.14 |
| Stomach | 1.00 | 1.02 | 0.99 |

| | | | |
|---|---|---|---|
| cancer | | | |
| Heart disease | 1.00 | 0.97 | 1.03 |

A journalist concluded from these data that if a husband smoked, it greatly increased the risk of his wife dying of certain diseases. Evaluate this statement.

_____

_____

_____

_____

_____

_____

_____

_____

**(Total 4 marks)**

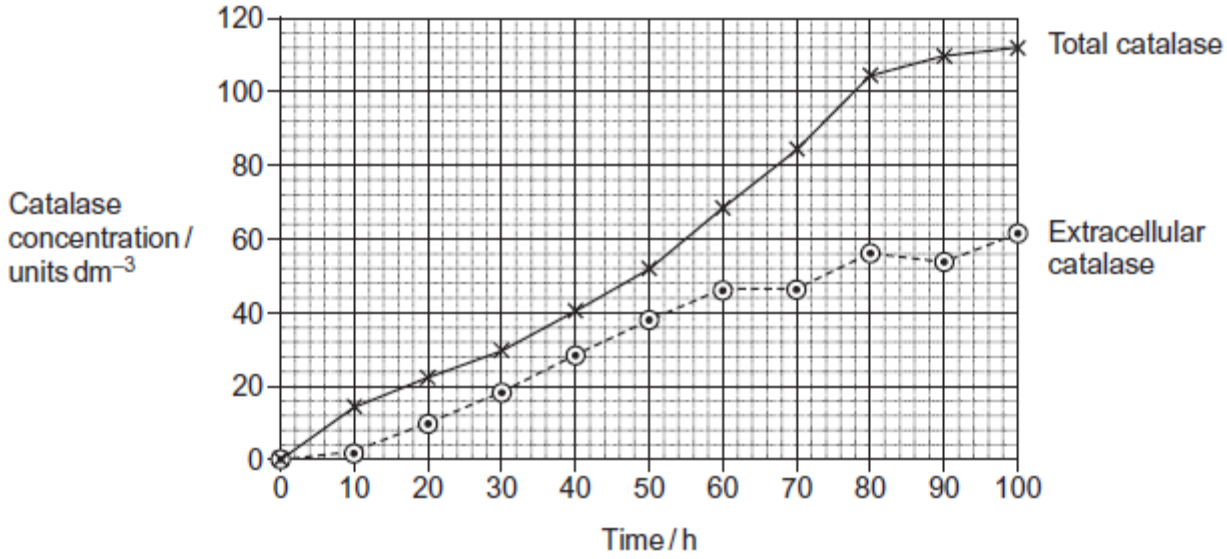
## Q3.

Some of the catalase produced by *Aspergillus niger* is intracellular and some is extracellular. Intracellular enzymes stay inside the cells that produce them. Extracellular enzymes are secreted from the cells that produce them.

Another group of scientists grew a different strain of *A. niger*.

- *A. niger* grows from tiny structures called spores. The scientists kept the spores in an isotonic medium at a low temperature until they needed them.
- They put spores of *A. niger* into a 500 $cm^3$ flask containing a sterile medium. The medium contained starch.
- They measured the total amount of catalase and the amount of extracellular catalase produced by the fungus over a period of 100 hours.

The graph shows their results.




(a) (i) The scientists kept the spores in an isotonic medium until they were needed. Suggest why it was important that the medium was isotonic.

_____

_____

_____

_____

_____

**(2)**

(ii) The scientists kept the spores at a low temperature until they were needed. Suggest why.

_____

_____

_____

**(1)**

(b) Starch is a source of carbon, hydrogen and oxygen for the fungus. Name one other chemical element that must be in the culture medium before *A. niger* can synthesise catalase. Give the reason for your answer.

Chemical element _____

Reason _____

_____

_____

_____

**(2)**

(c) To get reliable results in this investigation, the medium must be sterile. Explain why.

_____

_____

_____

_____

_____

**(2)**

(d) (i) At what time was the concentration of intracellular catalase highest?

_____

**(1)**

(ii) Between what times was the rate of total catalase production highest?

_____

**(1)**

(e) Technologists prefer to manufacture extracellular enzymes rather than intracellular enzymes. This is because intracellular enzymes are more expensive to purify than extracellular enzymes. Suggest why intracellular enzymes are more expensive to purify.

_____

_____

_____

_____

_____

**(2)**

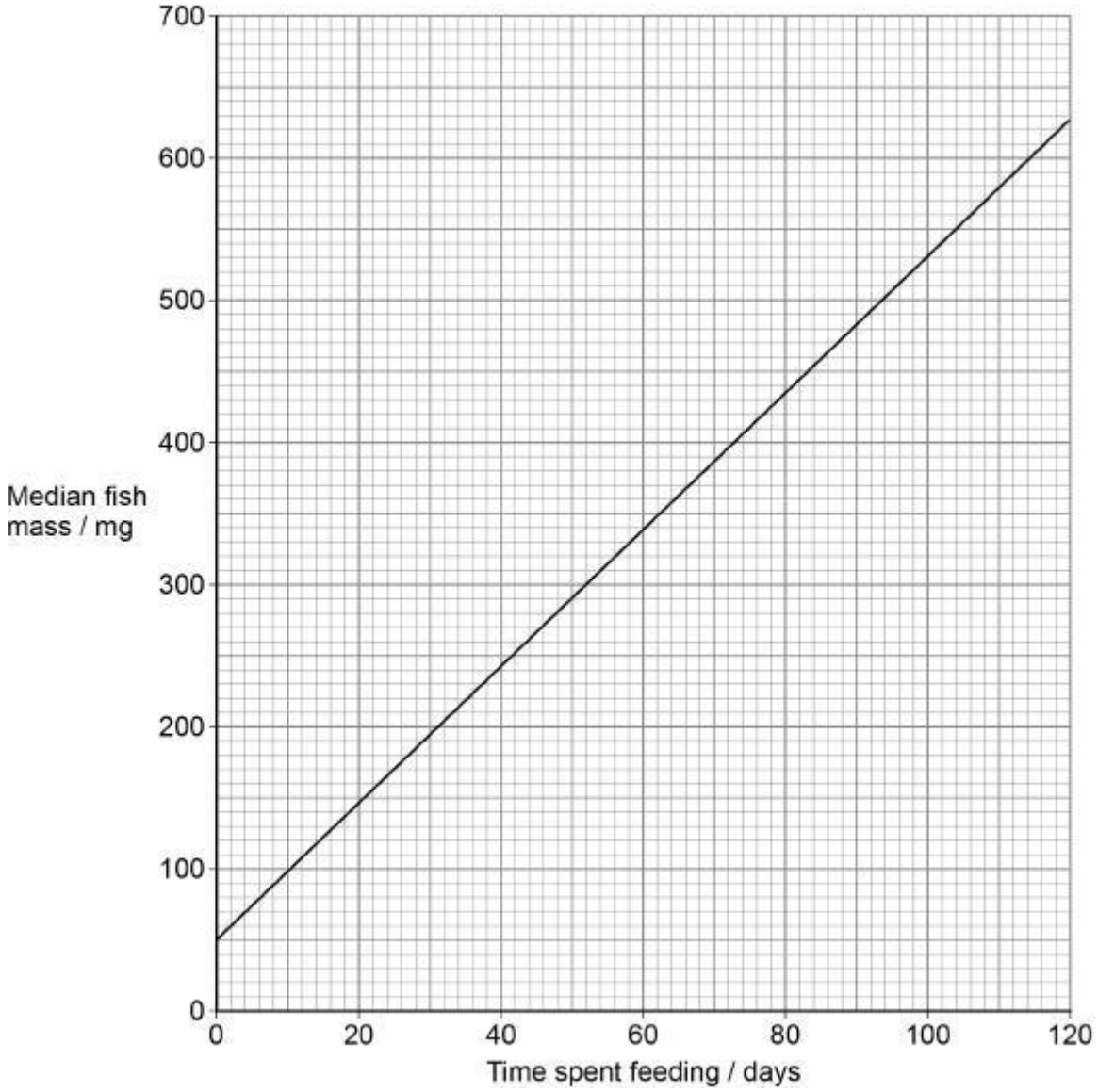
**(Total 11 marks)**

## MS1.6 Understand the terms mean, median and mode

## Q1.

Trout is a type of fish, often produced commercially in trout farms.

A scientist investigated the growth of farmed trout. She determined the median mass of a large population of trout at intervals. She started measuring on the day the newly hatched fish began feeding. Her results are shown on the graph below.




The best fit line shown on the graph is represented using this equation.

$$\text{median fish mass} = (m \times \text{days feeding}) + 50$$

where $m$ is the gradient of the best fit line.

(a) Use the graph above and the equation to calculate the median mass of fish after 195 days' feeding.

Show your working.

Answer _____ mg

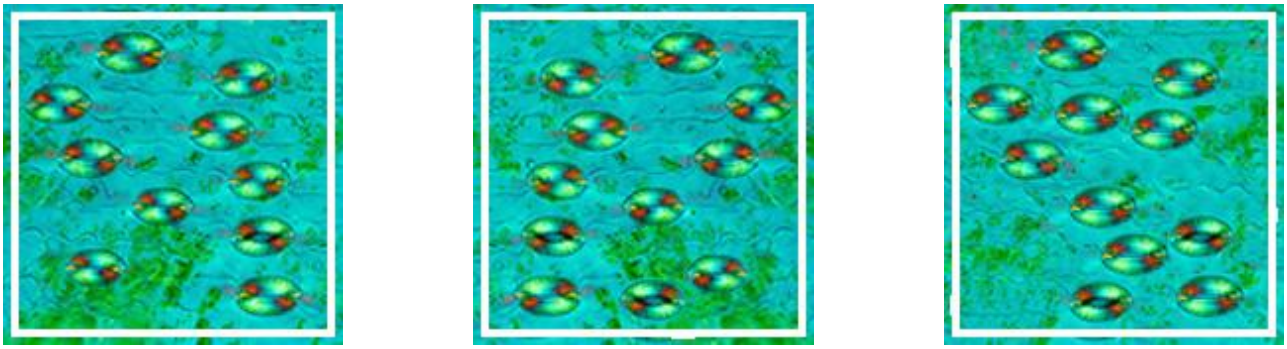
**(2)**
**(Total 2 marks)**

## Q2.

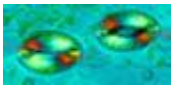
Scientists investigated stomatal density on leaves of one species of tree.

**Figure 1** shows three examples of the square fields of view the scientists used to calculate a mean stomatal density.

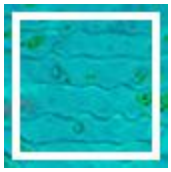
**Figure 1**



**Key**



Stomata



White lines show the counting field for stomata
(each edge of white square = 250 $\mu$m)

(a) Calculate the mean stomatal density in the three fields of view in **Figure 1**.

Give your answer as number of stomata per mm$^2$

Show your working.

Stomatal density _____ per mm$^2$

**(2)**
**(Total 2 marks)**

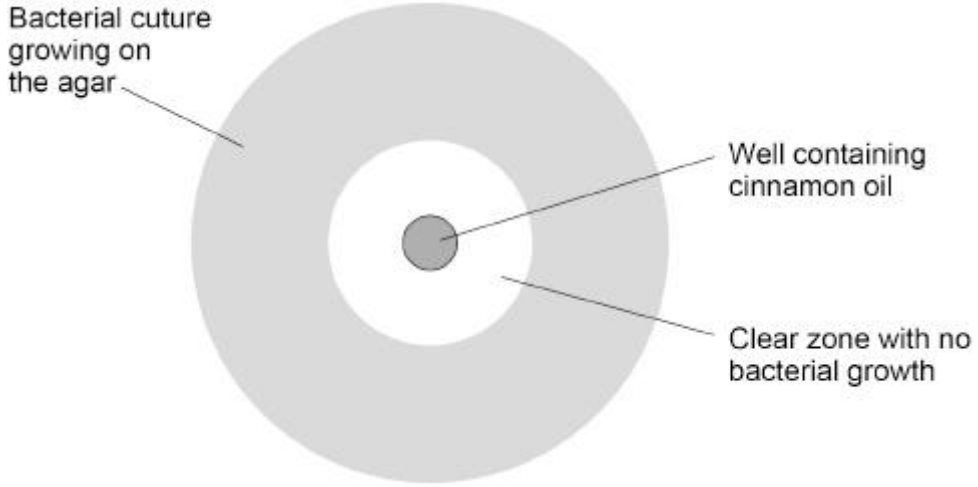
**MS1.10 Understand measures of dispersion, including standard deviation and range**

**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 |
| *Bacillus* spp. | 15 | 14 | 0 |
| *Staphylococcus aureus* | 20 | 17 | 0 |
| *Listeria monocytogenes* | 18 | 12 | 0 |
| *Escherichia coli* | 16 | 12 | 0 |
| *Klebsiella* 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 ± 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.

_____

_____

_____

**(2)**

**(Total 2 marks)**

## 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.

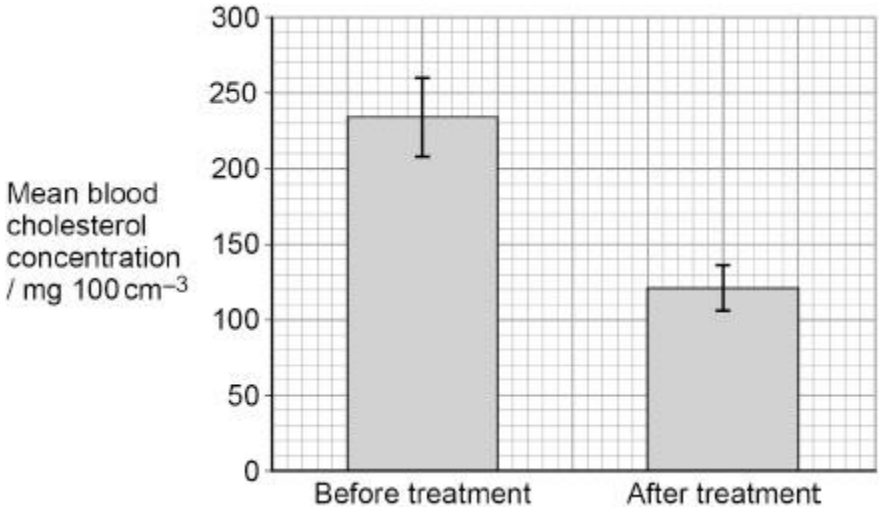
They:

- 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 ±2 standard deviations from the mean, which includes over 95% of the data.

**Figure 2**




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

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**(5)**

**(Total 5 marks)**

## MS2.2 Change the subject of an equation

### Q1.

Some enymes digest protein. They hydrolyse the peptide bonds between amino acids. The extent to which a protein is digested is called the degree of hydrolysis (DH). The DH value may be calculated from the equation:

$$DH = \frac{100 \times \text{Number of peptide bonds hydrolysed}}{\text{Total number of peptide bonds present}}$$

(a) (i) A protein molecule contains 151 amino acids. What is the total number of peptide bonds in this molecule?

_____

**(1)**

(ii) A molecule of this protein is digested. The DH value of the digested protein is 18. Calculate the number of peptide bonds that have been hydrolysed.

Answer _____

**(1)**

### Q2.

(a) Describe the relationship between size and surface area to volume ratio of organisms.

_____

_____

_____

_____

_____

**(1)**

(b) A scientist calculated the surface area of a large number of frog eggs. He found that the mean surface area was 9.73 $mm^2$. Frog eggs are spherical.

The surface area of a sphere is calculated using this equation

$$\text{Surface area} = 4\pi r^2$$

where r is the radius of a sphere

$$\pi = 3.14$$

Use this equation to calculate the mean diameter of a frog egg.

Show your working.

Diameter = _____ mm

**(2)**

## MS3.1 Translate information between graphical, numerical and algebraic forms

## Q1.

A scientist investigated the effect of the lung disease emphysema on lung function.

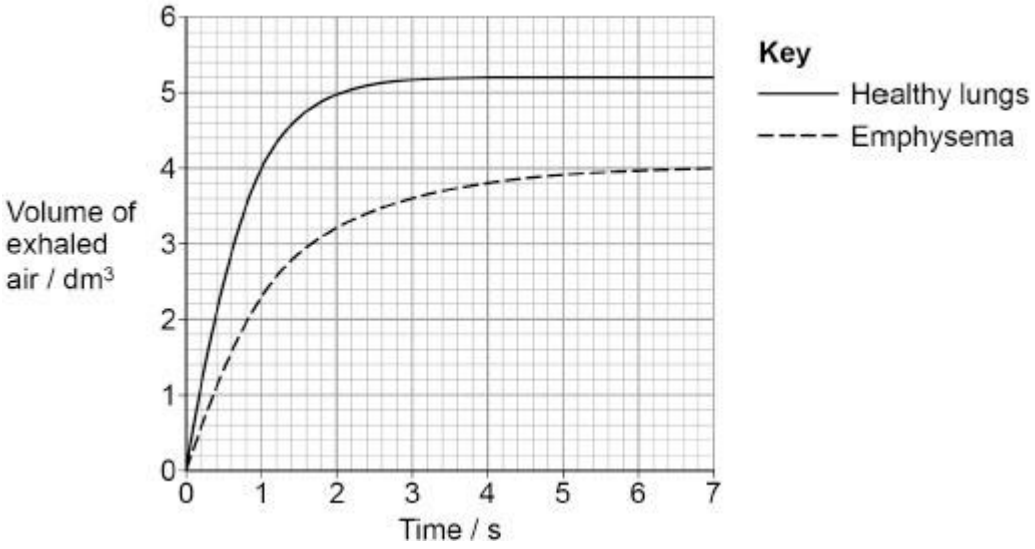
They investigated lung function in:
- a person with emphysema
- a person with healthy lungs.

The scientist told each person:
- to breathe in fully
- then breathe out fully and as quickly as possible.

The scientist measured the volume of air exhaled in one breath.

**Figure 1** shows the scientist's results.

**Figure 1**




(a) Forced expiratory volume ($FEV_1$) is the maximum volume of air that is breathed out in one second. $FEV_1$ is used to measure lung health.

What is the percentage decrease in $FEV_1$ for the person with emphysema compared with the healthy person?

Tick (✓) **one** box.

23.1% ☐

30.0% ☐

42.5% ☐

73.9% ☐

**(1)**

(b) Use **Figure 1** to determine the speed of exhalation, in $dm^3\ s^{-1}$, for the person with healthy lungs **at** time = 2 s

Show your working.

Speed of exhalation _____ $dm^3\ s^{-1}$

**(2)**

(c) The main effects of emphysema on the lungs are the breakdown of:

- the walls of the alveoli
- the elastic tissue in the lungs.

Use this information and the data in **Figure 1** to suggest why gas exchange is reduced in a person with emphysema.

_____

_____

_____

_____

_____

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_____

_____

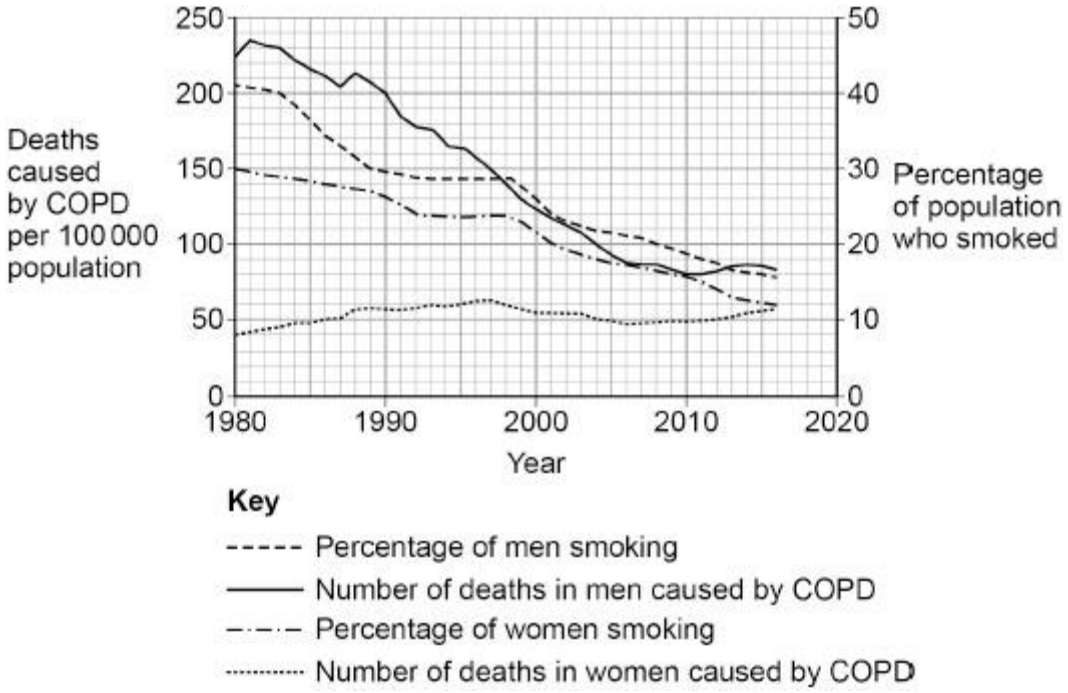
_____

**(3)**

(d) Chronic obstructive pulmonary disease (COPD) is the name for a group of lung diseases that cause breathing difficulties. This includes emphysema.

**Figure 2** shows the number of deaths caused by COPD from 1980–2016. It also shows the percentage of the population who smoked, for the same time period.

**Figure 2**




A journalist looked at the data in **Figure 2** and concluded that smoking is a cause of COPD.

Evaluate this conclusion.

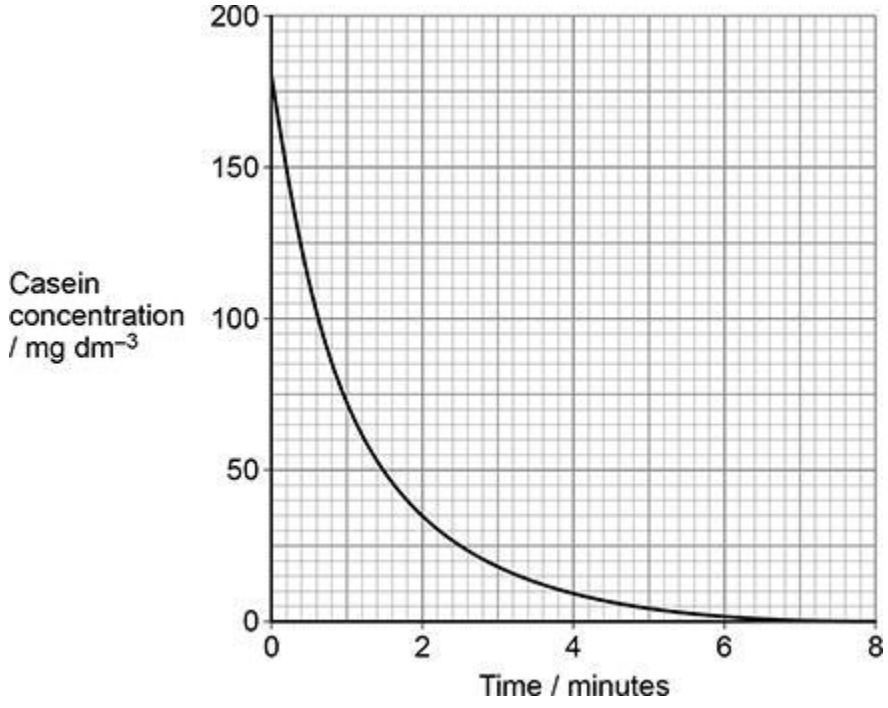
**(3)**

**(Total 9 marks)**

**MS3.5 Calculate the rate of change from a graph showing a linear relationship and MS3.6 Draw and use the slope of a tangent to a curve as a measure of rate of change**

## Q1.

(a) The graph below shows the scientist's results.




Use the graph above to determine the rate of casein hydrolysis at 2 minutes.

Show how you obtained your answer.

Answer _____ mg $dm^{-3}$ $minute^{-1}$

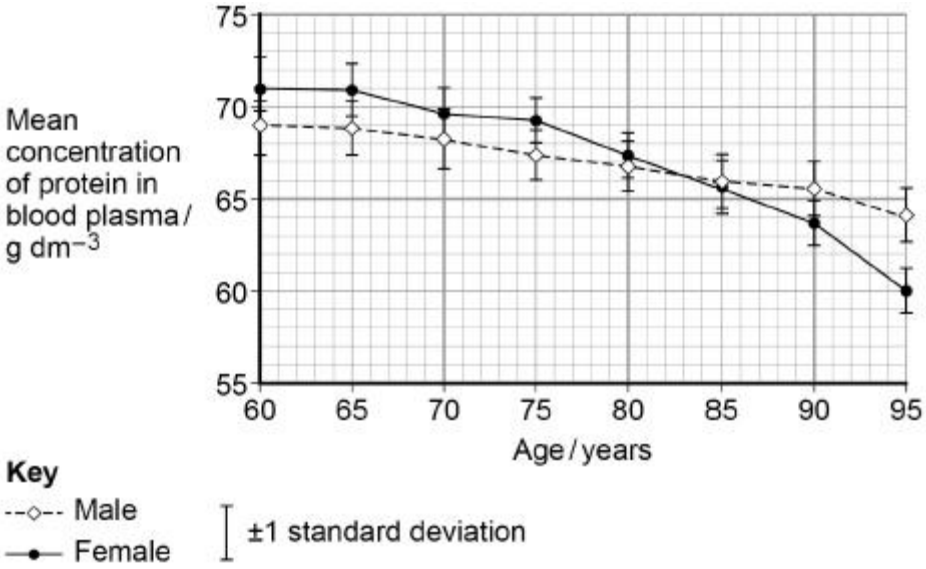
**(2)**

**(Total 2 marks)**

## Q2.

Scientists investigated how the concentration of protein in blood plasma changes in people between the ages of 60 and 95.

The graph shows the scientists' results. The bars show ±1 standard deviation.




(a) Use the graph above to calculate the rate of change of the mean concentration of protein in the blood plasma of males between the ages of 60 and 95.

Show your working.

Answer = _____ g $dm^{-3}$ $year^{-1}$

**(2)**

**(Total 2 marks)**

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

## Q1.

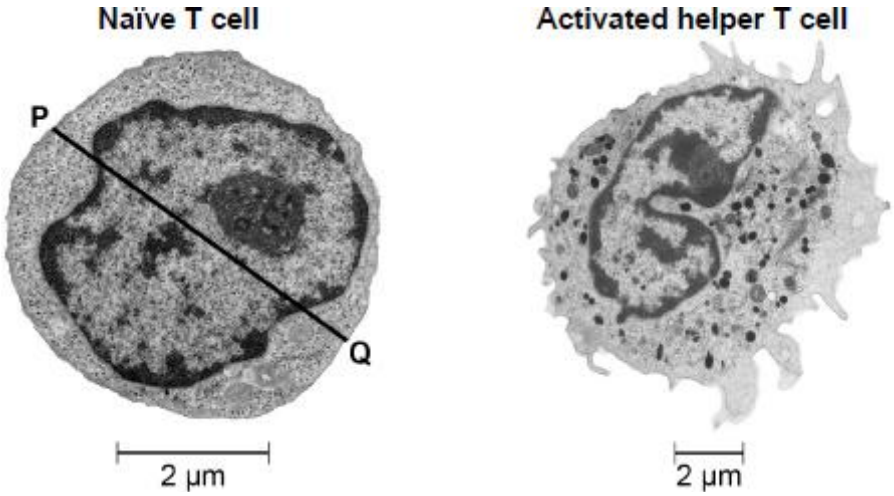
Scientists investigated the activation of T lymphocytes.

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 µm$^3$

(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.

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

Show your working.

Volume of naïve T cell _____ µm$^3$

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 µm$^2$ 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 µm in diameter and 1 µm in length.
The surface area of a microvillus is calculated using this equation

$$2\pi rl + \pi r^2$$

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.

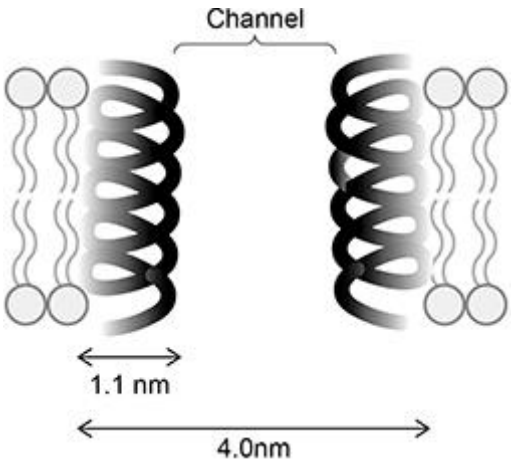
Ratio _____ :1

**(2)**

## Q3.

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

**Figure 3**




(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 $nm^2$ **and** to 1 decimal place.

Answer _____ $nm^2$

**(2)**